

# Shaping an Integrated Energy Future

By Len Bolger and Eddy Isaacs

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The continuing prosperity and high quality of life of Canadians depend on a secure supply of affordable energy, produced with minimal impact on the natural environment. Our ability to sustain this supply will depend on two factors. First, there must be a critical mass of people with the right knowledge and a passion for achieving this goal. Second, these people must be able to become experts at collaboration, applying their diverse skills, perspectives, and interests to the creation of technological breakthroughs.

You may be surprised to hear people like us — an engineer and a scientist with together over seventy years of experience in the Alberta energy industry — citing a “soft” factor like collaboration as the key determinant of Canada’s energy future. Rest assured we’re not talking vaguely about people getting along together. We’re talking about a disciplined process of getting diverse thinking out on the table, seeing new connections, and co-creating innovative solutions to our most pressing problems. We’re talking about structures that will allow all the players to put out their ideas and work together effectively to capitalize on opportunities, without constantly running up against organizational barriers.

The need for collaboration is not new. In this chapter we’ll highlight how some unique partnerships have produced significant breakthroughs in the past and contributed to our current prosperity. But we believe we’re now at an important crossroads. Our ability to use the available resources in a responsible way is limited by our current technology. To do the applied research needed and develop it into practical commercial technology will require an unprecedented level of collaboration amongst many players.

## **The Need for Integrated, Breakthrough Solutions**

We believe that transforming the way we collaborate is key for two main reasons. The first reason is that we now think the big opportunities are in integrated solutions. In the past, the strategy was to focus on one form of energy, pick a priority (like developing our ability to produce bitumen from the oil sands), and concentrate investment in that area. We’ve learned to appreciate, however, that the various components of the energy industry in Western Canada — conventional oil and natural gas, heavy oil, bitumen, coal, coal bed methane, petrochemicals, and renewable sources — are tightly interconnected. The solution for the petrochemical industry’s need for new “feedstocks,” the raw material used to produce products, may be a by-product of the oil sands industry. The need to

reduce the oil sands industry's dependency on natural gas may be solved by coal or by waste from petroleum, forestry, and agriculture. The problem of dealing with the resulting carbon dioxide (CO<sub>2</sub>), a greenhouse gas, may be solved by using it to get more oil out of existing fields — trapping the CO<sub>2</sub> safely underground at the same time — or to produce methane (the main component of natural gas) from coal beds to help offset the decline in natural gas. We'll look more closely at these integrated opportunities later. The point is that if each industry sector tries to solve its problems in isolation, much potential value will be lost.

The second reason we're advocating more collaboration is that incremental improvement is not enough. We need breakthrough innovations, the kind of innovations that require people with pieces of the solution to work together in new ways.

The oil sands provide a good example of the magnitude of the challenges we're facing. As early as the 1920s, a few visionaries were pursuing the crazy idea that bitumen, a sticky substance that looks like frozen molasses, could be turned into a valuable source of energy. These pioneers have driven some amazing technological advances over the past seventy to eighty years. Unfortunately we've reached the limits of what current technology can do. We're using natural gas — a lot of it — to produce the hydrogen needed to upgrade the bitumen into something of greater value. Our natural gas resources are starting to decline and will become more expensive. The current recovery processes use a great deal of water, at a time when we're all becoming more concerned about water supply and quality. Emissions of greenhouse gases from the process are high. These problems will not be solved by incremental change.

Solving these challenges will require the coming together of three things. First, there must be strategic research that is clearly directed towards an end goal. Second, there must be patient capital — as opposed to investment made in anticipation of quick payoffs. And finally, there must be the know-how to turn research results into commercially viable solutions. It's because we need all three that active collaboration is key: among industry, universities and other research providers across Canada, and federal and provincial governments. We also need to be continually scouring the world for technology created elsewhere that we might learn from or adapt to our needs. We must seek opportunities to leverage international sources of funding by partnering with people across and outside Canada on common issues. We're now exploring new ways of building networks that will allow us to do all this.

Before we look at what we can learn from the past and our view of the future, we want to emphasize two considerations that underlie our thinking, but that may not be universally understood and accepted. The first is that Canada and the rest of the world will continue to depend heavily on energy from hydrocarbons such as oil, gas, and coal for the foreseeable future. The second is that when it comes to production of this energy, "business as usual" is not an option.

## The Hydrocarbon Present

We recognize that investments in renewable energy are critical to our long-term future. We also believe that there are great gains to be made in improving energy efficiency across the entire value chain, from large-scale energy production to the choices made each day by energy consumers.

At the same time, all the numbers we analyze in the course of our work tell us not to expect the combination of conservation efforts and development of renewable sources to meet domestic and global energy needs for the next forty to fifty years. The Paris-based International Energy Agency (IEA), for example, has predicted 70% growth in worldwide demand for primary sources of energy by 2030. The IEA expects 88% of this increased demand to be met by oil, natural gas, and coal. It predicts that production of nuclear energy and hydro will remain virtually flat, however. While production from other renewable sources — primarily wind — is expected to almost double, these sources will still meet only 2.5% of overall demand.<sup>1</sup> Many years of research and development will be needed to overcome the cost, technology, and infrastructure limitations to energy production from renewable sources.

In the meantime, we will continue to rely on energy from hydrocarbon sources. We in Canada have an advanced economy and a prosperous lifestyle that depend on affordable energy. We also have an abundant supply of hydrocarbon reserves. When we talk about reserves, we mean proven sources of hydrocarbons from which energy can be produced using technology available today. This doesn't include the vast potential sources of hydrocarbons — resources that experts suspect exist but can't yet prove, or that can't be extracted at a competitive cost using available technology.

Estimates of exactly how big those reserves are vary widely depending on the methods and assumptions used. One thing is clear, however: The international community's recent acceptance that energy from Alberta's oil sands is recoverable with existing technology and market conditions has changed the picture dramatically. At this year's International Energy Outlook conference, a leader from the U.S. Department of Energy cited figures from the *Oil and Gas Journal* that raised Canada's proven oil reserves to 180 billion barrels from 4.9 billion barrels, now that the oil sands are included. This makes Canada the second-largest holder of proven oil reserves in the world, behind Saudi Arabia and ahead of Iraq.<sup>2</sup> If you add coal and natural gas, by most estimates Canada has one of the largest supplies of hydrocarbons in the world.

Energy directly or indirectly accounts for about one-half of the Alberta economy. The Canadian Association of Petroleum Producers calculates that the oil and gas sector contributes some \$15.6 billion annually to both the federal and provincial governments through royalties and income taxes alone.<sup>3</sup> So our focus in Alberta — our contribution to Canada's economy and to fueling the future — is to partner with other interested provinces to figure out how to get more of these resources out of the ground, get more value from the resources, and do it in a way that protects our land, air, water, health, and quality of life.

The last part of this statement is very important to us. Precisely because the production of energy from hydrocarbons comes at a significant environmental cost, the energy industry is very aware of the urgent need to reduce this impact. Back in the mid-1980s, Jack MacLeod, then president of Shell Canada, introduced the “triple bottom line” mindset that is now common in the industry. A triple bottom line mindset is one that considers the environmental and social “bottom lines” of equal importance to the financial bottom line. Leading Alberta-based companies like Suncor, Syncrude, EnCana, Nexen, TransAlta, Shell Canada, and many others have public sustainability commitments and report regularly on environmental performance.

Companies across the industry are working together to find ways of increasing energy efficiency and reducing emissions. In 1999, for example, the Canadian Association of Petroleum Producers in partnership with the Clean Air Strategic Alliance set a target to reduce flaring by 60 to 70% by 2007. Flaring is the practice of using controlled burning to dispose of waste gases that occur in the production of crude oil. This practice contributes to emissions of sulphur dioxide and greenhouse gases. By 2001, industry had already reduced flaring in Alberta by 53%.<sup>4</sup>

Improvements are being made, but we have a long way to go. Hence the need to invest in finding and implementing breakthrough technology that will allow us to realize the value of hydrocarbon resources with minimal environmental impact.

## **A Hydrogen Future?**

We see our work as a necessary stage in the long-term transition from a hydrocarbon economy to an economy based on some form, or forms, of renewable energy. There are indications that hydrogen has good potential to play an important role in that future. Already Alberta is producing about 70% of the hydrogen generated in Canada, much of it for industrial use in the upgrading and refining of oil. Significant sources of excess hydrogen exist here, and the advent of fuel cell technology to convert this hydrogen into useable electric energy would be a significant advance.

This won't be easy. Pure hydrogen doesn't exist in a natural state. You have to produce it from a hydrocarbon source such as oil or natural gas, or from water. Hydrogen produced from water through a process of electrolysis causes no greenhouse gases or other emissions, as long as the electricity used to break down water into its elements (hydrogen and oxygen) is produced from a “clean” source such as wind or nuclear. With current technology, this process uses a great deal of electricity and is very expensive. Hydrogen produced from natural gas is less expensive, but we've already noted that supplies of natural gas are starting to decline and becoming more expensive. It's most feasible in the near and mid-terms to expect to see hydrogen produced from coal and other low-value hydrocarbons. It may surprise some to learn that this process produces near-zero emissions. It's much cleaner than the process currently used to turn coal into electricity.

Hydrogen's big attraction is its potential as a means of storing energy produced by a renewable source, such as windmills, for use when the wind isn't blowing. The downside is that we'll have to invent reliable technology to make it safe. Hydrogen needs to be under very high pressure, so safe storage is difficult and expensive. There have been many successful projects demonstrating that hydrogen fuel cells can be used to run vehicles and generate power. However, much more work on storage and transport is required before fuel cells will be competitive and widespread commercial application can be achieved.

Then we'll need to create infrastructure for the delivery of hydrogen, or for the generation of hydrogen on-site when it's needed. That challenge shouldn't be underestimated. It's easy to take for granted the very complex infrastructure that allows you to fill your car with gasoline when you need it. Did you know that the gasoline you buy in the winter is different from the gas you buy in the summer? It has to be more volatile so that it will flow and vaporize at colder temperatures. If you used the same gas in the summer, the engine would vapour-lock and stop. The gas you buy in Kamloops is different from the gas you buy in Toronto because it needs to work at a higher altitude. Providing this convenience for customers involves significant scheduling and logistical challenges. We've no idea now what challenges a hydrogen delivery system will present, but we can be reasonably sure they will exist.

So while we work towards creating a possible hydrogen future, we need a parallel effort to make better, environmentally responsible use of coal, conventional oil, heavy oil, bitumen, and natural gas.

### **“Business as Usual” Is Not an Option**

Some people believe that the status quo is just fine, and wonder why we're worried about investing in the future. If that thinking had prevailed in 1974, the year the Alberta Government established the Alberta Oil Sands Technology and Research Authority (AOSTRA) with an initial investment fund of \$100 million, we would already be in trouble.

In 1973, 92% of the oil produced in Alberta was “light” oil that's under high pressure in the ground and flows naturally on its own. “Heavy” oil — oil that doesn't flow easily and must be pushed out of the ground using special techniques — accounted for 4% of production. The remaining 4% came from the bitumen in the oil sands, which is essentially a solid oil. Alberta's premier at the time, Peter Lougheed, was a visionary who saw that conventional light oil production had peaked and was beginning to decline. In fact, by 2001 it had declined by 60%. The shortfall has been filled by increased production of heavy oil using new extraction techniques (16% of total oil production in 2001) and the extraction of bitumen from the oil sands (43% of total production in 2001). The Alberta Energy and Utilities Board projects that by 2010, 75% of total oil production will be from the oil sands.<sup>5</sup>

Experts now estimate that conventional natural gas production has peaked and will start to decline within three years. We have no shortage of coal, but coal is widely perceived to be a dirty fuel and many are arguing that we should stop using it altogether. Coal is actually much cleaner today than it was thirty years ago. The Coal Association of Canada reports that while coal-fired electrical generation capacity in North America has almost tripled over the last thirty years, related sulphur dioxide and nitrous oxides emissions have been reduced by 80% and 55% respectively.<sup>6</sup> However, there is still much work to be done in coal-fired energy technology to consider its use an environmentally responsible option over the long term.

## **The Good News**

We do see concrete possibilities for solving these problems with the right technologies. Our current methods of extracting light oil, for example, are leaving about 70% of the oil in the ground. Once the pressure has dropped to the point where the oil stops flowing naturally and it's no longer feasible to push it out with water, we abandon the field. One opportunity lies in pumping CO<sub>2</sub> into the ground to mix with the oil, increase the pressure, and start the flow again. CO<sub>2</sub> is a greenhouse gas and an unwanted by-product of many industrial processes. There are good indications that pumping it into the ground, if done properly, will solve the problem of keeping it out of the atmosphere. Research is now underway to determine how to make underground sequestration of CO<sub>2</sub> a permanent solution. This is just one example of the many opportunities we see to get more resources out of the ground.

Other opportunities lie in adding greater value to what we do get out of the ground. The oil sands have been the focus of much of Alberta's investment over the past thirty years because while Canada is a minor player on the world stage in light and heavy oil (with 2.4% share of the world's resources), we're the world player in bitumen. Canada has 58% of the world's bitumen resources, all in the Alberta oil sands.<sup>7</sup> The Alberta Energy and Utilities Board estimates that there are potentially 315 billion barrels of recoverable bitumen in the oil sands. That translates to several hundred years of supply at current production rates.<sup>8</sup> But there are significant barriers in the way of our realizing full value from this resource.

We've already touched on the environmental issues: the need to reduce emissions and the amount of water used. Bitumen in its natural state has little value. It needs either hydrogen addition or carbon removal before it can be used for fuel. This is accomplished through an upgrading process that adds hydrogen and turns bitumen into synthetic crude oil. The cheapest source of hydrogen for upgrading is natural gas, which has more hydrogen in it than any other hydrocarbon. The "steam reforming" process for hydrogen releases CO<sub>2</sub> along with other emissions. We also use natural gas to create steam that we add to the bitumen at very high pressure to get the bitumen out of the ground, again generating significant CO<sub>2</sub> emissions.

This reliance on natural gas is a problem, because it's soon going to become far too costly and valuable to be used for bitumen upgrading. As one of our colleagues likes to say, "Using natural gas to make synthetic crude is like inventing a process that turns gold into lead." Without some major technological improvement, it's projected that the oil sands of Alberta will require one billion cubic feet of gas per day. To appreciate just how much that is, consider that the entire output of natural gas from new developments in the Mackenzie Delta is also expected by some estimates to be about one billion cubic feet of gas per day.

### **Seeing the Opportunities: An Integrated View**

This takes us back to the opportunities that arise when we start thinking about the energy industry as an integrated system, rather than each sector in its own silo. One option we have is to use petroleum coke (a by-product of bitumen upgrading) or coal instead of natural gas to produce hydrogen and steam. If the coke or the coal is burned in air (which is basically 80% nitrogen and 20% oxygen, with traces of other atmospheric gases), a mixture of CO<sub>2</sub> and nitrogen (with traces, again, of the other gases) is produced as a result. If we use pure oxygen rather than air to burn the coke or the coal, the by-product is then pure CO<sub>2</sub>. That's important, because then we can capture this CO<sub>2</sub> without incurring the additional costs of separating it out, pump it into depleted conventional oil fields to build up the pressure and increase the flow of oil, and trap the CO<sub>2</sub> in the ground to reduce its emission as a greenhouse gas. Or we can pump the CO<sub>2</sub> into coal beds to free the methane. The reason for deadly explosions in coal mines is that there's a lot of methane in coal, and some of it will be released from the coal seam when there's a reduction in pressure. We can release the methane from coal on purpose by pumping CO<sub>2</sub> into it. The coal prefers the CO<sub>2</sub>, absorbs it, and releases the methane, which can be used to partially offset the expected decline in natural gas production.

Here's another example. The petrochemical industry in Western Canada is heavily dependent on natural gas liquids such as ethane, which are by-products from natural gas extraction. These are the raw materials for petrochemical production. Petrochemicals are used in the production of plastics — everything from plastic wrap to kitchenware to siding on homes. Again, declining reserves and increasing costs create a scenario in which the competitiveness of the entire industry is threatened if an alternative is not found. What we've learned is that some of the by-products of oil sands processing have the potential to be used as feedstocks for the petrochemical industry. We just need to build the right technology to make this happen.

### **A History of Innovation**

We have no doubt that the new technologies can be invented or adapted to meet our needs. Canadians are self-reliant and innovative. We base our confidence on a long history of successful innovation, led by entrepreneurs and visionaries. The story of the oil sands, for example, was shaped by pioneers such as Karl Clark, a scientist who worked with the Alberta Research Council (ARC) when it was established in 1921 — in itself an

innovative organization as the first provincial science and technology research body in Canada. In 1929, Clark discovered and patented a hot water flotation process that is to this day the most viable method of extracting oil from the sand. Clark and his co-workers built a pilot facility near Fort McMurray before the outbreak of World War II. With the boom of conventional oil after the war, people lost interest in the gooey bitumen, but the success of today's oil sands production companies is directly attributable to the work of people like Clark, Sidney Ellis, R.C. Fitzsimmons, and Max Bell.

It's also attributable to the leadership of visionary companies like Syncrude Canada Ltd. and Suncor Energy. Syncrude, for example, is the world's largest producer of synthetic crude oil from oil sands and the largest oil producer in Canada. Many Canadians are not aware that the development of Syncrude was a huge industrial undertaking, equivalent in scope to the building of the St. Lawrence Seaway. Hundreds of different operations are involved in producing its product — to mine the sand, extract the bitumen, and upgrade it into a synthetic crude oil called Syncrude Sweet Blend.

The CEO of Syncrude, Eric Newell, has a passionate belief in the future of the oil sands that is highly contagious. The thousands of people who have contributed to the success of Syncrude to date have been motivated to persevere in the face of many setbacks, learn from failures, and refuse to be defeated. The environment of Mildred Lake, Syncrude's main field just north of Fort McMurray, is harsh, with temperatures falling to minus 40 degrees Celsius for long periods in winter. Oil sands mining requires much outdoor work, and in the early days mining equipment designed for warmer climates broke down continually under these extreme conditions. The teeth in the huge excavators quickly eroded in the cold, and the cost of replacing these teeth was a problem that was only overcome by finding new materials equal to the challenge. Innovations that Syncrude and other industry players like Suncor have implemented over the years through a learn-by-doing approach have brought the per-barrel cost of production down by over 50% while reducing CO<sub>2</sub> emissions per barrel by 45%.

A large and committed team of people is required to operate Syncrude and Suncor, and it has not escaped their attention that there are many talented Aboriginal people in the community who only need some training to be able to contribute. Syncrude is now the largest Canadian industrial employer of Aboriginal people, who make up 11% of the total employee population of 4,000. Syncrude now supplies 13% of Canada's petroleum requirements, producing 81.4 million barrels in 2001, and spends more than \$30 million annually on research and development. The company states on its website that it has returned more than \$5 billion to date to the people of Alberta and the rest of Canada in the form of royalty payments and federal and provincial taxes.<sup>9</sup>

## **A Tradition of Entrepreneurship**

In celebrating a visionary leader like Eric Newell of Syncrude — and he's only one of many we could profile here — we're not suggesting that innovation depends on one champion at the top of an organization. We don't believe in the lone-cowboy hero who

rides in and single-handedly saves the day. We could point to many examples where teams of people with no conferred “authority” got a good idea and decided to pursue it. There was the team at Imperial Oil, for example, who succeeded in proving the potential for large-scale commercial extraction of heavy oil. We said earlier that heavy oil is very viscous and does not flow naturally like light oil. The idea that perhaps you could extract heavy oil by injecting steam into the reservoir was dismissed by the experts, who concluded that the steam would not penetrate very far into the formation because the viscous oil forms a barrier. A small team nevertheless convinced their management to let them try, proved that it would work, and established the pilot from which an entire new industry in heavy oil production was born at Cold Lake. It now produces in the order of 110,000 barrels per day.

Similarly, the team at Shell Canada who promoted the idea of building a refinery that would run on synthetic crude has made a huge contribution to the financial viability of the oil sands. To understand this, it’s important to know that not all crude oil is created equal. Compare a barrel of conventional light crude oil from one field in Alberta with a barrel that came from another field not far away and you’ll find that the molecular composition varies quite a bit. That’s a problem for the refineries that turn crude oil into gasoline and diesel and so on, because what they produce has to meet a standard set of specifications. The refineries have to configure their processing to work for a specific type of crude, and then make sure their supply stays within the acceptable ranges of variation to fit that configuration. As a result, most refineries can’t add more than 10% synthetic crude to their supply. Shell’s Edmonton refinery is currently the only refinery in the world configured to take only synthetic crude. In the beginning it bought synthetic crude from others to upgrade. Then it did a kind of “backward integration” in 2003 when it opened its own mine and started producing and shipping the bitumen itself.

In the process of learning to refine synthetic crude, an entrepreneurially minded group of Shell employees realized they could turn a problem into a profitable opportunity. The problem they were having with the composition of the synthetic crude could be solved by removing a certain type of molecule. The opportunity was that this molecule is the perfect raw material to produce styrene, used to make products such as foam cups and meat trays. Again, there were technology challenges involved that were overcome by committed teams learning by doing. They started producing styrene in 1984, much of it for export. This is a great example of the principle of “value-added production” at work.

Big corporations aren’t the only drivers of innovation. The Seaman brothers, led by the brother most Albertans know as “Doc,” came from Saskatchewan years ago and proved themselves to be very successful wildcatters. A wildcatter is the oil patch equivalent of a water diviner. They’re independents with the instinct and guts to drill holes in exactly the right places to find oil. The good ones become very wealthy, and the Seaman brothers were good. Instead of retiring to somewhere warm to enjoy their earnings, they’ve chosen to stay in Alberta and invest in small, entrepreneurial companies that are developing alternate energy and technology to solve many of the industry’s environmental and efficiency problems.

Entrepreneurial companies like the Computer Modelling Group are driving important advances in three-dimensional modelling techniques that help companies predict how much oil they can produce from a given reservoir and determine how best to get it out of the ground. It's important to understand that "reservoirs" aren't big pools of underground oil. The oil comes from porous rock that once was an ocean bed. You might picture this rock as a less porous version of a giant sponge holding oil, natural gas, and water. Production companies need to decide where and how to drill to have the best chance of getting at the oil and gas without too much water getting into the well and making the oil production too costly. They collect raw data through a variety of means: seismic technology, analysis of rock samples, "wireline logging," which involves putting a tool down a hole on a wire to check the density of the rock, and so on. What the modelling technology does is to turn all this raw data into a three-dimensional picture of underground reservoirs that is really useful to the decision makers. This technology is now being used all over the world.

## **The Critical Role of Governments**

People like the Seaman brothers have an important role to play in driving the innovation needed to sustain a secure supply of affordable, responsible energy. However, they can hardly be expected to take on the challenge single-handed. Nor can industry be expected to make large investments in research and development that have no hope of return for many years. Some of the most important advances with the potential for big payoffs can take twenty years and several hundred million dollars. When industry ceases to be profitable, it ceases to exist. There's a clear role, therefore, for governments to provide leadership and investment, as the stewards of these resources on behalf of all Canadians.

We've used the plural "governments" because we mean federal and multiple provincial governments, not just the government of Alberta. As members of the leadership team of the Alberta Energy Research Institute (AERI), the successor to AOSTRA, we're very aware that the issues we're talking about transcend provincial borders. The resources are spread through the Western Canada Sedimentary Basin, which takes in large parts of British Columbia and Saskatchewan and a bit of Manitoba, and so we're really talking about an integrated Western Canadian energy industry. Also, we need to apply the best brains — wherever we find them — to the technology challenges we're facing. And finally, the benefits of this investment will accrue to all Canadians.

The most obvious benefit is increased confidence that there will be a secure and dependable supply of affordable, responsible energy to fuel the needs of Canadians now and in future generations. Less well understood is how many of the direct benefits of new energy investment accrue to companies outside of Western Canada. In a typical \$5-billion oil sands development project, more than 60% of the capital is spent outside Alberta, on goods manufactured in other Canadian provinces.<sup>10</sup> Taxes flow back to the federal government, where they can be applied to important social priorities.

## **Local Knowledge Is Key: The “Huff and Puff” Story**

It's rarely possible to simply purchase a technology developed elsewhere and apply it in the Canadian energy industry. Some years ago there was a lot of interest in technology that was being used in California to produce heavy oil, including the cyclic steam injection system called “huff and puff.” Ninety percent of the heavy reserves in the oil sands can't be excavated with mining equipment because they lie too deep underground, and it was thought that “huff and puff” might be the solution. It wasn't. But the many years spent trying and the dollars invested produced a lot of learning that eventually resulted in a made-in-Canada solution: steam-assisted gravity drainage (SAGD).

The solution only became possible after the invention of horizontal drilling and improvements in three-dimensional seismic technology. The seismic technology allows you to use sound waves to see what's under the surface without excavating — not unlike ultrasound. With this knowledge, you can make better decisions about where to place wells. The SAGD process involves drilling two horizontal wells, injecting steam from one to “melt” the heavy oil and bitumen and make it fluid, then draining the oil by gravity from that chamber into the second well, which is used for production.

According to independent estimates, the invention of SAGD made enough additional reserves recoverable to support 340 commercial projects, each producing 25,000 barrels per day for sixty years. Across Canada, each project would create 823 permanent jobs, of which 540 would be in Alberta. There's also good news on the environmental front. Traditional oil sands mining involves disturbing large tracts of land and then reclaiming them once they're mined. The SAGD process requires only two small holes. While we don't pretend this has no environmental impact, it's much less disruptive to ecosystems. Compared to other thermal recovery processes, the new process has 35% less greenhouse gas emissions.<sup>11</sup>

The story of SAGD is a perfect example of the kind of industry–government collaboration we believe is necessary. The first steps in developing the concept were made by industry, which quickly realized that the technical and financial uncertainties were greater than it could take on. AOSTRA saw too much good potential in the technology for it to be abandoned altogether. It stepped up to the plate and invested over \$80 million of public money over fifteen years to field test the technology and prove its technical and economic viability. Industry became heavily involved again at the pilot stage and invested \$900 million in their own field pilots, turning the beta-test into a commercially viable technology.

Building on this knowledge, a hybrid steam-solvent process has recently been invented. Preliminary findings indicate this process can increase oil production by 19% over SAGD with half the water use.<sup>12</sup>

## **The Public–Private Experiment**

The role that public–private cooperation has played in the history of the energy industry in Alberta to date is, to our knowledge, unique. The Government of Alberta relies on the Alberta Science and Research Authority (ASRA) in making decisions on research investment. When we explain to colleagues elsewhere in the world that ASRA’s board is made up mostly of private-sector members, we’re usually met with some very surprised looks. It seems logical to us, however, that industry leaders would be heavily involved in making the strategic decisions on where money for research and technology development should be invested, since we’re counting on those industry leaders to apply the resulting technology to benefit all of us.

Our organization, AERI, is part of ASRA, and has been given a broad mandate to look at all forms of energy in Alberta. AERI is also governed by a board that includes leaders from business and industry. We’re charged with deciding how to invest funding earmarked by the Alberta government for energy research, and how to manage that investment. As we consider the complex challenges that face us at this crossroads, we see an urgent need to take to a new level the collaborative approach that has worked well for Alberta in the past.

Innovation is a complex process. It requires research, but it also needs investors who believe they can profit by commercializing the research, people capable of implementing the innovation, policy-makers to ensure that the innovation is safe and in the public interest, and a receptive market of people ready to adopt the innovation.

Academic institutions and other research providers such as the Alberta Research Council, the federal Natural Resources Canada, and the National Research Council laboratories need to be involved from the beginning in the process of shaping and launching the innovation agenda. Universities and colleges have a critical role to play in building the all-important human capacity we’re expecting to sustain the hydrocarbon economy in the near term and build the integrated energy economy of the future. We need to be thinking now about what combination of technical know-how and attitudes — towards environmental responsibility, towards working as part of a collaborative team — will best equip today’s students to play their role.

These institutions are also home to the scientists and other experts who will need to do the basic research and invent the science that will make the new technology possible. Typically, all this talent will be engaged in finding answers to problems that are inherently interesting but may have no application to the pressing problems threatening our future prosperity. This basic research is essential for increasing our store of scientific knowledge. It has served us well in the past and must continue. Increasingly, however, we need some of this talent to take on what we call “mission-oriented” research focused on solving specific problems or creating a significant opportunity.

In the past, we've worried about the existence of two solitudes: academic researchers and the potential users of research. Too much brilliant research results in a published paper that's remote from the realities facing industry and doesn't get used. The time and resources required to turn an innovative idea into a viable solution can be considerable. Once you get into the "big laboratory" of the commercial market, you inevitably run up against issues you never thought of or didn't see when you were working at a smaller scale. We believe that as an empowered government body, AERI can play a role in trying to bridge this divide, providing leverage funding and structuring important initiatives so that it's in the interest of all the key players to collaborate. We've found champions in universities and in industry who share this mission and are taking the lead in their organizations to make this happen.

## **Learning to Collaborate**

Of course, the two-solitudes issue can hamper collaboration within a sector or an organization as easily as it does between organizations. Government ministries and departments aren't always great at working together effectively. Companies primarily working in coal haven't had much reason to talk to companies engaged in oil sands mining and processing. Research and marketing departments within the same company have occasionally been known to be working at odds. Rivalries may possibly develop between different groups of researchers at the same institution.

Because we believe active collaboration to be the key determinant of future success for the energy industry in Canada, and because we know it doesn't always happen naturally, we've been making a conscious effort to learn how to do it better. For the past six months, AERI has been using a disciplined process called the Challenge Dialogue System™ to get key players engaged in a structured conversation designed to produce action — not just talk. This is part of our effort to move from a model that has us identifying and funding a series of discrete projects towards a more program-like approach. That means identifying a desired future state in which our priority problems are solved, assessing our current situation, and then building a portfolio of linked and complementary initiatives that need to all come together to create that future state. The future-state scenarios might be something like "A cost-competitive and sustainable supply of coal-based electricity, with all emissions (including carbon dioxide) from power plants reduced to near-zero levels." Or "More upgrading of bitumen in Alberta to ensure that more of the value of the resource remains in Canada." Or "An orderly transition from a hydrocarbon economy to a hydrogen economy based on environmentally responsible renewable technologies."

We argued earlier that these challenges are much bigger than Alberta. We've been encouraging interested partners across Canada and even outside Canada to join in a network of people actively engaged in charting future directions and participating where they can make a contribution. We're not presumptuous enough to pretend to be setting the energy innovation agenda for Canada. We just realize that while we attack the immediate issues we see and that we're uniquely placed to address, there will be points of

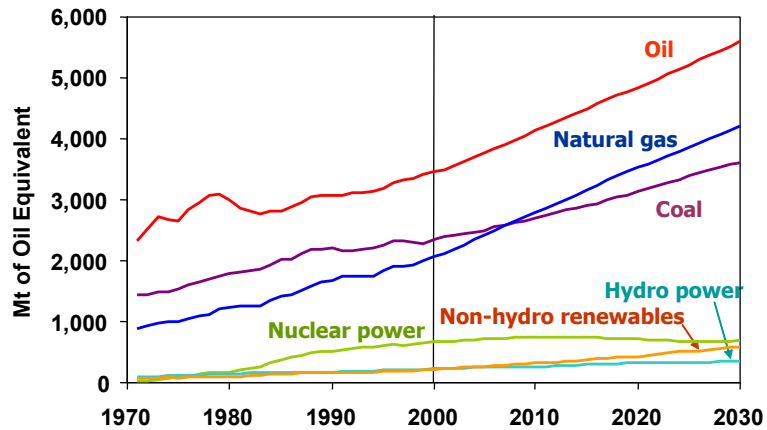
connection and opportunities to collaborate with others addressing other important energy issues.

Action is starting on many fronts even as we finalize details on what this network will be called, how we will engage other important voices in the ongoing dialogue (especially groups focused on relevant social and environmental issues), and how exactly the network will operate. We've already benefited enormously from focused interaction with people from the federal and other provincial governments and key players in the energy industry in Canada.

If we all stay focused and committed, perhaps ten years from now someone will be sitting down to write the story of how a small group of people with some passion around a shared vision learned from the successes of the past, figured out how to collaborate effectively to shape an integrated energy future, and had a major impact on the social, environmental, and economic prosperity of Canadians.

## FIGURES

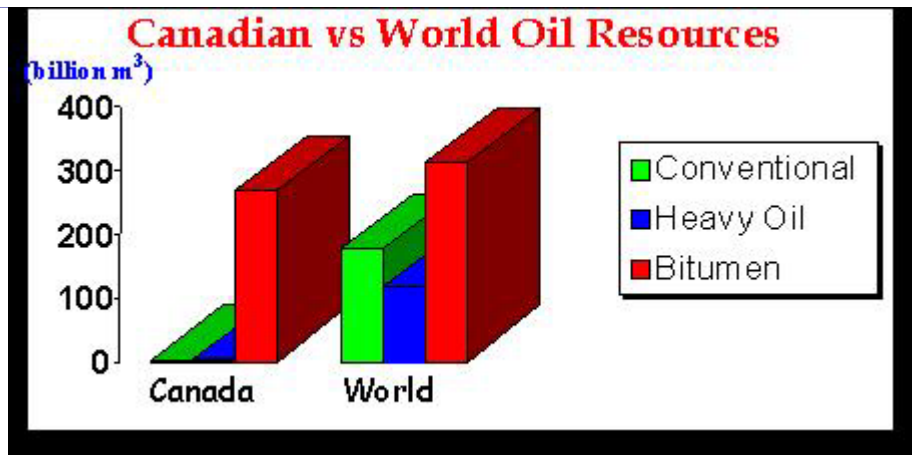
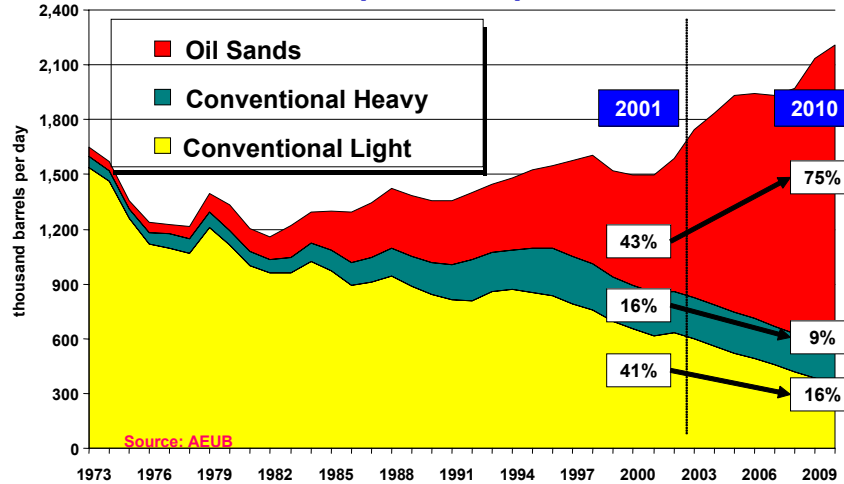
### World Primary Energy Demand Reference Scenario



International Energy Agency, World Energy Outlook, 2002



### Alberta Liquid Petroleum Production (1973 - 2010)



### ABOUT THE AUTHORS

Len Bolger spent 31 years at Shell Canada, finishing that career as President, Shell Canada Chemical Company, and then Vice President, Research and Technology. After retiring from Shell, Len became co-founder and Chairman of AdvaTech Homes Canada, a position he still holds. Len is also a Fellow, Canadian Academy of Engineering; a member of the Board of Management, Alberta Science and Research Authority; Co-Chair, Alberta Energy Research Institute; Director Emeritus, the Canadian Institute for Advanced Research; Director, React Energy Corporation, and Director, Alternative Fuel Systems.

Dr. Eddy Isaacs is the Managing Director of the Alberta Energy Research Institute (AERI). Previously, Dr. Isaacs served for more than twenty years with the Alberta Research Council (ARC), where he was responsible for ARC's programs in heavy oil and oil sands. He currently serves on the Boards of the Petroleum Technology Alliance of Canada (PTAC), Canadian Oil Sands Network for Research and Development (CONRAD), the IEA Weyburn Monitoring Project and is the co-chair of the Technology Working Group of the National Air Issues Coordinating Committee on Climate Change (NAICC-CC).

AERI was formed on August 1, 2000, as successor to the Alberta Oil Sands Technology and Research Authority (AOSTRA) but with a broader mandate. AERI promotes energy research and technology evaluation and transfer in areas that include conventional and unconventional oil and gas, coal, carbon management, improving energy efficiency, and renewable energy as part of a cleaner energy strategy for Alberta.

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<sup>1</sup> Fridtjof Unander and Carman Difiglio, "Energy and Technology Perspectives: Insights from International Energy Agency Modelling." Presentation made at IEA's World Energy Outlook 2002.

<sup>2</sup> C. Walsh, "Canada's Oil Reserves 2<sup>nd</sup> Only To Saudi Arabia" (Dow Jones Newswires, www.petroleumworld.com, 5-6-3)

<sup>3</sup> "Industry Facts and Information -- Canada" on the Canadian Association of Petroleum Producers website (www.capp.ca).

<sup>4</sup> "Action on Energy: A Progress Report from Alberta's Oil and Gas Industry" found on the Canadian Association of Petroleum Producers Website (www.cap.ca).

<sup>5</sup> Alberta Energy and Utilities Board. EUB Statistical Series 2001-98: *Alberta Reserves 2000 Supply/Demand Outlook/Overview*.

<sup>6</sup> Submission by The Coal Association Of Canada to the 59<sup>th</sup> Conference of Canada's Energy and Mines Ministers (Winnipeg, Manitoba, September 15-17, 2002, p. 3)

<sup>7</sup> This figure was calculated using Alberta Energy and Utilities Board statistics (see footnote 5), as well as statistics from the World Energy Council's Survey of Energy Resources (1995) and from Meyer et al, 15<sup>th</sup> World Petroleum Congress (1997).

<sup>8</sup> "Industry Facts and Information – Oil Sands" on the Canadian Association of Petroleum Producers website (www.capp.ca.)

<sup>9</sup> All figures from Syncrude's website (www.syncrude.com).

<sup>10</sup> National Oil Sands Task Force Report (1995). Cited in a presentation by Bill Almdal, "Oil Sands Update", Regional Issues Working Group 2002.

<sup>11</sup> Larry Fisher and Louise Gill, Supply Costs and Economic Potential for the Steam Assisted Gravity Drainage Process, Study No. 91, Canadian Energy Research Institute, September 1999.

<sup>12</sup> Michelle Dacruz, "Better than SAGD/VAPEX Technology Will Be a Step Forward," in *Fort McMurray Today* ( June 25, 2003) page A3 (citing figures from the Alberta Research Council).