The Data Utility

Preamble

This paper will provide an outline of the data utility concept, the economic theory that underlies its advantages, and a comparison of the datafication challenges faced by governments today to that of past challenges encountered during electrification. The paper will leverage regulatory models used to successfully develop electricity, natural gas and water, and apply the relevant elements to the data transmission challenge. The paper will then lay out a simple economic analysis, guiding principles and sandbox methodology of deployment with a new Franchise Competitive Performance-Based Regulation (FCPBR) model for a data utility market model.

The Problem: Data is Key to Current Social and Economic Well-being Will Become More Important in the Future

Economic growth is no longer characterised by the returns to labour, but the creation and transmission of data. New industries have developed in which their sole product is the creation and manipulation of data. This has allowed our society to grow our economy by better use and allocation of resources, which has improved economic efficiency and quality of life.

Data needs to be transmitted to release its full value. Traditional industries have used data transmission to increase remote monitoring and control to increase productivity. Data has very little value until it is transported to where it has value. This is the equivalent of being able to bring a product to market.

The fundamental social fabric of the modern community is carried through data transmission — access to data transmission is critical to our society's cultural development. Families rely on group text and apps like Facebook or Whatsapp to support, build and maintain the core social fabric. Data transmission is so critical that children as young as five years old have cell phones for safety and connectivity reasons. Most modern families rely on data transmission to enable their core social functions. Twitter is a core communication tool of communities to build narratives and traditions. Our cultural fabric has changed due to our data transmission ability.

Modern democracies depend on the ability of its citizens to access open data transmission services. Data transmission is key to politics, as can be seen by the use of social media in uprisings like the Arab Spring.

Guiding Market Design Principles

Data transmission is key to the economic and social fabric of society. Our success as a society is dictated by our ability to achieve accessibility, security, reliability and affordability of the services we deem to be utilities. A data transmission market design must strike a balance of these four principles to deliver the greatest value to society.

Accessibility

- All people have access to data transmission at a similar cost and quality, no matter their location.
- All types of traffic are treated equal. The system is agnostic to content.
- The data grid is made up of layered networks that have different security standards, and reliability to accommodate all network users.
- Legislative protections for consumers guaranteeing security, reliability and cost certainty.

Security

- The data grid is layered with separate networks accommodating different levels of security.
- Data must be protected, based on central architecture classification.
- Network Security must be hardened by design through hardware and software.

Reliability

- The data grid must be designed to be redundant, resilient and fixable.
- Post-disaster level of reliability for core networks.

Affordability

- The system is designed to be the lowest cost while providing the greatest value for society.
- The data grid must be affordable and be providing service at cost.
- Oversight of an independent regulator and consumer groups.

Lesson Learned from Water, Natural Gas and Electricity Grid Developments

Water, natural gas and electricity grids were developed in much of the world using regulated cost of service market models that provided incentives and consequences to effectively deliver secure, reliable, affordable and accessible service that has maximized social value of the services. These grids have been successfully deployed through an evolving regulatory framework that aims to increase efficiencies. Water, natural gas and electricity grids owe their success to the cost of service regulatory model which has allowed for rapid expansion, low cost and high-quality services. This paper is strictly focused on the grid development only and has not considered the production and consumption components.

History of the Water, Natural Gas and Electricity Grids with Focus on Electricity

The water, natural gas and electricity grids started at different times but in the same way. A generalized summary of their development is as follows.[1][2][3][4][5] Development of the grid began with technological innovation and need which made the utility service possible. This may have included pumps, drilling or generators that were developed to address the needs of an increasingly urbanized population that did not have access to clean drinking water, heating or lighting. This facilitated the need to construct linear infrastructure to allow the technological innovation to meet the need.

Private companies took the lead setting up small grids distributing their product. These private companies were most likely the primary consumers of the product themselves. Electricity grid development followed this patterned most distinctly. Regions did not always follow this pattern specifically, but generally the first locations of technology deployment followed this pattern with late adopters skipping steps. By default this created a facilities-based competition market model. As the service became increasingly adopted and prices of primary production dropped, networks expanded further from their original primary users with new providers entering the market that were purely producers. In general, multiple network connections only exist on the edge of the overlapping radial grids. This led to urban electrification while the rural areas were left dark. This was not a concern to general society since electricity was not seen as critical to the social and economic fabric of the society.

As electricity became critical to the social and economic outcomes of the society, its value definition switched from an individualistic lens to a collective lens. This brought rise to a need for a market to achieve maximized social value. Town councils stepped in and either started their own electricity companies or formed central buying authorities to barter on the behalf of their citizens to drive down costs by providing lower grid infrastructure cost and bring long-term stability. Grid utilization was drastically increased by the change in market structure and the change to a collective consumers with larger bargaining power.

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[1] "How electricity grew up? A brief history of the electrical grid." *Buzz: The Power2Switch Blog*. Last modified October 25, 2012. https://power2switch.com/blog/how-electricity-grew-up-a-brief-history-of-the-electrical-grid/.

[2] “Powering Generations.” *TransAlta*. Last modified January 26, 2012. https://issuu.com/rapidbooks/docs/transalta-book?layout=http%253A%252F%252Fskin.issuu.com%252Fv%252Flight%252Flayout.xml&showFlipBtn=true.

[3] "History of the electricity market." *Alberta Utilities Commission*. Accessed July 22, 2019. http://www.auc.ab.ca/pages/history-electric-industry.aspx.

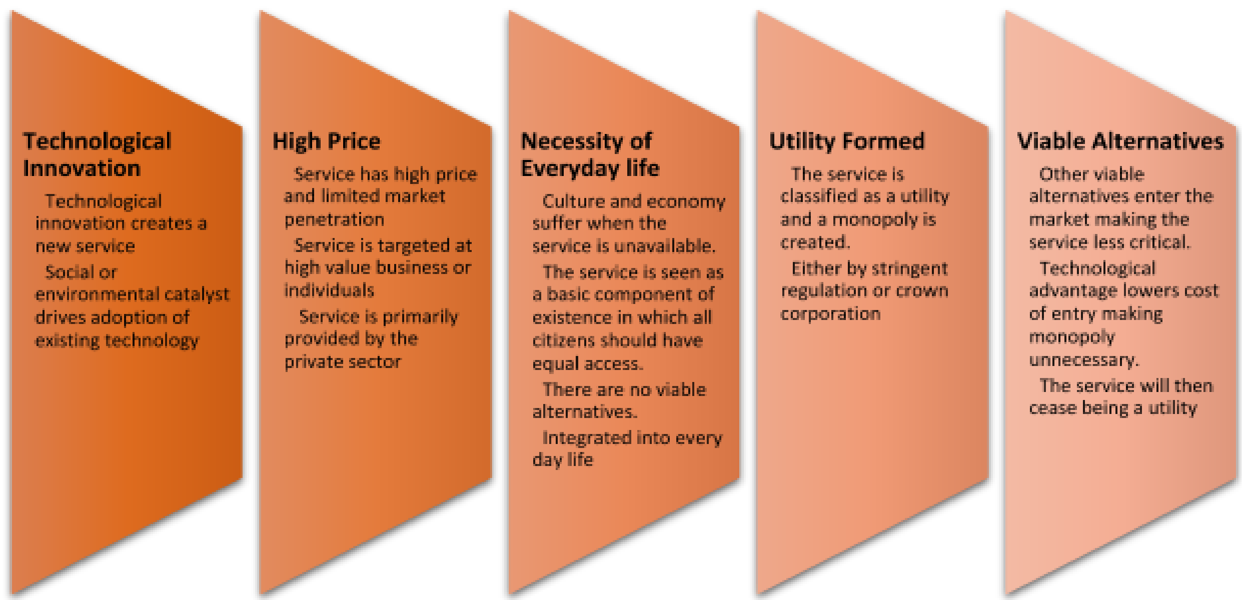
[4] "A History of Electric Power in Manitoba." *Manitoba Hydro*. Accessed July 22, 2019. https://www.hydro.mb.ca/corporate/history/history_of_electric_power_book.pdf.

[5] “History of Electricity.” *Institute for Energy Research*. Accessed July 22, 2019. https://www.instituteforenergyresearch.org/history-electricity/.

Market evolution from this point on varies by region. Cost of service models are common to all variations, but have different incentives and consequences built in to the market in an effort to achieve improved accessibility, security, reliability and affordability. Some examples of regional variations are ownership models, central planners and performance incentives. A utility become synonymous with a cost-of-service market model.

As technology changes and societal expectations change, electricity grids may not be needed and the utility could be dissolved. This change could be due to technology that allows for harvesting of electricity in sufficient quantities at the source for a low price. This would then make the power grid obsolete. A diagram of the lifecycle of the utility can be seen in Figure 1.

Figure 1: The Lifecycle of a Utility



Cost-of-Service Utility Market Design Basics

Characteristics of a Utility Service
Only a select type of service can be cost effectively delivered by a utility under a cost of service rate model. These types of services are said to have natural monopoly tendencies. The service needs to have either of the following characteristics to be more efficiently run as a cost of service utility.

- A customer must have no other choice in service provider since the market is too small for multiple service providers due to the economies of scale. This results in a natural service monopoly. An example of this would be grain elevators in the early 1900s.
- Linear infrastructure with full network utilization and master planning results in lower prices then multiple networks (water, natural gas grid, electricity grid).

In order for the service to be classified as a utility it must meet the following criteria:

- A business that provides an everyday necessity to the public.
- Equal access is demanded by society.
- Reliability and security are critical to national interests.
- Capital intensive business.
- A commodity that cannot be stored and in which the customer cannot economically withhold.
- No viable alternatives of service.

It’s important to note that not all services become and remain a utility permanently. As technology changes and societal needs change, the service classification of a utility changes. As an example, railways in Canada were formally considered to be a utility, but with the improvement in road networks and trucking technology their utility status was removed. Trucking provided cost effective competition to balance the market without regulatory oversight.

The Data Utility

The data market can be derived into four primary elements below. The data utility scope is only focused on the data transmission and distribution section of the market. The other market segments would result in poor natural monopolies and should remain as facilities-based competition. The data utility would cover both wired and wireless infrastructure for data transmission and distribution.

Data Creation, Modification and Consumption

- Cell phones, computers, televisions
- Placing a phone call
- Watching a movie on Netflix
- Reading or creating an email

- Streaming or uploading to YouTube

Data Storage
- Server farms
- A hard drive on a personal computer

Data Transmission and Distribution
- Intercountry fiber optics
- Intercity fiber optics
- Last mile fiber optics
- Antenna and towers

Data Retailers
- Procures wholesale data access from utility and resells to consumers

The data utility would be composed of multiple agencies whose role it is to define incentives and consequences with control and enforcement. See Table 1 below for a summary of the agencies and actors.

Table 1: Summary of Agency and Actors

Agency	Structure	Role
Government	Government	Passes acts and regulations creating the agency and market below. Defines high-level accessibility, security, reliability and compensation requirements
Surveillance	Government	Investigates market participants for compliance
Public Utilities Board	Quasi-judicial government appointed	Determines utility profits, data grid rules, compliance and tariffs
Public Data System Operator	Arms length non-profit organization of government	Defines network architecture and reliability requirements. Determines where large interregional lines are required
Data Utility	Private investor owned	Ownership and operation of the data utility infrastructure
Intervenors	Consumer, industry advocacy groups	Hold data utility and Public Data System Operator accountable

Contractors	Private companies	Bids on construction contract for data utility
Retailers	Private companies	Package data and hedge risk for retail consumers. Sell differentiating products such as phone, cable, internet or security systems.

The data utility would operate one data grid that would provide all of the data transmission services. The data grid would be a layered network to provide different capacity and security requirements. The product differentiation summary would be as follows in Table 2.

Table 2: Summary of Data Grid Layered Network

Network	Description	Typical Users
A: Critical	Transmits critical information needed to furnish the necessities of life. Must be available during and post disaster and hardened against cyber attacks by software and hardware. Loss of connection leads to human loss. Fixed network only.	Police, fire, ambulance, hospitals, bulk power system, water system, natural gas
B: Important	Transmits information that is important to society but not critical for its function. Loss of connection lead to economic loss and possible life. Fixed network only. Software and hardware security.	Traffic light controls, video surveillance, oil and gas SCADA, industrial control systems, train controls, self driving car networks
C: Smart Grid	Control and measurement of demand response elements and small generators. Wireless and fixed network.	Rooftop solar, small generators, customers with electric cars, ect.
D: Internet of Things	General internet traffic. Security is primary software based. Wireless and fixed network. Primary software security.	Residential, commercial, cell phones, cable, internet, smart fridges, home security systems

Regulatory Models of Utilities

Cost of service utility regulation models have evolved from the government-owned and operated department to privately-owned utilities governed by complex regulatory models that strive to increase efficiencies by creating incentive structures. Table 3 shows a summary of existing regulatory market designs for utilities.

Table 3: Summary of Existing Regulatory Market Designs

Utility Market Design	Description	Pros	Cons
Government Owned Vertically Integrated Corporation with Public Utilities Board (PUB) Oversight	The government owns shares in a company that is operated at arm's length and receives oversight from an independent quasi-judicial body. Company has a monopoly on all components of the market.	● Simple form ● No incentive to overbuild system ● Operational cost control though PUB hearings ● Some protection from government meddling ● Incentive to provide service	● No financial incentive for operational efficiencies ● No incentive for innovation ● The government can easily use the utility as a political tool causing long-term stability issues ● Increases government debt load
Privately Owned Vertically integrated Corporation with Public Utilities Board (PUB) Oversight	The government owns shares in a company that is operated at arms length and receives oversight from an independent quasi-judicial body. Company has a monopoly on all components of the market.	● Simple form ● No incentive to overbuild system ● Operational cost control though PUB hearings ● Protection from government meddling ● Long-term stability	● No financial incentive for operational efficiencies ● No incentive for innovation

		because government can not shift cost • Incentive to provide service	
Grid Infrastructure Segregated Market with Performance Based Regulation	Services are separated into different components. Retail and production are run as facilities-based competition where the linear grid infrastructure is a cost of service regulation market model. Compensation for cost of service market component is based on benchmark to other jurisdictions and productive expectations. This formula is readjusted every 5 years. During the 5 year term the company is able to make improvements and keep the profits until the test year when it is trued up.	• No incentive to overbuild system • Operational efficiency incentives • Protection from government meddling • Long-term stability because government can not shift cost • Incentive to provide service • Innovation incentive	• Complex model

A New Regulatory Market Model for the Data Utility: Franchise Competitive Performance-Based Regulation (FCPBR)

A Franchise Competitive Performance-Based Regulation (FCPBR) is an enhanced Grid Infrastructure Segregated Market with Performance Based Regulation (PBR). The FCPBR is an enhanced PBR framework used in Alberta, Canada. It would create competition between utilities by placing the right of operating their franchise at risk for poor performers. A country would be divided into franchise zones. These zones would be large enough that no significant cost savings would be gained through amalgamation. A utility which ranks in the bottom 10 percent of performance (cost, security, reliability, retailer satisfaction) would be forced to sell their franchise to a new owner through an auction in which any profits of the sale would go back to ratepayers. Protections would be put in place to ensure competition is preserved after forced franchise sales. In addition to the loss of a franchise in the event of consistently poor performance, incentives would be available to high performers financed by the sale of the poor performer's franchise.

PBR models of electricity utilities in Alberta would be used to create operational efficiency incentives. The FCPBR discussed above would include the components of the PBR framework detailed below by the Alberta Utilities Commision.

> Rate regulation for electric and gas distribution utilities in Alberta is performed under a form of performance-based regulation, which was put in place by the Alberta Utilities Commission to replace the traditional cost of service rate regulation. Performance-based regulation is designed to mimic competition, encourage efficiency by providing incentives for the utility to reduce costs, while safeguarding reliability, and in so doing to keep utility rates lower than they might otherwise have been for customers.
> Under performance-based regulation, rates are calculated annually by means of an incentive-based formula rather than by the traditional ratemaking method which sets rates based on the costs utility companies are expected to incur in a given year. The more efficient the utility operates, the more savings it realizes, which results in a greater rate of return and since these benefits are then shared with customers, lower rates. Quality of service is safeguarded through separate, enforceable, Alberta Utilities Commission requirements. Performance-based regulation also reduces the regulatory burden because once the formula is set, the utilities do not need to get their costs approved annually as they would under the traditional ratemaking method, until the PBR term has expired. Alberta has five year PBR terms.[6]

[6] "Distribution Rates." *Alberta Utilities Commission*. Accessed July 22, 2019. http://www.auc.ab.ca/pages/distribution-rates.aspx.

A Data Utility Compared to Current Status Quo

A comparison of the data utility under a FCPBR to a standard facilities-based competition market is presented below based on the four guiding market design principles that define maximised societal value.

Table 4: Comparison of a FCPBR and Standard Market Models

Guiding Market Design Principle	FCPBR Market Model	Standard Facilities-Based Competition Market Model
Accessibility	● Similar prices across all regions with rural area having full access. ● All traffic is treated equal allowing the economy to determine the merits of the data. ● Obligation to provide services ensures access. ● Financial incentive to provide access.	● Drastic price differences by region with rural areas left unserviced. ● Traffic merit is determined by the facilities owner leading to economic and social distortion. ● No requirement to provide security. ● Financial incentive to provide access in urban areas.
Security	● Financial incentives to spend on security. ● Financial consequences if security requirements are not met.	● Bilateral contracting power is mismatched leading to minimal security requirements.
Reliability	● Financial incentives to spend on security. ● Financial consequences if security requirements are not met.	● Bilateral contracting power is mismatched leading to suboptimal reliability outcomes for society.
Affordability	● Legislated rights of service security and cost ensure all data traffic is with the data utility and separate	● Customers prices can be raised at any time. ● Customers are captive resulting in higher prices and no

	private networks. ● Price increases are minimal close to inflation. ● Integrated network. ● Planning and full network utilization leads to lowest delivered cost. ● Incentive to deliver high quality service and keep operating costs low.	predictability. ● Low network utilization and no integrated network planning leads to high network system cost and underused infrastructure. Multiple private networks are built for individual data needs.

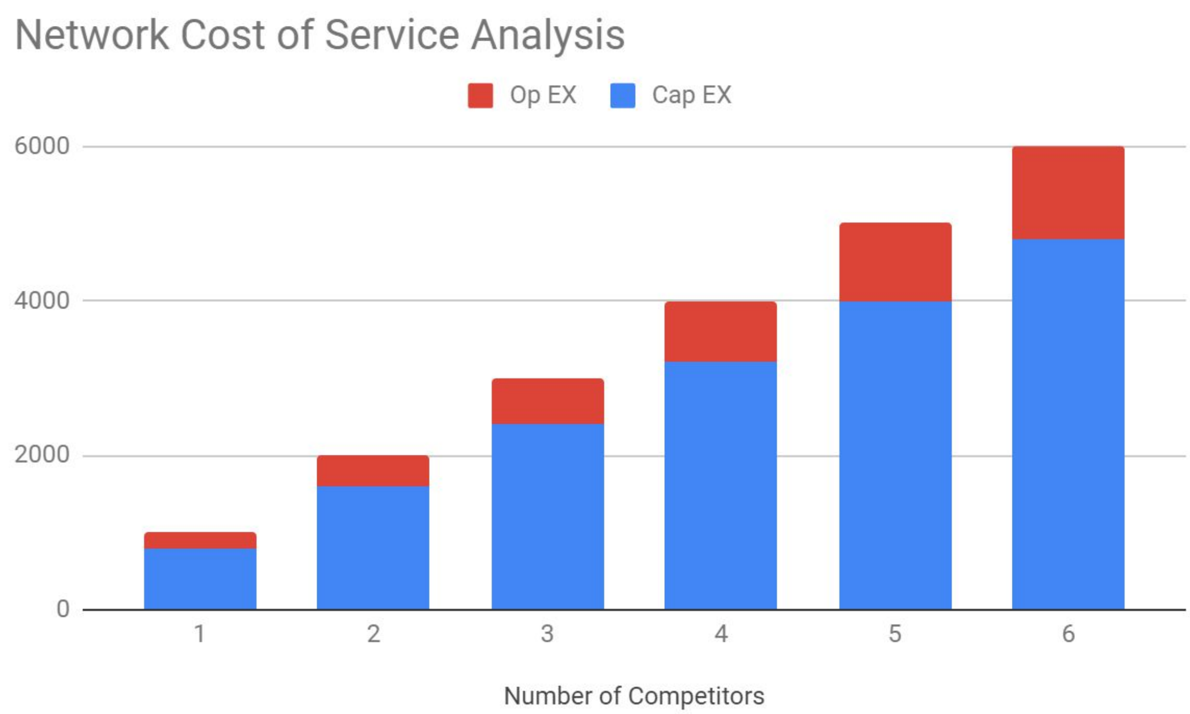
Data Utility Economic Analysis

To examine the potential cost savings of a data utility, a network cost of service analysis and pricing analysis can be used to demonstrate why linear infrastructure has drastically different characteristics to other product segments. For example, market models used for optimal value creation in pencil manufacturing will not lead to optimal results for linear infrastructure.

Network Cost Analysis

A utility, by definition, has larger capital expenditures than operational expenditures. This is highly dependant on whether the utility is vertically integrated or has segregated wires. Segregated wire utilities are on the lower end of that range. Figure 2 shows that the cost of service rises as more competitors enter the market. This is typical of a utility and is the main reason for the creation of the utility model. This trend is in direct contradiction to typical economic theory in which the cost of the product lowers as more competitors enter the market since the price of the service is the highest bearable cost of the market. Competition can bring down operating cost, but even a poorly run utility will be more cost effective than a facilities-based competition model. There is little opportunity for opportunity cost efficiencies for capital costs.

Figure 2: Network Cost of Service Analysis



Captive Market Cost

A competitive facilities-based competition market will price a product at the highest bearable cost of a market[7]. This will either incentivise more competitors to enter the market or drive competitors to leave the market. This is the "invisible hand" that controls supply and demand. This market form is highly effective in most markets and industries. Linear infrastructure is an exception to this and is evident by the creation of utility models to deliver services that have linear infrastructure. In a facilities-based competition market, the price is determined by the highest bearable cost of the consumer. The highest bearable cost can far exceed the cost to provide the service. If a service that is critical to society has no viable alternatives or holds the characteristics of being linear infrastructure with no ability to store the service, a utility model must be used to drive optimal social outcomes. This is because more competitors entering the market increases the cost of services due to large infrastructure costs. These parallel networks are invasive, taking up valuable land in our cities.

Facilities-based competition models for linear infrastructure leave rural areas underserved and cities with captive consumers. This is because of the "captive paradox": The first network operator to build a network to the customer captures the customer. The price of the service is the highest price the consumer will bear which far exceeds the cost of service. In standard

[7]How demand and supply determine market price." *Government of Alberta*. https://www.alberta.ca/how-demand-and-supply-determine-market-price.aspx

markets this is a signal that encourages competitors to build networks to compete and drive down cost. For linear infrastructure the captive consumer remains captive because if a second operator builds a new network the incumbent lowers their cost below the new competitor's cost and bankrupts them. This is a known issue in linear infrastructure and why most consumers do not have concurrent competing facilities running to their house. This turns the market into an unregulated oligopoly which provides low cost service at a high cost. The captive paradox is another reason why the utility model was created.

Electrical Utility and Data Utility Synergies

Electricity grid regulated market models are not the only thing that could be advantageous to the data utility. Electrical system infrastructure offers a natural co-use facility. Electricity networks are accustomed to operating in a similar manner for the last 50 years, but significant changes are on the horizon. Decarbonized society will drive increased electricity consumption[8] at the same time as increased intermittent renewable generators coming online to lower the carbon footprint of the grid. Further to load and generation changes, changing consumer preferences, cheap solar panels, cheaper storage and electric vehicles are introducing demands to our electric system that it was not designed to accommodate.

In order to prepare our electric grid for these upcoming changes, increased communication infrastructure is at the core of the grid of the future (smart grid). In addition, we will need the ability to monitor and control millions of devices on the system. Infrastructure will need to be as secure and reliable as the grid itself. If increased communications for control and monitoring are not built, the grid will become unreliable or increased capacity will drive extremely high system upgrade costs. If the communications network required to enable a smart grid is built as part of a wider data grid, we will be able to save substantial costs.

Electrical wire utilities have existing backbone communications networks to control and monitor the bulk power system. These communications networks are air gapped from the internet and include fiber optics and microwaves towers. Fiber optic can be placed directly on live high voltage power lines or placed inside the lightning protection ground wire. The existing structures and right-of-ways owned by the electrical wire utility can be leveraged for additional fiber optic or wireless antenna infrastructure. This will save infrastructure costs for the ratepayers of both the electrical and data utility.

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[8] "Canada's Challenge and Opportunity." *McGill University: The Trottier Energy Futures Project*. April, 2016. https://mcgill.ca/tised/files/tised/final_report_on_tefp_canadas_challenge_and_opportunity_transformations_for_major_reductions_in_ghg_emissions.pdf

Implementation Strategy

Implementing a data utility in a jurisdiction with a large number of incumbents is challenging. A staged approach is necessary to ensure fairness and to allow for market changes to incumbents. Having differing market models can be an effective method of price regulation for all. A principle-driven approach is of utmost importance to success. The proposed staged implementation strategy is summarized below.

Phase 1

Define Principles of Market Design

- Guiding market design principles will be defined.
- Desired outcomes will be defined.
- Economic models will be created to determine potential cost advantages.

Phase 2

Defined Grid Architecture

- One data grid will have multiple separate networks nested inside. Some of these networks will be air gapped from each other.
- Consistent requirements will be implemented for communication protocols on each network.

Standard Contracts

- Standard obligation contracts will be mandatory for all market participants. This will cover payment and cancelation clauses.

Reliability and Security Obligations

- Each network within the data grid will have specific security and reliability requirements for market participants.

Infrastructure Nesting

- All infrastructure will be nested on existing infrastructure, but the existing infrastructure owner will be given the opportunity to own and operate the asset and provide agnostic service back to the incumbent telecoms and new entries.

Protype a Special Regulation Data Utility Zone

- A representative zone will be chosen in which a data utility franchise licence and FCPBR is to be implemented. This zone will drive down prices in the existing facilities-based competition market since it lowers the highest bearable cost.

Phase 3

Based on successful pilot

Incumbent Company Restructuring

- Incumbent data companies will have their operations separated into three businesses allowing for true cost of service determination.

Equal Competitor Access

- All existing infrastructure will be open to all competitors at equal cost.

Central Data Grid Grid Planner

- The Public Data System Operator will plan the system by approving incumbent placements of infrastructure and directing regulated power utilities where to build data infrastructure. Incumbents are able to advocate for data transmission infrastructure location.

Phase 4

Zonal Franchise Auctions

- The country will be divided into zones that are geographically similar and provide minimal amalgamation advantages.
- Existing data transmission infrastructure will be bought from incumbents at net book value.
- An auction will be held to select franchise operators. Proceeds from the auction will be used to compensate incumbent infrastructure owners.
- Public utilities board will decide a tariff under the proposed FCPBR.
- Retail market will remain an open competitive market.

Prototype and Refinement

The next step for the data utility market design concept is real-world jurisdiction modeling This modeling would derive the value proposition based on existing infrastructure and customers. This model would identify the high value jurisdictions for a data utility by examining operational versus capital cost. Jurisdictions should strive to have multiple market models in their jurisdictions to I provide real-world examples of competitiveness.

Conclusion

A data utility comprised of one data grid with a layered network structure would maximize the social value to society while enhancing competition in the retail component of the market. This data utility should follow the Franchise Competition Performance-Based Regulation (FCPBR) market model. The FCPBR model will ensure the lowest cost service to the consumer while ensuring we have a hardened network to resist cyber attacks. Governments need to take action using the knowledge to use the lessons we have gained learned by building the electrical, water and natural gas grids.The economic and social well-being of society is at stake.