

Abstract: *The telecom industry has seen tremendous changes, replacing in just a few short years the Plain Old Telephone System that took over a century to build with the Internet and cellular networks. Since telecom and electric utilities have a lot in common, like linear assets, large customer base and territory, and technology-driven culture, what can we learn from the transformation of telecom to better manage the ongoing technological changes in electric utilities?*

Thank you.

The electricity industry has perhaps not seen that much change since the days of Thomas Edison. Incredibly, he could still recognize the major components of a distribution network. However, Alexander Graham Bell would not be recognized today's Internet and cellular networks.

In order to appreciate **what the future may hold for us**, I would like today to take you on a very **personal journey**, looking at what **happened in the telecom** industry over the last decades.

Hopefully, this will show that we all have a great future ahead of us.



I would like you to meet **Maurice**, my father, working at Hydro-Québec as a distribution dispatcher in 1960.

Technology has changed too. Just look at the **rotary phones** on his desk. The **black** ones are connected to Bell Canada for 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 dams** in Northern Québec would call my father on the green phone and ask him if they could talk to their wives. 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 bypassing Bell was free.

Photo: Benoit Marcoux, family collection.



Fast forward to 1997, **20 years ago**.

I was in Toronto doing my best to bypass Bell's traditional phone business. I was then operating the **world's largest Internet telephony network**. We offered wholesale international phone minutes at a few **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. We were tiny in a global telephone network that carried billions of minutes of calls per day, but it clearly announced what was to come.

Phone companies were in denial. Traditional telephone folks looked at us and said that Internet telephony would not work on a large scale, 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... But our **service was inexpensive and convenient**, and customers liked it, 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 facing **extinction**.

Photo: Benoit Marcoux, family collection.



Now, please meet my **two-year-old grandson, Charles**. He loves his ruggedized iPad, especially to watch amateur baby videos on YouTube.

Last night, I did a **FaceTime** videoconference with him and the **marginal cost was zero**, entirely bypassing the phone system.

In just a few years, the **Internet has replaced a century-old infrastructure**, and it happened **much faster** than people in the telephone industry thought possible.

Ask yourself: **Could it happen** to electric utilities?

Well, within 10 years, you will **produce and buy bulk solar or wind for one penny per kWh** and matching storage for not much more, **balancing and transiting it all on your network**.

This is fundamentally changing the economics of the electric utility industry.

New economics will redefine our relationship with customers and cause us to operate our systems in new ways.

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 has been **dropping by 17% per year* since 2010**. We are now seeing new systems being built for **less than \$1 per watt**, or 1 million dollars per MW. That is the price to build a 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 less than **3¢ per kWh** in sunny areas. Large wind farms are down to 2¢.†

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. ***

Trend this out perhaps **5 years and you will be at 1¢** per kWh for bulk renewable 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.

If you think that costs will level off, think again: solar penetration is well ahead of the past forecast, as we have been **consistently underestimating** it.**** This is very much like Moore's Law in computing, but for solar, wind and energy storage.

What the Internet and wireless did to telephone companies, solar, wind and storage will do to electric utilities. So, let's see what the future of electric utilities may look like. I would say there are 3 key points.

* <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.

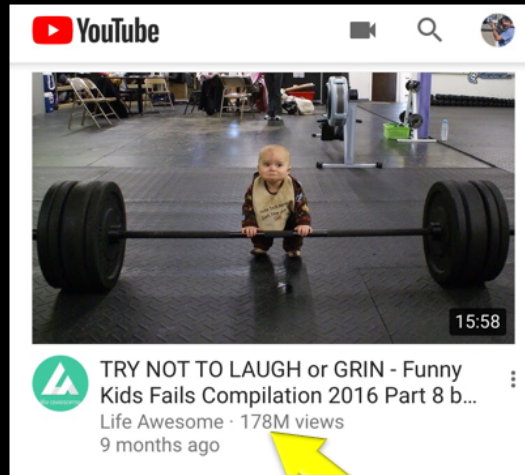
† https://blogs.scientificamerican.com/plugged-in/wind-energy-is-one-of-the-cheapest-sources-of-electricity-and-its-getting-cheaper/?wt.mc=SA_Twitter-Share, retrieved 20170906.

*** <http://www.forbes.com/sites/williampentland/2017/01/18/wyoming-considers-de-facto-prohibition-on-solar-and-wind-energy/>, retrieved 20170211.

**** The underestimated potential of solar energy to mitigate climate change, Felix Creutzig et al., Nature Energy, 25 August 2017.

Photo: Benoit Marcoux.

Power from the People



First, with low-cost renewables, **customers will become power producers**, whether you want it or not, and it will transform our relationship with them.

In media and telecom, ordinary people also became producers. Charles loves to watch amateur baby video on YouTube. This one has been viewed **178 million times**. Every time, there is an ad and the daddy or mommy who produced the video gets a bit of money. Overall, videos that people put on YouTube generate **\$15 billion a year in advertising revenue**.

In our industry, low cost solar means that many customers will **generate power, with or without incentives or net metering**. It will just make sense. They may just take the free electrons when they can, and **wasting them if they can't neither use nor sell them**.

And by the way, we have **cut down on our cable TV** subscription. Customer-owned generation will have a similar effect on utilities. Many will have solar panels and they **will buy less** from you.

In essence, for the first time, utilities will see **competition from their own customers**.

The Power of Choice



Second, people will have more choice in how they buy, use or sell energy product and services.

The electricity industry will be a whole **ecology of vendors** helping customers building and managing microgrids or bringing power to market, basically monetizing of the difference between a **penny per kWh and a dime** per kWh. Just like consumers can **call loved ones** with Bell, FaceTime or Skype, electricity customers will have more choices than ever.

This is a real business opportunity for electric utilities to diversify and to become **Energy Service Providers**, just **like telephone** and cable companies went into media, content and infrastructure management. Customers will be looking up to utilities, with their brand name, to help them out making sense of all this.

This is the chance for **utilities to have deregulated microgrid offerings**, and many are doing just that.

Powerbroker



Thirdly, the distribution grid will become an **energy interchange network**.

The main business of the distribution grid will **not be to distribute energy**, but to be a **common carrier for energy brokered through its network**, possibly with **Blockchain** technology **facilitating economic transactions**.

- Just like we went from one-way **cable hookup** and **rotary phones** to **broadband Internet access** and **smart TVs**, **distributed intelligence will be pushed to the edge** of the electricity grid or behind the meter.
- Just like **telecom systems reroute around failed lines** and control **set-top boxes**, the electricity network will use **distributed intelligence for two-way power flows**, **advanced protection**, **self-healing** and **demand management**.



Traditional utility wisdom in Canada is that **customers are OK with outages** and that improving reliability would only increase costs and push rates up.

The new reality of electric utilities upends this traditional wisdom.

First, customers are redefining what is meant by quality. Traditionally, Canadian Utilities used duration of interruptions, or SAIDI, as their main measure of reliability. To optimize SAIDI, Canadian Utilities adopted a **fuse saving protection strategy**, which unfortunately means a lot of short interruptions for many customers. However, **customers are far more sensitive to the number of outages** because even a short one, resets electronics, stops manufacturing processes and **throws distributed generation off-line** for a sustained period. Interruption frequency metrics like SAIFI and MAIFI, or simply the number of service interruptions, will replace SAIDI as our main quality metrics.

By the way, the **telecom industry went through a similar redefinition of quality**. It used to be that the main quality measure was sound quality during a call. Nowadays, customer satisfaction is driven more by the convenience of mobility and the possibility of easily doing videoconferencing or multiple parties calls.

What Drives Operating Costs

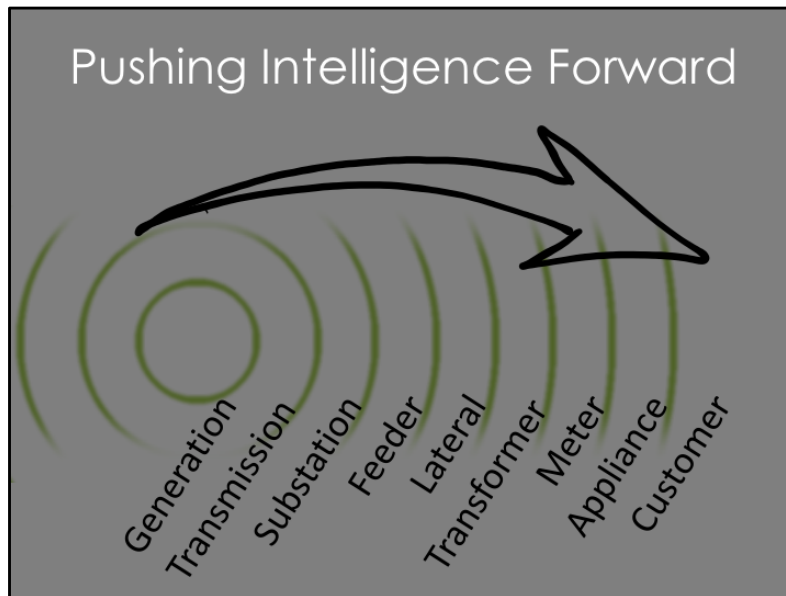
☒ SAIDI

☒ SAIFI / MAIFI

Second, the number of interruptions is what is driving operating costs, not the duration. Replacing a blown fuse costs the same whether one or 100 customers are affected, and whether customers have been out of power for 10 minutes or 10 hours.

We are then seeing that the **service quality perceived by customers and the operating cost drivers of utilities are getting more and more aligned.**

Where does it lead us to?



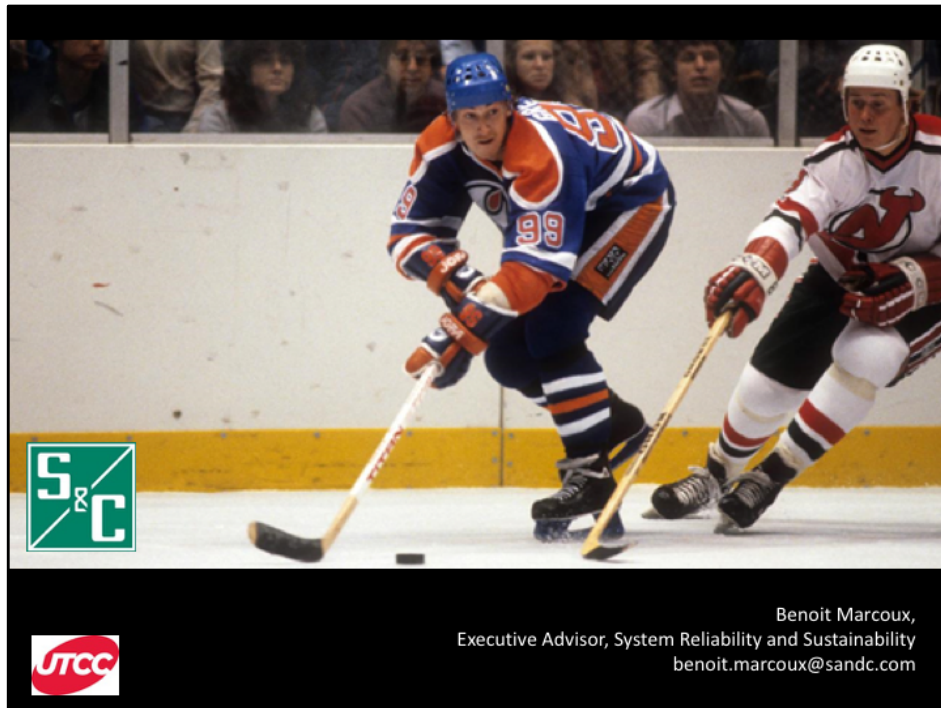
Through the internet and wireless revolution, **telecom companies have pushed intelligence deep in the network**. The central office and the cable head end have effectively moved curbside or halfway up wood poles. Other examples are edge computing and smart set-top boxes.

In order **to improved perceived service quality and to keep operating costs down, utilities are starting to do the same**. We all know about smart appliances and smart meters. But we see intelligence being pushed forward into the distribution grid with:

- Customer and utility **microgrids** to integrate renewable sources;
- Community energy storage (**CES**) to shave peak and to keep the light on;
- **Lateral reclosing** to clear faults near where they occur and to avoid truck rolls;
- Advanced **2-way protection** to account for distributed generation;
- As well as smart switches to **automate restoration** on feeders;

Using modern protection and control strategy along with energy storage deep into the grid, we can **reduce the number of service interruptions, which improves customer satisfaction and operating costs**, all at once. It is win-win-win.

However, to achieve those objectives, utilities need **system-wide focus and integration**, just like telecom companies have. It cannot be piecemeal and has to be system wide. This system approach is the only way to minimize the number of **customers affected** by a fault, with **protection moved to laterals** and sublaterals and **microgrids and distributed storage** that maintain electrical service through disruptions.



Low-cost renewables will continue to get less expensive, at perhaps 20% a year, as will batteries. They are the triggers of a major transformation of the electricity industry, just like the Internet and cellular caused the transformation of the telephone industry. The electricity network will become a “grid of microgrids” with intelligence moved to the edge of the network.

Winning utilities will be the ones who, like Wayne Gretzky said, will skate to where the puck is going – the **edge of the ice ring**, in this case.

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 3000 MW of renewable energy. We’ve integrated 200 MWh of energy storage, from four different battery chemistries on five continents, over the last 12 years. We helped implement many microgrids. We have trained engineers to help you.

Thank you,