UNIVERSITY OF CALGARY

Brownfields to Brightfields: Re-Purposing Alberta's Unreclaimed Oil and Gas Sites for Solar Photovoltaics

by

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A RESEARCH PROJECT SUBMITTED

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

GRADUATE PROGRAM IN SUSTAINABLE ENERGY DEVELOPMENT

CALGARY, ALBERTA

AUGUST, 2020

Abstract

A portion of Alberta's unreclaimed 'brownfield' oil and gas sites could be re-purposed as 'brightfields' with solar photovoltaic installations supporting provincial objectives to reduce carbon emissions from electricity generation, address brownfield liabilities and mitigate cumulative effects of development. Elemental Energy (Alberta 2003) Inc. has initiated a re-purposing pilot project however formal institutions, such as policies and regulations, and informal institutions, such as norms and values, may influence expansion of this sustainable endeavour. Through interviews and document analysis, this research investigated, "What are the opportunities and barriers to developing solar photovoltaic infrastructure on Alberta's unreclaimed oil and gas sites?" The findings suggest that existing institutions support re-purposing a subset of brownfields with micro-generation systems, however policy and regulatory ambiguity hinder broader expansion by affecting the economic feasibility of distributed generation projects, limiting the number of re-purposing candidate sites and reinforcing constraining mindsets in the power generation and oil and gas industries.

Acknowledgement

I wish to express my sincere gratitude to Dr. David Ince for his provision of knowledge, guidance, and time as my academic supervisor. His steadfast support throughout the duration of this project and despite the complexities presented by the COVID-19 pandemic were instrumental to the successful completion of my capstone research. Contributions from Keith Hirsche were invaluable, I am thankful for his support as my organization representative for this project. Mr. Hirsche's knowledge of and passion for the subject matter and pursuit of its implementation is inspirational. I would also like to thank Dr. Irene Herremans and Kelvin Tan for their ongoing encouragement. Finally, I want to acknowledge and express my appreciation and gratitude to the individuals that were willing to give their time to participate in an interview in support of my research.

To my husband, Tim, thank you for your unwavering love, patience, and support throughout this project. I am so blessed to have you on my team and by my side through life's journey. I am excited for what the next chapter holds for us.

To my family, friends, and colleagues, thank you for your grace and inspiration.

To my Mom, thank you for your loving encouragement and for delivering comforting care packages to me when they were needed most.

To my late Dad, your wise voice continues to remind me that, "if it was easy, everyone would be doing it." Your guiding hand has never left my shoulder.

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List of Abbreviations

ABMI	Alberta Biodiversity Monitoring Institute
ACREI	Allied Community Renewable Energy Interests
AEP	Alberta Environment and Parks
AER	Alberta Energy Regulator
AESO	Alberta Electric System Operator
ALSA	*Alberta Land Stewardship Act*
AUC	Alberta Utilities Commission
CAQDAS	Computer-Assisted Qualitative Data Analysis Software
CER	Canada Energy Regulator
CGCB	Community Generation Capacity Building Program
CO_2e	Carbon Dioxide Equivalent
CRIN	Clean Resource Innovation Network
DC	Direct Current
DCG	Distribution-Connected Generation
DER	Distributed Energy Resources
DFO	Distribution Facility Owners
EEA	Energy Efficiency Alberta
EEI	Elemental Energy (Alberta 2003) Inc.
EPC	Emissions Performance Credits
EPEA	*Environmental Protection and Enhancement Act*
IRENA	International Renewable Energy Agency

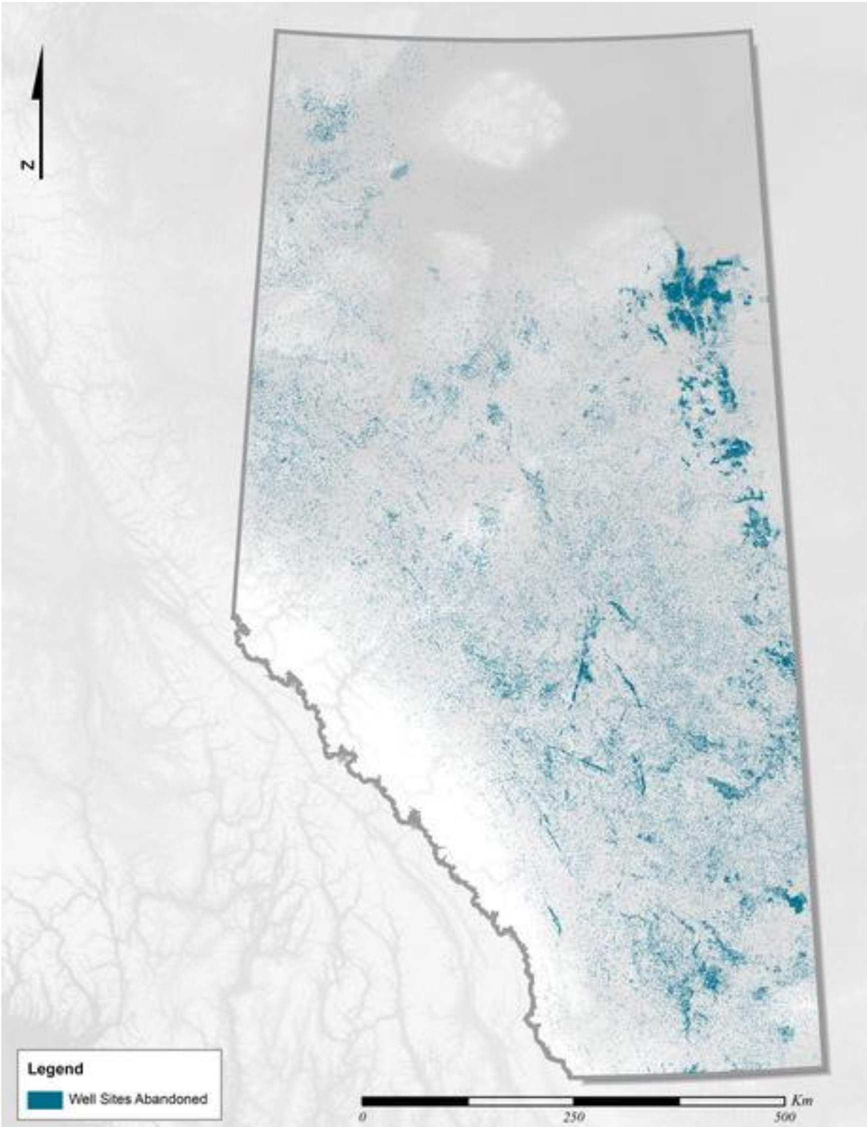
kW	Kilowatts
kWdc	Kilowatt, Direct Current
kWh	Kilowatt Hour
LUF	Land Use Framework
MCCAC	Municipal Climate Change Action Centre
MCGC	Municipal Community Generation Challenge
MD	Municipal District
MW	Megawatt
MWac	Megawatt, Alternating Current
MWdc	Megawatt, Direct Current
MWh	Megawatt Hour
NREL	National Renewable Energy Laboratory
OGCA	*Oil and Gas Conservation Act*
OWA	Orphan Well Association
PPA	Power Purchase Agreement
PTAC	Petroleum Technology Alliance Canada
PV	Photovoltaic
SED	Specified Enactment Direction
SEDV	Sustainable Energy Development
SEEDS	Southeast Alberta Energy Diversification Symposium
TIER	Technology Innovation and Emissions Reduction (Regulation)
Yr	Year

Chapter 1. Introduction

1.1 Overview

Alberta's Renewable Electricity Act legislates that 30% of the Province's electricity supply be generated by renewable energy resources by 2030, supporting the federal long-term vision to reduce carbon emissions from electricity generation (Government of Alberta, n.d.-d). Renewable energy sources comprised 17.4% of Alberta's installed capacity in 2018 and 10% of gross generation (Alberta Electric System Operator [AESO], 2019; Alberta Utilities Commission [AUC], 2019). Southern Alberta has been identified as having the highest solar energy resource potential in Canada, and due to technological advances and decreasing costs, solar photovoltaic energy ("solar PV") represents a significant area of renewable energy generation growth potential (Natural Resources Canada, 2020). A disadvantage to solar PV is the extent of land disturbance required for ground mount installations which not only negatively impacts the environment and project economics but also contributes to public resistance to development. According to a query run in AccuMap (v. 29.11a), there are over 68,000 abandoned and unreclaimed ('brownfield') oil and gas well sites located across Alberta that could potentially be re-purposed as 'brightfields' with solar PV development, representing an opportunity to partially address Alberta's inactive oil and gas infrastructure liability issue (IHS Markit, 2019). The extent of the surface footprint from Alberta's abandoned well sites, derived from Alberta Biodiversity Monitoring Institute (ABMI) data collected in 2016, is shown on the map in Figure 1 below.

Figure 1: ABMI Map of Abandoned Well Sites Footprint (circa 2016)



(Alberta Biodiversity Monitoring Institute, 2018b)

The RenuWell Project team, in collaboration with the Municipal District (M.D.) of Taber, has identified an opportunity to re-purpose about 1,000 inactive brownfield oil and gas sites located in the M.D. with small-scale solar PV. This opportunity could potentially accelerate the closure and reclamation of oil and gas infrastructure in the area, reduce electricity costs for irrigated agriculture with distributed solar energy generation and mitigate the need to disturb high quality agricultural land for renewable energy development (Hirsche, 2019b). The RenuWell Project is currently in a pilot phase and existing formal and informal institutions and associated market barriers may foster or impede expansion of the concept. Building upon the work completed by the RenuWell Project team and the M.D. of Taber, this interdisciplinary research project considers aspects of energy, environment and policy development to investigate the question, "What are the opportunities and barriers to developing solar photovoltaic infrastructure on Alberta's unreclaimed oil and gas sites?" For context, opportunities are represented by favorable conditions for expansion of the RenuWell Project concept beyond the pilot phase and barriers are represented by unfavorable conditions or hindering factors.

Alberta's Municipal Government Act describes brownfields as abandoned or underutilized commercial or industrial properties that are, or might be contaminated, but are suitable for redevelopment (Government of Alberta, n.d.-a). In this research, brownfield oil and gas sites are defined as those inactive locations where the surface area has been disturbed for oil and gas development and the site is in the closure stage of the life cycle. At these sites, hydrocarbon production has ceased, and infrastructure may or may not yet be fully abandoned. The land occupied by the oil and gas location has not yet been reclaimed or returned to equivalent capability where it can support land uses in a manner similar to before it was disturbed.

A sustainable energy development opportunity exists in the idea of re-purposing a portion of these brownfield oil and gas fields as 'brightfields' with solar PV deployment, thereby increasing Alberta's supply of renewable electricity in support of a clean growth economy while mitigating new surface disturbance. Adding electricity supply generated from renewable energy resources to Alberta's grid has numerous benefits, including a reduction in the health and environmental impacts from air pollution and greenhouse gas emissions from coal- and natural gas-fired power plants (Valiante, 2013). Socioeconomic benefits of grid decarbonization include the development of local human capacity to construct and operate the infrastructure and an opportunity to leverage and expand upon the existing skillsets of former oil and gas sector employees in support of the transition. Solar PV development represents a significant economic opportunity for Alberta; according to Calgary Economic Development, "Every 150 MW of installed solar energy capacity represents $310 million in investment, 1,875 direct full-time equivalent construction jobs and 45 permanent direct jobs in operations" (Calgary Economic Development, n.d., para. 2). Additional benefits of the concept include a cost savings for both brownfield oil and gas site closure and solar PV development through the re-purposing of previously disturbed land and existing infrastructure such as access roads and grid tie-ins (Hirsche, 2019b).

A study by Spiess and De Sousa (2016) reviewed the factors inhibiting the re-purposing of brownfields with brightfield development and found that the technical and environmental barriers "only differ from conventional renewable energy projects (e.g. on greenfields) in the event of site contamination" (p. 507) and, from a social perspective, "evidence conjectures that there is less contextual public opposition to brightfields compared to conventional renewable energy" (p. 507). Institutions, defined as the rules that structure human interaction and political, social or economic exchange, are largely outside of the control of brightfield developers and can hinder or halt a project from moving forward (North, 1990; Spiess & De Sousa, 2016). According to North (1990), institutional constraints "consist of formal written rules as well as typically unwritten rules of conduct that underlie and supplement formal rules" (p. 4). Some of the institutional factors unique to Alberta and identified by the RenuWell Project team as affecting the pilot proposal from expansion include current oil and gas liability management policies, a lack of a framework for grid modernization and the absence of a mechanism to address potential orphan renewable energy infrastructure.

1.2 The RenuWell Project

Keith Hirsche, President of Elemental Energy (2003) Inc., provided the following background on the RenuWell Project as context for this research project:

> In January 2016, Elemental Energy (2003) Inc. (EEI) began investigating the potential for developing small scale (500 kW) solar installations on abandoned oil and gas sites and initiated stakeholder consultations with the Alberta Energy Regulator (AER), oil and gas operators, renewable energy developers, Alberta Innovates, the Orphan Well Association (OWA) and landowners. In November 2018, a location for a pilot project was identified in the M.D. of Taber in collaboration with landowners, the AER and OWA, and the development approval process was initiated. During these meetings, it became obvious that while many regulatory issues had been resolved on the provincial scale, there was no precedent for evaluation or approval of these developments at the municipal level. Fortunately, the Municipal Climate Change Action Centre (MCCAC) had initiated a call for proposals in the Community Generation Capacity Building (CGCB) Program which had been created to accelerate the development of small scale and community generation renewable energy projects that had been enabled by the recently enacted Small Scale Generation Regulation (MCCAC, n.d.).
>
> In partnership with the M.D. of Taber, EEI developed a proposal for the CGCB Program and formed the RenuWell Project which brought together a team of professionals to develop a policy framework for municipal governments to utilize in evaluating these redevelopment opportunities. The proposal was accepted in March 2019 and the RenuWell Project began an extensive program of broader stakeholder engagement to develop and support a series of policy

recommendations for the re-purposing of abandoned oil and gas sites into solar generation. During the stakeholder consultation process, the RenuWell Project has garnered significant attention from all key stakeholders as well as the media. However, progress has been slowed by a level of regulatory uncertainty that has arisen in response to the disruptive changes that the rapid emergence of distributed generation systems is having on the established entities that comprise Alberta's electrical utility sector.

During the course of the RenuWell Project, the M.D. of Taber was invited to submit a proposal to the MCCAC/Alberta Innovates Municipal Community Generation Challenge (MCGC) to secure funding for a demonstration pilot project. In partnership with the St. Mary River Irrigation District/Irrican, a proposal was submitted to construct 2.0 MW of solar generation on four inactive wells sites in the M.D. of Taber. This proposal is currently in the final stages of the funding review and the status will be confirmed shortly. While the M.D of Taber/RenuWell Project team is likely to succeed in developing a pilot project in the near term, the existing formal institutions and associated market barriers are impeding expansion of the concept. (personal communication, February 16, 2020)

On August 13, 2020, the MCCAC announced that it is investing $2.1 million in the RenuWell Project under the MCGC. The funding will support the development of 2 MW of solar PV electricity generation installations on brownfield oil and gas sites located in the M.D. of Taber to demonstrate the benefits of widespread deployment of the re-purposing concept (MCCAC, 2020).

1.3 Research Goals and Objectives

Building upon the recently completed work conducted by the RenuWell Project team, the main objective of this research project was to determine the institutional factors affecting the expansion of the pilot project and understand interactions and interrelationships in order to develop policy recommendations. Applying institutional theory, a qualitative investigation into the formal and informal institutional and resultant market influences that drive and inhibit the repurposing of Alberta's brownfield oil and gas sites as brightfields. The investigation was conducted through a comprehensive literature review and an analysis of existing policies, regulations, reports, public records and data collected from interviews with key stakeholders. A systems map provides a visual representation of the research findings and four hypotheses that are proposed.

This research work was conducted in parallel with the AUC Distribution Inquiry, Small Scale Generation Regulation public consultation and the Tariff Inquiry which are currently in the process of examining these important issues. Several members of the M.D. of Taber/RenuWell Project team are participating in the Distribution Inquiry under the name Allied Community Renewable Energy Interests (ACREI) and a number of significant issues are documented in the formally filed response to the AUC's Information Request (Bennett, 2020a).

1.4 Interdisciplinary Nature of Research

In accordance with the Sustainable Energy Development (SEDV) capstone research requirements, this interdisciplinary research project which investigated the opportunities and barriers to re-purposing Alberta's brownfield oil and gas sites for solar PV deployment addresses three dimensions, including energy, environment and policy development, as further detailed below.

1.4.1 Energy

The energy dimension is addressed through an assessment of the technological and institutional factors influencing Alberta's transition to an increased supply of renewable energy to its current electricity mix, with a focus on small-scale solar PV including micro-generation and distributed generation. The addition of micro-generation and distributed generation to Alberta's grid represents a potentially disruptive change shifting the Province's centralized system to an increasingly decentralized system. This shift would enable solar PV developers, whether individual landowners, community-based generators, rural cooperatives, oil and gas companies or solar PV companies, to reduce electricity expenses and hedge against increasing electricity costs (Nadkarni & Hastings-Simon, 2017). The transition to a more decentralized grid would also potentially reduce transmission losses inherent to centralized generation. Furthermore, as periods of high solar PV generation align with increased electricity demand, distributed solar PV mitigates peak generation capacity requirements (Nadkarni & Hastings-Simon, 2017).

1.4.2 Environment

The environment dimension is addressed in this research project through a quantitative analysis of the reduction in carbon dioxide and other emissions associated with incremental solar PV energy supplied to Alberta's electricity grid. Additionally, as the RenuWell Project represents an opportunity to reduce the cumulative effects of energy development on the landscape, this research analyzes the mitigation of new land disturbance resulting from re-purposing oil and gas brownfields as solar PV brightfields.

1.4.3 Policy Development

Formal and informal institutions constrain or determine the opportunities that organizations are formed to take advantage of; moreover, institutional structure can motivate or deter innovation (North, 1990). This research project addresses the policy development dimension through a qualitative evaluation of the institutional factors and resultant market barriers specifically affecting the concept of brightfield deployment on oil and gas brownfields and the potential changes to

Alberta's legislation, regulations and directives required to legitimize this innovative and disruptive concept.

Chapter 2. Background and Alberta Context

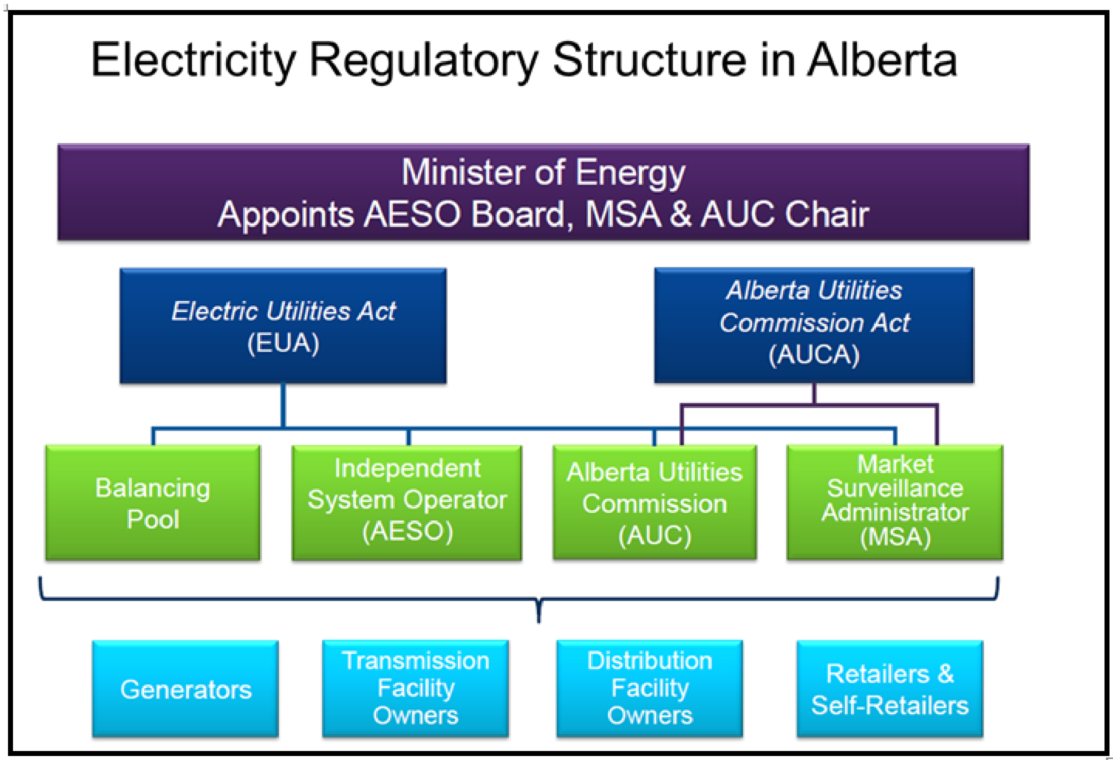
This chapter provides background information regarding decentralized solar PV electricity generation as well as oil and gas development in Alberta that is relevant to the RenuWell Project and the concept of re-purposing brownfield oil and gas sites as solar PV brightfields. As re-purposing represents an opportunity to mitigate the cumulative effects of energy development on undisturbed land, land use considerations specific to Alberta, with a focus on the South Saskatchewan Region due to its attractiveness for solar PV deployment, are discussed in detail. The objective of the chapter is to provide context for the subsequent literature review and investigation into the research question.

2.1 Alberta's Electricity Market and Regulatory Structure

Alberta's electricity grid is primarily centralized in structure. Large facilities generate electricity which is distributed via 26,000 km of transmission lines to multiple end users including residential, farm, industrial and commercial markets (AUC, 2017). Interconnections with B.C., Saskatchewan and Montana provide limited electricity import/export capacity. Approximately 82% of Alberta's 16,332 MW of installed electricity generation capacity is comprised of coal or natural gas fuelled power plants (AUC, 2019a). To reduce greenhouse gas emissions, the Province has committed to phase out coal-fired power plants (Government of Alberta, n.d.-c). Additionally, Alberta's *Renewable Electricity Act* includes a target to increase renewable electricity generation in the Province to 30% of the total by 2030 (Government of Alberta, n.d.-d). Renewable energy sources comprised 17.4% of Alberta's installed capacity in 2018 and 10% of gross generation (AESO, 2019; AUC, 2019a). Alberta's electricity market, managed by the AESO as the Independent System Operator, is deregulated and energy-only. Electricity is offered for sale by independent power producers into the wholesale power pool where it is purchased in bulk by retailers for sale to end use consumers. Generators incur the capital and operating costs of producing the electricity and are paid for the electricity they produce at wholesale pool prices. The pool prices are settled based on hourly supply and demand. According to the AUC, over the past decade there has been an increasing number of ‘prosumers’ participating in Alberta’s electricity market, including firms, community groups and individuals that both generate and consume electricity, signalling interest in a shift towards a decentralized grid structure (AUC, 2017).

The electricity regulatory structure in Alberta is overseen by the provincial Ministry of Energy and is shown in Figure 2. Governing legislation includes the *Electric Utilities Act* and *Alberta Utilities Commission Act.* The AUC is responsible for issuing decisions regarding the full life cycle of transmission and distribution infrastructure development (AUC, n.d.). In addition to ensuring fair market access to Alberta’s grid for generators and competitive pricing, the AESO is responsible for the planning and design of the transmission system to ensure reliability (AESO, 2018). The AESO does not construct or own transmission infrastructure, however, once the need for enhanced or additional transmission infrastructure is determined by the AESO to be in the public interest, and the development application is reviewed and approved by the AUC, the AESO directs the area Transmission Facility Owner to execute on the development (AESO, 2018).

Figure 2: Electricity Regulatory Structure in Alberta



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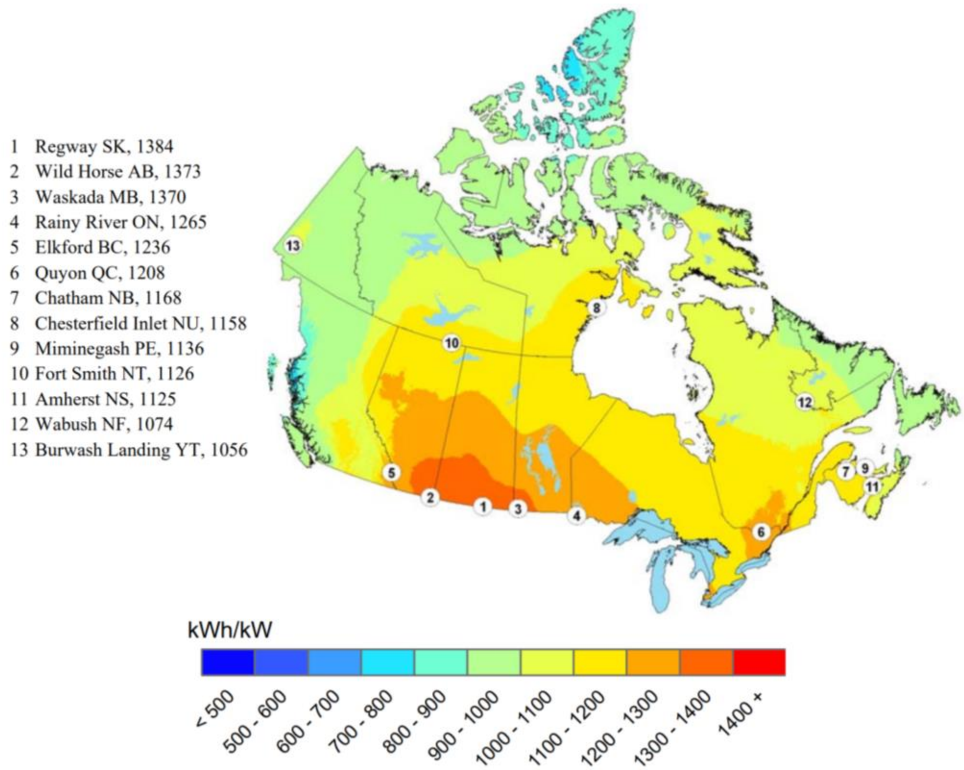
According to the AESO 2019 Long-term Outlook, which forecasts load and generation to guide transmission planning, an additional 13 GW of new generation capacity is expected to be added to Alberta's electricity system between 2019 and 2039 including a combination of natural-gas fired and renewable energy generation (AESO, 2019). In its reference case scenario, the AESO forecasts that solar energy generation capacity will increase from 15 MW to 481 MW which seems conservative based on recently proposed projects that increase the total to approximately 700 MW (AESO, 2019; Morgan, 2019). The forecast assumes the additions will be from utility-scale solar PV installations, however the AESO anticipates that there will also be small-scale installations providing electricity to Alberta's grid (AESO, 2019). To prepare for this disruptive transition to a more decentralized grid, the AESO published a Distributed Energy Resources Roadmap in June

2020 (AESO, 2020a). Additionally, a multi-stakeholder Distribution System Inquiry led by the AUC is ongoing to consider impacts of this transition on consumers, incumbent utility companies and other stakeholders.

Supporting Alberta's legislated renewable energy generation target, the RenuWell Project contemplates re-purposing a portion of Alberta's brownfield oil and gas sites through installation of ground-mount solar PV micro-generation or distributed generation systems with capacity up to 1 MW. The RenuWell Project pilot is proposed to be constructed in the Taber area of Southern Alberta. Alberta has an abundant solar energy resource and Southern Alberta represents an ideal geographic area to pilot and expand the re-purposing concept as shown in Figure 3. Figure 3 is a map that was developed as part of a larger mapping project undertaken by Pelland, McKenney, Poissant, Morris, Lawrence, Campbell, and Papdopol (2006) to support assessment and decision-making for solar PV projects. The map illustrates how the average annual solar PV production potential varies geographically across Canada and how southeastern Alberta is a solar "PV hotspot" (Pelland et al., 2006). The map in Figure 3 was reproduced from an official work that was published by the Government of Canada on the Natural Resources Canada website and the reproduction has not been produced in affiliation with, or with the endorsement of the Government of Canada.

Figure 3: Yearly PV potential map for latitude tilt and the 13 “PV hotspots” in each Province and territory in Canada



(Pelland et al., 2006)

To illustrate the magnitude of Alberta’s solar energy resource, the average solar energy production potential in Canada is 1,133 kWh/kW installed/Yr and Alberta’s average solar energy production potential exceeds the Canadian average by 13% at 1,276 kWh/kW installed/Yr as supported by Figure 3 (energyhub.org, n.d.).

2.2 Solar PV Technology and General Environmental Considerations

Solar PV systems generate direct current (DC) electricity through the conversion of solar energy in a solid-state solar PV cell made of a semi-conductor material (Boyle, 2012). Crystalline silicon solar cells are the most prevalent in solar PV systems followed by thin-film solar cells made of cadmium telluride or copper indium gallium diselenide (U.S. Department of Energy - Office of

Energy Efficiency and Renewable Energy [EERE], 2013a). Solar cells represent individual PV units that can be combined and scaled accordingly to meet power generation requirements. Connected solar cells form panels which can be used individually or further connected with other panels to form an array (EERE, 2013a). Additional equipment is required including inverters, which convert the direct current electricity generated to alternating current required for transmission or use and which 'communicate' with the grid utility, as well as mounting infrastructure such as cabling and racking (EERE, 2013b). Interconnection of the solar PV array to the host load and/or to the grid completes the system. Storage components such as batteries may also be incorporated into the system however use of storage is currently limited due to cost and availability. As solar PV costs are declining and renewable energy demand is expected to grow, storage technologies are concurrently evolving to address the intermittent nature of solar PV generation.

The amount of energy generated from the solar PV system varies depending on several factors including the abundance of the solar resource, orientation and tilt of the array, peak power rating of the array, effects of shading and temperature and the efficiency of the PV modules and inverter (Boyle, 2012). Solar PV system efficiency for commercially available technology ranges between 17 and 20% (MCCAC, 2017). A solar PV system's capacity factor compares the actual average output of the system to its maximum rated output. Due to the intermittent nature of solar PV, capacity factors range from approximately 13% to 17% for small scale solar PV installations in Alberta (Canada Energy Regulator, 2019). Installation of arrays with trackers can increase the capacity factors; however, trackers are more commonly employed in utility-scale solar PV projects and are less common in small-scale installations as contemplated by the RenuWell Project.

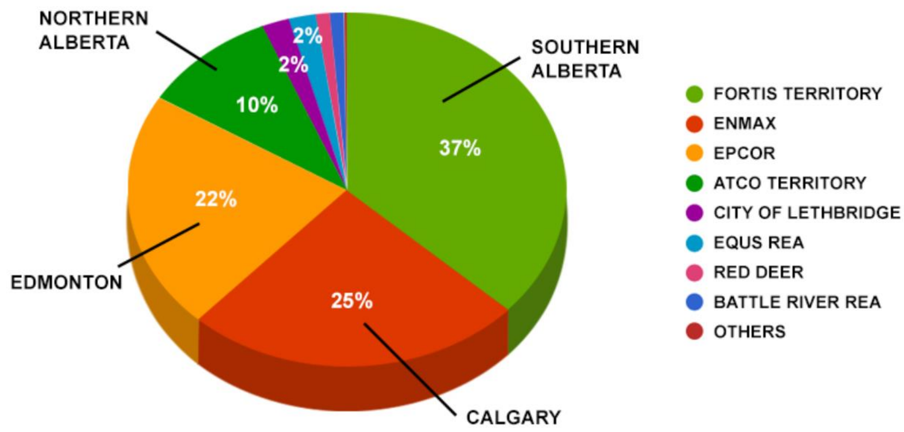
Solar PV systems have a low environmental impact relative to other types of electricity generation. Once the system is installed and operational, there is no associated pollution emitted to the environment and minimal noise (Boyle, 2012). Additionally, there is no water used in system operation. On the negative side, solar PV systems may be considered a visual nuisance and, if ground-mounted, will occupy land area (MCCAC, 2017). Safety concerns during solar PV system operation include risk of fire which can be mitigated through preventative measures such as input from the local Fire Marshal in system design, use of components that meet required safety standards and installation of emergency shut down equipment (Government of Alberta, 2017a; MCCAC, 2017). Although the environmental impacts of an operating solar PV system are minimal, there are impacts associated with upstream processes including raw materials extraction, manufacturing and installation, and downstream processes including decommissioning and disposal. In 2012, the U.S Department of Energy National Renewable Energy Laboratory (NREL) analyzed and harmonized hundreds of life cycle assessment studies which provided varying estimates of the greenhouse gas emissions from solar PV. To harmonize the estimates, the NREL compiled the results of the studies and applied consistent methods and assumptions to the data (NREL, 2012). The NREL study showed that solar PV systems generate approximately 40 g of carbon dioxide equivalent (CO_2e) per kilowatt hour (kWh) and that greenhouse gas emissions are primarily generated during the upstream and downstream phases of the system life cycle (NREL, 2012). As a comparison, the study indicated that coal-fired generation generates approximately 1000 g of CO_2e per kWh, primarily in the operations phase of the system life cycle (NREL, 2012). Disposal of system components at the end of the solar PV life cycle has been identified as a key environmental concern and highlights the importance of recycling solutions as many of the system components, including rare elements, can be recycled (Alberta Solar Installers, n.d.). Recycling options are currently limited but are evolving due to a predicted worldwide spike in disposal in 2030 based on current solar PV system life expectancy (Alberta Solar Installers, n.d.).

2.3 Small-Scale Distributed Generation and Micro-Generation

Re-purposing Alberta's brownfield oil and gas sites as brightfields represents a disruptive opportunity to leverage existing infrastructure from oil and gas development such as access roads and grid tie-ins and add decentralized capacity to Alberta's grid through the deployment and integration of solar PV micro-generation or small-scale distributed generation. According to the OECD, increased penetration of distributed energy resources represents a disruptive innovation in the retail electricity market in a jurisdiction such as Alberta, as it changes the traditional, centralized market structure and business models (OECD, 2018). The environmental benefits resulting from the addition of decentralized solar PV electricity generation to Alberta's grid include a decrease in greenhouse gas emissions due to reduced fossil fuel-based generation, a reduction in transmission line losses due to proximity of generation and consumption and lower peak generation capacity requirements due to alignment of high solar generation with increased electricity demand (Nadkarni & Hastings-Simon, 2017). Decentralized solar PV electricity generation, if designed to function in both a grid-connected and stand-alone manner, may also provide electric system resilience and redundancy through prevention and mitigation of power disruption during outages (NREL, 2014).

The AESO has identified that decentralized electricity generation from solar PV is growing in Alberta, exhibiting exponential growth in the past ten years (AESO, 2019). In preparation for an increasing trend in distributed energy generation, particularly solar PV, the AESO published its Distributed Energy Resources (DER) Roadmap in June 2020 to proactively consider issues associated with reliability, market participation, tariff, and stakeholder engagement (AESO, 2020a). Three primary factors are attributed to driving this growth including consumer demand for green energy, supportive government policy including targets and incentives and the potential to hedge against increasing electricity costs (AESO, 2019). As of March 2020, there were 5,446 micro-generation and small distributed generation sites in Alberta representing 211 MW of installed capacity. Solar energy generation projects comprise 97% (5,269) of these sites and approximately 33% (70 MW) of the installed micro-generation and distributed generation capacity (AESO, 2020c). Most of the generation sites reported are micro-generators; there was only one solar PV distributed generation site representing 990 kW of installed capacity (AESO, 2020c). Solar PV micro-generation in Alberta has increased significantly over a short timeframe in terms of number of sites as well as installed capacity. To illustrate the magnitude of this growth, in 2015, AESO reported 1,104 micro-generation sites representing 7.5 MW of installed capacity (AESO, 2015). Figure 4 depicts the location of solar PV micro-generation sites in Alberta, identifies the local Distribution Facility Owner (DFO) and provides a breakdown of sites by type. Most existing micro-generation sites are located in Southern Alberta and were deployed by residential prosumers. Alberta's existing solar PV installations are split approximately equally between ground-mount and roof mount systems based on a review of existing systems conducted in 2018 (Solas Energy Consulting, 2018).

Figure 4: Micro-generation Sites in Alberta in January 2020



5091 PV Solar System; 77% Residential, 11% Commercial, 11% Farm, 1% Other.

Jan 2020	5,091 Solar Units Installed in Alberta
2012	355 Solar Units Installed in Alberta
2010	122 Solar Units Installed in Alberta

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Although individual investment in small-scale solar PV installation may be largely values-driven, there is economic incentive due to potential revenue generation as well as the opportunity to hedge against increasing electricity costs as further detailed below.

Solar PV micro-generation systems are connected directly to the building(s) that will consume the electricity and are designed to meet the consumer's own electricity needs or host load. The Micro-generator framework and AUC Rule 024 apply to these behind-the-meter systems and the enabling legislation is the *Electric Utilities Act* and associated Micro-generation Regulation. The nameplate capacity of micro-generation systems cannot exceed the consumer's total demand from the grid in the previous year to a maximum capacity of 5 MW (Nadkarni & Hastings-Simon, 2017). Large micro-generation systems range from 150 kW to 5 MW in size and small micro-generation systems are 150 kW or less (Nadkarni & Hastings-Simon, 2017). The micro-generator must prove that the greenhouse gas emissions from the system are less than 418 kilograms of CO_2e per MWh which represents the amount generated by a typical combined cycle natural gas plant (Government of Alberta, n.d.-b). Small-scale micro-generators are generally compensated at daily average retail rates for electricity produced in excess of the host load whereas large-scale micro-generators are compensated at the hourly wholesale power pool prices (Nadkarni & Hastings-Simon, 2017). An economic advantage of wholesale power pool price compensation for solar PV micro-generation is that the timing of peak solar production aligns with peak power pool pricing (Nadkarni & Hastings-Simon, 2017).

Distributed generation sources are standalone systems that supply the distribution system, which is the portion of the electricity grid that operates at 25 kV or less; moreover, these systems have minimal or no host load (Nadkarni & Hastings-Simon, 2017). Distributed generators sell electricity in excess of the host load to the DFO for use by all consumers on the local distribution system (Nadkarni & Hastings-Simon, 2017). These generation systems can be as large as 25 MW and are governed under the Small Scale Generation Regulation, Distributed Generation Framework and AUC's Rule 007.

In the case of both micro-generation and distributed generation systems, generators are the entities, community groups or individuals that own and manage the system and the electricity produced from it, allowing them to hedge against future electricity costs and receive credit or compensation for excess electricity that is sold to the grid (Nadkarni & Hastings-Simon, 2017).

Regulations pertaining to the development and interconnection of solar PV micro-generation and distributed generation systems are governed by the AUC and the AESO. The local DFO, which may be a private utility company, municipality or Rural Electrification Association, plays a key role in the deployment of these systems by providing the generator access to the grid through interconnection and facilitating the exchange of electricity (Nadkarni & Hastings-Simon, 2017). In the case of micro-generation projects, an application to the AUC is not required provided that "no person is directly or adversely affected, the power plant complies with AUC Rule 012: Noise Control…and there is no effect on the environment" (AUC, 2013, p. 1). The local DFO approves or denies individual notices for proposed projects and the retailer agrees to coordinate the credit compensation. Dispute resolution between generators and the DFO or retailer is overseen by the AUC (Nadkarni & Hastings-Simon, 2017). As outlined above, the micro-generator sells excess electricity to the DFO and is compensated by the retailer in the form of credits which are applied against the micro-generator's electricity bill (AUC, 2013).

Distributed generation projects undergo a lengthy application and review process prior to construction. Proponents for distributed generation projects must apply to the AUC for project approval, obtain interconnection approval from the DFO and register with the AESO as a pool participant (Nadkarni & Hastings-Simon, 2017). Once connected, compensation for electricity exported to the grid is paid through the AESO based on hourly pool prices. The distributed generator may also receive additional compensation in the form of Demand Transmission Service (DTS) credits depending on the location of interconnection. DTS credits reflect value generated by distributed generators that benefits DFOs through a reduction in the use of the transmission system to deliver electricity to consumers. When a DFO draws electricity from the power pool based on demand, it pays a DTS charge to the AESO. Distributed generation results in a reduction of this charge as the DFO draws less electricity from the power pool to meet local demand in the area of the distributed generation (Nadkarni & Hastings-Simon, 2017). The savings realized by the DFO are partially credited to the distributed generators. DTS credits have different names depending on the area DFO: Fortis Alberta - Option M credit, ATCO Electric – D32 Price Schedule and ENMAX – D600 tariff (Nadkarni & Hastings-Simon, 2017).

DTS credits are currently under review as part of the AUC's Distribution System Inquiry. One of the aspects of the credits under discussion is that, although the addition of distributed generation to the local grid results in cost savings for the DFO, these savings are not realized by electricity consumers (AUC, 2017). The outcomes of the AUC's review are important to future investment in distributed generation as the credits can be a significant component of the revenue earned by distributed generators and represent an important factor in assessing the economic feasibility of a distributed generation project and obtaining financing (Howie & Ross, 2017).

The Alberta Ministry of Environment and Parks (AEP) also has a role in project approvals by providing standards and best management practices to be followed to minimize the risks of solar energy projects on wildlife and wildlife habitat. In accordance with a Memorandum of Understanding between the AUC and AEP, the AUC refers solar energy generation project applications to AEP for review and advice on siting and other project life cycle considerations to ensure desired outcomes for wildlife and wildlife habitat are achieved.

2.4 Solar PV Project Economics Overview

The scope of this research project does not contemplate detailed economic feasibility of the concept of re-purposing brownfield oil and gas sites as solar PV brightfields as that work has already been completed by the RenuWell Project team. However, to provide additional context applicable to the investigation of the research question, general economic considerations applicable to solar PV installations in Alberta are outlined in this Section.

The cost of solar PV modules has declined significantly over the past decade. According to the International Renewable Energy Agency (IRENA), due to incremental improvements with each new installation, PV module prices have fallen about 80% since 2010 (IRENA, 2017). According to a 2019 report by the Canada Energy Regulator (CER) entitled "The Economics of Solar Power in Canada", in addition to decreasing installation costs and abundance of solar energy resource, local electricity prices play a significant role in driving the competitiveness of solar PV electricity generation. The CER's report evaluated the potential financial viability of solar power project deployment in 20,000 Canadian communities including 1,220 locations in Alberta. In the study, current cost, near future cost and low cost future solar installation scenarios were considered for solar PV installations in Alberta using an average reference electricity price of 8.84 cents per kWh. Assumed installation costs ranged from $1.59 to $2.21/Watt for commercial and community size installations and $2.252 to $3.197/Watt for residential installations. Considering flat rate market pricing, the breakeven price for residential, commercial and community-scale solar projects sized from 5 kW to 200 kW ranged from 8.91 to 12.25 cents per kWh rendering the systems uneconomic in current conditions (CER, 2019). Nevertheless, residential, commercial and community-scale solar generation projects were close to break-even or profitable in all cost scenarios where smart meters were deployed with a break-even price range of 6.70 to 8.95 cents per kWh (CER, 2019). Smart meters improve solar power project economics as the generator captures value from time of day electricity prices that fluctuate with demand. Additionally, as solar PV installation costs continue to trend downwards over time, it is reasonable to assume that the economics of small-scale solar PV projects will improve concurrently.

A 'discounted payback period procedure' is appropriate to analyze profitability of a solar PV micro-generation or distributed generation project as the majority of costs, including planning and siting, land acquisition, construction and installation, are incurred at project deployment. Economic benefits are realized over the lifespan of the infrastructure. A twenty-five year lifespan is quoted frequently in literature, however according to a study by the NREL on PV degradation rates, the average degradation rate of less than 1% per year supports reasonable system performance beyond the twenty-five year standard warranty term (Jordan & Kurtz, 2012). The financial benefits that accrue to the generator from micro-generation or distributed generation deployment include savings from a reduced amount of electricity imported from the grid as well as credit for electricity exported to the grid. Additionally, as mentioned above, generators hedge against future electricity prices over the lifespan of the solar PV infrastructure and distributed generators may benefit from receiving DTS credits.

Benefits accrue to the generator with increased certainty regarding return on investment if generators enter into a Power Purchase Agreement (PPA) to sell their electricity to a specific customer at an agreed-upon rate (Nadkarni & Hastings-Simon, 2017). Furthermore, Alberta's new Technology Innovation Emissions Reduction (TIER) Regulation provides an opportunity for distributed renewable electricity projects to market emissions offset credits to emitting companies governed under TIER, including those that emit 100,000 tonnes of CO_2e/Yr or more, and lower emitters, such as conventional oil and gas companies, that have opted into the TIER program. To qualify as an emission offset project under TIER, the distributed generation project must be 1 MW or larger in size or aggregated with other smaller projects to reach the minimum qualifying size (Government of Alberta, 2013).

There are currently no provincial incentive programs for solar PV deployment however certain Alberta municipalities offer local incentives. Additionally, in 2018, An Act to Enable Clean Energy Improvements and the associated Clean Energy Improvements Regulation came into force supporting the development of the Clean Energy Improvement Program. This legislation enables municipalities to voluntarily pass a bylaw whereby residential, agricultural and commercial property owners can enter into an agreement with the municipality to finance the entire initial cost of solar PV installation and pay the loan back over time through an assessment added to their municipal property tax invoice (Energy Efficiency Alberta [EEA], 2020a). Benefits to the program include a potentially favorable financing rate for the solar PV system installation costs and that the solar PV infrastructure is tied to the property, not to the landowner. Should the landowner sell the property, the installation and associated loan payment obligations would transfer to the purchaser. Initially, EEA, a provincial government agency, was appointed to assist with program development and administration of the agreements on behalf of the participating municipalities however the provincial government recently announced that EEA would be dissolved effective September 30, 2020. According to a blog post on the EEA website, MCCAC will be managing the program go forward (EEA, 2020b).

The return on investment and length of payback period for a ground-mount solar PV micro-generation or distributed generation project is dependent on a number of factors including the location of the project, land access and construction costs, size of the contemplated system, financing costs, grid costs including transmission and distribution, whether the system is eligible for retail or wholesale pool price compensation and system eligibility for DTS or emissions offsets credits. Of note, grid electricity transmission and distribution charges vary across the Province based on the cost to build, operate, and maintain the area infrastructure and the number of customers sharing the costs (Alberta Urban Municipalities Association, 2019). According to the Alberta Urban Municipalities Association, these costs can total up to 70% of a consumer's electricity bill. Distribution costs comprise 22%-47% of a consumer's bill and, due to geographic distance and sparse populations, charges are higher for rural consumers providing a greater financial incentive for deployment of decentralized solar PV generation installations in rural areas (Alberta Urban Municipalities Association, 2019).

2.5 Land Use Considerations

Ground-mount solar PV installations, as contemplated by the RenuWell Project to make use of brownfield oil and gas sites, may be more costly to install relative to roof mount installations due to required pilings and mounting materials however they can be more efficient as a result of the ability to optimize system placement, direction and tilt. An additional cost pertinent to ground-mount installations, both financially and to the environment, is the land area required. The extent of land area required depends on site specific factors such as the location of installation and the requirement for associated infrastructure such as access roads and transmission lines (Miistakis Institute, 2017). Sizing data for solar PV ground mount installations varies across existing literature however, according to a report published by NREL, the average capacity weighted land use for Small PV (>1 MW, <20 MW) is 5.9 acres/MWac (2.4 hectares/MWac) which includes the solar PV array, access roads and other associated infrastructure (Ong, Campbell, Denholm, Margolis, & Heath, 2013). A renewable energy development fact sheet issued by the Miistakis Institute (2017) to support decision-making by Alberta municipalities indicates that an average of approximately 4 acres per MW is required for solar power plants (Miistakis Institute, 2017).

2.5.1 Alberta's Land Base and Land Use Framework

In Alberta, the land base is divided into provincial Crown, federal Crown and freehold owned lands. Provincial Crown and freehold lands are further divided into two designated areas, the Green (or forested) Area and the White (or settled) Area as shown in Figure 5 (Government of Alberta, 2017b). The White Area is comprised of the central and southern populated portions of the Province and 75% of the land is freehold (privately held). The Green Area includes northern

Alberta as well as the mountains and foothills and is primarily provincial Crown land, also referred to as provincial public land (Government of Alberta, 2017b).

Figure 5: Alberta’s Green Area and White Area

(Government of Alberta, 2017b)

There is currently a moratorium for development of solar and wind energy projects on provincial Crown lands which make up approximately 60% of the total land base and no legislative regime in place for issuance of dispositions and approvals under Alberta’s *Public Lands Act* for these projects. Literature regarding the moratorium is limited however available documentation indicates that the moratorium decision was made by the Government of Alberta in 2005 to allow time for the development of a renewable energy strategy and policy for Alberta’s public land (Harper, Olthafer, & Bakker, 2016). There is no documented timeline for when the moratorium may be lifted. This issue has been identified as an obstacle to renewable energy development in

Alberta and a missed opportunity for the provincial government and municipalities to collect rentals, royalties, and tax revenues from these projects for the benefit of all Albertans (Ingelson, 2018). Solar and wind energy development can occur on freehold or private lands which represent 30% of the provincial land base with municipal and regulatory approvals and permitting in addition to landowner consent through private contractual arrangements and associated compensation.

Provincial and municipal land use plans govern renewable energy development, including ground mount solar PV, on provincial Crown and freehold land. As in other Canadian provinces, the Alberta government sets out the broad land use policies and plans that land-use decision-makers, primarily municipalities, must adhere to (Muldoon, Williams, Lucas, Gibson, & Pickfield, 2020). In 2008, the Alberta government issued the provincial Land-use Framework (LUF) which sets out a regional approach to land use decision-making with objective of sustainably developing the Province's natural resources and public and private lands. The *Alberta Land Stewardship Act* (ALSA) implements the LUF and governs provincial land use planning and coordination between land-use decision-makers and the Alberta government (Muldoon et al., 2020). Two of the seven strategies under the LUF address the cumulative effects of all anthropogenic activities, including energy development, on Alberta's landscape. Cumulative effects are defined in the LUF as, "the combined effects of past, present and reasonably foreseeable land-use activities, over time, on the environment" (Government of Alberta, 2008, p. 51). Strategy 3 states that development approvals have been historically made in Alberta on a 'piecemeal' basis and, in acknowledgement of the finite carrying capacity of the ecosystem, regional plans under the LUF will be used to manage the combined effects of existing and new activities going forward (Government of Alberta, 2008). Strategy 5 recognizes that land is a non-renewable resource and minimizing development footprint for the benefit of future generations is to be incorporated in land use planning decisions (Government of Alberta, 2008).

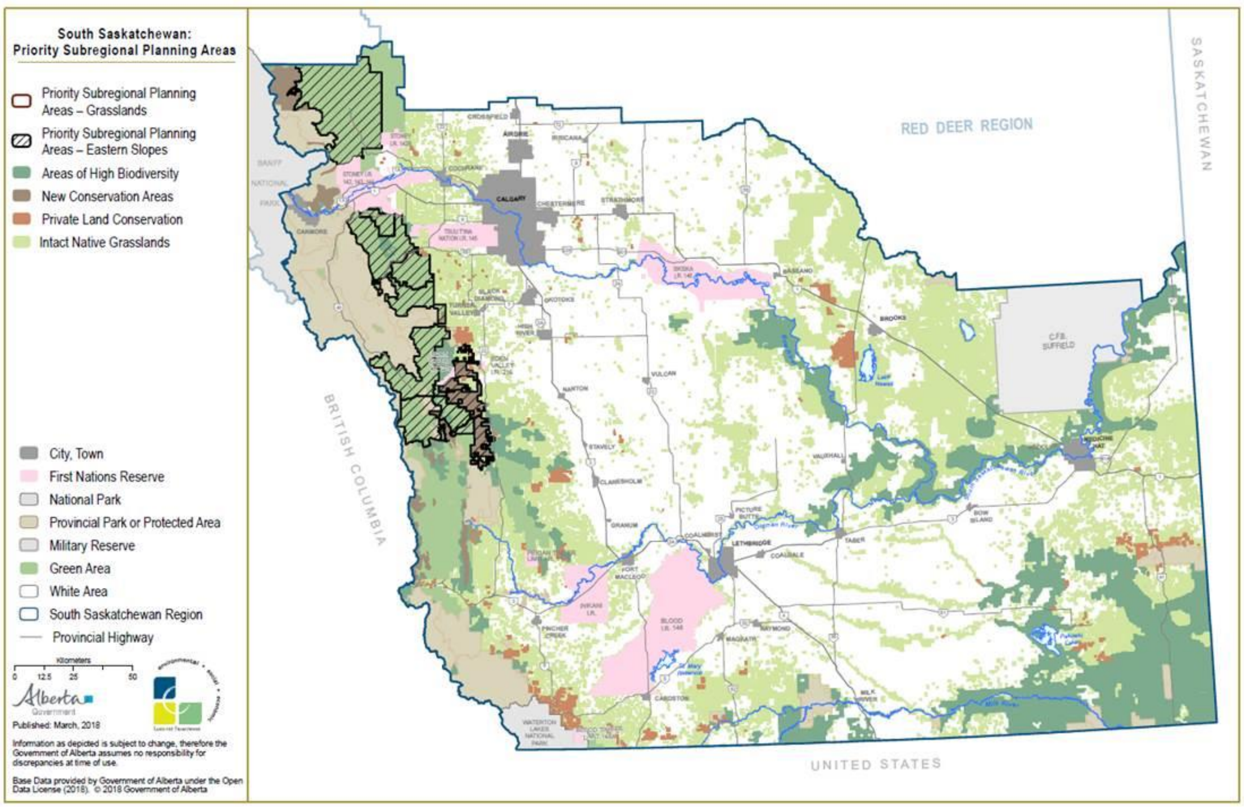
Under the LUF, seven regional land use plans covering Alberta's provincial Crown and freehold land base are to be developed and implemented. As of May 2020, regional land use plans were completed and approved under the LUF and ALSA for the Lower Athabasca Region, which is the northeastern portion of the Province where Alberta's oilsands development occurs, and the South Saskatchewan Region, which includes the City of Calgary south to the Canada-U.S. border and incorporates the M.D. of Taber. The balance of this Section is focused on land use considerations within the South Saskatchewan Region due to its favorable conditions for expansion of the RenuWell Project pilot concept as well as future solar PV development in general due to the region's solar resource potential and abundance of freehold-owned land area.

2.5.2 Solar PV Deployment in Alberta's South Saskatchewan Region

Acknowledging the area's abundant renewable energy sources, including solar energy, the South Saskatchewan Regional Plan (SSRP), as amended, enables renewable energy development within the South Saskatchewan Region. The SSRP outlines the Province's desired regional objectives to maintain and create opportunities for responsible green energy development and production which supports community and industry sustainability (Government of Alberta, 2014). Strategies to achieve the objectives include putting appropriate policies in place to attract new investment and removing barriers for renewable energy development in the region and facilitating addition of incremental renewable power to the grid through reinforcement of the transmission system (Government of Alberta, 2014). As detailed in the ACREI's Final Submission to the AUC's Distribution System Inquiry, the strategy to reinforce the transmission system primarily facilitates and acts as an indirect subsidy promoting development of large utility-scale transmission-connected renewable energy projects over small-scale solar PV installations which are connected directly to the distribution system (Bennett, 2020b).

A map of the South Saskatchewan Region is shown in Figure 6. The map illustrates the diverse land areas comprising the region including Indigenous reserves and other lands under federal jurisdiction, urban areas, settled and forested areas, priority planning areas, conservation areas and easements, and areas of intact native grasslands. The region is approximately 84,000 square kilometers in size and encompasses 13% of Alberta's land base (ABMI, 2018a).

Figure 6: South Saskatchewan: Priority Subregional Planning Area

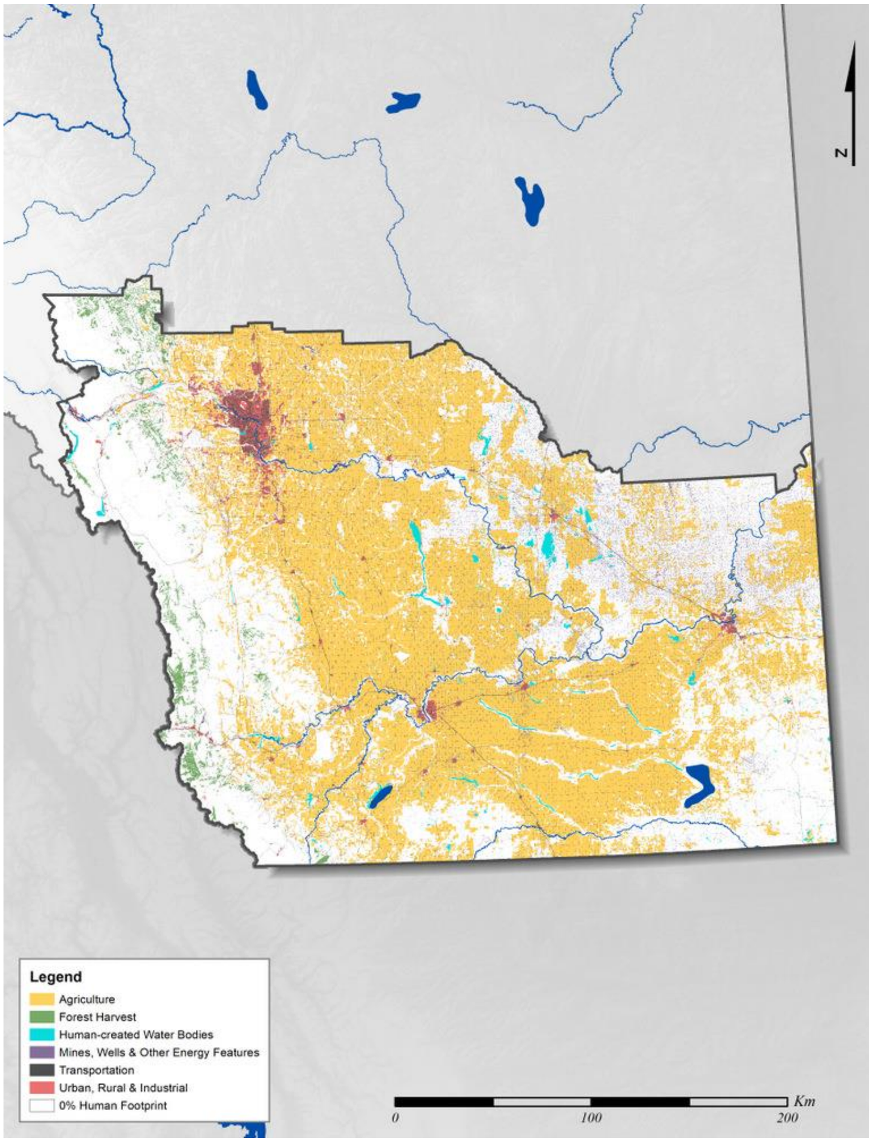


(Government of Alberta, 2018, p. 140)

Alberta's Grasslands Natural Region covers 78% of the South Saskatchewan Region representing the area's largest ecosystem and, despite intensification of settlement activities such as agriculture and energy development, contiguous areas of intact native grasslands remain as shown in Figure 6 (ABMI, 2018a; Government of Alberta, 2018). In addition to acting as a carbon sink, native grasslands provide valuable ecosystem services such as forage production, soil protection, natural weed deterrence, nutrient cycling, water purification, pollination, and stability through diversity (MULTISAR, 2020b). The Grasslands Natural Region is also home to 85% of Alberta's species at risk which continue to be threatened by such causes as habitat degradation or disappearance, human disturbance, and isolation of populations (MULTISAR, 2020a). As Alberta's grasslands are under significant anthropogenic developmental pressure, it is a provincial priority to manage and reduce the cumulative effects, such as disturbance, conversion and fragmentation, resulting from oil and gas exploration and development, renewable energy development, forestry extraction, transportation infrastructure, electricity transmission infrastructure, municipal development and rangeland improvements, in this biodiverse ecosystem (Government of Alberta, 2016).

The human footprint map prepared by the ABMI and shown in Figure 7 illustrates existing anthropogenic surface disturbance by type in the South Saskatchewan Region (circa 2016). According to the ABMI, in 2016, approximately 52% of the region was disturbed by human footprint, primarily agricultural land use followed by transportation and energy development (ABMI, 2018a). Mitigating fragmentation and conversion of high value agricultural land is also a focus of Alberta's land use policy and incorporated in the SSRP in recognition of the agricultural industry's historical significance and importance to the provincial economy and culture (Alberta Agriculture and Forestry, 2018). Furthermore, it is recognized by the Province that agricultural land use competes with other land uses such as energy development (Alberta Agriculture and Forestry, 2018).

Figure 7: ABMI Map of Total Human Footprint (circa 2016) in the South Saskatchewan Region



(Alberta Biodiversity Monitoring Institute, 2018a)

Costs of land access for renewable energy development can be approximated using published land value data which varies depending on location. Reflecting the value attributed to agricultural land in Alberta, according to Statistics Canada, the average value of farmland and buildings in the Province as at July 1, 2018 is $2,683.00/acre or $6,707.50/hectare (Statistics Canada, 2020). The average is not reflective of the true range of variability in farmland values across the Province. According to the 2018 FCC Farmland Values Report issued by Farm Credit Canada (2019), the most valuable farmland is in the southern half of the Province where the solar energy resource is the highest. Within the South Saskatchewan Region, 90% of farmland sales in 2018 ranged from $1,900.00 to $14,100.00 per acre with an average value of $6,157.00, over twice the value published by Statistics Canada (Farm Credit Canada, 2019; Statistics Canada, 2020).

2.5.3 Summary of Land Use Considerations

Alberta's LUF, which is legislated in the ALSA, includes documented strategies to mitigate the cumulative effects of anthropogenic disturbances on the landscape, including energy development. Consideration of cumulative effects from renewable energy development are important as project deployment is geographically limited to freehold-owned lands, primarily located in the south east area of the Province. The SSRP enables renewable energy development however the area comprising the South Saskatchewan Region is over 50% disturbed from existing anthropogenic activities. Deploying ground-mount solar PV installations on land previously disturbed by oil and gas development, as contemplated by the RenuWell Project, represents a strategy to mitigate the cumulative effects of further disturbance and fragmentation of Alberta's high value grassland ecosystems and agricultural lands for renewable energy development.

2.6 Brownfield Oil and Gas Sites

This section provides information on Alberta's growing oil and gas brownfield site liability and the regulatory framework applicable to site closure to illustrate the magnitude of the brightfield re-purposing opportunity. As further detailed below, there is potential to re-purpose both inactive and orphan brownfield oil and gas sites with solar PV deployment resulting in cost savings for the oil and gas company in the case of an inactive site or the OWA in the case of an orphan as well as for the solar PV developer due to re-use of disturbed land and existing infrastructure. The provincial and federal governments have both signaled that addressing the issue of inactive oil and gas site closures is a priority, supporting the expansion of the re-purposing concept.

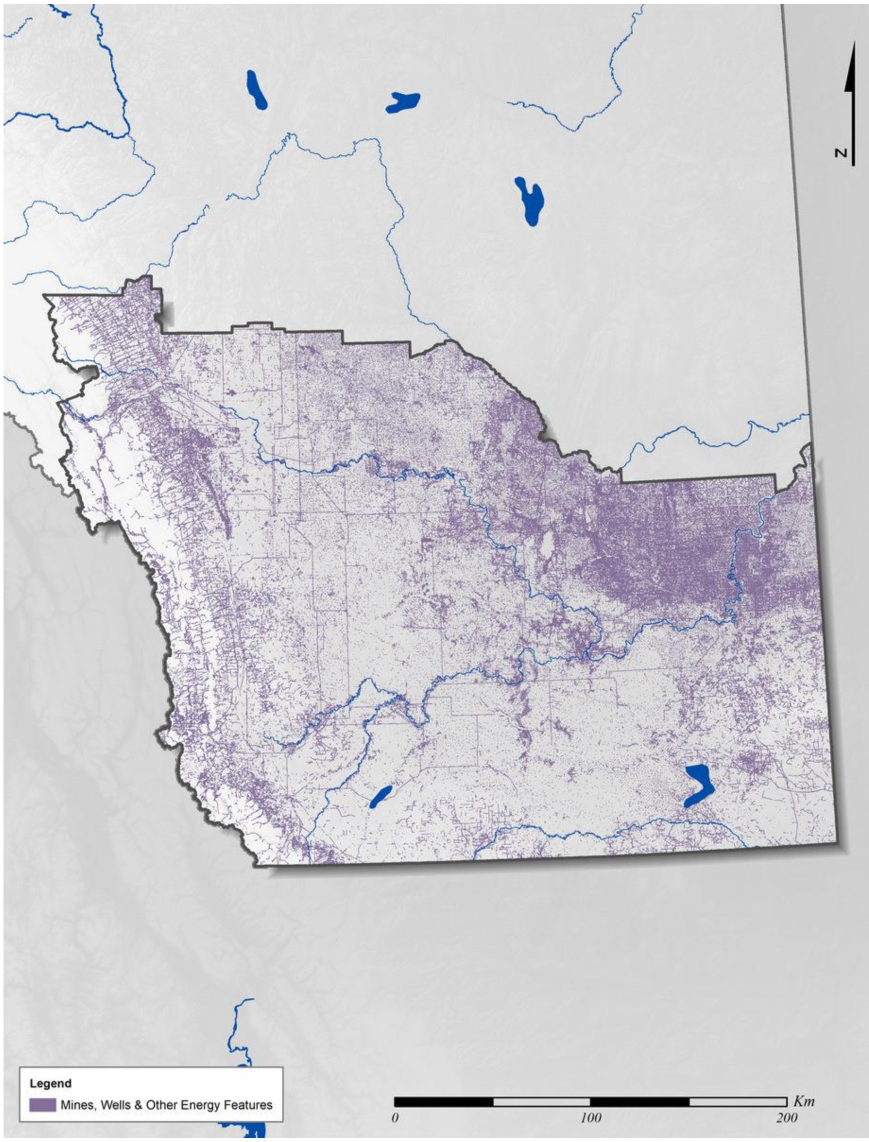
2.6.1 Socioeconomic and Environmental Impacts of Brownfield Oil and Gas Sites

The development and sale of crude oil and natural gas has been a primary contributor to Alberta's economy, however slowing global demand, market access constraints and persistently low oil prices have resulted in a decline in the industry and a significant increase in the number of inactive and orphan oil and gas sites. According to a report issued by the C.D. Howe Institute in 2017, approximately one-third of the Province's 450,000 oil and gas wells are inactive, defined as no longer producing and not yet fully remediated. These inactive wells represent a potential social cost ranging from $338 million to $8.6 billion (Dachis, Shaffer, & Thivierge, 2017).

Inactive sites are the responsibility of a solvent licencee unless designated as orphans by the AER. Unfavorable economic conditions, reduced investment and low oil prices have led to growth in the number of inactive oil and gas sites as well as licencee insolvencies, increasing the probability of continued growth of the orphan infrastructure inventory (Dachis et al., 2017). A significant portion of Alberta's inactive and orphan infrastructure is located on freehold land and frustration amongst affected landowners is evident. Landowners may not be receiving annual rentals owed as compensation from the licencee for use of their land and the presence of orphan infrastructure may also impact property values (Thiessen & Achari, 2015). Additionally, the municipality in which orphan infrastructure is located no longer receives property tax payments. According to Rural Municipalities of Alberta, members are owed over $173 million in outstanding property taxes from oil and gas companies (Rural Municipalities of Alberta, 2020). The RenuWell Project proposes to convert a portion of these inactive and brownfield oil and gas site liabilities into assets with solar PV deployment, an opportunity that K. Hirsche of EEI has been investigating and discussing with regulators and other stakeholders since 2016 and has been pursuing as part of the RenuWell Project team and its partners through the MCCAC's CGCB Program and MCGC since early 2019. (K. Hirsche, personal communication, February 16, 2020)

As shown in Figure 1 Chapter 1, there is a significant surface footprint attributable to over 68,000 abandoned brownfield oil and gas sites in Alberta, where the infrastructure is abandoned but the surface is not fully reclaimed, representing a subset of the 155,000 inactive sites mentioned above and including orphan sites (ABMI, 2018b; Dachis et al., 2017; IHS Markit, 2019). Alberta's brownfield oil and gas sites range in size from 2 to 5 acres, ideally sized for solar PV micro-generation or distributed generation installations with capacity of up to 1 MW (Hirsche & Stendie, 2020). Focussing on the South Saskatchewan Region due to its favorable attributes for solar PV development and to illustrate the potential availability of brightfield candidate sites, the surface footprint from energy features including abandoned oil and gas sites located in the region is shown in Figure 8. Note that in Figure 8, the energy footprint polygons are outlined for visibility (ABMI, 2018a).

Figure 8: ABMI Map of Energy Footprint (circa 2016) in the South Saskatchewan Region



(Alberta Biodiversity Monitoring Institute, 2018a)

2.6.2 Oil and Gas Infrastructure Closure Regulatory Framework

The AER reports to the Government of Alberta's Ministry of Energy and is responsible for regulating the full life cycle of oil and gas projects in the Province from construction through reclamation and closure under the *Responsible Energy Development Act* and other governing legislation, regulations and specified enactments a portion of which are further detailed below

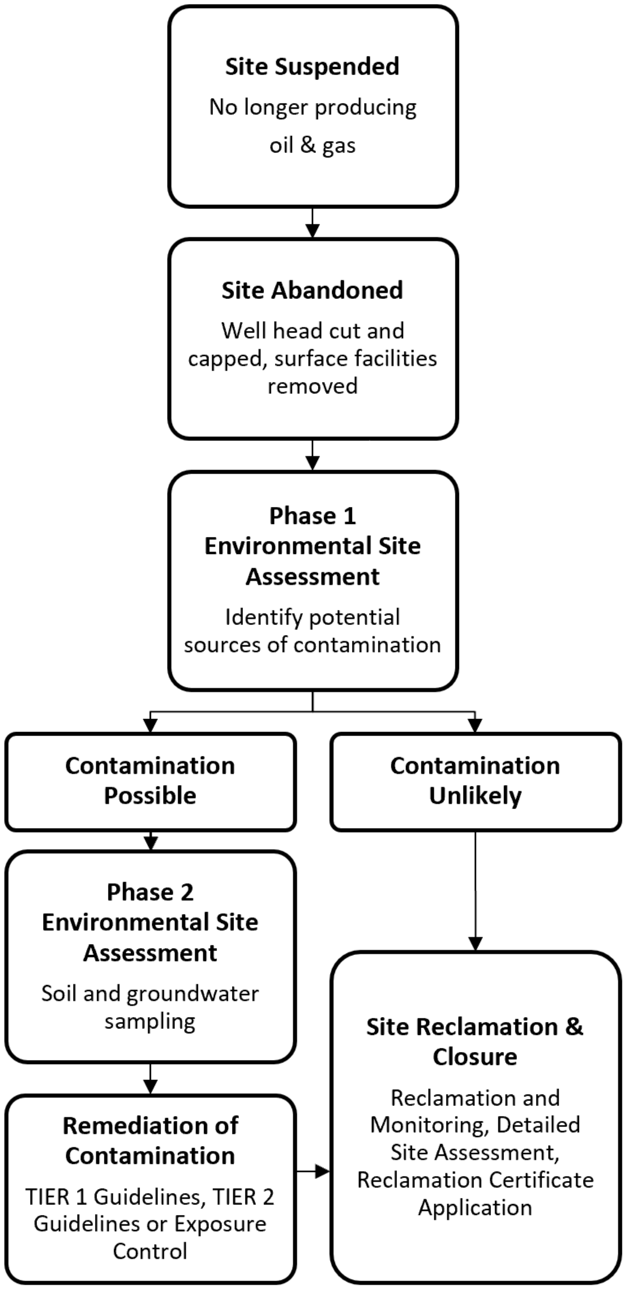
(Government of Alberta, 2020a; AER, n.d-b). Once an oil and gas well, pipeline or facility site is inactive or non-productive for a legislated period (six to twelve months), the site licencee is responsible for suspending the infrastructure to reduce risk to the environment (AER, 2020). Following suspension, if the infrastructure is no longer required, the licencee must dismantle and properly abandon. There is generally no specific timeline for infrastructure abandonment although there are some exceptions. Under Sections 25 and 27 of the *Oil and Gas Conservation Act* (OGCA), the AER may issue an Order to a licencee to suspend, abandon or transfer wells, pipelines and facilities within a specified timeline if there has been a contravention of the regulations or if the AER considers it necessary to protect the public or the environment (*Oil and Gas Conservation Act*, 2000, s. 25, 27). Additionally, if the licencee's right to access the minerals expires, the AER will issue a notice to the licencee to abandon the well(s) which accesses those minerals within a prescribed timeframe.

Once abandonment is complete, there should be no further surface infrastructure located on the brownfield oil and gas site. The infrastructure licencee is then responsible, pursuant to Alberta's *Environmental Protection and Enhancement Act* (EPEA), Contaminated Sites Policy Framework and Conservation and Reclamation Regulation (CRR), to return the land disturbed by the oil and gas development to its original state through remediation of any contamination followed by reclamation (AER, n.d.-a). There is no legislated timeline for a licencee to complete remediation or reclamation, however, as in the case of suspension and abandonment, there are some exceptions. Under the Remediation Regulation, licencees responsible for contamination have two years from when they became aware of the issue or ought to have known about it to complete the remediation of the site and meet legislated criteria or propose an alternative timeline to the AER for approval (Leuschen, 2018). Additionally, under Sections 140 and 241 of the EPEA, the AER can issue an

Environmental Protection Order compelling the licencee to conduct site remediation and reclamation activities within a specified timeframe (*Environmental Protection and Enhancement Act*, 2000, s. 140, 241).

To achieve closure of a brownfield oil and gas site, the licencee is required to conserve and reclaim the land used for oil and gas activities to equivalent land capability under Section 137 of EPEA and apply to the AER for a reclamation certificate (AER, 2019). Figure 9 illustrates the process steps to achieving reclamation certification and closure for both inactive and orphan oil and gas brownfield sites. The timeframe to complete the process varies and is dependent upon legislated timelines and unique brownfield site attributes such as whether the site is contaminated.

Figure 9: Stages of Oil and Gas Brownfield Site Closure



(Adapted from Alberta Agriculture and Forestry, 2016; Clean Resource Innovation Network [CRIN], 2020)

AER's Specified Enactment Direction 002 (SED 002) outlines the reclamation certificate requirements, criteria and guidelines for brownfield oil and gas sites which are developed and updated by AEP. Supporting the RenuWell Project, Section 7.4.7 of SED 002 allows for a reclamation certificate to be issued to the licencee and certain facilities from oil and gas activities to remain in place as improvements for the landowner (AER, 2019). A survey plan or sketch showing the improvements along with written acceptance from the appropriate parties agreeing to leaving the improvements in place are submitted with the reclamation certificate application (AER, 2019). Examples of oil and gas site improvements that can remain in place and specifically support the RenuWell Project concept include power lines and access roads. SED 002 enables the licencee to complete its closure requirements and apply for a reclamation certificate under the legislation while allowing for the site to be re-purposed for solar PV deployment prior to return to equivalent land capability. Pursuant to the regulations, after reclamation certificate issuance, licencees remain liable and responsible for surface reclamation issues for a period of twenty-five years after reclamation certification and indefinitely for contamination (AER, 2014).

2.6.3 Orphan Oil and Gas Infrastructure

Upstream oil and gas infrastructure in Alberta, including wells, pipelines, and facilities, are designated as orphans by the AER when there is no longer a legally responsible or financially able party accountable for outstanding closure activities (OWA, n.d.-a). This occurs when the infrastructure licencee becomes defunct or insolvent before conducting required abandonment and/or reclamation work as detailed above. According to the OWA, which is a non-profit operating under the delegated authority of the AER, the inventory of orphan infrastructure has increased significantly in recent years. As of August 2020, there were 2,959 orphan wells requiring abandonment and 3,212 sites requiring reclamation (OWA, n.d.-b). The OWA manages the safety and environmental risk of orphan infrastructure and conducts outstanding closure activities on behalf of the defunct licencee. The OWA does not pay surface compensation owing under surface leases for orphan sites to the landowners however landowners can make a claim for unpaid compensation to the Surface Rights Board (OWA, n.d.-c). The Association is partially funded through an annual oil and gas industry levy that is legislated in the OGCA and is prorated over all viable licensees in Alberta based on each company's proportionate share of provincial deemed liabilities (OWA, 2019). Loans and grants have also been provided to the OWA by the provincial and federal governments (OWA, 2019).

Orphan oil and gas sites represent disturbed land that could be re-purposed for small-scale solar PV deployment. L. De Pauw, Executive Director of the OWA, (personal communication, August 27, 2019) explained during a presentation to the Canadian Association of Petroleum Landmen that, when a site is designated as an orphan by the AER, the OWA is granted legal access to the site owned by the defunct company in order to conduct closure activities under Section 101 of the OGCA and Section 250 of EPEA. He also noted in his presentation that the OWA was exploring opportunities for alternative closure such as re-purposing orphan sites for renewable energy projects however that executing on these opportunities may require legislative changes (personal communication, August 27, 2019). The OGCA and Orphan Fund Delegated Administration Regulation outlines the powers and authorities that the AER delegates to the OWA to manage orphan sites which are limited to orphan site suspension and abandonment operations. Bill 12, the Liabilities Management Statutes Amendment Act, 2020, which received Royal Assent on April 2, 2020 and will come into force upon proclamation as SA 2020, c 4, amends the OGCA and *Pipeline Act* and allows future amendments to the Orphan Fund Delegated Administration Regulation to enable the OWA to play a more active role in reducing the orphan site inventory by expanding its delegated authorities (Bankes, 2020). Although the extent of the impacts of Bill 12 are yet to be investigated at the time of writing of this study, enactment of the Bill is presumably a step in the right direction towards enabling the OWA to execute alternative orphan site closure opportunities such as re-purposing for renewable energy generation.

2.6.4 Alberta's Site Rehabilitation Program

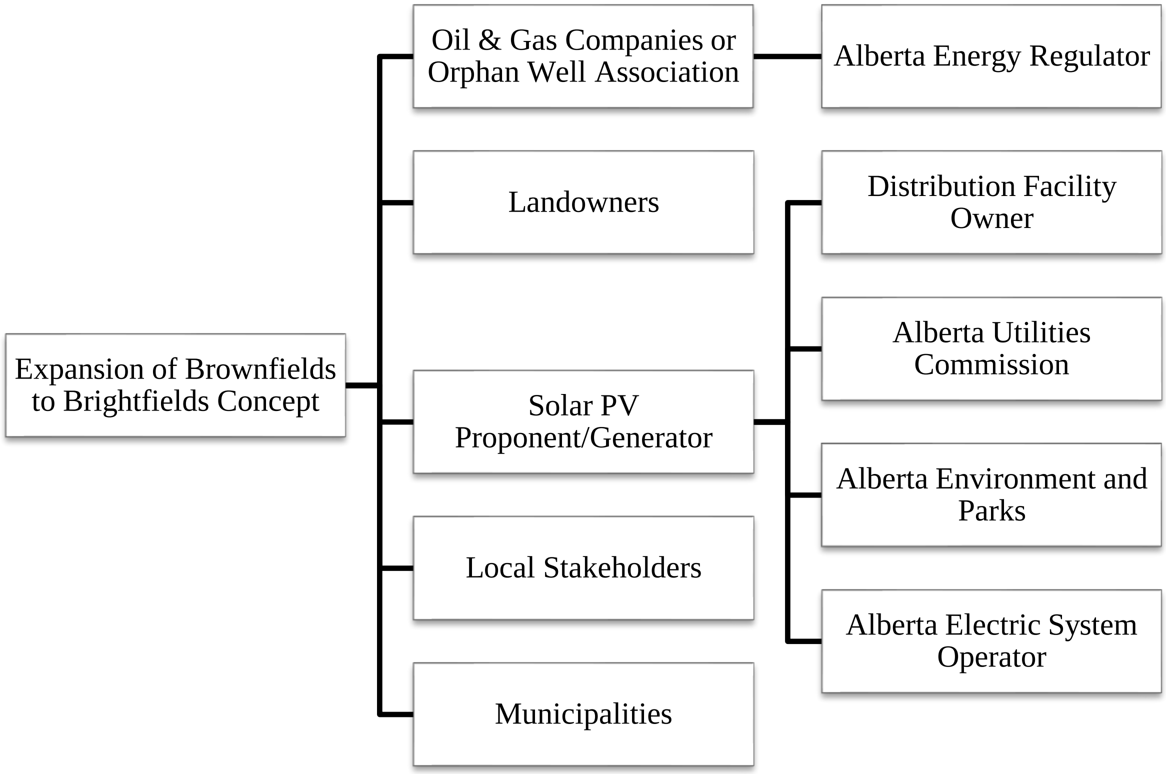
Clean up and closure of Alberta's inactive oil and gas sites is a provincial and federal government priority. On April 17, 2020, Canadian Prime Minister Justin Trudeau announced that the federal government would be providing $1.7 billion in financial aid to clean up inactive wells with approximately $1 billion designated for Alberta (Harris, 2020). Following the federal announcement, Alberta announced its Site Rehabilitation Program to deploy the funding in increments to oil field service contractors to perform abandonment and reclamation work to close inactive oil and gas sites on behalf of site licencees (Alberta Energy, 2020). Of note, sites where a licencee has not made surface lease payments are considered high priority and landowners may apply to nominate a particular oil and gas site for closure under the program (Alberta Energy, 2020). Objectives of the program include job creation and support for the environment. Moreover, work conducted under the program must be completed and reported to the AER by December 31, 2022 illustrating the urgency and importance of addressing this issue (Alberta Energy, 2020). The Site Rehabilitation Program is overseen and managed by Alberta Energy.

2.7 Summary

Alberta's unique electricity market and abundant solar resource make it an attractive jurisdiction to deploy solar PV micro-generation and distributed generation to meet provincial targets and offset greenhouse gas emissions. Deploying smart meters could make these projects financially viable in the short term and the economics are likely to improve over time due to decreasing solar PV installation costs. The South Saskatchewan Region of Alberta has many enabling features for solar PV deployment and rural landowners may be economically motivated to install small-scale solar PV to take advantage of peak pricing alignment with peak solar generation, hedge against increasing electricity costs and to mitigate increasing transmission and distribution costs. The region is under significant pressure from anthropogenic disturbance and, as over half of the area is presently disturbed, the Province has documented objectives to mitigate the cumulative effects of incremental development. As land access required for ground mount installations represents a significant financial and environmental cost, the concept of re-purposing of inactive and brownfield oil and gas sites and existing infrastructure represents an innovative opportunity to reduce the pressure to disturb valuable native grassland ecosystems and agricultural land for renewable energy deployment.

There are numerous stakeholders that have a role in enabling the expansion of the concept of re-purposing oil and gas brownfields as solar PV brightfields as illustrated in Figure 10. At the transactional level, there is the freehold landowner (surface lessor) whose land is disturbed by an oil and gas brownfield, the oil and gas company that is the licencee and surface lessee of the brownfield site and the solar PV developer who wishes to re-purpose the disturbed land area leveraging existing infrastructure. Rural landowners are directly impacted by the presence of inactive oil and gas infrastructure and increasing electricity transmission and distribution costs therefore garnering local support for re-purposing is key. There are various government bodies with legislative oversight over the implementation of the concept including the AER, AUC and AESO under the purview of the provincial Ministry of Energy, the provincial Ministry of Environment and Parks as well as local municipal governments. The OWA also plays a role in implementation and expansion on orphan brownfield sites in place of a defunct oil and gas licencee.

Figure 10: Interested Stakeholders to Concept of Brownfield to Brightfield Re-purposing



(Author, 2020)

Re-purposing Alberta's oil and gas brownfields as solar PV brightfields has the potential to generate numerous sustainable benefits that align with provincial objectives. As detailed in Chapter 3, institutions can influence the success of this innovative endeavor by fostering social acceptance or maintaining the status quo. Existing formal and informal institutions within the current Alberta context partially enable the re-purposing concept however, as it represents a disruptive change to both the electricity generation and oil and gas industries, this research proposes that further institutional changes are required to fully legitimize and support expansion of the concept.

Chapter 3. Literature Review

The redevelopment of industrial and commercial brownfields is not a new idea, however the initiation of the RenuWell Project inspires further evaluation of the benefits, opportunities, and barriers specific to re-purposing Alberta's brownfield oil and gas sites (as brightfields) with small-scale solar PV deployment. For the purposes of this research, benefits are environmental and socioeconomic advantages of the re-purposing concept and opportunities comprise favorable conditions that support expansion of the concept beyond the pilot phase. Conversely, impediments represent unfavorable conditions or obstacles and barriers represent critical obstacles to expansion. Substantial research has been published regarding the benefits of brownfield redevelopment in general as well as the barriers or impediments. A portion of this literature specific to the re-purposing of industrial brownfields as solar PV brightfields is detailed in Section 3.1.

The RenuWell Project represents an innovative sustainable energy development opportunity which requires legitimization and a more active level of social acceptance for expansion relative to conventional power generation or large-scale renewable energy projects. Existing formal and informal institutions may affect expansion of the re-purposing concept by fostering opportunities or exerting influences that constrain expansion. The influence of institutional factors on legitimizing innovative renewable energy project deployment comprises the balance of the literature review and supports the development of a conceptual framework to address the research question.

3.1 Benefits and Barriers to Brightfield Development

Brightfields represent a sustainable solution to address potentially contaminated brownfield sites. Benefits of and barriers to brightfield development are documented in a study by Spiess and De Sousa (2016) who conducted a survey of expert brightfield developers in North

America and Europe. Employing the triple bottom line framework, the study findings were categorized as environmental and technical, social, or economic. The identified advantages and barriers to brightfield development are outlined below and supported by additional current literature sources. A summary table is provided in Section 3.1.4 for ease of reference.

3.1.1 Environmental and Technical

Spiess and De Sousa (2016) identified the following environmental benefits of brightfield development: reduced pressure for development of undisturbed land, increased renewable energy generation and associated reduction in greenhouse gas emissions, and the potential to address site contamination reducing risk of brownfields to public health and safety (Spiess & De Sousa, 2016). Specific advantages of conversion of brownfield oil and gas sites to solar PV brightfields include a reduction in new land disturbance for renewable energy development, the ability to leverage existing oil and gas site infrastructure and the opportunity to lower greenhouse gas emissions as outlined by K. Hirsche of EEI in presentations he delivered at the Southeast Alberta Energy Diversification Symposium (SEEDS) in March 2017, a meeting held by Petroleum Technology Alliance Canada (PTAC) in October 2017 and the Remediation Technologies (RemTech) Symposium in October 2019 (K. Hirsche, personal communication, March 3, 2017; K. Hirsche, personal communication, October 5, 2017; Hirsche, 2019a; Hirsche, 2019b).

Achieving Alberta's legislated objective that 30% of the Province's electricity supply is to be generated by renewable energy sources by 2030 could require a significant level of new land disturbance. A study conducted by Palmer-Wilson et al. (2019) found that decarbonising Alberta's fossil fuel-based electricity generation system over a 45-year period through solar and wind installations could "lead to a tenfold expansion of the land area impacted by electricity generation" not including the impact of the transmission infrastructure, that could take up approximately 0.92%

of Alberta's total land area (Palmer-Wilson et al., 2019, p. 202). Tens of thousands of hectares of land disturbed from prior oil and gas development could be partially re-purposed as brightfields leveraging existing infrastructure such as grid tie-ins and access roads, alleviating the pressure to disturb new land area with renewable energy development. As outlined by K. Hirsche of EEI in presentations he delivered at a meeting held by PTAC in October 2017 and at the RemTech Symposium in October 2019, if 10% of the existing inactive or orphaned brownfield oil and gas sites were re-purposed for solar PV generation, that would represent a sustainable use of over 30,000 acres of previously disturbed land and 6,200 MW of solar energy generation capacity (K. Hirsche, personal communication, October 5, 2017; Hirsche, 2019a; Hirsche, 2019b). This solar generation capacity would meet and exceed Alberta's renewable electricity supply objective, potentially producing over 8 million MWh and offsetting 4.5 million tonnes of greenhouse gas emissions annually (Hirsche, 2019a; Hirsche, 2019b; Hirsche & Stendie, 2020).

Spiess and De Sousa (2016) found that potential site contamination is a critical barrier to re-purposing brownfields for renewable energy development due to liability risk. Thorough due diligence in brightfield site selection is an imperative (Spiess & De Sousa, 2016). Highlighting the importance of site selection and the availability of potential brightfield candidate sites, Thiessen and Achari (2017) employed statistical modelling to analyze public data and estimate the environmental risk of 298 brownfield well sites located on agricultural land in Alberta. The study determined that well type is a primary predictor of environmental risk and that most wells reviewed did not present significant adverse effects to biological receptors (Thiessen & Achari, 2017). Disturbance of remedial work, land and resource constraints as well as load and transmission constraints were also identified as technical and environmental barriers to brightfield development (Spiess & De Sousa, 2016).

3.1.2 Social

The potential social benefits of brightfield development identified by Spiess and De Sousa (2016) include community revitalization, disappearance of a visible nuisance and elimination of the social stigma associated with the brownfield site (Spiess & De Sousa, 2016). Visibility of small-scale renewable energy projects facilitates dialogue and learning regarding the benefits of deployment amongst local community members (Nadkarni & Hastings-Simon, 2017). Specific to Alberta, Nahas (2019) conducted interviews with various stakeholders regarding the impacts of the Supreme Court of Canada's Redwater Energy Appeal ruling and found that re-purposing of orphan oil and gas wellsites is a potential economic opportunity to be explored; moreover, the study found there was interest from landowners to re-purpose orphan sites for solar PV.

Although the study by Spiess and De Sousa (2016) found that there is less contextual public opposition to brightfields relative to renewable energy development on previously undisturbed lands, social barriers were identified including physical and contextual opposition as well as opposition for institutional and socioeconomic reasons. Public fear of contamination migration, disturbance of remediation and development of another type of visual nuisance were the top reasons for social opposition. Additional reasons included lack of public participation in the development decision-making process and distrust of the brightfield developer and regulators regarding the level of communication of information regarding the risk of adverse affects to health and the environment (Spiess & De Sousa, 2016).

3.1.3 Economic Including Financial, Regulatory, and Institutional

The potential income generation and job creation from brightfield development in addition to the re-use of existing infrastructure at brownfield sites represent potential economic benefits (Spiess & De Sousa, 2016). Various parties could develop and/or derive benefits from brightfield development. Brightfield developers could include individual landowners, community groups, solar developers and the brownfield oil and gas site licencees. Income generation opportunities associated with small-scale PV generation in Alberta are detailed in Chapter 2 and applicable to brightfields. Local human capacity is required to construct and operate the infrastructure creating an opportunity to leverage and expand upon the existing skillsets and knowledge of former oil and gas sector employees. As mentioned in Chapter 1, solar PV development represents a significant economic opportunity for Alberta; according to Calgary Economic Development, "Every 150 MW of installed solar energy capacity represents $310 million in investment, 1,875 direct full-time equivalent construction jobs and 45 permanent direct jobs in operations" (Calgary Economic Development, n.d., para. 2). Additionally, according to the Pembina Institute, "small and community-scale solar PV projects create up to 2.8 times as many jobs and 3.4 times as much local impact as large-scale alternatives" (Nadkarni & Hastings-Simon, 2017, p. 10). Local municipalities could also benefit through the collection of property taxes payable for brightfield sites (Hierlmeier & Environmental Law Centre, 2006).

Re-purposing brownfield oil and gas sites as brightfields could result in a reduction of abandonment and reclamation costs for oil and gas companies (or the OWA in the case of orphan sites) due to re-use of existing infrastructure. Furthermore, as the land would be cleared and some infrastructure left in place, the solar developer would benefit from cost savings related to construction and installation activities. In his presentations at the SEEDS event and PTAC meeting held in March and October 2017, respectively, K. Hirsche estimated cost savings of up to 40% for oil and gas infrastructure abandonment and site reclamation and up to 25% for solar PV installations. (K. Hirsche, personal communication, March 3, 2017; K. Hirsche, personal communication, October 5, 2017)

According to the literature, the primary economic barriers to brightfields include the inability of developers to secure access to capital to develop or reduce risk and liability associated with the brownfield site. These barriers are interrelated and link directly to the risk and potential liability due to actual or perceived brownfield site contamination (Spiess & De Sousa, 2016). Additionally, Spiess and De Sousa (2016) found that there is less support from formal institutions for brightfield development than for conventional renewable energy projects resulting in transaction costs that create a competitive disadvantage for proponents. Some of the associated market barriers include a lack of capacity and incentives for brightfield development as well as limited support from utilities (Spiess and De Sousa, 2016).

3.1.4 Summary of Benefits and Barriers to Brightfield Development

The following Table 1 summarizes the sustainable benefits, opportunities and barriers or impediments to brightfield development as outlined in existing literature.

Table 1: Benefits, Opportunities and Barriers or Impediments to Brightfield Development

Category	Benefits	Opportunities	Barriers or Impediments
Environmental & Technical	• Re-use of disturbed land[b, f] and existing infrastructure[b, c] • Lower greenhouse gas emissions[b, c, f] • Address contamination risk[b, c, f]	• Site availability[b, c] • Low contamination risk depending on site type[g]	• Risk of disturbance of remediation work[f] • Resource and grid constraints[f]
Social	• Community revitalization [d, f] • Address visual nuisance and stigma associated with brownfields[f]	• Landowner interest in re-purposing concept[c, e] • Less contextual opposition to brightfields relative to greenfield development[f]	• Perception of risk of contamination migration[f] • Brightfield visual nuisance[f] • Distrust in developer and/or regulatory approvals process[f]
Economic	• Cost savings[c] • Income potential [c, f] • Job creation[c, d] • Public revenue source [a, c]	• Various possible investors[c] • Leverage existing skillsets [c]	• Lack of support from regulators[f], utilities[c, f] • Risk tolerance of lenders and insurers[f] • Lack of incentives[f]

([a]Hierlmeier & Environmental Law Centre, 2006; [b]K. Hirsche, personal communication, March 3, 2017; K. Hirsche, personal communication, October 5, 2017 [c]Hirsche & Stendie, 2020; [d]Nadkarni & Hastings-Simon, 2017; [e]Nahas, 2020; [f]Spiess & De Sousa, 2016; [g]Thiessen & Achari, 2017)

The benefits and barriers or impediments outlined above affect the social acceptance and legitimization of brightfield development. Formal and informal institutions are influential in fostering social acceptance in the expansion of this sustainable endeavour as detailed in the balance of Chapter 3 and supported by existing literature.

3.2 Institutional Theory and Renewable Energy Innovation

The redevelopment of oil and gas brownfields represents a significant opportunity in Alberta that aligns with policy objectives regarding renewable energy deployment, oil and gas site closure and mitigation of the cumulative effects of anthropogenic activities. The majority of industrial and commercial brownfield sites across the Province remain undeveloped due to complex legal, financial and community challenges that need to be addressed (Hierlmeier & Environmental Law Centre, 2006). Informal and formal institutions play a key role in addressing these challenges and stimulating the sustainable entrepreneurship required for brightfield development. This section defines institutions and summarizes the role they play in generating social acceptance and legitimizing sustainable innovation such as that represented by the re-purposing concept.

3.2.1 Social Acceptance of Renewable Energy Innovations

Continuous improvements in solar PV technology have resulted in significant reductions in construction and operation costs, supporting solar project development in alignment with government policies and targets. Despite improving rates of return and advancements in the technology, social acceptance is a critical requirement for renewable energy projects to be successfully implemented. An article by Wüstenhagen, Wolsink and Bürer (2007) provides three unique considerations that influence social acceptance of renewable energy innovations. Firstly, the scale of renewable energy developments relative to conventional power plants require that numerous siting and individual investment decisions need to be made. Moreover, distributed generation and micro-generation projects necessitate more active acceptance by the public as opposed to passive consent in the case of larger projects (Sauter & Watson, 2007). Secondly, also due to scale and energy density, renewable energy projects potentially have increased visibility and other impacts that directly affect the end user. Thirdly, incumbent technologies have an advantage over renewable energy development due to insufficient recognition of externalities in the energy sector that create an uneven playing field (Wüstenhagen et al., 2007). Externalities include costs of fossil fuel based energy production and consumption that are not properly accounted for or valued in the energy market, these externalities include such factors as air pollution, climate change impacts and other sources of environmental degradation (IRENA, 2016). It is noteworthy that the nature of oil and gas infrastructure development in Alberta also requires that many siting and individual investment decisions are made prior to development and the infrastructure can be highly visible depending on type.

Wüstenhagen et al. (2007) define three interrelated dimensions of social acceptance for renewable energy projects, including socio-political, community and market acceptance, and provide a conceptual image of these dimensions as shown in Figure 11.

Figure 11: The Triangle of Social Acceptance of Renewable Energy Innovation

(Wüstenhagen et al., 2007, p. 2684)

According to Wüstenhagen et al. (2007), socio-political acceptance is grounded in key stakeholder support of institutional policy frameworks that develop and enhance market and community acceptance of renewable energy project siting and investment. Community acceptance is more specifically focused on support for projects from residents, local authorities and other stakeholders in the vicinity of the project location. Some of the factors affecting community acceptance include the actual and perceived levels of procedural justice in the project approval decision-making process, distributional justice regarding the sharing of costs and benefits from the project and level of trust between project developers and the local community through the project life cycle. The third dimension of social acceptance, market acceptance, includes demand by consumers for renewable energy innovation and investment in development of supply (Wüstenhagen et al., 2007).

3.2.2 Defining Formal and Informal Institutions

North (1990) defines institutions as “any form of constraint that human beings define to shape interaction” (p. 4) and further divides these constraints into two categories, formal and informal. Formal institutions are defined as including “political (and judicial) rules, economic rules, and contracts” (North, 1990, p. 47). Informal institutions are unwritten rules such as norms, values or conventions that underlie formal institutions (North, 1990). The main role of institutions is to provide structure, however institutions themselves are constantly evolving in an iterative or discontinuous manner (North, 1990). Both formal and informal institutions influence, incentivize, and legitimize organizational choices and behaviour (North, 1990).

According to literature, formal and informal institutional influences can also lead to isomorphism within an organizational field. Institutional isomorphism occurs when institutional pressures influencing a group of organizations that make up a field, including suppliers, firms, consumers, and regulatory bodies, result in the organizations becoming increasingly similar in structure (DiMaggio & Powell, 1983). This trend towards homogeneity within a field does not necessarily support rational organizational decision-making or translate to increased efficiency (DiMaggio & Powell, 1983). According to DiMaggio and Powell (1983), there are three mechanisms of institutional isomorphism. Coercive isomorphism results from formal pressures such as laws and government mandates, informal pressures exerted amongst organizations and cultural or societal expectations. Mimetic isomorphism occurs when organizations model themselves on one another due to uncertainties. Finally, normative isomorphism is driven by the level and influence of professionals and professional organizations within an organizational field (DiMaggio & Powell, 1983).

3.2.3 Institutional Isomorphism and Sustainable Entrepreneurship

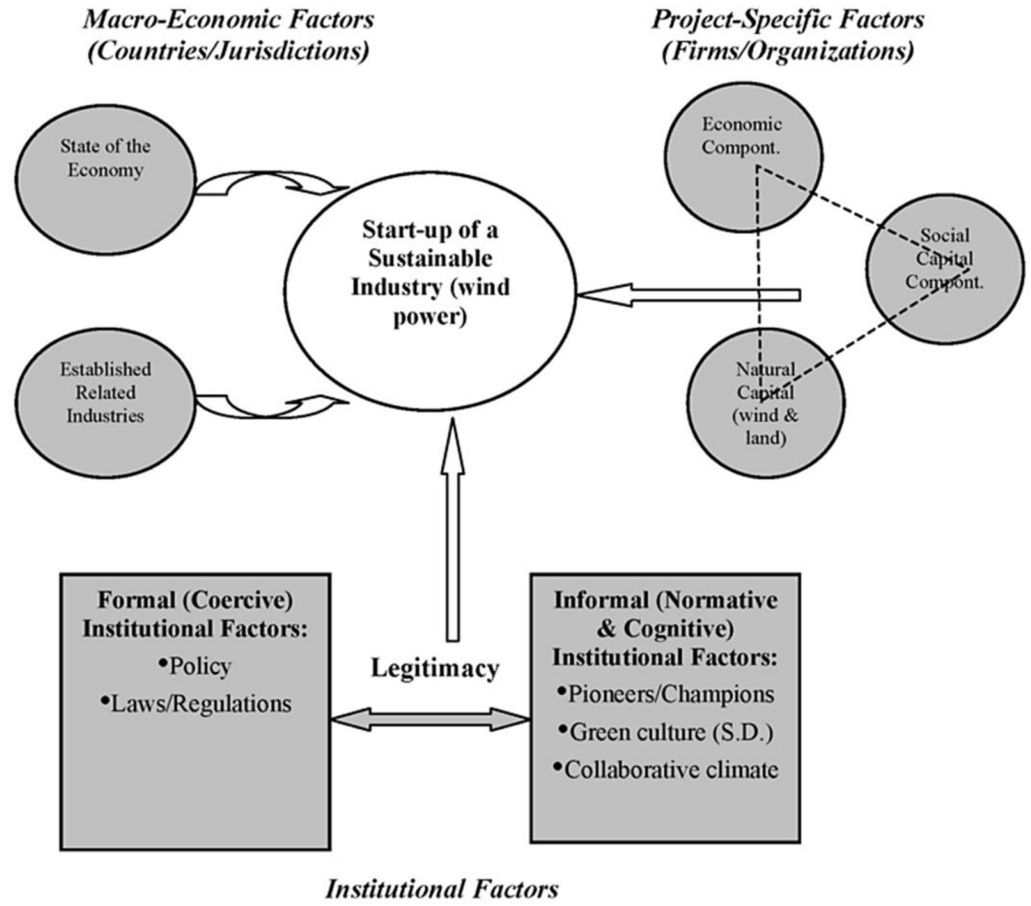
The RenuWell Project represents an innovation that is disruptive to Alberta's electricity generation and oil and gas organizational fields. Three field level hypotheses proposed by DiMaggio and Powell (1983) illustrate that institutional isomorphic pressures may affect the organizations within both fields. The first hypothesis is that the more the organizations within a field transact with government agencies, the greater the extent of institutional isomorphism within the field. Secondly, the more structured an organizational field is, the higher the degree of institutional isomorphism. Thirdly, the greater extent of professionalism in a field, such as the requirement for credentials to be employed in the field and existence of industry associations, the more likely isomorphism will be present (DiMaggio & Powell, 1983). As detailed in Chapter 2, both the electricity generation and oil and gas industries in Alberta engage in transactions with government agencies and are structured. There is also a high degree of professionalism in each field as indicated by the skills and qualifications required to participate as well as the presence of industry associations. The pressures of institutional isomorphism may impact the successful expansion of the RenuWell Project. According to a study by Sine, Haveman and Tolbert (2005), institutions influence the level of innovative and entrepreneurial activity within an organizational field by altering the costs, benefits and risks associated with new ventures. Moreover, institutional isomorphism may affect the success and founding rates of disruptive innovative ventures (Sine et al., 2005).

From the converse perspective, literature suggests that sustainable entrepreneurs can influence institutions and affect change in support of their innovative endeavours. According to a study by Thompson, Herrmann, and Hekkert (2015), sustainable entrepreneurs seeking to develop innovative renewable energy projects and disrupt the isomorphism present in an organizational field are often required to actively shape and reform existing institutions in order to be successful. Sustainable entrepreneurs engage in several different strategies to instigate change as “institutions are, by definition, entrenched and supported through a coherent and ordered social system” (Thompson et al., 2015, p. 608). Thompson et al., (2015) summarized the various mechanisms that sustainable entrepreneurs employ to engage in institutional change according to literature: creating new symbols to reshape and share ideas, constructing new measures that communicate benefits of the proposed innovation effectively, identifying organizational failings and theorizing proposed solutions, building consensus by offering tangible or intangible benefits to other stakeholders and forging new collaborations amongst stakeholders.

3.2.4 Linking Social Acceptance and Legitimacy

By providing legitimacy to sustainable innovation, formal and informal institutions influence the level of social acceptance for renewable energy projects. Espinoza and Vredenburg (2010) developed a model for sustainable energy development that suggests that macro-economic, project-specific, and institutional factors all have an influence on the start-up of a sustainable industry as shown in Figure 12. Moreover, formal (coercive) institutions such as policies, laws and regulations, and informal (normative and cognitive) institutions such as champions, jurisdictional environmental commitment, and a collaborative climate, legitimize sustainable industry start up, innovation and growth (Espinoza & Vredenburg, 2010).

Figure 12: A model explaining the start-up of a sustainable industry



(Espinoza & Vredenburg, 2010, p. 221)

Legitimacy can enhance or constrain industry start up and firm growth as it impacts capital investment, market access and government protection (Aldrich & Fiol, 1994). According to Suchman (1995), "Legitimacy is a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (p. 574). There are two dimensions of legitimacy of entrepreneurial ventures: cognitive legitimation which "refers to the spread of knowledge about a new venture" (Aldrich & Fiol, 1994, p. 648) and sociopolitical legitimation which "refers to the process by which key stakeholders, the general public, key opinion leaders, or government officials accept a venture as appropriate and right, given existing norms and laws" (Aldrich & Fiol, 1994, p. 648). Measures of cognitive and sociopolitical legitimation outlined by Aldrich and Fiol (1994) include the level of public knowledge and acceptance of a new industry, availability of government subsidies for the industry and the influence of its leaders, creating a link between legitimacy and the concept of social acceptance of renewable energy innovation as introduced by Wüstenhagen et al. (2007).

3.3 Role of Institutions in Social Acceptance and Legitimacy

Broad public support for renewable energy development within a jurisdiction does not necessarily translate into local social acceptance which is demonstrated by positive investment and siting decisions for specific projects (Wüstenhagen et al., 2007). Moreover, micro-generation and distributed generation projects require acceptance from a unique type of stakeholder, introduced earlier in this paper as 'prosumers', representing consumers turned co-producers who provide the site for development, invest in the infrastructure and potentially change their consumption (Sauter & Watson, 2007). Based on existing literature, the following sections describe the role of both formal and informal institutions in influencing the dimensions of legitimacy and social acceptance of small-scale solar PV installations.

3.3.1 Role of Institutions in Socio-Political Acceptance

Socio-political acceptance is measured by the level of support by all key stakeholders, including the public, in the proposed renewable energy technologies and enabling formal institutions, including policies, legislation and regulations (Wüstenhagen et al., 2007). It is an important dimension of social acceptance as the conditions required to attract investment in renewable energy projects are largely the result of supportive institutional frameworks and policies developed at all levels of government (Wüstenhagen et al., 2007). Institutional policy frameworks such as favorable regulations, local involvement in siting decisions, economic incentives, collaborative spatial planning tools, reliable financial procurement systems and guaranteed access to the grid for investors, support the related dimensions of market and community acceptance of renewable energy projects (Wüstenhagen et al., 2007). A study by Doblinger, Dowling and Helm (2016), suggests that policy makers can stimulate demand for renewable energy and drive or constrain innovation and risk-taking by project developers. Furthermore, Thompson (2018) suggests that the institutional context affects sustainable entrepreneurial endeavours. Ince, Vredenburg, and Liu (2016) studied the relationship between institutional factors and renewable energy development in various jurisdictions in the Caribbean found that informal institutions in a particular jurisdiction, such as 'green culture' and 'how things get done', play a significant role in the development and success of formal policies supporting renewable energy.

In Alberta, power generation projects including solar PV are governed by numerous pieces of legislation and associated regulations as detailed in Chapter 2. Governing regulatory bodies include the AUC, AEP, AESO and Alberta Energy. Illustrating the importance of these formal institutions in expansion of the brightfield re-purposing concept, an occasional paper issued by the Canadian Institute of Resources Law suggests that the current regulatory framework governing power generation projects is complex, unclear and potentially unfair to proponents as a result of having multiple regulators with no designation of a lead agency, the existence of overlapping jurisdictions and an overall lack of fundamental due process (Maharaj & Canadian Institute of Resources Law, 2019). Moreover, the regulatory risk presented by the complicated regulatory framework may favour incumbents and contribute to proposed renewable energy projects being deemed uneconomic, counteracting Alberta's legislated objective to transition to a more diverse electricity supply mix (Maharaj & Canadian Institute of Resources Law, 2019). The oil and gas brownfield re-purposing concept incorporates an additional governing body, the AER.

3.3.2 Role of Institutions in Community Acceptance

Siting decisions for renewable projects contain environmental, social, and economic risk components as summarized in Section 3.1 that may have a significant impact on local stakeholders. The level of acceptance of renewable energy projects by local stakeholders, including residents and authorities, is affected by perceived or actual fairness in the decision-making process and distribution of costs and benefits of the project (Wüstenhagen et al., 2007). It is also impacted by the level of trust that local stakeholders have in the investors and project developers as well as the regulatory framework for project approval. Institutions play a role in community acceptance by developing and overseeing the procedural and distributional justice frameworks and processes, enabling local involvement in project planning and siting decisions, facilitating local ownership and ensuring that potential risks are well communicated to local stakeholders and managed by the appropriate party (Wüstenhagen et al., 2007). Institutionalizing local participation in planning and siting decisions supports the recognition of the various local interests that are relevant to successful project implementation (Wüstenhagen et al., 2007).

3.3.3 Role of Institutions in Market Acceptance

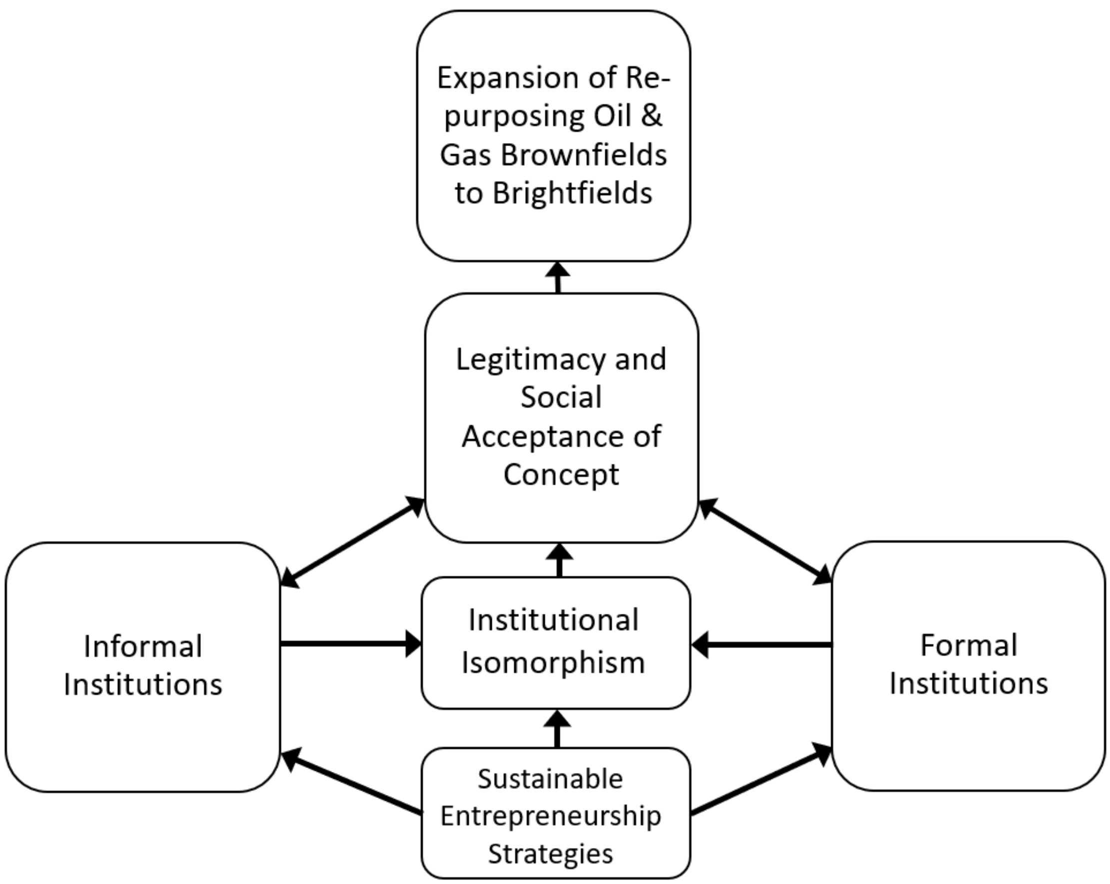
Market acceptance is the process of adoption of an innovation signified by consumer demand and financial investment by developers to generate supply. The nature of micro-generation and distributed generation requires that affected landowners actively accept the infrastructure development including potentially investing in the project. There is a spectrum of investment opportunities where the role and level of involvement of the landowner ranges from consenting to a third party developer siting infrastructure on their land to passive consumption to sharing in the costs and benefits as a member of a community generation group to fully participating as an individual prosumer (Sauter & Watson, 2007). Acceptance amongst existing firms and grid ownership structures may impact opportunities available to potential investors for sustainable innovation. Relating this to the role of institutions in market acceptance, Wüstenhagen et al. (2007) suggest that existing or incumbent firms in the energy industry can influence policy development including financial procurement system design and access to the grid for renewable energy investors. A study by Ince et al. (2016) suggested that the level of influence of the incumbent utility provider in a particular jurisdiction negatively correlates with renewable policy effectiveness.

3.4 Conceptual Research Framework

Re-purposing Alberta's brownfield oil and gas sites as brightfields with solar PV deployment represents a sustainable innovation that is potentially disruptive to both the power generation and oil and gas industries in Alberta. Existing formal and informal institutional factors appear to exert isomorphic forces on both organizational fields limiting the opportunities and reinforcing the barriers and impediments associated with the legitimization of brightfield development on brownfield oil and gas sites. The level of social acceptance of the concept is a measure of legitimacy and is critical to its expansion. Changes to formal and informal institutions may alter the isomorphic forces they exert and influence all three dimensions of social acceptance: socio-political, market and community.

A conceptual framework is appropriate to facilitate an integrated way to address the research question (Imenda, 2014). According to Imenda (2014), "a conceptual framework may be defined as an end result of bringing together a number of related concepts to explain or predict a given event, or give a broader understanding of the phenomenon of interest – or simply, of a research problem" (p.189). Focussing in on the portion of the sustainable industry start-up model proposed by Espinoza and Vredenburg (2010) (Figure 12) that illustrates the impacts of institutional factors on legitimacy and social acceptance of a sustainable innovation provides the basis for a conceptual framework to investigate the research question. Based on the literature review, the framework is expanded to incorporate the concept of institutional isomorphism as well as the influence of sustainable entrepreneurship strategies on institutions and institutional isomorphism.

Figure 13: Conceptual Framework



(Adapted from Espinoza & Vredenburg, 2010; and based on the work of DiMaggio & Powell, 1983; Thompson et al., 2015; Wüstenhagen et al., 2007)

The redevelopment of brownfields as brightfields is a sustainable entrepreneurial endeavour that has the potential to generate environmental, social, and economic benefits. Brownfields across Alberta and in other jurisdictions remain largely undeveloped due to complexities and uncertainties attributable to perceived contamination and environmental liability. Brownfield sites each have unique characteristics and levels of potential risk and sustainable redevelopment opportunities may be overlooked if all brownfields are viewed through a similar lens. Institutions can hinder these endeavours by exerting isomorphic forces and maintaining the status quo or support these endeavours through fostering community, socio-political and market acceptance. This research focusses in on the redevelopment of a subset of brownfields located in a single jurisdiction. It advances existing literature through a primarily qualitative investigation into the opportunities and barriers specific to re-purposing Alberta's oil and gas brownfields as brightfields focussing on the formal and informal institutional factors affecting legitimacy and social acceptance of the concept.

Chapter 4. Methods

Both qualitative and quantitative approaches were employed in this project to investigate the research question. Quantitative and qualitative data were collected and analyzed incorporating the three dimensions of energy, environment and policy development as outlined in Chapter 1. The data collection and analysis methodologies are further detailed below.

4.1 Quantitative Analysis of Reduction in Greenhouse Gas Emissions and Land Use

The energy and environment dimensions were addressed in this research project through an analysis of the reduction in carbon dioxide and other emissions associated with incremental solar PV energy that would be supplied to Alberta's electricity grid from RenuWell's proposed pilot locations. Additionally, as the RenuWell Project concept represents an opportunity to reduce the cumulative effects of energy development on the landscape, the mitigation of new land disturbance resulting from brightfield development was quantified.

4.1.1 Data Collection and Analysis

The RenuWell Project team provided the geographic locations and hosting capacity data for five priority sites that the team is proposing as options for its pilot project under the MCGC. According to K. Hirsche, the pilot contemplates deployment of 1 MWdc solar installations on two of the five priority sites with construction contemplated in early 2021 (personal communication, June 4, 2020). The project team is further contemplating development of an additional 10 MWdc on up to 20 oil and gas leases. All proposed sites are located in the Taber area of Southern Alberta.

This research contemplated the hypothetical deployment of 500 kWdc ground-mount fixed solar PV installations on all five proposed pilot sites. Utilizing secondary data sources including the NREL's PVWatts® Calculator and the United States Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator, the first-year annual electricity generation and greenhouse gas emission offsets were calculated for the five proposed pilot locations as well as the approximate area of greenfield land use avoidance. Lifetime electricity generation and greenhouse gas emissions offsets were calculated assuming a twenty-five year lifespan and 1% degradation rate per year for the infrastructure and a 1.7% grid emissions intensity decline rate, compounded annually (Canadian Energy Research Institute, 2015; Jordan & Kurtz, 2012).

4.2 Qualitative Analysis of Institutional Influences

Due to the complexity of the institutional and market influences that drive and inhibit the repurposing of Alberta's brownfield oil and gas sites as decentralized solar PV brightfields, a qualitative methodology was employed to investigate the research question through the collection and analysis of predominantly non-numerical data related to the three dimensions of energy, environment and policy development (Anderson, 2010). A qualitative methodology was chosen as the findings can be useful to policymakers by providing a description of the context for decision-making (Anderson, 2010). Building upon the literature review and with the objective of identifying themes to answer the research question, two qualitative research methods were utilized:

1) a document analysis of policies, reports, public records, newspaper articles and blog posts applicable to brightfield development and,
2) interviews with key stakeholders and subject matter experts.

Triangulation, or employing two methodologies to study the same research question, supports the validity of the study (Anderson, 2010).

4.2.1 Sample Selection and Data Collection

To collect primary research data, twenty-four interview requests were sent out between May 11 and June 10, 2020 to a selected sample of key stakeholders and subject matter experts chosen based on their relevance to and level of knowledge of the research question (Anderson, 2010). The participants had varied backgrounds related to the oil and gas and power generation organizational fields and the RenuWell Project. Due to the new and innovative nature of the concept of re-purposing oil and gas brownfields to brightfields, a snowball sampling technique was employed whereby interviewees were asked if they could recommend other potential primary data sources such as interviewee candidates with a knowledge of the research question or publicly available documentation related to the concept for analysis. A total of thirteen interviews were completed. In-person interviews as originally contemplated were not a viable option due to social contact restrictions imposed due to the COVID-19 pandemic. Virtual platform or phone interviews were conducted with eleven interviewees and two interviewees elected to submit written responses.

To enable flexibility in the interview and support discovery and deeper dialogue, interviews followed a semi-structured format (Gill, Stewart, Treasure, & Chadwick, 2008). A framework of key interview questions was derived and adapted from existing literature as well as a Ph.D. thesis authored by Anthony DePrima and published in 2018 entitled, "The Brightfields Phenomenon: A Study of Critical Success Factors, Barriers and Implications for Sustainability" (DePrima, 2018). Six interviewees requested a copy of the interview questions in advance. The interview question framework is included in Appendix A and questions were posed to interviewees in a conversational manner. The structure of the interview allowed for divergence from the questions included in the framework to explore the topic in more detail. Interviews were recorded, however where an interviewee preferred not to be recorded, detailed notes were taken by the author during the interview. Interviews were conducted in full adherence to the University of Calgary's Faculty of Graduate Studies Interview Code of Conduct. Confidentiality agreements and informed consent letters were provided to all participants and therefore their identities and organizations remain anonymous. All interviewees expressed a willingness to discuss any follow up questions.

Upon completion of the interviews, interviewees were organized into stakeholder groups. The six interviewee stakeholder groups included:

1) Representatives from Government Agencies (two interviewees)
2) Representatives from Regulators (two interviewees)
3) Renewable Energy Industry and Industry Association Representatives (three interviewees)
4) Oil and Gas Site Closure Representative (one interviewee)
5) Energy Consultants (two interviewees)
6) Municipal and Other Local Representatives (three interviewees)

The stakeholder groups were developed based upon similar attributes between interviewees and interviewee organizations to provide a means of condensing the qualitative data while maintaining anonymity of the interviewees and their organizations.

Concurrently, documentation, including policies, reports, public records, newspaper articles and blog posts were systematically reviewed and examined for data relevant to the research question including information, quotes, and excerpts (Bowen, 2009). A total of eighteen documents were analyzed, a list of which is provided in Appendix B. The purpose of the document analysis was to provide context, background and historical information relevant to the research question, support the development of the interview questions, and verify or support data collected from the semi-structured interviews (Bowen, 2009).

4.2.2 Data Analysis

Thematic analysis was conducted to analyze the data collected from both the document analysis and semi-structured interviews. Interviews were transcribed manually by the author. To compile the data in an organized manner for analysis, the documents and interview transcriptions were imported into NVivo 12 Plus, a computer-assisted qualitative data-analysis software (CAQDAS). According to Hoover & Koerber (2011), there are three benefits to employing CAQDAS, specifically NVivo software, in qualitative data analysis: efficiency, multiplicity, and transparency. The software supports efficient coding through the ability to import qualitative data sources and use a drag-and-drop method to code excerpts from the sources for easy retrieval and summary reporting. The software enables import and coding of multiple types of qualitative data sources facilitating multiplicity and supporting thorough and complex analysis. Finally, use of NVivo supports research transparency through the ability to access data collection and interpretation information from the system (Hoover & Koerber, 2011). Confidentiality was maintained through installation of the NVivo 12 Plus software on a local computer accessed only by the author, password protection of the research project within the software and use of pseudonyms in the interview transcriptions.

The data was manually coded and classified under emergent themes and sub-themes developed by the author within the NVivo 12 Plus software program using an iterative four-phase theme development process, including initialization, construction, rectification and finalization, as outlined by Vaismoradi, Jones, Turunen, and Snelgrove (2016) and shown in Table 2 below. Codes are defined by Miles and Huberman (1994) as "…tags or labels for assigning units of meaning…" through attachment to "… 'chunks' of varying size - words, phrases or whole paragraphs…" (p. 56). Coding is used to organize data in a manner that facilitates clustering of information and supports analysis and the formation of conclusions to address the research question (Miles & Huberman, 1994).

Table 2: Phases and stages of theme development in qualitative content and thematic analysis

Phases	Stages
Initialization	Reading transcriptions and highlighting meaning units; Coding and looking for abstractions in participants' accounts; Writing reflective notes.
Construction	Classifying; Comparing; Labelling; Translating & transliterating; Defining & describing.
Rectification	Immersion and distancing; Relating themes to established knowledge; Stabilizing.
Finalization	Developing the story line

(Vaismoradi et al., 2016)

A combination of deductive and inductive thematic analyses was conducted. In the initialization phase, meaningful recurrent issues and ideas in the data were documented. Prior to commencement of coding, a list of codes representing expected themes was initially derived from the literature review and conceptual framework proposed in Chapter 3. Definitions were created by the author based on the literature review and secondary sources to assign meaning to the codes and ensure consistency in coding over time. Codes were revised, added, and combined inductively as additional themes emerged throughout the analysis. A list of sixty codes was developed throughout the initialization and construction phases. Secondly, in the construction phase, the codes were analyzed, compared, and organized into potential sustainable benefits associated with the re-purposing concept and emergent overarching themes related to supportive and constraining institutional influences representing opportunities and impediments. The list of codes that was developed including assigned categories is detailed in Appendix E. In the rectification and finalization phases, the emergent themes were related to the literature review and connected back to the research question and conceptual framework to exhibit how this research project advances existing literature on the subject and substantiate policy recommendations.

Chapter 5. Findings and Analysis

5.1 Overview

Analysis of secondary quantitative data and primary and secondary qualitative data resulted in the identification of sustainable benefits associated with the expansion of the concept of re-purposing Alberta's brownfield oil and gas sites as solar PV brightfields ('re-purposing concept') which align closely with those described by EEI and the RenuWell Project team and in existing literature. The quantitative and qualitative findings and analysis regarding the sustainable benefits of the re-purposing concept are detailed in Sections 5.2 and 5.3, respectively.

Analysis of the primary and secondary qualitative data, which was conducted based upon the conceptual framework introduced in Chapter 3, yielded eight emergent themes related to the supporting and constraining influences of institutional factors and isomorphism on the expansion of the re-purposing concept. Each overarching theme is analyzed and detailed in Section 5.4. A system map is provided in Section 5.4.9 to illustrate the themes and observed interrelationships between the themes. The system map supports the proposal of four hypotheses derived from the qualitative analysis.

To support the data analysis and findings, excerpts from the analyzed documents and interview transcripts are indicated in *italic* font throughout the remainder of this research paper. Where the excerpt is retrieved from an analyzed document, the document reference is provided. Interviewee identities and organizations remain anonymous in adherence to agreed upon confidentiality agreement and informed consent provisions as outlined in Chapter 4. The stakeholder group classification is provided with the interview excerpts to provide context. The classification is identified in brackets at the end of each interview transcript excerpt. If multiple excerpts were drawn from one interview transcript, the stakeholder group is provided at the end of the last excerpt.

5.2 Reduction in Greenhouse Gas Emissions and Mitigation of Land Use

According to K. Hirsche, the RenuWell Project team is proposing to deploy two ground mount solar PV installations on brownfield oil and gas sites as a pilot project (personal communication, June 4, 2020). Each installation is proposed to be approximately 1 MWdc in size (K. Hirsche, personal communication, June 4, 2020). Five priority sites within the M.D. of Taber have been selected by the team as location options for the pilot installations. All five priority sites are inactive oil and gas wellsites, four are abandoned gas wellsites and one is a historical contaminated site (K. Hirsche, personal communication, June 4, 2020). Four of the five sites have been designated as orphans. Utilizing data provided by the RenuWell Project team in addition to secondary data sources, the potential reduction in greenhouse gas emissions and mitigation of greenfield land use was approximated. Plots of the approximate pilot locations as well as the calculations including assumptions and references are provided in Appendix C and Appendix D, respectively. Results of the quantitative analysis are detailed below.

If the RenuWell Project team were to deploy five solar PV installations sized to occupy the approximate area previously disturbed by oil and gas activities, use of 4 hectares or 10 acres of greenfield land, not including access, would be avoided. Additionally, the installations would generate a total combined amount of approximately 3.312 million kWh and offset 1,888 tonnes of CO_2e in the first year of operation, which is equivalent to removing 406 passenger vehicles from road travel (United States Environmental Protection Agency, 2018). Based on an average residential electricity consumption of 7,200 kWh per year, the first year energy generation from the hypothetical systems would be sufficient to meet the electricity demand of 460 Alberta households (Energy Efficiency Alberta, 2018).

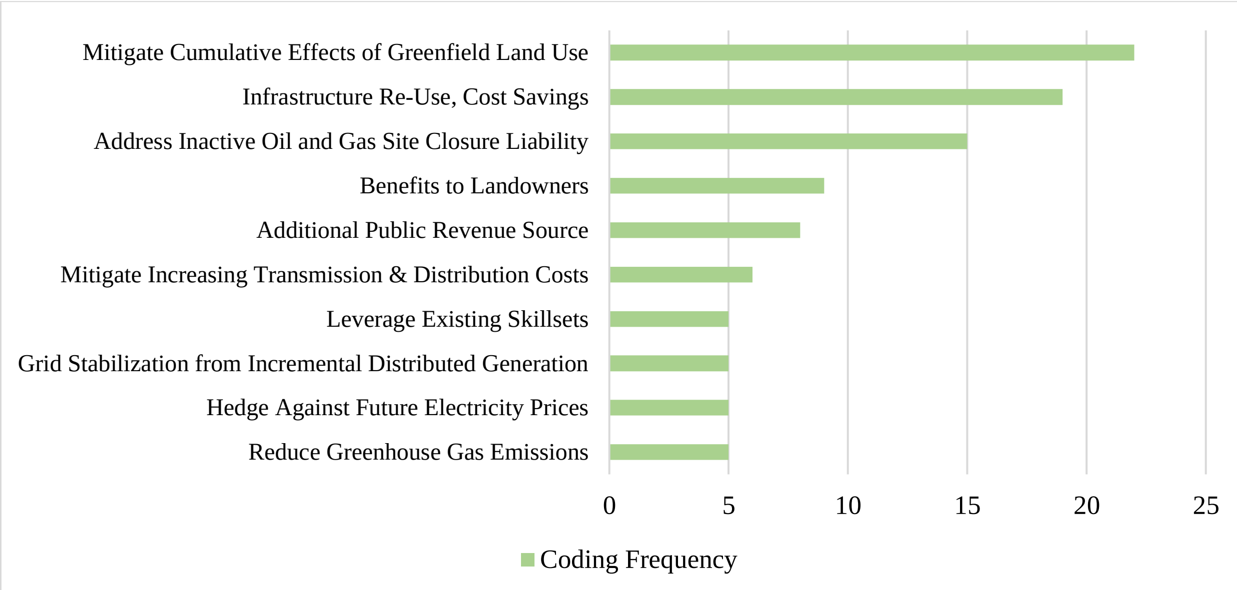
Assuming a twenty-five year solar PV system lifespan and 1% degradation rate as outlined by Jordan & Kurtz (2012), the combined lifetime energy generation of the systems is estimated as 73.6 million kWh. Lifetime carbon offsets of 34,716 tonnes of CO_2e were calculated using an annual grid emissions intensity decline rate of 1.7% compounded annually (Canadian Energy Research Institute, 2015).

In addition to illustrating the energy generation potential, the quantitative analysis detailed in this Section shows how the re-purposing concept presents a scalable opportunity to significantly offset greenhouse gas emissions from electricity generation and mitigate the cumulative effects of greenfield land disturbance for energy development in alignment with provincial objectives.

5.3 Additional Sustainable Benefits Derived from Qualitative Data

Sustainable benefits related to the expansion of the re-purposing concept were identified through thematic analysis of the interview transcripts and documents. The benefits which were identified and analyzed are illustrated in Figure 14. Figure 14 also includes the coding frequency count for each identified sustainable benefit. The coding frequency value illustrates the number of times the theme was coded across all primary and secondary qualitative data sources. There were thirty-one data sources analyzed and 98 excerpts coded representing potential benefits associated with expansion of the re-purposing concept. As illustrated by Figure 14 and the selected excerpts provided in the discussion below, the results of the data analysis align with existing literature and reflect that the re-purposing concept represents a sustainable energy development opportunity with the potential to provide environmental benefits as well as socioeconomic benefits to a broad range of stakeholders.

Figure 14: Sustainable Benefits of the Re-purposing Concept Derived from Qualitative Data



(Author, 2020)

Supporting the quantitative analysis conducted in Section 5.2, environmental benefits of expansion of the re-purposing concept identified in the qualitative data included the mitigation of cumulative effects of additional greenfield energy development, particularly on high value agricultural lands and ecologically sensitive grasslands, as well as a reduction in greenhouse gas emissions from electricity generation. Additionally, the findings suggest that the re-purposing concept is viewed by key stakeholders as a viable opportunity to address a portion of Alberta's inactive oil and gas infrastructure closure liability with benefits to multiple stakeholders.

> *There's a huge need for us to take advantage of the existing infrastructure we have in the province. Whether that be roads, sites, cleared areas so that we're not using ag land, infusing money back into municipalities and so on. I think that there are so many reasons that we should be doing it.* (Interviewee from Stakeholder Group: Government Agency Representatives)

> *So seeing this as an opportunity to reduce reclamation costs but also be kind of that win-win solution for the oil and gas industry as well as landowners and municipalities and kind of everyone in between was really what attracted us to it…the opportunities on the more*

> *specific side are really that the lower cost access to using some of this existing infrastructure in developing these projects and also avoiding more greenspace development for solar PV projects are very attractive… specifically some rural municipalities already have concerns with when it comes to renewables is not wanting to take up more agricultural land…* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

> *…small scale solar builds up your local distribution system and makes it more efficient and it also eliminates the need for additional transmission systems because it maximizes the utility.* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

As outlined in a newsletter issued by the AER,

> "*We're pleased when we see land that has already been disturbed being reused for another industrial purpose," says Corey Zadko, the AER's manager for Enterprise Reclamation. "It is always better to reuse an area that has already been disturbed instead of creating a new disturbance."* (Doane, 2020, para. 4)

Interviewees noted the potential cost-savings for oil and gas companies, the power generation industry and electricity consumers through re-use of disturbed land and existing infrastructure.

> *…from the solar project's perspective, they can go anywhere but they're happy to locate somewhere where the land is already disturbed, that's value-stacking.* (Interviewee from Stakeholder Group: Energy Consultants)

> *Well the big one is recovering the stranded assets…from the oil industry side that it will make reclamation cheaper if they can leave the gravelled access road and the powerlines in place but you also got it from the Alberta Utilities Commission and the power side because they're the ones that have to remove those powerlines and they were put in place for a reason. They are part of the grid and if we can leave them there and make use of them, you're recovering stranded assets which lowers the electrical price for all Albertans...* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

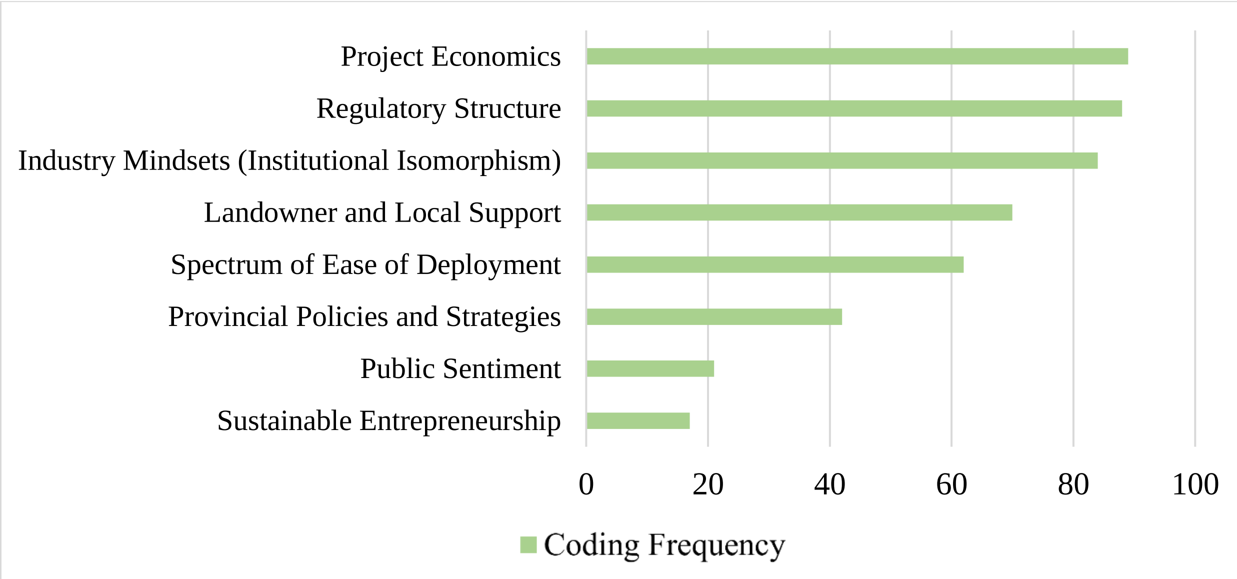
Additional socioeconomic benefits suggested in the data analysis include indirect benefits to local communities through economic development, incremental public revenue from solar PV infrastructure deployment and an opportunity to leverage existing skillsets to construct and operate. The re-purposing concept was also viewed as an opportunity to mitigate increasing transmission and distribution costs and support grid stabilization through incremental distributed generation. As mentioned above, many of these sustainable opportunities and benefits associated with expansion of the re-purposing concept have been identified by EEI and the RenuWell Project team in addition to aligning with existing literature.

5.4 Identification and Analysis of Institutional Influences on Concept Expansion

To address the research question, the interview transcripts and documents were analyzed for themes representing opportunities and barriers associated with institutional influences on re-purposing brownfield oil and gas sites as solar PV brightfields. Circumstances or conditions that were favorable for expansion of the re-purposing concept were coded as opportunities (supportive). Impediments included those conditions or circumstances that represented an obstacle to be overcome (constraints), relative to barriers which would block the concept from expansion. Gaps were identified as absent conditions that, if put in place, support expansion of the re-purposing concept.

Analysis of primary and secondary qualitative data resulted in the emergence of fifty sub-themes or codes which were categorized into eight overarching themes comprising the formal and informal institutional factors which support and/or constrain or represent a gap influencing the expansion of the concept of re-purposing Alberta's oil and gas brownfields as brightfields. As outlined in Chapter 3, institutions can hinder sustainable innovation by exerting isomorphic forces and maintaining the status quo or support sustainable innovation by fostering legitimacy and social acceptance. The emergent themes as well as coding reference count are shown in Figure 15. The coding frequency illustrates the number of times the theme was identified across all the primary and secondary qualitative data sources. There were thirty-one data sources analyzed including interview transcripts and documents.

Figure 15: Emergent Themes Related to Influences of Formal and Informal Institutions



(Author, 2020)

The fifty sub-themes comprising the eight emergent themes were categorized as supportive, constraining, or representative of a gap as related to the expansion of the re-purposing concept. The sub-themes, impact categories and coding frequencies are detailed in Appendix E and summarized by overarching theme in Table 3.

Table 3: Coding Frequency of Institutional Influences on Expansion of Re-Purposing Concept

Emergent Theme re: Institutional Influence	**Impact of Theme on Expansion of Re-Purposing Concept Coding Frequency**			
	Supportive	**Gap**	**Constraining**	**Grand Total**
Project Economics	25	0	64	89
Regulatory Structure	44	18	26	88
Industry Mindsets (Isomorphism)	0	37	47	84
Landowner and Local Support	46	18	6	70
Spectrum of Ease of Deployment	28	0	34	62
Provincial Policies and Strategies	6	25	11	42
Public Sentiment	14	0	7	21
Sustainable Entrepreneurship	17	0	0	17
Coding Frequency	**180**	**98**	**195**	**473**

(Author, 2020)

The following sections analyze and discuss the eight emergent themes. Key excerpts from the interview transcripts and documents are provided in each section to support the analysis and findings. Observed relationships between the themes are summarized and illustrated in a system map to provide a visualization of the dynamics observed in the data analysis. Four hypotheses are proposed based on the system map for future testing.

5.4.1 Public Sentiment

Excerpts coded to the theme of public sentiment were both supportive and constraining regarding expansion of the re-purposing concept. Supporting the expansion of the re-purposing concept, interviewee comments and excerpts from the analyzed documents regarding the influence of public sentiment and values, representing an informal institution, indicated a growing social interest in renewable energy development and motivation of multiple stakeholders to address Alberta's inactive wells issue. One interviewee acknowledged a general pro development ethos or culture in the province which they felt was supportive of expansion of the re-purposing concept.

As outlined in the CRIN Novel Land and Wellsite Reclamation report (2020):

> *With a growing inventory of inactive and orphan wellsites, cleaning up legacy assets has become an urgent priority for industry, government, and various stakeholder groups. All groups share the goal of wanting sites reclaimed for maximum ecological, economic and social benefit.* (CRIN, 2020, p. 2)

And as one interviewee noted,

> *I think also with the oil and gas sector being kind of a trailblazer with distributed energy resources, there's certainly a lot of experience and a lot of understanding of how those resources interact with the grid or are little grids unto themselves in some cases and so there's definitely a lot of advantages over other jurisdictions where these resources aren't common…* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

Comments made by interviewees regarding constraining public sentiment reflected that some Albertans believe that renewable energy development competes with non-renewable energy development in the Province rather than forming part of a larger energy mix.

> *…[there needs to be a] change in mind set of general population in Alberta that renewables and oil and gas are competing interests when if done properly they can complement one another (solar to power high demand oil and gas infrastructure)…*
>
> *With a segment of the population, renewable energy is seen as a threat to folks that have made their living from resource-based industries.*
> (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

As public awareness of the re-purposing concept grows, the specific influence of this informal institution on policy development and as an indicator of socio-political acceptance will likely become more evident.

> *I don't know how much effort's being put in at the government level. It certainly seems to get a lot of traction. Clearly, I think there's a lot of the voting public in Alberta that would like to see. I mean it makes sense, why wouldn't you re-use that infrastructure? And I think most people agree with it.* (Interviewee from Stakeholder Group: Oil and Gas Site Closure Representative)

There exists a relationship between government policy and public sentiment or opinion as illustrated by a study conducted by P. Burstein (2003) which found that the impact of public sentiment on policy can be substantial, highlighting the importance of this informal institution and its connection to the development and implementation of supportive policy and regulations, both formal institutions.

5.4.2 Provincial Policies and Strategies

Supportive policies are an indicator of socio-political acceptance of sustainable innovation (Wüstenhagen et al., 2007). The data reflected mixed results regarding the impacts of the influence of Alberta's renewable energy policies and strategies applicable to the expansion of the re-purposing concept. Of the 42 excerpts coded to this theme, over 50% represented gaps.

The legislated objective to generate 30% of Alberta's electricity from renewable energy sources by 2030 was identified as a supportive overarching driver representing a commitment to increase green energy in the Province. The provincial government is also committed to proactively address the inactive well liability issue and clean up activities have been accelerated by the recent funding provided by the federal government and the execution of the Site Rehabilitation Program. Additionally, as re-purposing of Alberta's inactive oil and gas sites involves coordination between two provincial ministries, Alberta Energy and AEP, supportive Ministerial strategies were identified in the document analysis including objectives of both ministries to collaborate and manage the cumulative effects of resource development in support of sustainable regional outcomes. Further, Alberta Energy has identified the following key objective and initiative in its current Ministry Business Plan:

> *Collaborate with other ministries to establish a balanced and sustainable approach to manage the cumulative effects of resource development, including liability management and regional planning.* (Government of Alberta, 2020a, p. 66)

> *The ministry addresses the growing inventory of orphaned well sites, while creating jobs in the oilfield and environmental service sectors and maintaining the polluter pays principle.* (Government of Alberta, 2020a, p. 66)

The re-purposing concept aligns with the abovementioned objectives, supporting concept expansion.

The provincial residential and commercial solar incentive programs as a driver of growth of micro-generation over the past five years was discussed with interviewees as well as the potential impacts of having no foreseeable future incentive programs. The programs are fully subscribed, and some interviewees showed hesitance in speculating on the impacts of a lack of government programs on future growth of solar PV installations in the Province. The availability of economic incentives was identified in the literature as an indicator of socio-political acceptance of renewable energy innovation (Wüstenhagen et al., 2007). According to the AESO 2019 Long-term Outlook, there is uncertainty surrounding future policies and programs.

> *Under current policy, the quantity and pace of integrating additional renewables to the grid is expected to be driven primarily by market decisions. Further uncertainty exists due to potential, but yet-to-be-determined policies and programs at the provincial and federal level.* (AESO, 2019, p. 5)

> *The main generation risks in the South Planning Region are related to renewable development. The amount and pace of development will be dependent on overall market profitability, renewable technology costs and any future amount of renewable support from government policy.* (AESO, 2019, p. 27)

The decision to discontinue the Climate Leadership plan, cancellation of the Renewable Electricity Program, limited renewable energy incentive programs and de-funding of EEA creates uncertainty surrounding the provincial government's execution strategy to achieve Alberta's 30% by 2030 target. This includes consideration of what role small-scale decentralized solar PV generation will play in achieving that target. These gaps represent a potential impediment to the expansion of the re-purposing concept. The following excerpt from the AUC Proceeding 24116 Distribution System Inquiry – Module One Technical Conference notes (2019) illustrates the importance of provincial strategy in driving utility mandates and regulatory frameworks supportive of grid modernization and installation of distributed energy resources (DERs):

> *Mr. Felder (Pembina) stated that for many of the 16 states referenced, the efforts to modernize the grid originated as a high-level directive from the state legislature for the utilities and public utilities commission to pursue, but the details for which came as a result of regulatory proceedings and exhaustive stakeholder consultations. Mr. Felder indicated, however, that adoption of DERs ultimately depended on the public utilities commissions' mandates in each jurisdiction…* (AUC, 2019b, p. 4)

The pending outcomes of ongoing reviews and inquiries regarding distributed energy generation in Alberta, some of which are further detailed in Section 5.4.4, may provide some clarity on provincial strategy in the near future, however the analysis in the sections that follow suggest that a lack of a clear policy execution strategy or mandate leads to regulatory ambiguity which may affect market acceptance and expansion of the re-purposing concept.

5.4.3 Regulatory Structure

The influence of the current regulatory structure was one of the top-cited themes in the interview and analyzed documents, representing 19% of all excerpts coded. K. Hirsche of EEI had previously determined through stakeholder consultation and engagement that the provincial regulatory framework was generally supportive of re-purposing oil and gas brownfields as solar PV brightfields (personal communication, February 16, 2020). The findings in this research align with those ideas presented by K. Hirsche as half of the excerpts which referenced the regulatory structure as a consideration, cited it as a supportive influence on expansion of the re-purposing concept.

The data analysis reflects that Alberta's de-regulated electricity market and existing legislative framework, which enables the deployment of solar PV electricity generation, are generally seen as supportive of the expansion of the re-purposing concept. As outlined in the literature, favorable regulations support socio-political and market acceptance of sustainable innovation (Wüstenhagen et al., 2007). Alberta's Micro-generation Regulation and associated AUC Rule 024: Rules Respecting Micro-generation were cited sixteen times in the interviews and analyzed documents as supportive of the deployment of solar PV micro-generation systems, particularly systems that are sized up to 1 MW. An excerpt from a key observation in the AUC's Alberta Electric Distribution System-Connected Generation Inquiry Final Report (2017) illustrates this sentiment regarding distribution-connected generation (DCG):

> *Participants agreed that the current regulatory and legislative framework will support the continued growth of DCG, and new regulations or legislation are not required. The recent amendments to the Micro-generation Regulation significantly enabled small-scale DCG for individual Albertans.* (AUC, 2017, p. 16)

Interviewees also commented on the ease of deployment of solar PV micro-generation under the current legislative framework and approval processes:

> *…regarding micro-generation, I think the success in that space really proved that there are some good policies in place. Micro-generation regulation itself I think is highly praised by industry as being something very easy to navigate and has set processes…and that's been a big help to lowering barriers to installers...* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

> *Microgen is easy, it has a simplified process, it doesn't need AUC approval because it's broadly equivalent to the load, it's likelihood of overwhelming the load is low...there's a relatively low number of barriers for microgen.* (Interviewee from Stakeholder Group: Energy Consultants)

The data collected reflected that the Small Scale Generation Regulation, which enables small-scale distribution-connected generation, is somewhat supportive of expansion of the re-purposing concept however there are some associated constraints as further detailed in Section 5.4.7 below.

> *But in terms of enabling legislation, the community generation regulation or the small scale generation regulation does provide access for this type of installation. It's not perfect but I don't see the government looking at any amendments on this anytime in the near future. So, I think this is something that whoever is developing solar on wellsites is just going to have to work with*. (Interviewee from Stakeholder Group: Representatives from Government Agencies)

Regulatory documents and directives identified as supportive of the deployment of solar PV on brownfield oil and gas sites include the Contaminated Sites Policy Framework, Conservation and Reclamation Regulation and the AER's SED 002. However, it was also mentioned that remediation and reclamation of the oil and gas site in accordance with SED 002 and other applicable remediation and reclamation legislation is to be completed prior to solar PV re-purposing. This requirement represents an impediment to the expansion of the re-purposing concept as it precludes the opportunity to conduct concurrent brownfield oil and gas site remediation and solar PV generation. It limits the number of readily available re-purposing site candidates thereby contributing to a spectrum of ease of deployment as further detailed in Section 5.4.7 below.

The Government of Alberta's Wildlife Directive for Alberta Solar Energy Projects (2017) was also identified as supportive. The Directive provides guidance on best practices for solar project siting to achieve the desired objectives of minimizing habitat loss and fragmentation:

> *Activities should be located adjacent to existing operations, existing access, or within anthropogenic clearings wherever practical to minimize the spatial extent of cumulative disturbance as well as to minimize the need for associated access.* (Government of Alberta, 2017c, p. 10)

> *The amount of cumulative vegetation clearing should be minimized through an integrated review of planned disturbance between all land users.* (Government of Alberta, 2017c, p. 13)

Aligning with existing literature, the complexities presented by multiple regulators with jurisdiction over the re-purposing concept was cited as a factor that may constrain expansion of the re-purposing concept. Indications of institutional isomorphism were also reflected in some of the comments.

> *…the whole Alberta government system is set up under the assumption that only producers will buy oil and gas sites…* (Interviewee from Stakeholder Group: Oil and Gas Site Closure Representative)

> *I think right now the challenge is just trying to work through all those individual and independent process steps and try to match them at the end of the process…* (Interviewee from Stakeholder Group: Representatives from Regulators)

> *I think just because it touches on so many different things of like land reclamation and new energy development and municipal taxes and all those things, it's just going to be kind of pretty critical that everybody is on the same page there.* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

The need for regulatory changes was also identified to support expansion of the re-purposing concept by enabling increased penetration of distribution-connected generation. Interviewees commented on the matters being reviewed in the regulatory inquiries and hearings that are ongoing which create uncertainty of return on investment in distributed solar PV generation. These include the AUC Distribution System Inquiry and the review of substation fractioning as further detailed in Section 5.4.4.

> *…Alberta's transmission regulation and the legislative framework around that never envisaged there would be DERs [Distributed Energy Resources] of anywhere near the scale we have now.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

> *Distributed generation on the other hand…there just isn't necessarily that same set kind of understanding around policy in that space. Whether that's from installers or from the wire*

service providers so the small-scale generation regulation attempted to kind of address that but I think there's also kind of still barriers in terms of some of the studies that need to be completed for projects to connect that are a little bit based on pricing models that are a little antiquated now probably based on larger generators and not specifically built around the concept of smaller distributed generation around the province. (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

Two policy/regulatory gaps were identified by interviewees including the moratorium on development of solar PV infrastructure on Crown or public lands as detailed in Chapter 2. The following comment by one interviewee relates the opportunity to re-purpose oil and gas sites located on Crown lands to the mitigation of cumulative effects of energy development in ecologically sensitive areas,

…you're not allowed to put solar and wind on native grass and yet there is lots of oilfield brownfields on Crown land that have gravelled access roads and the power lines huge infrastructure…if you come back in you're going to disturb the native grass again it's going to be very intrusive if the stuff's already there why don't we put some of these small scale solar projects on there? (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

The second gap identified was related to the varied municipal taxation structures applicable to renewable energy development.

…if you look at a solar project today, probably the second largest expense on the project is going to be the municipal taxes… (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

…some municipalities have a favorable land development framework in place for something like this already where renewable energy projects kind of have a basis to go off on the tax structure. Others we know even from just micro-generation projects have really nothing in place for how to deal with renewable energy projects at this time… (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

As municipal taxes can be a significant component of solar PV project cost, certainty in taxation rates is an important consideration.

An opportunity was identified which supports expansion of the re-purposing concept under the existing regulatory framework regarding aggregation of small-scale solar PV generation systems for emissions performance credits (EPCs). Although the current regulatory framework allows for aggregation of systems to meet the size requirements to receive EPCs, it was suggested by interviewees that the adjacency requirements under the Micro-generation Regulations and the Quantification Protocol for Distributed Energy Generation limited and/or eroded potential economic return for small-scale generators.

> *Under the new microgen regulations I can potentially aggregate…if you have a number of electrical loads, either well sites or barns if it's a farm, and you're on the same named distribution line, you can put solar on one of those properties to supply all of - let's say 5 wells. But they have to be on the same named distribution line, you have to have the same retailer and you have to have rights to the land.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

> *…under that system you would need to get to a certain size just to be able to play in terms of getting EPCs, right, Emissions Performance Credits, and it's really inaccessible to projects that are of a smaller size.…even under that system, the verification and audit elements of that protocol are just too expensive for what you could do with a microgen size project.*

> *…you're looking at a revenue that just doesn't account for the sort of professional time you need for going through the protocols in terms of verification and audit…*
> (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

There was reference in the documents and interview transcripts to the application of blockchain technology to facilitate ease of aggregation of micro-generation systems. Specifically, EQUS has partnered with ReWatt Power to provide this opportunity to micro-generators in the EQUS distribution service area (EQUS, 2020). This represents an opportunity to be explored for application to the brownfield oil and gas site re-purposing concept considering standard well site spacing and enhancing return on investment for smaller scale projects.

According to the literature, favorable regulations that provide a framework for a fair, collaborative and predictable development approvals process, support sociopolitical, community and market acceptance of renewable energy development (Wüstenhagen et al., 2007). The current regulatory structure has supportive elements, constraining elements as well as gaps to be addressed to facilitate expansion of the re-purposing concept. The existing framework enables deployment of solar PV micro-generation systems on fully remediated sites. Analysis of the data suggests that the constraining regulatory elements and gaps represent impediments to expansion of the re-purposing concept as opposed to barriers. Moreover, the analysis suggests that the current regulatory structure creates ambiguity leading to a spectrum of ease of deployment and uncertainty in project economics, particularly related to the deployment of solar PV distributed generation systems.

5.4.4 Project Economics

Project economics was the top-cited theme in the interviews and analyzed documents and over 70% of excerpts were coded as constraining to expansion of the re-purposing concept. As further detailed below, the project economics of re-purposing oil and gas brownfields as brightfields supports the decision to pursue this option, however it was noted across the data that there is uncertainty surrounding return on investment for distributed generation systems due to the current regulatory structure as well as site-specific considerations. These latter factors are impediments to the development of the project.

Despite a lack of provincial incentive programs related to solar PV installation, interviewees expressed that there is current investment interest by solar developers, landowners, community groups, rural cooperatives and oil and gas companies to develop small-scale solar PV generation projects and hedge against increasing electricity prices, supporting expansion of the re-purposing concept.

> *…there's definitely still substantial interest and development at the larger scale of microgen…*
>
> *… if you have the right situation and your various costs related to land and stuff like that are low, your installation costs are relatively low and you've got the scale to kind of bring down the costs through economies of scale, you could be looking at some pretty low prices that if you're looking at as not so much as return of investment but looking at it as a hedge against future electricity prices going up and that's kind of your interest…*
> (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

Decreasing costs and continually improving efficiency of solar PV infrastructure, the ability to value-stack through re-use of existing land and infrastructure, the federal renewable energy project depreciation tax incentive and the Clean Energy Improvement Program were also noted as supportive of project economics of the re-purposing concept. Some interviewees commented that, for micro-generation scale projects, the incentive for installation is still largely values-based due to limited economic returns generated from the tariff structure.

The need for a clear mechanism to execute on the re-purposing concept and an understanding of the economics was identified frequently in the qualitative data. The findings suggest that ongoing regulatory inquiries and hearings in the power generation field are creating uncertainty regarding the return on investment and project economics for distributed solar PV energy generation projects in Alberta.

> *The primary challenge for distributed generation is uncertainty in the regulatory environment.* (Interviewee from Stakeholder Group: Energy Consultants)
>
> *You almost can't ignore it because it's so central to the economics of these projects right now and whether or not you can get a solar project financed of scale.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

The first is the AUC Distribution System Inquiry whereby issues surrounding the future of distributed electricity in Alberta such as issuance of DTS credits is under discussion. DTS credits are issued by the DFO to distribution-connected generators that are not classified as micro-generators and are considered in distributed generation project economic analysis and investment decisions. These credits reflect value generated by distributed generators that benefits DFOs as outlined in Chapter 2. Excerpts from the interview transcripts and documents illustrate the differing opinions regarding whether DTS credits should continue to be issued to distributed generators.

> *And there's also been some question marks around those Option M credits and whether or not they'll continue to be available in any particular region and can you bank on them. So even though if you built tomorrow you could start making these credits at a certain dollar per megawatt hour and that could really make your project economics of your project work but a year out we still have them and if you don't have any certainty around that or a certain degree of certainty then you can't take that revenue source to the bank and get your project financed.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

According to the AUC's Alberta Electric Distribution System-Connected Generation Inquiry Final Report (2017):

> *DCG proponents viewed transmission-based credits as an enabler to DCG and expressed concerns that DCG investments would not be made without the availability of these credits. However, the distribution wire owners proposed that the dissolution of transmission tariff-based credits would reflect a more equitable allocation of costs*. (AUC, 2017, p. 72)

> *The AUC observes that because the AESO does not provide a credit to the distribution wire owners for reduced transmission system costs due to DCG, the distribution wire owners that provide this credit today must recover the cost of this credit from all of its distribution customers. This amounts to a cross-subsidy from non-DCG customers to DCG customers.* (AUC, 2017, p. 73)

The second matter creating uncertainty for distributed generators and future investment in solar PV distributed generation systems is the issue of substation cost fractioning. Currently, the potential costs for substation upgrades that may be charged to distributed generators transmitting to a particular substation represents a future exposure of unknown amount and timing. This issue is currently undergoing review and consultation through the AESO. As one interviewee commented:

> *There is one major issue, or a couple of major issues, that are outstanding around the distributed generation scale, one is who covers the costs of new substations when they come into an area and there's been a long ongoing AESO and AUC process to figure out how to fraction those substations costs, it's really complicated but essentially, if you're the last project to come into an area, you could get tagged for the full cost of a substation to upgrade even if that substation was going to be needed without you in coming years anyway.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

Additionally, as outlined in the AUC Module One Technical Conference notes from the Distribution System Inquiry (2019):

> *In Alberta, substation fractioning is an additional cost the generator has to pay, but also a future, unknown amount, which could be significant, depending on the "reverse power load" provided to the transmission system. In other words, if substations need to be upgraded for whatever reason in the future, existing distribution-connected generation customers could be faced with further costs, and these costs are unknown.* (AUC, 2019b, p. 13)

On June 25, 2020, the AESO put forward a proposal to revise the ISO tariff provisions to address this uncertainty and stakeholder comments to the proposal are due July 17, 2020 (AESO, 2020b).

Incremental additions of distributed generation may require investments by distribution system owners to upgrade and accommodate reflecting a further cost uncertainty.

> *…the distribution wire owners confirmed that the distribution systems are capable of accommodating DCG at the current time, and into the foreseeable future at the current growth rates and at relatively little cost. The distribution wire owners will also be required to enhance their systems to accommodate the intermittency of solar, wind and other renewables to maintain the reliability of their distribution service. However, as the capacity to accommodate more distribution-connected generation decreases, distribution wire owners will have to make investments at various places on their systems to accommodate further growth of distribution-connected generation. These future investments are likely to increase costs and will require careful planning by the distribution wire owners in order to take into account their unique local circumstances.* (AUC, 2017, p. 121)

The current application and interconnection process for distributed generation projects was also seen as a constraining factor and a deterrence to investment in smaller scale solar PV projects due to the impacts of the process on project economics. As one interviewee commented:

> *So right now, if you're looking to do a distribution-connected solar project, anywhere say minimum about a quarter million dollars in studies. And a year. And you just can't afford to do that on a small scale.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

In addition to the magnitude of associated costs and length of project approval timelines, interviewees' comments generally reflected issues identified in the following excerpt from the AUC's Alberta Electric Distribution System-Connected Generation Inquiry Final Report (2017):

> *DCG proponents stated that the process to connect large-scale DCG is complex and time-consuming and does not easily enable the development of alternative and renewable DCG. The reasons for this are three-fold: (1) the distribution systems were not built to accommodate the bidirectional flow of electrical energy for commercial sale, and, therefore, the technical connection requirements are more complex; (2) visibility of the system is limited; and (3) the application processes vary.* (AUC, 2017, p. 45)

The availability of financial incentives or subsidies are identified in the literature as a sociopolitical indicator of legitimization of a sustainable endeavour. The growth in solar PV micro-generation installations over the last five years was largely attributed to the provincial solar installation incentive programs in place during the timeframe.

> *So, prior to 2017, what was driving solar adoption was personal values. Really, that was the main driver. Values that you had personally as a business owner or as a homeowner.* (Interviewee from Stakeholder Group: Representatives from Government Agencies)

> *There was a really great incentive that the previous provincial government introduced with the residential and commercial solar program. It was extremely successful; I think it happened to coincide with a remarkable decrease in the cost of solar PV. Right around when that initiative was introduced in 2017, I'd say that was kind of a tipping point of the cost of solar having come down to like a level that was reasonable for businesses and homeowners even with Alberta's extraordinarily low electricity rates, it was still cost competitive.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

> *Government programs can account for certainly in the 90% of the amount of capacity that was installed through that period with the microgen.*
>
> *…at the beginning of 2015, there was a bout 5.5 MW installed of microgen solar and now we're up over 70 MW. So that's a twelve-fold increase in those five years. That's been a huge expansion but like I said the vast majority of that would have taken advantage of one of the types of programs*.
> (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

As mentioned above, many interviewees indicated that they did not expect any new programs in the foreseeable future. A lack of provincial incentives or subsidies for micro-generation or distributed solar PV generation projects may represent an impediment to the expansion of the re-purposing concept due to impacts on project economics resulting from the retail tariff paid to micro-generators for grid exports and generally low wholesale power pool prices.

Some interviewees suggested the need for a clear understanding of the economics of re-purposing specifically from the oil and gas site licencee perspective. The RenuWell Project team has identified that the concept represents an opportunity for cost savings for both the oil and gas company and the solar developer due to infrastructure re-use (Hirsche, 2019b). Additionally, as outlined by K. Hirsche in his presentation at the SEEDS event in March 2017, the oil and gas licencee may wish to re-purpose its own brownfield sites as brightfields to power its active operations in the area. (K. Hirsche, personal communication, March 3, 2017)

Uncertainty surrounding project economics represents an impediment to the market acceptance and expansion of the re-purposing concept. The uncertainty surrounding re-purposing project economics appears to be closely tied to regulatory ambiguity. Sustainable entrepreneurship activities being undertaken by the RenuWell Project team are raising awareness and supporting stakeholder dialogue regarding re-purposing project economics. As an example, some team members are participating in the AUC's Distribution System Inquiry which is ongoing. The team is also drafting The RenuWell Guidebook: Turning Liabilities into Assets, authored by K. Hirsche and L. Stendie (2020) as a multi-stakeholder resource which outlines economic considerations for potential re-purposing proponents.

5.4.5 Landowner and Local Support

As the benefits and impacts of solar PV micro-generation and distributed generation projects are primarily localized to the vicinity of the installation, and due to the visibility of solar PV installations and requirement for landowner and other local approvals to construct, landowner and local support emerged as an important theme regarding the expansion of the re-purposing concept. This aligns with the literature, specifically the article by Wüstenhagen et al. (2007), which suggests that local support is an indicator of community acceptance of renewable energy innovation and that trust and fair dealings between local stakeholders, regulators and proponents are key factors. Comments and extracts from relevant documents reflected the importance of local support, particularly from landowners and municipalities, and identified some of the constraining factors. Over 65% of excerpts coded under this theme were categorized as supportive of expansion of the re-purposing concept.

An opportunity that is unique to the oil and gas brownfield re-purposing relative to general brightfield development is represented by landowner interest. Rural landowners are negatively impacted by the growing inventory of orphan and inactive oil and gas infrastructure located on their freehold-owned lands as detailed in Chapter 2 and it is understandable that some may wish to have their land remediated and reclaimed to equivalent land capability as opposed to having it re-purposed. Moreover, landowners affected by inactive oil and gas infrastructure on their property represent both a potential consumer and investor in a solar PV re-purposing project and their support is critical in legitimizing this endeavor. Supporting expansion of the re-purposing concept, interviewees commented on the potential benefits to Alberta's rural landowners impacted by inactive and orphan oil and gas infrastructure including replacement of lost surface rentals income. As landowners may have large electricity needs due to agricultural operations, re-purposing area that was already disturbed represents an opportunity for landowners to hedge against increasing electricity costs individually or as part of a community-based generation group or cooperative.

> *…irrigation is the big thing and solar peaks when the irrigation needs peak, that's why it works so well with micro-generation. We have guys down here who actually put in lots of these projects on their pivot corners. So, without any incentives, just built it, some had to do their own utility line to get it, form their own cooperative to have a few farmers on the lines.* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

Furthermore, as two interviewees noted, some agricultural activities such as grazing can still take place around solar panels if shade-tolerant grasses are used, given the width of the space between the solar panel rows.

In an article published by The Globe and Mail dated February 18, 2020, the reporter, E. Graney, spoke with Mr. Merrill Harris, Reeve of the M.D. of Taber who reflected on supportive local sentiment about the re-purposing concept:

> *Mr. Harris said while many of his constituents aren't over the moon about massive solar projects that sprawl over thousands of acres of grass and farmland, they're not against using land already disturbed by oil and gas wells. "We all see that the oil fields around here are mature. We haven't seen oil rigs drilling around here very much. There was a little bit early this winter, but nothing like in the early 2000s when you could see four or five drilling rigs out your window every day," he said. "The infrastructure is there, the road into the lease is there, the electrical poles are all still there, so why not turn it into something else and use it for something beneficial?"* (Graney, 2020, para. 18-20)

There are some notable differences between oil and gas infrastructure development and renewable energy development relating to formal institutions which are pertinent to landowners and may impact local acceptance of the re-purposing concept. Firstly, the solar developer would need to enter into a new surface lease with the landowner in order to re-purpose the brownfield oil and gas site. The surface land leasing process for renewable energy infrastructure differs from oil and gas surface lease negotiation as summarized in the following excerpts from a document issued by the Farmers' Advocate Office (2017):

> *Negotiating for a wind or solar lease is different than negotiating with the oil and gas industry. In Alberta, there is no right of entry or expropriation process for a renewable energy power plant. Participation in a wind or solar lease for a power plant is 100% voluntary, and you are under no obligation to entertain a proposal. Contracts are negotiated bilaterally between the landowner and the renewable energy developer.* (Farmers' Advocate Office, 2017, p. 5)
>
> *While power plants are entirely voluntary, there may be a need for associated infrastructure, such as substations or distribution and transmission lines, when a power plant is established. The Surface Rights Act process for right of entry applies to associated infrastructure…* (Farmers' Advocate Office, 2017, p. 5)

The document continues to explain that there is currently no standard contract for solar leases nor is there legislated compensation or a requirement for a Licensed Land Agent to negotiate on behalf of the solar proponent (Farmers' Advocate Office, 2017). Further, as the leases are private agreements, disputes would be settled in the courts, not by the Surface Rights Board as with oil and gas leases (Farmers' Advocate Office, 2017). To address the matter of surface leasing for re-purposing and to facilitate trust-building and collaboration, the RenuWell Project team, in consultation with multiple stakeholders including landowners, has developed a template solar PV lease agreement to serve as a starting point for negotiation for inactive oil and gas site re-purposing (Hirsche & Stendie, 2020).

A gap in policy to address orphan renewable infrastructure was identified in the documentation and mentioned by several interviewees as a potential impediment to landowner and local acceptance due to the legacy of inactive oil and gas infrastructure. According to the Farmers' Advocate Office (2017):

> *Landowners should be aware that there is no industry or government-funded "orphan" program that would remove the infrastructure and reclaim the solar or wind lease belonging to an insolvent company. In oil and gas, the Orphan Well Association (OWA) takes care of the end-of-life remediation and reclamation needs in the event that the operator is no longer financially viable. The OWA is funded through oil and gas industry levies paid by licensees and collected by the Alberta Energy Regulator (AER). This program does not extend to wind and solar leases.* (Farmers' Advocate Office, 2017, p. 20)

A few interviewees offered rationale as to why an orphan renewables program may not be required to the same extent as the OWA provides for orphan oil and gas infrastructure.

> *I actually don't see a reason to have a solar backstop, or not to the same extent. With oil and gas sites, the high risk there is that you're handling liquids. Anytime you're handling liquids that are either salt or hydrocarbon, you can severely impair a site and costs are substantial. Clearly solar is much less risk.* (Interviewee from Stakeholder Group: Oil and Gas Site Closure Representative)

> *A farmer can't solve a downhole problem and a farmer can't solve a wind turbine foundation that's been left behind, but a farmer can solve a solar problem. A solar project, it's pretty benign. Put together with one 9/16ths wrench you could take the whole farm apart.* (Interviewee from Stakeholder Group: Energy Consultants)

The report by the Farmers' Advocate Office (2017) further speaks to the reduced risk related to orphan renewable energy infrastructure, this aligns with comments made by an interviewee regarding the longevity of the solar resource, contrasting it to oil and gas development.

> *Unlike an oil and gas lease, a renewable energy lease gains value over time. Whereas an oil or gas well will become depleted over time, a wind or solar site may be considered "proven" as it ages. Therefore, even an older site could remain attractive to investors. Lease agreements are generally longer than the lifespan of the equipment, providing an opportunity for repowering.* (Farmers' Advocate Office, 2017, p.19)

The findings suggest that the risk associated with a lack of orphan renewables program appears inherently lower than may be perceived, however an education/awareness campaign and/or implementation of an appropriate orphan renewables program may help support local acceptance.

The RenuWell Project team continues to work diligently to garner local acceptance for the concept of re-purposing brownfield oil and gas sites with solar PV supporting a growing rural interest in energy independence. In addition to landowner support, municipal support forms an important component of community acceptance due to the role of municipalities in land use planning and approvals. The RenuWell Project has received support from the M.D. of Taber through direct collaboration and from the MCCAC through the CGCB program supporting expansion of the concept. The importance of supportive municipal and local governments and a willingness of municipalities to amend existing land use policies and bylaws to enable the concept was reflected in the interviewees' comments.

> *…the M.D. of Taber through the specific project it looks like they have a lot of good processes or at least a willingness to amend any of their existing processes to make this work and I think specifically sort of the land development team that they have there has been really innovative in ways to make this work…* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

The collaboration exhibits a model that could be applied in other Alberta municipalities and the RenuWell Project team is working with the M.D. of Taber through the MCCAC's CGCB program to develop a re-purposing deployment framework that is transferable for use by other municipalities. Interviewee comments reflected municipal interest outside of the M.D. of Taber in deployment of distributed solar PV generation.

> *I've dealt with a number of other municipalities that are exploring community generation…not specifically though on the kind of abandoned sites concept, just more generally around development of these projects at a distribution-connection scale.* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

As one interviewee commented when discussing different municipal solar programs,

> *And Brazeau County and they have a program, I believe it's purely driven by their council who had an interest in it and the demand from the acreage owners there so there's definitely interest from the rural participants to become more energy independent. So, again, totally different values come into play there.* (Interviewee from Stakeholder Group: Representatives from Government Agencies)

In alignment with the literature, landowner and local support emerged from the qualitative data analysis as a factor influential in expansion of the re-purposing concept. Quotes coded to this theme were largely supportive, representing an opportunity for expansion. The findings suggest that both formal institutions, such as the current regulatory structure and informal institutions, such as the value of energy independence, have an influence on continuing to foster local and landowner acceptance. Sustainable entrepreneurship activities undertaken by the RenuWell Project team and its partners are working to influence these institutions and raise local awareness of the benefits of the re-purposing concept. As an example, to address the potential risk to landowners associated with the identified procedural gap regarding standard renewable energy project surface land leasing, the RenuWell Project team is championing the collaborative development of a standard lease template.

5.4.6 Sustainable Entrepreneurship Strategies

K. Hirsche of EEI and the rest of the RenuWell Project team in collaboration with the M.D. of Taber and with support of the MCCAC have been engaging in extensive sustainable entrepreneurship activities since the re-purposing concept was conceived in 2016. The literature identified the following mechanisms that sustainable entrepreneurs engage in to instigate change: creating new symbols to reshape and share new ideas, constructing new measures that communicate benefits of the proposed innovation effectively, identifying organizational failings and theorizing proposed solutions, building consensus by offering tangible or intangible benefits to other stakeholders and forging new collaborations amongst stakeholders (Thompson et. al, 2015). The creation of The RenuWell Guidebook: Turning Liabilities into Assets (Hirsche & Stendie, 2020), the development of a re-purposing surface lease template and the facilitation of numerous multi-stakeholder engagements represent some examples of the sustainable entrepreneurship activities that the RenuWell Project team is engaging in. The M.D. of Taber's willingness to amend land development processes to support the re-purposing concept is a further example and sets the stage for expansion into other municipalities.

The RenuWell Project team was identified by interviewees as champions for the re-purposing concept and for ensuring landowner interests and concerns are addressed. As one interviewee commented regarding some of the positive outcomes of the team's ongoing multi-stakeholder engagement and consultation efforts:

> *Was really great to see that data kind of documented clearly and showing that there definitely is an interest here and what some of the concerns might be and how they're relatively easy to address in the scheme of things so I think a lot of that on the ground consultation was great to provide support for the project and build those connections, I think specifically in some of those rural areas of Alberta, something like that is key to building that kind of ground up support and not just having this be something that comes from the top down from something like government as a you must do this but rather showing how it can benefit them and solve an issue that they're already dealing with then hopefully be a win-win for the other players involved as well.* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

Even though the re-purposing concept is in its early stages, awareness is growing. The data suggests that physical deployment of the RenuWell Project pilot will represent a further mechanism to foster collaboration, community acceptance and counteract isomorphism in support expansion of the concept beyond the pilot phase.

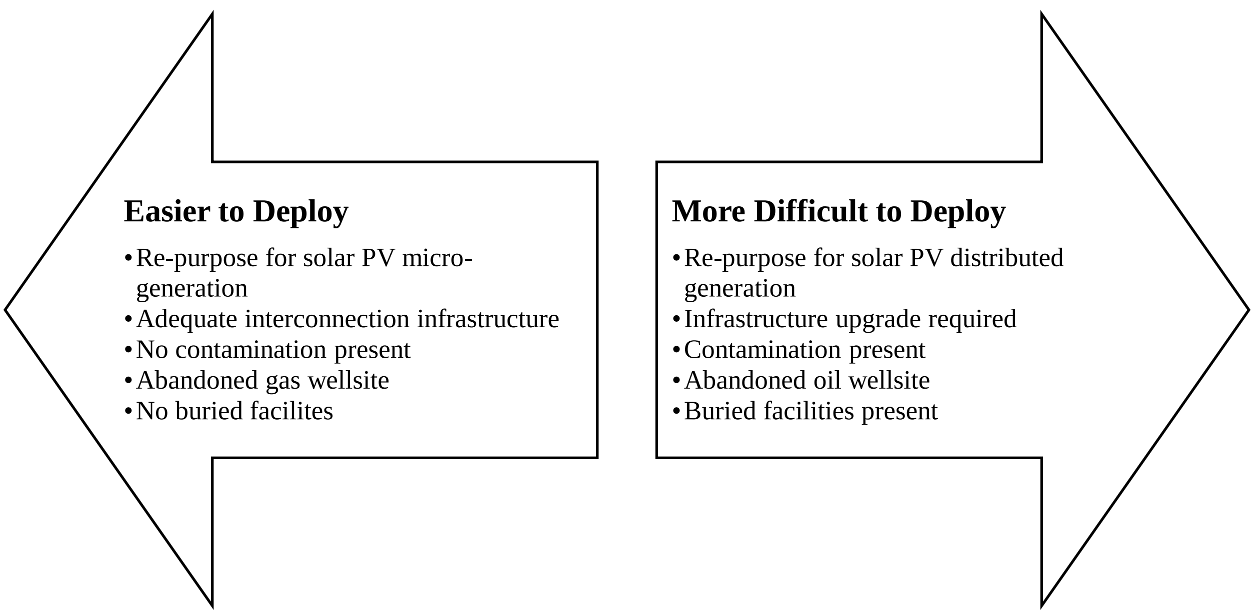
> *In terms of what would make successful, I think you're right, I think it's just a matter of getting one or two of these off the ground and getting them to point where you can almost treat them as a demonstration project where you can say, look we have real live examples where landowners are now getting a rental again, where we've re-purposed an access road and a lease site, and that we're making a meaningful contribution either to offset costs to that landowner or in some cases to actually put it back into the grid and to offset costs to grid users.* (Interviewee from Stakeholder Group: Oil and Gas Site Closure Representative)

The analysis suggests that the sustainable entrepreneurship efforts of the RenuWell Project team and its partners are working to build landowner and local support for the re-purposing concept and influence existing institutions in support of its expansion.

5.4.7 Spectrum of Ease of Deployment

A spectrum of ease of deployment of solar PV infrastructure on brownfield oil and gas sites emerged from the data as a theme supporting the need for development of a collaborative framework. Although there are tens of thousands of inactive brownfield oil and gas sites across Alberta, unique brownfield site attributes combined with the different approval processes for solar PV micro-generation projects relative to distributed generation projects creates a spectrum of ease of deployment of the re-purposing concept. Various factors contributing to the spectrum are shown in Figure 16. Some brownfield sites will be more suitable re-purposing candidates than others.

Figure 16: Select Contributing Factors to the Spectrum of Ease of Deployment of the Re-purposing Concept



(Author, 2020)

Interview transcript excerpts referenced the magnitude of sites available for re-purposing based on Alberta's inactive well inventory and solar PV siting flexibility.

There are a number of opportunities in Alberta where small scale PV can be deployed on previously disturbed sites. These include safely abandoned and reclaimed wellsites that have not received a reclamation certificate, reclaimed areas of other disturbances such as mines and aggregate operations, and other brownfield sites. (Interviewee from Stakeholder Group: Representatives from Regulators)

…the beauty of solar energy is that it's not locational-specific the way that historical energy sources have been, right? Like coal plants are located where they are because that's where the coal is. Hydro is located where it is because that's where the hydro is. Solar is almost universal in Alberta. (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

Twelve phrases identified in the interview transcripts and analyzed documents reflected the relative ease of physical deployment of the solar PV infrastructure itself however, as mentioned above, the spectrum of ease of deployment is driven by a number of factors related to the attributes of the existing brownfield oil and gas sites including status (inactive or orphan), land ownership, geographic locations, site dimensions, potential site contamination and risk category, interconnection availability, hosting capacity and existing infrastructure (surface and buried). Additionally, as detailed above, solar PV micro-generation systems undergo a more streamlined approval process relative to distributed generation systems, contributing to the spectrum.

According to existing literature on brightfield development, potential site contamination and the associated environmental liability represents a critical barrier (Spiess & De Sousa, 2016). The quantity of references to the theme in the qualitative data reflected the importance of this issue however data excerpts reflected that this issue is site-specific and represents more of an impediment as opposed to a critical barrier. An interviewee commented on the varying levels of environmental liability risk presented by different site types aligning with existing literature.

If they're gas sites, shallow gas especially, there's not much contamination risk. (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

As mentioned above, remediation and reclamation of the oil and gas site in accordance with the AER's SED 002 and other applicable remediation and reclamation legislation is to be completed prior to re-purposing for solar PV. According to a newsletter issued by the AER (2020):

> *In some cases, a full site reclamation may not be called for as the solar company would only have to turn around and undo the work that was done to reclaim the site when it installs its panels. In these situations, the AER can issue a reclamation certificate under requirements from the 2010 Reclamation Criteria for Wellsites and Associated Facilities.* (Doane, 2020, para. 8)

> *Once a reclamation certificate is in place, the solar company becomes the new "homeowner" with full responsibility for the site, including tidying it up.* (Doane, 2020, para. 9)

An interviewee commented that this requirement may limit site availability for re-purposing.

> *The problem from my perspective is most landowners are going to go – well, if its reclamation ready, reclaim it and I'll farm it, I don't want something else on there.* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

Some interviewees agreed that remediation and reclamation should be completed prior to site re-purposing however there were suggested circumstances where it may make sense to re-purpose the site prior to completion of remediation and reclamation, such as sites with low risk contamination or those that cannot be remediated, as well as sites where the freehold land is owned by the oil and gas company. Many ideas and solutions were proposed by interviewees to address the environmental liability issue such as initial site due diligence, bioremediation of contaminants concurrent with solar PV energy generation, creation of a legacy fund for potential future liability and issuance of reclamation bonds by the oil and gas company.

> *Additional policy direction for existing operators as well as developers to clearly articulate roles, responsibilities, and expectations on addressing outstanding contamination and reclamation issues [is needed].* (Interviewee from Stakeholder Group: Representatives from Regulators)

> *… from a government regulatory perspective, it's very complicated for them to take a site that's got some limitations to it and transfer it to another industry and another ownership stream.* (Interviewee from Stakeholder Group: Oil and Gas Site Closure Representative)

> *Contamination liability ultimately falls on the oil and gas company or the OWA.* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

The qualitative data analysis suggests that additional multi-stakeholder dialogue is required regarding the potential to re-purpose oil and gas sites prior to remediation and reclamation to develop an enabling regulatory framework which upholds the 'polluter pays' principle.

Unique oil and gas brownfield site characteristics, potential environmental liability from perceived contamination and the level of regulatory ambiguity related to distributed solar PV generation systems relative to micro-generation systems creates a spectrum of ease of deployment of the re-purposing concept. The spectrum supports the need for a framework for collaboration and data-sharing between interested stakeholders to identify priority re-purposing candidate sites and support expansion of the concept.

5.4.8 Institutional Isomorphism

Indications of institutional isomorphism in both the power generation and oil and gas organizational fields were identified in the qualitative data analysis. As outlined in the literature review, isomorphic influences constrain the expansion of sustainable innovation by altering the associated costs, benefits, and risks of execution (Sine et al., 2005). Different timelines between the organizational fields for the activities associated to re-purposing was identified as an impediment that was not identified in existing literature. These factors influence market acceptance, supporting the need for a collaboration within each organizational field as well as a cross-industry framework for collaboration and data-sharing.

5.4.8.1 Power Generation Field

The professional field of power generation is currently undergoing transition due to innovations in distributed energy generation, energy storage and smart infrastructure. Moreover, the data suggests that isomorphic influences are constraining distributed energy generation installations as reflected in the transcripts from the ongoing hearings and reviews. According to excerpts from the AUC's Alberta Electric Distribution System-Connected Generation Inquiry Final Report (2017), the existing system design and complex governing legislation creates challenges for this transition.

> *The distribution system has traditionally operated with a one-way delivery of electrical energy from centrally located generation plants to end-use customers with relatively little or no monitoring and control automation.* (AUC, 2017, p. 25)

> *The legislative framework that enables the provision of electrical energy in Alberta with this restructured model is complex and involves an intricate weaving of provincial and federal acts and regulations along with other legislative instruments, many of which were developed in a piece meal fashion over time, thereby contributing to the challenges of planning for the future.* (AUC, 2017, p. 16-17)

As outlined in Chapter 2, the AESO is responsible for grid infrastructure planning to meet provincial demand. Comments from the AESO in the AUC Proceeding 24116 Distribution System Inquiry – Module One Technical Conference notes (2019) reflects the challenges associated with increased distribution-connected generation as it relates to grid system planning:

> *Mr. Mossing (AESO) replied that the AESO has imagined the technology that is so cheap that everyone can afford to defect from the grid but he is not aware of the actual existence of that technology. The "electrification of everything" movement points to the need for* more *wires, not less. Alberta has made the investment in the grid, so we should try to be using it and making the most of our investment. When the AESO is planning to build something, it does think about the long term, but it also thinks about the short term because it does have a mandate to keep the lights on. He stated that those power needs are not going to come from a battery.* (AUC, 2019b, p. 13)

In the AUC's Alberta Electric Distribution System-Connected Generation Inquiry Final Report (2017), DFOs indicated that organic growth of distributed generation could generally be accommodated however concerns were expressed by stakeholders regarding the potential that increased penetration of distributed generation will result in stranded assets and additional costs to consumers.

> *As the amount of distribution-connected generation (DCG) grows, more changes will likely be necessary and these changes will be expensive, especially if the capacity of the distribution systems must be increased. All of these factors raise issues of cost allocation in order to ensure fairness of rates charged among and between customers who choose to participate in DCG and those that do not.* (AUC, 2017, p. 9)

> *Distribution wire owners are concerned that future investment in the assets and technology on the distribution system that would be necessary to achieve the government's renewable energy goals could result in stranded assets and their associated costs.* (AUC, 2017, p. 41)

> *This risk exists because most distribution system assets, such as poles, conductors, and cables, have relatively long lives. For example, ATCO Electric noted that over 90 per cent of its distribution assets have expected average lives of 40 years or more. If these assets are no longer required because of the increased deployment of DCG and the assets are removed prematurely from service before the end of their useful lives, the distribution wire owners will have to bear the financial consequences…ENMAX considered this matter to be a barrier to the future development of DCG as distribution wire owners may be reluctant to invest in the assets and technology that may be necessary to help achieve the government's renewable energy goals if doing so results in stranded assets and financial loss.* (AUC, 2017, p. 77)

As one interviewee commented:

> *…Alberta's transmission regulation and the legislative framework around that never envisaged there would be like DERs of anywhere near the scale we have now. So, it's kind of like, ok, maybe somebody will connect a small generator but it's not material enough to factor into this law that was written at the time when it was like purely transmission-connected coal. But now there's so much DER on the grid and that's not just solar or wind but also from the growth of the oil sands and cogen facilities and battery storage as well. And so ultimately, it's a question of whether the transmission regulation is fit for purpose.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

A further interviewee comment reflects the importance of the ongoing hearings and reviews on potentially alleviating some of the constraining isomorphism:

> *And the challenge is that the utilities in particular, their business models are not built around incorporating these new frameworks. So, until we can give them some assurance that we recognize that their overall business model needs to be transitioned and protected, they're*

not all that interested in innovation. (Interviewee from Stakeholder Group: Energy Consultants)

The qualitative data reflected the importance of the reviews and hearings that are underway to allow an opportunity for all stakeholders to express their concerns and interests related to the complex transition to a more decentralized and modernized grid structure. The outcomes of the proceedings may reduce some of the regulatory ambiguity, uncertainty surrounding project economics, and influences of isomorphism on the expansion of the re-purposing concept.

5.4.8.2 Oil and Gas Field

Indications of isomorphism in the oil and gas profession were derived primarily from the CRIN Novel Land and Wellsite Reclamation report (2020) and reflected the oil and gas industry's siloed thinking, individual pursuit of liability management (as opposed to collaborative) and hindering regulations. The need for a change in mindset surrounding asset retirement was a notable observation.

> *Industry continues to be siloed in its thinking and needs to find ways to be more holistic different stakeholders are coming at it from different paths.* (CRIN, 2020, p.19)

> *There is a low risk tolerance here for doing things differently.* (CRIN, 2020, p. 24)

> *Data sharing is a shortcoming and a divisive element…Data is held close to ground. Without this data it is difficult to connect the dots.* (CRIN, 2020, p. 24)

> *Feedback from the workshop highlighted a need to 'change the brand' of asset retirement from connotations of spending, frustration and pain, to a positive message of environmental, social and governance (ESG) opportunities; technology and skills export potential; and business innovation and opportunity. These potential benefits of asset retirement beyond liability reduction and ecological restoration need to be more clearly demonstrated, they added.* (CRIN, 2020, p. 3)

Interviewees commented on similar indications as well as perceived regulatory gaps and the need for a clear transfer framework.

…this is a brand-new concept in Alberta and there's not necessarily a great policy framework in place for this sort of transfer model as much as just direct reclamation of these sites through the oil and gas industry. (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

It was noted that excerpts and comments on the execution of the Site Rehabilitation Program to clean up inactive oil and gas sites reflect isomorphism within the oil and gas organizational field as re-purposing opportunities are not being considered in the program. According to a CBC news article,

Nothing in the plans that the province has announced so far includes funds for repurposing sites. (Seskus, 2020, para. 11)

The accelerated timelines associated with the Site Rehabilitation Program was noted by one interviewee as an impediment associated with isomorphism, namely the different paces of the two industries related to the activities associated with the re-purposing concept.

5.4.8.3 Differing Timelines

An impediment that arose from the qualitative data was the mismatched pace of the solar PV developer and the oil and gas proponent or OWA who is seeking to close the brownfield site. Once a closure program is developed, the site licencee or the OWA is driven to close out the site (or multiple sites in an area) as promptly as possible to achieve economies of scale and remove the liability from the books. The AER's Area Based Closure program incentivizes closure activities and provides a platform for coordination between companies. The following interviewee comment reflects the issue,

…they'll [solar PV developers] express interest in sites that they think there's some potential either because there's good connection to the grid or whatever but it's slow…well in the meantime, we've got crews going, going, going and we're pulling infrastructure and we're abandoning as fast as we can so the challenge is the two industries are at an extremely different pace right now… (Interviewee from Stakeholder Group: Representatives from Regulators)

Differing timelines and drivers for the oil and gas site licencee or OWA and solar PV developer may create a narrow window for re-purposing and further supports the need for a framework for collaboration to facilitate expansion of the re-purposing concept.

5.4.8.4 Level of Collaboration and Data-Sharing

A framework for collaboration and data-sharing amongst multiple interested stakeholders is important to support the expansion the re-purposing concept and was identified as a gap. Forging collaboration is identified in the literature as a mechanism to influence institutional isomorphism (Thompson et al., 2015). As outlined above, and to work to address this gap, the RenuWell Project team is developing The RenuWell Guidebook: Turning Liabilities into Assets, a multi-stakeholder reference guide for step-by-step deployment of the concept.

Improved data-sharing is needed to foster collaboration between landowners and the power generation and oil and gas organizational fields to identify candidate sites and expand the re-purposing concept. The data also suggested that it is also required within the two fields. As noted in the CRIN Novel Land and Wellsite Reclamation report,

> *A framework for decision-making based on asset properties and the stakeholders involved needs to be put in place.* (CRIN, 2020, p. 22)

> *There is a perception that data is the key to unlocking the problem and collaboration is going to be key (less site by site and more scalable).* (CRIN, 2020, p. 23)

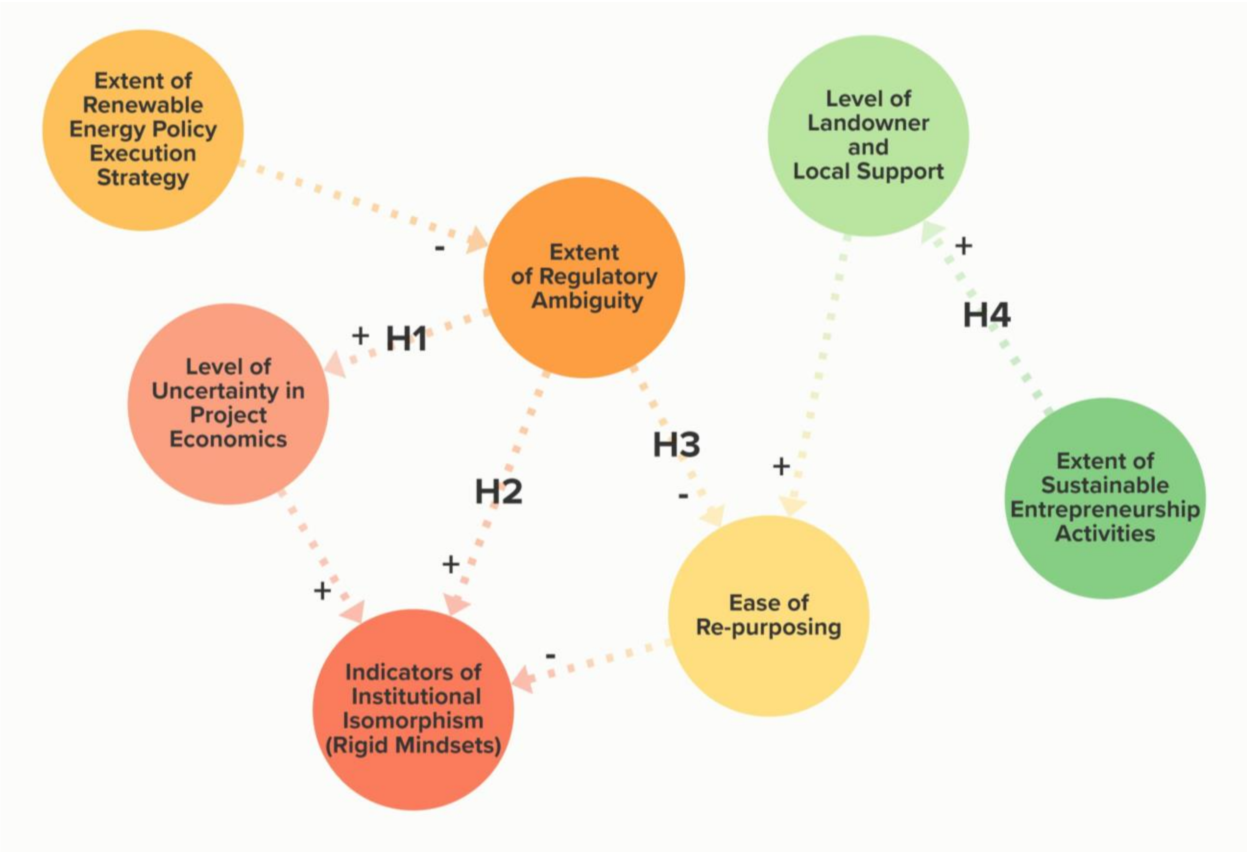
Specific to the power generation organizational field, data sharing amongst stakeholders within the organizational field was identified as an important need to facilitate effective distribution system planning applicable to supporting the re-purposing concept. The AUC’s Alberta Electric Distribution System-Connected Generation Inquiry Final Report (2017) outlined that the AESO and transmission facility owners have limited visibility of distributed connected generation.

Additionally, the sharing of distribution feeder capacity for distributed generation siting was identified as an area for improvement (AUC, 2017).

5.4.9 System Diagram Illustrating Relationships

Through a qualitative investigation of the research question based upon the conceptual framework provided in Chapter 3, eight emergent themes were identified representing the supporting and constraining influences of institutions on expansion of the re-purposing concept. The identified supporting and constraining influences represent opportunities and impediments or gaps related to concept expansion. Relationships between the themes observed throughout the analysis and based on existing literature are illustrated in the system map in Figure 17. Based on the research findings and system map, four hypotheses are proposed and summarized with supportive excerpts from the interview transcripts and analyzed documents in Table 4.

Figure 17: System Map of Institutional Influences on Expansion of the Re-purposing Concept in Alberta



(Author, 2020)

Ongoing regulatory reviews in the power generation industry regarding distributed energy generation and associated cost factors such as the complex approval process, issuance of DTS credits and financial exposure related to substation fractioning and distribution system upgrades were identified as impediments to deployment of distributed solar PV generation systems. Additionally, the varied municipal taxation structures for renewable energy developments across Alberta was identified as a gap potentially affecting project economics. The data suggests that regulatory ambiguity results in uncertainty in solar PV distributed generation project economics, potentially deterring investment in a re-purposing project. This represents the first hypothesis proposed by this research, H1.

The regulatory structure applicable to the re-purposing concept exerts forces of institutional isomorphism within both the oil and gas and power generation industries and plays a role in creating a spectrum of ease of deployment directly through favorable or constraining regulations and indirectly through fostering community acceptance through fair and just development approval processes. This research suggests that the extent of regulatory ambiguity creates uncertainty surrounding the mechanism for execution of the re-purposing concept which further appears to reinforce indicators of institutional isomorphism in both industries. This represents the second hypothesis proposed by this research, H2. There is a need for further collaboration and data sharing amongst interested stakeholders to address the issue of differing paces/timelines between the oil and gas and power generation industries and support expansion of the re-purposing concept.

Provincial policy and execution strategies regarding renewable energy development, oil and gas liability management, land use and grid modernization influence the regulatory frameworks applicable to expansion of the re-purposing concept. There exists uncertainty surrounding the provincial government's execution strategy to achieve Alberta's 30% by 2030 target, including grid modernization and what role small-scale decentralized solar PV generation plays in achieving the target. As provincial strategy was indicated as important in driving utility mandates and regulatory frameworks supportive of grid modernization and installation of distributed solar generation, the data suggests that gaps in renewable energy policies and unclear execution strategies may result in regulatory ambiguity and a wider spectrum of ease of deployment for small-scale solar PV installations on oil and gas brownfields. The requirement to fully remediate the brownfield oil and gas sites prior to re-purposing also contributes to the spectrum of ease of deployment. This represents the context for the third hypothesis proposed by this research, H3.

The RenuWell Project team and its partners are engaging in ongoing sustainable entrepreneurship activities, such as forging collaborations, consensus-building and illustrating the benefits that the re-purposing concept presents, which the literature and data suggest is influential in instigating both formal and informal institutional changes required to support its expansion (Sine et al., 2005). Their efforts have included communication of information regarding the potential benefits of the re-purposing concept through engagement with a wide range of interested stakeholders. The RenuWell Project team members, representing champions for the re-purposing concept, are locally known in the M.D. of Taber and all interviewees indicated their knowledge of or familiarity with one or more of the team members. A study by Ince et al. (2016) found examples of champions who garnered support for their projects through their formal and informal legitimacy. The study further suggested that project success is affected by the level of informal relationships (Ince et al., 2016). This research suggests that expansion of the re-purposing concept will have a larger impact on local stakeholders, such as rural landowners and municipalities, relative to other interested parties. Additionally, according to existing literature, project deployment will require a more active level of acceptance. Moreover, this research proposes that the extent of informal legitimacy of project champions engaging in sustainable entrepreneurship activities positively correlates with the level of local support for the re-purposing concept. This represents the fourth hypothesis proposed by this research, H4.

Table 4: Proposed Hypotheses based on Qualitative Analysis

Hypothesis	**Related Excerpts**
H1: The extent of regulatory ambiguity positively correlates with uncertainty of return on investment in a re-purposing project.	*You almost can't ignore [the regulatory environment] because it's so central to the economics of these projects right now and whether or not you can get a solar project financed of scale.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)
H2: The extent of regulatory ambiguity positively correlates with the extent of indicators of isomorphism within the oil and gas and power generation industries.	*…they'll express interest in sites that they think there's some potential either because there's good connection to the grid or whatever but it's slow…in the meantime, we got crews going, going, going and we're pulling infrastructure and we're abandoning as fast as we can so the challenge is the two industries are at an extremely different pace right now.* (Interviewee from Stakeholder Group: Oil and Gas Site Closure Representative) From the CRIN Novel Land and Wellsite Reclamation report regarding oil and gas brownfield site closure: *There is a low risk tolerance here for doing things differently.* (CRIN, 2020, p. 24) *Regulation on repurposing is cited as non-existent and/or unclear. There is uncertainty and lack of flexibility for re-purposing ability. Site specific and case-by-case re-purposing leads to scale problems.* (CRIN, 2020, p. 22)
H3: The extent of ambiguity in applicable regulatory frameworks negatively correlates with ease of deployment of the re-purposing concept.	*The primary challenge for distributed generation is uncertainty in the regulatory environment.* *We need to have AUC inquiry come out and be positive for small-scale solar generation.* (Interviewees from Stakeholder Group: Municipal and Other Local Representatives) *…this is a brand-new concept in Alberta and there's not necessarily a great policy framework in place for this sort of transfer model as much as just direct reclamation of these sites through the oil and gas industry.* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives) *…the whole Alberta government system is set up under the assumption that only producers will buy oil and gas sites…* (Interviewee from Stakeholder Group: Oil and Gas Site Closure Representative)
H4: The extent of sustainable entrepreneurship activities conducted by known champions positively correlates with the level of local support for the re-purposing concept.	*…I think a lot of that on the ground consultation was great to provide support for the project and build those connections…specifically in some of those rural areas of Alberta, something like that is key to building that kind of ground up support and not just having this be something that comes from the top down…but rather showing how it can benefit them and solve an issue that they're already dealing with then hopefully be a win-win for the other players involved as well…* (Interviewee from Stakeholder Group: Municipal and Other Local Representatives)

(Author, 2020)

5.5 Summary

The quantitative and qualitative analyses conducted in this research project resulted in the identification of ten themes representing potential socioeconomic and environmental benefits associated with the expansion of the concept of re-purposing Alberta's oil and gas brownfields as solar PV brightfields. The benefits derived from the data analysis align with those identified by EEI and the RenuWell Project team as related specifically to the brownfield oil and gas site re-purposing concept and as well as those identified in existing literature associated with brightfield development in general. The identified benefits align with provincial objectives surrounding increasing renewable power generation, mitigation of cumulative effects from energy development and addressing inactive oil and gas liability.

To address the research question, a qualitative analysis of the formal and informal institutional influences effecting the expansion of the concept resulted in the emergence of fifty sub-themes categorized into eight overarching themes reflecting both supportive and constraining effects of institutional influences and indicators of isomorphism in both the oil and gas and power generation industries. As detailed in the analysis, the identified institutional influences represent opportunities and impediments which affect socio-political, community and market acceptance, as defined by Wüstenhagen et al. (2007), and legitimization of the re-purposing concept.

There are opportunities for expansion of the concept beyond a pilot phase and the data reflected that local and landowner awareness and support is growing. There is investment interest in small-scale solar PV installations and current regulatory frameworks enable deployment of solar PV micro-generation systems on fully remediated brownfield oil and gas sites. Unique oil and gas brownfield site characteristics, the moratorium on development of solar PV on Crown land and regulatory ambiguity, particularly as it relates to distributed generation systems, create uncertainty surrounding re-purposing projects and a spectrum of ease of deployment. There is a need for increased understanding by stakeholders of the mechanism of execution, economics, and scalability of the re-purposing concept. The research analysis suggests that differing paces for oil and gas closure and solar PV development may also be a limiting factor.

The analysis illustrated that the constraining effects and gaps represent impediments as opposed to barriers and highlighted the importance of regulatory clarity surrounding distributed generation installations as well as a the need for a framework for collaboration and data-sharing to support expansion of the re-purposing concept. Reviewing the qualitative data for further observed patterns between the institutional influences resulted in the development of a system map (Figure 17) illustrating relationships suggested by the data and forming a basis for the development of four hypotheses. The efforts of the RenuWell Project team and its partners are working to change the constraining influences and address gaps however the findings suggest that additional regulatory clarity and stakeholder collaboration is needed. The qualitative analysis informed the policy and regulatory recommendations detailed in Chapter 6 which are proposed to support the expansion of the re-purposing concept beyond the pilot phase.

Chapter 6. Conclusions, Limitations and Suggested Future Research

6.1 Conclusions

There are a number of significant socioeconomic and environmental benefits associated with the expansion of the concept of re-purposing Alberta's oil and gas brownfields as solar PV brightfields beyond the pilot phase. The re-purposing concept represents a sustainable opportunity to leverage existing disturbed land and infrastructure for renewable energy development in support of provincial objectives to mitigate the cumulative effects of energy development on the landscape, specifically on Southern Alberta's high value grasslands and agricultural lands, and reduce greenhouse gas emissions from electricity generation. Investment interest in solar PV micro-generation and distributed generation systems to leverage Alberta's abundant solar resource and hedge against increasing electricity costs, potential benefits to landowners such as surface rental income, cost savings to both solar PV developers and oil and gas companies, additional public revenue, job creation and the potential to address a portion of Alberta's 155,000 inactive oil and gas sites represent key drivers. EEI, the RenuWell Project team and partners such as the M.D. of Taber have been engaging in various sustainable entrepreneurship activities, increasing awareness and support amongst the numerous stakeholders with an interest in the concept.

Formal and informal institutions are influencing the opportunities and impediments associated with the expansion of the re-purposing concept by fostering or hindering expansion. Solar PV micro-generation systems with capacity up to 1 MW, as contemplated by the RenuWell Project team, are straightforward to deploy on fully remediated brownfield sites however investment in these small-scale installations remains largely values-driven as the economic benefit is limited to a hedge against future electricity prices and retail compensation for electricity exported to the grid. Aggregation and implementation of blockchain technology to achieve EPCs could improve the economic return. The complexities surrounding larger distributed energy generation installations resulting from ongoing regulatory reviews and complicated approval process, combined with unique brownfield oil and gas site attributes and differing timelines between brownfield site closure and solar PV development, creates a spectrum of ease of deployment and uncertainty surrounding project economics. The qualitative analysis conducted in this research project suggests that these factors reinforce existing indicators of institutional isomorphism within both the oil and gas and power generation organizational fields to maintain the status quo. A framework for collaboration and data-sharing could counteract these indicators of isomorphism.

The following policy and regulatory recommendations were developed based on the research findings and support the expansion of the concept of re-purposing oil and gas brownfields as solar PV brightfields beyond the pilot phase. They are proposed with the intent to prioritize brownfield use for renewable energy development, facilitate collaboration amongst interested stakeholders, support an increased penetration of distribution-connected generation and shift stakeholder mindsets about oil and gas liability management towards implementation of innovative solutions such as the re-purposing concept.

1. Development of a clear provincial strategy to achieve 30% renewable energy generation by 2030, mitigate cost uncertainties surrounding distributed generation systems and increase investor confidence including:
    i. review of the moratorium on solar and wind energy project development on Crown land to increase the number of re-purposing candidate sites

ii. clarification of matters currently under review in the Distribution System Inquiry that are creating uncertainty surrounding the economics of distributed generation projects including:

   a. whether or not DTS credits will continue to be provided by DFOs to distributed generators and

   b. how future costs from substation fractioning will be fairly allocated to distributed generators

iii. implementation of a streamlined approvals and interconnection process for distributed energy generation systems

2. Implementation of standardized surface leasing procedures for renewable energy projects and development of an orphan renewables program to support landowner and local acceptance

3. Express provincial government support for the re-purposing concept through Site Rehabilitation Program funding eligibility

4. Development of a framework for cross-industry collaboration and data-sharing in support of expansion of the re-purposing concept

   i. suggest that the lead ministry to facilitate collaboration is AEP as the regulator of the site once it is re-purposed

   ii. issuance of documentation clarifying roles and responsibilities of the multiple regulatory bodies as it relates to the re-purposing concept such as that between AEP and AUC entitled "Roles and Responsibilities of Alberta Environment and Parks (AEP) and the Alberta Utilities Commission (AUC) Re: Applications to construct and operate wind and solar power plants"

iii. development of a platform for data-sharing to support re-purposing of previously disturbed land area and assist in site selection and planning to incorporate features similar to the Landscape Analysis Tool for Alberta public land; RenuWell mapping tool could form basis for an expanded platform

iv. regulatory trigger for brownfield oil and gas site licencee to review, identify and share information on candidate sites for re-purposing at Phase 1 or Phase 2 Environmental Site Assessment stage

5. Suggest that AER and AEP work with interested stakeholders to develop a framework to allow re-purposing prior to full remediation of sites on a case-by-case basis facilitating alternative closure such as use of emerging bioremediation technologies

Representing a more specific regulatory recommendation in support of Alberta's Land-use Framework objectives regarding cumulative effects mitigation, the Government of Alberta (AEP) could consider amending the Wildlife Directive for Alberta Solar Energy Projects to change the best management practices which address minimizing additional anthropogenic disturbance from solar energy development to standards, ensuring that existing disturbed areas including brownfield oil and gas sites are considered first for new developments.

The concept of re-purposing Alberta's oil and gas brownfield sites as solar PV brightfields, as currently being piloted by the RenuWell Project team and its partners, represents a unique and disruptive sustainable energy development opportunity to address a portion of Alberta's existing inactive oil and gas liability. It can be executed upon on a number of brownfield oil and gas sites in Alberta under existing conditions, mitigating the cumulative effects of energy development on the landscape. Changes to existing institutions could narrow the spectrum of ease of deployment and reduce uncertainties further supporting concept expansion. As one interviewee memorably commented,

> *…it's really symbolic. There's a really neat opportunity for solar to show how it can contribute to solving a very Alberta problem.* (Interviewee from Stakeholder Group: Renewable Energy Industry and Industry Association Representatives)

Moreover, as the issue of inactive oil and gas liability is not a uniquely Alberta problem, a well-developed framework for collaboration and implementation of the concept of re-purposing oil and gas brownfields as solar PV brightfields has potential for application in other jurisdictions further supporting expansion of this innovative concept.

6.2 Limitations

This research project is limited by the amount of qualitative data that could be collected and analyzed within the project timeframe. As the research progressed, it became apparent that the expansion of the concept of re-purposing oil and gas brownfields as solar PV brightfields requires collaboration between a variety of interested parties and that not all affected parties' perspectives on the concept were incorporated due to time limitations. Specifically, the study lacks perspectives from Indigenous rightsholders. Further, the number of interviews did not allow for a quantitative survey to test hypotheses. Due to the innovative nature of the concept and the fact that it is currently in a pilot phase which is pending physical deployment at the time of writing, some opportunities and impediments identified in the research are opinion-based and speculative. Additionally, as oil and gas liability management as well as the development of a policy framework supporting grid modernization and increased penetration of distribution-connected generation in Alberta are current issues undergoing regulatory and public review, the identified opportunities and impediments to the expansion of the concept were concurrently evolving as this research was being conducted.

6.3 Suggestions for Future Research

This research project focussed on the opportunities and barriers or impediments to deployment of solar PV infrastructure on inactive brownfield oil and gas sites located in a single jurisdiction. As inactive oil and gas infrastructure liability is an issue that exists outside of Alberta, future research could apply and investigate the research question in other jurisdictions as a comparison. Additionally, the concept of re-purposing former industrial sites for renewable energy generation could be investigated for application to other types of industrial brownfield sites such as coal mines. The opportunities and impediments of applying the concept to oil and gas brownfield sites located on Indigenous reserve lands or other federal lands could also be explored. As the RenuWell Project is in the pilot phase, a case study could be conducted once the project is constructed and operational to test the sustainable industry start-up model proposed by Espinoza and Vredenburg (2010). Further, a quantitative study could be designed to test the influences of the formal and institutional factors identified in the system map and hypotheses proposed by this research project. Additional research opportunities include the feasibility of concurrent re-purposing of brownfield oil and gas sites and bioremediation of hydrocarbon contamination and the economic case for application of blockchain technology to aggregate re-purposed brownfield oil and gas sites for EPCs.

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Appendix A: Interview Question Framework

	Question	Purpose/Link to Conceptual Framework
1	Please describe your background/work experience	Understand interviewee relevance to the subject matter
2	Solar PV Micro-generation in Alberta has grown significantly over the past five years. What do you feel is driving this growth?	Understand interviewee knowledge of the subject matter Facilitate understanding of the potential opportunities presented by the concept
3	What is your level of knowledge/familiarity about the concept of re-purposing Alberta's unreclaimed (inactive) oil and gas sites for small-scale solar PV deployment?	Understand interviewee knowledge of the subject matter
4	What opportunities does the concept present?	Facilitate understanding of the sustainable energy development opportunities presented by the concept Identify links to formal and informal institutions and subsequently legitimacy and social acceptance of the innovation
5	What factors do you consider to be critical to the expansion of the concept, including barriers to be overcome?	Facilitate understanding of the critical success factors and potential barriers to the expansion of the concept Identify links to formal and informal institutions and subsequently legitimacy and social acceptance of the innovation Indicators of institutional isomorphism in electricity generation and oil and gas industries
6	According to literature, actual or perceived site contamination is a critical barrier to brownfield redevelopment due to potential risk and liability. From your perspective, what is required to address this barrier?	Facilitate further understanding of a critical barrier identified in literature

	Question	Purpose/Link to Conceptual Framework
7	What existing policy and regulatory frameworks in Alberta support the expansion of the concept of re-purposing abandoned, unreclaimed (inactive) oil and gas sites for small-scale solar PV deployment? Constrain?	Investigate influence of formal institutions on legitimizing the concept, also on social acceptance
8	What existing processes support local acceptance of the concept? Any weaknesses or gaps?	Investigate role of institutions in supporting community acceptance as a measure of legitimacy
9	Looking outside of policies, regulations, and processes, what informal activities are occurring that support the expansion of the concept?	Investigate role of informal institutions in developing legitimacy for the concept Investigate potential sustainable entrepreneurial strategies related to promoting legitimacy of the concept
10	Can you please help me identify other individuals that are key to the expansion of the concept?	Facilitate snowball sampling
11	Can you recommend any public documents that can provide me with additional information regarding the opportunities and barriers impacting the concept?	Facilitate snowball sampling

Note: “concept” refers to the re-purposing unreclaimed (inactive) oil and gas sites in Alberta for small-scale solar PV deployment

(Author, 2020)

Appendix B: Summary of Documents Analyzed

No.	Medium	Date	Title	Citation	Focus or Main Topic
1	Newspaper Article	01-May-20	How Alberta could give old wells new life - but it has nothing to do with crude	Seskus, 2020	Re-purposing orphan and inactive wells in Alberta for other energy uses
2	Newspaper Article	18-Feb-20	In Alberta, abandoned oil wells are being transformed into solar energy sites	Graney, 2020	Pilot project in Taber to re-purpose oil and gas wellsite for solar PV
3	Web Article	10-Dec-19	Alberta company harnesses the sun to fuel well site operations	Canadian Energy Centre, 2019	Using solar to power existing wellsites
4	Regulatory Newsletter	01-Jun-20	Meet the New Neighbours: Solar energy companies are moving on to old oil and gas sites to save money and land	Doane, 2020	AER expressing general support for the concept, confirming contamination remains responsibility of licencee
5	Government Guideline	14-Aug-17	Renewable Energy in Alberta	Farmers' Advocate Office, 2017	Guide to assist rural landowners in negotiating wind and solar leases

No.	Medium	Date	Title	Citation	Focus or Main Topic
6	Regulatory Directive	04-Oct-17	Wildlife Directive for Alberta Solar Energy Projects	Government of Alberta, 2017c	Wildlife Directive for solar energy developers - standards and best practices
7	Policy Document	2020	Budget 2020 - Government of Alberta - 2020-2023 Alberta Energy Business Plan – Energy	Government of Alberta, 2020a	Current Business Plan for the Government of Alberta Ministry of Energy
8	Policy Document	2020	Budget 2020 - Government of Alberta - 2020-2023 Alberta Environment and Parks Business Plan	Government of Alberta, 2020b	Current Business Plan for the Government of Alberta Ministry of Environment and Parks
9	Policy Summary	No Date	Renewable energy legislation and reporting	Government of Alberta, n.d.-d	Summary of 30% by 2030 renewable energy generation goal, supporting legislation and how progress is tracked

No.	Medium	Date	Title	Citation	Focus or Main Topic
10	Blog Post	2019-Apr-18	Alberta Election 2019: The UCP has Concluded that Alberta's Renewable Electricity Program (REP) is a Costly Subsidy	Howie, 2019	Summary of United Conservative Party political platform on renewables, specifically the Renewable Electricity Program
11	Stakeholder Workshop Report	2020	Novel land and wellsite reclamation: Integrating emerging technologies to enhance environmental management of legacy assets	CRIN, 2020	Summary of workshop held in November 2019 exploring novel oil and gas reclamation including re-purposing
12	Regulatory Review	29-Dec-17	Alberta Electric Distribution System-Connected Generation Inquiry Final Report	AUC, 2017	AUC Inquiry into distributed generation to support Alberta's 30% by 2030 renewable energy objective

No.	Medium	Date	Title	Citation	Focus or Main Topic
13	Regulatory Report	17-Oct-19	Alberta Electric System Operator 2019 Long-term Outlook	AESO, 2019	AESO forecast of provincial load and generation requirements over the next 20 years to guide transmission system planning, long-term adequacy assessments and market evaluations
14	Regulatory Review Proceeding Transcripts	31-Oct-19	Proceeding 24116: Distribution System Inquiry - Technical Conference, September 10-12, 2019	AUC, 2019b	Module One Technical Conference Notes on 7 topics related to Alberta's Distribution System: Topic 1 and 2
15	Regulatory Review Proceeding Transcripts	31-Oct-19	Proceeding 24116: Distribution System Inquiry - Technical Conference, September 10-12, 2019	AUC, 2019c	Module One Technical Conference Notes on 7 topics related to Alberta's Distribution System: Topic 3 and 4
16	Regulatory Review Proceeding Transcripts	31-Oct-19	Proceeding 24116: Distribution System Inquiry - Technical Conference, September 10-12, 2019	AUC, 2019d	Module One Technical Conference Notes on 7 topics related to Alberta's Distribution System: Topic 5 to 7

No.	Medium	Date	Title	Citation	Focus or Main Topic
17	Blog Post	21-Mar-19	How Should We Assess Transmission Upgrades When They are Requested by the DFO?	Bankes, 2019	Review of two AUC Decisions regarding transmission system upgrades requested by DFOs with dissenting opinion
18	Blog Post	02-Jan-20	Alberta's Renewable Energy Conundrum in Charts and Numbers – Why Capacity Factors Matter	A Chemist in Langley, 2020	Blog post reviewing renewable energy systems in Alberta

(Author, 2020)

Appendix C: Plots Illustrating the RenuWell Project's Five Proposed Pilot Locations

Pilot Location #1 (Approximate)

Figure generated in NREL PVWatts® Calculator (NREL, n.d.)

Pilot Location #2 (Approximate)

Figure generated in NREL PVWatts® Calculator (NREL, n.d.)

Pilot Location #3 (Approximate)

Figure generated in NREL PVWatts® Calculator (NREL, n.d.)

Pilot Location #4 (Approximate)

Figure generated in NREL PVWatts® Calculator (NREL, n.d.)

Pilot #5 (Approximate)

Figure generated in NREL PVWatts® Calculator (NREL, n.d.)

Appendix D: Calculations and Assumptions

Summary of Energy Generation, Greenhouse Gas Emissions Reduction and Greenfield Land Use Avoidance

Site	Location (Unique Well Identifier) (1)	Site Type	Geographic Coord. (1)	Approx. Area (m^2) (2)	Capacity Factor (%) (3)	Hosting Capacity (kW) (4)	System Capacity (kWdc) (2)	First Yr Energy (kWh) (3)	Emission Offsets Factor (tonnes CO2e per MWh) (5)	First Yr Gross Annual Emission Offsets (tonnes CO2e)	First Yr Emission Offsets Equivalency to # of Passenger Cars Not Used (6)	Lifetime Electricity Generation (kWh) (7)(8)	Lifetime Emission Offsets (tonnes CO2e) (5)(7) (8)(9)
1	16-19-008-17W4	Abandoned Gas Well (Inactive)	49.667, -112.288	8,094	15.1	990	500	660,509	0.57	376	79	14,675,099	6,923
2	12-15-009-17W4	Historical Oil and Gas Site (Orphan)	49.736, -112.237	8,094	15.3	1,516	500	672,028	0.57	383	83	14,931,027	7,043
3	15-10-010-16W4	Abandoned Gas Well (Orphan)	49.813, -112.090	8,094	14.9	15,186	500	653,958	0.57	373	81	14,529,550	6,854
4	14-15-010-15W4	Abandoned Gas Well (Orphan)	49.8277, -111.960	8,094	15.1	3,659	500	662,894	0.57	378	82	14,728,089	6,948
5	12-15-010-15W4	Suspended Gas Well (Orphan)	49.824, -111.966	8,094	15.1	898	500	662,894	0.57	378	82	14,728,089	6,948
	Totals			**40,470**		**22,249**	**2,500**	**3,312,283**		**1,888**	**406**	**73,591,853**	**34,716**

(Author, 2020)

Note: See the next page for Calculation Assumptions

Calculation Assumptions:

(1) Locations provided by K. Hirsche (personal communication, June 1, 2020); Geographic Coordinates obtained from AER GIS Conversion Tool (Alberta Geological Survey, n.d.)

(2) Available disturbed area assumed to be 2 acres (0.8 hectares) per brownfield oil and gas site; system capacity assumed to be 500 kW based on 2 acres (4 acres/MW) (Miistakis Institute, 2017)

(3) Capacity Factor and First Year Energy Generation data derived using NREL PVWatts® Calculator (National Renewables Laboratory, n.d.)

(4) As provided by K. Hirsche (personal communication, June 1, 2020)

(5) 0.57 tonnes CO2e per MWh (Government of Alberta, 2019)

(6) Total Passenger Vehicles calculated using EPA Greenhouse Gas Equivalencies Calculator (United States Environmental Protection Agency, 2018)

(7) 1% degradation rate (Jordan & Kurtz, 2012)

(8) 25 year lifespan (Jordan & Kurtz, 2012)

(9) 1.7% compound annual decline rate of Alberta grid emissions intensity (Canadian Energy Research Institute, 2015)

Appendix E: Summary of Coded Themes

Major Category	Category	Name	Effect of Factor on Concept	Count of Files	Count of References
Industry Mindset (Isomorphism)	Other	Need for Collaboration and Data-Sharing	Gap	9	32
Industry Mindset (Isomorphism)	Isomorphism	Indicators of Isomorphism in Power Generation Industry	Constraining	10	26
Industry Mindset (Isomorphism)	Isomorphism	Indicators of Isomorphism in Oil and Gas Industry	Constraining	5	15
Industry Mindset (Isomorphism)	Isomorphism	Mismatched Pace Between Power Generation and Oil and Gas Industries	Constraining	4	6
Industry Mindset (Isomorphism)	Formal Institution	Execution of Site Rehabilitation Program	Gap	4	5
Landowner and Local Support	Informal Institution	General Municipal Support	Supportive	7	18
Landowner and Local Support	Informal Institution	Landowner Interest	Supportive	10	15
Landowner and Local Support	Formal Institution	Lack of Orphan Renewables Framework	Gap	6	12
Landowner and Local Support	Informal Institution	Landowner frustration due to inactive O&G	Constraining	4	6
Landowner and Local Support	Formal Institution	Lack of Standardized Leasing for Solar Installations - RenuWell developing template	Gap	1	6
Landowner and Local Support	Informal Institution	Local Support	Supportive	4	5

Major Category	Category	Name	Effect of Factor on Concept	Count of Files	Count of References
Landowner and Local Support	Formal Institution	Municipal Framework for Implementation in Development	Supportive	4	4
Landowner and Local Support	Informal Institution	Growing Value of Energy Independence	Supportive	3	4
Project Economics	Formal Institution	Uncertainty of DTS Credits	Constraining	7	18
Project Economics	Formal Institution	Interconnection Process and Costs	Constraining	8	15
Project Economics	Other	Investment interest in Micro-generation and Distributed Generation	Supportive	7	15
Project Economics	Other	Unclear Mechanism and Economics	Constraining	6	12
Project Economics	Other	Uncertainty of Costs for Distribution System Upgrades	Constraining	3	9
Project Economics	Formal Institution	Substation Cost Fractioning	Constraining	4	7
Project Economics	Other	Decreasing Costs of Solar PV Infrastructure	Supportive	6	6
Project Economics	Other	Limited Economic Value from Micro-generation; Personal Values-driven	Constraining	1	3
Project Economics	Formal Institution	Clean Energy Improvement Program	Supportive	2	3
Project Economics	Formal Institution	Depreciation Tax Credit - 100% Yr 1	Supportive	1	1

Major Category	Category	Name	Effect of Factor on Concept	Count of Files	Count of References
Provincial Policies and Strategies	Formal Institution	Lack of Government Incentives for Solar PV Installation	Gap	12	25
Provincial Policies and Strategies	Informal Institution	Level of Jurisdictional Green Commitment	Constraining	5	11
Provincial Policies and Strategies	Formal Institution	Provincial Ministry Strategies and Objectives	Supportive	3	6
Public Sentiment	Informal Institution	Alberta Mindset of Renewable Energy Competing with Non-renewable Energy	Constraining	3	7
Public Sentiment	Informal Institution	Growing Interest in Renewable Energy Development	Supportive	5	6
Public Sentiment	Informal Institution	Motivation to Address Inactive Wells Issue	Supportive	2	5
Public Sentiment	Informal Institution	Pro Development Ethos	Supportive	2	3
Regulatory Structure	Formal Institution	Micro-generation Regulation	Supportive	7	16
Regulatory Structure	Formal Institution	Moratorium on Development of Solar PV on Crown Land	Gap	6	13
Regulatory Structure	Formal Institution	Multiple Regulators and Jurisdictions	Constraining	4	11
Regulatory Structure	Formal Institution	Regulatory Changes Required	Constraining	8	11
Regulatory Structure	Formal Institution	Aggregation for Emissions Performance Credits	Supportive	4	9

Major Category	Category	Name	Effect of Factor on Concept	Count of Files	Count of References
Regulatory Structure	Formal Institution	Ease of Micro-generation System Deployment less than 1 MW	Supportive	7	8
Regulatory Structure	Formal Institution	Municipal Taxation Structure for Renewables Varies Across Municipalities	Gap	3	5
Regulatory Structure	Formal Institution	Current Hearings and Inquiries - Power Generation Industry, Grid Modernization	Constraining	3	4
Regulatory Structure	Formal Institution	Deregulated Electricity Markets, Energy-Only	Supportive	3	3
Regulatory Structure	Formal Institution	Small Scale Generation Regulation	Supportive	2	3
Regulatory Structure	Formal Institution	Overlapping Exemption and SED 002	Supportive	2	2
Regulatory Structure	Formal Institution	AEP Wildlife Directive	Supportive	1	1
Regulatory Structure	Formal Institution	Conservation and Reclamation Regulation	Supportive	1	1
Regulatory Structure	Formal Institution	Contaminated Sites Policy Framework	Supportive	1	1
Spectrum of Ease of Deployment	Formal Institution	Environmental Liability	Constraining	10	21
Spectrum of Ease of Deployment	Other	Site Availability for Re-Purposing	Supportive	9	16
Spectrum of Ease of Deployment	Other	Unique Site Characteristics	Constraining	7	13
Spectrum of Ease of Deployment	Other	Ease of Re-Purposing for Solar PV	Supportive	8	12

Major Category	Category	Name	Effect of Factor on Concept	Count of Files	Count of References
Sustainable Benefit	Sustainable Benefit	Mitigate Cumulative Effects of Greenfield Land Use	Supportive	13	22
Sustainable Benefit	Sustainable Benefit	Infrastructure Re-Use, Cost Savings	Supportive	11	19
Sustainable Benefit	Sustainable Benefit	Address Inactive Oil and Gas Site Closure Liability	Supportive	7	15
Sustainable Benefit	Sustainable Benefit	Benefits to Landowners	Supportive	6	9
Sustainable Benefit	Sustainable Benefit	Additional Public Revenue Source	Supportive	8	8
Sustainable Benefit	Sustainable Benefit	Mitigate Increasing Transmission & Distribution Costs	Supportive	5	6
Sustainable Benefit	Sustainable Benefit	Reduce Greenhouse Gas Emissions	Supportive	5	5
Sustainable Benefit	Sustainable Benefit	Hedge Against Future Electricity Prices	Supportive	3	5
Sustainable Benefit	Sustainable Benefit	Grid Stabilization from Incremental Distributed Generation	Supportive	4	5
Sustainable Benefit	Sustainable Benefit	Leverage Existing Skillsets	Supportive	5	5
Sustainable Entrepreneurship	Informal Institution	Champions	Supportive	7	11
Sustainable Entrepreneurship	Other	Sustainable Entrepreneurship Activities	Supportive	4	6

(Author, 2020)