

Make no mistake, the end of oil is on the horizon, and with it come significant implications for business and opportunities for the redesign of industry.

Confronting the World's Most
Important Strategic Challenges:

The End of Oil

by **Anita McGahan**

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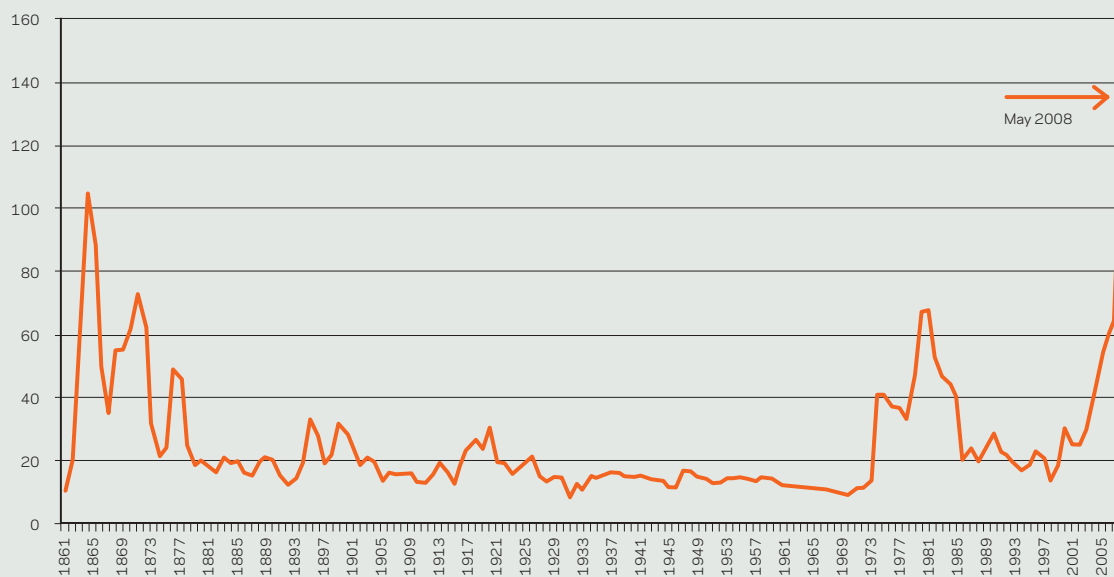
WHILE MANY IMPORTANT TOPICS have been adequately addressed by the field of Strategic Management, we have yet to fully confront – in both our research and teaching – many of the most important strategic problems and opportunities of our time. Examples include credit pricing, financial-system capacity, military services, digital communications, poverty alleviation, drug-resistant disease and climate change. These phenomena are so significant and pervasive in their implications that they almost defy analysis – they are mind-boggling and far-reaching and difficult to take on, both analytically and practically.

Each of these issues will not only fundamentally change the course of business over the next 50 years, they will also affect us personally, socially and culturally. These are the defining issues of this century, and our curriculum and research must address them

if we are to retain our relevance and inspire the next generation of students to commit themselves to value-creating careers. At the Rotman School, we are seeking to innovate in our MBA curriculum by thinking with our students about these issues and their implications over the course of their lifetimes. The first step in considering these issues is to understand the facts about them.

In this article I will focus on one such issue: the end of oil – specifically, oil derived from petroleum. The forthcoming end of petroleum-derived oil will fundamentally change the course of business on the scale of the Internet, the credit crisis, and perhaps even climate change.

What are the facts? The price of oil for much of the 20th century was low by historical and current standards. **Figure One** shows U.S. crude oil prices from 1861 through to 2006. This chart



Source: U.S. Census Bureau: Bicentennial edition historical Statistics of the U.S. colonial time to 1976 / BP Statistical Review of World Energy 2007 / U.S. Bureau of Economic Analysis, GDP-deflator time series / U.S. DOE: Energy Information Administration / James L. Williams, WTRG Economics

expresses the first purchaser prices in 2006 dollars per barrel and it shows very high prices around the period from 1861 through about 1881, followed by relatively inexpensive oil during the 20th century. Today's oil price of less than \$100 per barrel – down from highs of about \$140 per barrel in the summer of 2008 – is still much higher than during the oil crises of the 1970s. Many complex factors interacted to create these conditions, and additional research is needed on the factors that drive oil prices today. What we know is that current prices are as affected by expectations about the future as about the current state of supply and demand.

Are we in the midst of a crisis? No. At an estimated 1.2 trillion barrels, proven reserves are about 40 times the annual consumption of 26 billion barrels per year globally. About 80 per cent of this volume is in OPEC countries, but we also know that there are unproven reserves out there that have yet to be discovered. By the best available estimates, there are somewhere between 2.3 and 3.9 trillion barrels of oil on the planet today – enough to cover decades more of oil consumption, provided we don't increase our consumption.

Can we continue to consume at current levels? There was a period up until about 1970 or so when growth in oil consumption was out-pacing growth of the population. With the oil crises of the 1970s, growth per person – on average across the planet – leveled off. Since the late 1970s, the consumption of oil per person has remained about constant, although the average obscures important inequalities (with big increases in per-capita consumption among the relatively rich). The bottom line is that current conservation efforts are keeping our global consumption proportionate

to world population. So far, our appetite for oil has not been curbed by price increases.

So what will happen over the next few years? There are almost as many scenarios as there are experts on the topic. If consumption grows at about three percent per year and if unproven reserves are relatively low, then, according to U.S. Department of Energy estimates, we may reach 'peak oil' (a term that describes the point of a precipitous decline in oil availability) as early as around 2035 or 2040.

On the other hand, if unproven reserves on the planet are relatively abundant and accessible, and if major conservation efforts lead to zero per cent growth in consumption, then we may reach the peak of oil in the year 2125, according to the Department of Energy estimates. Overall, estimates on the date for peak oil range from between 46 and 91 years in most moderate scenarios. The bottom line is that in the next 50 to 100 years, petroleum-based oil is going to run thin, leading to enormous disruption in industry structure as well as to opportunities for the next generation of business leaders.

What can we do now to take advantage of the opportunities? Three sets of ideas play an important role.

1. Finding Substitutes for Oil

Two-thirds of our oil today is used in transportation, but what about the rest? Reflecting on this problem led artist Chris Jordan [featured on the cover of *Rotman's* Spring 2008 issue] to create "Intolerable Beauty: Portraits of American Mass Consumption." On his website he describes his journey, exploring around U.S.

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shipping ports and industrial yards, “where the accumulated detritus of our consumption is exposed to view like eroded layers in the Grand Canyon.” Here, Jordan found “evidence of a slow-motion apocalypse in progress. I am appalled by these scenes, and yet also drawn into them with awe and fascination. The immense scale of our consumption can appear oddly comical and ironic and even darkly beautiful; for me its consistent feature is a staggering complexity.”

The result: beautiful large-scale photographs which, when studied closely, reveal the enormous amount of petroleum that we consume, particularly in plastic bags and packaging, bottles for soft drinks and water, and cellular telephones. Jordan’s work illustrates waste in these and other products, many of which could be re-used as durables rather than as consumables. If plastic detergent bottles were somehow re-used rather than thrown away, we would solve two problems: the accumulating volume of them in dumps, and the shortage of petroleum for manufacturing new ones. The public is increasingly motivated to think about these problems, as evidenced by the popularity of movies such as **Al Gore’s** “An Inconvenient Truth” and “Who Killed the Electric Car?”

The end of oil will create fundamental opportunities for product innovation. Anything made of plastic will be affected. Polyethylene accounts for about half of the United States’ 80 billion-pound production of plastics and resins. Three-point-four billion gallons of oil were used to create the disposable diapers used in the U.S. alone in 2005. Think of a world in which plastic bottles and disposable diapers as we know them are unavailable. Investments in alternative products carry the potential to generate a great return down the road – but advances in basic science may be required to commercialize them economically.

Even technological breakthroughs will not be enough to innovate at the appropriate scale, however. Consider something as simple as plastic eyeglass frames and lenses, for which alternative technologies are readily available. Before you dismiss eyeglasses as a trivial use of plastic, consider that Harvard Historian **David Landis** has noted that glasses are one of the most important inventions of the Industrial Revolution because they have had such an impact on productivity. It is impossible to imagine a time

when they might be unavailable altogether. But try to get most any MBA candidates to take up a business plan based on the idea of replacing plastic with glass lenses, and you will immediately run into a wall. Who wants eyeglasses made out of glass rather than plastic? It is hard to imagine even such a relatively small, straightforward transition. The marketing challenge alone is daunting. Replacing technologies such as those used in air conditioning and telecommunications and computing so that they not rely on petroleum but rather on other kind of materials will be an even larger challenge.

Petroleum-based oil is used in a large range of industrial and commercial sectors to make products as diverse as lubricants, air conditioning equipment, consumer electronics, computing technologies, home appliances, furniture, telecommunications equipment, and fire-retardation systems. Building materials, adhesives and coating represent an entire category in which petroleum-derived products will eventually have to be replaced. PVC piping for water or electrical conduits, nylon in our carpets, resins and glues, and paints all rely on petroleum. When oil runs out, we will need alternatives for all of them.

Consider infrastructure such as telecommunications, cellular telephone towers, our roads, water treatment distribution and storage plants – all of these will require replacement technologies. Many rare metals such as copper are also depleting, and some of the world’s most respected companies, which rely heavily on plastics, must confront the replacement of fundamental technologies on a very large scale over the next 10 to 50 years.

Almost all of our medical infrastructure in the first world today is based on plastics. Hospitals are typically air-conditioned to 62 degrees to guard against the transmission of disease, using petroleum-derived machines and power. Many medical products and consumables are made out of plastic, including syringes and adhesive tapes. Eventually, all will have to be replaced by alternative technologies. Figuring out how to conserve – and coming up with product innovations that use the rare amount of plastic that remains – will be critical.

One of the most striking challenges we will face over the coming decades will be to manage our food supply chain to use petroleum-based fertilizers and cultivation technologies

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efficiently. At present, the food supply of all developed countries is dependent on fossil energy, with the output/input energy ratio of U.S. agriculture crops estimated at 1.4. Research suggests that if the planet were not cultivated with petroleum-based fertilizers and petroleum-harvesting technologies, there would only be sufficient food to support about *half* the number of people that are currently on the planet. Coming up with alternative ways to generate food will be a critical challenge of this century.

The first challenge, in a nutshell: we must inspire our students to think about entrepreneurship at the broadest possible level. There is great opportunity to create value by innovating around these problems, and the time to begin is now – several decades in advance of peak oil.

2. Collaborative Innovation

The second challenge associated with the end of oil involves learning how to work together – and to design organizations that work together – to implement these innovations. We know that the greatest impediments to technological progress are organizational. And the organizations that must be activated to confront the end of oil are complex and multi-faceted. Stewardship of oil consumption occurs at multiple levels: super-national organizations, governments, universities and business organizations are all involved in managing the way that way we interact with oil.

The challenge of figuring out how to work together is even more formidable than the challenge of innovating around petroleum in products and services. Barriers to coordination across functional areas within organizations are legendary. In the 21st century, our students are going to not only have to do that, but also get diverse organizations – with incentives, goals, resources and capabilities that are not always aligned – to work together. International organizations such as the **United Nations** don't always have the same goals as sovereign governments; and they rarely have interests that are aligned with those of businesses such as **IBM** or the big mining and manufacturing companies. Complicating matters further is the fact that much of the research on the technologies required to lessen our dependence

on oil is government-funded and is enacted in universities and other research organizations, which almost always have different goals than the businesses that ultimately commercialize their technologies.

What are best practices at this level? Consider the automobile industry, which is already dealing with the implications of petroleum depletion. The economics of petroleum, hybrid, flex fuels and hydrogen differ significantly. A benchmark on miles per gallon for highway driving is about 25 for petroleum, 37 for hybrid and electric, and 20 for flex fuels. The cost per gallon of these different fuels varies from \$3.50 for petroleum and hybrid/electric to \$3.10 per gallon for flex fuels and \$1.50 per gallon for hydrogen. Fuel pumps in gas stations must be retrofitted for petroleum alternatives: currently, 200,000 stations in the United States are adaptable to hybrid and electric and an estimated 1,200 of them are adaptable to flex fuels. Hydrogen requires entirely separate dispensation apparatus.

What is the best target to shoot for? Should we focus on moderately efficient hybrid fuels, which require significant petroleum but capitalize on established infrastructure? Or should the standard be the more volatile and radical hydrogen technologies, which also carry the potential to be more efficient once implemented? How should the infrastructure transition be managed?

The answers to these questions are not simple, but the problem in answering them lies mainly in coordinating the replacement of old with new infrastructure. Product innovation by automobile manufacturers has been impressive. The issue is in figuring out whether the most efficient solution to the end of petroleum-derived oil is a transition to hybrid or 'flexfuels', involving major changes to existing infrastructure, or the wholesale replacement of existing infrastructure (particularly gas stations), involving expensive new refueling stations.

There are also major questions in play regarding appropriate regulation, roadway design, manufacturing facilities, and resale markets. One of the most important concerns regarding the transition to hydrogen cars lies in the fact that oil and gas companies – which have vested interests in the existing infrastructure – do not

have fully-aligned incentives to invest in new infrastructure, in part because of the cannibalization of their core business that would occur with the transition away from petroleum-based oil. Intervention of some sort is needed for coordination. Vision and leadership are essential.

Coordinating across levels of government and between government and business is no small matter. Consider, for example, what happened in London and New York regarding congestion charging. In London, the congestion charging program was implemented in 2003 and extended in 2008. In ecological terms, the program has been enormously successful, with private auto traffic dropping about 20 per cent during the period of the initial implementation in 2003. Over the first few years after implementation, usage of taxis was up slightly, buses and coaches up very slightly and use of pedal cycles went up 72 per cent. The result: road safety has improved, people are walking and taking the Tube more, and overall there's been a 15 per cent drop in emissions. Despite this success, London's Mayor **Ken Livingstone** was voted out earlier this year as a result of the lack of popularity of the program, as frustrated commuters responded to the adjustment. In New York a proposal to implement a similar system failed out of concern about the equity implications of slapping more charges on drivers.

3. Socio-Political Implications

The transition away from petroleum carries fundamental political, economic and social implications. We know, for instance, that the principal land-based locations of unknown reserves are in conflict zones. Consider what happened in Chad in 2003: after a major oil field was identified, exploitation began with the hope that Chad would have a chance for peace and prosperity from the wealth generated by these fields, but instead internal dissent blossomed and new civil war broke out over the spoils. Under-sea reserves are difficult to tap safely, and accessing these reserves requires unprecedented technologies. That will be enormously expensive.

Of course, tapping unproven reserves will only delay the inevitable challenge of replacing products and services based on

petroleum-based oil with alternatives. Regardless of how and when the transition occurs, questions will arise about the equity implications of the way that oil is currently distributed and consumed. Some of us have long had access to cheap oil, while others have not. Will we seek to replicate the underlying social systems that have developed with the mining of petroleum?

In closing

The challenge we face at Rotman – and that all business academics face – is to inspire the next generation of leaders to anticipate these challenges and to lead through them. The opportunity at stake is to capture the entrepreneurial drive and energy of young people from around the world in the interests of taking on these challenges at their root by understanding the implications for organizations, cooperative agreements, and the relationship between business and society.

Engaging, communicating and advocating for solutions to the world's most important strategic challenges, while encouraging the integration of the political, economic and social implications of such problems, will be a major challenge for those of us involved in business education over the coming decades. Rest assured: we are rolling up our sleeves. **R**



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Editor's Note: Prof. McGahan will be a presenter at the June 2009 Life-Long Learning Conference; see our back cover for details.