Special

Engineering Canada's clean-tech future

"It is estimated that the global demand for innovative clean technologies will grow to $3 trillion by 2020. This is a massive export opportunity for Canada," says Dr. Vicky Sharpe, president and CEO of Sustainable Development Technology Canada.

Jobs, revenues and new ways of doing business

Vicky Sharpe has no doubt about the current state of Canada's clean-tech sector. As president and CEO of Sustainable Development Technology Canada (SDTC), she sees clean-tech advances being applied every day in traditional sectors of the economy, such as oil and gas and forestry, and in new and emerging sectors such as renewable energy and water treatment.

"Ask anyone in the natural-resources sector, and you will find someone eager to increase efficiency and productivity, and reduce costs and waste. That is just what clean-tech does – and that is why the industry is quickly becoming a centrepiece of the Canadian economy," says Dr. Sharpe, noting that it is this desire to do more with less that is launching the clean-tech industry to new heights.

"Our clean-tech sector is already worth $10.6 billion in revenues and now employs 50,000 people – up 18 per cent over last year. These are impressive numbers and we are confident they will continue to rise."

She points out that the growth of the sector in Canada is in line with the growing global move toward new ways of doing business through improved and cleaner technology.

"It is estimated that the global demand for innovative clean technologies will grow to $3 trillion by 2020. This is a massive export opportunity for Canada. Of course, there is also strong domestic demand for clean-tech, especially within the natural-resources sector, which is a cornerstone of the Canadian economy," says Dr. Sharpe.

Funded by the Government of Canada, SDTC is a not-for-profit corporation that finances and supports the commercialization of clean technologies.

One such company is Quadrogen Power Systems. As a beneficiary of SDTC support, Alakh Prasad, P.Eng., knows the value of the organization to him as an entrepreneur. And as an engineer, he appreciates the expertise and knowledge needed to advance Canada's clean-tech sector.

Mr. Prasad is president and CEO of Quadrogen, a Vancouver-based clean-tech company that designs, builds and installs high performance gas clean-up solutions for the renewable energy sector. The technology his company is developing converts and removes fuel contaminants to ultra-clean level and reduces the operating and maintenance costs of renewable energy production while improving system reliability.

That's important because biogas such as landfill gas or syngas derived from organic waste for renewable power generation is green, but not clean and can cause equipment problems that negatively affect performance, drive up cost and reduce reliability.

"The global market for biogas clean-up systems is over $15 billion," says Mr. Prasad. "Quadrogen has long-term plans to achieve 20 per cent penetration into this market and generate $3 billion in revenue for its products and services."

Another company in the SDTC portfolio is Tenova Goodfellow Inc., (TGI), an Ontario firm whose technology is helping the steel industry reduce energy use and greenhouse gas emissions.

Company director Howard Goodfellow, Ph.D., P.Eng., says the technology has significant benefits for operators of electric arc furnaces (EAFs), which are used in the energy intensive, scrap metal melting process that currently produces about one-third of the world's steel with a total energy consumption of almost 385 million MW hours per annum globally.

"The EAF remains one of the least automated, energy intensive heavy industrial processes largely due to the harsh operating environment that makes sensor reliability and related process monitoring and control extremely difficult," explains Dr. Goodfellow.

SDTC is working with TGI to demonstrate the company's clean technology in collaboration with leading Canadian steel producer ArcelorMittal Dofasco.

The technology has already been demonstrated successfully in full-scale basic oxygen furnace (BOF) steelmaking facilities, cement plants and coal-fired power plants, and global market opportunities are being pursued, says Dr. Goodfellow.

To help companies like Quadrogen and TGI, SDTC operates two funds aimed at the development and demonstration of innovative technological solutions. The $590-million SD Tech Fund supports projects that address air quality, climate change, clean water and clean soil. The $500-million NextGen Biofuels Fund supports the establishment of first-of-kind large demonstration-scale facilities for the production of next-generation renewable fuels. To date, the SD Tech Fund has completed 19 funding rounds, committing more than $560 million to more than 228 projects. The NextGen Biofuels Fund has over half its fund earmarked, with four projects approved for funding.

Dr. Sharpe emphasizes that SDTC does much more than simply finance groundbreaking technologies. It also works closely with an ever-growing network of stakeholders and partners to build the capacity of Canadian clean-technology entrepreneurs, helping them form strategic relationships, formalize their business plans and build a critical mass of sustainable development capability in Canada. SDTC leverages its network to help portfolio companies secure private-sector expansion capital and enter global value chains and markets through multinational corporations.

"Ten years ago there was confusion about what constituted clean-tech. We worked with the industry to position it as a recognized driver of productivity, competitiveness and export revenues, and we have helped develop and deliver Canadian technology innovations to market. In the process, we have established a commercialization funding model that has become recognized in Canada and globally for its effectiveness," she says.

The results are impressive. Revenues of SDTC-supported companies grow at twice the rate of non-SDTC companies, says Dr. Sharpe. SDTC's investments have helped create 7,000 jobs in rural and urban communities across Canada, and are expected to generate $5 billion in revenues by 2015.

ONLINE?

For more information, visit sdtc.ca.

SDTC BY THE NUMBERS

19
Funding rounds completed to date

$560 million
Allocated to 228 projects

$1.4 billion
Additional funding leveraged from other project partners for a total project value of $1.9 billion

2.4:1
The ratio of industry-partner contributions to SDTC investment with 83 per cent coming from private sources

ACADEMIA

Engineering schools, grads helping propel industrial solutions

Canadian engineering schools are helping to propel Canada's clean-tech sector through dynamic partnerships involving industry and professional engineering bodies. Beyond preparing grads for jobs in this emerging field, universities and colleges are developing new technologies and launching commercial applications that are showing results.

Paul Cyr, senior technology transfer officer at the University of British Columbia's University Industry Liaison Office (UILO), sees it every day. The office facilitates industry interaction with the research expertise, discoveries and capacity of UBC, and a significant number of those interactions involve clean-tech.

"We have a history of clean technology companies coming through UILO and we are definitely seeing an increase in the number of technologies and ideas that are in the so-called clean-tech sector," says Dr. Cyr.

Among the successes that have come out of UBC is Westport Innovations, now a leading global supplier of technologies that allow engines to operate on clean-burning fuels. Another, Ostara Nutrient Recovery Technologies, designs, builds and markets a nutrient recovery technology that transforms phosphorus and nitrogen from municipal and industrial water treatment facilities into a high-value, eco-friendly fertilizer.

Dr. Cyr says UBC's various engineering departments have been responding to the needs of the emerging clean-tech sector for more than 10 years.

The university has created the Clean Energy Research Centre (CERC), which includes faculty members from several different disciplines of engineering, he

Academia, Page CTE 2

ONLINE?

For more information, visit ospe.on.ca

INSIDE

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ENGINEERING CANADA'S CLEAN-TECH FUTURE

OPINION

Canadian innovation an engine for export growth

The message is clear: The world wants clean-tech. The global market for clean technology in 2011 was pegged at $1 trillion, and it is predicted to grow to as much as $3 trillion by 2020. Vicky Sharpe, president and CEO of Sustainable Development Technology Canada (SDTC), discusses how Canada can seize its share.

While the global clean-tech numbers are impressive, what do they mean for Canada?
They represent an extraordinary opportunity for Canada. Our share of the market in 2011 was $10.6 billion – and over half of that came from international customers. When the global market hits $3 trillion, as expected by 2020, the numbers for Canada will shoot up as well. That is only seven years away. The opportunities are endless.

So, clean-tech is heavily exported?
Yes. In fact, currently 80 per cent of all Canadian clean-tech companies export – a number that is expected to rise to 90 per cent by 2014. It is important to note, too, that the average SME in Canada is not following this trend: according to Industry Canada, only nine per cent of Canadian SMEs export goods and services.

There is more to the story: clean-tech is also attracting foreign investment to Canada. Consider the fact that of our funding, $18.5 million in investments have attracted $619 million in capital commitments by foreign multinationals to build manufacturing capacity here in Canada. As well, 53 of SDTC's more mature projects have attracted $2.3 billion in follow-on financing from around the world, which represents a 15 times leveraging of public funds. Those numbers will only climb as Canada's clean-tech market grows.

Where are Canada's clean-tech customers and partners located?
That's the best part of Canada's international clean-tech customer base: it is very diverse. Of the 80 per cent of companies that export, 55 per cent of them are exporting to non-U.S. markets. It points to a sector that is not tied to the success of any given economy, making it resilient and flexible.

The Canadian government is keen to develop partnerships overseas. How does clean-tech fit into that effort?
Clean-tech is a huge part of what Canada has to offer overseas. Recently, Prime Minister Stephen Harper led a trade mission to India. The great news of the event was that 14 Canada-India deals were inked during that mission – and over a third of those were clean-tech deals signed with SDTC-supported companies. It showed that clean-tech companies are expanding Canada's reputation overseas and positioning Canada as an important trading partner to one of the world's fastest growing economies – India – and one that is hungry for clean-tech innovation. We expect to see similar situations play out in years to come.

What do Canada's potential international clean-tech partners have to say?
We have a number of partners who are as excited about Canada's clean-tech future as we are. We are working with governments to establish best practices for sharing information and sharing technologies, ensuring that clean-tech sectors around the world get the boost they need to continue to grow. Consider our memorandum of understanding signed with the United Arab Emirates late last year. The memorandum commits both parties to work together to enhance clean-tech development and adoption, through measures such as joint projects, technology transfer and information sharing. The goal is to further develop a robust clean-tech infrastructure, along with a lively community of small and medium-sized enterprises in both countries. We are looking to develop similar initiatives with countries around the world.

Export Development Canada (EDC) is doing exciting work in this area. Are you working with that agency as well?
Absolutely. EDC and SDTC have complementary approaches, which makes bringing a technology to market more streamlined and efficient. EDC's programs can help to incite commercial financing, similar to the way SDTC's process de-risks technology development and levers private-sector investment. Apart from the financial instruments that they deploy, the involvement of both EDC and SDTC can often reassure downstream investors and customers.

FROM CTE 1

Academia: Coursework, R&D and applied projects yield results

says. "It is focused specifically on clean energy research, and the engineers working there collaborate within UBC and externally."

Through CERC, UBC now offers a master's of engineering degree in clean energy, with some 20 graduates a year.

"They are being specifically trained in the clean energy sector, through a combination of coursework and applied projects for companies such as BC Hydro," explains Dr. Cyr.

Training for the challenges of the future does not end when engineers graduate. In Ontario, for example, the engineering and business schools at McMaster University, Queens University, the University of Toronto and the University of Western Ontario have formed the Advanced Design and Manufacturing Institute (ADMI). Supported by industry and the Ontario Society of Professional Engineers (OSPE), the institute provides practicing engineers with the necessary knowledge, tools, technology, business and management skills to remain at the forefront of their profession.

With two program streams available – business and management or technology and processes – ADMI courses provide participants with access to the finest expertise in engineering design, manufacturing and management.

The Bioenergy Research & Demonstration Facility, a partnership between the University of British Columbia, Vancouver's Nexterra Systems Corp. and GE Energy, is North America's first commercial demonstration of a community-scale heat and power system fuelled by biomass. SUPPLIED

As chair of OSPE's energy task force, Paul Acchione, P.Eng., appreciates the value of improving the skills and training of engineers involved in the development of clean technology.

"Engineers are in the thick of it – and should be," says Mr. Acchione.

Engineers are already playing a significant role in the emergence of Canada's clean-tech sector, he adds, through product development and design as well as research and development, alongside universities and colleges.

"In fact, almost all of the universities are actively involved in sustainable technology and breaking new ground in the development of clean-tech," notes Mr. Acchione.

Statoil is committted to using the best availlable technology to reduce the environmental impact of its oil sands operations. HARALD PETTERSEN / STATOIL

PROGRESS

Winning technologies helping companies develop oil sands more cleanly, safely

There are many good reasons why Statoil, the Norwegian multinational energy company, and Thailand's PTT Exploration and Production budget $30 million a year for technology development. As partners in Canada's oil sands, the companies know that new technology is the key to improved performance, as well as crucial to the social licence they need to operate.

Dan Zilnik, the leader of climate and environment for Statoil in Canada, says the partnership has identified several themes within the technology development plan, including facilities and the environment.

"We're looking only at projects that fulfill the true sustainability objective of improving environmental and economic performance easily."

Dan Zilnik
is the leader of climate and environment for Statoil in Canada

"We have two major goals in that theme. The first is to reduce our CO_2 by 25 per cent by 2020, and then reduce it by a further 15 per cent, to 40 per cent, by 2025," says Mr. Zilnik. "Secondly, we want to reduce our water usage by 45 per cent by 2020. We're going to do this with technology, and by operating our facilities really well."

Specific technologies the company is exploring include bitumen extraction techniques and different ways of making the steam used in the process. One is the SDTC-supported solvent co-injection project, which will improve the current dominant method for oilsands recovery by adding solvents to the steam-powered process. The solvents reduce steam use, resulting in up to a 20 per cent lower energy requirement and water consumption, as well as the ability to dig deeper into the bitumen-bearing zone.

"Another interesting idea we're looking into is to use natural gas, beyond just creating steam. The neat thing about some of these schemes is that you can create electricity as a byproduct of creating steam, so we would be co-generating electricity and steam at the same time," he says.

That's important for the environment, suggests Mr. Zilnik, because it means buying less electricity, which currently comes from a coal-fired facility.

"But even more exciting, in my opinion, is that we are starting to look at how we can go beyond using only steam in the extraction process. One possibility is co-injecting a solvent with the steam to chemically liberate the oil. If you get the solvent back up, then it becomes a kind of loop, where you're really reducing your steam usage dramatically," he says.

As a multinational, Statoil has the ability to bring technology to the oil sands that has been proven elsewhere in the world, which creates some "easy wins," according to Mr. Zilnik.

"For example, we will be introducing a steam control valve in the oil sands operation that we already use in other places. It will allow us to carefully control where and when we deploy steam, which means a much more efficient development of the reservoir, less CO_2 and a lower steam-to-oil ratio. It's an easy win, through implementing a known technology," he says.

Statoil believes in a balanced approach to technology development that benefits the economics of a project, is safe and improves environmental performance, he notes.

"We're looking only at projects that fulfill the true sustainability objective of improving environmental and economic performance easily. We see that there's a lot of room to improve environmental performance, while improving our economics," explains Mr. Zilnik.

Statoil sees improved performance, based on improved technology, as its most important contribution to the dialogue around the development of the oil sands.

"Energy is a vital resource, but we recognize that there is a cost to develop it. We think it's important to have a rich dialogue on this, and we want to be part of it. Improving our performance will change the dialogue more than anything else," Mr. Zilnik adds.

ENGINEERING CANADA'S CLEAN-TECH FUTURE

OPINION

Time to engineer Clean Wave Two: the case for nuclear is overwhelming

By John Stewart,
Director of Policy and Research,
Canadian Nuclear Association

Engineering a clean technology future is not uncharted territory. Scientists, engineers, visionaries, inventors and salespeople of the generation of Sir Adam Beck, the Canadian pioneer of public electricity grids, inter-urban transit and health institutions, knew they were building a cleaner society based on a new set of technologies, especially electricity.

It worked. The 20th-century Canada they left behind, while more populous and urban than the one Mr. Beck's generation grew up in, was in many ways a healthier, safer and greener one.

That was no accident. They engineered it. A set of then semi-applied technologies (hydro-electricity, sanitation) was ripe for wider application. Mr. Beck's contemporaries saw the huge benefits of applying them more fully – not only for profit, but also for society's benefit.

They developed hydroelectric resources. They extended and integrated our utility grids. They electrified Canada's homes and farms. In the process, they left Canada with strong engineering capacity, sophisticated manufacturing and a culture of good infrastructure and regulatory systems that protect the public.

They didn't succeed everywhere. Often they were simply ahead of their time; public health care, for example, took two more generations to bloom. And Mr. Beck's public-minded system of efficient inter-urban trolleys across southern Ontario was blocked by the rise of the automobile in the 1920s. His hydroelectrically driven vision had to share the world with inexpensive fossil fuels.

Even so, that generation imagined and achieved what we can call Clean Wave One. It left Canada with tremendous benefits of engineering: abundant energy, good mobility, better environmental quality, longer lives.

Canadians continue to have the strong, dynamic and imaginative engineering culture that delivered those benefits. That engineering culture continues to be available to us for Clean Wave Two. If the technological opportunities exist, we can imagine and achieve a second clean technology future.

The semi-applied technologies that are ripe for wider application this time include:

- Electricity storage and conservation systems, particularly improved batteries;
- Electronic controls, raising efficiency in all energy systems;
- Ergonomics, user interfaces, biometrics, health, safety and medical technologies;
- Applications of electricity to the transportation grid; and
- Non-hydro, non-fossil electricity generation: solar, wind, nuclear.

Of these opportunities, nuclear might be the slowest to come to most minds as a building block of Canada's clean technology future. But it fits.

- Nuclear energy now has five to six decades of practical and commercial development behind it. It's already been demonstrated to work affordably, reliably and safely.
- Its carbon emissions from operation are virtually zero, and its land footprint (per energy unit) is smaller than that of wind or solar energy.
- In recent decades, while new nuclear plants have been modest in number, designs have become far more sophisticated, including being simplified and modularized.
- The used nuclear fuel from many plants built so far is 95 per cent unburned. Only about five per cent of the energy has been used; the rest has gone into storage. With new reactor designs, there's a vast opportunity for more energy, vastly trimming the waste stream.

Many of the world's fastest-advancing economies are just beginning to use nuclear. As they develop, they will build their systems around the newest, safest, most reliable designs.

Canada will be one of those economies – but only to the extent that we invest in the necessary engineering.

Nuclear engineering isn't an isolated silo that strengthens only nuclear energy.

- Nuclear engineering advances materials science, putting it at the heart of modern manufacturing and industrial competitiveness.
- Nuclear engineering also advances medical imaging, analysis, diagnosis, treatment and sterilization, putting it at the heart of modern medicine and health.

These two areas – materials science and health technology – alone are core areas for Clean Wave Two, even if nuclear is not used for clean energy production.

Seen this way, the argument for nuclear engineering is overwhelming. It's an integral part of our next step in life quality.

Many of the world's fastest-advancing economies are just beginning to use nuclear. As they develop, they will build their systems around the newest, safest, most reliable designs. Canada will be one of those economies – but only to the extent that we invest in the necessary engineering.

CAREERS

Growing nuclear jobs offer handsome compensation – and purpose

For a young person who wants to be part of engineering Canada's clean-technology future and is looking for a career that's stable, well-paid and in an industry with high standards of health, safety and training, nuclear industries offer one of the best options, according to the Canadian Nuclear Association (CNA).

Association members have already built one of the cleanest, lowest-emitting, most reliable and affordable energy sources available to Canadians, says Heather Kleb, the CNA's acting president and CEO.

"There's a 50-year record now of generating power safely and with virtually no carbon emissions," she notes. "But we want to do much more. There have been dramatic advances in the technology, not just for electricity, but in many other applications, and we are looking for people who are serious about working in science, engineering or a skilled trade to help us realize the possibilities."

Ms. Kleb points out that nuclear industries already directly employ more than 30,000 Canadians in research, engineering, manufacturing, mining, fuel production, electricity generation, medicine, food safety and related fields. It is estimated that by 2017, another 12,000 direct jobs and a similar number of secondary jobs will be created in the sector, if current investment plans are realized.

Employment opportunities cover a range of disciplines, Ms. Kleb says. These include public and private research laboratories, clean electricity generating plants in Ontario and New Brunswick, reactor designers and suppliers, engineering firms, university research reactors in several provinces, nuclear medicine, medical supplies, medical imaging, public health, uranium exploration in several provinces and territories and mining in Western Canada.

"Salaries in many of these jobs average about $100,000 annually, in organizations that are here to stay and facilities that last for several decades," she adds. "For highly qualified personnel, such as those with advanced degrees in science or engineering – and we employ thousands – average salaries are in the $130,000 to $160,000 range."

Ms. Kleb says that in addition to above-average compensation, the benefits of jobs in the nuclear sector include stable employment and high standards of health, safety and training, as well as being able to make a contribution to minimal-carbon energy.

"Our member-companies do a lot of workforce development in-house, partly because they develop so much proprietary knowledge. This leads to big investments in employees, who acquire durable skills related to durable infrastructure – skills they can use for decades to come," she says.

CNA policy director John Stewart says that nuclear technology helps to develop Canada's manufacturing and innovative capabilities.

"One company told us that, while nuclear is just two per cent of their revenue, it drives their whole company to learn global best practices and pass tough quality audits. They believe that two per cent of their business creates priceless value for their future," he explains.

"We are engineering Canada's clean technology future," adds Ms. Kleb. "And we're an unbeatable career option for people who are serious about participating in that."

"For highly qualified personnel, such as those with advanced degrees in science or engineering – and we employ thousands – average salaries are in the $130,000 to $160,000 range."

Heather Kleb
is the Canadian Nuclear Association's acting president and CEO

BY THE NUMBERS

Estimated future nuclear jobs

9,500
Plant operations until at least 2050

5,000
Plant refurbishments through approximately 2024

10,000
New plant construction for about five years

Source: CNA-CME economic impact study 2012. Conservative estimates. Figures do not include indirect job effects or jobs in the uranium sector.

Nuclear technology plays an important role in medical diagnosis, such as the magnetic resonance imaging machine seen here, and offers interesting and rewarding career opportunities. ISTOCKPHOTO.COM

OPINION

Ontario's energy advantages offer a better environment and economic prosperity

By Don MacKinnon,
President, Power Workers' Union

Canada's economic success is clearly linked to rapid fossil fuel development, which makes better management of greenhouse gas (GHG) emissions imperative. Ontario has two natural energy advantages that can help deliver significant environmental and economic benefits for all Canadians – a successful reactor technology and vast biomass resources. Achieving these outcomes requires provincial and federal leadership working collaboratively to make the necessary investments in these advantages.

Environment Canada data estimates that by 2020, GHG emissions from the oil sands will exceed those from all transportation and electricity generation in Canada and the total emissions of every province except Alberta and Ontario. Both oil sands mining and in situ oil sands development will contribute; however, in situ production is more GHG intensive and will overtake mining by 2017.

Ensuring Canadians have clean, affordable, reliable and secure electricity for the future while creating tens of thousands of jobs and economic wealth requires federal and provincial support for investments in CANDU technology and Ontario's biomass resources. Specifically, Ontario must select Enhanced CANDU 6 technology for its new reactors and convert its coal stations.

Failure to mitigate these rising emissions will come with a substantial economic cost for all Canadians. A September 2011 National Round Table on the Environment and Economy [NRTEE] report concluded that unless GHG emissions are reduced, the economic impacts of climate change on Canada could be billions of dollars per year.

Leveraging Canada's successful CANDU reactor technology can help mitigate GHG emissions. This can be accomplished by continuing support for current uranium mining operations and ongoing reactor refurbishments; constructing two new reactors at the Darlington Generating Station in Ontario; building new reactors in Western Canada to help with in situ oil sands production; and revitalizing international reactor sales initiatives.

Globally, nuclear generation avoids about two billion to three billion tonnes of carbon dioxide emissions per year, while in Canada CANDU reactors have avoided 2.4 billion tonnes of GHG emissions since 1972. On an annual basis, Canada's CANDU fleet avoids about 90 million tonnes of GHG emissions, the equivalent of about 18 million cars, or about 12 per cent of Canada's total emissions. As well, these nuclear reactors have helped Canada avoid 48.9 million tonnes of sulphur dioxide emissions since 1972.

Canada's $6 billion plus a year nuclear industry supports 160 supply chain companies and 60,000 high-value jobs. According to a 2012 study done by the Canadian Manufacturers and Exporters for the Canadian Nuclear Association, new investments in Canada's nuclear industry could drive an estimated 40 per cent growth in Canadian employment over the next five years. Building a pair of Enhanced CANDU 6 (EC6) reactors outside of Canada supports over 2,200 person-years of direct, high-wage work and over $2.5 billion in economic activity here in Canada.

Ontario's forest and farms can provide extensive supplies of carbon-neutral biomass fuel in the form of wood wastes, agricultural residues and purpose-grown crops.

Further GHG reductions and more jobs and economic benefits can be realized by converting Ontario's coal stations to utilize this domestically sourced, renewable fuel and natural gas.

Besides reducing GHG emissions, these provincially owned generation assets are recycled and Ontario's energy security is improved as natural gas imports from the U.S. are reduced. Investments in biomass fuel supply chain infrastructure are estimated to create about 3,500 jobs and contribute about $600 million annually to Ontario's GDP. These investments will also support Canada's emerging bio-economy sector.

Ensuring Canadians have clean, affordable, reliable and secure electricity for the future while creating tens of thousands of jobs and economic wealth requires federal and provincial support for investments in CANDU technology and Ontario's biomass resources. Specifically, Ontario must select Enhanced CANDU 6 technology for its new reactors and convert its coal stations. As well, federal government support is needed to secure project financing and encourage CANDU reactor sales in other provinces and countries.

The NRTEE aptly defined our collective challenge as "not just coping with climate change, but prospering through it." Ontario's energy advantages can help deliver both.

ENGINEERING CANADA'S CLEAN-TECH FUTURE

INTERNATIONAL TRADE

Rising to worldwide demand, Canadian firms push into foreign markets

With the value of the global clean-tech market forecast to grow to $3 trillion by 2020, from $1 trillion in 2011, Canadian companies operating in the clean and sustainable technology sector are well positioned to take advantage of new export opportunities as they emerge.

Analytica Advisors, one of Canada's leading clean technology consulting firms, says the country's clean-tech companies are nine times more likely to export their products and services than the average Canadian small and medium-sized enterprise.

In its 2013 Clean Technology Industry Report, Analytica says Canada's clean-tech sector is becoming an economic driver, employing 52,600 people in more than 700 companies across all regions of the country. It says there is the potential to increase employment to more than 126,000 people by 2020.

The report adds that 82 per cent of clean-tech companies in Canada already export. By 2015, 70 per cent of their total revenue is expected to come from outside the country.

When the report was released last October, Céline Bak, Analytica's president and CEO, called clean technology Canada's first new industry of the 21st century.

"It has a growing presence in international markets and is bringing economic opportunity across the country. At current growth rates, this will become a $26-billion industry in the next five years, employing over 100,000 people. Much of this growth will be driven by exports to international markets," she noted.

None of this comes as a surprise to Rod Lever, clean-tech lead at Export Development Canada (EDC), Canada's export credit agency.

"The report's findings reflect what we at EDC are seeing on the ground," says Mr. Lever. "Canada's traditional economic sectors, like mining and forestry, are recognizing the important role that clean technology can play in reducing costs and resource consumption."

But those benefits are not restricted to Canadian companies alone, which is why clean-tech has such good potential in the export market, he adds.

"One of the reasons why such a high percentage of our clean-tech companies are exporters is because of the huge demand for clean and sustainable solutions to environmental challenges around the world," explains Mr. Lever.

BY THE NUMBERS

52,600
People employed by Canadian clean-tech companies in 2011

17%
Compounded employment growth 2009 to 2011

700
Clean-tech companies in Canada

$10.6 billion
Canadian clean-tech company revenues

$5 billion
Clean-tech export revenue

Source: Analytica Advisors 2013 Canadian Clean Technology Industry Report

Vancouver's Saltworks Technologies, whose stand-alone reverse osmosis and nanofiltration system is shown here, is eyeing exports to countries that need help with the challenges of growing populations in water-stressed regions. SUPPLIED

In the Caribbean, for example, the drivers for clean-tech tend to be the cost of energy, much of which is generated by using diesel fuel, he notes. Alternative fuels, such as compressed natural gas or biofuels, as well as solar energy are potential clean-tech solutions in such situations. Meanwhile, in China, water scarcity and air quality are prompting a search for clean-tech answers.

"We are in the process of determining Canada's emerging clean-tech strengths and matching them to specific global markets, where we believe there are good opportunities," says Mr. Lever.

That process will be supported by a collaboration agreement between EDC and Sustainable Development Technology Canada (SDTC), which was announced late last year.

"Clean-tech companies need to scale up and go global, which provides a natural fit for EDC and SDTC to work together to help put Canadian companies at the forefront of the industry," said Stephen Poloz, president and CEO of EDC, when the agreement was announced.

Vicky Sharpe, president and CEO of SDTC, added that while her organization has helped companies in its portfolio attract more than $3 billion in private capital through its network of industry and early-stage equity investors, more needs to be done to unlock commercial bank financing for the sector.

"This collaboration will help Canada claim its share of the multi-trillion-dollar global clean technology market, with the potential to drive huge job growth in this field – from more than 52,600 in 2011 to 126,000 positions by 2020," said Dr. Sharpe.

Over the past 10 years, SDTC has helped promising clean technology companies bridge the development and demonstration gap, by providing financing, guidance and industry connections to help them scale up and prove their technical and market viability. However, even after proving the value of their technologies domestically, many companies face a formidable obstacle in getting into the global marketplace. That's what EDC and SDTC are working together to address.

"One of the important benefits of this agreement will be sharing information in a way that enables SDTC's portfolio companies – those that have successfully demonstrated their technology – to quickly and efficiently transition to EDC as they approach the bankability and exportability stage," Mr. Poloz said.

Construction of the N-Solv pilot plant on Suncor's Dover Lease. Companies like N-Solv are helping Canada's oil sands operators protect the environment and perform more efficiently. SUPPLIED

CAREERS

Processes help improve environmental performance of oil sands operations – and Canada's bottom line

While the bitumen in Alberta's oil sands is already a significant contributor to Canada's economic well-being, new technologies that are emerging to help improve the environmental performance of oil sands operators are starting to make their own mark on the country's industrial landscape.

One company that's attracting increasing attention is N-Solv Corporation in Calgary, which has developed a warm solvent extraction process for the in situ oil sands. The process eliminates water consumption and reduces greenhouse gas emissions by 85 per cent, according to CEO John Nenniger.

"Drastically improved energy efficiency is an existential issue."

John Nenniger
is CEO of N-Sov Corporations

Dr. Nenniger initiated the development of the N-Solv process, starting with early calculations and laboratory experiments in the late 1990s. He has a doctorate of science in chemical engineering from the Massachusetts Institute of Technology and has been a research and consulting engineer in the oil and gas industry for more than 25 years.

"Our process produces a better-quality oil because the solvent leaves the nasty compounds, including heavy metals and asphaltenes, behind in the underground reservoir. This eliminates the shrinkage due to coke rejection in the upgrader – which can be as much as a quarter of each barrel of bitumen – so our oil is a lot more valuable. Also, the N-Solv process plant is much simpler than steam, so the capital cost is cut in half," says Dr. Nenniger.

The company has designed and built a pilot project in the oil sands, which will start up later this year on a site hosted by Suncor.

Dr. Nenniger says N-Solv's technology, funded by SDTC, could double the net back per barrel of oil and triple the profit per dollar of investment compared to steam, which has enormous implications for Canada's economy. It could also have a significant beneficial impact on climate change.

"It takes tens of thousands of years to get rid of excess CO_2 by natural processes like weathering of rocks. Greenhouse gases from historical fossil fuel consumption will continue to add excess heat to the planet for thousands of years. Drastically improved energy efficiency is an existential issue," he says.

Another company set to make an impact is Saltworks Technologies of Vancouver. Its solutions for water treatment include desalination, advanced separations, industrial waste water treatment, brine treatment and solids production.

Among the company's achievements so far is a NASA contract to develop a desalination system for the International Space Station.

"The same technology we are using for NASA is being applied to oil sands brackish water treatment in Alberta and mine run-off treatment in B.C.," says Saltworks CEO and co-founder Ben Sparrow, P.Eng., who invented the company's thermo-ionic desalination process.

In the context of the oil sands, that means waste water can be reused, by removing salt and other contaminants.

"Canada is blessed with an abundance of natural resources. However, it's water-intensive to extract those resources, so it makes sense to develop ways to re-use the water," says Mr. Sparrow.

He adds that the SDTC-supported Saltworks technology removes salt from seawater and brackish water, by harnessing low-temperature waste heat or solar energy to help drive the process. The technology reduces the amount of energy required for desalination, providing significant cost savings to customers, with a much lower impact on the environment. Saltworks has also co-developed a solid salt maker, which accepts highly concentrated discharge to produce solid salt.

"Our product is well suited for inland operations, because it desalinates industrial reject and brackish water with higher fresh-water recovery and reduced environmental footprint," Mr. Sparrow notes.

Globally, the company's technology can help address the challenges posed by growing populations in water-stressed regions, as well as stricter laws on the discharge of waste saltwater.

"Governments are recognizing the value of water. It can be recycled. Waste water shouldn't be left as a legacy cost for future generations, and we can help prevent that," he adds.

PROFILES

Entrepreneurial engineers a force among promising companies

Some of Canada's most promising clean-tech companies are headed by executives with engineering backgrounds. Here are a few of these visionaries and the innovative companies they lead:

EFFENCO

Mechanical engineering was the common denominator among the three founders of Effenco. But it was a mutual passion for transportation and green technology that brought them together in Montreal in 2006 to establish what is now regarded as one of Canada's 10 most promising clean-tech companies.

Effenco, a name derived from "Energy Efficiency Company," makes hydraulic hybrid systems for refuse trucks that run on diesel or natural gas. The systems improve energy efficiency and reduce greenhouse gas emissions.

Effenco's clean-tech reduces fuel consumption by 20 per cent on a refuse truck. FABRICE GAËTAN

SDTC supports two projects with Effenco.

In its 2012 Cleantech Index, Corporate Knights magazine identified Effenco as one of the 10 most promising clean-tech start-ups in Canada.

Effenco president Benoit Lacroix, PhD, says the company's technology is important because reducing fuel consumption by 20 per cent on a refuse truck is equivalent to removing four to six cars from the road.

The three company founders – Mr. Lacroix and vice presidents David Arsenault, Eng.M.Sc., and Dany Fouquet, Eng.M.Sc. – got to where they are today in a somewhat roundabout route. They initially met as undergraduates through an international competition called Formula SAE.

"We designed and built little race cars and raced them against other universities. Before and during our undergrad, we all worked for international companies, but there was such good chemistry between the three of us that we knew we had to do something more. So we merged our interests in transportation and green tech to create Effenco," recalls Mr. Lacroix.

He believes that a big part of the company's success comes from its approach to the development of the technology.

"We developed the system with and for our customers. We didn't spend years in our laboratory developing something that we then tried to sell. Before we even had the first part of the first drawing, we included the end-users. Anyone that was close to the problem was part of our development process," he explains.

TERRAGON ENVIRONMENTAL TECHNOLOGIES

Peter Tsantrizos, PhD, says that in some societies, people generate up to 2.5 kilograms of garbage and 300 litres of waste water daily. That's part of his motivation for developing processes to turn solid and liquid waste into resources that can be used in the habitats where they are generated.

As president and CEO of Terragon Environmental Technologies of Montreal, another company in the SDTC portfolio, Dr. Tsantrizos says that engineering is the enabler of clean-tech.

"The biggest challenge for engineers is creating the right vision about what the tool has to do. The objective of the technology being developed and how it might be used beneficially is the first and most important challenge for engineering."

When it comes to solid and liquid waste, Dr. Tsantrizos is adamant that they are resources and should not be discharged and transferred to others, but used beneficially within the habitat.

"Our technology aims to enable that, whether it's solid waste for energy or liquid waste for reusable, clean water," he says.

For example, Terragon worked with SDTC to demonstrate the company's Micro Auto Gasification System (MAGS), which is designed to convert mixed waste into carbonaceous ash and a clean gas fuel that can be used to power the waste treatment system and provide additional energy to the user. The MAGS technology is now commercially available and used in ships, hotels, military bases, work camps, enterprises and other applications.

In an another demonstration project with SDTC, Terragon is testing its Wastewater Electrochemical Treatment Technology (WETT) that is designed to help habitats reduce their water consumption by up to 75 per cent by reusing their water for applications like laundry, toilets and irrigation.

WETT operates on electricity, does not use chemicals or biological treatment and does not require specially trained personnel, explains Dr. Tsantrizos.

"The system is compact, robust and capable of intermittent operation. It can be adjusted to handle almost any type of wastewater and can provide tertiary treatment," he says.

Terragon will demonstrate the WETT technology in a Canadian Coast Guard vessel, a merchant marine vessel, a private home and at its own facilities.

S2G BIOCHEMICALS INC.

In North Vancouver, Mark Kirby, president and CEO of S2G BioChemicals Inc., found a clean-tech challenge in producing glycols for the industrial chemical industry without using petroleum products, the traditional source material for glycols.

S2G's solution is a technology – also supported by SDTC – now on its way to commercialization that uses sugar, including cellulosic sugars derived from waste biomass, as a source material for glycols. Mr. Kirby says this is important from an environmental perspective, because demand for glycols is growing at more than three per cent annually.

S2G engineers monitoring equipment at the company's pilot plant that produces glycols for the industrial chemical industry. SUPPLIED

"'Bio'-glycols are a growth sector limited by commercial availability. Our customers, producers of common household and industrial products, want to use biochemical glycols produced by S2G and its partners, companies in the agricultural, forestry and bio-fuels industry, as an environmentally friendly, sustainable product with equivalent cost and quality to glycols sourced from petrochemicals. We have rapidly commissioned a pilot/demonstration plant and are building commercial plants in Canada and abroad that will provide significant added value to sugars and supply glycol users with a clean alternative to petrochemicals," he says.

With more than 25 years of experience in the sector, Mr. Kirby is no stranger to clean-tech or the engineering required to create it. Trained as a mechanical engineer, he is a former director of corporate development at Ballard Power Systems. Before that he was vice president of business development for QuestAir Technologies, a technology startup in Vancouver. He admits that there are many challenges for a small company starting out, like S2G.

"Technology development challenges rely heavily on engineering: project engineers, process engineers, mechanical engineers, electrical engineers, chemical engineers to design experiments and analyze results. A lot of advanced engineering is needed to accurately scale up and design commercial production facilities," he explains.

He believes that S2G's technology could be a valuable Canadian export. "Canada is an exporting nation. Our goal is to export high-value products, derived from our raw materials. We can also be an exporter of technology, to help other countries achieve their own environmental goals."

NEXTERRA SYSTEMS

Bioenergy project's success a beacon of Canadian prowess

In the world of clean technology, Nexterra Systems is one of Canada's veterans. The Vancouver company has grown over the past 10 years into a world-leading provider of commercial scale, renewable energy systems that produce high-value heat and power from low-value waste that would otherwise end up in landfill.

Customers for Nexterra's advanced biomass gasification systems range from the University of British Columbia, the U.S. Department of Energy's Oak Ridge National Laboratory, the Dockside Green development in Victoria, the University of Northern B.C., and forest products companies Tolko Industries and Kruger Products.

Mike Scott, Nexterra's president and CEO, says the company's technology converts waste feedstocks into "syngas" that can be used to displace natural gas or other fossil fuels to produce heat, power or as a renewable feedstock for chemical production. The cost-effective and reliable systems produce ultra-low emissions that are as clean as those from natural gas.

"We are focused on what we call community or 'distributed' plant-scale systems. We're building district energy systems that are ideal for industrial plants, university campuses or hospitals, residential communities, or for distributed power generation of up to 15 MW," he explains.

In the past 10 years, Nexterra has built seven systems, with an eighth nearing completion. The company's first plant using its second generation technology was completed at UBC in September last year. The plant produces an engine-grade gas that is then burned in a GE Jenbacher internal combustion engine to produce heat and power – a first in North America.

The engine will produce 2 MW of clean, renewable electricity that will offset UBC's existing power consumption, enough to power approximately 1,500 homes. The Nexterra system will also generate 3 MW of thermal energy for campus heating, enough steam to displace up to 12 per cent of UBC's natural gas consumption. This will reduce UBC's greenhouse gas emissions by up to 5,000 tonnes per year, which is the equivalent of taking more than 1,000 cars off the road.

The project, officially named the Bioenergy Research and Demonstration Facility, represents an important milestone in Nexterra's quest to reliably convert low-value waste feedstocks into higher-value renewable fuels and chemicals, says Mr. Scott.

"We are seeing significant interest in this next-generation solution from around the globe, and look forward to further proving the system at UBC and then replicating it worldwide," he notes.

That's important, he adds, because Nexterra sees tremendous opportunities for Canada to play a leadership role in clean-tech.

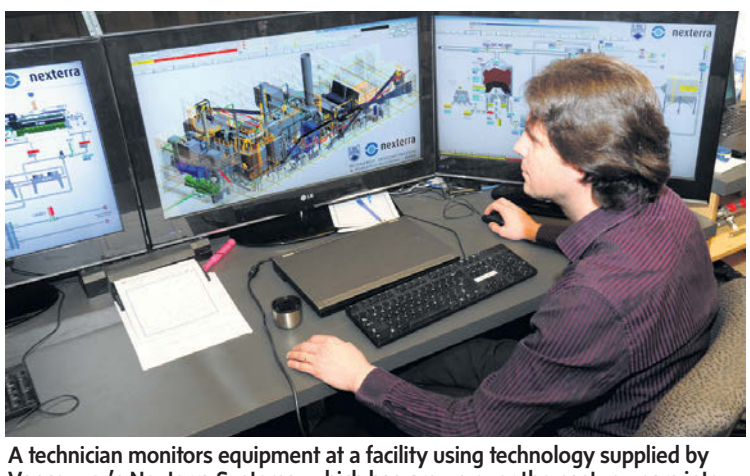
"We see the value for Canada. These are knowledge-economy jobs, they're high-paying jobs, they're high-value jobs."

Mr. Scott says the governments of Canada and British Columbia have played important roles in helping Nexterra get over a number of the challenging hurdles on its journey toward commercializing its technology.

"One of the things that people sometimes don't appreciate is that while Nexterra's technology is clean-tech, it's not like software bits and bytes. These are big, capital-intensive projects. The customers are quite risk adverse and conservative. Producing cost-effective, clean and reliable energy is right at the core, which is obviously very important because people don't want the lights to go off and they don't want the heat to go out," he says.

One of the biggest hurdles was to get a demonstration plant up and running at commercial scale. That's where government support was crucial to the company's success.

"We are now one of only a handful of gasification companies in the world with commercially operating and proven plants at the scale we're focused on, and we are using that as a platform for expanding internationally," he says.



A technician monitors equipment at a facility using technology supplied by Vancouver's Nexterra Systems, which has grown over the past 10 years into a world-leading provider of commercial-scale, renewable energy systems. SUPPLIED

By the numbers

1
Ontario's rank in the 2012 Corporate Knights third bi-annual Green Provincial Report Card

10
Canadian companies on the latest Corporate Knights Global 100 list of the world's most sustainable corporations

21
Highest ranking for a Canadian company on the Global 100 list (Teck Resources)

130-plus
Clean-tech companies on the Toronto Stock Exchange and the TSX Venture Exchange

$18.3 billion
Combined quoted market value of TSE and TSX clean-tech companies as of October 31, 2012

Source: Corporate Knights

ENGINEERING CANADA'S CLEAN-TECH FUTURE

EXPERT OPINION

Canada can realize the rewards of getting ahead of the innovation curve

By Tom Rand, P.Eng., PhD, Managing partner of the MaRS Cleantech Fund and senior advisor of the MaRS Cleantech Practice

Woodland Biofuels Inc. of Mississauga is one of the clean-tech companies that the MaRS Cleantech Fund has invested in. Here, Woodland president and CEO Greg Nuttall is speaking at the announcement of a $4-million investment in the company by the Ontario government through the Innovation Demonstration Fund. SUPPLIED

Clean technology is like the microchip in the 1960s – but bigger. Lots bigger. Information technology drove economic growth in places like Silicon Valley and created lasting wealth. Clean-tech will do the same and bring high-value jobs to places that get ahead of the innovation curve. Canada is already a leader. But if our emerging clean-tech companies are to become global players, they need more capital, partners and global market access than their IT-based cousins.

Clean-tech is infrastructure. It's big wires, not just little ones. It's projects, not just patents. That means more capital: venture to get going and project finance to expand. Mission-critical energy systems have little tolerance for technology risk. So partnerships with global players are not a luxury, but a necessity. It's tough to get clean-tech to market.

But the rewards are bigger. Global clean-tech markets are expected to reach $2 trillion to $3 trillion by 2020. If Canada gets just two per cent of that market, our clean-tech industry will rival the auto sector. To reap those rewards, we need a coherent, long-term, national strategy. It's not enough to invent stuff. Our entrepreneurs need support to tap into this fast-growing global market.

We're off to a good start. Our clean-tech industry generates more than $8 billion in revenue and spends more on R&D than the entire oil and gas sector. Funding programs like Sustainable Development Technology Canada (SDTC), which collaborate with the private sector to lower the risk of early projects, have been very effective in planting the seeds. Venture firms, like Chrysalix and Enertech, provide some capital to grow these companies. But the venture well in Canada is nearly dry, and it can't support the higher capital requirements of emerging Canadian clean-tech startups.

At MaRS Cleantech, we focus on three areas to grow the industry. We start with innovation. The key drivers of high-value jobs are inventions and entrepreneurs. The privately backed $30-million MaRS Cleantech Fund provides much-needed early-stage capital. The MaRS partnership reduces many of the risks of early-stage investing, and has catalyzed this private-sector pool of capital.

We then enable collaboration between stakeholders. Innovators, regulators and policy-makers have different priorities and often speak different languages. MaRS translates. The big corporations have markets, but need more innovation. Entrepreneurs invent, but can't get access to the market. MaRS brings them together.

Finally, we take action at home to position our companies for export markets. If we can open up the data on all those smart meters that Ontario installed, for example, then our entrepreneurs will leverage Ontario's lead and invent new energy management tools that the whole world will use. If we can get home-grown energy storage technologies working on our grid, those companies can anticipate huge export markets.

But global markets require big capital. The Export Development Bank of Canada recently announced its intention to support Canadian clean-tech projects abroad through its partnership with SDTC. That's a good start. We also need our pension funds and Big Five banks to develop the expertise needed to understand the risks and rewards of getting Canadian clean-tech into global markets.

If you solve a big problem in a market economy, you get a big reward. Clean-tech targets some of the biggest global problems of the 21st century: air quality in Beijing, clean water in California and the onslaught of extreme weather that climate change has in store for all of us. Canadian innovation can address those problems, all over the world. And create real value here at home.

"Innovators, regulators and policy-makers have different priorities and often speak different languages. MaRS translates. The big corporations have markets, but need more innovation. Entrepreneurs invent, but can't get access to the market. MaRS brings them together."

Tom Rand
is managing partner of the MaRS Cleantech Fund