CLEAN ENERGY SOLUTIONS CENTER
ASSISTING COUNTRIES WITH CLEAN ENERGY POLICY

Clean Energy Innovation in Canada

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For more information, see the clean energy policy trainings offered by the Solutions Center.

Webinar Panelists

Andrew Noseworthy	Atlantic Canada Opportunities Agency
Bettina Hamelin	Natural Sciences and Engineering Research Council of Canada
Andy Reynolds	National Research Council Canada
Chris Boivin	Sustainable Development Technology Canada

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Eric — Hello everyone. I'm Eric Lockhart with the National Renewable Energy Laboratory and welcome to today's webinar, which is hosted by the Clean Energy Solutions Center in partnership with Mission Innovation. Today's webinar is focused on clean energy innovation in Canada.

One important note of mention before be begin our presentations is that the Clean Energy Solutions Center does not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solutions Center's resource library as one of many best practices resources reviewed and selected by technical experts.

Before we begin, I'll quickly go over some of the webinar features. For audio, you have two options. You may either listen through your computer or over your telephone. If you choose to listen through your computer, please select the mic and speakers option in the audio pane. Doing so will eliminate the possibility of feedback and echo. If you choose to dial in by phone please select the telephone option and a box on the right side will display the telephone number and audio PIN you should use to dial in.

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presentations at cleanenergysolutions.org/training and you may follow along as our speakers present.

Also, an audio recording of the presentations will be posted to the Solutions Center training page within a few weeks, and will be added to the Solutions Center YouTube channel where you will find other informative webinars as well as video interviews with thought leaders on clean energy policy topics.

Today's webinar agenda is centered around the presentations from our guest panelists: Frank De Rosier, Andrew Noseworthy, Andy Reynolds, Chris Boivin, and Bettina Hamelin. These panelists have been kind enough to join us to discuss clean energy innovation in Canada.

Three additional technical experts from Natural Resources Canada: Dean Haslip, Jus Ron and Jiuan Chen will be joining the panelists for the question and answer session.

Before our speakers begin their presentations, I'll provide a short, informative overview of the Clean Energy Solutions Center initiative. Then following the presentations we will have a question and answer session where the panelists and technical experts will address questions submitted by the audience and we'll have closing remarks and a brief survey.

This slide provides a bit of background in terms of how the Solutions Center came to be. The Solutions Center is one of 13 initiatives of the Clean Energy Ministerial that was launched in April of 2011 and is primarily led by Australia, the United States, Sweden and other CEM partners. Outcomes of this unique initiative include support of developing countries and emerging economies through enhancement of resources on policies relating to energy access, no-cost expert policy assistant and peer-to-peer learning and training tools such as the webinar you're attending today.

The Solutions Center has four primary goals: it serves as a clearinghouse of clean energy policy resources, and it also serves to share policy best practices, data and analysis tools specific to clean energy policies and programs. The Solutions Center delivers dynamic services that enable expert assistance, learning and peer to peer sharing of experiences. And lastly, the center fosters dialog on emerging policy issues and innovation around the globe.

A primary audience is energy policy makers and analysts from government, technical organizations in all countries, but we also strive to engage the private sector, NGOs and civil society.

A marquis feature that the Solutions Center providers is the no-cost expert policy assistance known as Ask an Expert. The Ask an Expert program has established a broad them of over 30 experts from around the globe are available to provide remote policy advice and analysis to all countries at no cost.

For example in the area of renewable energy policy we were very pleased to have Paul Kumar from the Renewable and Sustainable Energy Institute

serving as one of our experts. If you have a need for policy assistance and renewable energy policy or any other clean energy sector we encourage you to use this valuable service. Again, the assistance is provided free of charge.

If you have a question for our experts please submit it through our simply online form at cleanenergysolutions.org/expert. We also invite you to spread the word about this service to those in your networks and organizations.

Now I'd like to provide brief introductions for today's panelists. First up today is Frank Des Rosiers, who's assistant deputy minister of innovation and energy technology sector at Natural Resources Canada.

Following Frank we will hear from Andrew Noseworthy. In addition to his role as senior advisor to the president at Atlantic Canada Opportunities Agency he's also the federal co-chair for the working group on clean technology innovation and jobs.

After Andrew we will hear from Andy Reynolds, who's the general manager of energy, mining and environment at Canada's Natural Resource Council.

Following Andy we will hear from Christ Boivin, who is vice president of investments at Sustainable Development Technology Canada.

And our final speaker today is Dr. Bettina Hamelin from the Natural Sciences and Engineering Research Council of Canada. And with those brief introductions I'd like to welcome Frank to the webinar.

Frank: Thank you so much, Eric. So it is a great pleasure for Canada to be host of today's session, following the presentation by our colleagues from the USA, Andy and France. And we'll strive, over the next 90 minutes or so to give you a snapshot of the option keys that we have in terms of clean energy innovation in Canada. And I'll kick-start the presentation by giving you a bit of an overview of the landscape in the country. But then I'll turn to my colleagues to dive a little more deeply into respective key players in that space. And then we'll have time for Q and A.

So turning onto the presentation itself, I want to, I guess, first emphasize to the very many people listening from university, governments, private sector investors the sheer importance of energy for Canada. And it's something that some of you may be familiar with but it's probably useful to anchor it in a bit of data in terms of the sheer importance to Canada's economy, and you see here on the slide some data with regard to the contribution in terms of GDP, employment, capital expenditures, exports, foreign investments. It is a fairly significant goal driver for the country, and one that we pay a great deal of importance to and make sure that we get it right. Get it right in terms of impact on the economy but also in terms of _____ impact.

And maybe one statistic which I would take a moment to share with you just for you to appreciate the sheer importance of it in terms of _____ _____ —about 80 percent or so of GG emissions in Canada are related to the production or use of energy. So you understand why we're paying such

attention to this and want to make sure that our various players in the ecosystem, energy innovation in Canada are effective contributor to help us address those important issues.

In terms of resource endowment I think it's fair to say that Canada has been blessed with tremendous resource in terms of energy, both on the renewables side and in terms of fossil energy as well.

In terms of renewable energy we are the second largest hydroelectric producer in the world. We also have very large wind, bio energy, solar, marine, geothermal potential that give rise to a very sizable portion of our production of electricity, over 80 percent, which is non-emitting. So this is, I guess, one of the blessings of having such a large country.

But we also have a large amount of fossil energy. We're the fourth largest well producer of natural gas. We have the third largest proven oil reserves after Venezuela and Saudi Arabia. So I ask and appreciate—again, this is an area where we've got a lot to deal with.

The next slide gives you a bit of a quick snapshot of the importance that we—and the size of the _____ technology sector that have developed over the years in Canada. As many colleagues on the line would appreciate this is a fast-growing global market; expect it to grow to some $2.5 trillion by the year 2022, and Canada clearly wants to be a key actor there, not just in terms of acquiring and purchasing those technologies for domestic use but very much the export platform. We have some 55,000 workers in this particular area. Thanks to a highly educated workforce we have a large number of high-caliber universities and colleges which equip us with a lot of talented engineers and professionals to work in that particular domain. And those are in acute demand given the sheer importance of natural resources in a country, so naturally domestically this is an area of keen interest. But as I mentioned we would like to make sure that we grow this base to serve global market needs.

The next slide touches on the new government. Meanwhile you'll save in a year or so but it's still reasonably new and this Prime Minister Trudeau has made it very clear in the very first week of his mandate and ever since domestically about the importance he and his government attach to making sure that one is able to fill that vision, that vision of having a clean, innovative economy that balances both economics and environmental protection goals. And this is something that we and government feels quite passionately about, that they are very much compatible goals who have to be pursued with energy and vigor.

So as you'll see throughout the pronouncements not just by the prime minister by the cabinet members and officials it's something that we very much want to translate into a very concrete set of actions as they relate to major global discussions, whether it's around climate change or more generally around the issue of sustainability.

The next slide gives you a bit of a quick perspective in terms of what has been done in terms of early actions by this government as early as their first budget three months into governing the budget, 2016. There was already a number of announcements, around $200 million envelopes set aside for energy R&D and demonstration projects that were announced and are being implemented as we speak with a particular emphasis around oil and gas, electric charging infrastructure, smart grid renewables, energy storage, along with a host of other technologies.

We've also announced setting aside a $20 million envelope for the Canada Excellence Research Share and fields related to green and sustainable technology, as well as other tax measures, particularly geared towards electric charging stations and energy storage.

So these were meant to be no regrets, early action by the government. But clearly the ambitions of the government are much greater than this. But they wanted to take the time to meaningfully engage with our provincial and territorial colleagues so that then the number of discussions at the most senior levels, and to come with a few also with the various actors in a country. From private sectors, universities, to first nations and others.

And then a significant envelope set aside that are expected to be committed very shortly. The first one that is referenced on the top of this slide is over a billion dollars set aside to support clean technology development, with a particular emphasis in the natural resources sectors for obvious reasons as described earlier.

A second envelope is a $2 billion low carbon economy fund that is meant to accompany and support the efforts of our provincial and territorial governments to engineer that transition toward a lower carbon economy.

And the third and last is a $20 billion to zero green infrastructure fund which is expected to a significant component around climate change mitigation measures. And all of those will rise to discussion very shortly and domestically and announcements over the coming weeks and months.

Moving on to the next slide, so monies and envelopes are important but just as important in our mind is making sure that we have the right enabling environment for the companies and the technologies being developed add up to succeed and prosper on domestic and global markets.

So I thought just maybe spending a moment to emphasize some of those elements which are in our minds very important indeed. First, to signal that Canada as a G7 county has been widely recognized as a greatest nation for innovative work and technologies and that cut across multiple sectors.

We have a very strong IP regime in place, a very attractive tax treatments, with the second lowest corporate tax rate in the G7, and very generous tax incentive for R&D that are applied across.

Another key feature which I touched on earlier is the talent pool. And this is a source of great pride and we've invested sizable amount of monies both at the federal and provincial level to make sure that we have a topnotch talent base. And it is a source of great competitors' strength and we'd be delighted to make this talent available for support of those various projects and investments.

In terms of R&D spending in education and our education the percentages that kind of they've devoted to it are among the highest of the G7 or G20 countries. And as a result we've been able to track over the past decade in particular a large number of top academics from around the world and we'll hear from Bettina and others in terms of those particular efforts that we're still pursuing with a great deal of vigor.

To the right hand side on your slide you'll see as well other fairly significant demand pool factors which we think will result in very significant attraction for getting those products to markets.

The first one is a carbon pricing. So the government has been on record to indicate that by the year 2018 we'll be introducing a carbon price regime across the country. There's already, in the vast majority of our provinces, covering over 80 percent of the population covering pricing regimes already in place but by 2018 it will be applied across your country, moving up by the year 2022 to $50 a ton.

Other mention the reference before is the monies being invested on green infrastructure, and to emphasize some of the federal announcement but provincial governments also have made a number of announcements along those lines.

Green of an operation was also a topic that was suggested by many of our companies as being one of those areas where we should show some leadership. And the government heard that and announced by the ministry of the environment and the prime minister this past month that we'll be pursuing this with renewed vigor.

And the last component I wanted to touch on is the area of green procurement. Just like across any one of our respected countries our national governments and provincial government purchase a whole lot of things and we'll be in the process over the coming months to announce a new green procurement policies that will apply to the vast amount of purchasing activities that the government is actually spending each and every year.

Maybe one last dimension I would like to flag which is in an area all too important for the growth of companies is access to financing. So we have a number of funding vehicles. We'll hear from Chris Boivin very shortly about some of those that are present across the federal family. But we also have, in terms of financial market participants the Chart of Stock Exchange which is the number one in terms of list of clean technology and renewable energy companies in the world with over 120 or so companies listed with assures coming not just from Canada and the U.S. but also from Europe and Asia.

And this is a growth area that GSX or the Charter Stock Exchange wants to pursue quite actively.

Allow me perhaps to close on this overview by touching on the announcement around mission innovation. So the audience on the call I would suspect would be [crosstalk] with those treatments since that was made by those 21 world leaders which is to double the level of investment over the next five years to attract increased level of private sector investments thanks to the Breakthrough Coalition and the Bill Gates Foundation but also to engineer and encourage a greater degree of collaboration. And I must say that Canada was an enthusiastic partner in this initiative and we really want to make sure that we're able to meaningfully seize on the option piece not just domestically but also globally. So this call today is another one of those opportunities for us to reach out.

Allow me first to signal in terms of doubling of the federal investments. In the case of Canada this is I guess the beauty of having majority governments. The commitment is rock solid, so that the government has already announced its intention to double its investment from $370 million per year to $775 million by the year 2019-20. Those monies have been booked in the fiscal framework and there has already been announcement, as I mentioned, in the last budget in 2016. But you should expect over each and every budgets to have measures being announced to get us to that point. And this is not a country to other jurisdictions, something that we have to kind of wrestle and debate and argue. It is firmly set in our fiscal planning horizon.

And similarly in terms of collaboration Canada has played an active role both in the domestic and global scene to show some leadership in that space. We are very much open for business and we'd be delighted to work, whether business to business, as universities to universities, government to government or a mixture of the above to get some projects initiative on the way. We already have very strong ties, as we are going to see very shortly, which are partners in North America in particular, U.S. and Mexico. We've also been working quite closely with Asian partners and European partners; we'll be more than happy for all those colleagues listening on the phone to connect.

And I guess that brings us to the second leg of our presentation, which is to drill down a bit more in terms of what are those various players in Canada, especially on the pedal scene, and I would like to signal right from the get-go that each of those speakers and their teams would be delighted to follow up with any one of you on the call to further explore those opportunities.

So now I'm shifting gears here to speak about what Natural Resources Canada brings to the table. Just for clarity Natural Resources Canada is both the energy and mining and forestry department of Canada. It is a sizable sector for the country; it accounts for about a fifth of Canada GDP. So it is certainly an area of focus for us.

We also—the lead department for emission innovation in Canada—this is why we're hosting you today. And as you'll see here in the slides we've been

active in clean energy R&D for many years. We have strong networks with the Industry Academy of Provinces and international partners, and we also have a significant science capacity in-house, within our national energy lab.

That's what you see in the following slide. Those national energy labs are spread around the country, so allow me perhaps to speak to those briefly and we do have those lab VGs on the call, should you have more detailed questions to ask them.

So we start with three CanmetENERGY national laboratory. Starting on the left-hand side in the west in Alberta where the focus of the research of this facility is around heavy oil, oil sands, piped oil and gas, work around Osteo, the property and response as well as slurrying and venting emissions. In each of those areas we've had significant amount of international collaborations and work with large oil and gas companies from Canada and around the world. The lab is widely recognized to be if not the, one of the very top labs in heavy oil research in the world and attracts very high caliber researcher from the universities but also other national labs in the planet.

Next stop I just want to touch on is one based in Bahan and it's in the eastern part of the country in the Province of Quebec. The lab focuses on energy efficiency but also on the industrial processes. They've got quite a bit of expertise also in terms of developing solutions for remote and lower-income communities and with a few of getting them appraisal which is I know a priority for many countries who are looking for solutions for those remote communities. And also significant expertise in renewable and distributed energy solutions, or smart grid, actually preferred.

The third lab is the one based here in Ottawa, also focusing on energy efficiency both for residential, commercial and industrial use. It's got a sizable expertise in carbon capture utilization and storage which have one of the world's top teams involved, again with private sector firms and international partners.

We're going to see shortly in the presentation we do large-scale projects, particularly with the U.S. Department of Energy which has been a terrific partner, especially for next gen technologies. Another area of focus is bioenergy and renewables again.

And two more labs I would like to flag, their lab in Hamilton, Ontario which is focusing on materials related work, especially as they relate to lightweighting and material technologies working very closely with the aerospace industry but also the automotive sector. It's a brand new lab and with a great deal of expertise that has been shared with our North American colleagues up to now but will be, again, open for business with others. And lastly the Chalk River facilities, which is the _____ national laboratory for nuclear energy research and also does work in the area of hydrogen and energy storage.

On the next slide it's showcased some of those partners. I'd like to emphasize that every one of those national labs I've described before are focusing on the area of applied research. Our universities have a great deal of strengths on the basic research side but those research studies are being pursued are very much applied. So every one of them are driven typically with partners and you'll see a bit of a snapshot of those there. So you'll see that you have a combination of international partners, USDOE, Sener, our colleagues from China: Chinese Academy of Science. But also universities as well as provincial representative from SaskPower, Hydro Quebec, along with many others.

And just to showcase that this is something we're very used to and we have a whole bunch of mechanisms to collaborate, whether it's in terms of project care, management, IP management—it's something we're actually pretty good at to manage those relationships smoothly.

And I'd like to close the presentation by showcasing some of those innovative energy technologies that are currently being worked on. The first one is a CCUS project that was just announced recently, two weeks ago with the gas technology _____ from Chicago, General Electric, Lindy Group from Germany, Penn State University with support from the U.S. Department of Energy and Alberta Innovates as well. And it looks to capture 98 percent of the emissions coming from those out of fossil fuel or _____ fuel, electricity generation facilities using a high pressure, fluidized bed compression technology.

This is a fairly large-scale project, $20 million and that is currently underway. The second area of emphasis is on flaring and venting. Given our respective governments' focus on methane reductions. Many of our governments are committed to sharply reduce those emissions over the coming years. We've actually been doing a lot of work with both domestic players but also partners in the U.S. with partners in Mexico as well and Colombia and China, all those. And would be more than happy to partner with colleagues on this.

Advanced refrigeration technology is one area that our mission innovation countries partners focus. You might think Canada is cold enough, why do we need to worry about this. Well we see a lot of waste happening there, whether in grocery store or hockey arenas, which we have plenty of around here. So we actually develop a lot of expertise in next gen technologies to sharply reduce energy requirements for cooling technologies. And we do have interest coming from the Middle East but also the U.S., South America and elsewhere.

RETScreen is a widely used software by some one million users around the world, which is happily making clean energy decision around project assessments. So many one of you and your staff can use in over 500 universities, and it's been translated in 36 languages and this project has been advancing with the NASA and the U.S.

And maybe two last projects to touch on—the next one is around energy storage, a bigger emphasis from any one of our countries. And Canada has a

lot to offer there, both on the private side, university, and national labs where we have around battery storage, seasonal storage and the example is flywheel and many other technologies and we've very active in that place and we'd be delighted to partner with you.

And lastly in terms of heavy oil or oil sands research we've been working with pretty much every single of those large, often, companies, working with them, many of which are multinational companies to make sure that we reduce the energy requirements for extraction and are able to _____ impact as well. It's a big business; we've got some 175 billion barrels on reserve there, so just in terms of sheer scale it is a big macro play from a global energy perspective.

From this allow me to turn over to Andy Noseworthy.

Andrew Thank you, Frank. Perhaps we could move to the next slide.

Just by way of context I want to provide some comments that build off of some of Frank's comments and give you a sense of some of the emerging priorities within the government of Canada that will impact on clean tech and also introduce you to some of the existing agencies and supports that are offered within the government of Canada's industry portfolio related to clean tech.

Earlier this year the government launched its inclusive innovation agenda with a mission to redesign and redefine how it supports innovation and growth in Canada and the objective with this approach is to make Canada a leader in innovation. Over the summer our government consulted with Canadians to determine priorities in this plan and from this work emerged three core areas which you see at the bottom of the slide.

The first was the importance of strengthening skill to Canadians. We heard that broad skills development and work-based earning were essential, and we heard that it was especially important to strengthen entrepreneurship skills in Canada. We also heard the education on coding needs to be more deeply embedded in our education system as digital technologies become more deeply woven into our lives.

Secondly we heard that new technology development must be further supported and encouraged. We heard that new efforts to grow world-leading clusters in Canada would have great value, clusters that can serve as a magnet for cutting edge research investment, talent and commercialization. And we also heard that placing Canada on the cutting edge of breakthrough or disruptive technology development was actually quite a cinch.

Final theme that we hear consistently was the importance of supporting growth in our leading companies. And we heard that government's support of business needs to be far more accessible and the export readiness of our company potentially.

So woven through all of these comments was a strong view that Canada can position itself as a clean tech leader and the government is now in the process of considering a range of specific initiatives that will give effect to these ideas and respond to these considerations.

So a second priority for the government of Canada relates specifically to climate change. Following the Cost 21 meeting in Paris late last year Canada's first ministers agree to something called the Vancouver Declaration which is a collaborative foundation for a comprehensive new climate change policy in effect. And in fact first ministers are meeting again in just a few weeks to take stock of the work that's been done since they signed that declaration back in March.

As part of the Vancouver Declaration first ministers set up four working groups: one on carbon pricing, one on mitigating the impact of climate change with a focus on major industrial sectors, a third on adapting to climate change and beginning with the effects on communities.

The fourth group actually relates specifically to clean technology innovation and jobs. And the results of all four of these working groups are determined to be public; the groups have all been quite collaborative, involving officials from all provinces and territories as well as the government of Canada. All four groups are now in the process of presenting your final reports to ministers and all of these reports contain concrete options for future action and collaboration. We anticipate that all four of the reports will be released before the end of this month.

I've had the opportunity to co-chair the working group on clean technology innovation and jobs. And we'll be presenting our report to Canada's innovation ministers next Friday. We also hope that our report will come out at the end of the month. Like the broader consultations on the innovation agenda we also undertook very extensive consultations of our own. And we consistently heard that clean tech is not only important in addressing the challenge of climate change but that it's an essential foundation to an effective innovation policy. Indeed, there was a high level of alignment from what we heard, and the messages that came through in the broader consultations that the government undertook on its innovation agenda.

Consistently we heard that there was a need to encourage early stage innovation in Canada, especially the development of breakthrough technologies related to clean tech, and also to ensuring that Canada's approach to technology development is focused and more mission oriented. We also heard that strengthening technology commercialization in Canada is essential as are building stronger clean tech companies, talent and export capacity.

The importance of stronger technology adoption in Canada results are very much stressed in our consultations and perhaps the strongest message we heard was the importance of collaboration and coordination in building Canada's clean tech capacity. We heard consistently that international collaboration and collaboration between Canadian governments was

important in this area, and just as importantly we heard that collaboration between governments, industries, stakeholders, and indigenous people was important. So all of this work is informing government policy and over the next year new initiatives will come forward. And as I've said our report will be available later this month.

While our inclusive innovation agenda and climate change initiatives are focused around shaping new directions I would be remiss if I didn't mention that Canada already has strong and valued tools in the area of clean tech. The Natural Sciences and Engineering Research Council, or NSERC, delivers brands to clean technology projects—and Bettina who'll speak after me will provide more detail of their work. Sustainability development technology, Canada finances, prototyping and pre-commercial demonstration of clean tech projects—and Chris Boivin who is with us will elaborate further on this during his presentation.

The National Research Council of Canada undertakes direct research and provides support services to industrial and research R&D; Andy Reynolds will be sharing more details in this later this morning. Government of Canada, beyond these agencies, has a series of six regional economic development agencies that provider regionally tailored programs, services, knowledge and expertise and with over 100 business centers across Canada the Business Development Bank of Canada offers financing and venture capital to commercialized clean tech.

Finally—I didn't mention this—the Industrial Technologies Office and the Automotive Innovation program within ISED is the Department of Industry in Canada. Both provide targeted support for clean technologies. ITO provides non-repayable contributions to support large-scale technology demonstrations in aerospace, defense and space. AIP provides support to the development and implementation of innovative fuel-efficient technologies and pro _____.

Extensive information on all of these initiatives is available via the Government of Canada's web portal, but we'd also be happy to provide you with further information as needed.

So in conclusion I'd say the government of Canada has an extensive array of supports for clean technology development and the inclusive innovation agenda and climate change initiatives I mentioned are intended to really expand this toolkit increasing investment in clean growth and clean technology.

And with that I'll now turn things over to Bettina, the vice president of research partnerships at NSERC to talk about their programs and activities.

Bettina

Thank you very much. I'm going to give a bit of an overview of the Natural Sciences and Engineering Research Council in Canada. NSERC is Canada's largest investor in academic and college research in the natural science and engineering. Our budget is a bit over a billion dollars annually, and this serves to fund anything from small, individual grants to support fundamental

research, to small team grants to larger strategic networks to large multidisciplinary networks of centers of excellence that bring on board really a whole range of partners from the research innovation ecosystem. This funding supports a talent pool of about 12,000 researchers across the country as well as the training and development of over 30,000 students and trainees annually.

So NSERC's mission is really in the academic space. Two-thirds of the budgets are dedicated to fundamental research, but our mission has really evolved over the past ten years to put much greater emphasis on working with companies. And we have had success through our business-facing programs to work with companies directly looking at innovations to help the companies achieve their goals.

Over the past five years we have actually doubled the number of academic industry partnerships. About 30 percent of professors funded through NSERC participate in academic industry partnerships, and you can imagine that come disciplines are more prone to it than others, for example engineer, about 70 percent, work with companies.

And so we do this either indirectly through our flexible set of grants for collaborative research and development, or directly through a program that helps a company hire an employee to work on a specific research question in house.

These programs have different contribution expectations. Companies may participate in some programs with no cash contributions, but the more ambitious the project and the more the federal government is investing the more skin in the game we expect from the companies as well, and it has gotten strong interest from industry who contribute about $200 million annually in leveraged partner contributions.

With respect to clean tech and clean energy sector just to give you an idea of how much investment goes into this sector, so overall in clean tech in 2014-15 we invested $180 million. That also includes climate change research, specifically clean energy accounted for about $88 million. And with that investment it makes NSERC the third largest Canadian investor in this area after the Atomic Energy of Canada, Ltd. and NRCan, obviously. And it supports about 1,200 researchers active in this area across Canada in universities and colleges and more than 3,000 students being trained annually in this area.

We have just a few examples here for you. Obviously there's a lot going on in this sector but a few examples standing out. For example the first one here is we have great expertise in Canada in the area of lithium ion batteries and that has attracted Tesla Motors to actually come to Canada, work with Dr. Jeff Dahn at the Hausa University and actually put an R&D foothold into Canada because of that expertise. And that is something we very much like to see is this collaboration with multinational companies coming and working with us but bringing R&D capabilities to Canada at the same time.

Other partners include the public utilities, Manitoba Hydro—it's very much involved in clean energy technologies and invest in a whole host of technologies, like for example also an American model that help harness renewable energy resources more cost effectively. And fuel cells are of course an important area and to come up with new materials to replace the platinum-based materials currently used is often an area of expertise.

This is funded through an opportunity that we call Discovery Frontiers Program. It's a highly competitive program but it is an international program. So you can see the partners' organizations are international and multinational companies but also universities from around the world to join forces.

To give you an idea of the network funding—and I think the slide is coming up in a second—we have strategic network programs, and it is to give you an idea of how encompassing these networks can be. Here you have a couple of examples in wind energy and in smart net zero energy buildings. These are networks that bring together numerous universities and researchers as well as numerous partners nationally and also internationally to give you an idea of the kinds of funding that that we use to support these networks. And this is part of NSERC's strategy to go global as one of our strategic priorities but to allow Canadians to work internationally and to attract international researchers and companies to work here in Canada is one of our goals.

And the last slide is just to give you an impression of the number of partners, and of course that is not a complete list. But certainly we take great pride in the partnerships that we strike through the academic and industry partnerships.

And I'm going to hand it over to Andy Reynolds, general manager Energy Mining and Environment.

Andy

So I'm delighted to have a few minutes to introduce you to the National Research Council of Canada. The NRC is a research and technology organization; it's a national RTO, research and technology organization. And this is an agency of the government of Canada.

As an agency we have a pretty broad outlook on the challenges facing the country. So you can imagine that we are focused on challenges as broad as cities of the future, of aging in place, the future of health care, the challenges of remote communities, cyber security. And indeed we also have some mandated tasks associated with the weights and measures lab, so we're Canada's national metrology organization, and we also run the astronomy infrastructure for the country as well.

We're best thought of as a hybrid of a traditional government lab and an economic development agency. And so you would have seen in Andrew Noseworthy's slides that we're part of the agency of portfolios that report to the industry ministry. You can see on the map here that we have facilities all across the country, almost 4,000 employees and as well as conducting research we also support small and medium enterprises and a number of other

entities. And I'll talk a little bit more about the industrial research assistance program later.

We have quite a commercial outlook, so we recognize that there's not much we can achieve by ourselves. We have to work with clients and partners in order to make real progress on deploying technologies. And so we have a strong focus on stakeholders, but private sector in particular.

And what we try and find is shared goals because that leads to a higher probability of industry uptake. Indeed, we have several thousand clients at any one time. And in the next slide you'll see the program approach that we used in order to focus substantial effort on these goals.

You'll see that even with 4,000 employees we only have 38 programs and this enables us to focus a critical massive effort onto defined challenges. And for any of these we can draw capabilities from across the organization, skills, facilities, equipment, expertise. And this enables us to build multidisciplinary teams to solve particular problems and it also gives us the structure with which we engage industry, stakeholders and collaborators.

The other thing I would mention about this approach is that it gives us a strong time domain discipline, a sense of urgency, a sense of milestones and progress because all of these programs are time limited.

And then to illustrate them with a few examples to bring out the different features. We have an energy storage program which is really aligning itself with the whole value chain for energy storage. That takes us all the way from the raw materials suppliers, so for example the vanadium supply chain is going to be quite important to flow battery development, and all the way through to the deployment end. So we work with system operators, electric system operators, regulators to understand the market readiness level issues as well as the technology readiness level issues. And I'm pleased to say that in working with this value chain we're collaborating with the CanmetENERGY lab at Godin and we have some quite complementary skills there.

A second program I'd like to draw attention to is the algal carbon conversion program where this really demonstrates our ability to map large-scale demonstration projects with industry partners. And we're partnering with a cement company and also a company, Pond Technologies that makes photo bioreactors to use CO2 emissions from the cement manufacturing process as an input to algal cultivation and a biorefinery to make valuable products from those algae.

The final example that I'd like to draw attention to is our role as the National Metrology Lab. We're collaborating with the environment ministry on metrology of black carbon emissions. It's quite a challenge to regulate black carbon emissions if you don't know how to measure them. And the science of this is actually quite deep.

I'll just briefly mention a few other areas that we're working in that are related to clean energy: bioenergy, particularly for remote communities, marine

energy, vehicle propulsion, the Arctic program that addresses some of the remote area challenges. High performance buildings—obviously a lot of energy efficiency opportunities in the built environment. And in most of these areas I would say there is collaboration with the other departments and agencies that you've heard from today.

I just have a couple more slides on some key areas. The Industrial Research Assistance Program that I mentioned earlier is a longstanding program that the NRC runs to support small and medium enterprises and their research needs. This is not only a funding program but it's also a highly valued advice program. We have these industrial technology advisers in the field whose ____ advice to growing companies is really quite cherished.

This is my final slide. We have various international relationships that we run on behalf of Canada and the one I'd like to draw attention to here is Eureka, which is a European-centered international network for innovation and for the promotion of collaborative projects. Canada is an associate member of Eureka and the NRC runs Canada's point of contact out of our national office for Eureka. And this enables us to coordinate with other nation's national funding support to collaborative projects between industry partners in multiple nations. And we've had some pretty good success with that so far.

That completes the information I wanted to give you on the NRC. I'd like to hand over now to Chris Boivin as SDTC which is one of our partner agencies in the industry portfolio. Over to you, Chris.

Chris

Well thank you, Andy, and thank you all for giving me an opportunity to speak to you today about our program. It's a true pleasure to get to speak to such a broad and global audience.

SDTC or Sustainable Development Technology Canada is an arms' length fund that was created by the government of Canada back in 2001. Its purpose is threefold: first and foremost we fund the development and demonstration of new innovative technologies related to climate change, clean air, clean water and clean soil to make progress towards sustainable development.

And, the definition of sustainable development that we use is essentially meeting the needs of today without compromising the ability of future generations to meet their needs. And that's broader than just the environment; that's looking at the social impacts as well as the economic impacts of the projects that we fund.

The second aspect of our purpose is to foster and encourage innovative collaboration and partnering to channel and strengthen the Canadian capacity to develop and demonstrate sustainable development technologies. The way that manifests itself in our funding model is that we don't just fund single entity projects, we actually fund consortiums. And those consortiums typically comprise the end user or the customer, eventual customer for the technology, key players from the value chain that will adopt that technology. It can include government and academic labs such as Canmet, the NRC and

entities funded by NSERC. It can also include not-for-profits, NGOs and the financial community.

The final part of our purpose is to ensure timely diffusion of the technologies that we fund. And the way that we look to achieve this is we don't just look at the technology when we are assessing the projects that we are going to fund we're looking at the strength of the market plan, the team, the management team, the business case, the value proposition and the margin of performance, and the ability of that technology to get adopted into value chains as reflected by participation of end users within the projects.

A few high-level stats about SDTC. So we've been in operations for 15 years. We have four offices across the country. Companies can apply to us at any time, just give us a call and we can help you assess whether you are fit for our program. We have invested almost a billion dollars to 320 projects to-date and 73 of the technologies we funded are now in the markets. Our billion dollars invested has leveraged a further $2.5 billion of investments into these projects and 80 percent of that has come from private sector and industry.

Where we fit specifically in the innovation continuum we typically use the technology readiness level language ladder to illustrate this. So the earliest we would consider participating with a project is at TRL 3: project must be passed proof of concept, must have validated the fundamental theory behind the innovation. And ideally they've at least constructed a pre-alpha version of the technology to vet its feasibility. And our objective is really to graduate projects at TRL 8. So that initial production phase, that initial rollout into the markets. Some project achieve this in one go with SDTC but others take a couple iterations to advance through that continuum, particularly the high cap ex and more complex technologies.

In terms of our allocation profile are fairly well distributed across Canada's major industries and sectors. The lion's share of our investments has gone into energy utilization, energy exploration and production, power generation and transportation. And this is consistent really with the big buckets of GDP for the country and the largest contributors to emissions and environmental impact in the country.

A few more high-level stats about the performance of the fund or our portfolio since inception. So estimate that through the diffusion of the technologies we've funded since 2001 those technologies are currently achieving about 6.3 megatons per year of GHG emissions reduction and avoiding about $100 million of costs through health impacts from criteria air contaminants, water remediation costs and soil remediation costs. We estimate that the same portfolio of companies is achieving about $1.4 billion a year in revenues and that that has created about 9,200 direct and indirect jobs.

To give you a sense of where those stats come from this is not a complete list—as I said we have over 320 projects. But these are some of the ones that you may have heard of that are in the market today or about to hit the market. I encourage you to take a look at each one of these companies and their offerings as they can certainly contribute to the sustainability agenda globally,

not just in Canada. But you can see quite a diversity there. We've invested from Gen4 small modular nuclear reactors and terrestrial energy, General Fusion, direct air capture in carbon engineering, carbon sequestration in cement through carbon cure, solvent-based extraction to displaced emissions in the oil sands production, advanced chips for data centers—the list goes on. So I really do encourage you to take a look at those companies and their offerings.

And finally, in keeping with our purpose the partnerships we strive to facilitate go broader than just those that are created in our portfolio companies. We've also put significant effort into partnering with the provinces in Canada to achieve common objectives of reducing emissions particularly for large final emitters. Last year we announced partnerships with Alberta through the CCMC and Alberta Innovates and more recently with Ontario through the Ontario Centers of Excellence. And the intention here is to facilitate the funding process for applicants and really accelerate opportunities into the market in a really targeted way that addresses some of the big buckets of emissions in Canada.

And with that I believe we're at the end of the presented materials and we will pass it over to the moderator for the question and answer session.

Eric Thank you very much. Those are fantastic presentations. Thank you. So we have a lot of great questions coming in. Just a reminder to the attendees that you can enter questions into the questions pane at any time and we'll see them over here.

The first question is for Frank and asks if you can comment on how the $2 billion low carbon economy fund will be structured. Will this fund be dedicated to R&D or more later stage growth of clean tech companies?

Frank Thank you so much Eric. So the specifics around the $2 billion fund are in current discussion with the provinces. There'll be a first ministers meeting in the early part of December, on December 8th and 9th. We expect that those issues will be hopefully finalized. So I'm not yet at the liberty of speaking specifically to how and where the monies will be allocated but it's coming very soon. In the next month or so we should be able to go public on it.

Eric The next question is about tying together all the different groups and efforts that have been described on the call. And the attendee asks if—how a company might approach partnering and how to navigate the different groups and where to start—who to talk to about next steps and stuff like that across all these different initiatives.

Frank That's actually a very good question. And we heard earlier from Andy Noseworthy the importance of that one-stop shop. That was certainly feedback we heard especially from the small and medium-sized enterprises. We were looking for that simplicity of contact. So we're working toward fulfilling that very mission of having a kind of dedicated hub whereby companies would be equipped to—or universities or international partners or whoever could have a no wrong door approach whereby you can be guided

whether you need support in terms of the basic research, the applied research, the demonstration stage, the product commercialization and financing. So in the interim we do have those contacts that you have here established. I would suggest that by reaching out to Yoto Coquinas the director general in the admission innovation secretariat along with Chris Dawson, with _____. We would be able to direct you to wherever needs assistance. And as soon as we have this apparatus established Andy and I we're exploring using both electronic means but also other communication modes to make it easy on partners to be directed to where best to go would be an effective way to appreciate.

Andy, do you want to add anything on this?

Andrew Yeah, sure, just to reinforce your points, Frank. I completely agree with everything you've said. The short answer to the question is whoever presented the question should feel free in contacting any of us at any point and we will assist you in navigating the systems and come back to Frank's principle point: notwithstanding the broad array of stuff that we presented to you this morning you should understand that there is already a close collaborative approach within governments in Canada around this area and we are seeking to in fact make it more integrated and collaborative on a go forward basis.

Frank And just for ease of reference for colleagues this is Frank De Rosier again from Natural Resources Canada. Further to Andy's point, if you access slide number 41 of the presentation that is on the screen you actually have those contact name titles and anything else, just to make it easy for you to connect. So the names I've referenced earlier were the first two, and they'll be on the website and available to all.

Eric That's right, we'll be posting all the presentations so any can access them.

Sort of a follow-up question that entered in part is one attendee asked the best route to follow for a pre-proof of a concept of a clean technology. So this very early stage where to start.

Frank To do a research type proposal? I'm not sure I understand that question.

Eric The attendee described it as a pre-proof of a concept that's a clean technology, which I take to mean earliest stages for potentially more on the applied research than direct research. They clarify prior to lab testing or proof of concept, sort of very early stage.

Frank It could either be within the comic space which Bettina can speak to in a second, or if it's more in the applied research will be more, I guess, contacting with the National Lab _____. Bettina, do you want to add in terms of the academic earlier stage?

Bettina Well I think earlier stage academic fundamental research or applied research would quality through a collaborative R&D program at NSERC. So I think I would invite you to contact NSERC and to pursue these ideas. So we don't

have a limitation with respect to how far advanced you have to be in order to qualify for a collaborative R&D program.

Frank And if in doubt I would reach out to NSERC or _____ _____ innovation secretariat and we'll be able to direct you.

Eric Thank you very much. The next question is for Andy, and if you could talk a little bit more about international relationships. You touched on Eureka and how you see them evolving as mission innovation increases funding with partner countries.

Andy Yes. So we certainly see the value in international relationships. And you would see a range of those on our website. For instance collaborative relationships with Germany and Israel spring to mind recently. And also with Australia.

I tell you, we sort of grow these organically as the opportunities arise and as the policy direction takes us there. And I think it's going to be important that we coordinate within all these agencies within Canada quite effectively. But there's no doubt I think that from the clean energy perspective mission innovation is going to drive us towards much greater readiness for international collaboration. I think we would welcome that and I think it's going to be a good thing.

Frank And maybe _____ _____ here to build on Andy's point the instruments that Andy describe are certainly in effect and we've been using them quite extensively, but we would like to do more of it. And very much in the spirit of mission innovation and building those collaboration across borders we've already kind of raised our hand more than once to be either lead or colleagues and as part of our new programming that will be announced over the coming weeks and months we'll want to devote more resources to international partnerships.

Eric Thank you both. The next question talks about the transit of a technology from proof of concept to commercialization and how the different organizations represented here work with companies to do financing, questions about capital structure and to what extent debt is available versus equity.

Frank So, we have a combination of funding models. We heard from our SDTC colleague Chris Boivin about some of the clients being offered. Similarly within our account we have a large number of those programs to support either R&D or demonstration projects. They are of a grant nature. We also have with some of our agencies the ability to access other funding mechanisms. I don't know if Chris you want to speak to those?

Chris Sure. So from the SDTC perspective we typically fund as a grant a third of a project, and the intention of doing that is really to crowd in the other funding so to buy down some of the risk. But some of the work we do, for example, will involve helping our proponents close the rest of the money for the project, so we do matchmaking with the angel and venture capital community

and other private sources of funding such as industry partners as well. And we do try to leverage the breadth of government in going that to make sure we have a nice broad network of opportunity.

The other program that SDTC had was a no interest loan based program for biofuels which was essentially a very soft instrument to allow for repayment only from free cash flow. That instrument was to fund up to 40 percent of a project, and really again the intent was to crowd in other sources of debt and enable those to come and balance out the funding package for projects to actually take off and start realizing opportunities.

Frank And, the emphasis around the pathway to commercialization is certainly something we're very mindful of. We heard that from our academic research to our applied research to our demonstration like it's something that we emphasize. And when we assess proposals—because we want to make sure that those great technologies get somewhere, both on the domestic and global market.

Andrew It's Andy Noseworthy here. I'd just add that I think this is an important area where you're going to see new initiatives by Canadian governments over the course of the next year or so as well. So stay tuned.

Eric Thank you all for those answers. We touched on this a bit but there's a follow-up question for Chris about the consortium arrangements and where they start and who the anchor partners are and then how they evolve and what some of the challenges are there for recruiting the whole group of diverse stakeholders for those.

Chris Sure. The typical project is structured around an SME for SDTC. So the SME is usually the originator of the technology and they're the lead applicant. And then what we look for to really bet that it's a strong opportunity is what level of participation is there from sophisticated financial community members as well as from industry and value chain partners. So typically we look for at least one value chain partner or one adopter, potential adopter in the project structure depending on how early stage the technology is. Sometimes it's not always practical for that to be the case. And then we also look for the balance of skills. If they're short on some of the research skills are they partnering with the right research entities to fill that in. There's a fair bit of flexibility in that consortium model. No two opportunities are alike, so sort of the partners they need tend to vary. But typically when the opportunities come to us they have a notional ascent and have had some preliminary discussions with partners for participating in the project. And those sort of get cemented through the application process and eventually contracting of our project. Everyone has to sign off on some general Ts and Cs to then execute the project. Does that answer the question?

Eric Yeah, that was great. Thank you very much.

The next question—there's two related questions on a slightly different tract that are related, and feel free to let me know if they're potentially too detailed. But they both relate to carbon sequestration. And the first is how successful

carbon sequestration through algae has been and if there are useful products coming out there. And the second is about second-generation CO2 emissions capture membranes for fossil fuel combustion plan and what the progress and plan is there. Again, a bit detailed but we also do have some technical experts on the line.

Frank How about if I call a friend on this one: Dr. Dean Haslip, who is the lab DG for a national _____ in Ottawa. Dean, do you want to take it on?

Dean So, for the first question on algae I think that question is actually better for Andy. I think he mentioned in his presentation work on algal techniques. I think the other question is probably a little bit too detailed for a discussion here but I would be more than happy to follow up with the question offline. We could connect him or her with some of our technical experts here at the lab and sort of address any of the issues or concerns they might have and perhaps share some ideas that they might have for new ideas going forward.

Andy So it's Andy Reynolds here from NRC. I'd be happy to say a few words about the algal carbon conversion program. We've done quite a lot of work on this over the last five years or so on techniques for the microalgae strain development, cultivation bioprocessing, and we're working with industry partners, Pond Technologies and St. Mary's Cement to employ a demonstration project which really will come to fruition next year.

This is a fairly substantial scale. It's a 25,000-liter photo bioreactor and Pond Technologies is a company that is already active in CO2 utilization for things like high value food additives. We see that there's a wider range of products that can be developed from algae cultivated in CO2, but I think it's important to know that this is really a question of carbon utilization rather than sequestration. I encourage you to take a look at that project. There were some news releases on it just this week actually. There was an open day and a press event. So that's been showing up in the news just recently, and it'll be very interesting to see how this project develops over the next year or so.

And I would just finally add that there's also interest from an oil sands company that could potentially use technology like this to recycle some of the carbon emissions from oil sands processing. So a potentially quite large value but a lot depends on the product range that can be created and the uses of those products in terms of the ultimate GHG impact.

Eric The next question: is there a renewable heat strategy being developed? It seems like it might be a good opportunity for significant GHG offsets says the attendee.

Dean I think Dr. Jill Jean, director general for our national lab in Bahan is our go to guy when you get to heat and management. He's got a lot of expertise in this area. So Jill, do you want to pick it up?

Jill Absolutely. Definitely that's an important one. In several countries a lot of research has been done on looking at renewable heating and cooling, as much as not only heating but also cooling, for instance. In Canada we've

demonstrated one of the first solar cooling technologies with solo concentrators. So definitely yes, heat pumps are the center. Heat storage, for instance in Canada—we've done the seasonal storage demonstration where you can get basically 90 percent of the heat load of a small _____ over the period of a year. So yes, there are a number of technologies that are being pursued and that's one of the key area that we want to accelerate.

Eric The next question's a little bit at the high-level organizational side. The attendee asks how Canada's activities in the clean energy ministerial differ from its plans under mission innovation and how both are expected to evolve.

Frank Sure, happy to take that one, that's _____ _____. So yes, Canada is an active member of the CEM and there are two set of activities that are very much aligned. And actually the last clean energy ministerial took place in San Francisco, hosted by the Americans back in June of 2016. Happened to coincide with the emission innovation ministerial meeting the following day. So it was done jointly, and the intention is to pursue that approach going into our next set of meetings in Beijing scheduled for the early part of June 2017, where both processes will be happening _____ _____ _____. So they're very much reinforcing.

Bettina If I could just appeal to Coquinas so if I could just add [audio interference] mission innovation, it's important to note the distinction between the two, mission innovation focuses on technology development and pre-commercial demonstration of technologies. The Clean Energy Ministerial focuses on technology deployment. But we are working to make sure there's coherence between the two initiatives.

Frank And the membership that you have for this is very close indeed. They are not identical but with the 21 members mission innovation and the 24 or 5 members of clean energy ministerial almost _____ one another but not quite.

Eric Thank you very much. I want to quickly note that for attendees who ask questions that we didn't have an opportunity to get to as the presenters alluded to we'll make connections online as needed—offline, rather, as needed.

At this point we'd like to turn to any closing remarks any of the panelists would like to make?

Frank Thank you so much. This was a great pleasure for Canada to be able to tell our story and update you colleagues in Canada and around the world in terms of the opportunities taking place here.

I'd just like for emphasis to convey that the governor of Canada is a key member of Mission Innovation and wants to make sure that we are pursuing it with vigor and passion, to use the prime minister's word, both domestically and around the world. So our offer was extended now from our various speakers is very genuine. If you colleagues are interested to reach out and pursue the dialog discussion we would be delighted to do so. You will see in the annex of the presentation more detailed information about both those contacts but the kind of _____ expertise that we have across our federal

family and our country and we'll be very happy to follow up. And again, in doubt just fire us an email and we'll be happy to pursue it some more.

I don't know if any one of my colleagues would like to add to this.

Andy

Yeah, it's Andy Reynolds here from the NRC. I just wanted to point out for the benefit of those who are listening in from within Canada to have questions about how to navigate the system. It's worth contacting the government of Canada's concierge service, innovation and concierge service. There's a website for that. And that was established partly to deal with this navigation challenge and ensure that you're connected to the right agencies within Canada.

Other than that I would second what Frank said and I'm very grateful for the opportunity to participate in it.

Eric

Great. Thank you all again very much. We'd like to ask our audience to take a minute to answer a quick survey on this webinar at this stage. We have five short questions for you to answer and your feedback is very valuable to learn what we're doing well and where we can improve. In just a moment I'll display the first question.

"The webinar content provided me with useful information and insights."

"The webinar's presenters were effective."

"Overall the webinar met my expectations."

"Do you anticipate using the information presented in this webinar directly in your work and/or organization?"

Finally, "Do you anticipate applying the information presented to develop or advise policies or programs in your country of focus?"

Thank you for answering our survey. On behalf of the Clean Energy Solutions Center I'd like to extend a thank you to all of our expert panelists and to our attendees for participating in today's webinar. We had a great audience and we really appreciate your time. I invite our attendees to check the Solutions Center website if you'd like to view the slides and listen to a recording of today's presentations as well as previously held webinars.

Additionally you will find information on upcoming webinars and other training events. We are now posting webinar recordings to the Clean Energy Solutions Center YouTube channel. Please allow about one week for the audio recording to be posted.

We also invite you to inform your colleagues and those in your networks about Solutions Center resources and services including no-cost policy support. Have a great rest of your day and we hope to see you again at future Clean Energy Solutions Center events. This concludes our webinar.