inventing the future

by Vinod Khosla

"Some people see things as they are and say why? I dream things that never were and say why not." Robert Kennedy said something like this more than 40 years ago, and it's even more applicable today. We have all seen the forecasts on why the world won't change — how we're doomed to our fate, chained to a future where oil remains the dominant commodity, unshakeable, and impossible to replace. The mistakes of the past persist — extrapolating historical data while ignoring deviations from the norm, and failing fully to understand the shock potential of technology. That is the world of economists and econometrics. I live in the world of innovation and innovators — one driven by the power of ideas fuelled by entrepreneurial energy.

Cellulosic biofuels have seen an explosion of interest in the last few years as we start to come to grips with the climate change problem. Meeting the needs of this challenge requires an unprecedented coordination of capital, intellect, and pragmatism. Yet we remain confident that we will succeed — foreseeing $1.99 a gallon cellulosic ethanol at neighbourhood service stations within 5 to 10 years, with 75 per cent reductions in carbon emissions, water use and land use.

The world of fuel chemistry and production is undergoing exciting change. The broad range of possible biofuels include butanol, cellulosic gasoline, cellulosic biodiesel, cellulosic 'biocrude', and many more. The potential for customized chemistries means that we can remove a hydroxyl group here, add a hydrogen there, and create a longer or shorter carbon chain to optimize the fuel for the intended purpose.

Some common chemical and biological pathways have been utilized successfully for decades to make biofuels' such as fermenting sugar to produce ethanol. Others are newer and innovative. Most exciting is how these ideas have come to be the target of companies, varying from small, privately funded start-ups to such behemoths as BP. This is the power of the innovation ecosystem, as researchers and innovators from very disparate fields come together to prove out new approaches. This is why traditional 'energy research' organizations and companies are unable to make sufficient progress and why most breakthroughs will come from the innovation ecosystem. It is the reason why traditional 'pundit's forecasts' lag far behind the reality of small entrepreneurial companies. It is why General Motors just announced a partnership with Coskata to produce $1.00 per gallon cellulosic ethanol made from waste and Range Fuels of Broomfield, Colorado, announced similar cost points using wood waste — both by 2010!

There are many examples of these innovative companies. LS9, in San Carlos, California, is using synthetic biology to move pathways from plants into bacterial cells to try to make petroleum from fermenting cellulosic feedstocks. Amyris, a company funded by $40 million from the Gates Foundation to develop the anti-malarial drug artemisinin, is transforming itself into a next generation biofuels company using the same technology platform. Gevo, a company formed in response to "you can't do that with synthetic biology yet" is taking on BP-Dupont in the race to commercialize butanol.
Range Fuels has developed an anaerobic gasification process to convert biomass into ethanol. Elsewhere, researchers looked at its synthesis gas production process and speculated that they could improve it by using bugs that convert syngas to ethanol. Coskata was born as a science experiment with a license to the technology from the University of Oklahoma, a few million in seed funding and a few great researchers. Lanza believes they can produce 50 billion gallons of ethanol from steel mill exhaust, while Mascoma is innovating the traditional biochemical pathway to produce it at dramatically lower costs. Kior is bypassing ethanol and producing a biocrude appropriate for feeding directly into refineries. The ideas and innovations don't stop!

"While the technology may work", critics say, "land use and feedstock needs render it impractical as a large scale solution." Once again, we disagree. We believe that the United States, the world's most prodigious consumer of oil, can meet all its light vehicle fuel needs by 2030 with relatively limited additional land. We consider four principal sources of biomass:

- energy crops on agricultural land and timberlands using crop rotation schemes that improve traditional row crop agriculture and recover previously degraded areas;
- winter cover crops grown on current annual crop lands during the winter season when they are generally dormant (while improving land ecology);
- currently unused excess forest product (about 225 million tons according to the US Department of Energy); and
- organic municipal waste, industrial waste and municipal sewage.

Take one scenario: using about 70 per cent of excess forest waste, 50 per cent of annual crop land for winter cover crops, and 15 billion gallons from waste by 2030, we would need only an additional 14 million acres of dedicated crop land (while reclaiming about 15.5 million acres of land currently used to grow corn for ethanol) to meet most (of the United States') light vehicle fuel needs in 2030.

While science and technology will continue to be important in increasing yields, improved agronomy practices are also a major factor. A few offer significant potential:

- crop rotation;
- polyculture plantations, which have significant environmental benefits and are more efficient;
- perennial energy crops, which need less replanting and help restore soils
- better agronomic practices such as no-till farming and non-irrigated crops

One understated benefit is the potential for biofuels to help places like Africa. In the future world of cellulosic ethanol, the $300 billion the US spends on oil purchases and the EU's $136 billion spending on oil imports could be allocated to Africa, with its vast potential for biomass cultivation. This would also help developing economies in China, India and Latin America by reducing the price of energy, and may be the single most important poverty alleviation tool we have. A focus on biomass will generate new income for Africa, India and Latin America's rural poor as well as America's rural population. America, with its agricultural advantages, will almost certainly produce all its own fuel. But Latin America and Africa might supply Europe, China and India, resulting in a new, more distributed and diverse geopolitical balance of energy and incomes.

Are we being too optimistic and overstating the rate of change? On the contrary, I believe we are understating the potential impact. Critics argue from the "what is" as opposed to "what can be" approach. Their argument is circular: "if it isn't true today, it won't be true tomorrow and hence is not worth working on". We disagree, primarily because we are technology optimists.

We have seen exactly the same happening in the past. In 1982, when we started Sun Microsystems, we were told that competing against IBM and Burroughs was inconceivable. In a 1996 meeting with the heads of media giants like the Washington Post, Knight-Ridder, Tribune, Cox, and the New York Times, I attempted to explain how the internet would disrupt their business: now Google is worth more than all of them combined. Just a few years ago, every major telecommunications carrier noted that they would never adopt internet protocols: today, venerable AT&T has been sold for a song because they failed to heed the innovation the internet offered.

The point is to highlight how fast change happens — driven by the power of technology. Alan Kay said it well: "the best way to predict the future is to invent it." This is clearly starting to come about.