The Intersection of the Environment and Niche Technology:

A Cross-Jurisdictional Analysis of the Integration of Energy Storage Technologies in North America

by

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i. Foreword

The purpose of this Major Paper is to offer a robust examination of the three components of the Plan of Study (POS) submitted to the Faculty of Environmental Studies in January 2017. The three components of the POS are Energy Sustainability and Energy System Transitions, Market Integration of Sustainable Energy Technologies and Energy Policy Process. This multifaceted examination will be approached through the consideration of the integration of energy storage technologies into North American electricity markets.

The underlining theme of this paper is the analysis of the intersection of the environment and niche energy technologies. This paper intends to examine the energy landscape in several North American jurisdictions as prototypical models and to identify the best framework for Canadian provinces to incorporate environmental technologies into their supply mix. There are several types of technologies, considered “environmental technologies,” that are currently in market. To provide an in-depth analysis of system transitions, market and regulatory barriers, and politics, energy storage is used as a representational case study. Energy storage, in all of its iterations, is used as the case study for the purpose of this work and serves as the area of concentration, highlighted in the POS.

The first component of the POS sets out a theoretical framework for this paper. Applying a tested normative framework that is widely used in relation to system transitions, offers a basis and structure for the theme of technological transition of electricity systems. The second component offers an analysis of two Canadian markets along with the Federal Energy Regulatory Commission in the United States and the California Independent System Operator. The purpose of this area is to identify market rules and barriers that prohibit, or promote, the advancement of energy technologies such as energy storage. The third component identifies best practices for policies related to environmental technology. This section sets out to examine how larger political issues and consumer engagement affect the proliferation of energy technologies. Finally, the paper concludes with several recommendations for Ontario in its adaptation to the increased need for environmental technologies.

Each element examined, is directly connected to a primary objective of this paper; to meet the pre-determined learning objectives as stated in the POS. The areas of concentration, and the three components of the POS enriched the learning objective. This study facilitated an in-depth understanding of the theoretical framework, energy storage technologies, markets and market rules, politics and how each of these elements operates within Ontario. Coursework, research for the Sustainable Energy Initiative and attendance at multiple energy storage conferences assisted with meeting these learning objectives beyond the writing of this paper.

ii. Abstract

The purpose of this paper is to identify regulatory and market barriers to energy storage as a model for the adoption of future sustainable energy technologies in Ontario. This paper examines current barriers and makes recommendations for increased sustainable energy technologies, such as storage, in Canadian markets. Utilizing the Multi-Level Perspective theoretical framework, this paper deconstructs the current state of energy storage technology in North America. An agnostic energy storage technological overview is provided to offer an understanding of where the technology is today and how quickly it is advancing. Three cross-jurisdictional storage markets are reviewed: Ontario, Alberta, and California, along with the American Federal agency, FERC. Each jurisdiction examined is evaluated by highlighting the key regulatory bodies along with the market rules and structures that currently apply to storage. Finally, the paper concludes with a policy overview, a view on the role of consumer engagement, and recommendations for adoption of new energy technologies. The recommendations are offered as a result of the comparative analysis conducted, interviews with energy professionals in Ontario, and a legal and policy review along with a literature review. While it is concluded that major barriers presently exists for energy storage in North America, the paper finds that major transformations are occurring resulting from pressure from consumers and the need to combat climate change.

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1. Introduction

For many, conversations related to the validity of climate change and its effects are redundant.[1] Arguably, a general consensus exists that the climate has warmed and the planet continues to do so as a result of human activity.[2] Dialogue, domestically and internationally, in politics and at the institutional level has mostly moved beyond the plausibility of climate change and has shifted to solution finding and problem-solving.

In Canada, the electricity sector plays a large role in contributing to climate change. According to Environment and Climate Change Canada, in 2015, the electricity sector was the fourth largest source of greenhouse gas emissions (GHG) in the country.[3] As populations increase, both domestically and globally, reliance on electricity grows. While it is accepted that electricity is required in most societies for the fundamentals of survival; it is only when its reliability and affordability are challenged, consumers stop to consider the privilege that is afforded by electricity.

The relationship between the electricity sector, climate change, and environmental consciousness has not gone unnoticed. An awareness about the need for transformation in the electricity sector is occurring on several platforms, albeit, slowly and amongst few. On the one hand, electricity is a requirement for most societies, but the methods for generation and procurement are increasingly out-dated and adversely contributing to the climate challenge.

The amount of carbon emissions from the electricity sector varies by jurisdiction, but carbon emissions lack a respect for borders and political boundaries. In the United States, for example, the electricity sector is the country's main carbon emitter, with approximately 33% of annual

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[1] Note.The United Nations Framework Convention on Climate Change defines climate change as "means of change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to the natural climate variability observed over comparable time periods.,"3

[2] According to NASA, "the planets average surface temperature has risen 2.0 degrees Fahrenheit (1.1 degree Celsius), since the late 19th century, a change driven largely by increased carbon dioxide and other human-made emissions into the atmosphere." See, NASA, *Global Climate Change Vital Signs of the Planet*.

[3] Government of Canada, Environment and Climate Change Canada. *Greenhouse Gas Emissions by Canadian Economic Sector.* https://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=F60DB708-1

emissions.[4] This is compared to Canada, where the same sector contributes to around 10%[5] of the carbon emissions.[6] In contrast, estimates for the Asia Pacific region, suggest that the power sector will contribute to almost half of the region's carbon dioxide emissions by 2030.[7]

The evidence and data suggest that the electricity sector is simultaneously contributing to climate change while facing the burdens of its effects. A report conducted by Ontario lawyers, Zizzo and Allan, states, "according to the Intergovernmental Panel on Climate Change (IPCC), the electricity sector is one of the sectors most at risk of being disrupted by climatic variation."[8] The report says, "events such as high winds, flooding, excess ice build-up, hail and extreme heat and cold could influence the integrity and reliability of electricity grids."[9] With that in mind, it appears that the existing system and its generating production are quickly becoming antiquated and potentially obsolete and not able to meet the changing climate variations. As a result, transformation appears inevitable. The electricity system requires modifications to both reduce emissions and withstand the effects of the changing global climate. These changes are required to maintain reliability and affordability for consumers.

Some consumers, many activists, and few governments understand that the time has come to adapt to new technologies and policies as it relates to electricity. But progress and evolution are not easy, particularly when change will disrupt and transform the status quo and the entire

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[4] Kroft, J., Drance, J., *Carbon Emissions and the Canadian Electricity Sector*. https://www.stikeman.com/en-ca/kh/canadian-energy-law/carbon-emissions-and-the-canadian-electricity-sector

[5] Ibid.,https://www.stikeman.com/en-ca/kh/canadian-energy-law/carbon-emissions-and-the-canadian-electricity-sector

[6]Note. Canada has a unique electricity sector, which offers a different supply mix in each province. For some, including Manitoba and British Columbia, hydroelectricity is the main source of electricity while Ontario is mixed from renewables, nuclear, gas and hydro, etc. According to the Report of the Standing Senate Committee on Energy, the Environment and Natural Resources, *Positioning Canada's Electricity Sector in a Carbon Constrained Future*, "Canadians can be proud that the country's electricity systems are over 80% non-emitting and among the cleanest in the world." Executive Summary., V

[7] Asian Development Bank. *Climate Risk and Adaption in the Electric Power Sector*.Vi

[8] L. Zizzo, T. Allan, J.Kyriazis., *Understanding Canadian Electricity Generation and Transmissions Sectors' Action and Awareness on Climate Change and the Need to Adapt*., 7. Originally from, IPCC *Impacts*, *Adaptation and Vulnerability,* note 4 at 550

[9] Ibid.,7

system currently in play. In order to evolve, fundamental and arguably disruptive transformation within the electricity sector and electricity markets will be required. The need for electricity will not decline, but the methods for generating it, and encouraging it, can be adapted and are arguably shifting.

The intersection of the environment and technology is not a new phenomenon, particularly as it relates to electricity and the energy sector. In fact, according to Solomon and Krishna, history proves there is evidence that major energy transformations have already taken place.[10] That being said, transitions "lasted over a century or longer and were stimulated by resource scarcity, high labour costs, and technological innovations."[11]

While major transformations as noted above, had a tendency to evolve at a slower pace, the world has never been as technologically advanced as it is now. The exponential growth of technology is making the transformation in many sectors, inevitable, quicker and potentially disruptive.[12] This is of particular interest in the electricity sector. New sources of generation, procurement, storage and distributed energy resources are emerging at a rapid pace. Technologies that are emerging today can assist with reliability, load balancing, reducing GHG and the intermittency of renewable energy sources.

A particular type of electricity technology that has the ability to reduce GHG, assist with renewable integration, reliability and assist with the evolution of grids globally is energy storage. The concept of energy storage is not new, but the rapid development and diversity of the technology is unprecedented. Energy storage has diverse capabilities and can be utilized in several ways. For example, "energy storage resources help with the transition from traditional predictable resources to renewable, intermittent resources, and provide many other

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[10] B. Solomon, K. Krishna., *The Coming Energy Transition: History, Strategies and Outlook.*, 7422
[11] Ibid.,7422
[12] Shingles, Briggs, O'Dwyer. *Social Impact of Exponential Technologies, Corporate Social Responsibility 2.0*. https://dupress.deloitte.com/dup-us-en/focus/tech-trends/2016/social-impact-of-exponential-technologies.html

supplementary benefits to the grid."[13] According to the International Energy Agency (IEA), energy storage has the ability to "provide infrastructure support services across supply, transmission and distribution, and demand portions of the energy system."[14]

K&L Gates's *Energy Storage Handbook,* specifically notes the range of services storage can offer. Storage can be "installed from residential to utility scale, perform as generation or load, can provide several market products and can be used to defer massive investment in transmission and distribution infrastructure."[15] As the technology for storage has evolved, from in-home use to reliability from intermittent renewables, to large-scale institutional projects, the regulatory system and its administrative bodies have not proved capable of keeping up with the technological pace. Nor are they necessarily adapting as quickly as necessary to adhere to global carbon reduction objectives. As desire for energy storage increases, there is a need to create an advanced regulatory system, along with market adaptability that will allow for the adoption of energy storage and other environmental technologies, as quickly as they are being developed.

This paper will seek to analyze the current state of energy storage in North America as a case study. The purpose is to determine how policies, regulatory bodies, and markets can adapt to the changing landscape of environmental technologies. This paper will look at how a technology like storage is breaking through the regulatory barriers and market limitations, to become normalized in cultural practices.

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[13] K&L Gates. *Energy Storage Handbook*.,5
[14] International Energy Agency.*, Technology Roadmap: Energy Storage., 9*
[15] K&L Gates. *Energy Storage Handbook*., 5

2. Theoretical framework

The journey through which a technology becomes a reality is not novel. Throughout history, leaders and thought provokers have applied their vision and brought ideas into the dominant culture. Whatever the reason for technological advancement, there is often a systemic need for such a development. For the purpose of this paper, the discussion of climate change has led to a need to examine technological advancements that can assist with sustainability.[16] The discussion includes technology that is often considered disruptive, unstable or revolutionary. According to Frank W. Geels, systemic changes are referred to as socio-technical transitions.[17] Socio-technical transitions "…involve alterations in the overall configuration of transport, energy, agri-food systems, which entail technology, policy, markets, consumer practices, infrastructure, cultural meaning and scientific method."[18]

Applying a normative framework such as socio-technical transition theory to a technology such as energy storage provides a tested roadmap for success (and acknowledgment of potential failures and critiques), in transitioning an environmental technology into the mainstream. Identifying the process by which to breach barriers, and seize opportunities, in the proliferation of a technology for sustainability, will assist with creating a smoother pathway for storage.

A well known and culturally accepted example of a technology transitioning from novelty to practice is examined by Geels in, *The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriage to Automobiles (1860-1930).* The transition from horse-drawn carriages to automobiles in the United States offers a case study of historical transition theory at play.[19] Lawton and Murphy note that "early socio-technical transition work focused on how technological artefacts (sewage systems, for

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[16] Note. For the purpose of this paper, sustainability is defined as the ability to "meet the needs of present energy demand without compromising the needs of the future." See, Sharma, Atul., Kumar Kar, Sanjoay. *Energy sustainability through green energy.*,Vii

[17] Geels, F.W., *The multi-level perspective on sustainability transitions: Responses to seven criticisms*.,24

[18] Found in, Geels, F.W., *The multi-level perspective on sustainability transitions: Responses to seven criticisms*.,24. Originally from, Elzen & Geels., *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy*.

[19] Geels, F.W., *The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriage to Automobiles (1860-1930).,*449

example) were historically developed and diffused into society, providing key insights into the social, and political factors that shaped these development trajectories."[20]

The transition from idea to implementation has been studied for some time, from various perspectives. The theory is a culmination of disciples ranging from "technology innovation and diffusion, evolutionary economics and the sociology of large technical systems, to provide a framework for understanding how shifts in large and complex socio-technical systems unfold."[21] Socio-technical systems are the result of, according to Geels, "a cluster of elements, including technology, regulation, user practices and markets, cultural meaning, infrastructure, maintenance networks and supply networks."[22]Geels states that actors and social groups influence socio-technical systems, they are: universities, firms, knowledge institutes, public authorities, public interest groups, and users.[23]The principle being that transitions are interrelated and revolve around the participation or push and pull from different players.[24]

Within the socio-transitional theory falls a framework called the multi-level perspective (MLP).[25] While the MLP is not without criticism, the MLP is widely used in modern transition work.[26] This may be a result of its appearance of offering a more tactical and governance-focused approach for supporting technology and system transformations.[27] As summarized by McCauley

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[20] Found in, Lawhon, M., Murphy., *Socio-technical regimes and sustainability transitions: Insights from political ecology.,* 357, Originally from, Geels, *The hygienic transition from cesspools to sewer systems (1840-1930) the dynamics of regime transformations*.

[21] McCauley, S., Stephens, J., *Green Energy Clusters and Socio-technical Transitions: analysis of a sustainable energy cluster for regional economic development in Central Massachusetts*, USA., 214

[22] Geels, F.W., *The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriage to Automobiles (1860-1930).,* 446

[23] Ibid., 446

[24] Ibid., 446

[25] Note. For an in depth analysis and explanation see, Geels, F.W., *The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriage to Automobiles (1860-1930)*

[26] See, Geels, F., *The multi-level perspective on sustainability transitions: Response to seven criticisms*.

[27] Twomey, P., Gazilusoy, I., *Review of System Innovation and Transitions Theories: Concepts and frameworks for understanding and enabling transitions to a low carbon built environment.*,12

and Stephens, the MLP states that transitions are "the result of interactions among actors, institutions, and technologies" at three conceptual levels.[28] Those levels are the landscape, the regime, and the niche.

The three levels within the MLP, described as "non-linear," play their own role in the advancement of system transitions.[29] The "socio-technical niche" level is where the technology is created, in other words, space where the innovation occurs. The "socio-technical regime" level is the space that captures actors and rules such as institutions, regulations, policies, and markets. The term "socio-technical landscape" is used to define the exogenous environment.[30]

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[28] McCauley, S., Stephens, J., *Green Energy Clusters and Socio-technical Transitions: analysis of a sustainable energy cluster for regional economic development in Central Massachusetts*, USA., 217

[29] Geels, F.W., *The multi-level perspective on sustainability transitions: Responses to seven criticisms.,* 26

[30] Geels, F.W., *The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriage to Automobiles (1860-1930).,* 450-451

The relationship between the three concepts is illustrated by Geels from his work in *The multi-level perspective on sustainability transitions: Response to seven criticisms*:

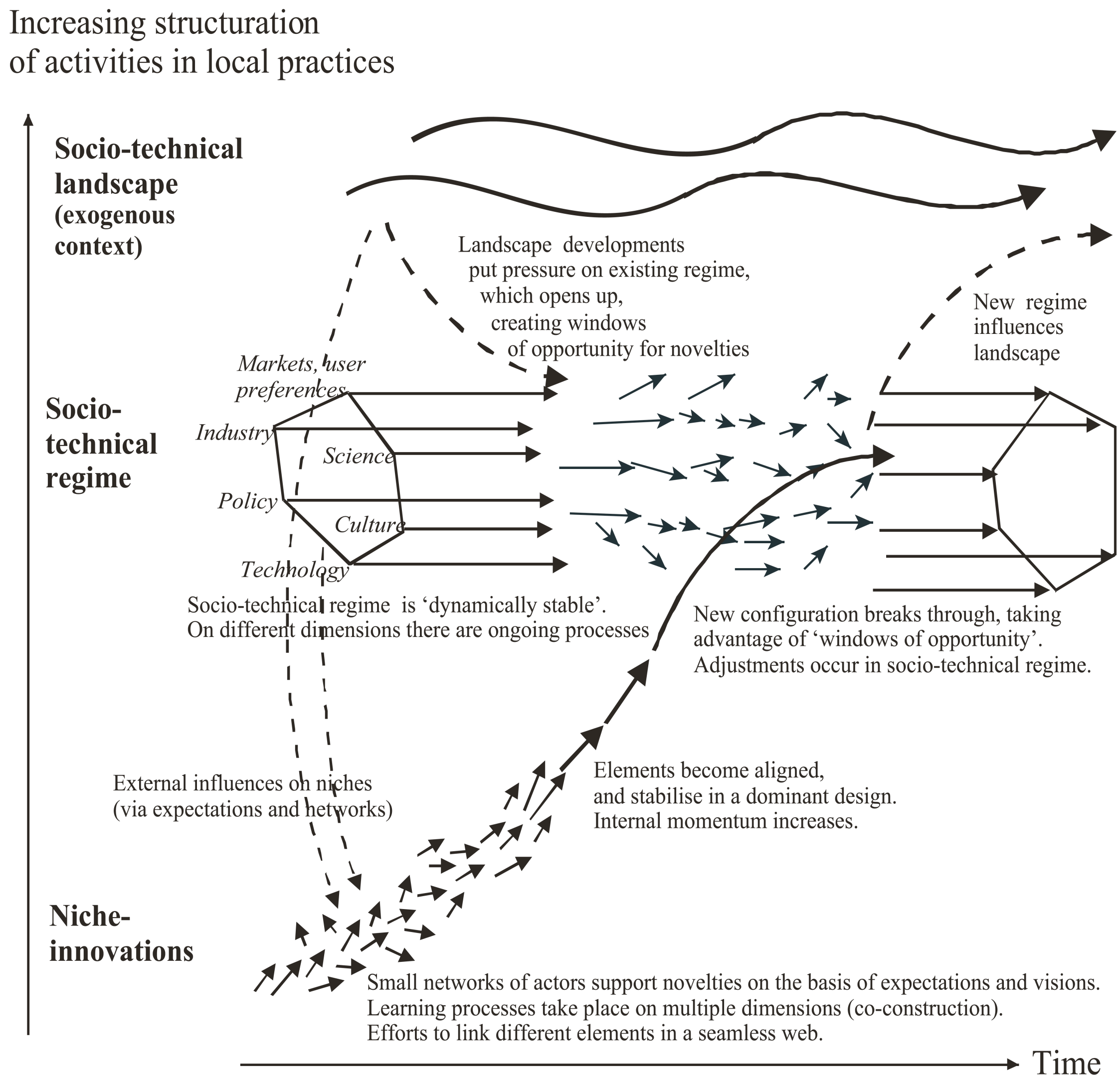

Figure 1 Geels, F., The multi-level perspective on sustainability transitions: Response to seven criticisms. Pg 28. Adapted from Geels, (2002:1263)

In essence, the interplay between the three concepts can be summarized as follows: the niche is the space for technology development. Fluctuations and changes within the landscape increase pressure on the regime. The disruption that occurs in the regime, as result of the pressure from the landscape, facilitates opportunities for niche technology to advance.[31] This is when a technology like energy storage has the potential to prosper.

By virtue of this theory, it can be argued that currently, storage and its various iterations live within the niche level. While the technology is advancing at a rapid pace, it seems as though the technology has just begun to infiltrate the regime. This may be the result of the promotional work by the company Tesla and the work of certain jurisdictions like California. The abundance of storage technology on the market or in the language of popular culture does not necessarily mean that the regime is ready to accept it. Arguably, disruption in the landscape is presently occurring; this can be highlighted by discussions around climate change and sustainability, the electrification of automobiles, branding from companies like Tesla and the Paris Agreement.[32]

It does not appear that the reverberations from the slight disruptions in the landscape have put enough pressure on the regime to fully embrace a technology such as storage. While storage continues to advance at the niche level, preparations at the regime are emerging, specifically for storage. This is evidenced by work that is being done by the Federal Energy Regulatory Commission (FERC) in the United States, licence approvals at the Ontario Energy Board and work in states like California.

Continued work (including education) around climate change and sustainability will foster the necessary pressure to allow for a break in the regime, allowing storage, its variants, and future iterations to truly proliferate. As noted above, this type of proliferation has historically taken decades. The speed of the adoption of the technology and awareness about the need for sustainable products will assist with a quicker transition than has occurred in the past. That being said, preparations need to continue taking place in order to move quickly enough once the landscape offers the right opportunity. This includes making valuable contributions to policy, market rules, and the regulatory system. The purpose is to create an adaptable and agile

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[31] Geels, F., *The multi-level perspective on sustainability transitions: Response to seven criticisms.,*27,28
[32] Note.For Further information on the Paris Agreement, see United Nations Framework on Climate Change. http://unfccc.int/paris_agreement/items/9485.php

framework to apply as quickly as possible to the regime. Regulations, policies, and market rules must learn to adapt and evolve as quickly as the technology is at the niche level.

3. Methodology

This paper offers a cross-jurisdictional comparative analysis of the integration of energy storage in select North-American markets. This paper aims to primarily address energy storage in Canada, with a broader examination of the incorporation of sustainable energy technologies into provincial markets. Specifically, the analysis seeks to identify recommendations and procedures to transition the Ontario energy sector to a technologically advanced and low-emission system by way of energy storage, inter alia. In order to achieve a robust analysis with substantive recommendations, it was prudent to examine other jurisdictions that are currently integrating storage into their markets or have already done so. The cross-jurisdictional comparative analysis of energy storage examines the current state of storage in electricity markets in Ontario, Alberta, the state of California and the United States Federal Energy Regulatory Commission.

In order to fully examine the markets in each jurisdiction and the policies within the jurisdiction, primary documents were examined and summarized. Specifically, governing legislation, government directives, system operators' reports, market rules, proposed policies and studies by regulators were examined to determine what commonalities and variations exist. Academic journals and news articles related to storage and sustainable energy technologies were used to supplement the primary source materials.

Further bolstering the primary and secondary materials, was attendance at various energy storage conferences both in person and by way of webinars. In addition, multiple interviews were conducted with leading professionals in the energy sector in Ontario and Washington, D.C. Interviewees ranged from lawyers, lobbyists, and energy storage business strategists to policy researchers.

4. Energy Storage Technology

The purpose of this paper is not to make a determination on which class of energy storage technology is best suited for any jurisdiction. In fact, this paper aims to be informative, yet entirely technology agnostic. This paper sets out to use storage as a case study for the transition of a sustainable energy technology from the regime and landscape; it follows that an explanation of the specific storage technologies that are currently on the market should be highlighted.

While technology agnostic, one vital characteristic of energy storage that must be addressed, particularly when discussing a technology's viability in markets, policy objectives and within the regulatory framework, is whether the specific discussion is related to residential (for in-home consumer use) or commercial/larger energy storage (utilities or large institutions).[33] This section is designed to offer an overview of large-scale energy storage. Batteries, however, straddle both residential and large-scale use. This section will discuss batteries but not discuss in-home use or other distributed energy resources (DER).[34] Residential batteries and DER technology will be discussed in the Cultural Shift section.

Electrical energy storage (EES) is the "process of converting energy from one form to a storable form and reserving it in various mediums; then the stored energy can be converted back into electrical energy."[35] In other words, EES is "a means by which electricity imported from a power grid, is converted into a form that could be stored at off-peak demand, when energy cost is usually low or during surplus generation, and converted back into electricity at peak demand or when needed."[36]

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[33] Note. The important of differentiation regarding consumer and large-scale energy storage is the result of a discussion with NRStor staff through interview conducted on September 12, 2017.
[34] Note. Distributed energy resources may be defined as "behind-the-meter power generation storage resources typically located on an end-use customer's electric grid…resources may be capable injecting power into the transmission and/or distribution system or non-utility local network in parallel with the utility grid." This definition includes energy storage See, New York Independent System Operator, *A Review of Distributed Energy Resources*., 1
[35] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 511
[36] Akinyele., Rayudu., *Review of Energy Storage Technologies for Sustainable Power Networks.*,76

Benefits and capabilities of an EES system can include:

a) Meeting peak electrical load demand;
b) Time-varying energy management;
c) Assisting with the intermittency of renewables;
d) Quality/reliability;
e) Meeting remote and automobile requirements;
f) Support for smart grids;
g) Supporting distributed power generation;
h) Reducing electricity imports, for some jurisdictions, during peak demand.[37]

Categorizing storage depends on several factors. According to Luo, et al., 2015, "one of the most widely used methods [of categorization] is based on the form of energy stored in the system."[38] Specifically, the authors state that storage is usually compartmentalized as follows:

a) *Mechanical:* includes pumped hydroelectric storage, compressed air, and flywheels;
b) *Electrochemical*: includes conventional rechargeable batteries and flow batteries;
c) *Electrical:* includes capacitors, supercapacitors, superconducting magnetic energy storage;
d) *Thermochemical*: solar fuels;
e) *Chemical*: hydrogen storage with fuel cells;
f) *Thermal*: heat storage and latent heat storage.[39]

Alternatively, the Energy Storage Association has divided energy storage into six main categories:

a) *Solid-state batteries*: which includes advanced chemistry batteries and capacitors;
b) *Flow-batteries*: energy is stored in electrolyte solution for longer and has quick response time;
c) *Flywheels*: mechanical devices, store energy and deliver instantaneously;

[37] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 511-512
[38] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*.,513
[39] Ibid., 513

d) *Compressed air*: to create energy reserve by way of using compressed air;
e) *Thermal*: captures heat and cold to foster energy on demand;
f) *Pumped hydro-power*: large reservoirs of water to use for energy.[40]

Any evaluation of energy storage is invariably technical. The scope of this paper will not offer an analysis of the technical variants of the different varieties of energy storage. A macro approach and overview of the different types of storage is offered. The Energy Storage Association's mission states that they are dedicated to the "adoption of competitive and reliable energy storage systems for electric service."[41] Based on the organization's cross-jurisdictional reach (associations in both Canada and the United States) and dedication to the promotion of energy storage, their six categorizations will be used for the technological overview.

4.1. Solid State Battery Storage

Battery storage technology is the result of electrochemical processes that convert stored chemical energy into electrical energy.[42] Batteries typically fall into one of two categories: solid-state batteries and flow batteries.[43] Storage batteries are defined as rechargeable electrochemical systems used to store energy.[44] Under the definition of Solid State Battery Storage, The Energy Storage Association includes the following batteries:

a) Electrochemical capacitors
b) Lithium-Ion batteries
c) Nickel-Cadmium
d) Sodium Sulfur batteries [45]

4.1.1. Electrochemical Capacitors

[40] Energy Storage Association. *Energy Storage Technologies*. http://energystorage.org/energy-storage-1
[41] Ibid., http://energystorage.org/energy-storage-1
[42] K&L Gates., *Energy Storage Handbook*., 6
[43] Ibid.,6
[44] Hadjipaschalis, Poullikkas, Efthimiou., *Overview of current and future storage technologies for electric power applications*., 1515
[45] Energy Storage Association. *Energy Storage Technologies*. http://energystorage.org/energy-storage-1

Electrochemical capacitors have many names and can also be referred to as "electric double layer" and "supercapacitor" or "ultracapacitor."[46] The most common name used in the literature tends to be supercapacitor. Supercapacitors are "very high surface area activated capacitors that use a molecule-thin layer of electrolyte as the dielectric to separate charge."[47] Supercapacitors have a few advantages compared to other storage technologies. Firstly, they maintain a long-life cycle and have a lifespan of 10-20 years. They can also respond to a charge need within seconds.[48] On the negative side, they have low energy density and cannot be used as a continuous power source.[49] The Energy Storage Association states that supercapacitors are evolving quickly and applications related to the electricity grid will be a part of the evolution.[50] While the technology for supercapacitors is growing, it is yet to be determined whether the supercapacitor will be as strong as a contender as the three main types of battery on the market.

4.1.2. Lithium-Ion Batteries

Lithium-Ion batteries are positive electrodes made of lithiated metal oxide, and a negative electrode composed of layered graphitic carbon.[51] According to the Energy Storage Association, the name does not refer to a single electrochemical couple; it typically refers to a range of chemistries, characterized by the transfer of lithium ions between the electrodes during the charge and discharge reactions.[52] Lithium-Ion batteries are an example of a battery that straddles both residential use and commercial use. These batteries can be found in applications ranging from laptops and cell phones to electric vehicles.[53] There are fundamental drawbacks to this type

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[46] Ibid. http://energystorage.org/energy-storage-1
[47] Hadjipaschalis, Poullikkas, Efthimiou., *Overview of current and future storage technologies for electric power applications*.,1517.
[48] Guerra, Maria., Can Supercapacitors Surpass Batteries for Energy Storage? http://www.electronicdesign.com/power/can-supercapacitors-surpass-batteries-energy-storage
[49] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 26
[50] Energy Storage Association. *Energy Storage Technologies*. http://energystorage.org/energy-storage-1
[51] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 41
[52] Energy Storage Association., *Lithium-Ion Batteries*. http://energystorage.org/energy-storage/technologies/lithium-ion-li-ion-batteries
[53] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 41

of battery. Firstly, this battery typically requires an onboard computer to manage its operation, which according to Luo, et al., increases costs.[54] Secondly, and arguably more devastating, is that according to Fuchs et al, this type of battery will have difficulty gaining wide social acceptance due to lithium mining and the limited number of countries that host such resources.[55]

Currently, there are vibrant discussions around the viability of the natural resources needed for this type of battery. The environmental effects coupled with the social justice concerns regarding mining of said materials. Cobalt, a necessary metal for lithium-ion batteries is often sourced from mines that exploit children as labourers. These concerns about the benefits versus the consequences of lithium-ion batteries may be an impediment to more rapid adoption.[56] The use of these batteries is becoming more prevalent as they are becoming increasingly used in electric cars. Yet, the sustainability issue related to the use of these batteries is not a conversation that is largely occurring at the mainstream or popular political level. Lower emissions are a prime example of the benefit of using these batteries for electric cars. This highlights a question about the macro and social benefits of this type of technology. If lithium-ion batteries are the result of the use of finite materials that are mined at a social justice cost, should consumers continue to allow them to be used in cars? In principle, these batteries are the antithesis of sustainability, which on its face is an objective of what storage is trying to achieve.

4.1.3. Nickel-Cadmium

A nickel-cadmium battery uses nickel hydroxide and metallic cadmium as the two electrodes and an aqueous alkali solution as the electrolyte.[57] According to the Energy Storage Association, this type of battery has had some advances in electrode technology, thus maintaining its

[54] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 517

[55] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 42. For additional analysus on the darker side of lithium-ion batteries.

[56] For further information, see West, Karl.,*Carmakers electric dreams depends on supplies of rare minerals.* https://www.theguardian.com/environment/2017/jul/29/electric-cars-battery-manufacturing-cobalt-mining

[57] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 518.

practicality.[58] While this battery has been used for some larger scale storage projects, it has a fundamental drawback; according to Luo, et al, this type of battery is made from drastically toxic materials, namely cadmium and nickel, these materials are harmful to the environment.[59] The use of known toxic materials for a sustainable energy project (which is typically one of the major selling points of battery storage) appears to be counterproductive and irresponsible. While this battery has some positive attributes, highlighting it as a productive and useful tool for sustainable energy projects is unproductive for environmental sustainability projects.

4.1.4. Sodium Sulfur Batteries

The Sodium-sulfur battery uses molten sodium and molten sulfur as the two electrodes and uses beta-alumina as the solid electrolyte.[60] To achieve the appropriate reaction, this battery operates at an extremely high temperature to ensure that the electrolytes are in a liquid state.[61] This battery has been used for several large-scale energy storage systems. According to the Energy Storage Association, currently this battery is being applied in over 190 sites in Japan alone, with approximately 270 Megawatts of stored energy.[62] As opposed to some of the other types of batteries, this battery requires inexpensive, non-toxic materials, which have a high degree of recyclability.[63] It appears that sodium sulfur is the least detrimental with respect to the environment. Thus, the justification of this battery is not as negatively impactful as others, maintaining integrity with regards to sustainability.

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58 Energy Storage Association., *Nickel-Cadmium Batteries*. http://energystorage.org/energy-storage/technologies/nickel-cadmium-ni-cd-batteries

59 Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 518

60 Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 517

61 ibid., 517

62 Energy Storage Association. ,Sodium Sulfur., http://energystorage.org/energy-storage/technologies/sodium-sulfur-nas-batteries

63 Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 517

4.2. Flow Batteries[64]

Flow batteries' active ingredient is salt, which dissolves in a fluid electrolyte. The electrolyte itself is stored in tanks.[65] The charging and discharging of the electrolyte is pumped through a central unit where a current is either applied or delivered.[66] One of the major advantages of this unit is that the power of this system is independent of its storage capacity.[67] This battery is typically used for large to medium scale projects. According to Fuchs, this technology may be able to bridge the gap between medium and long-term storage abilities, i.e., to assist with weekly fluctuations of a renewable power generation.[68] Alternatively, this technology has high manufacturing costs and a much more complicated system than other batteries.[69]

High costs aside, this technology does not use toxic materials nor are there any obvious social justice issues. For some, flow batteries are preferred over other kinds of batteries due to their long life cycle. A German utility has set out plans to build the world's largest battery using flow technology.[70] The size and scale of this project are said to have the capacity to meet the electricity needs of the city of Berlin for an hour or 75,000 homes for an entire day.[71] The project is set to complete by 2023.

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[64] Note. It should be noted that there are several different types of flow batteries that fall within the flow battery categorization. For a detailed overview of different flow batteries, see Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*.
[65] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 38
[66] Ibid., 38
[67] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 518
[68] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 38
[69] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 518
[70] Hanley, Steve., *World's Biggest Grid Scale Battery will be built in German Salt Mine.* https://cleantechnica.com/2017/07/18/worlds-biggest-grid-scale-battery-will-german-salt-mine/
[71] Ibid., https://cleantechnica.com/2017/07/18/worlds-biggest-grid-scale-battery-will-german-salt-mine/

4.3. Flywheels

Luo et. al, note that typically a modern flywheel consists of five major components: a flywheel, a group of bearings, a reversible electrical motor/generator, a power electronic unit and a vacuum chamber.[72] A flywheel system utilizes electricity to accelerate or decelerate the flywheel. In other words, the stored energy is transferred to and from the flywheel through an integrated motor or generator.[73] Typically, flywheels are constructed within a high vacuum environment, and the amount of energy stored will depend on the rotating speed of the flywheel and the inertia.[74] Flywheels have a high life cycle and power density. As a result, they are well suited for projects that demand high power for a short period of time.[75] Based on their short storing periods, they can be used for projects such as grid stabilization for trains or trams or weak grids.[76] The Energy Storage Association notes that flywheels are good resources for capturing energy from intermittent energy sources and delivering uninterrupted power to a grid.[77] They also can respond instantaneously.

Concerns regarding flywheels, according to Fuchs, et al. are based on lower energy density capacity, the need for a vacuum chamber, safety concerns and the need for a cooling system for the superconducting bearings.[78] Due to the safety concerns, flywheels typically need to be constructed within safety walls, taking up significant space. Unlike others, this technology does not rely on any toxic materials.[79] As a result, this type of technology can be considered an environmentally sustainable storage technology.

In Ontario, NRStor Inc. and Temporal Power came together to introduce the first grid-connected commercial flywheel facility in Canada. The project by NRStor and Temporal Power is based in

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[72] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 515
[73] ibid., 515
[74] ibid., 515
[75] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 24
[76] Ibid., 24
[77] Energy Storage Association, *Flywheels*. http://energystorage.org/energy-storage/technologies/flywheels
[78] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 25
[79] NASA., *Flywheel Program*. https://www.grc.nasa.gov/WWW/portal/pdf/flywheel.pdf

Minto, Ontario and produces 2 MW.[80] In 2015, a year after the flywheel went online, NRStor and Temporal Power noted, "…the facility has withdrawn and rejected over 2 million kilowatt hours (kWh) or 2-gigawatt hours (GWh) of energy."[81] The news release also indicates "a similarly sized natural gas generator might produce over 9,000 metric tons of CO2 emissions providing the same amount of regulation service."[82] Finally, flywheels do not require fuel input and therefore do not release greenhouse gas emissions when in operation.[83]

Based on the technical and environmental attributes of flywheels, it appears that this technology is playing a large role in the energy storage field. According to Fuchs et al., research is currently being conducted to improve flywheel technology. Specifically, research is being done related to the development of high-speed flywheels and lower cost flywheels with higher energy capacity.[84]

4.4. Compressed Air Energy Storage

The Energy Storage Association compares Compressed Air Energy Storage (CAES) to pumped hydro facilities in relation to their applications, output and storage capacity.[85] Instead of water, CAES is air compressed and stored under pressure in an underground cavern. During low demand, surplus electricity drives a reversible motor/generator unit, in turn, to run a chain of compressors for injecting air into a storage vessel.[86] When power generation cannot meet

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[80] NRStor Inc. *NRStor announces one year of commercial operations at 2MW flywheel facility*. http://www.nrstor.com/news/nrstor-announces-one-year-of-commercial-operations-at-2mw-flywheel-facility/
[81] Ibid., http://www.nrstor.com/news/nrstor-announces-one-year-of-commercial-operations-at-2mw-flywheel-facility/
[82] Ibid., http://www.nrstor.com/news/nrstor-announces-one-year-of-commercial-operations-at-2mw-flywheel-facility/
[83] Ibid., http://www.nrstor.com/news/nrstor-announces-one-year-of-commercial-operations-at-2mw-flywheel-facility/
[84] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 24
[85] Energy Storage Association. *Compressed Air Energy Storage*. http://energystorage.org/compressed-air-energy-storage-caes
[86] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*.,514

demand, the stored air is released and heated by a heat source that may be from the combustion of fossil fuels or the heat recovered from the compression process.[87]

To date there are only two CAES systems globally, one is in Huntorf, Germany at 320 MW and the other is in McIntosh, US at 110 MW.[88] Both of these plants operate without heat storage and therefore use natural gas as their heating source.[89] Currently, in Canada, the Ministry of Natural Resources and Forestry has suggested that Southern Ontario may be an appropriate location for a CEAS facility, specifically Goderich, Ontario.[90] The Ministry notes that Goderich is a suitable location, given that the region is abundant in salt deposits and has the right kind of rock. Depending on the proposed regulatory framework related to CAES licence in Ontario, the facility could be set for operation by as early as 2018.[91]

To operate a CAES system, certain geological requirements are necessary, namely the need for a salt cavern. While CAES systems can offer some advantages, the physical geological demands limit its scope. This, in turn, limits its popularity and market demand, which according to recent developments in Ontario, the factors appear to have been mostly overlooked.

4.5. Thermal

Thermal energy is the result of several different types of technology that store heat energy using different insulated repositories.[92] Thermal energy is usually categorized into two distinct groups: low-temperature thermal systems and high-temperature thermal energy storage. These systems

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[87] Ibid.,514

[88] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 21

[89] Ibid., 21

[90] Stevens.,Hines., *Canada: Proposed Regulation of Compressed Air Energy Storage in Ontario*. http://www.mondaq.com/article.asp?articleid=639426&email_access=on&chk=2204528&q=1565102

[91] Note. For further information on the proposed regulatory framework and licences related to CAES, See Stevens and Hines, *Canada: Proposed Regulation of Compressed Air Energy Storage in Ontario*. http://www.mondaq.com/article.asp?articleid=639426&email_access=on&chk=2204528&q=1565102

[92] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*.,523

tend to store medium-term energy in similar regions that pumped hydro is found.[93] Thermal energy storage systems have been used so far for applications ranging from load shifting to generation.[94] There are currently a few large-scale projects using thermal energy storage, ranging from projects in the United Kingdom, Florida and a joint US-China project in Beijing.[95] While research is continuing to advance this technology, Fuchs et al. note that, to date, only large-scale projects are economically feasible, making this an interesting application but not readily available for analysis into the market in the present day.[96]

4.6. Pumped Hydro Power

The most widely used and accepted type of storage tends to be pumped hydropower, which according to International Renewable Energy Agency (IRENA), is 99% of storage in use today.[97] Pumped hydro is one of the oldest storage technologies and one of the most trusted and understood. A pumped hydro system is two interconnected water reservoirs located at different heights: penstocks connect the upper and lower reservoirs.[98] During off-peak, the water is pumped into higher-level reservoir and during peak hours the water is released back into the lower reservoir.[99] The water powers turbines, which in turn drive electrical generators. The amount of electricity stored will be the result of the height difference between the two reservoirs and the total volume of water stored.[100]

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[93] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 30
[94] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*.,524
[95] Ibid.,524
[96] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 30
[97] IRENA.,*Battery Storage for Renewables: Market Status and Technology Outlook*., 4. Originally from, International Energy Agency.,*Technology Roadmap: Energy Storage. 2014*.
[98] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*.,17
[99] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 513
[100] Ibid.,513

To date, there is approximately 127 GW of installed pumped hydropower.[101] While pumped hydro technology is typically considered well tested and dependent on large water reservoirs, new advances in the technology are making strides. According to Luo et. al. some pumped hydro systems are using flooded mine shafts, underground caves and oceans as reservoirs. Also, the authors note that wind or solar generation combined with pumped hydro is being developed.[102]

Advancements concerning pumped hydro are exciting and potentially offer an opportunity for further pumped hydro storage. However, this technology will always be limited by the physical attributes of the geography, making it the opportunities for advancing this type of storage somewhat narrow.

It is beyond the scope of this paper to analyze the technical components of the energy storage systems that are highlighted above. However, throughout the examination of different types of ESS a few larger sustainability and political themes emerge. Below, a comparison table has been created to review the EES noted above against larger political and policy dimensions. The table offers a low to high score on specific storage systems' scalability, environmental sustainability, and cost-effectiveness. By examining the relationship of a storage system to matters of policy and environmental sustainability, a conclusion can be drawn about which type of technology makes sense for specific jurisdictions.

[101] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*.,17

[102] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*., 513

Storage Technology	Scalability	Environmental Sustainability	Cost-Effectiveness
Electrochemical Capacitors	Medium. Currently used for short term storage, new advances in technology making it more appealing[103]	Medium to Low. Negative environmental impact as a result of use of materials used for their development and operation[104]	Low. But, if mass produced, cost would go down
Lithium-Ion Batteries	High. Used for medium term storage. Potential for this battery increased due to personal electronics and cars[105]	Low. Resources for this material are finite. Mining for materials is a major concern and only available in few countries[106]	Low. Due to manufacturing and packaging[107]
Nickel-Cadmium	Low. Few projects exists but cost and hazardous materials prohibit growth[108]	Very Low. Requires toxic heavy materials that are hazardous[109]	Low. Approximately twice the cost of lithium batteries[110]
Flow Batteries	Medium. As a result of its "independent scaling of power and energy"[111]	Low. This technology does not require toxic materials but the size of the tanks is a consideration.[112]	Low. As a result of scale and manufacturing costs.[113]

[103] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 26

[104] European Parliament's committee on Industry, Research and Energy. *Outlook for Energy Storage Technologies*., 11

[105] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 41

[106] Ibid., 42

[107] European Parliament's committee on Industry, Research and Energy. *Outlook for Energy Storage Technologies*., 13

[108] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*. Pg 518

[109] Ibid., 518

[110] European Parliament's committee on Industry, Research and Energy. *Outlook for Energy Storage Technologies*., 12

[111] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 38

[112] European Parliament's committee on Industry, Research and Energy. *Outlook for Energy Storage Technologies*., 15

[113] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*. Pg 518

Storage Technology	Scalability	Environmental Sustainability	Cost-Effectiveness
Flywheels	Medium. High cycle life and power density, which make them a good fit for high power for a short period of time, such as grid stabilization, however do to its size, perhaps not largely scalable.[114]	Medium. This technology does not require chemicals or toxic materials but does require significant safety precautions due to the nature of the design.[115]	Low. Manufacturing costs are higher than other technologies.[116]
Compressed Air Energy Storage	Low. Mainly due to the geological requirements necessary to develop and install this technology.[117]	Medium. Due to the geological requirements and large area needed for construction.[118]	Low. Do to high installation costs and lower costs of competing technologies.[119]
Thermal	Medium. Significant research is being done related to advancing thermal tech and currently there are several major thermal projects worldwide.[120]	Medium. Research is being conducted to ascertain thermal's ability to assist with low carbon energy supply.[121]	Medium. Only large-scale projects have the potential to be competitive and cost effective. [122]

[114] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 24
[115] European Parliament's committee on Industry, Research and Energy. *Outlook for Energy Storage Technologies*., 21
[116] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 25
[117] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 21
[118] European Parliament's committee on Industry, Research and Energy. *Outlook for Energy Storage Technologies*., 19
[119] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 23
[120] Luo, Wang, Dooner, Clarke., *Overview of current development in electrical energy storage technologies and the application potential in power system operation*. Pg 524
[121] Ibid., 524
[122] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 31

Storage Technology	Scalability	Environmental Sustainability	Cost-Effectiveness
Pumped Hydro Power	Medium. Widely used globally but requires certain geological conditions (water)	Medium. Large impact as a result of large-scale construction needed to build dams and sites[123]	Low. Investment costs remain high[124]

Table 1 Technology Overview

4.7. Conclusion

Based on the summaries above, it is clear that an ideal category of storage technology does not exist. Most of the storage technologies noted above have a decent to good value proposition, but none of them offer what would be an objective set of all-around or perfect positive characteristics. Storage is meant to be a progressive technology that will offset carbon emissions and assist with the greater climate challenge the globe is combatting. But, when a storage technology has a significant social justice impact, or utilizes finite or toxic materials, on its face, it seems to be counter-productive. Many of the technologies summarized above are meeting the carbon transition goal of storage while not causing any harmful effects on the environment or social justice. Those technologies will likely continue to receive research funding and investments and will continue to advance. With the right set of circumstances, jurisdictional conditions addressed and regulatory barriers examined, certain storage technologies will have the ability to meet a significant growth scale.

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[123] European Parliament's committee on Industry, Research and Energy. *Outlook for Energy Storage Technologies*., 19

[124] Fuchs., Benedikt Lunz., Leuthold, Dirk Uwe Sauer., *Technology Overview of Electricity Storage*., 20

5. Energy Storage Markets

Market type overview: Monopoly, liberalized and hybrid

As energy storage technology advances within the niche, the landscape will maintain its growing pressure on the regime. Discussion in the media, civil society, within academic circles, the scientific community and beyond, related to the environment and human health as a result of pollution and air quality, are examples of high-level pressures from the landscape. As acknowledgements related the need to develop sustainable technologies puncture the regime, the regime, in turn, must be prepared to respond quickly, usefully, and tangibly to the integration of sustainable technologies, such as renewable integration and storage. Electricity markets are arguably one of the first layers of regime acceptance, as they can influence the institution. Regime change can also occur the other way, by way of the institutions guiding the market. If the market regulators lead the way for the institutions, whereby they are encouraging rules and markets for new technologies to join the market easily, there is a possibility for a quicker transition to sustainable technologies.

Leading the discussion on the adaptability of the markets is a question of whether the current market structure (depending on jurisdiction) is the ideal framework for the influx of the variety of technologies that are booming within the niche.[125] While market renewal or change is typically framed around the integration of renewables, storage falls under the same category – it is a potentially disruptive and not distinctly referred to in most market rules. The International Energy Agency has stated that the integration of renewable generation will require a transformation in the whole power system.[126] Further, as pointed out by the Mowat Center in *Pricing Outcomes: A Framework for a 21st Century Electricity Market for Ontario*; the Independent Electricity Operator (IESO), Ontario's electricity system and market operator, has recognized the need for reform and has begun working on their market renewal project.[127] Other

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[125] Carlson, R. *Pricing Outcomes: A Framework for a 21st Century Electricity Market for Ontario., 2*

[126] Found in Carlson, R. *Pricing Outcomes: A Framework for a 21st Century Electricity Market for Ontario*., 2.Originally from: International Energy Agency. *Next Generation Wind and Solar Power: From Cost to Value*., 8-10
https://www.iea.org/publications/freepublications/publication/NextGenerationWindandSolarPower.pdf

[127] Ibid.,2

jurisdictions in Canada, such as Alberta, are working toward a transition within their current market structure. Whether the re-design of the markets will be specifically beneficial for storage is somewhat unknown, as both Ontario and Alberta, have yet to implement their new designs.

It should be noted that globally, significant work is being done to incorporate storage and renewable energy into markets and regulatory frameworks; this can be seen in places like Germany and the United Kingdom.[128] However, the purpose of this paper is to examine storage and markets in North America with the intention to apply the results and recommendations to Ontario and other Canadian jurisdictions. The European model is vastly different than the North American model and thus beyond the scope of this analysis.

Within Canada, the *Constitution Act*, 1982 Section 92A (1)(c)[129] gives complete authority to provinces to have jurisdiction related to the development, conservation, and management of sites and facilities within the province for the generation and production of electricity.[130] In other words, across the country, a consistent and unified market approach to energy markets and technological integration does not exist. Some jurisdictions, such as Manitoba and British Columbia, operate under a vertically integrated monopoly market system. Monopoly markets are typically characterized by a single seller of a commodity, in this case, electricity, whereby the seller doesn't have substantial competition.[131]

Other provinces, specifically Ontario and Alberta operate within organized markets. Organized markets are sometimes referred to as "liberalized markets" or "organized wholesale markets." The justification for Ontario and other jurisdictions to engage in a wholesale or liberalized market is that competition to supply electricity to the market in real-time ensures that consumers receive the lowest possible electricity costs.[132] PJM, a regional transmission organization in the

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[128] Note. For more information on energy storage policies internationally, see Renewable Energy Association, *Energy Storage in the UK: An Overview*., 17-19
[129] *Constitution Act, 1982*, being Schedule B to the Canada Act 1982 (U.K.), 1982, c. 11.
[130] Clark., Stoll., Cass. *Ontario Energy Law: Electricity*., 20
[131] The Economic Times. *Definition of 'Monopoly*.'
https://economictimes.indiatimes.com/definition/monopoly
[132] IESO. *Ontario's Power System: Electricity Market Today*.
http://www.ieso.ca/en/learn/ontario-power-system/electricity-market-today

United States notes, "two decades of research and numerous studies have demonstrated competitive wholesale markets [within the PJM jurisdiction and elsewhere] bring increased operational efficiency and innovation, resulting from transparent market prices…"[133]

A defining feature of the wholesale market scheme is typically the understanding that within the wholesale market, technological advancements can flourish and rates are low. This feature is opposed to a monopoly market that is led by a single utility, which may or may not initiate exploration in progressive [sustainable or diverse] technologies. For example, Manitoba, which is a vertically integrated monopoly, has a single utility, Manitoba Hydro. Most of Manitoba's electricity is generated from hydroelectric dams, resulting in some of the lowest rates for electricity in the country. On its face, Manitoba's electricity Crown Corporation is not incentivised to explore different types of technologies (this is not to suggest that Manitoba has not engaged in any type projects related to renewables, or storage technology). Whereas, for example, wholesale markets, according to IESO, offer an opportunity for an open electricity sector, which will "help level the playing field for different participants and technologies, for example, allowing consumers to compete against generators to provide services that help balance the system."[134]

While Ontario is considered a liberalized market, the electricity market in Ontario is also known as a hybrid market.[135] A hybrid market is when electricity services can be provided via competitive markets and others cannot, due to natural monopolies or market power.[136] An example of a hybrid market characteristic is when generation services are traded within the market yet transmission investment, and upgrades are financed through the rate base.[137] A hybrid market is simultaneously market driven and regulated by way of institutions and the government.

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[133] PJM Interconnection. *Resource Investment in Competitive Markets*., i.
[134] IESO. *Ontario's Power System: Electricity Market Today*. http://www.ieso.ca/en/learn/ontario-power-system/electricity-market-today
[135] Clark, Stoll., Cass. *Ontario Energy Law: Electricity*.,10.
[136] Sioshansi., Denholm., Jenkin. *Market and Policy Barriers to Deployment of Energy Storage*.,7
[137] Ibid.,7

5.1. Ontario – Monopoly to Liberalization

In 1995, the Conservative government, under the authority of Premier Mike Harris, ran on a platform, inter alia, which promised the electricity deregulation and liberalization.[138] This initiative began the transformation in Ontario from a monopolistic market, controlled by Ontario Hydro, to a competitive market. Before the restructuring, Ontario Hydro along with some smaller municipal utilities were responsible for providing power to all of Ontario and the provincial government set all electricity prices.[139]

In 1998, the government of Ontario passed the *Energy Competition Act* (ECA), which included the *Electricity Act* (EA) as Schedule A. The principal objective of the ECA was to move away from a monopoly based electricity system to a competitive wholesale electricity system. The purpose of the new *Act* was also to provide opportunities for job creation, increased investment, and new tools for environmental protection and to offer safe, affordable and reliable electricity.[140]

The EA of 1998, set out the framework for Ontario's competitive market restructuring, while the ECA eliminated Ontario hydro and created five separate entities.[141] As of April 1999, two commercial companies: Ontario Power Generation (OPG) and Hydro One, both Crown corporations, came online. In addition, two not-for-profit entities were created: The Independent Electricity System Operator (IESO), a Crown corporation and The Electrical Safety Authority (ESA). Lastly, another entity called the Ontario Electricity Financial Corporation (OEFC) was created. The OEFC purpose is responsible for serving and paying down the "stranded debt" of the former monopoly.[142] Ontario's competitive market opened on May 1, 2002.

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[138] Clark., Stoll., Cass. *Ontario Energy Law: Electricity*., 5
[139] IESO. *Overview of the IESO- Administered Markets*., 2
[140] Clark., Stoll., Cass., *Ontario Energy Law: Electricity*., 6
[141] Note. A product of the ECA was also the creation of the *Ontario Energy Board Act*, 1998, S.O. 1998, c. 15, Sch B. The ECA enhanced the role of the OEB, giving the board authority to license and set rates for transmission and distribution. A discussion of the OEB will be provided in another section of this paper. For Further information, see Clark., Stoll., Cass., *Ontario Energy Law: Electricity.*
[142] IESO. *Overview of the IESO- Administered Markets*., 2

In 2003, the government of Ontario switched from a Conservative government (which had initiated the competitive electricity market in the province) to a Liberal government that didn't entirely support open competition. As result of politics, and the success or lack thereof, of the open market, the Liberal government opted to create "hybrid" market.[143] To support the hybrid system, the Liberal government introduced the *Electricity Restructuring Act*, 2004. The objective of this Act was to: restructure, promote the expansion of electricity and capacity including renewables, facilitate load management and demand, encourage conservation and regulate prices.[144] The Act also created the Ontario Power Authority (OPA), which is the body meant to address forecasting needs and to prepare integrated system planning for conservation, generation, and transmission. In 2012, the government announced that the OPA would merge with the IESO and Bill 75, the *Ontario Electricity System Operator Act*, 2012 was created to guide the merger of the two institutions.[145]

The most recent development in electricity legislation in Ontario is the Legislature's approval of the *Energy Statute Law Amendment Act*, 2015 (Bill 135). The bill was passed in June 2016. An overarching criticism of this legislation was the increased power and authority given to the Ministry of Energy in developing the long-term planning of Ontario's electricity sector, while simultaneously limiting the role of the IESO and the OEB.[146]

The organization of the electricity sector in most wholesale markets is complicated. This complication is mostly as a result of the multiple actors involved, including regulatory bodies and market overview and politics. There are multiple acting bodies, some with the same enabling legislation, others that operate under a different authority, either legislative or policy. While theoretically separate, each body affects another in either a direct or non-direct way. An example of this is clear when discussions about the relationship between the IESO and OEB arise. The IESO, while prima facie independent, operates via the authority of the EA and with a licence

[143] Clark., Stoll., Cass., *Ontario Energy Law: Electricity., 10*
[144] Ibid., 11
[145] Ibid.,13
[146] Stevens., *Ontario Legislature has Passed the Energy Law Statute Amendment Act, 2015, (Bill 135).* http://www.airdberlis.com/insights/blogs/energyinsider/post/ei-item/ontario-legislature-has-passed-the-energy-law-statute-amendment-act-bill-135

from the OEB. To be a market participant in the IESO market, for example, a licence is first required from the OEB. For conceptualization and description, this paper separates the IESO and the OEB, but it should be clear that each body affects the other and there truly is not a perfect divide between the two as they are tied by legislation, policy, and politics.

5.1.1. Ontario Energy Board

The Ontario Energy Board (OEB) operates under the authority of the *Ontario Energy Board Act*, 1998 and the *Electricity Act*, 1998. The OEB's main objectives, with regards to electricity regulation in the province, are to:

a) Protect consumers concerning electricity prices, and the adequacy, reliability, and quality of electricity service;
b) Promote efficiency in the generation, transmission, distribution, sale, and demand management of electricity, and to facilitate the maintenance of a financially viable electricity industry;
c) Promote electricity conservation and demand management;
d) Facilitate the implementation of a smart grid;
e) Promote use and generation of electricity from renewable energy sources, and;
f) Facilitate the implementation of all Integrated Power System Plans approved under the Electricity Act, 1998.[147]

The Ontario Energy Board is meant to be a consumer protection agency that "ensures consumers are treated fairly and that the energy system is reliable and sustainable."[148] The regulatory body is responsible for, among many other things, rate setting and licencing, including approving all licences for any market participant in the province, including the IESO.[149] The OEB is an independent body that does not hold any statutory authority to make policy.[150] The OEB is a critical player in the electricity landscape in Ontario. Almost every electricity entity in the

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[147] In Clark., Stoll., Cass. *Ontario Energy Law: Electricity.,*312, from *Ontario Energy Board Act*, 1998, S.O. 1998, c.15, Sch B, s. 1(1).
[148] Ontario Energy Board. *What we do*. https://www.oeb.ca/about-us/what-we-do
[149] Clark., Stoll., Cass. *Ontario Energy Law: Electricity.,*312
[150] Warren, Robert. *Regulatory Independence: The Impact of the Green Energy Act on Regulation of Ontario's Energy Sector*. http://www.weirfoulds.com/regulatory-independence-the-impact-of-the-green-energy

province has a relationship with the OEB, whether it is for a rate application approval for a utility or commenting on a directive from the Ministry of Energy.

5.1.2. Independent Electricity System Operator

The Independent Electricity System Operator (IESO) of Ontario, as created by the *Electricity Act*, 1998, acts as Ontario's electricity system and market operator, which manages the integrated power system and serves as the supervisor of the wholesale electricity market in Ontario.[151] The IESO is a not-for-profit agency and a Crown corporation that is considered independent from all of the other market participants in the province.[152] The body is also not an agent of the Crown nor does the body have authority to buy or sell electricity.[153] As noted, the IESO operates under the authority of the *Electricity Act*, 1998 but it is also operates under the stipulations laid out by the licence granted to it by the Ontario Energy Board (OEB), under the authority of the *Ontario Energy Board Act*, 1998.[154] Alternatively, the OEB is the only regulatory board under the *Electricity Act*, 1998 that has the power of oversight related to the business of the IESO, this includes the operation of the markets.[155]

Under the authority of the *Electricity Act*, 1998 the IESO was given ten statutory objectives, namely:

a) To exercise and perform the powers and duties assigned to the IESO under the *Electricity Act*, the market rules, and its OEB licence;
b) To enter into agreements with transmitters giving the IESO authority to direct the operations of their transmission systems;
c) To direct the operation and maintain the reliability of the IESO-controlled grid to promote the purpose of the *Electricity Act;*
d) To participate in the development by any standards authority of standards and criteria relating to the reliability of transmission systems;

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[151] Clark., Stoll., Cass. *Ontario Energy Law: Electricity.,* 309
[152] Ibid.,309
[153] Ibid., 309
[154] Clark., Stoll., Cass. *Ontario Energy Law: Electricity*.,310,
[155] Ontario Securities Commission. Securities Law and Instruments. http://www.osc.gov.on.ca/en/SecuritiesLaw_ord_20141113_212_independent-electricity-system-operator.htm

e) To work with the responsible authorities outside Ontario to coordinate the IESO's activities with their activities;
f) To collect and provide the OPA and the public information relating to the current and short-term electricity needs of Ontario and the adequacy and reliability of the integrated power system to meet those needs;
g) To operate the IESO-administered markets to promote the purpose of the *Electricity Act*;
h) To plan, manage and implement the smart metering initiative or any aspect of the initiative;
i) To oversee, administer and deliver the smart metering initiative or any aspect of the initiative;
j) To establish and enforce standards and criteria relating to the reliability of transmission systems.[156]

The IESO is responsible for publishing system forecasts, market information, and performing financial settlement transactions within the province.[157] Also, the IESO manages the Controlled Markets and Market Participants[158] and the grid under the authority of the Market Rules.[159]

Market Rules are written by the IESO, and the rules are the authority by which all Market Participants in the province must abide. The Market Rules administered by the IESO govern the operation of the wholesale market (which is divided into two distinct markets: wholesale and retail).[160] The main objectives of the Market Rules, as determined and written by the IESO, are to "promote an efficient, competitive and reliable market for the wholesale and purchase of

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[156] *Electricity Act*, s 5(1) found in: Zacher, Duffym, Brown. *Energy Regulation in Ontario*. 9.1-9.2.
[157] Clark., Stoll., Cass. *Ontario Energy Law: Electricity*.,309
[158] Note. It should be noted that Market Participants are also subject to OEB licensing. See, Clark., Stoll., Cass. *Ontario Energy Law: Electricity.,* 309
[159] Ibid., 309
[160] Clark., Stoll., Cass. *Ontario Energy Law: Electricity*., 324. As defined by the authors, the wholesale market refers to trade of large volumes of electricity and large loads connected to the transmission system. The Retail market is defined by small purchases of electricity by residences and small businesses from electricity retailers or distributors. IESO's *Overview of the IESO Administered Markets* notes that there are three distinct categories within the wholesale market: real-time markets, financial markets and procurement markets.,8

electricity and ancillary services in Ontario" coupled with maintaining and promoting reliability.[161] It is here, within the market rules and the OEB licence requirements, that the integration of storage is either promoted or defined. It is also within the Market Rules that embracing storage and technologies has the ability to positively influence the relationship between the market and the institutional players that have the authority to promote storage.

5.1.3. IESO Market Rules

To participate in the IESO electricity market as a Market Participant, it is first necessary to obtain a licence from the OEB pursuant to Part V of the *Ontario Energy Board Act*, 1998.[162] An electricity storage licence, as authorized by the OEB, and then subsequently approved by the IESO, allows a licencee to generate electricity or provide ancillary services for sale within the IESO markets or directly to another person.[163] The licence provides for the purchase of electricity or ancillary services, or sale of electricity or ancillary services within IESO markers or to another person, in the case of sale, but not to consumers (see appendix x for OEB sample Electricity Storage Licence).

Upon receipt of a licence, a Market Participant is then subject to all market rules related to the activities as described by the licence and the market rules.[164] The IESO market rules set out nine classes of participants allowed to obtain authorization to participate in the market. The classes of market participant are set out in Chapter two, section 2.1.1 of the Market Rules and are as follows:

a) Generators;
b) Distributors;
c) Wholesale sellers;
d) Wholesale consumers;
e) Retailers;
f) Transmitters;

[161] IESO. *Market Rules for the Ontario Electricity Market*, Chapter 1, s. 3.1.1
[162] IESO, Market Rules. Chp 2-1
[163] OEB. *Electricity Storage License*. https://www.oeb.ca/industry/licensed-companies-and-licensing-information/apply-licence/electricity-storage-licence
[164] IESO, Market Rules. Chp 2-1

g) Financial market participants;

h) Demand response market participants;

i) Demand response auction participants.[165]

The IESO market rules are paramount to participation in the IESO controlled grid and the provision of ancillary services. The market rules govern the way electricity and related services are sold, purchased and dispatched in the IESO administered markets. Before the *Electricity Restructuring Act*, 2004 within the IESO existed the Market Surveillance Panel (MSP), which was tasked with monitoring; investigating and reporting on activities within the IESO administered markets. As of 2005, the IESO MSP transferred to the OEB.[166]

It is clear the storage does not fit nicely into any of the above categories. That being said, the OEB licence allows for storage to operate within the market as an ancillary service. The Market Rules were updated as recently as September 2017, and as it stands there is no clear classification for storage to assume.[167] Storage has the unique ability to offer a wide range of applications ranging from generation to transmission, distribution and behind the meter generation.[168] Storage arguably can offer a diversity of services that complicates its ability to adhere to the current market category classes. In principle, this would be true for any technology that does not fit neatly within one of the classes. This complication is also the result of market rules that were created before the advancement of storage technologies and capabilities.

[165] Ibid., ch 2-1

[166] OEB. Electricity Market Surveillance. https://www.oeb.ca/utility-performance-and-monitoring/electricity-market-surveillance

[167] Note. When IESO incorporated 50MW of storage into the market, as per the Long Term Energy Plan:2013, procurement for storage was contracted as ancillary services as determined by the market rules. "The IESO will use the ancillary services framework as the means to integrate energy storage services into the IESO- administered markets to maintain system reliability in accordance with the IESO's market objectives." Contracts were available under the Alternate Technologies for Regulation framework, which the IESO has previously created to contract with other storage vendors. See, IESO. *Energy Storage Procurement Framework*., 9- 11

[168] Energy Storage Ontario. *Submission to the Independent Electricity System Operator Stakeholder Advisory Committee. Preliminary Ontario Planning outlook,3.*

A barrier to sustainable technologies is that currently, no explicit category exists for storage. To act as a Market Participant as a storage provider, a proponent has to contract with the IESO, outside the currently defined categories. This contract falls under the Alternate Technologies for Regulation (ATR) framework, which began as a pilot project in 2012. The ATR framework is the IESO's attempt to "assess technological capabilities, develop market mechanisms to facilitate competition and metering verification and settlement for alternate sources of regulation in future years."[169] This framework, as noted by IESO can be used for storage projects in Ontario.[170]

Such a framework is a positive step by the IESO. It follows that the IESO is aware that novel technologies already exist outside the current frameworks and will continue to be developed for the market. As a result, the market rules and categories will likely have to be amended to reflect the number of storage participants that want to get into the market. If the IESO maintains a different contracting structure for storage, it is a signal that the Ontario market is not ready to embrace the technological transformation that comes with storage. Ultimately the market is noting it is not ready to keep up with the pace of environmental technologies on the whole. The pilot projects reflect a seeming readiness to adapt to storage, but it is only a stepping-stone. There remains a need to enhance the market rules further to fully integrate storage.

5.1.4. Ontario's Long-Term Energy Plan: 2013

In 2013, the government of Ontario introduced the Long Term Energy Plan (LTEP) with an intention to adopt and foster renewable energy into the Ontario electricity supply mix. The LTEP operates under five keys principles: cost-effectiveness, reliability, clean energy, community engagement and conservation, and demand.[171] The LTEP, which emphasizes renewable energy and clean technologies, such as storage, simultaneously notes that nuclear power will "continue to be the backbone of Ontario's supply."[172] Within the LTEP, the government set forth an agenda to introduce 50 MW of stored energy capacity to be integrated into the market.[173] The Plan states

[169] IESO. *Energy Storage Procurement Framework*.,34
[170] Ibid.,34
[171] Government of Ontario. *Achieving Balance: Ontario's Long Term Energy Plan*., 4
[172] Ibid., 3
[173] Ibid., 7

"energy storage technologies have the potential to revolutionize the electricity system, increasing its efficiency, lowering costs and increasing reliability for the consumer."[174]

The IESO, in alignment with the government directive, issued two requests for proposals for the development of energy storage for the years 2014 and 2015.[175] To achieve the goals of the LTEP: 2013, The IESO divided the energy storage procurement operation into two phases:

Phase 1 (2014)	**Phase 2 (2015)**
"Investigate the capabilities of energy storage facilities, featuring diverse technologies…to offer either or both of the following: regulation, and reactive support and voltage control."[176] These are known as ancillary services. "The successful applications included: thermal energy storage, stationary batteries, flywheels and power to gas (hydrogen). With a total of 33.54 MW."[177]	"the IESO selected the remaining quantity of the 50MW grid energy storage target through a program that was focused on the capacity value of grid energy storage, along with understanding the approach to achieving arbitrage value."[178] "The remaining 16.75 MW was distributed among 5 proponents."[179]

Table 2 LTEP: 2013

The LTEP (the government), directed the IESO, in addition to adding the 50 MW of capacity to also "review the outcomes of the 50 MW energy storage procurement and incorporate the learnings…into a report to the Ministry of Energy on options for integration of energy storage into Ontario's electricity market and market-based procurements…"[180]

[174] Ibid.,83
[175] Stevens, David. http://www.airdberlis.com/insights/blogs/energyinsider/post/ei-item/an-introduction-to-energy-storage-in-ontario?utm_source=Mondaq&utm_medium=syndication&utm_campaign=inter-article-link
[176] IESO. *IESO Report: Energy Storage*.,11
[177] Ibid., 12
[178] Ibid., 13
[179] Ibid., 13
[180] IESO. *IESO Report: Energy Storage*., 1

In the *IESO Report: Energy Storage*, a few recommendations, and notable comments were suggested related to the use and integration of storage. Notably, the IESO indicates that while storage offers valuable and a wide range of services, including regulation, voltage control, operating reserve, and flexibility, "energy storage is not the only option for providing these services."[181]

While the IESO's report did not seem overly enthusiastic to incorporate storage into the grid, the initiative taken by the government to address storage in the LTEP is a positive step forward. It is a sign that there is awareness that there is a need to adopt and encourage sustainable technologies. Institutional directives are encouraging, as they are making room for the inevitable change resulting from the landscape pressure. The pace necessary to make said amendments is not on par with the technological advancements, but it should be noted that the institutions and the government are taking serious steps.

5.1.5. Ontario's Long-Term Energy Plan: 2017

In October 2017, the Ministry of Energy released its anticipated Long-Term Energy Plan. The main objective of the 2017 LTEP is "principally focused on the consumer while ensuring a reliable and innovative energy system."[182] The LTEP is a considerable document with eight chapters dedicated to highlighting the government's achievements and plans for the sector in the province. Chapter 3, titled *Innovating to Meet the Future* is the section that addresses the current state of storage in the province and the barriers to deployment of storage. The LTEP reiterates its goals as set out in the 2013 LTEP, i.e., procuring 50 MW of storage, etc.[183] The LTEP further notes that since 2013, it has become clear that storage has many regulatory barriers and hurdles to overcome, but the government has since identified those barriers and will update its regulations.[184] It should be noted that the paper does not specifically indicate what those barriers are, nor does the paper indicate how the government intends to overcome them. Other than noting that the global adjustment costs for storage is being addressed and regulations are being

[181] Ibid., 1
[182] Government of Ontario, Ministry of Energy. *Ontario's Long-Term Energy Plan: Delivering Fairness and Choice*., 6
[183] Ibid.,60
[184] Ibid.,60

updated, the LTEP 2017 does not offer a clear or substantive guide on the future of storage in the province.

5.1.6. IESO Market Renewal

The current market structure in Ontario is riddled with complexity and is seemingly ready for a transformation. As noted in the beginning of this section, an overarching theme related to electricity markets and the intersection of technology is whether the current market structure, i.e., liberalized or wholesale, is the ideal structure to encourage and adopt new technologies into the market. Ontario, and other jurisdictions in Canada and across North America have expressed interest in market renewal. Market renewal, in Canada at least, appears to translate to an interest in Capacity Markets, which is a consideration the IESO is currently exploring in its market renewal initiative. By way of background, capacity markets are generally considered as a

> competitive process run regularly by a system operator to identify and attract qualifying resources to meet forecasted future peak-demand levels plus a reserve margin. The system operator establishes the standard for capacity, but uses competitive market forces and private investment to achieve it at a least cost to consumers.[185]

While some jurisdictions are considering transitioning to a capacity market, criticism of the structure is often said to be of political interference and increased complexity.[186]

The IESO is currently in the process of restructuring the market, under the Market Renewal program. The Market Renewable program, according to the IESO has four principal initiatives:

a) Introduce a Day-Ahead Market to provide greater certainty to Market Participants and lower the cost of producing electricity;
b) Reduce the cost of scheduling and dispatching resources to meet demand as it changes from hour to hour and minute to minute through a Single Schedule Market and Enhanced Real-Time Unit Commitment

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[185] Charles River Associates. *A Case Study in Capacity Market Design and Considerations for Alberta*., 8

[186] Found in Carlson, Richard. *Pricing Outcomes: A framework for 21st Century Electricity Markets*.,7. Originally from, Hogan, M., *Follow the Missing Money: Ensuring Reliability at Least Cost to Consumers in the Transition to a Low-carbon Power System.,*58

c) Explore how Ontario's interties could be better used to meet unexpected short-term changes on the system;
d) Improve the way Ontario acquires the resources to meet our longer-term supply needs by implementing and Incremental Capacity Auction.[187]

The IESO's market renewal program is under the guidance of the Market Renewal Working Group, whose objective is to enhance Ontario's electricity market design by way of strategic guidance and policy considerations related to the design of the market.[188] The Terms of Reference guiding the Working group note that members of the Group will represent a broad range of market participants, notably; one of those groups is section 4.1.2.5, which is the Emerging Technologies category. The market renewal program has set a clear objective of highlighting the need to reduce barriers to entry into the market, which in turn will enable emerging technologies while allowing consumers to play a larger role in the sector simultaneously.[189]

The objective of the market renewal program is to address the current challenges in the market while forecasting the issues that will be concerns for the energy market in the future. At this point, stakeholder engagement and consultation is still ongoing. According to a recent IESO Technical Update, it appears as though the design of the new program will likely be published in the latter part of 2018.[190] As the IESO seeks to transform the market, the only other liberalized market in Canada, Alberta, has also recently undergone a market transition, namely to a Capacity Market design. This redesign lends itself to consider whether a capacity market, such as Alberta's, will assist with, or encourage, storage technologies.

5.2. Alberta

Similar to Ontario, Alberta has been defined as a competitive wholesale market. Analogous to Ontario, the Alberta market transitioned from a three-way vertically integrated market to

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[187] IESO. *Overview of Market Renewal*. http://www.ieso.ca/en/sector-participants/market-renewal/overview-of-market-renewal
[188] IESO. *Market Renewal Working Group: Terms of Reference*., 3.
[189] IESO. *Update on Market Renewal Program: Update to Technical Panel*., 3
[190] Ibid.,17

deregulation in 2001.[191] The path toward deregulation in Alberta was encouraged by the efforts of the *Electric Utilities Act*, 1996 (EAU) and the creation of the Power Pool of Alberta. The Power Pool was a not-for-profit agency that was tasked with providing a competitive, wholesale real-time spot market. The Power Pool was open to any "generator, marketer, distributor, importer or exporter that satisfied the qualification requirements established under the EAU and the rules and codes of practice of the Power Pool."[192] With few exceptions, all power within Alberta was sold through the Power Pool. To sell or purchase power within the Power Pool, a seller or purchaser had to fall within one of the three categories:

Categories of Sellers in Power Pool	**Categories of Purchaser in Power Pool**
1) "Marketers: are trading entities that have an agreement and are registered with the Alberta Electric System Operator (AESO)";	1) "Retailers: includes owners of local distribution systems, who may sell electricity to end-use consumers";
2) "Importers: Purchase energy through interprovincial agreements with border jurisdictions, such as Saskatchewan, British Columbia and into the United States";	2) "Direct access customers: can buy their electricity directly via Power Pool";
3) "Independent power producers: This subsection includes owners of non-regulated generating capacity that have been developed in Alberta since 1996."	3) "Exporters: can purchase energy from Power Pool, and may export to neighbouring jurisdictions, for example Saskatchewan or British Columbia."

Table 3 Power Pool AB [193]

While the Power Pool was the administrator of the wholesale electricity market in Alberta for a few years, it was eventually made redundant. In 2002, Power Pool merged with the provincial Transmission Administrator, to form the AESO.[194] The AESO is now the sole operator of the power grid in Alberta, and responsible for any activities that occur in the wholesale spot-market, which is still referred to as Power Pool.[195]

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[191] AESO. *Guide to Understanding Alberta's Electricity Market*. https://www.aeso.ca/aeso/training/guide-to-understanding-albertas-electricity-market/

[192] Blake, Cassels, Graydon LLP. *Overview of Electricity Regulation in Canada.*,3.

[193] Ibid.,3

[194] AESO. *Guide to Understanding Alberta's Electricity Market*

[195] Market Surveillance Administrator. *Alberta Wholesale Electricity Market*., 5

5.2.1. Alberta Electric System Operator

There are striking similarities between the Ontario market design and the Alberta market design, as a result of operating under a competitive market scheme. The AESO, like the IESO, is the province's independent market regulator. The AESO has been given authority to operate the market via the *Electric Utilities Act, 2003.* According to the AESO, the system operator has four objectives:

a) Operate an open and competitive wholesale market;
b) Direct the safe and reliable operation of Alberta's electric system;
c) Plan and develop the transmission line;
d) Provide customer access to the transmission system.[196]

The AESO sells power within Alberta and also can buy power through the province's Energy Trading System, an internet-based system that manages market transactions.[197] As is stands, Alberta is considered an "energy-only" model.[198] This model translates into generators only getting paid for the energy they produce. With regards to ancillary services within the province, the AESO operates an entirely separate market. The AESO has the sole authority within the province to provide and purchase ancillary services, which are operated on a third-party platform.[199] The electricity market in Alberta is further subdivided by the separation between the wholesale market and the retail market. The retail market is addressing the needs of smaller retail customers, which includes residential consumers.[200]

Operations within the AESO are governed by the Independent System Operator (ISO) rules, which is synonymous with the AESO. To purchase or sell within the electricity market, a proponent must apply to the AESO and then adhere to the ISO rules. The AESO will licence and regulate market participants through a variety of guidelines and a set of governing structures. They include, but are not limited to:

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[196] AESO. *Guide to Understanding Alberta's Electricity Market.*
[197] Blake, Cassels, Graydon LLP. *Overview of Electricity Regulation in Canada.,*4
[198] AESO. *Guide to Understanding Alberta's Electricity Market.*
[199] Ibid.
[200] Market Surveillance Administrator. *Alberta Wholesale Electricity Market*., 6

a) An application Form and Pool Participant Agreement. To become a Pool Participant a proponent would have to: submit an application and agree to the Pool Participant Agreement;
b) Adherence to ISO rules;
c) Agreement to operate within the Operating Policies and Procedures, which define the technical standards and operating policies for the provincial system;
d) Settlement System Code, which outlines the standards practices and processes required for settlements in the province;
e) Finally, the ancillary Services Technical Requirements, which is outlines the technical requirements that must be met.[201]

Under the AESO, market participants must meet said requirements and criteria to obtain a licence within the electricity market in Alberta. Around 2013, as a result of landscape issues, including renewable integration and a potential desire to redesign the market, the AESO began to examine the incorporation of various technologies, specifically storage, into the current market structure.[202] The initial examination revealed that the current technicalities constructed by the market design were limiting to storage. The AESO noted, "existing technical standards and market rules were developed based on experience with existing generation fleet and load characteristics."[203]

5.2.2. Alberta Market Redesign

As noted, the AESO began addressing the barriers to storage in 2013, with its *Energy Storage Initiative Issue Identification* paper. The drive toward integrating storage into the market in Alberta, according to the *Issues Identification* paper the initiative was driven by the funding from the Climate Change and Emissions Management Corporation, among other groups.[204] This drive toward integration of storage is coupled with the province's push for increased integration of renewables in the province, under the leadership of the *Climate Leadership Plan, 2015*. These factors created an opportunity for storage to get the spotlight that had not previously existed in

[201] Blake, Cassels, Graydon LLP. *Overview of Electricity Regulation in Canada.,*5
[202] AESO. *Energy Storage Initiative Issue Identification*., 5
[203] Ibid.,5
[204] AESO. *Energy Storage Initiative Issue Identification*., 4

Alberta. In other words, there appeared to be landscape pressure penetrating the regime. Perhaps global concerns related to carbon emissions and the benefits of renewables have been accepted as a reality by the government of Alberta. The government set a tone for addressing big picture issues related to climate concerns. The apparent awareness resulted in the push for renewables, and in turn, the ability of storage to address renewables' intermittent behaviour within the province of Alberta.

The *Energy Storage Initiative Issue Identification* paper was quick to address the main barriers to incorporating storage within the framework of the current electricity system. The 2013 paper noted that some of the issues facing storage were: "creating technical standards for ES to connect to and operate within the Alberta Interconnected Electric System, creating technical requirements for the provision of energy and ancillary services, asset clarification, market rules, operating reserves procurement practice and the ISO tariff."[205] While energy storage technology can store electric energy, storage systems and applications are known to be multidimensional. The multifaceted ability of storage is problematic concerning the rules of connecting to the grid. The technical barriers related to connecting to the Alberta Interconnected Electric System (AIES) is the generation and load interconnection standard.[206]

Generation and load, according to the AESO report, are different services and tend to be technically different.[207] Thus, different requirements exist for generation connections and load connections.[208] This difference, as noted in the report, poses a challenge, as storage is not necessarily easily defined as either generation or load. Leaving the authors of the *Initiative Issues Identification* paper to ponder: should storage utilize the existing connection standards? Should storage have its own connection standards?[209]

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[205] AESO. *Energy Storage Initiative Issue Identification*.,1
[206] AESO. *Energy Storage Initiative Issue Identification*.,7
[207] Ibid., 7
[208] Ibid.,7
[209] Ibid., 7

Further barriers as noted by the paper, state that in addition to the general requirements for obtaining status and connecting to the grid, storage faces some significant market rules roadblocks. The initial 2013 report states:

> two key ISO rules are Must Offer Must Comply Rule and the Outage Reporting Rule. In relation to certain unique features of ES, issues are likely to arise with respect to which ISO rules are applicable to storage and how the existing ISO rules can be applied to storage facilities.[210]

The *Energy Storage Initiative Issue Identification* paper started the discussion in Alberta about the acceptance of, and integration of, storage in the province. Subsequently, additional papers were released, examining the initial barriers posed by the 2013 paper. After consultations and work with stakeholders, the AESO responded by introducing recommendations to move forward with storage. The most recent recommendation paper from the AESO, written in 2015, stated that as a result of their consultations and to go forward, three priorities must be addressed:

a) Develop technical and operating requirements to connect and operate energy storage facilities;
b) Determine the appropriate tariff rate to apply to storage;
c) Review the technical requirements for the provision of Operating Reserves considering the attributes of storage.[211]

As a result of the highlighted priorities above and consultations with storage advocates in Alberta, the 2015 Energy Storage Integration paper offers five recommendations for the fluid incorporation of storage in the Alberta market; they are verbatim:

a) Complete the drafting of and file the ISO rules to address technical and operating requirements for battery storage facilities (Proposed Battery Facility Rules, with the Alberta Utilities Commission;
b) Storage facilities operate as generating units when injecting power into the grid and operate as load when purchasing or withdrawing electricity from the transmission system. The storage facility is using the transmission system and is required to pay the just and

[210] Ibid.,9-10
[211] AESO. *Energy Storage Integration*.,3

reasonable costs of the transmission system. An economic dispatch study will be performed to develop the ISO tariff treatment options for storage;

c) Maintain the minimum requirement of 15 MW ranging for regulating reserve (RR) and of 10 MW for spinning reserve (SR). The AESO conducted an off normal frequency study that gave strong indication that reducing the size of RR and SR assets negatively impacts the ability of the AIES to respond to frequency excursions;

d) The AESO will revise, ISO Rule 205.4 Regulating Reserve Technical Requirements and Performance Standards. ISO rule 205.5 Spinning Reserve Technical Requirements and Performance Standards and ISO Rule 205.6 Supplemental Reserve Technical Requirements and Performance Standards and other rules that may be incidentally impacted to reflect how energy storage technology will participate in operating reserve products. The AESO is targeting to initiate the consultation process on these revisions to file by 2016;

e) Examine the performance of current RR providers and assess if changing the current technical requirements and/or introducing new technologies (storage) could reduce the required amount of RR. The AESO has entered into partnership with the National Research Council to perform this study and target completion date is end of 2015.[212]

Since the *Integration Paper* was written in 2015, the electricity sector in Alberta has seen a lot of transformation. In addition to market restructuring, the recommendations from the Integration Paper were seemingly set into motion. According to the AESO website, in April 2016, rules were filed with the Alberta Utilities Commission for the Battery Facility Energy Storage Operating Requirements and the Battery Facility Energy Storage technical requirements.[213] The creation of these technical requirements aligns with the first recommendation of the 2015 AESO paper. The website further states that the AESO is in the process of sorting out the rate structure for energy storage facilities. Lastly, as per the recommendations, the AESO is consulting on the Operating

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[212] Ibid., 3-4

[213] AESO. *Energy Storage*. https://www.aeso.ca/market/current-market-initiatives/energy-storage/

Reserve rules to promote technological neutrality in the regulating, spinning and supplemental reserves.[214]

The institutional awareness and changes related to storage in the province of Alberta signal a shift within the regime. While not entirely institutionalized nor, are the market rules currently a reflection of the full integration of storage, there appears to be transformation occurring. Prima facie, storage is still sitting within the niche space in Alberta. Until the market rules set specific rules for storage, it will remain in the niche space. The AESO's work is suggesting that the province is adaptable, which means the regime is open to a technological transformation.

5.2.3. Alberta's Capacity Market

Within the transformative environment in Alberta, the market renewal project is also a sign of regime change. The market restructuring within the province can be tied back to the 2015 *Climate Leadership Plan (CLP)*.[215] The CLP highlights renewable integration into Alberta's electricity supply mix. The change in supply mix within the province, namely the push for additional renewables, according to the AESO is one of the principal justifications for the shift from an energy-only market to a different market structure.[216] The AESO noted that an energy-only market would not be sustainable with the changing supply mix. In response, the AESO examined several different market structure scenarios for the larger transformation.[217] After their analysis, the AESO declared that the ideal situation for Alberta's transformation and supply mix change was the adoption of a capacity market. The benefits of a capacity market, according to the AESO are, verbatim:

a) Ensure reliability and specifically compensate for firm generation;
b) Provide suppliers with revenue sufficiency and stability;
c) Implement key areas of the CLP and be robust to accommodate potential future policy evolution;
d) Maintain market incentives to preserve efficiency and flexibility;

[214] Ibid.
[215] AESO. *Alberta's Wholesale Electricity Market Transition Recommendations*.,1
[216] Ibid., 1
[217] Ibid.,2

e) Compatible with the existing transmission policy or future changes;
f) Allow a manageable amount of change with a high probability of success.[218]

In November 2016, the government of Alberta announced their intention to transition to a capacity market system. The government directed Alberta Energy to lead the policy component of the transition, while the AESO will lead the technical design side of the transition, with the incorporation of the new system by 2021.[219] How the transformation to a capacity market in Alberta will directly affect the integration of storage is somewhat unclear.[220] However, there is a general sense that capacity market will further foster renewables in the province, which in turn will promote storage.[221]That being said, it will be up to the AESO and Alberta Energy whether they intend to incorporate storage into the capacity market or maintain the current paradigm, which is to not specifically set rules that meet the unique characteristics of storage.

5.3. The United States – The Federal Energy Regulatory Commission, Regional Transmission Organizations, and Independent System Operators

The Federal Energy Regulatory (FERC) is an independent agency that regulates the interstate transmission of electricity, natural gas and oil.[222] The FERC website, along with the explanatory materials provided on the website, emphasize the distinct role FERC plays within the United States. To provide clarity, and an overview of the federal regulatory body; information provided on the website and guiding materials in terms of roles, is synthesized into a table in this section.

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[218] Ibid.,4
[219] Government of Alberta. *Letter to Bob Heggie, CEO of Alberta Utilities Commission*. March 27, 2017. http://www.energy.alberta.ca/Org/pdfs/AUCmandateLetter.pdf
[220] Note.For an alternative perspective related to Capacity Markets, See The Perils of Electricity Capacity Markets. https://www.greentechmedia.com/articles/read/the-perils-of-electricity-capacity-markets#gs.pNcm8TM
[221] Stevens & Chung. *Energy Storage Developments in Canada, the US and Beyond in the Last Twelve Months*. http://www.airdberlis.com/insights/blogs/firmblog/post/ei-item/energy-storage-developments-in-canada-the-u.s.-and-beyond-in-the-last-twelve-months
[222] FERC. *What FERC does*. https://www.ferc.gov/about/ferc-does.asp

It should be noted that FERC is organized with five commissioners who are nominated by the President of the United States.[223] However, the board may not have more than three commissioners who are aligned with the same political party. This makeup makes for a seemingly impartial or objective board. In particular, decisions made by FERC are not subject to Presidential or Congressional directives, as a court reviews FERC decisions.[224] Finally, The Commission's legal authority stems from *The Federal Power Act* and the *Energy Policy Act* of 2005.

The FERC website states the following mandates fall within or outside of the scope of the regulatory body. The overview provided by the website highlights the essence of what FERC does within the US electricity market. They are as follows, (points not directly related to electricity or transmission have been removed):

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[223] Greenfield, Lawrence. *An Overview of the Federal Energy Regulatory Commission and Federal Regulation of Public Utilities in the United States*., 3
[224] Ibid., 3

Within FERC mandate	Outside FERC's mandate
• "Regulates the transmission and wholesale sales of electricity in interstate commerce; • Reviews certain mergers and acquisitions and corporate transactions by electricity companies; • Reviews the siting application for electric transmission projects under limited circumstances; • Licences, and inspects private, municipal, and state hydroelectric projects; • Protects the reliability of the high voltage interstate transmission system through mandatory reliability standards; • Monitors and investigates energy markets; • Enforces FERC regulatory requirements through imposition of civil penalties; • Oversees environmental matters related to hydroelectric projects; • Administers accounting and financial reporting regulations and conduct of regulated companies."	• "Regulation of retail electricity to consumers; • Approval for the physical construction of electric generation facilities; • Regulation of activities of the municipal power systems, federal power marketing agencies, and most rural electric cooperatives; • Regulation of nuclear power plants; • Reliability problems related to failures of local distribution facilities."

Table 4 FERC Mandate [225]

It is important to note the section of the table that highlights the roles outside of the scope of FERC's mandate. Specifically, FERC is not in a position to interfere with the distribution of local electric energy or the rates, terms and consisting of the distribution.[226] FERC does not have authority to restrict the sale of electric energy to end-users (customers). As a result, local or regional regulatory bodies within the United States drive the role of managing the local distribution, rates, and relationships with consumers.

[225] FERC. *What FERC does*. https://www.ferc.gov/about/ferc-does.asp
[226] Greenfield, Lawrence. *An Overview of the Federal Energy Regulatory Commission and Federal Regulation of Public Utilities in the United States.,12*

5.3.1. Regional Transmission Organizations and Independent System Operators

Within the electricity sector, the use of the terms RTOs and ISOs are often used interchangeably in the literature. RTOs and ISOs are built around the three main interconnections in the United States.[227] However, ISOs operate a region's electricity grid; they administer the region's wholesale electricity markets and promote reliability planning for the region.[228] RTOs have similar responsibilities to the ISO, but RTOs have a role to play in terms of the transmission network as governed by FERC. The RTOs additionally "coordinate, control and monitor the operation of the electric power system within the territory."[229] Each RTO/ISO is under the jurisdiction and rules of FERC.[230] But, there remain subtle differences around the vernacular related to RTOs and ISOs.

Presently, there are four RTOs and seven ISOs in North America. Under the category of ISO, fall the AESO and IESO along with five other American counterparts.[231] This paper will further examine the California ISO (CAISO) and its relationship to FERC and energy storage.

5.3.2. California ISO

The California ISO is regulated by FERC and is a not-for-profit entity that operates the wholesale energy market in the state. The CAISO has several key principles that are similar to the AESO and IESO. Namely, the CAISO is responsible for:

a) Monitoring market performance;
b) Assessing market rules and ISO operational practices – with the intention of identifying ineffective market rules or ISO practices to recommend changes;
c) Conducting market analysis;
d) Referring market violations to FERC;
e) Managing and coordinating with regulatory and legal entities;
f) Providing advice.[232]

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[227] U.S Department of Energy. *United States Electricity Industry Primer*., 24
[228] Ibid., 24
[229] Ibid., 24
[230] Ibid.,26
[231] Ibid., 26

Other regulatory bodies that work with the ISO within the sector are The California Energy Commission and the California Public Utilities Commission (CPUC). While other jurisdictions in this analysis have been separated in their descriptions and seemingly isolated roles, California's regulatory bodies and government appear to work simultaneously and together. While the government is pushing out storage initiatives, the CAISO and CPUC are working toward the same goal concurrently. As a result, the landscape pressures collude with the regime in a tangible way.

California is arguably a leader in the incorporation of energy storage. This leadership is mainly due to the state's climate change and carbon goals. The state has passed multiple high-level bills and legislation related to climate change mitigation, starting as far back as 1988. More recently, California passed the *California Global Solutions Act*, 2006. The Act enforces that the state reduces its greenhouse gas emissions to 40% below the 1990 levels by 2030.[233] To meet the target, the state intends to introduce a 50% increase in renewable energy.[234] Subsequently, several bills have passed related to the reduction of GHG and environmental protections. These bills have also lead to a proliferation of work and progress related to storage. Increased work around storage has occurred from both within the state but also as a result of some progressive work from FERC.

In 2010, the state passed the California Energy Storage Bill AB 2514.[235] The bill set in motion a series of events and working groups geared to identifying barriers to storage and to finding solutions. The spirit of Bill 2514 was to encourage storage on a large and robust scale. In addition to building out more storage, the bill tasked the CPUC to identify targets for the state's large investor-owned utilities, to procure storage systems.[236] The bill required that the state's

[232] California ISO. *Overview.* https://www.caiso.com/market/Pages/MarketMonitoring/Overview.aspx
[233] California Government. *California Climate Change.* http://climatechange.ca.gov/
[234] Ibid.
[235] K&L Gates. *Energy Storage Handbook., 19*
[236] Ibid.,19

investor-owned utilities would collectively procure and install 1,325 MW of energy storage by 2024.[237]

In 2016, additional bills were passed which were directly related to storage. The bill, AB 2868, *California's Additional 500 MW Energy Storage Procurement Requirement,* made it mandatory for some of California's largest utilities to procure 500 MW of distributed, or behind the meter, energy storage initiatives.[238]

One of the leading technical documents on storage within the state is *Advancing and Maximizing the Value of Energy Storage Technology: A California Roadmap* written by the California ISO. The 2014 report highlights and analyzes the barriers storage will have to overcome to meet the transition and to be adopted into the California market. The *Roadmap* speaks to specify market technical issues in the ISO wholesale market. But, it also notes the challenge storage faces in regards to "the ability of these resources to provide additional services to the distribution utilities or the end-use customer whether the service is contracted for through the market or not."[239] Further, the *Roadmap* notes another major barrier to storage in California is the inability of the market to identify a valuation scheme for storage applications that offers multiple services. The *Roadmap* offers the example of a storage system that can serve as a transmission asset while also participating in the market.[240] It is noted that FERC is currently trying to address the fundamental problem associated with storage: how to categorize storage.[241]

The ISO Roadmap offers a synthesized summary of the steps that are needed for storage to adequately inject itself into the market. The 'action items' as they are referred to in the *Roadmap,* state that the following steps are necessary. It should be noted the *Roadmap* indicates that the top three recommendations are of high priority, while the last three are of medium priority. The suggestions are as followed, verbatim:

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[237] Ibid., 19
[238] K&L Gates. *Energy Storage Handbook., 20*
[239] California ISO. *Advancing and Maximizing the value of Energy Storage Technology: A California Roadmap.,*14
[240] Ibid.,14
[241] Ibid., 14

a) Clarify existing ISO requirements, rules and market products for energy storage to participate in ISO market;
b) Identify gaps and potential changes or additions to existing ISO requirements, rules, market products and models;
c) Where appropriate, expand options to current ISO requirements and rules for aggregations of distributed storage resources;
d) Define and develop models and rules for multi-use applications for storage;
e) Identify and develop models of hybrid storage configurations for wholesale market participation;
f) For configurations of greatest interest or likelihood of near-term development, clarify the requirements and rules for participation.[242]

As it stands, California is a leader in energy storage procurement and incorporation in North America.[243] Recent figures indicate that compared to the rest of the United States, California represents 86% of non-residential storage, 36% of utility storage and 31% of residential storage in the country.[244] This disproportionate concentration is largely due to the policies and legislative work of the state. The state is operating under an acute awareness that to maintain reliability for its population, while addressing larger environmental degradation issues, radical transformations and injections of technology are needed.

The push toward renewables is fostering an opportunity for storage to proliferate in the state, and this is exactly what is happening. Currently, California is home to the proposed largest battery facility in the world, the Tesla Giga-factory. Without the pressure from the landscape and in turn the institutional support from the state, California would not be a leader in the industry. As it

[242] Ibid.,15
[243] Note. It should be noted that the RTO, PJM created a "Frequency Regulation Market" and has since become one of the largest markets for storage, with California considered second to the PJM. See, Spetor, Julian. FERC *proposes to Open Up Wholesale Markets for Energy Storage and Aggregation*. https://www.greentechmedia.com/articles/read/ferc-proposes-to-open-up-wholesale-markets-for-energy-storage#gs.hV0hfR0
[244] Baralon, Juliette. *California Driving the Energy Storage Market Through Groundbreaking Legislation: New Case Study*. https://www.theclimategroup.org/news/california-driving-energy-storage-market-through-groundbreaking-legislation-new-case-study

stands, California is still addressing the nuanced issues related to the wholesale market participation. The California Energy Storage Alliance (CESA) is of the belief that the CAISO and CPUC have been successful on several fronts related to the market barriers facing storage. Namely, the state the advancements have been made specifically related to market rules for "multi-use applications, developing markets for flexible capacity and fast responding ancillary services, identifying high-value locations for energy storage deployment and incorporating energy storage into long-term system planning."[245]

While significant work has been done on storage in California, the path towards this has been made slightly easier by two major factors. The first is the larger institutional support, awareness, and assistance to promote storage, from the government and the regulatory bodies within the state. The second contributing factor is FERC's work related to storage, not just within California but other ISOs and RTOs in the United States. FERC's work on storage is indicating the reality of the benefits and role that storage will play as states and countries continue to look at transforming their electricity systems to a low carbon system.

5.3.3. FERC and Energy Storage

In 2016, FERC canvassed RTOs and ISOs within the United States to understand what the regional operators see as the most significant barriers to storage within their markets. In response to the intelligence gathered from the information requests, FERC summarized its position in a policy paper called the *Utilization of Electric Storage Resources for Multiple Services When Receiving Cost-Based Rate Recovery*. The document was published in 2017. The policy report states that one of its objectives is to "clarify precedent and provide guidance on the ability of electric storage resources to provide services at and seek to recover their costs through cost-based and market-based rates concurrently."[246] The introduction to the report further states

> …by providing energy storage resources the opportunity to receive cost-based rate recovery concurrently with other revenue from market-based services (through organized wholesale electric markets) there can be implementation details that may need to be addressed, including protections against the double recovery of costs from cost-based

[245] California Energy Storage Alliance. http://www.storagealliance.org/content/about-us
[246] FERC. *Utilization of Electric Storage Resources for Multiple Services When Receiving Cost-Based Rate Recovery.,1*

> ratepayers, adverse market impacts and regional transmission/Independent System Operators independence from market participants.[247]

The need of FERC to clarify its position is the direct result of two challenges that stemmed from operational and regulatory control over a pumped storage project in and sodium sulfur battery project, both in California.[248]

Before the policy paper by FERC, the regulatory body issued a Notice of Proposed Rulemaking (NOPR). The NOPR intends to work toward removing barriers that "prevented electric storage resources and distributed energy resources aggregators to participate in the capacity, energy and ancillary service markets operated by the ISO and RTOs and is subject to FERC jurisdiction."[249] The NOPR is robust in its attempt to drive the pace of storage forward with the regulatory bodies in the US. The NOPR would insist that the RTOs and ISOs would have to revise their tariff structures to implement a model that allows for the incorporation of storage.[250]

The most recent NOPR is a step forward and a strong signal that the federal agency is steering the conversation toward further integration of storage. All indicators suggest that FERC appreciates the potential storage can offer. Whether FERC is simply a champion of storage for the economic growth projections and valuations, or whether environmental concerns are the leading driver, the agency has worked toward storage for some time. Before the NOPR and policy paper, the regulatory body had initiated several orders related to the promotion and integration of storage into the wholesale market. To only name a few they range from:

- Order 890 – Opportunities for Non-Generation Resources
- Order 755 – Frequency Regulation

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[247] Ibid., 1
[248] Note. For further information and a detailed analysis see, FERC. *Utilization of Electric Storage Resources for Multiple Services When Receiving Cost-Based Rate Recovery.*
[249] Bobbish, Donna. *FERC accelerates Efforts to Integrate Electric Storage Projects into Jurisdictional Wholesale Markets*. Original source: *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Notice of Proposed Rulemaking.
[250] K&L Gates. *Energy Storage Handbook.,13*

- Order 784 – Opportunity for Ancillary Services, etc.[251]

As of today, FERC has yet to enforce or cement the NOPR. This lack of enforcement is likely the result of the current political administration in the United States and the recent appointments of two Commissioners. In addition to what appears to be a hold on the NOPR, FERC will face setbacks from the RTOs and ISOs. While California and the PJM are ahead of the pack, there is the potential for significant setbacks. Major market rule transformations have to occur before storage can have a level playing field. But, the initial push and various orders supported by FERC have started a conversation at the federal and state level. If a state, like California, has the guidance and insight from their governments and institutions, transformation will continue to occur theoretically from a bottom-up approach. If the states want it and value storage, or they want their markets to adapt to technologies, the transformation will occur. The landscape pressures will continue to foster the need for technologies like storage to penetrate the markets, but it is the duty of the institutions, regulatory bodies and politics to administer progressive change.

5.4. Conclusion

Based on the analysis above, there is no doubt that each jurisdiction and their institutional counterparts understand the change that is occurring within the broader electricity sector. Whether it is specific directives to examine the procurement of storage or general market renewal, the jurisdictions above have taken note and are moving forward. Unfortunately, the major barrier facing these jurisdictions, is simply time. While each jurisdiction examines storage and electricity technology in their own way, through their own regulatory bodies and institutional lens, the technology advances. What is occurring within the niche, as related to storage or broader technology, is not burdened by the wait for innovative legislation or market redesign. At the rate at which each of these markets is operating, once the market adapts to storage or sustainable technologies, new electricity systems with novel characteristics will emerge. This rapid emergence will make their redesign or policies potentially outmoded.

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[251] See, K&L Gates. *Energy Storage Handbook. 10-13,* for a further and detailed list of Orders as prescribed by FERC

The work that is occurring in each of these markets is an indication that, as the MLP theory suggests, the landscape is rumbling. The regime is taking notice and the opportunity for storage is now. The market and institutional awareness is a strong sign that the proliferation of sustainable technologies is beyond being ignored. The markets do not have a choice but to examine the variants of storage and apply it to their market rules. There is little doubt, based on the information that storage has infiltrated the electricity paradigm, the problem now is how do these jurisdictions move as quickly and unburdened as the technology does.

6. Policy and Technology

It is clear that on a variety of fronts, legislators, policymakers, and market analysts are trying to understand and deconstruct the barriers facing storage and other niche technologies. While it is evident that significant progress has been made, it is valuable to re-examine the motivation behind the promotion of storage and sustainable technology. While market rules are examined and reorganized, the underlining theme for the push for renewables, storage and electricity transformations is prima facie two-fold. The first is the overarching issue related to climate change, reducing GHG emissions and global commitments to climate change reduction. The second is monetary. Projections associated with the growth of the renewable sector, storage, employment, and potentially money gained by niche companies and utilities, is vast. According to a recent Bloomberg report, the global storage market is projected to double six times by 2030.[252] While many, including governments, promote electricity transformation for the environmental benefits; other stakeholders are simply doing it for monetary gain. This is not to say that a radical transformation is beneficial to all. This transformation is particularly fear-inducing to some utilities and institutions that refuse to engage in technology advancement-focused projects.

Regardless of the motivation behind the progress, whether it is environmental protection or simply capitalism; depending on the camp, the result is positive. To achieve either electric transformation for GHG reduction, or to make money, the results are the same: a transformation is occurring. If it is accepted that changes are happening, the next step is to solidify the changes within the regime. That means that legislation, policy, and regulatory bodies have to implement a robust framework to make the pivot to environmental technologies easier and reduce political, legal and market barriers.

Unfortunately, change does not happen in a vacuum. Any environmentally sustainable transformation within the regime will only occur as a result of the relationship between economics, technology, social and political factors.[253] Each element has its motivation and effect

[252] Bloomberg New Energy Finance. *Global Storage Market to Double Six Times by 2030.* https://about.bnef.com/blog/global-storage-market-double-six-times-2030/
[253] Meadowcroft, James. *Engaging with the Politics of Sustainability Transitions*., 70

on the larger picture. As the landscape continues to cave in, the work is being done at a high-level across North America and Europe. But, the time is now to build the framework for technologies to easily pivot from the niche to the regime.

In their article, *Innovation system analyses and sustainability transitions: Contributions and suggestions for research*, Jacobsson and Bergek argue that the only way to meet larger climate change goals is to introduce technology-specific policies.[254] The authors state that the usual policies, which tend to be general, related to climate change, are not capable of stimulating sustainable transitions. They argue that technology-neutral policies fail to appreciate the needs of a specific technology and thus fail to meet the challenge of the transformation.[255]

Based on the review of energy storage in the above sections of this paper, the argument put forward by Jacobsson and Bergerk, is, prima facie, compelling. The jurisdictions studied above have made efforts to restructure their market rules to allow for the introduction of storage. It is questionable whether general changes to the market rules around storage would be as beneficial, particularly considering the unique characteristics of storage.

Broader and general policy changes would likely not support the integration of storage as well as specific rules and regulations related to storage. The opinions posed by Jacobsson and Bergerk are challenged when it is considered that that policymakers and legislators cannot account for all of the different varieties of technology that are currently being fostered in the niche. If specific policies are needed to promote a technology, there will be a significant time lapse for any new technology that wants to join the market. Evidence for the slow-moving nature of the regulatory system and government is apparent when looking at the case of renewables and storage.

Technology-specific policies are an interesting way to promote and foster a technology. It is clear that technology-specific policies and work related to storage have been beneficial. Before technology-specific policies can be addressed, the political structure of a jurisdiction is first and

[254] Jacobsson, Bergek. *Innovation system analyses and sustainability transitions: Contributions and suggestions for research., 42*
[255] Ibid., 42-44

foremost the space where the conversation starts and finishes related to regime integration. According to Meadowcroft, "politics is the constant companion of socio-technical transitions, serving alternatively (and often simultaneously) as context, arena, obstacle, enabler, arbiter, and manager of repercussions."[256]

Without the support and leadership of the government and its actors, policies and legislation will likely not be promoted. In order to influence a politician, they must either be determined in their own respect or, more commonly, influenced by their constituents. If the citizenry is not engaged, the prospect of advancing a transition becomes challenging.

[256] Meadowcroft, James. *Engaging with the Politics of Sustainability Transitions*., 71

7. Cultural Shift

Regardless of the IESO in Ontario or another jurisdiction's attempts to incorporate storage into their market rules and policies, acceptance or rejection of environmentally sustainable technologies comes from the public. Presumably, it is the public that will dictate the next moves of politicians, which will, in turn, affect the institutions and regime transition. Sometimes, the pressures on the citizens may come from the landscape – this may be, for example, the result of smog days or scientific studies that motivate people to appreciate climate change. Public engagement may be the result of grossly expensive electricity rates, a fear of the refurbishment of nuclear generation plant, or the threat of installing a gas plant near a community, all examples from Ontario.

The instances above have actively engaged the public in the conversation related to electricity in the province. The response to the public's concern ranges from creating new legislation that is meant to lower electricity rates such as the *Fair Hydro Act, 2017*[257] to the Transportation Minister acknowledging a gas plant in a community is not ideal. The Minister instead approved a large battery storage facility.[258] In a province like Ontario, with a complex set of rules and regulatory bodies; understanding how to get engaged is an arduous task.

For some, the advancement of renewable energy or storage can be perceived as a tool for the government to simply increase rates. An example of this is the *Green Energy and Green Economy Act, 2009* in Ontario. The purpose of the Act was to promote renewables, to encourage smart grids and conservation in addition to investment and job creation.[259] Without examining the minutiae of the legislation, it should be stated that the Act was met with positivity but also

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[257] Note. There is significant controversy related to this Act. Specifically, concerns related to the financial strain put-forward to future ratepayers. See, Adams, Tom., *Ontario's Fair Hydro Plan Acts Upends Rate Administration and Finance*.

[258] Spurr, Ben. *Metrolinx scraps Eglinton Crosstown gas plant for 'innovative' battery solution.* https://www.thestar.com/news/gta/2017/03/28/metrolinx-scraps-crosstown-gas-plant-for-innovative-battery-solution.html

[259] Rodger, Mark. *Looking Back: 5 years under Ontario's Green Energy Act*. http://www.energyregulationquarterly.ca/articles/looking-back-5-years-under-ontarios-green-energy-act#sthash.N4KGYFnH.dpbs

significant criticism. Many felt that the Act increased rates for consumers.[260] It is prudent to note that within Ontario, several decisions and choices by the government, including nuclear refurbishment and the global adjustment fee, have led to the increase in rates. While many understand that environmental technologies didn't independently raise their rates, a significant amount of the public in Ontario still blamed renewables and green technology.

When there is a culture of apprehension or distrust of government initiatives related to sustainable technologies, adding new technology into the supply mix will likely result in backlash and fear of further increased rates. While government mistrust remains a key issue related to conversations about green technology, interest in residential distributed energy and electric cars is on the rise. In fact, the residential distributed energy market (DERs) is set to reach a total revenue of $423 billion in 2025, based on four key technologies: electric vehicle charging, distributed solar PV, distributed energy storage, and demand response."[261] The same source states that according to Navigant Research, the global market for residential DERs projects "that the annual revenue for the market is set to increase from approximately $19.7 billion in 2016 to an impressive $92.7 billion in 2025."[262]

Theoretically, it is the landscape pressure that is causing the public to become engaged in matters related to electricity, conservation, electric cars, and renewables. While the pressure from the landscape is undeniable, there are other factors at play - consumerism, brand recognition, and novelty. Whether the result of benevolence, concern for the effects of climate change, or greed, Elon Musk and Tesla, Inc. have become a brand name known to many.

Tesla has products ranging from solar roofs to in-home storage battery packs. The company has projects worldwide, from Hawaii to Australia. The electric car sales have exceeded exceptions,

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260 Blackwell, Richard. *Going Green: Does Ontario's energy shift have the power to sustain itself*? https://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/going-green-ontarios-energy-transformation/article25421677/
261 Hill, Joshua. *Residential Distributed Energy Market set to total $423 Billion in 2025.* https://cleantechnica.com/2016/10/31/residential-distributed-energy-market-set-total-423-billion-2025/
262 Ibid

and more consumers are choosing an electric car every day.[263] This evidence suggests that electricity, energy, and climate are contributing to a larger cultural shift. The demand is increasing alongside Tesla's continued popularity. As Tesla raises awareness and facilitates a low-emission electric conversation, public participation and interest are on the incline. As the public demands more electric cars and residential DERs, the government will have to follow suit. Upon the government's acknowledgement, institutional change will occur. As noted in the previous section, time remains the one factor that limits the transition. The government and the institutional bodies do not have the capacity or ability to work as quickly as companies like Tesla. Incremental technology policies and slow-moving market rejuvenation programs cannot keep up with the pace of the technology. All evidence suggests that the cultural awakening is occurring, but whether the government is agile enough to respond, at this point seems unlikely.

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[263] Bhuiyan, Johana. *Tesla is now worth more than Ford after delivering a record number of cars for the quarter*. https://www.recode.net/2017/4/3/15160462/tesla-ford-deliveries-record-sales

8. Recommendations

The analysis above has suggested that the regime is indeed responding to the exogenous pressure of the landscape. This response is evidenced by the work related to energy storage that is occurring in multiple jurisdictions in North America. While the technology is flourishing within the niche, it would be hard to discount what is happening at the institutional level. Markets in Ontario, Alberta, and California are explicitly designing rules and protocols for storage technology. Governments are initiating directives that investigate the benefits and unique characteristics of storage and are implementing strategies to adapt to the technology. While mostly positive, there are some overarching flaws facing storage, particularly in Ontario and Canada overall. The analysis above provides a comprehensive list of what is occurring in key North American markets. The information is synthesized to develop recommendations for the incorporation of storage into the regime at large. It should be noted that the following recommendations are designed specifically for Canada. The intention is to develop a scheme that transcends political jurisdictions, but due to the inherent differences between the Canadian and United States landscape, it is beyond the scope of this paper to determine next steps for the US. Recommendations range from macro-level to smaller scale recommendations:

8.1. Federal Direction

As noted in the introduction, the Canadian landscape is divided between the Federal government and the provinces. The *Constitution Act* has given authority to the provinces to govern matters related their natural resources, which includes electricity governance. This authority, in essence, results in a fragmented country lacking a clear and cohesive direction on low-emission electricity regulation. This authority also does not bode well with regards to an organized stance on integrating sustainable technologies into acceptance within the Canadian regime.

To achieve successful integration of storage and other sustainable technologies, macro direction is required, analogous to the regulatory direction administered by FERC. A constitutional amendment in Canada related to natural resources (specifically electricity) is incredibly unlikely. This unlikelihood is a result of the profound and difficult task required to engage in constitutional changes. Instead, the federal government is in a position to encourage storage integration or other technologies by way of financial incentives for provinces, specifically related to niche technologies. Financial incentives could be injected directly into the sector or given to the province at large.

Financial incentives for niche technology have benefits for both the federal and provincial governments. It bodes well for the federal government's international stance as an environmentally conscious country that intends to meet the Paris Agreement standards. Growing the niche technology industry can assist with making Canada a key player in the renewable sector globally, attracting talent and money into the country. The same factors would trickle down to the provinces, namely money, and talent.

There is a need within Canada for a comprehensive national agenda and structure related to sustainable energy technologies. The fragmented regulatory regime in the country is worsening the ability for the country to meet the lowered emissions promised in international agreements and the ability to foster sustainability. It is also creating potentially unbalanced provincial opportunities. The Federal government needs to take a stance on sustainability and address the current state of fragmentation that is currently guiding the country.

8.2. Provincial Subsidies for Niche Spaces

Incubators and start-ups are at the forefront of the niche to regime transition. It is within these enterprises that the technology can be fostered, created, tested and examined. Investments in collaborative spaces for newly forming companies or multi-company incubators can be a way for provinces to capitalize on niche technologies, both financially and environmentally. Provincial governments have an opportunity to make their provinces an attractive market for technology. Subsidies for worthwhile projects will make bringing niche technologies online easier. These spaces have to be allowed to work outside the confines of government restrictions, similar to private companies like Tesla. By injecting money into the niche, the return on investment is potentially high.[264] Technologies, like storage, may have the ability to save money for consumers and offer sustainability. Advanced projects, in turn, would be marketed to the world, potentially sold outside of Canada. Provincially subsidized incubators would go beyond money for

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[264] Jacobsson, Bergek. *Innovation system analyses and sustainability transitions: Contributions and suggestions for research., 44*

technologies. These spaces would offer curriculums and guidance related to the regulatory regime within their province and outside of Canada. They could also assist with creating policies and market designs to foster integration. Said spaces would offer business support and market integration assistance.[265] Provincial support would also likely encourage further support from the private sector. If private sector investors have assurances from the government, there may be more of an inclination to support technologies.

8.3. Technology-Specific Policies

As discussed in a previous section, technology-specific policies may be the way to promote storage into the broader regime.[266] It is clear that technologically specific work is precisely what is necessary for the further adopting of storage. Storage offers such a wide range of characteristics that broad policies cannot capture storage's distinctive characteristics. To promote storage into the wider regime, these specific policies, regulations and market rules are necessary. Storage-specific policies are necessary for the promotion of storage. Yet again, this does not account for the other technologies that are brewing within the niche. The government will have to adopt an approach to policy that can move as quickly as it is being developed. It is on its face, a system overhaul. The government structure is inherently the antithesis of the tech world, resulting in a clash between the niche and the regime.

8.4. Market Rules and Quick Responding Institutions

As technology in the niche develops, regulators and markets must keep up. The analysis above highlights the work that is being done in multiple jurisdictions to incorporate storage into markets. It is clear that all of the jurisdictions must address the technical barriers that storage faces as a result of market rules. These barriers are the result of market rules designed before storage and its various technological iterations were conceived. Adjusting the current technical barriers to storage is clearly the best way to bring storage into the market. The process that is

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[265] A similar framework exists in Ontario within MaRS Cleantech Fund. This is however, is a result of relationships with the private sector. Not the government. See, Rand, Tom. *The MaRS Cleantech Fund: Early-stage funding for the Canadian cleantech ecosystem*. https://www.marsdd.com/news-and-insights/mars-cleantech-fund-unlocking-early-stage-funding-fast-flowing-canadian-cleantech-ecosystem/

[266] Jacobsson, Bergek. *Innovation system analyses and sustainability transitions: Contributions and suggestions for research., 43*

occurring to change the market rules is, unfortunately, far too slow. It follows that by the time certain market rules are implemented; the technology within the regime may be different, making the process or the specific technical rules moot.

Instead, market rules have to be specific enough for storage (as a result of its technological characteristics) but simultaneously sufficiently broad to allow for new storage developments or other technologies. Pilot projects within regulator bodies are one way to keep up with the pace of the technology, but any government involvement slows down the process. Instead, market rules must be designed with a hint of openness to the various technologies that may come online. This openness would require clever crafting and wording, but the alternative is detrimental. If the market rules are designed specifically for the iterations of storage online now, they may not be relevant in a few years. Making the market redesign rules redundant. Instead, broader umbrella rules should be potentially the way forward.

9. Conclusion

Any analysis related to the electricity sector, arguably in any jurisdiction, is typically based on two underlying principles, with a third that falls somewhat behind. Reliability and rates are on par in terms of importance for any consumer. Consumers want reliable electricity as a fundamental to their daily lives. Yet, they want electricity at a rate this affordable. The third underlying principle related to the electricity is sustainability and it is largely correlated to the landscape issues facing North America and the world. If the first two factors are met, namely reliability and affordability discussion opens up for sustainability and thus technology.

The landscape issues facing the electricity sector are beyond discussion. This is evidenced by the work that is happening in the markets in jurisdictions discussed throughout this paper. Governments, regulators, and markets would not be working toward adopting a technology like storage, if there wasn't need or opportunity. The regime is responding to the transition that is occurring. The challenge is that ingrained in the regime are processes and policies that do not adhere to the same rules of the niche. The niche operates in a paradigm that is not bogged down by political interference or pressure. The work within regime alternatively is determined by the desires of the government, which, in turn, may be the desire of the consumer.

As the work continues in the niche, the cultural transition is simultaneously occurring. Companies like Tesla are creating brand recognition. At the same time, the landscape is highlighting disasters and issues that cannot be ignored. The more the consumer begins to examine these factors, the more pressure will be put on the government. Perhaps, consumer pressure will foster a need for the government to expedite their work in the regime space.

The case study for storage is an analog for other sustainable technologies. The complications and barriers storage faces are simply a foreshowing for any other new technology that seeks to enter the market. Storage is providing a wake-up call to governments, regulators, and markets, that the time has come to understand that exponential growth is occurring within the niche. If work is not done to adapt quickly, it is curious to wonder what will happen to the regime. Will the niche outpace the regime to the degree that it becomes potentially obsolete?

It is unlikely that the regime will loosen its power on the institutional and regulatory structure that governs the electricity sector. To stay relevant, techniques and policies must address the pace in which the regime has been able to respond to the niche.

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x. Appendix. OEB Electricity Storage Licence Sample

Ontario

Electricity Storage Licence

ES-20xx-0xxx

Name of Licensee

Valid Until

Month day year

Peter Fraser
Vice President, Industry Operations & Performance
Ontario Energy Board
Date of Issuance: Month day year

Ontario Energy Board
P.O. Box 2319
2300 Yonge Street
27th Floor
Toronto, ON M4P 1E4

Commission de l'énergie de l'Ontario
C.P. 2319
2300, rue Yonge
27e étage
Toronto ON M4P 1E4

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1 Definitions

In this Licence:

"**Act**" means the *Ontario Energy Board Act, 1998*, S.O. 1998, c. 15, Schedule B;

"**Electricity Act**" means the *Electricity Act, 1998*, S.O. 1998, c. 15, Schedule A;

"**Licensee**" means Name of licensee;

"**regulation**" means a regulation made under the Act or the Electricity Act;

"**storage facility**" means a facility that is connected to a Transmission or Distribution System and is capable of withdrawing electrical energy from the Transmission or Distribution System (i.e. charging), and then storing such energy for a period of time, and then re-injecting only such energy back into the Transmission or Distribution System, minus any losses (i.e. discharging).

2 Interpretation

2.1 In this Licence words and phrases shall have the meaning ascribed to them in the Act or the Electricity Act. Words or phrases importing the singular shall include the plural and vice versa. Headings are for convenience only and shall not affect the interpretation of this Licence. Any reference to a document or a provision of a document includes an amendment or supplement to, or a replacement of, that document or that provision of that document. In the computation of time under this Licence where there is a reference to a number of days between two events, they shall be counted by excluding the day on which the first event happens and including the day on which the second event happens. Where the time for doing an act expires on a holiday, the act may be done on the next day that is not a holiday.

3 Authorization

3.1 The Licensee is authorized, under Part V of the Act and subject to the terms and conditions set out in this licence:

a) to generate electricity or provide ancillary services for sale through the IESO-administered markets or directly to another person subject to the conditions set out in this Licence. This Licence authorizes the Licensee only in respect of those facilities set out in Schedule 1;

b) to purchase electricity or ancillary services in the IESO-administered markets or directly from a generator subject to the conditions set out in this Licence; and

c) to sell electricity or ancillary services through the IESO-administered markets or directly to another person, other than a consumer, subject to the conditions set out in this Licence.

3.2 The Licensee is authorized to conduct business in the name under which this Licence is issued, or any trade name(s) listed in Schedule 2.

4 Obligation to Comply with Legislation, Regulations and Market Rules

4.1 The Licensee shall comply with all applicable provisions of the Act and the Electricity Act, and regulations under these acts, except where the Licensee has been exempted from such compliance by regulation.

4.2 The Licensee shall comply with all applicable Market Rules.

5 Obligation to Maintain System Integrity

5.1 Where the IESO has identified, pursuant to the conditions of its licence and the Market Rules, that it is necessary for purposes of maintaining the reliability and security of the IESO-controlled grid, for the Licensee to provide energy or ancillary services, the IESO may require the Licensee to enter into an agreement for the supply of energy or such services.

5.2 Where an agreement is entered into in accordance with paragraph 5.1, it shall comply with the applicable provisions of the Market Rules or such other conditions as the Board may consider reasonable. The agreement shall be subject to approval by the Board prior to its implementation. Unresolved disputes relating to the terms of the Agreement, the interpretation of the Agreement, or amendment of the Agreement, may be determined by the Board.

6 Restrictions on Certain Business Activities

6.1 Neither the Licensee, nor an affiliate of the Licensee shall acquire an interest in a transmission or distribution system in Ontario, construct a transmission or distribution system in Ontario or purchase shares of a corporation that owns a transmission or distribution system in Ontario except in accordance with section 81 of the Act.

7 Provision of Information to the Board

7.1 The Licensee shall maintain records of and provide, in the manner and form determined by the Board, such information as the Board may require from time to time.

7.2 Without limiting the generality of paragraph 7.1 the Licensee shall notify the Board of any material change in circumstances that adversely affects or is likely to adversely affect the business, operations or assets of the Licensee, as soon as practicable, but in any event no more than twenty (20) days past the date upon which such change occurs.

8 Term of Licence

8.1 This Licence shall take effect on Month day year and expire on Month day year. The term of this Licence may be extended by the Board.

9 Fees and Assessments

9.1 The Licensee shall pay all fees charged and amounts assessed by the Board.

10 Communication

10.1 The Licensee shall designate a person that will act as a primary contact with the Board on matters related to this Licence. The Licensee shall notify the Board promptly should the contact details change.

10.2 All official communication relating to this Licence shall be in writing.

10.3 All written communication is to be regarded as having been given by the sender and received by the addressee:

a) when delivered in person to the addressee by hand, by registered mail or by courier;

b) ten (10) business days after the date of posting if the communication is sent by regular mail; or

c) when received by facsimile transmission by the addressee, according to the sender's transmission report.

11 Copies of the Licence

11.1 The Licensee shall:

a) make a copy of this Licence available for inspection by members of the public at its head office and regional offices during normal business hours; and

b) provide a copy of this Licence to any person who requests it. The Licensee may impose a fair and reasonable charge for the cost of providing copies.

SCHEDULE 1 LIST OF LICENSED STORAGE FACILITIES

The Licence authorizes the Licensee only in respect to the following:

1. The ownership and operation of **name of facility**, with an installed capacity of **xx MW** located at **address of facility.**

SCHEDULE 2 AUTHORIZED TRADE NAMES

1. None