Synopsis:

What would happen to the power industry if the cost to generate solar electricity reached 1¢/kWh?

What could be the impact of a carbon tax?

What are the business opportunities arising from the need for reliable power?

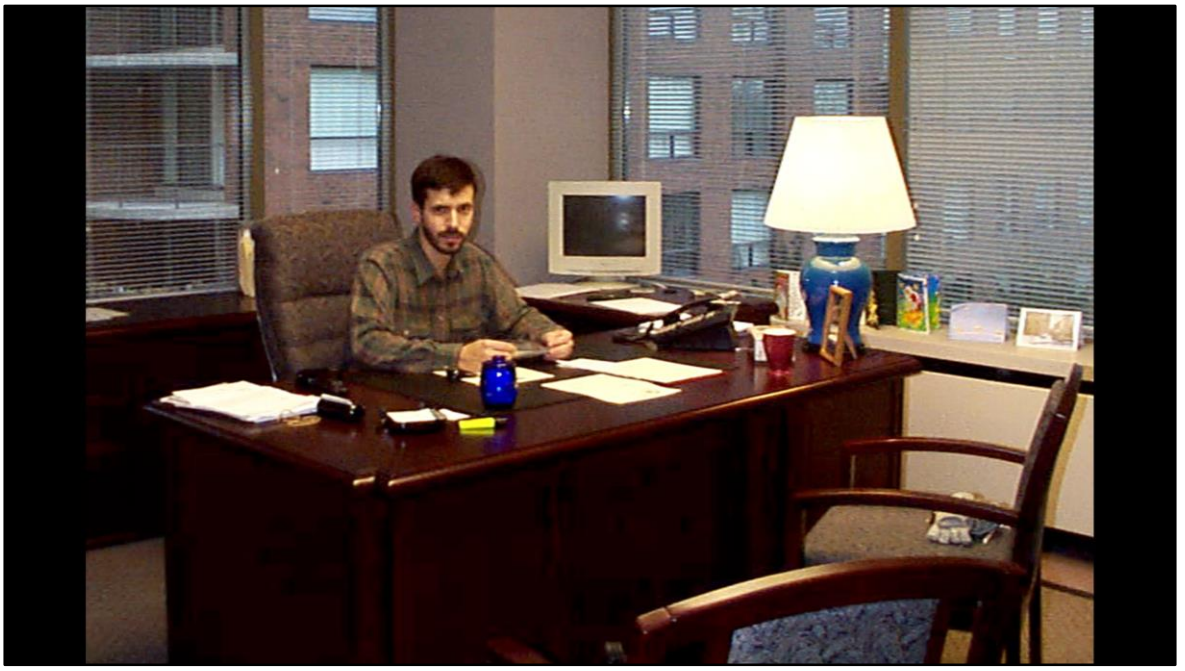
S&C Electric Canada Ltd. has been conducting industry leading analysis into these major market developments that shake up the power arena status quo. While electric utilities have seen tremendous transitions during the 125-year history of the CEA, the current rate of development is unprecedented. To paraphrase a famous quote by Wayne Gretzky, utilities need to "skate to where the puck is going to be, not where it has been." This presentation will provide power utilities with some insights into the future direction of the puck!

I would like you to meet Maurice, my father, working at Hydro-Québec as a distribution dispatcher in 1960. I was really proud of him as I thought that my father made a difference in people's life, helping to restore power during storms. I grew up reading about the big dams being built in Northern Québec.

A lot of things have changed in the industry since then. Just look at the rotary phones on his desk. The black ones are connected to Bell Canada external calls. The green one is on the internal Hydro-Québec phone network, not connected to Bell because Bell didn't want Hydro to bypass its network. Essentially, Hydro-Québec was operating its own telephone microgrid. Sometimes, guys building the dams would call my father on the green phone and ask him if they could to talk to their wife. He would dial the wife on the black phone and hold the 2 handsets together, bypassing Bell's network. (Make a gesture with the hands, thumbs to little fingers). Sound was bad, the conversation was certainly not private, but it was free.

Also, notice that he was smoking in the office – that has changed too. Eventually, this would contribute to his death, but he continued coughing and smoking for many years.

Photo: Benoit Marcoux, family collection.



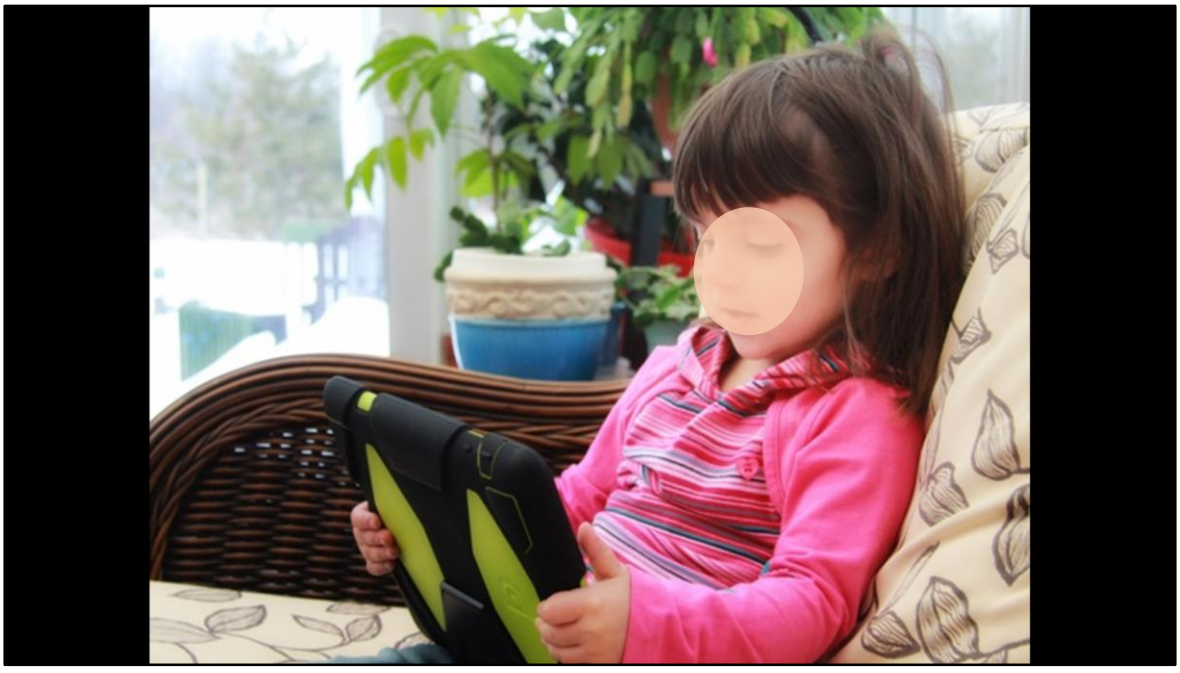
Fast forward to 1997, 20 years ago.

Cancer had not killed my father yet, but I was here in Toronto doing my best to kill Bell's traditional phone business. I was then operating what was the world's largest Internet telephony network. We offered wholesale international phone minutes at perhaps ten cents per minute instead of dollars per minute. We carried a million minutes of international phone traffic per day between 16 countries, bypassing local monopolies, much like my father did, but on a global scale. The telephone network carried billions of minutes of calls per day, so a million was not much, but it was a clear start.

Most people looked at us and said that Internet telephony would not work, that we could only survive by bypassing legal monopolies on a few routes, that voice quality was not good enough, that the IP telephony technology was not reliable, blah, blah, blah… Like my father smoking cigarettes, phone companies were in denial. But our customers liked our service because is was cheap, like the guys building the dams like my father's services.

Eventually, Skype launched in 2003, the iPhone launched in 2007, and the rest is history. By then, most phone calls used the Internet protocol at least part of the way. Traditional calls were already the exception.

Photo: Benoit Marcoux, family collection.



Now, please meet my two-year-old granddaughter, Clémentine. She loves her well-protected iPad and gets angry when the batteries run out.

Last night, I did a FaceTime videoconference with her and the marginal cost was zero, entirely bypassing the phone system. In just a few years, the Internet has replaced the Plain Old Telephone System that took over a century to build.

Could it happen to electric utilities? Well, it is already happening.

I am telling you that, within 10 years, you will buy bulk solar for one penny per kWh, and it will change everything.

Photo: Benoit Marcoux, family collection.

Look at the facts. Bloomberg has been tracking the cost of all-in system price for utility-scale solar arrays. It was $5 per watt in 2010, but $1.65 in 2016*, dropping on average 17% per year. We are now seeing new systems being built for $1 per watt, or 1 million dollars per MW. That is the price to build a Combined Cycle Natural Gas plant, but the sun is free and operating costs are essentially limited to window washing.

Right now, solar is the cheapest form of energy in 60 countries. **

Right now, bulk power purchase agreements for solar come in at about 3¢ or 4¢ per kWh in sunny areas, like in Dubai*** and southwest US. Large wind farms are at almost the same level.

Right now, there is a bill in front of the Wyoming state legislature to tax renewables in order to favor local coal producers. You know that you are onto something when it is being taxed. ****

Continue the same trend for 5 to 7 years and you will be at 1¢ per kWh for bulk solar power. There is no reason for this not to happen. Solar panels and power conversion electronics are being manufactured at an increasingly large scale. Experience and standardization are reducing the cost of integration. And this does not depend on any technology breakthrough. And then, add a few pennies for energy storage, and you'll have dispatchable power, not intermittent power.

This is very much like Moore's Law that states that cost of computing reduces by 50% every 18 months. That's a little faster than the cost reduction in solar power and energy storage, but it is the same idea.

* https://www.bloomberg.com/news/articles/2016-12-15/world-energy-hits-a-turning-point-solar-that-s-cheaper-than-wind, retrieved 20170127.
** http://www.sciencealert.com/solar-power-is-now-the-cheapest-energy-in-the-world, retrieved 20170127.
*** http://inhabitat.com/phase-3-of-worlds-largest-solar-park-slated-to-begin-this-month/, retrieved 20170127.
**** http://www.forbes.com/sites/williampentland/2017/01/18/wyoming-considers-de-facto-prohibition-on-solar-and-wind-energy/, retrieved 20170211.
Photo: Benoit Marcoux.

A great example is the village of Minster in Ohio, which signed a solar+storage power purchase agreement with Half Moon Ventures at just $0.07/kWh.* This is a 3 MW solar array backed up by an 7 MW/3 MWh energy storage system.

A new array and storage system is being planned, which will turn the entire village into a microgrid, and Dannon yogurt will be expanding its factory there to take advantage of it.

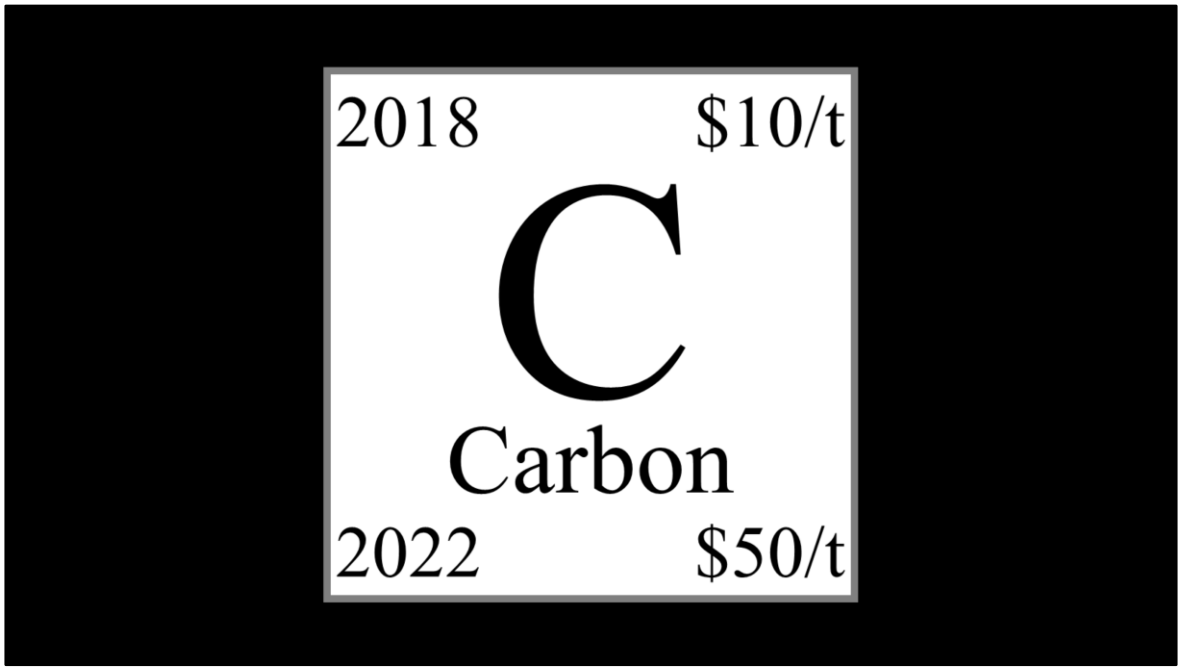
Reminder, Minster is in Ohio, which borders Ontario, across lake Erie. If it works in Ohio, it works here.

Trend this forward a few years and solar + storage will transform the electricity industry, wherever you are.

OK, then you may think that this is because of the carbon tax.

* http://www.utilitydive.com/news/inside-the-first-municipal-solar-plus-storage-project-in-the-us/421470/, retrieved 20170127.

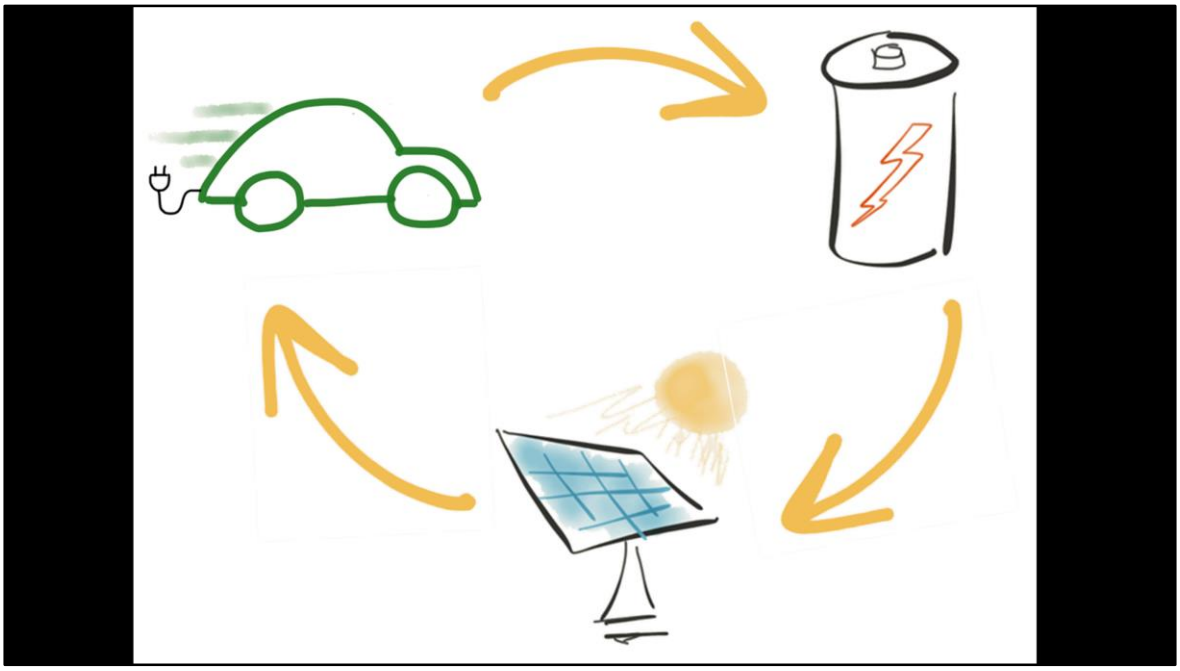
Photo: S&C.



The federal government does have a plan to tax carbon emissions at a price of $10 per ton of CO_2 in 2018, going up to $50 in 2022. Québec, Ontario, Alberta and BC have separate plans. For a Combined Cycle Natural Gas plant, the federal plan translates to about 0.5 ¢ per kWh in 2018, going up to 2.5 ¢ in 2022. For coal, that would be 4 ¢ in 22.

But the thing is that solar + storage is already competitive with traditional generation – a carbon tax is not needed to justify renewables on an economic basis. I would even say that having a carbon tax is emotionally charged, and that's sidetracking the main discussion on low-cost renewables. In any case, the true environmental cost of carbon emissions is probably $200 or $300 per ton, so the current tax numbers do not even reflect reality.

So, the insight here is that the low cost of renewables makes a carbon tax largely irrelevant for the power industry.



Much of the energy transition now benefits from a virtuous cycle between solar power, electric vehicles and energy storage.

Electric vehicles drive massive investments in battery manufacturing. Bloomberg has been tracking the cost of battery packs from $1000/kWh in 2010 to $273/kWh in 2016.* It will be $100/kWh in a couple of years. At this price, electric vehicles are more than competitive with vehicles with an internal combustion engine.

This also reduces the cost of fixed utility-scale energy storage. Utility-scale storage makes the sun shines and the wind blows 24 hours a day. And then, electric vehicles can be recharged by inexpensive solar energy during the day.

None of this cycle relies on a technical breakthrough in energy storage, solar arrays, self-driving vehicles, or new business models like car sharing. However, given the level of investment in those domains, we may see some breakthroughs that will just accelerate the virtuous cycle.

What are the consequences of this for T&D utilities?

* Bloomberg New Energy Finance, Advanced transport Research Note, Dec. 2016

Obviously, electric vehicles and, more generally, transportation electrification, are a growth avenue for utilities. This is good as electricity consumption is otherwise growing slowly, thanks to energy conservation programs and the advent of a service-based economy.

Most of the oil in Canada is used for transportation, and utilities will become the new oil companies – not a bad thing to be, in my opinion.

By the way, all this should also keep the price of oil and gas low for the foreseeable future, bar an international crisis.

Solar+storage plants do not need to be scaled up to gigawatts to be cost effective. You'll have more 100 MW-scale plants, and even some smaller ones connected to distribution. For example, Florida Power & Light just announced that it will build eight 75 MW solar plants across Florida – a total of 600 MW.* Solar and storage do not even have to be collocated.

This implies that the T&D network will become an energy interchange network, with two-way power flows, advanced protection, self-healing and demand management. A modern grid will be a key instrument to balance renewables. Renewables are not a threat to utilities. Renewables are a growth factor for energy service providers.

* http://finance.yahoo.com/news/fpl-accelerates-major-solar-energy-161300168.html, retrieved 20170220.

Obviously, many homes and businesses will have solar panels, but not many customers will actually go off the grid in the foreseeable future, because off-grid requires oversized solar panels and batteries to account for sunless days.

However, grid-connected behind-the-meter solar generation could still cost less than the power distributed by utilities – it may be more than a penny, but it will still be low enough to be justified.

+ Add behind-the-meter storage and business customers can improve their load factor, reducing costs.
+ Add uninterruptible power systems and businesses can protect themselves from short service interruptions.
+ Add microgrid capabilities and businesses can protect themselves from sustained outages, while contributing to demand management, peak shaving and grid stability.

Local generation and microgrids are becoming increasingly attractive to customers whose operations depend on reliable power.

Photo: iStock.

This is an example of distributed microgrid controllers. In this case, the controllers are the grey boxes installed beside these bidirectional electric vehicle chargers on a military base in Colorado.

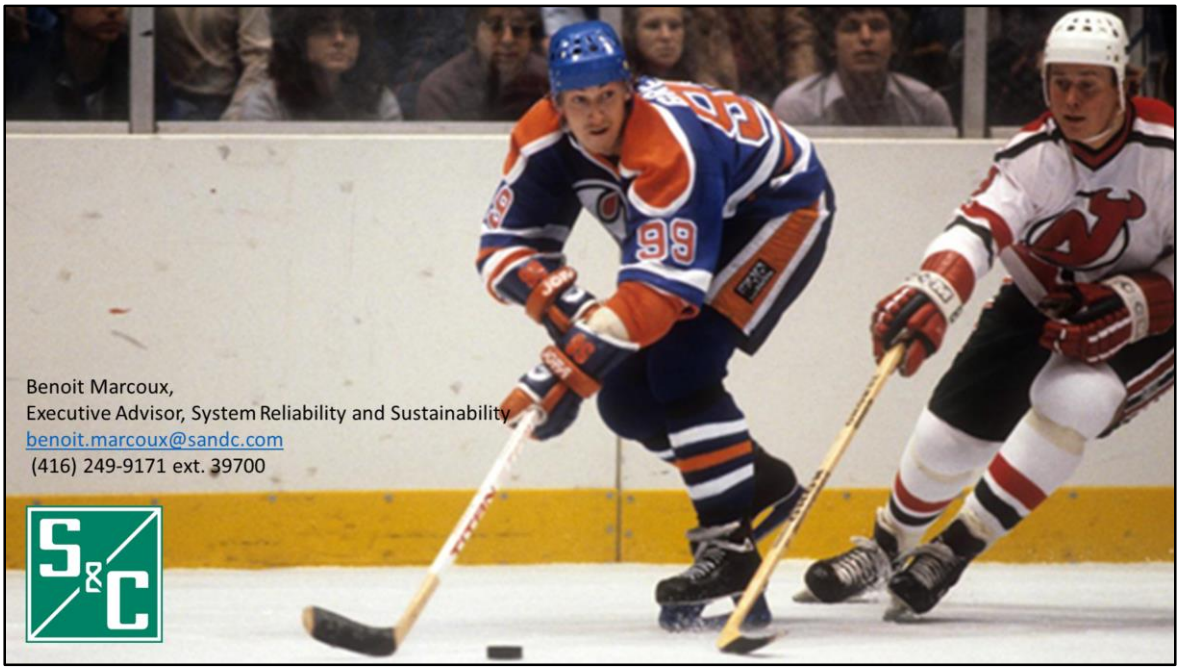
Like Clémentine and her iPad, business do not like to run out of power. Unlike Clémentine, more and more businesses are willing to pay to have resilient operations using microgrids.

Business customers will be looking up to utilities, with their brand name, to help them out making sense of all this. There is an opportunity for utilities to have deregulated microgrid offerings, and many are doing just that.

Some utilities, like Green Mountain Power in the state of Vermont, even help remote consumers to go off the grid. It just makes business sense as it is more cost-effective for all parties, and you will see more of this type of arrangement.

In this new environment, regulatory changes are needed to avoid cross subsidies between classes of customers – it took years for telecom regulators to figure this out. However, you should expect more deregulation and incentive-based regulatory schemes.

If you look at how it played out in telecom, the large telecom players like Bell, Telus, Rogers, Shaw and Videotron are still around, but they have merged, split, morphed, and grown into new sectors, like media and content. Chances are that the same kind of changes will come to utilities.



The advent of low-cost renewable energy is the trigger of a major transformation of the electricity industry, just like the Internet caused the transformation of the telecom industry. Low-cost renewables will continue to get less expensive, at perhaps 20% a year, as will batteries. This will transform the electricity network in a “grid of microgrids”.

Now that we know where this journey is taking us, winning utilities will be the ones who, like Wayne Gretzky said, will skate to where the puck is going.

At S&C, our responsibility toward you is to be there with you with the energy storage, microgrid, advanced protection and self-healing systems that you need in a world of low-cost renewable energy. We’ve helped develop almost 3000 MW of renewable energy. We’ve integrated almost 200 MWh of energy storage, from four different battery chemistries on five continents. Our experienced engineers understand the challenge of integrating solar and storage plants.

The CEA has existed for 125 years, S&C has existed for over 100 years, and, with our partners in the industry, we will be around to ensure the success of your projects in the years to come.

Thank you,

There is a handout for this presentation with a real Canadian penny glued on it, so do not forget to come and get your penny later.