The shocking business of electricity

McGill U.
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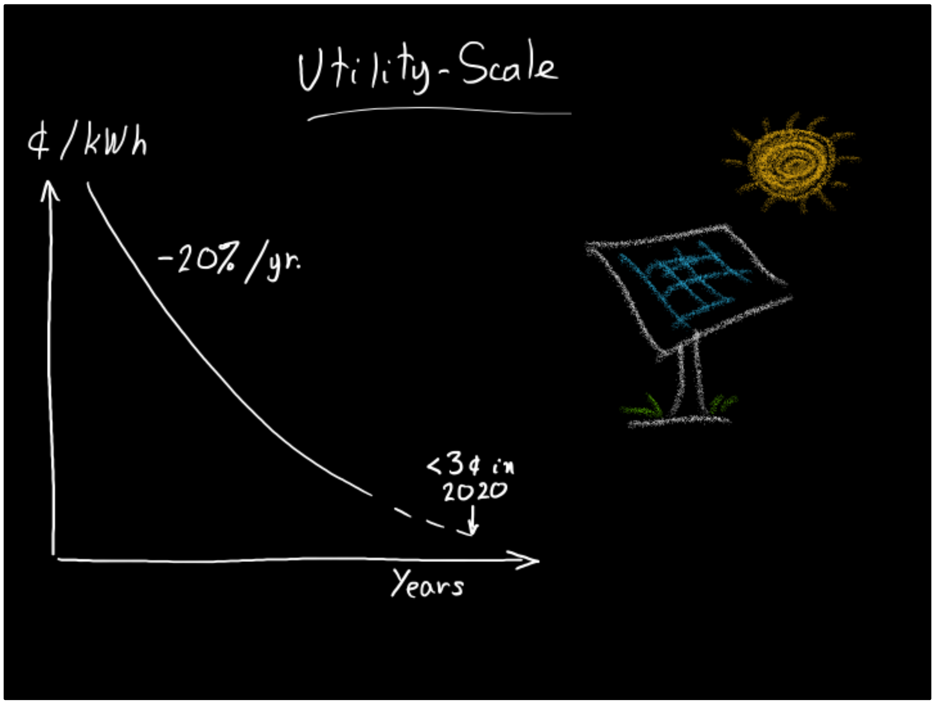
Safe Start slide

Highlight the importance of safety and not only technology in the context of a smart grid. Use my earliest memory (screwdriver in electrical wall socket) and said screwdriver as example.

In the 1880s, Nikola Tesla invented the 3-phase 60 Hz technology still used in the North American electrical grid, which was then commercialized by George Westinghouse, who was competing with the direct current system of Thomas Edison. However, Edison ended up inventing the utility business model, with central generation stations servicing large numbers of clients.

One hundred and thirty years later, the grid is still essentially the same, but it is beginning to transform.

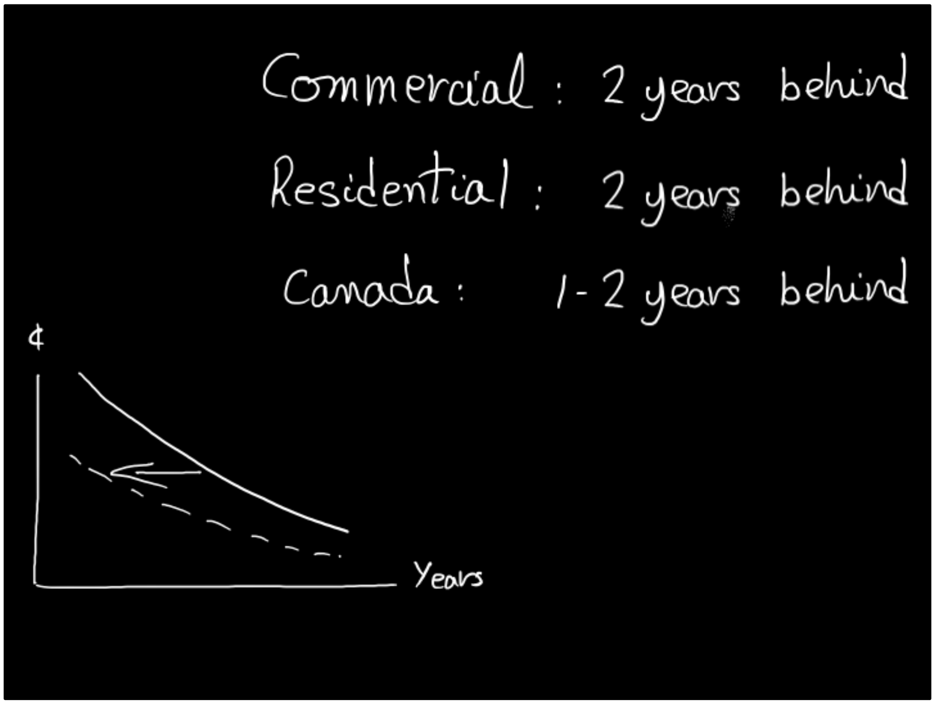


The cost of electricity produced from utility-scale solar PV systems is dropping about 20% a year – that's what feeds the barbarians.

Looking at auction data for systems to be delivered in 2020, we can see that prices will soon be well below 3¢ per kWh for the best utility-scale projects. That does not even pay for the coal to operate an existing coal plant.

But this is not the end.

- Solar is the renewable technology with the most patents, promising further improvements.
- The Chinese are driving it, with the most manufacturing, the best quality, and the largest installed base, and it is enshrined in their 5-year plan.
- Furthermore, the cost reductions are broad-based: solar panels, inverters, balance-of-system, installation, and operations have all seen cost reductions. At the same time, panel efficiency is getting better.
- And battery storage is following more or less the same trend.



That was for utility-scale systems. A hundred MWs or so.

Commercial systems of hundreds of kWs are just 2 years behind utility systems in terms of costs per watt. That is: the cost per watt of commercial systems today is the same as the cost of utility systems about 2 years ago.

Residential systems are just another 2 years behind.

Obviously, Canada does not get as much sun over the course of a year as, say, Arizona. Toronto, Halifax and Vancouver get 40% less than Arizona – but this is only 2 years worth of cost decline. If you are in Southern Alberta, you're in luck, as you're just a year behind Arizona.

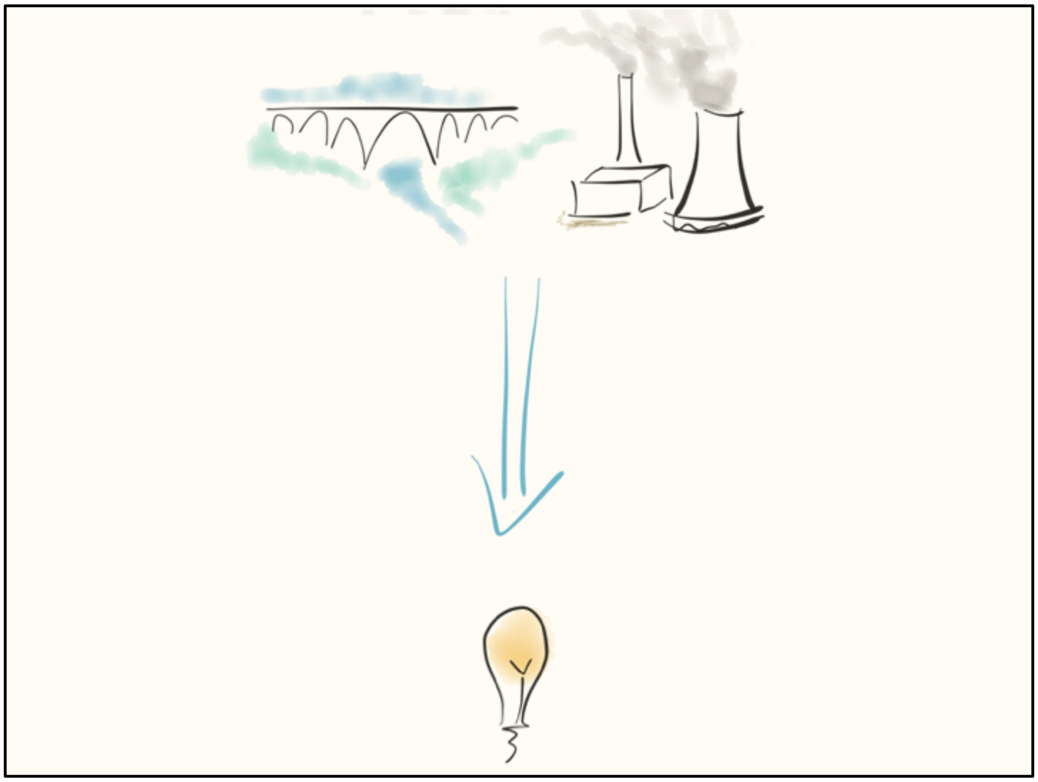
In just a few years, your customers, starting with the commercial ones, will be able to produce energy for much, much less than than they can buy now.

Obviously, barbarians, having learned from other industries like IT and Telecom, take advantage of exponential cost decline like this.

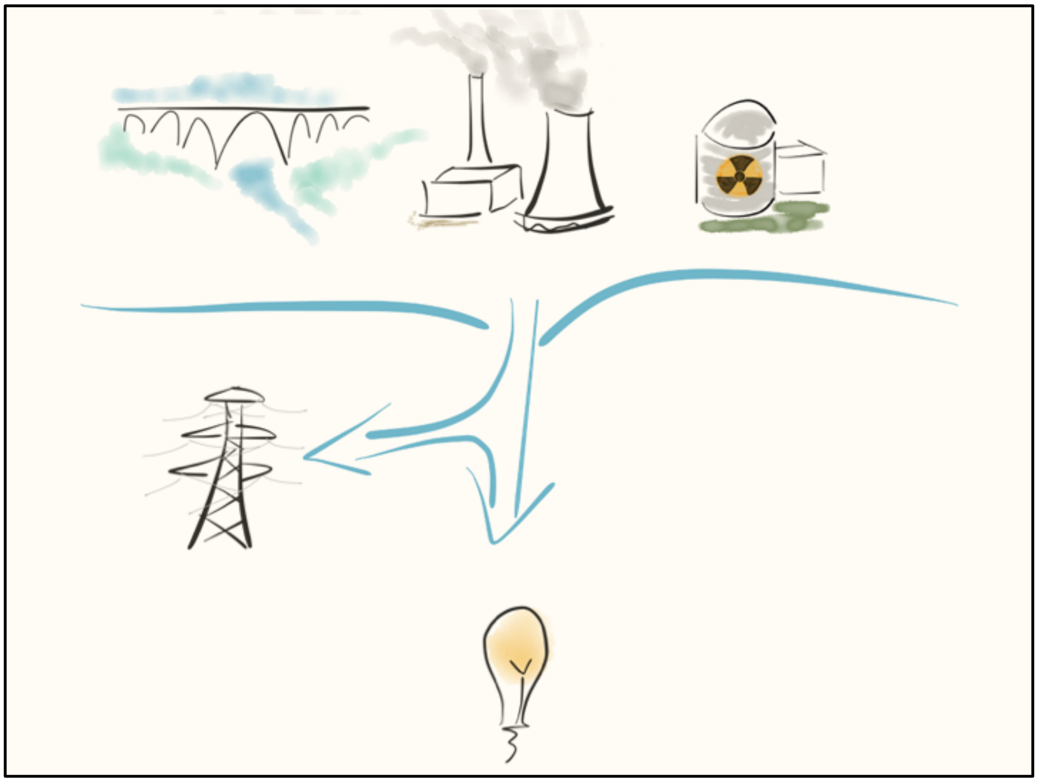
The federal government does have a plan to tax carbon emissions at a price of $10 per ton of CO_2 in 2018, going up to $50 in 2022. Québec, Ontario, Alberta and BC have separate plans. For a Combined Cycle Natural Gas plant, the federal plan translates to about 0.5 ¢ per kWh in 2018, going up to 2.5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

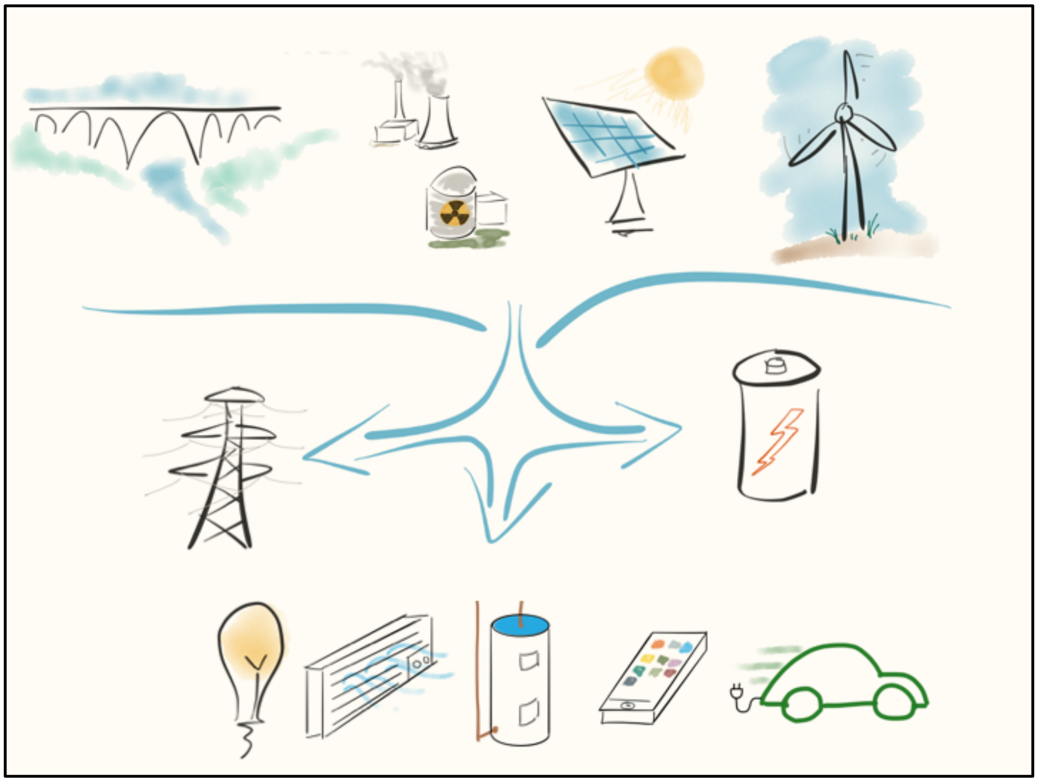


Early on, the grid was simple…



… but overtime new generation and transmission were added.

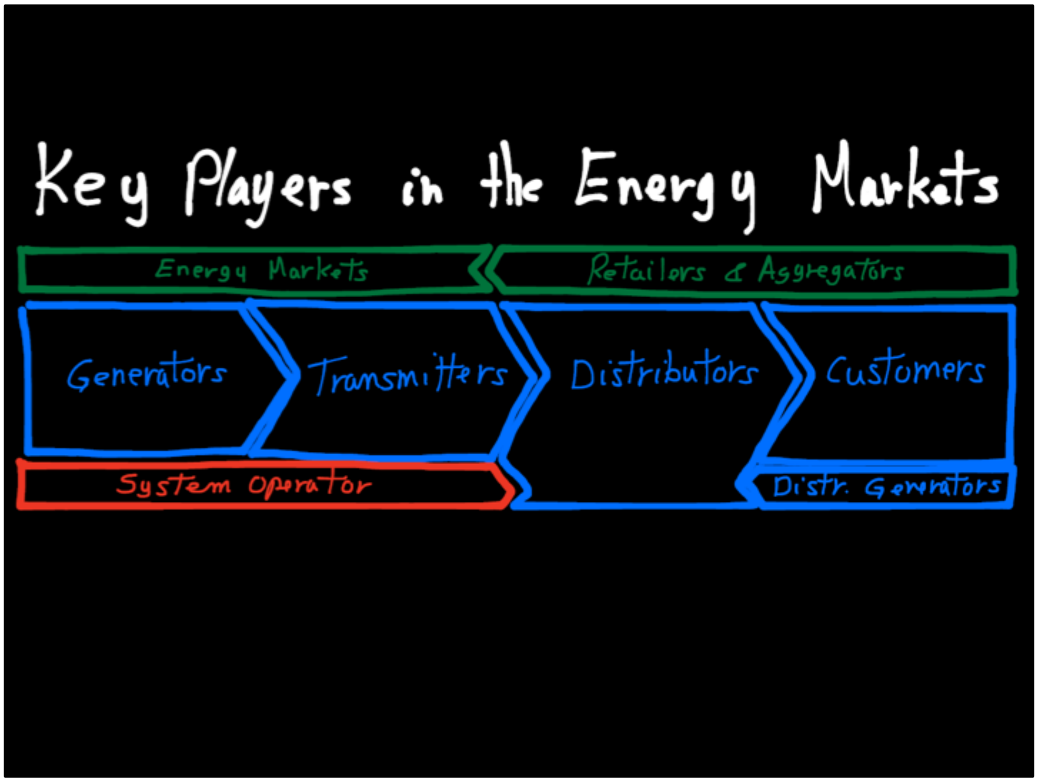
But the electricity industry is now facing new challenges…



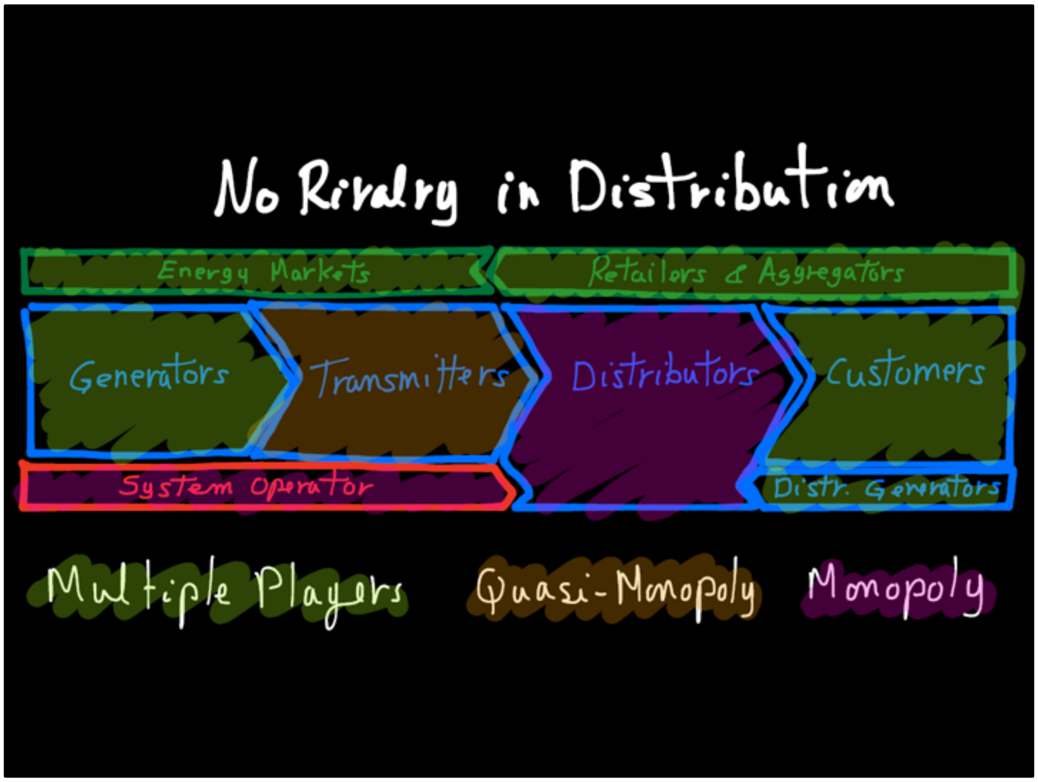
The grid is transforming and getting more complicated.

- We are decommissioning fossil plants to reduce GHG emission and nuclear plants because of safety concerns.
- There is only so many rivers, so the solution of building new hydro plants is not sufficient.
- We are then replacing fossil and nuclear base load plants with renewables that are intermittent.
- To compound the problem of balancing the grid, loads are also becoming peakier, with reduced load factor. Interestingly, many energy conservation initiatives actually increase power peaks.
- To connect the new renewable generation, we then need to build more transmission. The transmission network also allows network operators to spread generation and load over more customers – geographic spread helps smooth out generation and load.
- Building new transmission lines face local opposition and takes a decade. The only other alternatives to balance the grid are storage … and Demand Management.
- Another issue is that we are far more dependent on the grid that we used to be. With electrical cars, an outage during the night may mean that you can't go to work in the morning. So, we see more and more attention to resiliency, with faster distribution restoration using networked distribution feeders as well as microgrids for critical loads during sustained outages.
- Renewable generation and storage can more effectively be distributed to the distribution network, although small scale generation and storage are much more expansive than community generation and storage.
- With distributed generation, distributed storage and a networked distribution grid, energy flow on the distribution grid becomes two-way. This requires additional investments into the distribution grid and a new attention to electrical protection (remember the screwdriver).

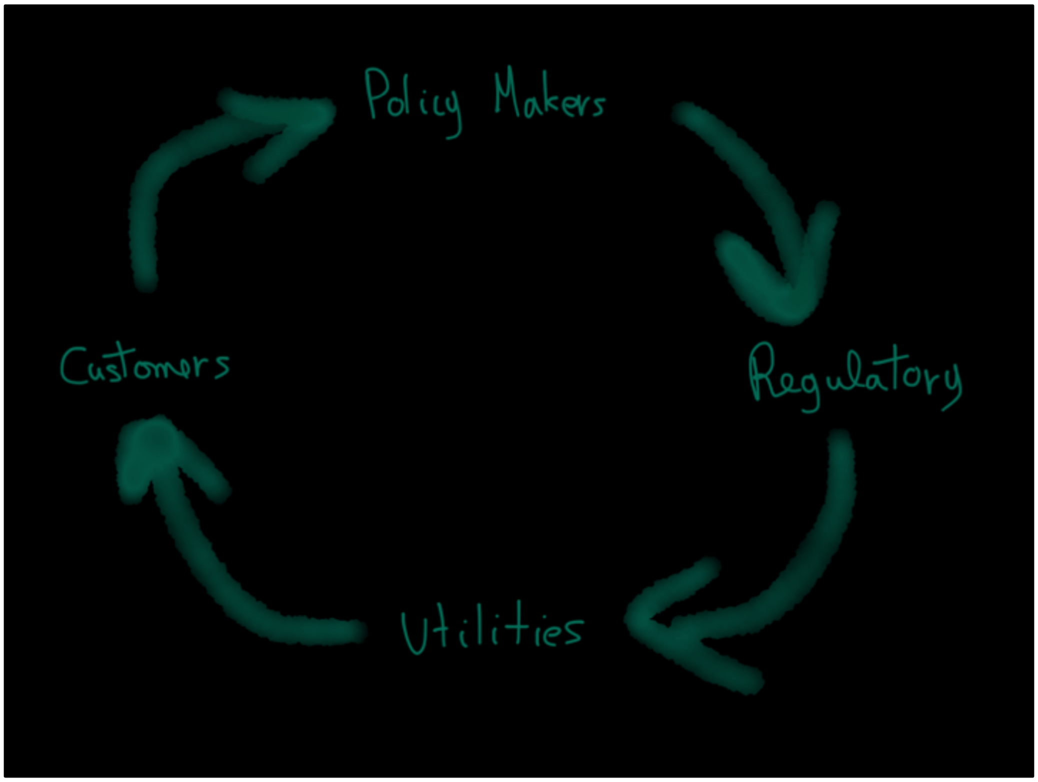
All of this costs money and forces the utilities to adopt new technologies at a pace that has not been seen in a hundred years. The new technology is expensive, and renewable generation, combined with the cost of storage, increases power costs. There is increasing attention to reduction of operating costs and optimization of assets.



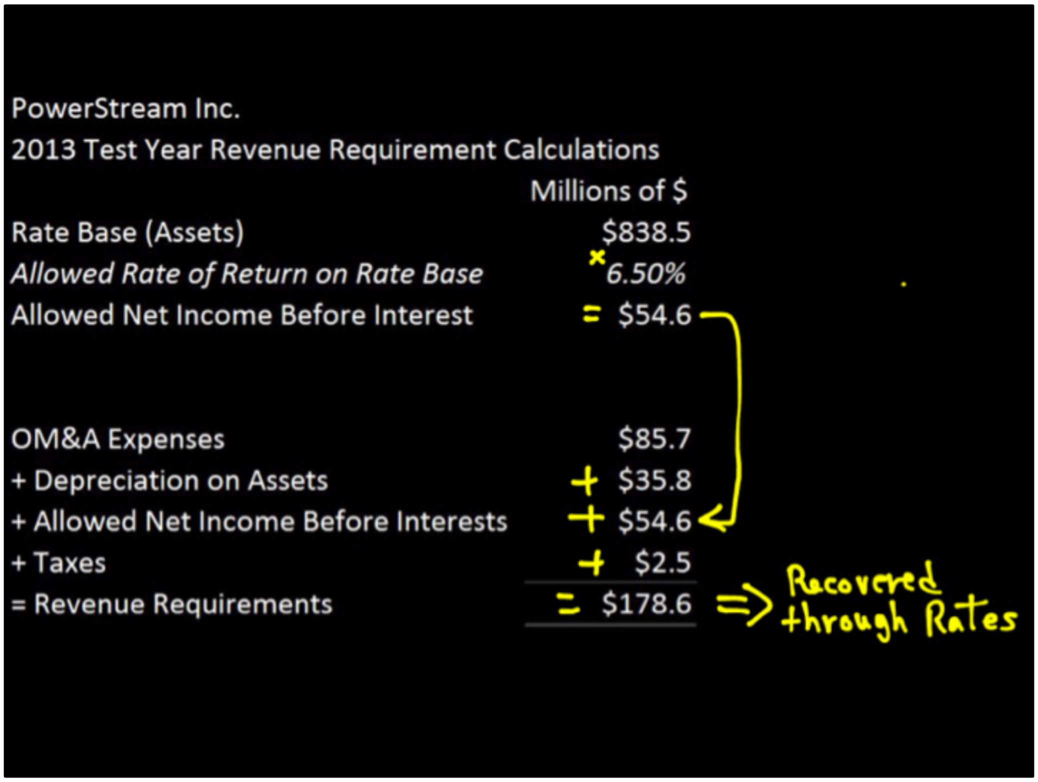
- Traditional large-scale generator own and maintain coal, natural gas, nuclear, hydro, wind and solar plants connected to transmission lines. Those are large plants - typically hundreds of megawatts.
- Transmitters own and maintain transmission lines - the large steel towers seen going from large generators to cities. Those typically run at 120,000 volts and more, up to over 1,000,000 volts in some cases.
- Distributors own and maintain the local infrastructure of poles and conduits going to customer sites. Those typically run at 1,200 to 70,000 volts, usually stepped down to 600, 480, 240 or 120 volts for connection to customers.
- Most customers are connected to distributors, although some large industrial facilities (such as aluminum smelters) are directly connected to transmission lines.
- While customers are connected to distributors, they purchase electricity from an independent retailer or from the retail arm of a distributor.
- With customer installing distributed generation on their premises, they sell back electricity to the market, often through aggregators.
- Retailers buy electricity from generators in an energy market - like a stock exchange, but for electricity.
- By definition, the energy produced at any instant must be equal to the energy taken by customers, accounting for a small percentage of losses in transmission and distribution. (We are starting to see large-scale storage operators, which may act as both consumer and generator, depending they are charging or releasing electricity in the network.) This critical balance is maintained by the system operator that direct generators to produce more ore less to match load; in some case, the system operator will also direct distributors to shed load (customers) if generation or transmission is insufficient to meet the demand.



- Distributors operate in a defined territory, often corresponding to a city, a state or a province, where they are the sole provider – thankfully, as there would otherwise be multiple lines of poles along roads. Retail is often a competitive industry, as there is no structural barrier to having multiple players.
- It is possible to have multiple transmission companies operating in the same territory, each owing one or a few transmission lines. System operators are monopolies over a territory, and they have to maintain independence. They are, in effect, monopolies, although system operators are often government- or industry-owned. Their costs are recharged to the customer base, directly or indirectly.
- Large generators are in a competitive business, competing in an open market, although distributed generators, which are much smaller, usually benefits from rates set by a regulator or a government.



Where utilities are allowed to spend money is first and foremost a policy issue – not a regulatory one, not an operation one. Arguments based on the cost of outages may resonate with policy makers, including Smart City stakeholders, because of public pressure or impact on the economy at large. However, these arguments do not resonate with regulatory agents (who follow policies) nor with utilities (who do not have customer outage costs in their financial statements). Individual users may or may not know their specific costs related to outages, but broad outage cost assessments will not affect them.



Regulated companies look at their business upside-down in comparison to companies operating in a competitive, free market.

Regulated companies take all their costs (operating expenses, depreciation on assets, taxes, even allowed return on their investments) and this is deemed equal to the revenues that they are allowed to recover from their subscribers (clients). This is called *revenue requirement* or *required revenues*. Required revenues are then divided by the energy to be provided (in kWh) to come up with a price (in ¢/kWh). In practice, different classes of subscribers get different rates, but the total has to be equal to revenues requirements.

If there is a significant variance between the projected revenues and the actual revenues, adjustments are made in subsequent years.

Consequences:

- Lowering OpEx means that required revenues will be lowered to compensate, but gross income remains unaffected.
- New investments mean a larger asset base, on which the shareholders are allowed to claim a return, meaning that gross income will be higher.

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