

TACKLING

the Challenge of a Cleaner

The Canadian oil and gas and coal industries can lead this country towards a “new industrial revolution” by capturing carbon dioxide (CO₂), storing it in depleted reservoirs and help launch a hydrogen industry at the same time, says the director of the Alberta Research Council.

Bill Gunter, who is helping to lead a “technology roadmap”, spearheaded by Natural Resources Canada (NRCan) into CO₂ capture and storage — a project involving several research bodies like the Alberta Research Council (ARC) and oil and gas companies — says the Canadian fossil fuel industry can show the way to achieve cleaner energy production to the rest of the world.

“I could see a time when we could ship CO₂ to the Middle East, once their (oil and gas) reservoirs are depleted,” he said. “It’s really exciting if you think out of the box.”

Both the oil and gas and coal sectors are working hard to find solutions to the greenhouse gas emissions problem.

Using clean coal technologies and storing high volumes of CO₂ in depleted oil and gas fields in Western Canada are two major initiatives, which advocates of the technologies say should make it more acceptable to society at large to use fossil fuels far into the future.

Another big opportunity — which industry is just beginning to develop — is gasification of coke which is expensive but has the added benefit of creating a synthetic gas stream (removing the need to purchase natural gas), hydrogen (used for upgrading) and a pure CO₂ stream which can be used to recover oil in conventional oil reservoirs. Suncor Energy Inc. filed an application in March for the first coke gasifier in Canada which it plans to build with a third upgrader at Fort McMurray.

Meanwhile industry and government are watching Nexen Inc. and its partner, OPTI Canada Inc., closely as they proceed with development of the Long Lake in situ oilsands project in Alberta which will gasify asphaltenes from

Hydrocarbon Future

bitumen, creating hydrogen (for upgrading into lighter oil) and a synthetic gas to fuel the steam assisted gravity drainage (SAGD) operation.

Gunter and others involved in developing the CO₂ Capture and Storage Roadmap held their third meeting in Calgary in late February. They are now finalizing a plan to produce a series of reports that will recommend actions governments and industry can take to help Canada lead the world in developing a hydrogen-based economy and reduce greenhouse gas emissions.

Ironically, that plan — a final report is expected by May — will envision the fossil fuel industry, much criticized by environmentalists, who see it as the major source of Canada's and the world's greenhouse gas emissions (GHG) problem, as being at the heart of a transformation to a hydrogen future and a key supplier of energy during the long transition period.

“Under the plan you're still stuck with a fossil fuel base (because the world can't escape its dependence on fossil fuels soon),” he said. “If we need 100 years to transfer from fossil fuels to renewables, we have to find cleaner ways (meanwhile) to use fossil fuels.”

There is work being done worldwide on CO₂ capture and storage, all of it being overseen by the Paris-based International Energy Agency (IEA).

In Canada the best known CO₂ capture project is in Weyburn, Sask., where Calgary-based EnCana Corporation and other industry partners and 24 research and consulting organizations have been involved in an Enhanced Oil Recovery (EOR) project that sees CO₂ injected into an aging oil reservoir to increase recoveries.

Results of a study, released last September at a conference in Vancouver, showed that a total of 20 million tonnes of CO₂ are expected to be injected

into the reservoir over the next 15 years, leading to the recovery of 130 million barrels of oil equivalent over the next 30 years.

Meanwhile, the study showed that 100% of the injected CO₂ would remain underground for 5,000 years, with none of it entering potable water aquifers.

The project, initially led by PanCanadian Petroleum Ltd., which EnCana took over two years ago, included the construction of a \$100 million U.S. pipeline to ship carbon dioxide 325 kilometres from the Great Plains Synfuels Plant at Beulah, North Dakota to a new receiving terminal at Weyburn. In total the project, first announced in 1997, involved an investment of \$1.1 billion Cdn. At the time PanCanadian and others involved in the project said it would stimulate the development of similar projects in the area.

Indeed, this past February Apache Canada Ltd. announced plans to spend \$95 million on a

26-km. spur line from the existing Dakota CO₂ line, along with compression and other infrastructure, as part of a project to inject CO₂ into the Midale field in the area, which has 515 million barrels of oil equivalent in place. Apache and its 30 partners estimate the project will help recover an additional 60 to 65 million barrels of oil from the formation.

The Great Plains Synfuels plant, built in the 1980s, converts coal mined from the area to 54 billion cubic feet a year of gas, leaving behind a pure CO₂ stream suitable for injection.

At Weyburn \$40 million was spent, funding that came from a number of government and corporate sources, to look at whether the technology is applicable to other parts of the world and the results were encouraging.

John Gale, Senior Project Manager with IEA says there are dozens of carbon capture and storage projects underway worldwide and all show the technology works. "It has a big role to play, if you're going to make big reductions in emissions of carbon dioxide, in particular," he said. "It's attractive because you don't have to rebuild your energy infrastructure and shift to a hydrogen-based economy."

Three other CO₂ capture projects are underway in Western Canada (in addition to the Apache-led project), including three separate projects that

were granted \$14 million in Alberta government royalty relief last summer. The companies involved are Anadarko Canada Corp., Devon Canada Corp., and Penn West Petroleum Ltd.

ARC's Gunter says the kind of technological link between Weyburn and Great Plains Synfuels — the use of recovered CO₂ from a coal gasification plant — paves the way for the future of the Western Canadian fossil fuel industry.

"You capture the CO₂, either from oilsands plants or from clean coal projects, and store it in spent reservoirs," he said. "You're replacing molecules with other molecules, so the solution is the problem. Meanwhile, you're getting a source for hydrogen."

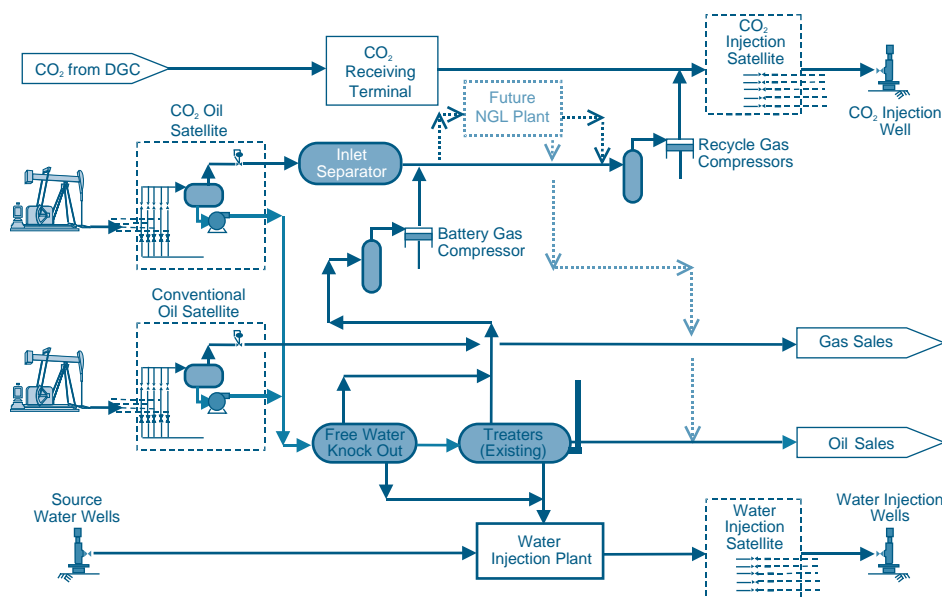
He says environmentalists who suggest hydrogen can be easily recovered from water and other non-fossil-fuel-based sources don't appreciate the science involved.

The CO₂ roadmap "looks 20 years into the future", so the shift to this new, low-polluting fossil fuel-based industry won't happen overnight, he says.

The roadmap envisions several hubs, with CO₂ being captured from the oilsands, from coal-fired plants and from petrochemical plants near Edmonton and Red Deer.

Before concerns about greenhouse gas emissions became a preoccupation of the Canadian and other governments, doing so would not have made economic sense, says Gunter. But in a post Kyoto world, the economics are changing. "What we're seeing is the cleaner technologies will become more competitive because of the environmental costs," he said. "How can we reduce CO₂ emissions with the least pain?"

Gunter says another factor that is contributing to the new industrial revolution he sees unfolding is high natural gas prices and the need to produce more gas for the North American market, which have made the economics of CO₂ capture and injection — and hydrogen extraction from synthetic gas created by gasification of coal or coke — more viable.



EnCana Weyburn CO₂ Flood Facilities A network of medium pressure gas gathering lines transports the solution gas and CO₂ mixture from the production satellites to the new recycle central compression station. The recycled mixture is then blended with purchased CO₂ and re-injected using a new CO₂ injection distribution network.

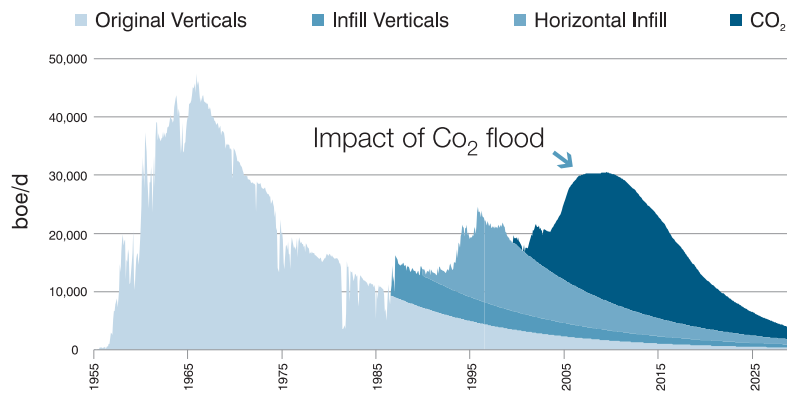


Weyburn CO₂ Flood Project For the CO₂ miscible flood, EnCana, and its partners in the Weyburn Unit, receive gas from the Dakota Gasification Company's Great Plains Synfuels Plant. This plant, located in Beulah, North Dakota, produces 160 MMcf of natural gas from coal gasification.

Both graphics courtesy of EnCana Corporation

Weyburn CO₂ Flood Impact

The historical production and predicted CO₂ response from the EnCana Weyburn project.



A closer look at the chemical formula for any fossil fuel reveals that hydrogen is present in all the formulas. The trick is to remove the hydrogen safely, and without any other elements present in the original compound.

Some fossil fuels have a high hydrogen to oxygen ratio making them better candidates for the reforming process. For example, natural gas and methane have the best hydrogen to carbon ratios, which is why once coal or coke is converted to synfuel it becomes much more viable to then recover hydrogen, while being able to use the synfuel as a source of fuel for steam in the oilsands, for instance.

Predictions that Alberta's booming oilsands industry might take up all new natural gas supplies from Canada's north, have led to a search for alternatives.

For instance, Nexen and OPTI are using OrCrude patented technology at an in-situ oilsands project they are building at Long Lake in northern Alberta. The OrCrude technology extracts asphaltenes (a waste byproduct of conventional coking operations) from bitumen to produce a syngas that can be used to create steam and extract more bitumen.

Gunter says the Long Lake Project is a step forward, but not the giant step that is needed in the oilsands.

"OPTI is a real advancement but they're not extracting the CO₂, so there will still be CO₂ emissions," he said.

ARC is involved in several CO₂ research initiatives, including one to monitor capture and storage and another to produce CO₂ more cheaply. However, it is also involved in fuel cell research, so it hasn't abandoned alternatives to fossil fuels.

One reason he sees the Western Canadian Sedimentary Basin (WCSB) as a perfect environment to test CO₂ storage and hydrogen extraction is because of the nature of the geology.

"Aside from being a mature basin (where CO₂ can easily be stored in older reservoirs) it's an aseismic (meaning not earthquake prone), stable zone," he said.

He says the many enhanced oil recovery projects underway will lead more rapidly to the new fossil fuel-based economy he sees, as will plans for a clean coal project in Western Canada.

The Canadian Clean Power Coalition, composed of large coal-using utilities like TransAlta Corp. and government agencies, plans to build Canada's first coal gasification plant by 2010.

The project, likely to cost at least \$1 billion, would be aimed at a slow conversion of Canada's existing coal-fired plants to clean-burning synfuel.

Gunter sees as possible five million tonnes of CO₂ being removed from Canada's fossil fuels by 2012 and 30 million tonnes a year by 2030.



Photo courtesy of EnCana Corporation

Long Lake Project

Conceptual view of the The Long Lake Project and its key components. SAGD technology will be used to recover bitumen. The bitumen will be partially upgraded using OPTI's proprietary OrCrude technology, followed by conventional hydrocracking and gasification. The end result will be a sweet, premium synthetic crude. And it will be produced in an economically, environmentally and socially responsible way.



Graphic courtesy of the Long Lake Project

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A CO₂ roadmap research paper says about 100 million tonnes of CO₂ are emitted annually as a result of the production and processing of oil and gas and that is expected to grow to 121 million tonnes by 2010.

About 130 million tonnes of CO₂ emissions are released from other industries in Canada and that is expected to grow to 138 million tonnes by 2010.

Coal-fired power plants produce about 110 million tonnes of CO₂ a year now and that is expected to grow to 119 million tonnes by 2010.

The federal government has committed to cut 240 million tonnes by 2012, about 72 million tonnes of which would come from the oil and gas industry — meaning CO₂ capture initiatives could go a long way towards allowing the oil and gas industry to comply with Kyoto.

The federal government has agreed to treat the oil and gas industry the same way as other large industries, capping its cost of reducing GHG emissions at \$15 a tonne.

Gunter says it may be necessary for Ottawa to raise that price in order to stimulate CO₂ capture and storage.

"There are predictions CO₂ will be \$50 to \$100 a tonne by 2030," he said.

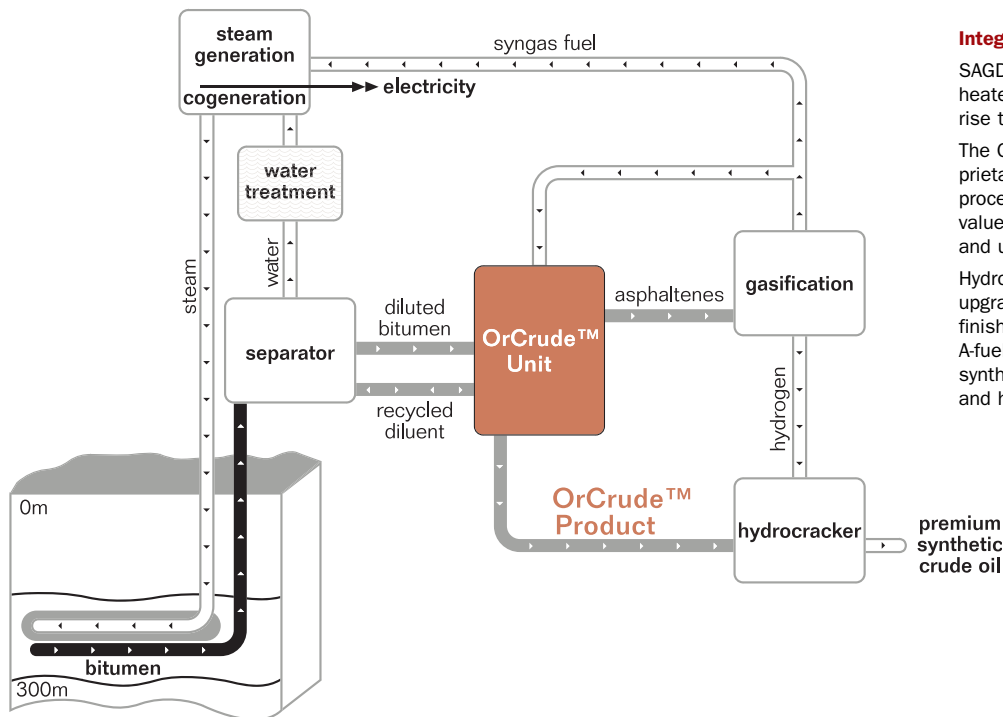
It costs about \$40 a tonne Cdn now to separate CO₂ from industrial exhaust, although technology exists to cut that by nearly half, said Curt White, carbon-sequestration science leader for the U.S. National Energy Technology Laboratory. He said the goal is to get it down to about \$8 a tonne (about \$10 a tonne Cdn).

"It's always going to be cheaper to put carbon dioxide into the air than somewhere else," said Howard Herzog, principal research engineer at the Massachusetts Institute of Technology.

"It costs a lot more than anybody seems willing to pay now, but if we decide we really want to solve the climate problem, then it's going to be a cost-effective option."

The U.S., which has not signed the Kyoto accord, is the world's leading emitter of CO₂, with 1.6 billion tonnes of emissions annually, about one-quarter of the world total.

Worldwide CO₂ emissions could triple over the next 100 years, reaching



Integrated Long Lake Upgrading Project

SAGD technology heats bitumen, and the heated bitumen and condensed steam rise to the surface.

The OrCrude upgrading process is a proprietary carbon-rejection process. The process removes the heaviest, lowest value components of the bitumen (A-fuel) and upgrades the rest.

Hydrocracking provides secondary upgrading of the OrCrude product into finished Premium Synthetic Crude. The A-fuel by-product is gasified to produce synthetic fuel gas for use in the project and hydrogen for use in the hydrocracker.

20 billion tonnes yearly, according to the Inter-governmental Panel on Climate Change.

Carbon dioxide is an essential ingredient in the atmosphere, keeping the earth warm enough to sustain life. However, during the last century, as fossil fuel use has grown dramatically, the excess quantities of CO₂ are seen as a major contributor to global warming (still disputed by some scientists).

In a draft document produced for the CO₂ Capture and Storage Roadmap the connection between fossil fuels and global warming is expanded upon. The paper says about 90% of the world's primary energy requirements are supplied now by fossil fuels. It says CO₂ is responsible for about 64% of the enhanced greenhouse gas effect.

And the draft paper holds out little hope the shift to a hydrogen economy will happen soon or without technical and economic challenges.

"Most of the hydrogen being produced in commercial quantities today originates from hydrocarbons," it says.

"More CO₂ is generated on a unit of heat basis by producing hydrogen from fossil fuels than by directly burning those fossil fuels.

"Emission-free hydrogen production by water electrolysis, powered by renewable, hydro or nuclear sources is as yet not cost-effective, so even the commercial production of hydrogen may have to rely on technologies that capture and contain CO₂ ..."

The roadmap paper goes on to say that modeling studies suggest up to 10 million tonnes a year of CO₂ could be captured and stored geologically every year in the Western Canadian Sedimentary Basin alone. The roadmap envisions "value-added" opportunities for CO₂ capture and injection and storage, such as enhanced oil recovery, being adopted extensively in the next few years. It says it has been estimated that 450 million tonnes of CO₂ could be stored in the WCSB, with most of that in Alberta. And the ultimate storage potential in Western Canada is 120,000 megatonnes. Worldwide it is estimated 1,250,000 megatonnes could be stored in geological formations.

Aside from the work being done in Canada, there is a great deal of work being undertaken elsewhere in the field of geological storage of CO₂.

The U.S., for instance, has brought together 14 countries (including

Canada) to form the Carbon Sequestration Leadership Forum, dedicated to developing and implementing the technology. The government is spending \$50 million U.S. a year to promote the technology. In addition, U.S. industries recently awarded Stanford and Princeton universities \$225 million U.S. and \$20 million U.S. respectively to study the technology over the next 10 years.

Australia is spending about \$100 million Cdn over the next seven years and has established the CO₂ Cooperative Research Centre.

The Canadian roadmap will include conducting a survey to look at all existing and planned CO₂ capture projects in Canada, a look at technology and other needs, and developing a Web site for the exchange of information.

Rick Hyndman, senior policy advisor with the Calgary-based Canadian Association of Petroleum Producers (CAPP), points out that the federal government telegraphed support for carbon capture and clean coal technology projects in the recent federal budget, when it announced more than \$3.2 billion in new funding for environmental initiatives.

Included in that funding was more than \$1 billion set aside in the new "Clean Fund," an unspecified amount it said would be spent on targeted technologies, and hundreds of millions of dollars more earmarked for partnerships with provinces, territories and corporations.

But while the oil and gas industry is committed to investing in technology to do its part in reducing its environmental footprint, he points out that the oil and gas industry isn't the main culprit. "The energy industry is only responsible for about 20% of the emissions," he said. "It's the end users, consumers, who are responsible for 80% of the fossil fuel-related emissions (mostly through the use of transportation fuels)."

And he argues that the energy industry would move quickly to seize a business opportunity if the hydrogen-based economy was supported by society. "If consumers were willing to pay the cost of fuel cell cars, running on zero emission hydrogen, the industry would move quickly to produce hydrogen," he said. "Ultimately using crude oil and natural gas to produce hydrogen is the solution."

Ian Potter, Director of Sustainable Energy Futures at the ARC says his agency, which receives federal and provincial funding of \$85 million a year

"Our best way of staying competitive and still be seen to be dealing with Kyoto is energy efficiency. We can't stop producing the oil and gas because if we do someone else will provide it and there would be significant damage to the Canadian economy (the industry contributes more than \$52 billion a year to the Canadian economy).

and employs 550 people, is just one of many energy-related agencies looking at CO₂ capture as a link to a hydrogen economy future.

For instance, the Alberta Energy Research Institute, formerly the Alberta Oil Sands Technology and Research Authority, which had its mandate broadened in 2000 to study renewable energy and clean coal and CO₂ capture, the National Centre for Upgrading Technology, a federally-financed research facility in Devon, Alberta, and Petroleum Technology Alliance Canada (PTAC) all are involved in CO₂ research.

Potter, who is also involved in the roadmap process, says the strategy goes beyond the formidable technological challenge of capturing and storing CO₂. "We have this meaningful source of CO₂, but how do you move it," he asked.

Pipelines would need to be built, much like the existing line from North Dakota to Weyburn, to move CO₂ from one area to another, something being studied as part of the CO₂ roadmap process.

He says CO₂ capture represents the only way Canada will meet its Kyoto commitment of reducing overall GHG emissions up to 2012 by six per cent from a 1990 baseline. "But it won't be done within the Kyoto time frame," he says, suggesting the federal government should extend its target beyond 2012 and concentrate on developing CO₂ related technologies.

The oil and gas industry has already made significant strides in improving its environmental performance, says David Pryce, a vice president with CAPP and a climate change expert with the organization.

CAPP's most significant accomplishment was in the area of vented and flared gases, excess gases that have traditionally been emitted into the atmosphere by the industry as a way of managing waste gases.

That started to change in 1997, when Pryce joined CAPP and made initiatives to reduce venting and flaring one of his missions. "We had been asked to deal with the issue by environmental groups," he said. "We decided to deal with it and to put it into a public forum."

That public forum was the Clean Air Strategic Alliance (CASA), an organization composed of industry members, government representatives, environmentalists and others.

Pryce said CAPP and its industry members decided the best way to deal with the issue was to set targets for flaring and venting emission reductions.

Part of the strategy involved lobbying the provincial government to eliminate royalties on flared and vented gases the industry captured. "When we flared and vented the gases we paid no royalty, of course," he said. "But there was no incentive to capture the gases because when we did we paid a royalty."

When the province agreed to lift its royalties "the industry blew past the targets". For instance, it has set a target of capturing 25% to 30% of flared gases and that is now 70% and higher. It also has managed to reduce venting by 38%, well above initial targets.

Pryce admits the industry had some help, aside from the royalty break. "It got to be profitable to capture the gas because of rising natural gas prices," he said.

There were other factors involved, including the maturity of the WCSB. "In the early years when there was only one operator in a field, it wasn't economical to invest in the technology needed to capture the gases," he said. "But as the field matured and there was more activity, including gathering pipelines, it started to make more sense. When you have 30 wells in an area, instead of just one or two, you have to decide what to do with all the vented and flared gas."

In the early 1990s, there were 6,000 wells drilled a year in the basin, but that has risen to 22,000 a year, illustrating the increased activity that has improved the economics.

"It [dealing with flaring and venting] has been our most obvious achievement as an industry," he said.

Pryce says the precedent of what the industry has done in the flaring and venting area sets a good foundation for what it can do in the future to capture and process CO₂. “CO₂ capture is the future,” he said. “Rather than sending money offshore to buy emissions credits (from other countries) we should bide our time to develop the applied technology.”

He points to other accomplishments of the oil and gas industry, such as its success in reclaiming lands disrupted by pipelines, conventional oil and gas activity and oilsands mining, reducing the industry’s impact on wildlife and other moves.

The industry’s priority has been to improve its energy efficiency as well, and it has achieved a one per cent a year improvement for the last decade.

“Our best way of staying competitive and still be seen to be dealing with Kyoto is energy efficiency,” he said. “We can’t stop producing the oil and gas because if we do someone else will provide it and there would be significant damage to the Canadian economy (the industry contributes more than \$52 billion a year to the Canadian economy). “If we can do it in a more energy efficient way we’re contributing positively to the issue.”

In a recent study on barriers to use of environmental technologies, the Petroleum Technology Alliance Canada says the oilpatch could save \$1 billion a year by introducing up-to-the-minute technologies that reduce greenhouse gas emissions, cut energy bills and reduce waste.

The PTAC report recommends government tax incentives to promote environmental innovation and direct funding to move innovative technologies towards deployment. Oil and gas producers are having difficulty identifying “best practice” technologies from the host of technologies being marketed to them and PTAC’s recommendations are aimed at increasing awareness and use of best practice technologies.

Mary Griffiths, an Edmonton-based biologist involved with the Pembina Institute, said there’s no question coal gasification and CO₂ capture represent significant technological improvements, but it doesn’t solve related environmental problems.

“What about all those mines where coal is taken from? There is damage to the environment from extracting the resource.” She says the same holds true for the oilsands, where environmentalists argue lands will never truly be reclaimed.

She agrees with Pryce (she also sits as a member of CASA) that energy efficiency is a key, not just for the industry but throughout the Canadian economy. But she also argues that Canada should be moving more rapidly towards the development of renewable sources of energy. She claims energy companies and utilities would move faster to adopt renewables if the “real cost” of their use of fossil fuels was imposed. “The fossil fuel industry gets to pollute for free,” she claims, arguing that there should be fossil fuel taxes imposed on the oil and gas and utility industries, as is done in Europe. Still, she acknowledges that “things won’t change overnight” and the world will be fossil fuel reliant for many more years.

Indeed, energy experts, such as CAPP’s Hyndman, argue that the sheer portability of gasoline (and natural gas converted for transportation fuel) makes it virtually impossible to replace it, even if the world moves increasingly to the use of renewables to produce power. “We should be moving more towards the use of wind power, small hydro and other renewable power sources,” he said.

“But Canada could probably cut its emissions at least in half if we captured the CO₂ from oil and gas and coal and produced hydrogen. “You still have compressors (in the field) and you’re still going to be producing gasoline and jet fuel, so you wouldn’t totally eliminate emissions. But ultimately using crude oil and natural gas to produce hydrogen is the solution.”

BY JIM BENTEIN



Graphic courtesy of the Long Lake Project