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HD **The Long Road to an Alternative-Energy Future; Why it will take many years for new technologies to make a dent in our current energy mix**

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New Nuclear Reactors

The Technology: Advanced nuclear reactors use simplified, standardized designs that should be cheaper and quicker to build and easier to operate. Passive safety features lower the risk of accidents. These "generation 3+" reactors consume more of the nuclear fuel, lowering operating costs and trimming waste. Looking ahead, some generation IV designs can recycle used nuclear fuel, producing even less waste and relying less on new uranium supplies.

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Current Status: About a dozen generation 3+ reactors are under construction around the world, and several more are planned, including nearly two dozen in the U.S. awaiting certification and licensing by the Nuclear Regulatory Commission. For generation IV reactors, an international group of scientists and researchers is coordinating research and development, and they've agreed to a list of six technologies to pursue.

WHY IT'S GOING TO TAKE SO LONG: While China and others are moving ahead with construction of the generation 3+ reactors, the first new plants in the U.S. aren't likely to appear until late in the decade; NRC certification of the first of the new designs may not occur before early 2012, and construction, even if accelerated, will take at least four or five years.

Another hurdle is financing. So far, four companies have been short-listed to receive $18.5 billion in federal loan guarantees designed to reassure investors worried about delays and cost overruns. President Obama is seeking total guarantees of $54 billion, which might spur more companies to proceed with construction plans. The first $8.3 billion in guarantees were approved last week. But at the current pace, only about 10,000 megawatts of new nuclear power is likely to come online by 2020. That's about the amount of wind capacity added last year, and about 10% of current nuclear capacity, or nearly 1% of total U.S. capacity.

Supply-chain problems, such as the limited number of forges capable of making large reactor containment vessels, also could hinder more rapid deployment.

Generation IV reactors, meanwhile, aren't expected to enter commercial development until well after 2020.

Carbon Capture and Storage

THE TECHNOLOGY: Carbon-capture technology pulls carbon dioxide from the smokestacks of coal and other fossil-fuel plants, pressurizes the **gas** and pumps it underground for permanent storage.

CURRENT STATUS: A handful of small-scale carbon-capture and storage pilot and demonstration projects are under way in the U.S. and elsewhere. In a test to capture CO_2 from an operating power plant, American **Electric** Power Co. is running a pilot at its Mountaineer plant in West Virginia, collecting about 1.5% of the plant's CO_2 emissions and storing them under the site. Other sites in Europe, Africa and Australia are investigating underground storage, but the Mountaineer project is the first to integrate capture and storage.

WHY IT'S GOING TO TAKE SO LONG: Technically, carbon capture has been shown effective in small, less expensive pilot projects. In capturing larger emissions streams, operators have to fine-tune the equipment and see

how it works in different weather conditions and using different grades of coal. In the most-advanced test, at AEP's Mountaineer plant, this stage is expected to take at least a year.

Once that is done, the next stage is building and operating a commercial-scale demonstration plant. AEP recently received $334 million in federal stimulus funds for its planned 235-megawatt demonstration plant. Designing the facility can overlap with the current pilot, but construction of the plant is expected to take several years; the goal is to have it online by fall of 2015. It would then have to be operated for several years to test its reliability and efficiency. AEP expects that power-plant builders could begin offering commercial versions of the technology by 2020.

Ultimately, commercial adoption also will depend on whether Congress decides to impose a price on carbon and what that price is. Carbon capture is expensive—it could double the price of electricity from some existing coal plants, and cuts plant efficiency by about 30%. Most experts agree that it is going to take a carbon price of at least $50 a ton to make carbon capture economically feasible.

Algal Biofuels

THE TECHNOLOGY: Algae are fast-growing, consume carbon dioxide and have the potential to produce more oil per acre than other biofuels. The oils they produce can be used to make substitutes for diesel fuel, aviation fuel and gasoline. Backers say the U.S. could meet its entire liquid-fuel needs with algal biofuels.

CURRENT STATUS: About 150 companies world-wide are working to commercialize algal biofuels, and U.S. government support has soared over the past few years; the Energy Department recently granted $44 million for research into commercializing algal biofuels and $97 million for algae pilot and demonstration projects.

In the biggest, Sapphire Energy of San Diego, Calif., plans to break ground on a 300-acre biorefinery in New Mexico later this year. Another recipient, Solazyme Inc., uses a fermentation method to produce algae-based fuels and has contracts to provide the U.S. Navy with 1,500 gallons of jet fuel and 20,000 gallons of diesel to power navy ships; the company is converting an existing plant in Pennsylvania into a demonstration biorefinery. Big oil companies, including ExxonMobil and BP, also have invested in algae-biofuel projects or companies.

WHY IT'S GOING TO TAKE SO LONG: As promising as the technology is, it hasn't proved that it can produce fuels in sufficient quantities or at a low enough cost to make a dent in U.S. liquid-fuel consumption. Solazyme's fermentation method, which grows algae in dark, enclosed tanks, is considered by some experts to be closest to maturity; the company expects to reach commercial-scale production by 2013, producing "hundreds of thousands" of gallons of oil or fuel substitutes. But it's a long way from being cost-competitive with oil.

Sapphire's open-pond method could deliver lower-cost (but still expensive relative to oil) agriculture-scale production. The company aims to produce one million gallons of "green crude" by the end of 2012, and hopes to begin commercial production within three years, with a goal of 10,000 barrels a day by 2018. But the technique hasn't yet demonstrated that such productivity levels are possible. It also has to deal with such issues as adequate water supplies, lower productivity caused by wild algae strains and supplies of easily accessible carbon dioxide.

Wind

THE TECHNOLOGY: Wind power is one of the fastest-growing alternative energy sources in the world—a low-carbon, renewable source of electricity that can deliver millions of watts of relatively low-cost power.

CURRENT STATUS: In the U.S., wind produced about 73 billion kilowatt-hours of electricity last year, about 2% of total generation and enough to power about 13 million homes. Industry capacity rose nearly 10,000 megawatts, or 39%, last year to a total of about 35,000 megawatts.

WHY IT'S GOING TO TAKE SO LONG: It may not. The U.S. Energy Department laid out a scenario for how wind could meet 20% of total electricity demand by 2030—about 300 gigawatts—displacing half of natural **gas**-powered and 18% of coal-fired generation. But a recent report by the National Renewable Energy Laboratory, or NREL, found that the Eastern U.S., which isn't blessed with substantial onshore wind resources, could hit the 20% target by 2024.

Still, reaching that goal is going to take significant investments in new transmission lines, especially in a transmission "superhighway" to carry electricity from parts of the country with lots of wind to places where demand is highest. The NREL study estimates the price tag could be as high as $93 billion. Local opposition to transmission lines can also present a challenge, especially when lines have to cross states to carry power to a neighbor.

It also may require significant additions of offshore wind power, which the Energy Department predicts could deliver about 17% of its projected 2030 total. Offshore wind generation promises more reliable power, and because it's closer to East Coast population centers, less transmission is needed. But offshore generation is about twice as expensive as onshore wind power and faces opposition from coastal property owners. Power from the first of a handful of proposed offshore wind projects is expected by 2012.

Solar

THE TECHNOLOGY: Energy from the sun can be used to make electricity directly with photovoltaic panels or indirectly using concentrated sunlight to heat a liquid, which produces steam to turn electrical turbines. Concentrating solar plants can be built to store heat and deliver power for several hours without sunlight.

CURRENT STATUS: Solar power (both photovoltaic and concentrating) produced an estimated about 3.2 billion kilowatt-hours of electricity in 2009. Total capacity—the amount of power that could be produced if the sun shone constantly—of solar photovoltaic systems has been doubling every two years, and the pace of increase is expected to rise further: An estimated 2,000 megawatts of solar capacity in 2009 was nearly 45% higher than in 2008. That includes about 980 megawatts of concentrating-solar projects; an additional 81 megawatts are under construction.

WHY IT'S GOING TO TAKE SO LONG: Even at that rate of growth, solar power is still minuscule: Solar generation in 2009 accounted for less than 0.1% of total electricity production in the U.S. Solar capacity remains less than 1% of the total. "The biggest obstacle is that we're starting at such a low level," says John Benner, a research manager at the National Renewable Energy Laboratory.

The cost of solar installations has fallen in recent years, but remains high, partly because demand continues to keep pace with supply. The cost for average residential installations was about $5.40 a watt of capacity in 2008 and $4.20 a watt for commercial, after a raft of federal, state and local incentives, according to a study by the Lawrence Berkeley National Laboratory. (Solar installations depend heavily on subsidies, which vary widely; without incentives, costs average $7.50 a watt.) Thanks to capital expenses, electricity from solar is expensive: Estimates of solar costs cover a broad range, from 25 to 46 cents a kilowatt-hour for residential and from 17 to 29 cents from a concentrating solar plant. That compares with about 7 cents a kilowatt-hour for coal and natural **gas** and 10 cents for wind, according to estimates by the **Electric** Power Research Institute.

Like wind farms, **utility**-scale solar photovoltaic and concentrated-solar projects also require additional transmission connections. Since most aim to build in the environmentally sensitive desert Southwest, where much of the land is publicly owned, they also face lengthy and complicated permitting reviews.

Electric Vehicles

THE TECHNOLOGY: In theory, **electric** vehicles could replace most gasoline-powered cars and light trucks. They can run entirely on battery power, or in the case of plug-in hybrids, on batteries that can be charged by a separate gasoline engine when needed as a backup.

CURRENT STATUS: About 56,000 **electric** vehicles are in use, but the numbers are deceiving—most are limited to low-speed driving and have limited range. So far, Tesla Motors Inc.'s Roadster is the only open-road **electric** vehicle, but a handful of other all-**electric** cars, including Nissan Motor Co.'s Leaf, are expected to come to market in 2010. The first commercial plug-in hybrids, led by General Motors Co.'s Chevy Volt, also are slated to be available later this year.

WHY IT'S GOING TO TAKE SO LONG: The biggest obstacle is cost. The advanced lithium-ion battery pack that powers the Volt, which can travel 40 miles on a charge, can cost as much as $10,000, though prices are expected to fall as production ramps up. The U.S. Energy Information Administration predicts that in 2030, the added cost of a plug-in hybrid will be higher than fuel savings unless gasoline costs around $6 a gallon.

Another challenge is the need for public recharging stations. Though most drivers travel fewer than 40 miles a day, well within the range of first-generation **electric** vehicles, consumers will balk if they worry about running out of juice.

Public charging spots are less important for plug-in hybrids, which are more likely to be recharged at home. Still, owners may need to upgrade their existing outlets to recharge more quickly; a 120-volt outlet will take about four to six hours to charge a plug-in vehicle and about 12 to 24 hours for an all-**electric** vehicle. A 240-volt outlet, which can charge an **electric** vehicle in about three to six hours, generally requires adding a circuit to the home's **electric** system to handle the additional load.

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Correction &Amplification: An earlier version of this article incorrectly attributed estimates comparing the cost of solar power with coal, natural **gas** and wind to Energy Power Research Institute.

CO useia : Energy Information Administration

IN isolar : Solar Energy | i163 : Electric Power Generation - Alternative Energy | i5020044 : Power Station Construction | irenewee : Renewable Energy Equipment | i35104 : Electric/Gas/Biofuel Vehicles | i1 : Energy | iindstrls : Industrials | i16 : Electricity/Gas Utilities | i16101 : Electric Power Generation | i32 : Machinery/Industrial Goods | i351 : Motor Vehicles | i502 : Heavy Construction | iaut : Automobiles | iconst : Construction | icre : Construction/Real Estate | ieutil : Electric Utilities

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