Notes for Remarks:

# Keeping the Lights On: New Challenges Call for New Approaches

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Check Against Delivery

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Connecting Today.
Powering Tomorrow.

Good morning. It's an honour to be here…at this prestigious institution.

You know, your website is right: "Behind just about every advance in information, power and energy, you'll find an electrical engineer." And that's certainly been my experience at the Independent Electricity System Operator. So I feel right at home being surrounded by so many engineers.

In my experience, the smartest people aren't those who know a lot, and do something great with what they know. That's almost to be expected.

Instead, I find the smartest people are the ones who know what they don't know…are curious about the unknown…are okay with uncertainty…and work hard to make sense of the unknown by turning it into something new.

Speaking of smart people, this is where I get to speak about Jatin Nathwani.

He's not only an internationally-recognized professor with more than 100 publications and seven books to his name … he's also a respected expert in the field of sustainable energy.

If you've taken courses from him…or if you've worked on committees with him…or if you know him from his work in the corporate sector…you know his reputation is well-deserved.

So, Jatin, it's an honour to be here today.

I'm going to speak for about half an hour this morning … and my comments will touch on three main points:

First, I'll share some thoughts on what we know for sure about the current state of Ontario's energy sector, from the perspective of the IESO. The "known knowns" if you will.

Second, what we don't know yet – the "known unknowns". The rapid pace of technological change that our energy sector is experiencing is challenging us on multiple fronts. I'll spend some time talking about what the most significant challenges are, and why.

And third, before taking your questions, I'll speak about the importance of embracing the unknown. How our system works, how electricity is delivered, and how the new

electricity market functions – all these things will be defined by the choices we make now, and in the next 10 to 15 years. This is a defining moment in the history of Ontario's energy sector. And this is why I believe that future leaders – like you – will be the people leading us forward, with some brilliant new ideas and a brand new mindset that understands how to embrace risk.

I'd like to start with a quick interactive exercise. Hands up if you use Siri or Alexa. Hands up again if you use a product like Nest for energy management. And now, hands up if you remember when these devices were first introduced.

I mention these household devices because they reflect just how quickly technology is transforming the energy sector … both for residential customers like you, for large customers like the University of Waterloo, and for the energy sector generally.

Technology is not just revolutionizing the sector here in Ontario, it's a global phenomenon.

This timeline gives you a sense of the scale of change…and the speed of change … that I'm talking about.

Here's what's happened in the last 18 years….

2000 A family in Morrison, Colorado, installs a 12-kilowatt solar electric system on its home. It's the largest residential installation in the United States to be registered with the U.S. Department of Energy's "Million Solar Roofs" program. At the time, world installed PV capacity was approximately 0.6 gigawatts.

2000 Toyota releases the Prius worldwide – the first hybrid electric car.

2006 Tesla starts production of luxury electric vehicles in California.

2007 First smart meter in Ontario is installed – 5 million more installed in next three years.

2010 Global installed solar PV capacity totals 40 GW.

2014 23 plug-in electric and 36 hybrid models are available in the U.S.
8,000 different locations in U.S. for public electric vehicle charging, with more than 20,000 charging outlets
234,000 plug-in electric vehicles and 3.3 million hybrids on the road in the U.S.

2016 Global installed solar PV capacity surpasses 303 GW, an increase of just under 800 per cent in six years.
Global smart meter deployment totals 700 million.

2020 Global installed solar PV capacity is expected to reach between 444 and 696 GW – an increase of between 100 and 200 per cent over four years.

Now, very quickly, how about some 'known knowns' in the areas of wind energy and energy storage:

According to the Canadian Wind Energy Association, more wind energy was built in Canada between 2006 and 2017 than any other form of electricity generation. Between 2012 and 2017, installed capacity grew by an average of 15 per cent per year. In the U.S., installed wind capacity grew at 45% during that same time period – and tens of gigawatts of wind capacity are currently in the build queue in U.S. wholesale markets.

Wind energy currently supplies approximately six per cent of Canada's electricity demand, generating enough power to meet the needs of over three million Canadian homes.

In Canada, the installed capacity of wind generation reached 12,239 MW in 2017.

And the story is similar when it comes to energy storage. Consider these facts:

According to Bloomberg New Energy Finance, the global energy storage market will double six times between 2016 and 2030, rising to a total of 125 gigawatts.

In wholesale markets in the U.S., total installed capacity is now approaching 750 megawatts.

Global energy storage capacity was less than 1 gigawatt in 2012.

Energy storage's trajectory is similar to the solar industry's expansion between 2000 and 2015, when solar share, as a percentage of total generation, doubled seven times.

According to the European Commission, the cost of energy storage batteries is expected to continue to tumble. Between 2007 and 2014, costs dropped by 70 per cent and are expected to do the same again by 2030.

It's a lot to take in.

But this isn't a test, so you don't need to remember anything, except this one point: In a very short amount of time, two quite significant things have happened.
First, renewable energy and distributed energy resources like energy storage … that weren't even on our collective radar 15 years ago … are providing an historic opportunity to fundamentally rethink how we manage electricity grids – the same grids that have been managed the same way, more or less, for generations.

And not just how we manage them technically…how we balance supply and demand on a second-by-second basis … and also how we integrate these technologies safely into the provincial grid in order to ensure reliability.

The second point is that while these advanced technologies are a good thing, from my perspective, particularly when it comes to cost, reliability and adequacy, it's the sheer speed with which they're becoming available that is causing a great deal of uncertainty.

The energy sector was built to be predictable and fairly risk averse. Consumers like that about us…and so do some investors. And today, after years of being slow and steady, our biggest challenges are speed and risk.

We are in a position where we are being called to adapt a new mindset and a new approach…and like it or not, we have to learn how to do this.
And this brings me to the second part of my presentation…

I'd like to give you a few examples of what the IESO is doing to address the changes that are coming at the sector quickly, from all sides … and also what we're doing to deal with this whole notion of risk.

As context, let me say a few words first about some recent changes in energy policy.

It's no secret that we're living in a time when "affordability" is right up there with "reliability" in discussions of electricity. It's one of the reasons governments and system operators are moving away from the traditional means of locking in supply over the long term and looking instead at options that will allow us to meet energy supply needs at materially lower costs.

Fortunately, with energy storage, distributed energy resources, and new market mechanisms, including auctions that enable suppliers to compete to meet system needs at the lowest possible case, the environment has changed.
Reliance on a centralized bureaucracy to determine the supply mix is gone. Market forces will determine the mix and also the cost of supply. And flexibility and choice are now the name of the game.

So, where exactly does that leave us?

Technologies – of various types – will now have the opportunity to freely compete against each other in order support the delivery of reliable, cost-effective power.

A great example of how this emerging wholesale market will work is the incremental capacity auction – which the IESO is currently designing with input from stakeholders.

This will be a competitive auction that will allow suppliers to bid for the provision of the system's medium and long-term electricity supply needs. Importantly, it will give us the flexibility that's needed in order to adjust quickly to constantly changing supply and demand dynamics.

I mention this as context… because it's important to understand that what's happening today in the energy sector is not innovation for its own sake.

It's innovation to help improve reliability…drive down costs…give consumers more choice…and mitigate and re-allocate some of the financial risks associated with building new/expensive infrastructure.

And I should emphasize that it's not just happening here in Ontario…but all around the world.

I want to give you two brief examples of what the IESO is doing to address what I call the "known unknowns" that have become part of our everyday experience as Ontario's system operator.

The first is energy storage. I mentioned earlier in the timeline slide that in 2012, global energy storage capacity was well under 1 gigawatt…and that by 2030, it is estimated to be approximately 125 gigawatts.

The IESO now has over 20 energy storage facilities, half of which are already in service and the remainder at various stages of development. We have also observed a recent investment surge in Ontario, involving energy storage facilities connected at the distribution level, outside of our electricity wholesale market. System operators across North America, including the IESO, are also giving consideration on how to harness the capabilities of these types of storage facilities as well.

We now have the first fully-dispatchable energy storage facilities in Ontario's electricity market, other than the Sir Adam Beck Pump Generation Storage facility at Niagara Falls.

We also have the first hydrogen power-to-gas facility… and the second flywheel facility in our market.

These types of energy storage facilities were unheard of 10 years ago, and now we're at a point where they can radically transform the way energy is delivered in Ontario, and how efficiently it is stored.

Storage is a viable potential future energy supply, and one that's particularly attractive in Ontario given the variable resources we now have.

As more renewable generation…and more distributed energy resources…connect to the grid, we need "eyes on" -- in real-time -- to see how these resources affect electricity delivery…and study their impact on the grid's sustainability.

As part of a multi-pronged research program, we will monitor how the energy storage facilities under contract balance supply and demand on a second-by-second basis while providing various ancillary services.
The IESO is also interested in energy storage because:

It can ease the points of congestion that occur in transmission and distribution networks by temporarily absorbing surges and excess power flow, and returning that energy to the system as demand requires.

This helps local distribution and transmission companies because it can allow them to defer, or even avoid, expensive system upgrades.

It can smooth out the fluctuations of solar and wind resources.

This brings added stability and even greater reliability to the electricity system.

It balances supply with demand on a second-by-second basis and supports voltage and frequency on the system.

This is another plus when it comes to reliability.

It can absorb surplus generation from renewable and other energy sources during off-peak hours and inject it back into the system when demand is higher.

We believe that through research that studies how well these facilities perform in terms of availability, reliability, accuracy in responding to dispatch, and overall performance… how well they perform over time, and in different seasons … we will be better equipped to deal with risk, and deliver on the incredible potential of this resource to help achieve the IESO's objectives.

As Ontario's designated Smart Metering Entity, the IESO is responsible for the implementation and operation of the province's Meter Data Management/Repository.

This is a central hub that consists of a common platform for storing, processing, validating and managing hourly electricity consumption information.

The information in the Repository supports the billing processes used by local hydro companies, in a highly secure environment.

Ontario's MDMR is one of the largest shared systems in the world…adding 100 to 120 million records every day. More than 65 local hydro companies are integrated into the hub… and every hour, nearly five million smart meters in the province send data to the MDM/R.

So, that sounds like a pretty safe, secure, and predictable use of technology, right? And it absolutely is. But here's the thing. In 2017, we worked with the Ontario Energy Board to go further than simply gathering data and storing smart meter data in the MDM/R.

We began developing protocols that would eventually allow approved third parties to gain access to the de-identified data in the repository … making it available to provincial electricity agencies … individual local distribution companies … and third parties.

Raw de-identified data could turn into usable information. And that information could stimulate greater innovation for the energy sector … and greater value for consumers.

Smart meter data will one day soon support:
Energy efficiency and demand management program design
Load forecasting and modelling
Pricing analysis
Transmission and distribution planning
Development of apps and other energy management tools
Identification of energy-savings opportunities within specific regions or sectors

Now, on that last point, I want to highlight that energy efficiency in Ontario – through the provincial Save on Energy program – has already proven to be the most cost-effective resource for meeting the province's electricity needs.

Since 2006, Ontarians have saved more than 68 billion kilowatt-hours through energy conservation and energy-efficiency initiatives.

The best news is that the cost to deliver these programs has also decreased by half in the past 12 years, to just over 2 cents per kilowatt-hour.

So, just as an example, if having more information from smart meters can lead to a better understanding of consumers' energy use … and ultimately to even more efficient conservation programs … then this is a really good reason to open up access, in a prudent way, to this de-identified data.

I've spoken about the energy sector's shifting landscape … and given two examples of how the IESO is addressing this transformation.

Before I conclude my remarks, I'd like to switch gears and talk briefly about the economics of uncertainty.
Does the energy sector have a choice when it comes to embracing innovation?

No, we absolutely do not.

Do we have a choice when it comes to embracing risk? Yes, we do.

And this is, I think, the real challenge the sector is facing.

From the IESO's perspective, innovation will improve energy outcomes, including reliability, cost and sustainability. Simply put, it will help us create novel solutions to address the "capital b" Big challenges where existing solutions no longer cut it.

And because we know this intuitively, as well as through our experience with energy efficiency programs, we are currently investing time and resources to the development of what we're calling our Innovation Roadmap.

The Roadmap will establish a risk profile for innovation-related investments that we will make down the road – a vastly different risk profile than what we currently use to manage the system.

It will use our unique vantage point within the sector to focus and coordinate our efforts around a shared set of goals for R&D. It will identify barriers to innovation – and help remove them. It will also establish annual innovation performance metrics to drive accountability.

And lastly, it will point us in the right direction for potential funding partnerships and research partnerships.

There is no choice about the changes we're experiencing in the sector.

Doing nothing would only add to the uncertainty.

And to the costs.

By choosing not to explore the potential that some of these new technologies represent … by choosing not to interpret all the data that we have at our disposal … by choosing not to take risks, we could end up buying more operating reserve than we need.

We could pay higher prices for supply than we should…

We could undermine the overall reliability of our energy system…

And the sector could assume higher investment costs, which might ultimately lead to higher costs for consumers.

And that's why, although it goes against the very safe mindset that the energy sector has prided itself on for generations, we must learn how to embrace uncertainty … we must get used to managing risk … and steer our way to a place where we manage innovation…rather than feeling that it is managing us.

Markets know how to absorb risk. And the province's current energy policy effectively shifts the risk to the market, rather than to ratepayers.

As system operator, we need to learn how to the same. And that's why now, given the speed of change, the IESO and the energy sector all around the world are on such a steep learning curve. We need to understand all the moving parts…and learn how to ensure reliability when everything else is in flux.

At the IESO, we believe that one of the best ways to manage change, risk, and uncertainty is through effective stakeholder engagement.

Reaching out to our stakeholders … gathering input … listening to different viewpoints … and depending on the issue, driving for consensus … this is all a really critical aspect of how we do business. It's partly about relationship building. But mostly, we do this

because in situations where the issues are highly complex, there is truth to the adage that two heads are better than one. No one can make the types of decisions that need to be made about the energy sector's transformation on their own. It's just not possible.

Last year, the IESO held 118 engagement meetings that over 5,300 people attended…either in person at regional meetings, conferences or committee meetings… or online, in webinars.

There were 50 meetings of the Market Renewal Working Group alone … and more than 170 decisions were made about new design elements.

And that's just one working group. The outreach we do with other committees such as the Energy Transformation Network of Ontario, the Stakeholder Advisory Committee, and the Energy Storage Advisory Committee – to name just a few – is invaluable. Jatin is a member of the Energy Transformation Network of Ontario…as are many other eminent and well-respected committee members. In order to make informed decisions … about today and tomorrow … we need to be well-informed.

Which brings me to you.

This is a terrific time for engineers, software developers, computer scientists, data analytics experts and artificial intelligence graduates to work in the energy sector.
I hope my comments today have given you something to think about, and much to look forward to.

And now, I'd welcome any questions you might have.

Thank you.