Perfecting Motion® — Tribology and the Quest for Sustainability

Episode 8 – Nuclear Power – A Clean Energy Option
Contributors: Dr. Neil Canter, STLE Advisor, Technical Programs and Services, Robin Manley, Vice President, New Nuclear Power Development, Ontario Power Generation

Neil Canter:
In our continuing quest for sustainability, we have been discussing new technologies such as converting waste plastic into fuels and lubricants, but we have also looked in some more traditional technologies that have been around for some time. A case in point was our examination of how the internal combustion engine can be made more sustainable. So, as we continue to look backwards to look forwards and always look at past technologies but to see how they are going to be used in the future, we are now going to address the potential for nuclear power to be a source of sustainable energy. The first nuclear power plants were built in the 1950s, which is about 70 years ago. The appeal of nuclear power is that no greenhouse gases are produced during the generation of electricity, in contrast to the use of coal and gas as alternative fuels. According to the World Nuclear Association, 13 countries obtained at least 25 percent of their electricity from nuclear power in 2020. Overall, there are 32 countries that produce at least some electricity using nuclear power. As of 2019, nuclear power contributed about 10 percent of global electricity production behind coal, gas and hydroelectric, according to the International Energy Agency (IEA).

Plans are in the works for many countries to expand their nuclear power capacities, in part in response to the need to reduce greenhouse gas emissions. Fossil-fuel power generation units still represent at least two-thirds of all global power plants. This figure has remained relatively stable over the last 15 years. It is clear there is interest in expanding nuclear power share of global electricity production, but there are still challenges with using this technology. To get an assessment of current and future nuclear power technology, we are pleased to welcome Robin Manley, Vice President of New Nuclear Development for Ontario Power Generation, located in Canada.

Robin, welcome and thank you for joining us.

Robin Manley:
Thank you very much for the opportunity to be here, Neil.

Neil Canter:
So let me start here for all of us who have been involved or heard about nuclear power or lived near a nuclear power facility. We will start with the challenges, as the nuclear power industry has faced many

of them, due to concerns about safety. How safe is nuclear power and what safeguards have been put in place to ensure that incidents such as Three Mile Island in 1979 will not occur again?

Robin Manley:
Well, first off there are international experts that look at the impacts of different kinds of energy forms on human health, accidents, deaths, et cetera, and when you look at those international studies, you see that nuclear power is actually one of the safest energy industries in the world—one of the safest ways of producing energy. At Three Mile Island, no one was harmed, no one. In North America, the nuclear power industry has safely operated for decades without causing any harm to anyone, so that is how safe it is. The next generation of nuclear power technologies has enhanced features, which we believe will make it even an order of magnitude safer than the existing fleet. So, we have complete confidence that it is one of the right tools to fight climate change and to reduce our impacts on global emissions and, thus, produce a better world for everyone.

Neil Canter:
Fair enough, thank you. So that everybody has a good grounding of how a nuclear power plant works, particularly a conventional one, before we get into some of the newer technologies, can you talk about a conventional nuclear power plant and how is electricity generated? In other words, going through the nuclear fission process.

Robin Manley:
So, fundamentally, a nuclear power plant's electricity generation works the same way as a coal or gas plant. You boil water, you use the boiled water to create steam. Steam drives a turbine, which results in the turbine driving a generator, and electricity comes out the backend. The thing that is fundamentally different is what is the energy source? What is the fuel source? So instead of combusting coal or gas or diesel, what you have is uranium, which is a naturally occurring substance and is around the world in the ground all over the place. You basically mined the uranium, and you refine it. You form it into fuel pellets and fuel bundles and then you put it into a reactor core in a certain configuration that allows the natural radiation, which is essentially neutrons that are an elemental particle. Neutrons come off naturally, and when they do they hit another uranium atom which triggers a chain reaction that causes additional neutrons to come off. And in that process another kind of energy, gamma rays, are emitted, and those gamma rays basically heat up the cooling water that is around the fuel and by heating up the water, that hot water boils and turns to steam. Steam drives the turbine that drives the dinner and electricity comes off. So, it is a natural process, a radiation, radioactive decay in uranium, which we enhance, and we essentially concentrate by putting the fuel in a certain configuration, and we control that natural reaction in a way that generates useful power.

Neil Canter:
Gamma rays obviously consists of radiation and are forms of the fission process. Can you explain what do they do?

Robin Manley:
So, a gamma ray is a kind of electromagnetic radiation, like light. It just happens to be a more energetic form of light with more energy in it. So, what we must do within our nuclear power reactor is we have to control that, and we must shield it and protect people from it. We know how to do that, and we do that very effectively. There are controls and there are limits to how much radiation people are allowed to be exposed to and we know how to do that, and We have successfully done it for decades. It is an

extremely safe industry that is very well studied, and we can demonstrate that there are no impacts or no measurable impacts on workers around nuclear power plants.

Neil Canter:
So, gamma radiation is similar to what you said is visible light or ultraviolet light or, shall we say, infrared light, part of what we consider to be an electromagnetic spectrum of lights from one end to the other in terms of doing that?

Robin Manley:
That is correct. And that kind of radiation of those gamma rays exist naturally in the world, and they come off all sorts of naturally occurring radioactive materials. You and I, where we live in the world, are exposed to a certain amount of background radiation everyday all year-round. It varies depending on the location and nuclear power plants emit much less radiation than the naturally occurring background radiation you are exposed to all the time.

Neil Canter:
Any idea how much less to what degree. Is it five times or 10 times less?

Robin Manley:
In our plants in Canada, it is approximately 1 percent of the natural background radiation. In other words, about 100 times lower.

Neil Canter:
I think that is good to know because people obviously have had concerns about nuclear power plants of radiation leaking and being harmful. Thank you, Robin, for providing a good perspective on that versus naturally occurring radiation.

Can you comment about sources of naturally occurring radiation. We are talking about the sun, but where else does radiation come from natural sources?

Robin Manley:
Well, I will give three examples. First, granite rock has naturally occurring radioactive material in it, so the rock that is used to build all sorts of houses, depending on where you live and what the kind of rock it is, there may be more or less radiation in that. Second, is a radon, which is a naturally occurring radioactive material that is in the ground and in rock. If your house is built in an area with more radon or, for example, if your house is more tightly sealed and has less air exchange, you will receive more radon dose than another person who has a much draftier house. And the third example I will give is bananas. Bananas have natural potassium 40 in it. It gives radiation off, including gamma rays, and when you eat a banana, you are getting a little teeny bit of radiation dose, part of your natural contribution that you get all the time. Humans and every other living organism involved with that, as part of our environment, and living organisms are adapted to that natural radiation. It is part of life.

Neil Canter:
It is interesting, as I did not realize that about bananas, and I eat bananas relatively frequently. Next time, I will think about that when I eat one. It is nice stuff you are talking about, in terms of potassium 40 obviously, as opposed to the one that is more naturally occurring, which is non-radioactive. In the case of radon, I live in an area near Philadelphia in southeastern Pennsylvania where we have radon,

and when I bought my house many years ago, we did radon testing to check for that. I think that gives people a perspective on where natural radiation comes from and how it impacts their own lives.

So, with all that said, let us now talk about some of the newer technologies that is coming up, particularly these small modular reactors (SMRs) that you have read about and see that they are being implemented. What are small modular reactors and how are they different from conventional nuclear power reactors?

Robin Manley:
In the United States, there are two main forms of nuclear power generation. They are both called light water reactors, which is to say that their cooling water is normal water. And basically, as I described, you have got this fuel and you heat it up, and you create steam, et cetera. So, this is a technology that is used in something like 100 nuclear power plants in United States. Very well understood, lots of experience using it. Most small modular reactors are based upon existing nuclear power reactors. For example, Ontario Power Generation in Canada is going to deploy a boiling water reactor called the BW RX300, which is an evolution. It is the 10th generation of designs that are used in the United States today and have been for decades and in other countries around the world as well. So, it is essentially a smaller version of what we have been operating for a very long time. It has some advantages and enhanced features. So, just to sort of explain, smaller is smaller, right, modular? The point is that you can build more of the components in a factory construction setting, where you have better opportunities of gaining efficiencies of cost, quality, control, et cetera. And then basically you can bring those components to the construction site and construct them more like Lego bricks than the older, traditional stick build kind of a reactor. Now it is not 100 percent factory constructed. Let us not exaggerate, but to some extent. It is also modular in the sense of, suppose your power demands were to increase over time in that area, the idea is that you would build several of smaller units versus one of a very large unit. That has some advantages for the jurisdiction that is deploying it, in that you are not putting as large a capital cost at risk for your first plant. You are also not having to pay for the interest on the debt of that capital cost for as long a period of time. Instead, you are putting a smaller, faster-to-construct, lower capital cost unit into service faster and you are starting to recoup your costs by selling the electricity to whoever is using it. So, fundamentally, an SMR is a smaller version of existing technologies.

Now that said, there are some advanced safety features and innovative features that are also built into the small modular reactors that are enhancements on what have been done before because we always want to learn and do better, have more safety, as well as simplify the design to make them easier to operate. I will also note that some of these so-called SMRs are what we are also going to call advanced reactors and *advanced* in the sense of having a more innovative technology that is a little bit more different than the traditional reactors that are more familiar in the United States. So, these would use more innovative kinds of fuel and different ways of cooling the reactor core than the light water reactors, which there are 100 of them in the US, and they are largely based on research reactors and prototype reactors that were made in various federal labs in the United States such as Idaho National Labs. There is an incredible amount of innovation and research that was done in the 1960s and 1970s in the US, and some of these advanced reactors are based upon those prototype or research reactors and basically turning them into power reactors now. Some of them will have higher temperature output, so instead of coming out at let's say 300 degrees Celsius, they might come out at a temperature that is more useful for an industrial application, approximately twice as hot and higher pressure, and that could be used, for example, in steel manufacturing, potash mining, oil sands, steam-assisted gravity drain applications. And by doing that, we could replace the use of fossil fuels in those heavy industries directly rather than going through an electricity loop, with the kind of efficiency losses that you get by going from heat to electricity to heat, for example. Instead, you would go direct to heat and get more efficient application.

Neil Canter:
For those not familiar with the Celsius scale, 300 degrees Celsius is close to 600 degrees Fahrenheit. That is interesting. You talked about uranium at the beginning, which is a naturally occurring element that is radioactive. What different types of fuels are being looked at here?

Robin Manley:
So, your traditional fuel in the United States is what we call low-enriched uranium. So, you take uranium, and you refine it, and you enrich it to about 4 percent. I am sorry for being a bit technical here, but you enrich it to about 4 percent of the Uranium 235 isotope, which is naturally occurring in the world at about 0.7 percent. The rest of uranium is mostly U238. 238 and 235 are the number that corresponds to the number of particles in a nucleus in the uranium atom. So, U235 is the radioactive version, and the United States has much experience with uranium enrichment, and so you enrich it to about 4 percent and use that fuel. Well, some of these advanced reactors would be a little bit more enriched somewhere between 10 and 20 percent enrichment, and what that does is it allows you to have a more concentrated fuel. Another thing that is sometimes different in some of these advanced reactor fuels is the physical form of the fuel is a little bit different. Instead of being a uranium oxide chemical composition, it might be a metallic uranium, or it might be a uranium that is encased in various layers of silicon carbide and graphite. These different ways of manufacturing the fuel provides certain kinds of benefits in different kinds of reactor cores where basically, the reactor physics, the way in which the neutrons bombard the different atoms and the way that the core is structured, what kind of cooling materials you use, what kind of what we call a moderator to slow down the neutrons to the right specific speed you need— these things all vary. There are many ways of constructing that reactor core, and certain kinds of fuels are more effective in certain different kinds of reactors. And again, all this knowledge was mostly gained in the United States research reactors around the 1960s and 1970s.

Neil Canter:
I think another way of defining U235 and U238 is it literally is the atomic weight of uranium for those with some technical background or remember their high school chemistry, in terms of the number of neutrons and protons which are in the nucleus. We try to give multiple definitions here to help the listeners out.

What was it just flexibility or what really led to the development of small modular reactors? You know your standard nuclear power plants would suggest that there are different energy needs and different situations or different applications. What really led the industry to look in that direction?

Robin Manley:
I think there were a couple of factors. One is from the 1950s, 1960s, 1970s, 1980s, 1990s and 2000s, reactors were always getting bigger. We were starting out with research reactors and then small power reactors of maybe 100 megawatts electric and then 200, 500, 800, 1,000 1,500 megawatts electric— always getting bigger. When you do that, you are also adding complexity to the plant, and you are adding physical size, more steel, more concrete, more capital cost. Now if your electricity costs of the

backend are lower, than that is a good thing. But what we were finding in the last generation of large plants that were being built is that the construction periods were going over schedule and the cost was going over budget. And some of these large projects were in the, you know, 10s of billions of dollars range for a plant that produces a great deal of power and, thus, a great deal of value. But that is a big capital cost for a company to manage the risk on. So, there were a couple of companies in the United States and elsewhere around the world that found themselves in difficult financial situations as a result of taking on these mega projects. So, one of the drivers was how can developers of technology and how can operators—project proponents—manage those costs, and one way to go about it is the sort of smaller bite-sized pieces. Another advantage of going smaller is not every electricity grid is enormous, if they are not all the size of New York and California.

If I can speak for Canada, where I am much more familiar than I am with the US, only Ontario in Canada can really absorb a gigawatt class reactor, a AP1000, like the one that is being built in the United States right now at Vogtle. The other provinces, their electricity grids are not that big, and you do not want to overwhelm any electricity grid with just one plant because if one plant, one source of electricity is 50 percent of your electricity, you have any kind of problem—it does not matter what kind of planet is. Well, you have any kind of problem, your grid goes down. You have a brownout or blackout, and nobody wants that. So, for reliability and security of supply, you want a distributed energy grid distributed across multiple sources. Also, it is good to have different technologies because if you have one technology problem, let's just pick wind. The wind is not blowing, well, the whole grid goes down. So, what do you do about it? You have different kinds of things, so you balance out the risk. If your electricity grid has, let's just say some hydro, maybe you are getting transmission lines from another state or another province, and suppose you have got some gas and suppose you have got some wind and some solar and you have got a small modular reactor, or three or four, and you are distributing across these different things, you are managing your risk tolerance. You are using your SMR to back up your solar and wind when those renewables are not generating. Suppose you need some peaking power at some particular time of the day when people go home and they turn on the air conditioner and the TV and the stove all at once, you turn on your gas plant then to suck up that peaking power demand. So, the SMR sort of size of around 100, 200, 300 megawatts proved to be just the right size for smaller electricity grids to sort of manage, in terms of cost and the right kind of puzzle piece, to fit into their grid forecast.

Neil Canter:
Good, thank you on that and one comment on Canada, which you know better. Canada's population is what, Robin, about 35 million people and what percentage of the country lives in the Ontario area where you talked about where that could require a larger nuclear power facility?

Robin Manley:
It is not quite half. I think we are like 40 percent or so.

Neil Canter:
As you know, there have been concerns from people about the safety of nuclear power plants. In general, you mentioned there have been upgraded safety measures on nuclear power plants.
Can you discuss what safety measures have been implemented with small modular reactors and how do they compare? Are they the same or are there any different measures compared to what is in conventional nuclear power plants?

Robin Manley:
They are mostly the same. So, we have had decades of experience running nuclear power plants, and we know there have been accidents. For example, you have Three Mile Island and Chernobyl Fukushima—you must acknowledge it. So, what do we do? Just like every other good industry, we learn from those things, and we make enhancements to our programs, our technology and how we operate plants so that we do not have those again. So, essentially with a nuclear power reactor, you must control the radioactive, control the radiation, and control the way the reactor operates. You must cool the fuel and you must contain the radioactive emissions—the "Three Cs" of nuclear power. With reactivity control, there is no major enhancements on these new technologies versus the other ones. Those have not been issues. As for cooling, what happened at Fukushima when the tsunami hit, it knocked out the electricity to the reactor and by knocking out the electricity, it stopped the reactor from being able to circulate new cooling water into the reactor coal. So, what have we learned from that? And this has been implemented in reactors all around the world already. What we learned is you need additional backup and redundant ways of providing electricity that won't be knocked out by any single event. So, you do not just rely on what is installed. You have additional remote ways of providing electricity that you can quickly hook up in the event of such an unforeseen but still possible scenario.

Neil Canter:
For clarification purposes, when you mean remote, you mean a few kilometers away from the actual facility?

Robin Manley:
It could be a kilometer way up on a hill, for example. So, the tsunami cannot hit it, for example, and then you bring in that remote diesel generator and you hook it up and you turn it on and within hours you have got that electricity reestablished. Another key feature is always having enough water. So, reactors always had plenty of water for almost any scenario, but that Fukushima event was unforeseen and unexpected, and they eventually ran out of water. So, what you do in the most recent designs is you either provide a very much larger supply of water, which we are doing, or you provide a different kind of cooling mechanism that cannot fail, and I will describe that, or you provide a kind of fuel that cannot melt and cannot cause a release of radiation. So, let's talk about the water. For the BWRX-300, what we have done is we have established that there is a sufficient supply of water for a week, even if nobody did anything. If we all stood around, and you know, which is never going to happen, right? So, yes, we have redundant separated supplies of electricity and ways of getting water in there, which will act on within hours. But even if we didn't, the reactor, the supply of water is for a week. So that addresses that problem. Some of these additional design features that some of the reactors have, the fuel is already molten, it is already melted, as it is supposed to be that way. So, some scenario where you hypothetically lose cooling, well you lose electricity. Well, in fact, what is going to happen is their fuel will solidify. It is just as safe in that form. So, it doesn't matter if it is molten, it doesn't matter if it is solid, it's perfectly safe under any circumstances. And another of these ones has this kind of fuel with the silicon carbide and graphite coating. Basically, up to about 2,000 Celsius and I cannot remember what that is in Fahrenheit.

Neil Canter:
That is 4,000 Fahrenheit, just multiplied by two.

Robin Manley:
Up to about that kind of temperature, it is undamageable. The reactor cannot get anywhere near that hot. Just the physics stuff—there is no way of generating that much heat, so you basically cannot damage the fuel no matter what you do. So, there are different ways in which we are learning from and enhancing the existing safety features that are already there and just saying, you know, here is yet another layer of defense.

Neil Canter:
Interesting. So, you are talking about the fuel modifications or more coatings on the uranium or different types of coatings doing that. What about the cooling side? You mentioned having enough water for a week, we are getting more to the situation in certain parts of the world where water is becoming a precious resource. In fact, you could argue, as we move into the climate change phase, water is becoming an issue. Are there any thoughts about figuring out a different cooling mechanism? Don't get me wrong, water is a great cooling mechanism but if there is not enough water to do this properly, is there a Plan B?

Robin Manley:
So, you always want to perform an environmental assessment and a licensing analysis that looks at the safety case for your reactor design in your environment, taking account of potential future changes. So, there may be parts of the world where a light water reactor does not make sense because, as you say, perhaps as climate change comes along and even though we take adaptation measures, maybe it is not the right reactor for that location. You want to consider that, and maybe you use what we call a high temperature, gas-cooled reactor, where instead the cooling is done through gas, or you use a reactor that uses passive cooling and essentially the reactor is cooled by air exchange. As long as there is air, there is going to be cooling for the reactor core. I am not an absolute expert here, but if I pick X energy, high temperature, gas-cooled reactor with this fancy coded fuel as an example, my understanding of it is cooled by gas but if, for example, there was some weird situation that happened that you didn't have gas cooling, the fuel is cooled by air.

Neil Canter:
Obviously, indirectly, so there is no radioactive or radiation leak from that standpoint?

Robin Manley:
Yes, because of all these many layers of coating around.

Neil Canter:
Let's move on to where do you see SMR is being used. You already referred to one application that I was asking about, which is renewable energy. Obviously, the wind doesn't blow. The sun is not out constantly, so those two renewable sources have limitations, in terms of what they can do from that standpoint. Do you see SMR's small modular units as being sort of an alternative or backup, if there is a rainy day going on and there is no wind that could be brought online in a situation, where a particular geographical territory is relying heavily on sustainable, but it is not always available?

Robin Manley:
We have done analysis in Ontario and many other jurisdictions have as well, and I don't mean to speak for everybody but most of those that I have spoken to view the SMR as being baseload generation. So,

right now, for example, we use coal or gas and hydroelectric, as well as nuclear as baseload generation. In other words, we try to run that as much as possible. The renewables, they just do this, like it doesn't matter if it is a daily or hourly cycle or whatever it is, but it goes up and down an incredibly spiky fashion. You do not want your refrigerator, microwave, TV, or Internet running on electricity that does that—it won't run. What you need is a baseload generation and then you need some sort of smoothing effect that allows you to handle those peaks and valleys that happen during the day and week in the year. So, we imagine the SMR as being part of the baseload generation along with hydro, and along with some wind and some solar, because if you have enough of those distributed and you have some batteries, you can smooth them out so that there is some capacity at all times. Again, within Ontario, we basically ran an optimization program called a "Net Zero Mixer" that allowed us to try different scenarios, more of this, more of that kind of clean energy, gas, batteries, et cetera. Optimize the price, lowest as possible and the GHG emissions, as low as possible. When we did that, we found that the best scenario was a mix of different energy options for our locale, including peaking gas at the right points because that is incredibly cost effective and if you are only peaking for a little teeny bit, you are not adding a lot of GHG emissions, so this ended up being the best scenario that we could see in Ontario.

Neil Canter:
Obviously, there are construction plans for bringing them (SMR) online. How rapidly do you feel they will be brought online in the near future?

Robin Manley:
So, there is no question that introducing a nuclear power plant takes time, not as fast as some other technologies because of all the regulatory controls and the licensing and permits that you need. It takes approximately in Canada about 12 years to go from startup project to deployment of a grid scale, small modular reactor—that is our estimate. At Ontario Power Generation, for example, for our first project we started the technology selection in 2019, but we already had the first regulatory license and environmental assessment in hand, and we are aiming to have power about the end of 2028 or maybe in 2029, so about 10 years after we started, but with a couple of years prior to that working on this environmental assessment. Now we hope that after we have done the first and second one, et cetera, we can shorten some of that regulatory review process because it will have been approved by the regulators. We have already proven the safety case as you have seen it and we have accessed it already. When we go and deploy it somewhere else, you need to look at the particular seismology and the local species at risk and local environmental conditions, and you need to make sure that is safe, but the rest of it you have already assessed, so it should take us less long. Also, future construction plans ought to be faster because we will have gotten all the details down. We will have the factory already going, they are producing the parts and the whole process should shorten, at least a little bit.

Neil Canter:
Okay. That is fair enough and understand, in terms of the lengthy process, which, again, so you have to factor as we are looking to get more sustainable sources of energy and move away from coal and natural gas. So, you assume future prospects for nuclear power to being pretty bright, in terms of doing this and what they are doing with long regulatory approval processes, but I assume you are feeling pretty bullish about where things are headed with nuclear power?

Robin Manley:
We are and let me say that as we, and many other experts have looked at this, including the International Energy Agency that you referred to earlier, the world supply of new clean energy is going to need to double or triple within the next 30 years to get to net zero. Nuclear is never going to make up half of the world's electricity supply. Right now, it is somewhere between 10 and 20 percent, but we are imagining that it is going to need to continue approximately that ratio because otherwise the cost to the world is going to be higher, and we don't want the cost to be higher. So, in order to optimize the cost and the speed at which we can combat climate change, the nuclear component is going to have to grow, as well as the renewables, batteries and the use of clean hydrogen produced by clean energy sources like hydronuclear or renewables. In order for all of these things to happen and for us to double or triple the clean energy supply around the world, the world is going to have to invest a lot of money into infrastructure. It doesn't matter what technology you pick, a lot of infrastructure of various kinds, so we think that nuclear will be a significant component of that. That is why we have decided to move first here at OPG and start these projects.

Neil Canter:
Very good. Net zero for those that don't realize is Net Carbon Zero, which is neutral carbon, which, of course is what we are trying to get to, in terms of going to sustainability and reducing the issues or the threat of global warming—getting above 1.5 Degrees Celsius or even 2 Degrees C, which is being debated.

Neil Canter:
Thank you, Robin. I think this is very valuable to our listeners, particularly from your perspective as a representative from the power generation industry. I appreciate your help and time.

Robin Manley:
Thank you very much, Neil. It was a pleasure speaking with you.

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CONTRIBUTORS

Dr. Neil Canter is an STLE Fellow and an STLE Certified Metalworking Fluids Specialist (CMFS)™, with more than 35 years of experience working in the lubricants industry. He received his doctorate in chemistry from the University of Michigan in 1983 and his bachelor's of science in chemistry from Brown University in 1978. Canter runs his own consulting company, Chemical Solutions, specializing in commercial development, marketing, product development and regulatory support for the lubricants industry. Canter is a member of STLE, the American Chemical Society (ACS), and the Society of Automotive Engineers (SAE). He is a contributing editor responsible for writing the monthly Tech Beat column in STLE's TLT magazine. He is also a member of STLE's Metalworking Fluid Education & Training Committee, STLE Education Committee, and the program chair for the STLE Philadelphia Section.

Canter recently assumed the position of STLE Advisor – Technical Programs and Services. Besides providing technical and commercial support, he is also the host of STLE's new podcast series: "Perfecting Motion: Tribology and the Quest for Sustainability."

Robin Manley graduated from Queen's University in 1986 with a degree in Physics and took his Master's in Astrophysics at Queen's and Western, with a thesis related to supermassive black holes at the centres of galaxies. He worked at Ontario Hydro and Ontario Power Generation from 1990 to June 2021, including senior leadership roles in Radiation Protection and Nuclear Licensing. In April 2019, Robin took on the role of Vice President of New Nuclear Development at Ontario Power Generation, accountable for the implementation of Small Modular Reactors (SMRs) at OPG. The high point of that role was leading the SMR technology selection, where OPG announced in December 2021 the choice of GE-Hitachi's BWRX-300 as its technology for the Darlington New Nuclear Project, to deploy Canada's first grid-scale Small Modular Reactor.

In July 2022, Robin started his own nuclear licensing and SMR consulting company, Paradymshyft Nuclear Advisory Ltd.