## A Framework for Understanding Energy Resources

ISSUE	PETROLEUM	NATURAL GAS	HYDROGEN	RENEWABLES	NUCLEAR	COAL
Fuel Supply Problems?	Yes and no. Many trillions of barrels are left, but perhaps several decades' worth is readily available at current prices.	No. Current estimates of proven reserves are 70 times present an- nual world consump- tion, and the size of proven reserves has increased every year since 1970.	Yes and no. The lightest gas, hy- drogen does not exist naturally on earth. However, it can be produced using a wide variety of pri- mary energy sources.	Yes and no. Most renewables occur in large but not inexhaustible, amounts. However, ancillary problems exist, such as the pos- sibility of running out of wind farm sites.	<b>No.</b> By most accounts, the world has a sufficient supply of uranium to accommodate greatly increased nuclear power generation. Reprocessing spent fuel could stretch this even farther.	<b>No.</b> Proven reserves in the United States alone are huge. China and India also have large reserves.
Major Cost Concerns?	Yes. Unexpected rise in demand or decline in production can have a sharp effect on prices, with often dramatic economic consequences.	Yes. Although large quantities of gas can be found underground, they are not always located in places of high demand.	Yes. Every piece of the hydrogen puzzle (production, storage, use in vehicles) faces a cost disadvantage of several times relative to competing alternatives.	Yes. Costs have declined, and some windpower installations produce cost-competitive electricity. In spite of this, currently subsi- dies are essential.	Yes. Nuclear power is unlikely to be econom- ically viable unless the cost of building a new plant can be re- duced significantly.	No. Coal is by far the cheapest, per Btu of energy, of the fossil fuels, and its price has steadily declined
Adverse Environmental Impact?	Yes. Although less damag- ing than coal, burning oil generates green- house gases, and spills affect marine life.	Some. Natural gas contains less carbon and is less of a problem than coal or petroleum, but it still emits pollu- tants, including nitrous oxides and solid particulates.	Yes and no. Combusting or using hydrogen in fuel cells produces very little, if any, direct pollution. But producing the hydrogen itself can harm the environment.	No. Environmental attrib- utes are, on balance, highly positive, though with some caveats. Wind turbines and biomass use may present some environ- mental challenges.	Yes and no. Nuclear power does not emit conventional air pollutants when used to generate electricity. However, finding safe storage for spent fuel has been extraordinarily difficult.	Yes. Burning coal gener- ates gases and airborne particles that threaten human health and, through acid rain, natural ecosystems.
Dependence on Unreliable Suppliers?	Yes. Ongoing wars and increasing terrorism in the Middle East, along with growing concerns about relia- bility of Russian oil, make this an impor- tant issue.	Some. The United States imports only 15% of its natural gas at this time, but this percent- age is likely to in- crease in the future.	Maybe. Hydrogen can be pro- duced using domestic sources, such as coal and renewables. However, the domi- nant current method uses natural gas, which is increasingly being imported.	<b>No.</b> Renewables, because they substitute for fuels subject to supply or price risks, enhance energy security.	<b>No.</b> Both the United States and Canada, as well as other friendly nations, have significant uranium deposits.	<b>No.</b> The biggest con- sumers, including the United States, are the biggest producers.
Serious Technical Challenges?	Yes and no. Major breakthoughs would be required to extract oil from new sources, such as tar sands. Improvements to cars and trucks can lessen pollution but may not greatly re- duce oil dependence.	No. Normal improvements in exploration and extraction technology can be expected to continue.	Yes. Significant technical barriers apply to all facets of a hydrogen system. On-vehicle storage and fuel cell technology are the most daunting, but hydrogen production and distribution are challenging as well.	Yes. For some time to come, certain renew- ables, such as solar photovoltaics and nonethanol biofuels, will be critically dependent on R&D and technological progress.	No. There are no real R&D or technological challenges to produc- ing nuclear energy. However, success will depend on keeping plant construction costs down and find- ing a politically acceptable way to dispose of wastes.	Yes. It is possible to hold emissions of noxious gases and particles to low levels, but this technology is rare in industrializing coun- tries. Likewise, tech- nology for capturing and storing carbon dioxide has yet to be fully developed.