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TALKING POINTS

Beyond Fossil Fuels

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The subject of energy is front-page news these days because of two huge challenges: oil dependency and global warming.

Sometimes they seem so big, so daunting and so complicated that many people throw up their hands and walk away.

But admitting defeat is not an option. And it doesn't have to be an option. Not since the Arab oil embargo of the early 1970's have the times been more propitious for a major shift in the way America uses energy.

Thirty years of research at the private and government level, here and abroad, have produced a range of new technologies that can help turn abundant energy sources — wind, biomass, solar, even water itself — into alternative fuels. These fuels, in turn, can help keep our cars running and our power plants humming, while reducing both our reliance on unstable Middle Eastern oil producers and our contributions to dangerous climate change.

Some of these technologies are in their infancy; others, if not wholly mature, are at least frisky teenagers. Global wind generation, for instance, has more than tripled in the last five years alone (PDF). The price of solar power has dropped dramatically. The production of fuel ethanol doubled between 2000 and 2005, and it could double again in the next three years.

Overall, renewable energy sources — mainly hydropower — provide just over six per cent of total U.S. energy, and about 10

percent of our electric power. But as technology improves and the price of conventional fuels like oil and natural gas skyrockets, newer forms of energy will become increasingly competitive and, inevitably, increasingly important.

Even so, bringing these technologies into the commercial mainstream, where they can make a real difference, will require public and private money and, particularly in the United States, a sense of urgency and a great deal of political will.

The inertia in the present energy delivery system is staggering. The infrastructure is huge and it has been constructed at great cost. Its basic ingredients — the millions of cars and trucks and the many thousands of power plants that deliver electricity — have been built pretty much the same way for years and years. Turning things around will not be easy.

But turn they must, and soon. As the Arab oil shocks 30 years ago demonstrated, as the terrorist attacks of 9/11 confirmed, and as $2.50 gasoline reminds us almost daily, our continuing dependence on the politically fragile nations that control most of the world's oil reserves jeopardizes our national security and drains billions of dollars from the American economy. It is not a healthy relationship. It is probably unsustainable. And it is incredibly expensive.

The United States consumes one-quarter of the world's oil — 20 million barrels — every day; about 12 million barrels of that is imported. Assuming a price of $60 a barrel, that means that $720 million is flowing out of this country every day to finance what President Bush himself called our oil "addiction."

The global warming picture is no less gloomy. Just in the last few weeks, a group of NASA scientists, headed by climate specialist James E. Hansen, argued that global warming has been more rapid over the last 30 years than anyone thought — about 0.2 degrees Celsius over each of the past three decades. If the trend continues unchecked, the group asserts, 60 percent of species

around the world could die by the end of the 21st century and sea levels could rise several feet, enough to completely transform coastlines.

Many scientists regard Mr. Hansen's conclusions (although not his data on warming) as far too alarmist. But there are few mainstream scientists left who dispute the need for moving quickly to slow, stabilize, then reduce the human contributions to the accumulated carbon load that already exists in the atmosphere. And what they usually mean by "moving quickly" is to begin making major changes in the way we use energy in the next ten years .

It is in this context of early action that alternative fuels — by which we mean, largely, renewable fuels — must be viewed. There are all sorts of marvelous, futuristic (and plausible-sounding) ideas out there, including space-based solar systems, advanced biomass, worldwide electricity grids, and the like, nicely summarized by Marty Hoffert of New York University in a paper for the Pew Center on Global Climate Change. But these are huge, enormously expensive projects, requiring a global budget, and none is likely to do much good in the near term.

There is, however, a lot that we can and should be doing right now.

I. A Renewable Called Efficiency

A quick but necessary word here on something that will do a lot of good in the near term — energy efficiency, that is, making much better use of the fuels we already have.

Amory Lovins, who runs the Rocky Mountain Institute in Aspen, Colo., and who has been preaching the virtues of energy efficiency and the promise of new technologies for years, is fond of pointing out that the United States uses 47 percent less energy per dollar of economic output than it did 30 years ago, lowering costs by about $1 billion a day.

Renewable fuels played only a small role in this transformation. What happened is that we took existing products and made them better. We manufactured more efficient light bulbs, built more efficient homes, streamlined our factories and, perhaps most important, got more work out of a gallon of gasoline by imposing strict fuel economy standards (which, regrettably, have not been seriously updated for three decades).

There is a lot more efficiency to be wrung out of the system. Anyone who has suffered recently through a blackout or brownout knows first-hand how old and inefficient much of the nation's transmission grid is. The same is true of things we do not normally regard as old or inefficient.

Take, for instance, the automobile. Lovins points out that despite 119 years of refinement, the modern car remains "astonishingly inefficient" , with only 13 percent of the energy even reaching the wheels. Constructing cars from light-but-strong materials like advanced polymer composites, he argues, would increase mileage dramatically. Make that same car a plug-in hybrid, running partly on gasoline and partly on advanced batteries that can be recharged at home overnight, and pretty soon consumers could be driving cars capable of well over 100 miles per gallon.

Overall, Mr. Lovins insists, full adoption of efficient vehicles, buildings and industries could shrink projected U.S. oil use in 2025 by more than half (that is, about 14 million of a projected 28 million barrels a day), lowering consumption to pre-1970 levels. And we wouldn't even need renewable fuels to get there.

But wouldn't it be wonderful if we had such fuels? Without renewables, we'll still end up burning (albeit much more efficiently) the same coal and natural gas that we burn today in our power plants and the same fuel oil that we burn in our cars and trucks. And it is precisely these carbon-based fossil fuels that we must distance ourselves from if we really want to come to grips with our dependence on foreign oil and with global warming.

II. The Promise of Biofuels

The commodity that may be best positioned to help the United States break its addiction to oil is already growing in America's fields and forests — plants and trees, known collectively as biomass. Fuels derived from biomass can be produced either by converting sugar or starch crops to ethanol, or by converting soybean and other plant oils to biodiesel.

Of these two biofuels, ethanol is the most promising. Despite biodiesel's growing popularity (the country and western singer Willie Nelson promotes it assiduously), only about 75 million gallons were produced in 2005, compared to nearly 4 billion gallons of ethanol.

President Bush mentioned ethanol in his State of the Union address this year. Entrepreneurs like Bill Gates have begun investing in it. Every blue ribbon commission on energy has embraced it as a fuel of the future. And both the government and several leading environmental and public policy groups, including the Natural Resource Defense Council and the Energy Future Coalition, have suggested that ethanol — combined with other strategies like plug-in hybrids — could reduce the need for imported oil to zero.

Until recently, there were only two kinds of ethanol that were at all well-known: ethanol made from sugar cane, which accounts for approximately 40 percent of Brazil's non-diesel automotive fuel; and corn ethanol, which, at nearly 4 billion gallons annually, and used mainly as an additive, accounts for between two and three percent of America's automotive fuel.

Corn ethanol's image has suffered from its association with the agribusiness lobby — in particular a politically connected company called Archer Daniels Midland — and with presidential candidates hustling support every four years in the Iowa primaries. It has also suffered from the widespread belief that it takes more energy to make corn ethanol than the end product

gives back, as well as from the belief that corn ethanol can't compete with gasoline without a generous federal subsidy.

All three complaints are outdated. A.D.M. is no longer the only big player in the field, which is growing rapidly to meet a Congressional mandate contained in the 2005 energy bill to expand the production of ethanol and biodiesel to 7.5 billion gallons by 2012, a target that almost surely will be met much earlier. Meanwhile, nearly every reputable study of corn ethanol's net energy balance (the value of inputs like plowing, planting and fertilizing vs. the value of the outputs) shows net benefits of 25 to 40 percent.

Finally, even accounting for its lower energy content, corn ethanol is competitive with gasoline in the United States when the price of oil is at $45 or above. That is well below the price of oil today , and also below where the U.S. Energy Information Agency expects the oil price to be over the next 25 years.

There is an added benefit. The corn ethanol studies also show that corn ethanol has a net benefit in greenhouse gas emissions of up to 20 percent.

So we are getting what we want: a competitive substitute for Middle Eastern oil that could also make a positive difference, albeit modest, in greenhouse gas emissions.

The real problem with corn ethanol is simply that there isn't enough of it, and for all sorts of good reasons having to do with sensible land use and the food supply, there never will be. By one estimate, devoting the entire U.S. corn harvest in 2005 to ethanol would have offset less than one-sixth of the nation's gasoline consumption, which exceeds 140 billion gallons a year, and nobody is talking about converting anything close to every kernel of corn to fuel.

What the experts are talking about is another kind of ethanol: cellulosic ethanol. This type of ethanol can be derived from a

range of crops, including native grasses like switchgrass, trees like poplar, and even the waste components of farming and forestry — in short, just about anything rich in cellulose.

This is where the real promise of ethanol lies. Crops that yield cellulosic ethanol can be grown specifically for energy, in some cases on agriculturally marginal land without pesticides or fertilizer. And the energy-in energy-out balance is terrific: it gives back about five times more energy than it takes to produce, according to most studies.

One reason for this is that the manufacturing process consumes the entire plant, including lignin, a non-fermentable component of the plant that can be burned to run the ethanol refinery. And while both forms of ethanol are better than gasoline for reducing greenhouse gas emissions (since the CO2 they absorb from the atmosphere while growing helps offset the CO2 they produce during combustion), cellulosic ethanol is far superior on this score because so little carbon-based fuel is used to produce it.

The rub is this: at the moment, there is no commercial production of cellulosic ethanol in the United States. A Canadian company called Iogen, a leader in the field, makes its ethanol from wheat straw, and is planning a major facility in Idaho, and BP and DuPont are getting into the game. A Spanish company called Abengoa could have its operations up and running by next year. Secretary of Energy Samuel Bodman recently announced a goal of making cellulosic ethanol a practical and cost-competitive alternative by 2012, with sufficient commercial production to displace 30 percent of the nation's gasoline consumption by 2030. These are not impossible goals, but a national commitment and big money will be needed to meet them.

III. Hydrogen: Hype or Hero?

President Bush did not really start paying attention to energy problems until 9/11, when it became clear that our usually reliable sources of Middle Eastern oil were seriously at risk.

In addition to the predictable supply-side policies (drilling in the Arctic National Wildlife Refuge, for instance) Mr. Bush offered up, as the ultimate savior, a hydrogen economy. The centerpiece would be a zero-emission fuel cell vehicle powered by hydrogen — a "Freedom Car," in Mr. Bush's words, running on "Freedom Fuel." Such a vehicle would not only end our dependency on oil. It could also have payoffs in terms of global warming (a benefit that went largely unmentioned by Mr. Bush, who does not like to acknowledge the dangers of climate change).

Hydrogen cars are not a new idea. People have been dreaming of them for years, and the Clinton administration invested in hydrogen fuel-cell technologies that could be used for both mobile energy-users, like cars, and stationary ones, like buildings. Mr. Bush has ramped up that investment considerably. He has also ramped up the rhetoric, holding out hope that by the early 2020's — when today's newborn will be getting their first driver's licenses — motorists will be able to drop by their local dealer and drive a hydrogen car off the lot.

An appealing prospect, and certainly one worth pursuing. But the obstacles are daunting. One is figuring out how to make the stuff. Hydrogen doesn't just sit there, like oil; it needs to be extracted from something. It can be extracted (or "reformed") from natural gas, oil and coal. But that requires a lot of energy and produces a lot of carbon dioxide, so the global warming benefits are minimal — even though the hydrogen itself, once produced, burns cleanly.

One potentially non-polluting source of hydrogen does exist — electrolysis, the use of electricity to break water into hydrogen and oxygen. So the ideal scenario would look like this: An electric current would be produced by a non-polluting source like wind power. The current would be applied to water to produce hydrogen. The hydrogen (the "Freedom Fuel") would be transported to a hydrogen filling station and pumped into a special car (the "Freedom Car") stacked with fuel cells that would

then recombine the hydrogen with oxygen to produce an electric current that — voila! — runs the car.

It's basically a mirror image of the process used to produce the hydrogen in the first place. The only residue is water vapor — no CO2, no smog-forming gases, no acid rain gases. And, of course, no need for Middle Eastern oil.

Our policymakers should keep after this. But they should also fully appreciate the obstacles — making the stuff, storing it, transporting it to a national network of filling stations and building those filling stations (itself a $500 billion proposition, by one estimate). And then there's the car itself, with all that new tank capacity and all those fuel cells. By some estimates the cost of that car has to come down 50-fold before a consumer will even think of touching it.

Hydrogen may well be the fuel of the future. But the operative word is "future." Did anyone say 2050? Whatever the target date, the dream of hydrogen cannot relieve us of the grittier, real-life task of quickly developing more fuel-efficient cars as well as cost-effective fuels to run them.

IV. Here Comes the Sun?

Finding new fuels for the world's transportation fleet is only part of the energy equation. The other big part is figuring out how to keep generating the power that a growing world needs without trashing the planet.

This is not primarily an oil problem, since very little oil, relatively speaking, is used to turn the lights on. More than 50 percent of America's electric power is supplied by coal; natural gas and nuclear energy supply about 20 percent each, and the remainder, just under 10 percent, comes from renewable sources like wind, solar, geothermal, and especially hydroelectric power. The main reason we need to increase the percentage of

renewables is to reduce the amount of carbon we are putting into the atmosphere.

Here again, it would help matters if we made better use of the tools we have. For one thing, we need to build a super-efficient grid. For another, we almost certainly need more and better nuclear plants, since nuclear energy is low-carbon energy. No new nuclear plant has been built for decades, mainly for cost reasons. But many people, including some environmentalists who once recoiled from the nuclear option, are now persuaded that global warming cannot be tackled without a new generation of cheaper, safer and more reliable nuclear plants.

Finally — since we're going to be living with coal for a long time to come — we have to figure out some way of stripping the carbon dioxide from the waste stream and putting it somewhere besides the atmosphere. There's great hope that it can someday be sequestered underground.

But renewables will also play a useful role. Geothermal energy is one possible source, though limited in scope. Ocean tides could be another, if someone could figure out how to harness them. The two that are most talked about are solar energy and wind energy.

Solar is particularly popular among environmentalists. Solar cells (also known as photovoltaic cells, or PV's) that convert sunlight directly into electricity could yield large benefits down the road; the energy they produce is essentially emissions- free. Solar energy also holds out almost magical promise: by one estimate, a 90-square-mile PV generating station in the western United States could produce enough electricity to meet the entire country's peak demand if you could figure out how to distribute it economically.

And here's more good news: The price of solar cells is coming down, dropping almost 20-fold since the mid-1970's and resulting in a six-fold increase in global annual production over

the last five years alone. In percentage terms, solar energy is the world's fastest growing source of power.

Now for the bad news: Solar power provides an almost invisible fraction, far less than one percent, of America's energy. The main reason is cost. Despite remarkable improvements in the technology — especially in the crystalline energy chips that are at the heart of it — the cost per kilowatt hour (kWh) of utility-scale PV's is still four to five times the cost of power generated by coal or natural gas or, nowadays, wind.

Costs are lower for so-called end-use PV's — those attached to, say, individual houses or office buildings. And for some remote locations far from the grid, PV's are often the least-cost source of power. As William Sweet observes in his recent book, "Kicking the Carbon Habit," solar power remains "one of those irritating glass-half-full, glass-half-empty stories — or maybe two-thirds empty, one third full." Even though prices may someday fall to competitive levels, and even though hardly a week goes by without someone announcing the construction of yet another PV panel on the top of some visible public building, Mr. Sweet insists, "the economic case for photovoltaics has yet to be demonstrated."

V. Favorable Winds

Fortunately, the same cannot be said of wind power. Mr. Sweet argues that of all renewable energy sources, "the really sensational story of the last decade has been wind."

As indeed it has. Encouraged by generous subsidies from benevolent governments, and by rapid improvements in technology, wind turbines have been popping up around the world, and especially in Europe, at a steady clip.

Germany, where "greens" have considerable influence, aims to replace all of its nuclear power with renewables; it already gets about one-tenth of its power from wind. Denmark, which gets

about one-fifth of its energy from wind, plans to meet fully half of its power requirements with wind by 2030. (Denmark has also become the leading producer of advanced turbines, further confirmation of the argument that those who are willing to fight global warming with cutting-edge technologies stand to profit from them, as Japan hopes to with solar cells). Britain, where global warming has become a big issue under Prime Minister Tony Blair, hopes to produce 20 percent of its energy from renewables, mainly wind, by 2020.

Measured against these grand ambitions, America seems unadventurous. As of 2005, according to the American Wind Energy Association, there were 9,149 megawatts of installed wind capacity in the United States, enough to power 2.3 million homes. With the industry forecasting another 3,000 MW this year, America's capacity could soon be about one-fourth to one-third of Europe's. That's good but not great, and still less than one percent of total output.

But those number are sure to grow. Improved technology (mainly in turbine construction) plus the rising costs of natural gas have made wind power increasingly economically competitive. The cost of wind power has fallen from 80 cents per kWh 25 years ago to between 3 and 6 cents today. In some parts of the country it's even cheaper than natural gas. And while today's price includes a government production subsidy of 1.9 cents per kWh, it still represents a huge drop over the last quarter-century, and a further affirmation of technology's promise.

Like almost any energy source, however, wind power brings concerns with it. Except in places where the wind seems to blow all or most of the time, in coastal areas and states like the Dakotas, wind power is intermittent. The places where wind power is most reliable are often the places furthest from the urban centers most in need of it. Costs can be high, especially when the turbines are placed offshore.

The towers themselves are huge, the length of a football field measured from their base to the tips of their blades; and conservationists, who otherwise love clean power, worry about the damage to bird life. And to some people, they are just plain ugly. The bitter dispute over a wind farm planned for Nantucket Sound off of Cape Cod, which the Kennedy family has famously opposed, is mainly about aesthetics.

Still, wind power is here to stay. The Department of Energy estimates that the wind resources between 5 and 50 nautical miles from America's coastline could support 900,000 megawatts of wind capacity—a good chunk of the nation's total needs. And that's not counting the Great Plains, sometimes called the "Persian Gulf" of American wind power.

Given its rich technological heritage, the United States should be a leader in renewable energy. It was, but is no longer, in part because we have become so comfortable with inexpensive conventional fuels and in part because the country's leadership has only lately begun to take renewables seriously.

John Podesta, a Clinton adviser now with the non-profit Center for American Progress, noted in a speech in California the other day that as recently as 1996 — to take just one example— the United States held 44 percent of the global solar cell market. By 2005, that figure had fallen to 9 percent. Add that to Brazil's dominance of the ethanol market and Europe's dominance in wind turbines and America is plainly missing some economic bets.

But that, too, could change, thanks to a recent upsurge in private investment. Mr. Podesta notes that worldwide, $38 billion in private venture capital flowed into renewable energy investments in 2005, a number that could nearly double by 2010. And much of this was American money from big players like Goldman, Sachs and the California Public Employees Retirement System. Where America lags is at the federal level. It's hard to figure out how much of the federal budget is devoted to energy, especially

renewable energy, since so many programs are scattered in so many parts of the budget. And tax breaks complicate matters, because they come and go. But according to one Energy Department official, the department's total research and development budget for renewable technologies last year was a mere $416 million.

In his Feb. 20 Advanced Energy Initiative, Mr. Bush recommended increases in all major programs. But compared to other government outlays— and measured against the need — these are pitiful numbers.

That, however, may be changing. Although complete "energy independence" may be a distant and even unattainable dream, the phrase is becoming increasingly central to the nation's political discourse, reflecting public anxiety about high gas prices, economic competitiveness, and terrorism all at once. We are hearing it in this season's Congressional campaigns, and we are sure to hear more of it as the 2008 presidential campaign begins.

This attention will, no doubt, eventually start translating into policy, and the American government will start to catch up with America's private sector.

After a slow start, renewable energy's time may finally have arrived.

Lela Moore provided research for this article.