FROM BROWN TO BRIGHT -

THE DEVELOPMENT OF RENEWABLE ENERGY ON MARGINALIZED LAND

By

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Author's Declaration

I hereby declare that I am the sole author of this dissertation. My supervisor Dr. Christopher De Sousa has contributed to this manuscript-style thesis insofar as he co-authored a manuscript that was published in the *Journal of Environmental Policy & Planning*, a peer-reviewed journal. The manuscript corresponds to chapter 6 and his research advice and thorough revisions merited his co-authorship.

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Title: From Brown to Bright: The Development of Renewable Energy on Marginalized Land

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ABSTRACT

Most post-industrialized countries are experiencing marked changes in the reutilization of land and the generation of electricity. On the one hand, the redevelopment of previously developed and potentially contaminated lands, so-called brownfields, has led to urban revitalization, rural wasteland recycling, as well as an increased protection of greenfields. On the other hand, the rapid growth of renewable energy installations has contributed to a more diverse, more distributed, and cleaner energy mix, albeit often on greenfield land. While brownfield redevelopment and 'conventional' green energy address land reuse and sustainable energy goals independently, brightfields could kill two birds with one stone. This nascent concept has thus far produced a scant amount of literature, regarding site typology, policy support and its barriers. This research addresses these significant gaps in the literature.

The typology or former land use of existing brightfields is examined in an international context, finding that Canada has so far few 'true' brightfields, while the United States and Germany can boast hundreds of projects. The brightfields in the United States seem to have a 'type, as the majority are located on landfills, while ex-military sites are the dominant former land use of so-called *Konversionsflächen* in Germany.

The examination of technical, regulatory, financial and social barriers to the implementation of brightfields constitutes a large contribution to the literature. It provides a useful insight into the challenges to develop brightfields and shows that its barriers are not simply the sum of brownfield and renewable energy barriers.

Lastly, this research finds that different types of brownfield owners may have different agendas and site selection priorities, which are not reflected in current site selection tools and a more context-dependent site identification tool is created using Analytical Hierarchy Process.

This dissertation presents original research that contributes to the understanding of brightfields and its literature. It analyses brightfield typology and support in an international environment, their advantages and disadvantages, while also providing a practical tool for brownfield owners to identify and compare candidate sites. By doing so, this research provides a significant contribution to this emerging field of study.

Acknowledgements

I would like to express my gratitude to my Supervisor at Ryerson University Dr. Christopher De Sousa for all his help and shared passion for the subject. This thesis and indeed my time at Ryerson would not have been possible, enjoyable and successful was it not for Chris. I feel privileged to have had him as a supervisor throughout this time.

I am also very thankful for the continuous support from all members of my Candidacy Committee, namely Dr. Corey Searcy, Dr. Ronald Pushchak, Dr. Gideon Woolfardt from Ryerson University along with Dr. Jose Etcheverry from York University. Later on, but with equal enthusiasm and support, Dr. Dan McGillivray, from the Centre for Urban Energy, joined my Defence Committee for which I am truly grateful. The CUE has also provided me with assistance throughout my PhD, as well as the opportunity to immerse myself into their wealth of knowledge via multiple internships. For this I am very grateful and would like to thank Birendra Singh in particular.

I would like to express my gratitude to Dr. Sarah Coffin from Saint Louis University for her expertise and insight that was invaluable to the completion and quality of this thesis. While protected by anonymity, to all the survey participants in Canada, Germany and the U.K, I am grateful for their contributions. In particular, I would like to express my gratitude to Michael Kraljevic (Director of Toronto Portlands Company) and David Kusturin (Chief Operating Officer at Waterfront Toronto) for their participation in the AHP interviews, as well as Hon Lu for providing me technical assistance and data on TPLC properties. I would also like to thank Dr. Liping Fang for his help regarding the Analytical Hierarchy Process, the Federation of Canadian Municipalities for providing me vital information on financial support for brown-brightfields and Robert Willes from ArcStar Energy and Adam Klinger from the U.S. EPA for their technical expertise.

Last, but certainly not least, I would like to thank my family and my friends at Ryerson: Dragan Miscevic, Nick Dimas, Paul Proios, Hirak Saxena, Waad Khogali, Brian Moroz and of course Amanda Wilson for their continued support.

Dedication

I would like to dedicate this dissertation to my loving parents who inspired and empowered me to go my own way and whose support and dedication made it possible.

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LIST OF ACRONYMS

Ac = acres
AC = Alternating Current
AHP = Analytical Hierarchy Process
ANP = Analytical Network Process
CERCLA = Comprehensive Emergency Response, Compensation, and Liability Act
CERCLIS = Comprehensive Environmental Response, Compensation, and Liability Information System
DC = Direct Current
DG = Distributed Generation
EPA = Environmental Protection Agency
FCSI = Federal Contaminated Site Inventory
GAO = General Accounting Office
GMF = Green Municipal Fund
IPCC = International Panel of Climate Change
kW = kilo Watt
LEED = Leadership in Energy and Environmental Design
LULU = Locally Unwanted Land Use
MAH = Municipal Affairs and Housing
MCDM = Multi Criteria Decision Making
MW = Mega Watt
NIMBY = Not In My Back Yard
NMP = Net Metering Program
NREL = National Renewable Energy Laboratory
NRTEE = National Round Table on the Economy and the Environment
FCM = Federation of Canadian Municipalities
PPP = Polluter Pays Principle
RPS = Renewable Energy Portfolio Standards
RSC = Record of Site Condition
FIT = Feed in Tariff
SOP = Standard Offering Program
PV = Photovoltaic
PW = Peta Watt
REPALI = RE-Powering America's Land Initiative
RESOP = Renewable Energy Standard Offering Program
CSP = Concentrated Solar Power
SARA = Superfund Amendment and Reauthorization Act
Tx = Transmission line

CHAPTER 1: INTRODUCTION

1.1. Introduction

Canada, the United States, Europe and a plethora of countries beyond have been experiencing striking changes in the reutilization of land (see McCarthy, 2002; Moss, 2003), as well as the generation of electricity (see Lean and Smyth, 2013). Globally, the rate of new renewable energy installations is increasing rapidly (see Figure 1.1) and surpassed conventional energy implementation in 2014 (Cox, Walters and Esterly, 2015). The deployment of wind and solar is exemplary; from 2011 to 2035 solar PV and wind energy capacity is expected to grow from 67 to 600 Giga Watt (GW), and 238 to 1100GW, respectively (IEA, 2012). Like conventional (i.e. fossil based) energy plants however, renewable energy infrastructures can require an equally significant land-use-footprint. Solar PV for instance may occupy even larger parcels of land compared to some fossil-based or non-renewable electricity generators, such as coal or nuclear energy (see Table 1.1). The footprint of any energy plant can impact agricultural productivity for example, but also be detrimental to ecosystems due to habitat fragmentation. From a "land ethics"[1] perspective, the introduction of energy installations may also be detrimental to the intrinsic value of the perceived landscape and have a negative impact on the historic continuity (see Barry, 1995) and irreplaceable character of the landscape. The footprint does however depend on the technology used. Consequently, land has become a scarce resource, especially in smaller and already densely populated areas like the United Kingdom. Subsequently, finding appropriate locations for the siting of renewable energy infrastructure is challenging, given high land costs, the augmented desire to protect greenfields[2] (from renewable energy installations), as well as the want for distributed generation of electricity.

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[1] Aldo Leopold (1949)

[2] Greenfields can be described as lands which have not been previously developed industrially or commercially, but that at some point may have been or are currently used by the primary sector, for landscape design or left to evolve naturally. Greyfields are derelict urban real estate assets and are here seen as a sub-group of brownfields and considered for brightfields in the urban area.

At the same time, marginalized lands like brownfields are still aplenty, despite notable redevelopment efforts in North America and Europe. The literature defines brownfields as potentially contaminated sites that are currently underused or abandoned, afflicted by either real or perceived contamination, but with an active potential for redevelopment (see Wernstedt, Meyer, Dixon, Yount and Basu 2007; De Sousa, 2000; De Sousa and Spiess, 2014; Alker, Joy, Roberts and Smith, 2000). The reuse of abandoned urban and rural properties, such as brownfields, has led to a practice of urban revitalization, rural marginalized land recycling, as well as an increased protection of greenfields and the preservation of arable lands (Adams and Watkins, 2008; De Sousa, 2000). Dorsey (2003) estimates that every acre of brownfield reuse helps preserve up to 4.5 acres of greenfields. Despite these successes, many of the estimated over 3.5 million sites in North America, Europe and elsewhere remain more or less vacant (Holstenkamp and Degenhart, 2011; Vanheusden, 2007; CABERNET, 2006). Meanwhile, greenfields continue to be consumed by urban and energy sprawl with negative effects on climate change (e.g. reduction of carbon sink) as well as the ecological health (e.g. habitat fragmentation and land use change).

The conversion of brownfields into so-called brightfields could kill two birds with one stone, by combining sustainable brownfield reuse and renewable energy generation (see Figure 1.2) (Adelaja Shaw, Beyea and McKeown, 2010). The concept of brightfields goes back to the 1999 U.S. *Brightfield Initiative's* plan to convert "contaminated sites into usable land by bringing pollution-free solar energy and high tech solar manufacturing jobs to these sites" (White House, 1999). The initiative claims that brightfields "address three of the […] greatest challenges: Climate Change, urban revitalization[3], and toxic waste cleanup" (ibid.). Based on a concept later on developed by the U.S. Environmental Protection Agency (EPA), the idea behind brightfields is to leverage brownfield attributes, such as frequently existing infrastructure (such as roads or the grid), their proximity to consumers and appropriate zoning.

[3] See Brockton Brightfield (see De Sousa and Spiess, 2013)

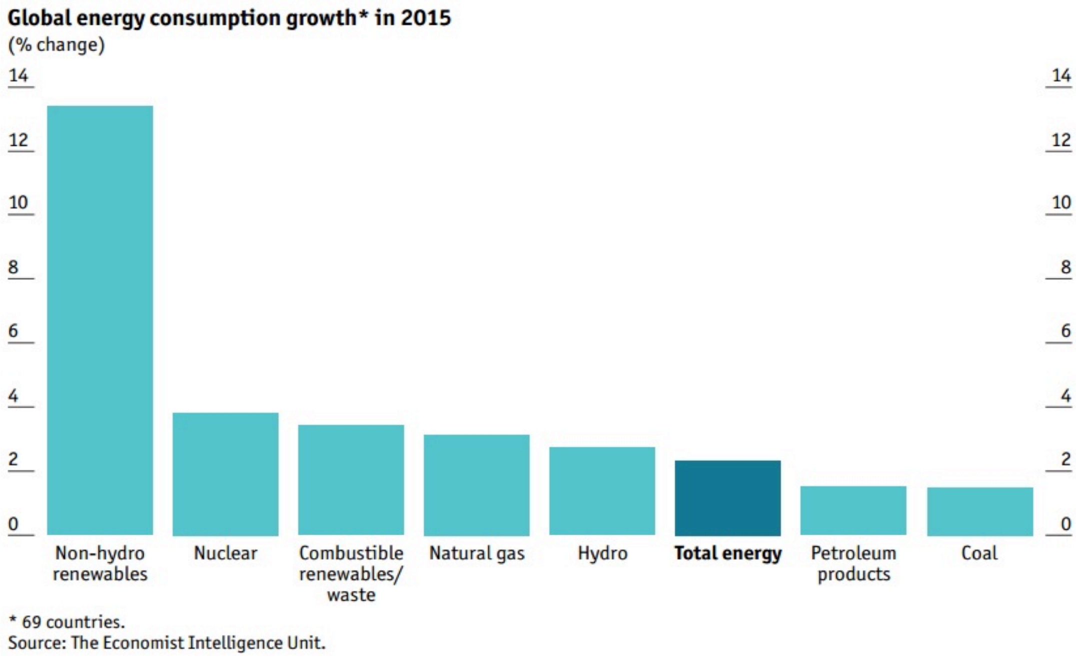

Figure 1.1. Global energy consumption growth in 2015. Non-hydro renewables experienced the highest annual growth rate at 13% per annum compared to petroleum and coal for instance. (The Economist, 2015).

The potential for this type of renewable energy infrastructure remains largely untapped. According to Milbrandt Heimiller, Perry and Field (2014), who suggest that the total amount of green energy produced on marginalized land (not just brownfields)[4] in the U.S. could produce as much as 13.1 PW/h of electricity[5]. Despite this staggering (and unrealistic) claim of the potential, the nascent brightfield literature has so far only produced a small amount of research and little is known about other the concept outside the United States, site typology, the barriers to implementation, as well as means to identify candidate sites.

This dissertation examines the development of brightfields from four distinct, yet interrelated perspectives. *First*, via a multi-country investigation, whose aim is to find out what types of sites (if any) are being used for the development of brightfields in Canada, the United States and Germany. This is a snapshot regarding typology and the extent of implementation as well as capacity. *Second*, via a comparison of the abovementioned countries regarding brightfield policies and whether federal brightfield policies and programs exist or, if not, whether current brownfield and renewable

[4] Brownfields and marginalized lands are used interchangeably, fully recognizing that the latter is an umbrella term.
[5] In 2014, the United States generated about 4,093 billion kWh of electricity (EIA, 2015)

energy policies suffice to support this concept. *Third*, the barriers to the development of brightfields are investigated from a developer's perspective in order to critically review the professed benefits, which have not been subjected to any scrutiny so far. *Finally*, this thesis aspires to find out what drives and motivates private and municipal brownfield owners if they were to develop a brownfield with renewable energy and how the site identification process can be improved amidst multiple siting criteria and priorities.

At its core the brightfield concept could help alleviate the problem of using (semi-) pristine habitat, greenfields and agriculturally valuable lands for the siting of green energy by utilizing already derelict, abandoned yet potentially contaminated lands. Thus, the brightfield concept as well as the body of research presented here, are first and foremost, embedded in the paradigm of and in the greater quest for sustainability. The overarching objective of this research is to help reconcile the human need for energy with the ecological health of the planet (see Harris and Goodwin, 2008) via the development of brightfields.

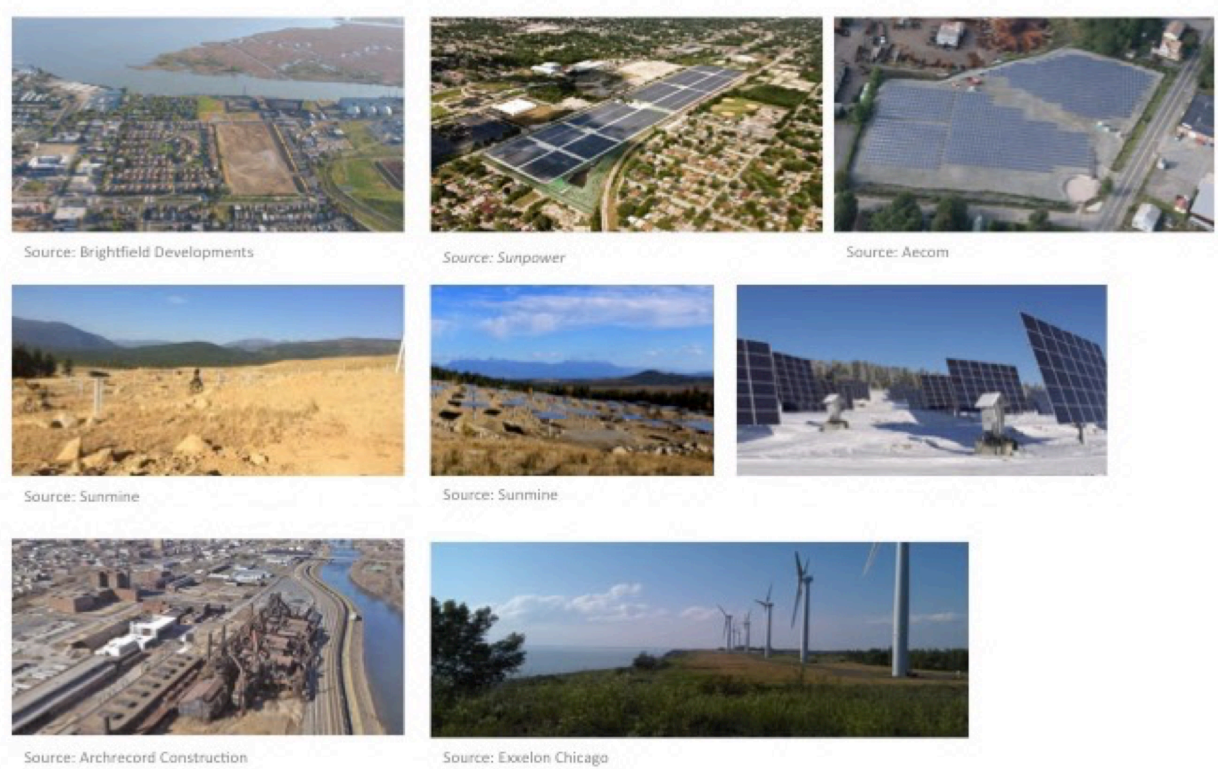

Figure 1.2. Brightfield examples. The first column showcases three examples of brownfields, while the second (third) column illustrates their transformation.

1.2. **Identification of the Problem**

Despite notable efforts in Canada, the United States and Europe to redevelop brownfields, many of the estimated 3.5 million sites in North America[6], Europe and beyond remain derelict and contaminated (Holstenkamp and Degenhart, 2011; Vanheusden, 2007; CABERNET, 2006). As a matter of fact, due to the decline in manufacturing in many industrialized countries, the number of brownfields is still growing globally.

At the same time, agricultural lands, wooded areas and greenfields continue to be consumed by energy installations needed to fuel our societies and economies. This energy sprawl has negative effects on climate change, ecological health, biodiversity, as well as grid resilience. The energy sprawl as defined by McDonald Fargione, Kiesecker, Miller and Powell (2009), is "the product of the total quantity of energy produced annually (e.g., TW hr/yr) and the land-use intensity of production (e.g. km^2 of habitat per TW hr/yr)". In simpler terms, energy infrastructures, especially solar energy farms that have a larger footprint, sprawl into previously pristine or semi-pristine environments, remove habitats and infringe on wildlife. This has had a negative effect on the popularity of some green energy projects and made the quest for siting renewables even more difficult amid public opposition. Tables 1.1 and 1.2 illustrate this 'Energy Sprawl'.

Energy Footprint of Energy Sources

Energy Source	**Footprint** (m^2/GWh)
Geothermal	160-900
Wind (on shore)	1'000
Nuclear	1'200
Solar thermal	3'200
Coal	5'700
Solar PV	7'500
Hydro (reservoir)	200'000
Biomass	460'000

Table 1.1. Energy footprint of selected power generation types. Solar PV requires 7500m^2 per every GWh produced. (Adapted from Smil, 2015).

[6] Mexico not included.

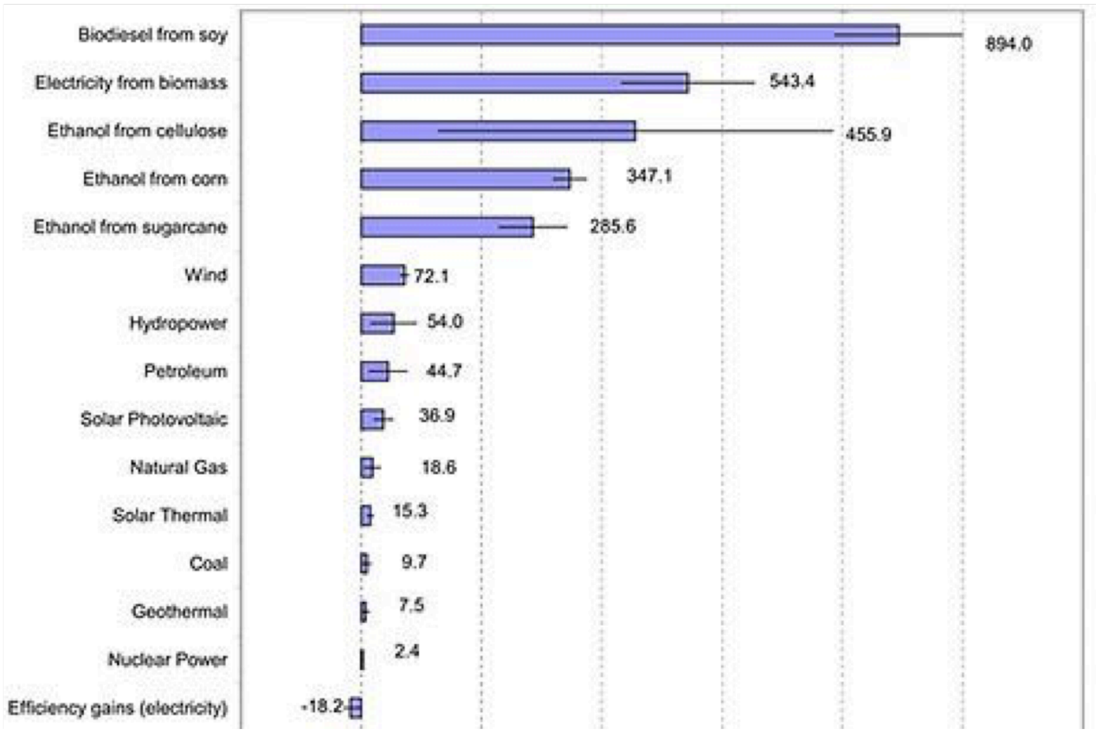

Table 1.2. Estimated land-use intensity by 2030 measures in Km^2/TWh/yr. (McDonald et al., 2009).

The paragraphs below illustrate several particular problems that are consequently addressed in the subsequent chapters. These problems are identified by the author and are the result of gaps in the literature as well as experience and personal conversations with brightfield developers, brownfield researchers and renewable energy experts. By and large, each chapter addresses a specific problem, although some problem(s) span several chapters.

The brightfield concept has only recently gained attention and the academic literature on it is rather scant and geographically unique with the majority of scholarly material coming from the United States. To date, there exists no work examining the typology of properties that are being used for brightfields, despite typology being a common assessment in the brownfield literature. Thus there is no answer to the question of whether this type of development truly is exclusive to the United States or whether other countries with similar brownfield problems are also producing brightfields, and, if so, how many, and what types of land (former land use) is being used? Chapter 4 addresses these problems.

The dearth of international brightfield literature is not only apparent regarding typology, but also policy. Both the brownfield and renewable energy literature has produced a large body of work on how policies support either concept. Apart from legal reviews (see Outka, 2010 and 2011), there is no work that investigates the brightfield program in the U.S., let alone other countries. Further, there is also no academic work to date that compares the U.S. brightfield program/initiative to Germany and Canada in order to see where these two countries stand in relative to one another. Thus, there is no answer to the question of whether countries other than the United States have federal brightfield strategies and policies and what such strategies and policies may look like. Are Canada and Germany advancing this development via federal programs like in the U.S. and if not, how (in the absence of federal nation-wide programs) else is the brightfield idea supported (if it is at all)? The objective of chapter 5 is to address these problems.

The purported advantages of using brightfields over greenfields for generating green electricity are well documented, although be it from non-scholarly sources. To date however, these benefits have not been exposed to any scrutiny. While brightfields are professed to have so-called triple-bottom-line benefits - that is profit, people and planet – no work exists so far that has critically examined these claims and investigated the barriers and challenges to the development of brightfields. Chapter 6 aims to answer these pressing questions.

While there are a number of site screening and evaluation tools examining site identification criteria (such as size, shading, distance to grid etc.) that help assess technical feasibility and economic viability, such tools lack non-technical and non-financial assessment criteria and are void of mechanisms for decision-support. So far, the literature has largely focused on identifying the potential capacity, measuring the Mega Watt peak (MWp) of brightfields on a state or national scale for utility-scale power plants (see Adelaja et al., 2010; Milbrandt et al., 2014). These existing site screening tools have assumed that the brownfields that are considered the 'best' in technical and economic terms are the ones that may be converted into brightfields. This largely ignores that brownfield owners are faced with a plethora of choices, agendas, and non-technical priorities regarding the reuse of brownfields. Chapter 7 aims to address this issue by proposing a site identification support tool that accounts for local context and agendas, as well as the owner's preferences and other[7] development priorities. While this proposed method could be used by both private and public brownfield owners, the author strongly envisages that municipalities may gain a better understanding of the potential of their brownfields and the advantages and disadvantages of brightfields. Coffin (2003) believes that municipalities as well as communities have historically struggled to "understanding the scope and breadth of their brownfield situation" (p. 34). The goal is to provide them an assessment and decision-making (DM) tool.

1.3. Significance and Contribution

The study of brightfields in general is pertinent because it addresses two pressing issues both in applied science and academia. Firstly, the allocation of land for power generation and the reuse of previously developed properties; and secondly, addressing green energy siting constraints and the want and need for more green energy. The following paragraphs explore this study's contribution to applied science and theory.

1.3.1. Applied Science

The combination of brownfield reuse and renewable energy is becoming a more and more common practice in the United States and, as it turns out, has been for some time now in Germany. The study of brightfields is very much applied research as opposed to basic or fundamental research. However, it is far from being called a best practice because of its novelty and because many installations continue to be built on greenfields and agriculturally valuable lands in a larger sense. Nevertheless, brightfields are being implemented using a wide range of technologies that drive innovation in countries like the U.S., Germany, and the Czech Republic et cetera. Identifying barriers and solutions and providing site identification and decision-support tools may contribute to a better understanding of brightfields and how this concept can be applied in practice. The applied science aspect of this research is born out of the desire to reconcile environmental health with the human need for energy. Even though this study is considered applied research, it is still anchored in and contributes to theory where possible.

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[7] Non-technical and non-financial

1.3.2. Theory and Literature

Whereas this research draws on, as well as aims to contribute to a multitude of theories and frameworks, the theory of sustainability is the overarching environment in which this dissertation is embedded. Jenkins (2009) believes that the theory of sustainability attempts to prioritize and integrate social responses to environmental and cultural problems. Sustainability is most famously defined as "the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Bruntland Report, 1987). While the sustainability principle has since been used in a plethora of ways (all related and interconnected) such as business sustainability, ecological sustainability, demographical sustainability and so on, this research adheres most closely to environmental sustainability. The latter involves making decisions and taking actions that are in the interests of protecting the natural world, with particular emphasis on preserving the capability of the environment to support human life via the conservation of our natural resources such as energy and water as well as the reuse of waste (Miller and Spoolman, 2011). By the same token, the combination of land recycling and green energy can be viewed as a part of the greater effort to mitigate the effects of climate change. While the traditional generation of electricity (via the burning of coal, gas, oil, etc.) and its negative impacts on climate change - via the emission of greenhouse gases - are well established, climate scientists have also identified land use change as a major contributor to the anthropogenic changing of global climates (see TEEB Manuel for Cities, 2011). Recycling lands instead of using (semi-) pristine ones for the generation of electricity could therefore mitigate the effects of climate change. Brightfields may become a part of the solution that prevents global mean temperatures from rising further. A more detailed description of different theories is given in subsequent chapters.

1.4. **Research Objectives and Structure of Dissertation**

The objectives of this dissertation are as follows:

- Contribute to the brightfield literature by exploring the current situation pertaining to the development of brightfields, terminology and typology in Canada, the U.S. and Germany (chapter 4);
- Explore how brightfields are supported (via federal programs and policies) in these three countries and determine the differences (chapter 5);
- Determine the barriers and challenges to the development of brightfield as well as the

measures for overcoming these (chapter 6); and

- Determine the motivations for private versus public brownfields owners and provide a priority- based decision-support tool for brightfield site identification (chapter 7).

Overall the objective of this dissertation is to contribute to the establishment of a more profound and rounded brightfield literature. The research presented here goes beyond the existing literature that has been focused on estimating the technical feasibility[8], maximum potential capacity along with capturing the benefits of this type of this marriage between renewables and brownfield redevelopment. Instead, this dissertation aims to expand the brightfield literature from a macroscopic approach to a more refined, microscopic and applicable understanding of brightfields, all the while being more critical compared to previous research.

This dissertation contains 8 chapters. Chapter 1 is the **Introduction,** while chapter 2 contains a comprehensive **Literature Review**. Chapter 3 provides the necessary Background regarding **Definition and Scale**. Chapter 8 is reserved for the overall **Discussion** as well as the final Conclusion. Table 1.3 provides a visual overview of the organizational structure of this thesis.

Chapter 4 examines the current situation in the United States, Canada and Germany with regard to the definition, typology and number of brightfields. Specifically, it aims to answer the following questions:

- How are brightfields defined in the three countries?
- How many brightfields are there approximately in the three countries?
- What is the combined installed peak capacity in each country?
- What type of brownfield is being used for brightfields (i.e. what was their former land use)?

Chapter 5 sheds light on how brightfields are being supported in these three countries and how these approaches are similar or different.

- Are there national brightfield strategies in Germany and Canada, similar to the EPA initiative?
- In absence of such, what individual policies could help the development of brightfields?
- Are these policies present in Germany and Canada and if so, do they apply to brightfields?
- Is there industry support for brightfields in these two countries?

[8] If every single brownfield was to be used for renewable energy (see Adelaja et al., 2010 and Milbrandt et al., 2014)

- How are these policies similar (or different) to one another and compared to the U.S?
- Is there convergence of policies?

Chapter 6 explores the challenges and barriers to the development of brightfields from the perspective of developers.

- What are the technical, environmental, financial, regulatory, institutional and social barriers?
- How can they be overcome?

Chapter 7 aims to provides a multi-criterion decision-making tool that could help identify brown-brightfield properties and investigates how it would differ from a simplified cost/benefit analysis

- What is the motivation for private brownfield owners, what is the motivation for municipalities to hypothetically develop a brightfield?
- Can AHP be used to identify brightfield candidate sites?
- How does the AHP compare to a cost/benefit analysis?
- What are the benefits and disadvantages of AHP for selecting a brightfield?

The three countries were chosen due to their similarity of their industrial past and subsequent brownfield legacy, leaving behind largely similar types of brownfields both urban and rural ones. Furthermore, these countries all have a strong desire to reuse their brownfields (albeit thus far for varying reasons) as well as increase the amount of green electricity that is being generated.

<table>
<tr><th>Chapter</th><th colspan="2">Framework(s)/ Method(s)</th><th>Data Collection</th><th>Data Analysis</th></tr>
<tr><td>Chapter 4</td><td>Comparison of functional typology</td><td rowspan="4">Literature Review</td><td>Primary and Secondary data</td><td>Quantitative & Qualitative</td></tr>
<tr><td>Chapter 5</td><td>Policy Convergence</td><td>Primary and Secondary data</td><td>Qualitative</td></tr>
<tr><td>Chapter 6</td><td>Expert Survey and case study analysis</td><td>Primary and Secondary data</td><td>Quantitative & Qualitative</td></tr>
<tr><td>Chapter 7</td><td>Survey & AHP (MCDM)</td><td>Primary and Secondary data</td><td>Quantitative</td></tr>
</table>

Table 1.3. Overview of the objectives, methodological approaches used to meet the objectives as well as data collection and analysis tools used.

1.5. **Contributions of Authors**

This statement of ownership confirms that Thierry Spiess is the sole author of this dissertation and the principal investigator and author of the chapters and corresponding manuscripts listed below. Dr. Christopher De Sousa has contributed to this manuscript-style thesis insofar as he co-authored a manuscript that corresponds to chapter 6; his research advice and thorough revisions merited his co-authorship.

- Chapter 4 is currently under review in *Energy Studies Review;*
- Chapter 5 is currently under review in the *Journal of Environmental Planning and Management;*
- Chapter 6 has been published in *Journal of Environmental Planning and Policy;*
- Spiess, T., & De Sousa, C. (2016). Barriers to Renewable Energy Development on Brownfields. *Journal of Environmental Policy & Planning*, 1-28.
- Chapter 7 is currently under review in *Journal of Environmental Informatics*.

CHAPTER 2: LITERATURE REVIEW

Epistemologically, the brightfield concept is located at the intersection of brownfields and renewable energy. Thus, the vast scope of these two disciplines, paired with the novelty of their marriage demands a very comprehensive literature review and therefore deserving of its own chapter.

The main goal of this literature review is to shed light on the evolution of the early brownfield literature - which in fact predates the coining of the term - towards the emergence of the brightfield concept, as well as the various tangents that make up this body of research. Although this research was born out of equal interest in both brownfields and renewable energy, the former is the vessel for this unique type of development and is what separates 'conventional' renewable energy projects from brightfields.

Thus, by and large this research constantly intersects the development of brownfields and the development of renewable energy. As a result of this, the literature and this very research encompasses a broad spectrum of disciplines and bodies of work that are being explored here such as the definition of brightfield, scale and typology, site contamination, risk and liability, public opposition, as well as barriers and challenges for brownfields and renewables. The methods and frameworks of analysis also necessitate the exploration of literature related to convergence, survey research or multi-criteria decision analysis.

2.1. **The Evolution of the Brownfield Literature**

Literature on what now are brownfields is far from being new. Works by Waldstein (1987), Frost (1988), Parry and Bell (1987), Corash and Lawrence (1989) or Chalmers and Roehr (1993) shed light on some of the earlier deliberations of the subject, mainly focusing on and using the language of contaminated sites. This coincides with the occurrence and media coverage of 'man-made' disasters and their repercussions on human, animal and ecological well-being, as well as a focal point on the environment in a larger sense. Dales (2002) highly cited "Pollution, property and prices" (originally published in 1986) illustrates this focus of early contamination literature insofar as the consensus was that technical solutions to pollution were never going to be good enough. Dales (2002) was one of the first who pointed towards now well-established policy solutions such as pollution trading or cap and trade. It is important to note that the early *first generation* literature reported mostly on properties and events with a truly apparent and widespread contamination, an inheritance from the Love Canal disaster (see Beck, 1979) or the Three Mile Island scare and its ramifications in American civil society (see Walsh, 1981).

However, in the 1990s, a new genre came into being with the inception of the term 'brownfield'. It marked the beginning of a focal shift away from the source of contamination (see Johnson, 1979; Nriagu and Pacyna, 1988) and environmental impact (see Håkanson, 1980), towards dealing with the aftermath (i.e. remediation) and especially the reuse of vacant property (see Tondro, 1994; Meyer, Williams and Yount, 1995; Pepper, 1997, 1998).

In 1993, the White House launched the *Brownfield Initiative*. The Clinton-Gore administration (1993-2001) alone had leveraged more than $2.3 billion in private sector investment, and generated 6'400 jobs through the brownfields redevelopment initiative[9]. Thus naturally, the brownfields literature expanded rapidly in the late 1990s as a result of this success and researchers sought to better understand the issue, its scale, and the key barriers to reuse. At first, these *second generation* researchers were chiefly concerned about where public and private responsibilities lie with the mess that these on-site activities had left behind, hence the focus on government responsibility and legal liability (see Maldonado, 1996; Dixon, 2000; Koch, 1998). The latter has perhaps been the most contentious of all brownfields issues; that is, who is liable for the cleanup of a site? How should liability be imposed and assigned? Yet, as the ability to manage risks and liability improved – in great part due to the creation of federal and provincial/state incentive programs and amendments to previously impeding regulations - so did the industry's focus. The latter emphasized the potential end-uses for these properties and definitively shifted their perception of hazardous liabilities to veritable land resource opportunities (see Tondro, 1994; Yount and Meyer, 1994; Koch, 1998; Greenberg et al., 2001).

That does not mean that liability is not still a concern, and because it is still a liability-laden environment, brightfields have been the topic of several legal works, such as Outka's legal reviews on the use of brownfields regarding the footprint of renewables (2011) and regulatory analysis (2010), Alberini et al. (2005) analysis of the role of liability, or Collins and Savage (1998) review of the regulatory landscape pertaining to brownfield liability.

Kirkwood's (2001) conceptual framework, based largely on the U.S. experience, explains how the theory and practice of brownfield redevelopment has evolved and converged in many important and progressive ways. This evolution has come about in three phases; with phase one

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[9] http://clinton5.nara.gov/WH/Accomplishments/eightyears-08.html

experiencing a theoretical and practical focus on the science of environmental cleanup spurred by pollution disasters in the late 1970s. This was followed by a second phase beginning in the late 1980s, with a theoretical focus on economic development and a practical focus on brownfield redevelopment aimed at building up the economic base of communities that ultimately led to new federal policy efforts in the 1990s. In the third and most recent phase, Kirkwood (2001) claims that the practice of brownfield redevelopment has not yet caught up with the theory, which has become situated in integrated planning models that stress wider regional concerns.

2.1.1. From Burden to Opportunity

The interest of developers and site owners shifted towards the practical reuse of brownfields and investment opportunities; research soon followed suit with what can be called *third generation*[10] researchers such as work by Cunningham (2002) or Meyer and Van Landingham (2000) and many others. Adams, De Sousa and Tiesdell (2010) remarked that this conceptual shift also took root in brownfields policy that went from regarding those sites as a 'problem' to viewing them as an 'opportunity'. Genske and Hauser (2003) as well as Knill (2004) also believe that brownfields are an opportunity rather than a burden and speak of "*Brache als Chance*". Waldis (2009) even speaks of a paradigm shift regarding the perception of brownfields, although be it in Germany only.

As a result of this new perception, the target audience also shifted away from policy-makers and the legal circles towards communities. Work published by Bartsch and Collaton (1996 and 1997) at the Northeast-Midwest Institute for instance targeted local economic development officials and identified the economic development and environmental cleanup opportunities associated with brownfields reuse (see also Paull, 2008) as well as the regulatory programs supporting these efforts, producing a slew of case studies of successful projects. The practice-oriented guide written by Simons (1998) published by the Urban Land Institute, also targeted community officials and developers. That is not to say that this shift in perception was exclusive to research on community improvement, as several popular books by Rafson and Rafson (1999), Russ (2000), and Davis (2002) were published to familiarize consultants, engineers, architects, lawyers, and other practitioners with the benefits surrounding brownfield redevelopment.

Nevertheless, communities became the new focal point of brownfield research. The United States Conference of Mayors, the official nonpartisan organization of cities with populations of more

[10]It is vital to note that there is considerable overlap of the three generations, both regarding context and chronology!

than 30’000 inhabitants and a champion of brownfield research, has produced one of the most influential series of publications on brownfields. The organization began conducting research on brownfields as early as1993, when a group of Mayors led by Chicago Mayor Richard Daley started working more closely with the U.S. EPA on brownfields. This body has since produced a series of regular publications outlining the status of brownfields throughout the country in the so-called National Report on Brownfields Redevelopment (2000) and best practice case studies in the series Recycling America’s Land (2000). The name of the latter production may have inspired the EPA’s RE-Powering America’s Land Initiative.

Having educated a broad audience on what brownfields are and their important role in community renewal, the academic community expanded its reach and began introducing brownfields into a host of other disciplines. A handful of studies examined the reuse of brownfields for housing development, which originally received less attention than commercial and industrial reuse, favoured for its employment-oriented outcomes (see Barker, 2004; Adams and Watkins, 2008; Ganser, 2008; Dixon and Adams, 2008). In the U.S., Greenberg (2002) presented solid arguments both for housing (i.e. affordability) and against it (e.g. risks of substandard redevelopment). Examining the controversy related to the location of housing on brownfields and examining the interests of diverse stakeholders, Adams and Watkins (2008) concluded that setting ambitious goals for residential brownfields redevelopment and pitting brownfields versus greenfields may not be a productive way to achieve sustainable housing (De Sousa and Spiess, 2014). Similar to De Sousa, Wu and Westphal (2009), Leigh and Coffin (2005) also examined property values surrounding brownfields, showing that brownfields (listed or potential) decrease housing values.

At the same time, the question arose whether brownfield redevelopment is an economic stimulus or a waste of the taxpayer’s money. Thus, brownfields became an increasingly popular topic among economists (see Allardice, Mattoon and Testa, 1995; Meyer and Estrin, 2001; Schoenbaum, 2002). Research by Meyer and VanLandingham (2000) and Leigh and Coffin (2005) explored the relationship between economic growth (or lack thereof) and brownfield redevelopment and the marketability of brownfields. Leigh and Coffin (2005) found that marketability and property values are also influenced by the negative social stigma of brownfields and that developers tend first to develop the properties that promise the best economic return in what is called a ‘creaming process’.

Another newly entered disciplines in that regard is environmental justice. Up until 2000, social issues surrounding brownfields were acknowledged, but received no or little attention.

Environmental justice, by definition, calls for no community to be subject to a disproportionate amount of environmental hazards. Popularity of the issue helped spark interest in brownfields, but remained somewhat peripheral as attention focused on economic development concerns instead (De Sousa and Spiess, 2014). However, in 2003 the Journal of *Environmental Practice* dedicated a special issue on brownfields and environmental justice, stressing the popularity and importance of the issue. Brownfields can often be found in low-income, low employment and coloured neighbourhoods, which represents an additional and unequal burden for its residents (Miller, Davidson, Lange, Meyer and Grelli, 2011; Rowan and Fridgen, 2003; Davies, 1999; Coffin, 2003, Cuba, 2003). Although surveys show that residents desire recreational and cultural facilities (see McCarthy, 2002), but economically starved neighbourhoods may opt for job creation and reduced energy costs instead (see Applegate, 1997). The Brockton (Massachusetts) brightfield offers an ideal example of neighbourhood improvement via the siting of a renewable energy installation that revitalized a marginalized neighbourhood and met several environmental justice goals, such as employment and education (De Sousa and Spiess, 2013). Flynn (2000) acknowledged that "environmental justice is not really about the environment or justice, but about community empowerment" (p. 51), rendering brown- and brightfield redevelopment a potential means for environmental justice. Rowan and Fridgen (2003), Applegate (1997) and Felten (2005) have also produced work on the subject of brownfield redevelopment as an opportunity to improve disadvantaged neighbourhoods. However, Davies (1999) points out that brownfield redevelopment only coincides with environmental justice goals if the issue of contamination is addressed. Environmental justice demands an active public participation. While in the past, developers "viewed community involvement as an impediment that added time and effort [...] early involvement of the community can help foster understanding and consensus and prevent protests and litigation" (McCarty, 2002, p.294).

In the context of brightfields, siting renewable energy infrastructures on brownfields can be regarded as a means to right the environmental wrong caused by the burden of previous or current hazardous activities and years of subsequent negligence. However, the benefits of renewable energy, which may apply to the public at a larger (and more distant) scale, may not always be perceived as such by the people that may have been the original beneficiary (Cowell, Bristow and Munday, 2011; Devine-Wright, 2005). Therefore, residents surrounding a brightfield must actively participate in the facility siting process in order to maximize the benefits for the local community such as job creation and remediation. McCarthy (2002) argued that (traditional) brownfield redevelopment has to achieve "broader community goals, such as environmental health and safety, job creation, urban revitalization, community involvement and greenfield preservation" (p. 294).

Environmental justice by and large goes hand in hand with sustainability. The contribution of brownfields redevelopment to sustainability can be two-fold; first by siting renewable energy and generating zero carbon electricity; and second by conserving the carbon sink of a greenfield. The removal of contamination and neighbourhood blight is desirable, but is an environmental justice issue and not a sustainability concern (De Sousa and Spiess, 2014). Inevitably, scholars wanted to investigate the benefits of using brownfields as opposed to greenfields (see Dorsey, 2003; Catney, Lerner, Dixon and Raco, 2008; Sarni, 2010; Greenstein, Rosalind, and Yesim Sungu-Eryilmaz, 2004; and Wedding and Crawford-Brown, 2007). De Sousa (2003) for example examined the conversion of brownfield to greenfield in urban environments; the public costs and benefits of doing so (2002) as well as pertaining to the quality of life (2006).

Regarding the use of brownfields for greenspace, Beatley (2000) pointed out that cities like Vienna and Zurich have dedicated 50 % and 25 %, respectively, of the city's land area to green-space, often using brownfield lands. Brownfield greening examples in Western Europe are countless, and a dedication to open space is normal and not limited to a few progressive cities (Beatley, 2000). Lewis (2008) declared that "long before the term 'brownfield' became part of planning jargon, European cities have been dedicating or reusing idle land for open space [...] and have continued to demonstrate a dedication to brownfield-to-greenfield projects" (p. 6). The European desire to reuse vacant land may be correlated to the age of its cities (compared to the 'New World'), which historically have evolved around a nucleus, making them very dense, and city walls often prevented outward sprawling.

The literature has made it apparent that not only the definition and research foci have evolved, but also the perception towards brownfields. From Bridges (1987) statement that derelict land is ..."in default of special attention [...] unlikely to be effectively used again within reasonable time" (p. 22); to the realization that some brownfields can now be regarded as a profitable investment opportunity and viable real estate and that most likely *can* be effectively used again.

2.2. Scale and Spatial Distribution

The *second-generation* brownfield literature was also interested in the scale of the 'problem'. The 'brownfield problem' (see De Sousa, 2000 and 2003; Couch, 2003) is "occurring in almost every post-industrialized nation due to the gradual, but steady migration of industries from the city core to its fringe" (De Sousa, 2003). Globally, this phenomenon has been occurring since the mid-1970s, leaving behind a veritable legacy of vast areas of underutilized or vacant and blight industrial sites. While originally the term emphasized urban and exurban land, the broadening of the scope resulted in the encompassing of abandoned open mining sites, mining facilities and other non-urban industry infrastructures. Leigh and Coffin for example (2000) examined the brownfield legacy via a unique demographic-spatial analysis finding a wide range of land types on the one hand, but also a strong correlation to poverty on the other hand.

As Coffin (2003) notes, if policy makers are to provide funding to address the brownfield problem, we first must determine the scope of the problem. As a result of a broadening brownfield definition, estimating the number of sites, has become increasingly difficult. This is largely due to the fact that meta-analyses consist of studies that have used different definitions for brownfields. Consequently, the estimated number of brownfield sites in a given jurisdiction can range widely. Chapter 3 provides an overview of the scale.

2.3. **Emerging Brightfield Research**

The various paragraphs above demonstrate that brightfields follow the trend towards a more sustainable and holistic reuse of brownfields. Some of the most notable (and rare) work on brightfields examined the total renewable energy capacity and its potential if all brownfields were to be transformed into brightfields (Adelaja et al., 2010; Milbrandt et al., 2014). This somewhat disregards local singularities and competing or alternative end-uses. The desire to showcase the potential of brightfields can manifest itself in either case study research such as Riberio (2007), Jensen (2010) or again Tansel, Varala and Londono (2013), Moss (2003), or large-scale and macroscopic assessments of an entire country. Lord Atkinson, Lane, Scurlock and Street (2008) introduced the idea of energy crops for biomass on brownfields. Adelaja et al. (2010) explored the potential of solar and wind energy on brownfields in Michigan and found that they could generate 4'320 MW of wind and 1'535MW of solar power, while creating over 17'000 construction and long-term jobs. Similarly, Milbrandt et al. (2014) suggested that the total amount of potentially installed capacity of renewable energy on all marginalized land in the U.S. could be as much as 13.1PWh. Outside the U.S., Klusáček Krejčí, Martinát, Kunc, Osman and Frantál (2013) examined the conversion of brownfields into solar power plants in the Czech Republic, where about 2 % of PV plants (>1MW) are being redeveloped on brownfields or close to 12 % in the South Moravian Region.

Government efforts to locate renewable energy facilities (solar, wind, landfill-gas or biomass) on brownfields have led to a wealth of resources, chiefly in the form of feasibility studies. The vast majority of material on the subject comes from the U.S. EPA and its affiliate programs (OSWER[11], AMLT[12], LMOP[13]) or the NREL[14]. Early academic research examines brightfields development in the U.S. and gauges the success of state and federal funding initiatives and other financial incentives, which are chiefly designed for wind and solar projects (NALGEP 2012; Jensen 2010). In 2012, the National Association of Local Government Environmental Professionals (NALGEP) has released a primer entitled 'Cultivating Green Energy on Brownfields: A Nuts and Bolts Primer for Local Governments'. This report provides an overview of renewable energy options, as well as tools for evaluating their economic feasibility and a review of issues regarding zoning, permitting and liability.

2.4. **Brownfields in the International Context**

Adams, De Sousa, and Tiesdell (2010) compared the British and the North American approach to brownfield redevelopment via a policy-maturing model, remarking that in the U.S., industrial revival has been seen as the priority, in contrast to the emphasis on residential redevelopment in England. De Sousa (2000) found that European and American brownfield policies are more and more convergent (intra and internationally) due to the similarity of incentives to encourage and stimulate the private market to undertake the costly and risky redevelopment effort. Canada, at the turn of the century had yet to enter what De Sousa calls the *cost/risk sharing* and *harmonization* stage (2000). Regarding intranational policies, De Sousa (2015) noticed that "Ontario's policy approach is somewhat further along in this evolution than the U.S. because municipal planning efforts in Ontario must be more aligned with wider urban growth concerns" (p. 18). The same cannot be said for Canada as a whole.

Ganser and Williams (2007) compared the United Kingdom with Germany, concluding that, while England's head start on the brownfield debate has led to a better understanding of residential opportunities on brownfields, in Germany, the complexity of the problem has failed to incorporate

[11] Office of Solid Waste and Emergency Response
[12] Abandoned Mine Lands Team
[13] Landfill Methane Outreach Program
[14] National Renewable Energy Laboratory

brownfields into the current (residential) planning system. To the current state of knowledge, only Frantal and Osman (2013) and Frantal Josef, Klusáček and Martinát (2015) have compared policy-frameworks and public attitudes regarding brightfields across multiple countries (the Czech Republic, Germany, Poland and Romania) and found that policies, practices and public attitudes remain different.

Thus the brownfield literature has spread outwards from American and British scholarly work and become very international. The same is true for the emerging brightfield literature, driven in Europe by studies like Frantal and Osman (2013). However, the brightfield literature outside the U.S. is in fact very small and limited to a handful of Czech researchers, most notably Frantal, Osman, Klusáček, Krejčí, Martinát, Kunc, and Tonev. There is also a great amount of comparative investigations pertaining to energy and energy policy such as Mabee, Mannion and Carpenter's (2011) study of the FIT market in Germany and Ontario, or the convergence of EU-wide energy policies (see Jacobs, 2012; Markandya, Pedroso-Galinato, Streimikiene, 2006; Kitzing, Mitchell, and Morthorst, 2012).

2.5. **Risk and Liability**

Neuman and Hopkins (2009) introduced the issue of risk of renewable energy on contaminated land. The combined risk of managing a contaminated, or potentially contaminated property and renewable energy infrastructure represents a unique challenge that cannot be met without an integrated and consistent application of risk management tools such as Commercial General Liability and Site Pollution Liability (Neuman and Hopkins, 2009). The authors also argued that for a project to be successful, the site and technology must undergo life-cycle assessments that include risk exposure, investment, engineering, procurement, construction, operation and site-closure plans.

The management of risk is important in the context of brightfields. Despite the fact that renewable energy, especially solar is seen as having little to no risk in the traditional sense (see Beck 1992) site contamination changes that. Neuman and Hopkins (2009), have focused on the assessment of risk of renewable energy projects, but 'only' taken site contamination into consideration. Inhaber's controversial work (1979) went even further in listing a number of risk sources pertaining to energy production in general such as raw materials, component production, plant construction, operation and maintenance, public health, transportation and finally waste disposal and deactivation for all sources of energy including solar. Market risk or financial risks are associated with the viable construction, operation of such a system and selling its products. Risk and exposure in the life cycle of a renewable energy project involve multiple parties; equity investors, local utilities, engineering, procurement, construction, operation, end-consumers and site closure plans (see Neuman and Hopkins, 2009). Inhaber (1979) claimed for instance, that solar uses the most amount of raw material per unit of energy produced (although mostly 'prebuilding') thus gives solar the highest occupational risk among all types of energy production, which is a disproportionate reflection today as it was 40 years ago.

2.6. **Land-use and Facility Siting**

As mentioned earlier, brightfields are epistemologically located between brownfields and renewable energy siting. Thus, the following paragraph explores the issue of land use and land allocation pertaining to the siting of renewable energy.

Land is a contentious and in many ways finite resource. It has thus become one of the single most crucial factors in energy siting. Each form of electricity generation utilizes land, be it in a renewable or non-renewable fashion. While renewable energy production generally has a smaller carbon footprint, the implications for land use and land allocations can be just as great as for traditional means of energy generation. Renewable energy siting problems are almost all land use related, be it resource availability transmission, or public opposition. The latter can elicit locally unwanted land use (or LULU) or NIMBYism (see Pushchak and Burton, 1983).

Further, land use change is reportedly one of the major contributors to climate change (see De Chazal and Rounsevell, 2009; Tilman, Socolow, Foley, Hill, Larson, Lynd and Williams, 2009). Searchinger Heimlich, Houghton, Dong, Elobeid, Fabiosa, and Yu, (2008) and Plevin, Jones, Torn and Gibbs (2010) estimated that land use change due to the production of mono-cultural biofuels may increase greenhouse gas emissions. Comparably, Tilman et al. (2009) argued that direct and indirect land use could potentially negate the greenhouse gas benefits derived from biofuel production due to the clearing of native land. Work by Gallagher et al. (2008) studied the production of biomass on metal saturated soil on urban brownfields in New Jersey, showing that ecosystem function measured as plant production is impaired at a critical soil metal load. In general terms, the work by Morell and Singer (1980) on alternative energy facility siting policies for urban coastal areas, provided an excellent introduction into the history, economics and social acceptance of energy facilities in cities with a significant waterfront. Alas, the book is over 30 years old and a lot has changed since, especially due to brownfield reuse.

The proper allocation and the appropriation of suitable land for solar and wind facilities are major challenges and do not chiefly depend on the cost of land, but also on slope, the environment, accessibility and of course resource availability. Elliot, Wendell and Gower (1991) produced an assessment of the available windy land area and wind generation potential in the U.S. Denholm and Margolis (2008) examined all 50 U.S. states regarding the amount of land that would be needed to provide a given state with 100 % of solar energy. They found that smaller, high population density states such as Washington D.C. would require over 100 % of their land, making it impossible to power a state via solar installations alone. The NREL (2012) produced guidelines in that respect for biomass production for biofuels on brownfields. Similarly, solar and wind farms have great implications on the conservation and utilization of land as the average footprint of wind a 1.5MW turbine is 2 acres and 0.15 acres for a 4kW PV system. These numbers vary widely and depend on the technology and geography. The NREL (2012) also studied the land use metrics and land use implications associated with solar energy (PV and CSP), by looking at the area impacted, the duration of the impact, and the quality of the impact.

The Canadian Wind Energy Association's turbines and land-use study (2012) investigated the impact of small and large wind farms and single installations on farmland by analysing the average acreage and arrangements. The siting of energy plants is a particularly interesting area of research and has produced a wealth of resources from Hobbs and Meier (2000), Keeney (1980 and 2013) and many others. Kahn (2000) for instance, investigated the barriers to the siting of power plants from a location as well as a risk perspective. One of the common denominator of these and similar studies is that suitable land is not as easy to come by as one might expect, or as Kahn (2000) put it: "the site chooses the technology" (p. 23).

Facility siting uses a variety of mechanisms to identify candidate sites. Screening procedures to identify candidate sites for energy siting is nothing new. Keeney (1980) described the three formal approaches of *exclusion*, *inclusion* and *comparative* screening. Furthermore, site identification and selection are two distinct operations. The former involves the finding of candidate sites, narrowing them down and ranking them based on a set of criteria, making a final selection (e.g. siting) on the other hand involves a few more crucial steps such as site impact and risk analyses. Hernández and Bennison (2000) distinguished between location decision-making and final decision-making.

There are a great number of site identification tools and research on siting procedures, especially retail stores, warehousing and energy plants, has produced a vast amount of literature over the past 40 years (see retail geography). However Hernández and Bennison (2000) noticed that a “great majority of retailers eschewed such formalized means of aiding their decision making in favour of personal experience and instinct, regarding the process very much as an ‘art’” (p. 358). Non-logical site identification techniques include; experience, checklists, discriminate models, gravity models and expert networks (Hernández and Bennison, 2000). AHP is part of a discriminatory site identification process, meaning that it compares various properties based on discriminatory weights

2.7. **Barriers to Renewables**

There are great many studies that have assessed the barriers to renewable energy development. Some of the more prominent ones are Painuly (2001), Beck and Martinot (2004), Reddy and Painuly (2004), Mirza Ahmad, Harijan and Majeed (2009), or Richards, Noble and Belcher (2012). The taxonomy of the barriers identified by Reddy and Painuley (2003) is as follows: (1) Awareness and information; (2) Financial and economic; (3) Market; (4) Technical; (5) Institutional and regulatory; and finally (6) Behavioural. Studies by Lord et al., (2008), Bardos et al., (2008) and Heerten and Koerner (2008) examined barriers to renewable energy on marginalized lands. However, these three studies focused solely on technical barriers for certain types of green technologies.

Meanwhile, academic work on barriers to brownfield redevelopment has become an important part of the literature. Bartsch and Collaton (1994) and Coffin and Shepherd (1998), produced some of the earliest work on the subject. The latter duo finding that legal liability, limited information, limited financial resources, and limited demand for the properties pose major barriers for brownfields. Similarly, work by Hudak (2002), Brachman (2004) and McCarthy (2002) aimed to identify policy and regulatory barriers to brownfield redevelopment.

The overcoming of barriers can often be related to best practices or knowledge transfer. The term technology transfer in this context has been defined by the International Panel on Climate Change (IPCC) as a broad set of processes covering the flows of know-how, experience and equipment [for mitigation and adapting to climate change] amongst different stakeholders including governments, private sector entities, financial institutions, non -governmental organizations (NGOs) and research/education institutions (IPCC, 2000). Thus, technology transfer plays a significant role in the adaptation, emulation and implementation of renewable energy technologies and mitigation climate change (see Meyer-Ohlendorf and Gerstetter, 2009). In that regard, work by and Wilkins

(2010) is important as it points out the importance of overcoming implementation and dissemination barriers (i.e. technical, financial and social ones) in order to increase the transfer of renewable energy technologies. The social contextualization of knowledge and barriers is also an important theme in Shove's (1998) work on barriers to technology transfer. Shove reminds us that technology, its implementation (and transfer) barriers as well as its acceptability and risk, depends on the socio-economic context (also see Kasperson and Kasperson, 1996; Burton and Pushchak, 1984).

2.8. **Public Opposition**

One of the major siting struggles apart from issues concerning land use is public opposition. Even before any ground is broken, renewable energy projects can face one of the biggest challenges; social acceptance (see Wüstenhagen, Wolsink and Bürer, 2007; Burton and Pushchak, 1983). While local resistance is common for nuclear power plants, petrochemical facilities or hydroelectricity infrastructures, the barrier of public opposition for renewable energy is a rather new angst (see Morell and Singer, 1980). Although, academics like O'Hare (1977), Thayer (1988), Jobert, Laborgne and Mimler (2007), Bosley and Bosley (1988) and others produced early work on this phenomenon, renewable energy technologies in the 1980's, especially wind, had a very high social acceptance level (Wüstenhagen et al., 2007). However, non-technical factors are exposed to a variety of apprehension from all stakeholders, including policy-makers and investors, not just the public (Wüstenhagen et al., 2007). This apprehension is often consequential of miscommunications between lay people, experts and policy-makers and their perceived risks and a decision-making based on an emotional rather than rational response, a process called affect heuristic (Slovic, 1987). Miscommunication can also lead to public-value failures due to [...]"insufficient means of ensuring articulation and effective communication of core values" (Devine-Wright, 2011, p. 179). Pushchak and Rocha (1998) confirm for instance that siting problems are often not technical in nature, but socially and habitually also politically motivated.

Opponents may in principle be in favour of renewable energies, but in practice oppose a particular development. On one hand, the term NIMBY is often used by proponents of the facility as ..."a succinct way of discrediting project opponents" (Burningham, 2000, p. 55); on the other hand, academics have often stigmatized it due to a poor understanding that results from a lack of a proper definition. In recent years however, researchers began to understand that this complex phenomenon goes beyond the selfishness of individuals (see Bell, Gray and Haggett, 2005; Breukers and Wolsink, 2007; Ek, 2005; Firestone and Kempton, 2007; Firestone, Kempton and Krueger, 2009). Though Bell et al. (2005) stated that NIMBYism is a 'self-interest reason' they also mention the desire for more democracy in the decision stage and more control in the operation stage as explanations for public opposition (although the three are methodologically difficult to differentiate).

Wolsink (2000) offered a detailed and quantified description for different types of resistance instead of simply pigeonhole them as naysayers. Similarly, Devine-Wright (2011) explained the emergence of public resistance by the presence of imperfect monopolies, imperfect public communication, an unfair distribution of benefits and suspicion of the developer's motives that can have people up in arms (Boholm and Löfstedt, 2004). Van der Horst (2007) and Wüstenhagen et al. (2007) analysed the effectiveness of renewable energy siting through the lens of NIMBY and public participation, further remarking on the importance of social context when conceptualizing such projects. Works by Haggett and Patrick Devine- Wright (2011) constitute some of the most prominent collection on NIMBYism and renewable energy. Social or public opposition does pose a significant challenge to renewable energy and has been the topic of countless studies (Kasperson and Ram, 2013; Cohen, Reichl and Schmidthaler, 2014; Wolsink, 2000), most prominently the work by Devine-Wright (2005, 2010, 2011). In general terms, the work by Morell and Singer (1980) on alternative energy[15] facility siting policies for urban coastal areas, provides an excellent introduction into the history, economics and social acceptance of energy facilities in cities with a significant waterfront. Alas, the book is over 30 years old and a lot has changed since, especially due to brownfield reuse. Wolsink (2010) found that members of an environmental movement in the Netherlands considered industrial areas and military training grounds, where the scenic value of the landscape could hardly be spoiled by turbines, to be suitable for wind power projects. Apart from this example, brightfields are by and large omitted from this corpus of scholarly work, a deficiency that part of this dissertation aims to address in chapter 5.

2.9. **Multi-Criteria Decision-Making**

Multi-Criteria Decision-Making or MCDM is sub-discipline of operations research that explicitly considers multiple criteria in decision-making environments (Köksalan, Wallenius and Zionts, 2011). The Analytical Hierarchy Process or AHP was developed by Saaty in the 1970s and is a MCDM tool that can be viewed as a structured technique for organizing and analysing complex decisions (see Belton and Stewart 2002; Saaty, 2008; Hummel, Bridges and Ijzerman, 2014). According to Saaty

[15] Not renewable energy!

and Vargas, (2006) AHP "is used to derive relative priorities on absolute scales (invariant under the identity transformation) from both discrete and continuous paired comparisons in multilevel hierarchic structures" (p. 2). It is important to note that "the best option is the one which optimizes each single criterion, rather the one which achieves the most suitable trade-off among the different criteria" (Șandru, Constantinescu and Boscoianu, 2014, p. 205). It reduces complex decisions to a series of pairwise comparisons that are subsequently synthesized to capture both subjective and objective aspects of a decision along with a technique for checking the consistency of the decision maker's (DM) evaluations, thus reducing bias in the DM-process (Tavana and Sodenkamp, 2010).

Although AHP is a product of decision-making and operation literature, as well as mathematics, it has been a popular concept for many years in other disciplines, especially in the retail/wholesale and grocery sector for evaluation store and warehouse locations (Cao and Guan, 2007; Liand and Wang, 1991; Hsu and Chen, 2007; Tierno, Puig, Vera and Verdu, 2013). Özdağoğlu (2012) used fuzzy Analytical Network Process in a multi-criteria decision-making methodology for the selection of facility location. MCDM and AHP in particular have been used in the context of renewable energy siting in studies by Nigim, Munier and Green (2004) and Aras, Erdoğmuş and Koç (2004) as well as finding locations for conventional energy plants (Akash, Mamlook and Mohsen, 1999). In fact, Pohekar and Ramachandran (2004) found that a total of 14 major studies used AHP in connection with renewable energy planning since 1990.

MCDM processes have also been used in the brownfield redevelopment literature. Chen, Hipel, Kilgour and Zhu (2009) used Case-Based Multiple-Criteria Ranking and MCDM to rank 81 U.S. brownfield redevelopment projects based on available data and an accepted benchmark; Zavadskas and Antucheviciene, (2006) used multi-criterion techniques to develop an indicator model to rank sustainable brownfield redevelopment alternatives; and Wedding and Brown (2007) used AHP to Measure site-level success in brownfield redevelopments. Chen, Hipel, Kilgour, Witmer and Zhu (2007) developed a strategic decision support for brownfield redevelopment, whereas Chen et al. (2009) developed a strategic classification support system for brownfield redevelopment using decision support system and multiple criteria decision analysis. Finally, Thomas' (2002) study on brownfield prioritization and selection process used multiple weighted attributes to "provide a model […] to help communities in selecting target sites for redevelopment" (Thomas, 2002 p. 95).

Although MCDM has been used in the brownfield literature, strategic support for redevelopment decisions at the government and community level is still lacking. One obvious problem is the lack of credible information about a city's situation, a deficiency a case study may remove (Chen et al., 2009). Nigim, Munier and Green (2004) explained the use and limitations of AHP (in the context of renewable energy siting):

> "*Decision-making is the study of identifying and choosing alternatives to find the best solution based on different factors and considering the stakeholders' expectations. Every decision is made within a decision environment, which is defined as the collection of information, alternatives, values and preferences available at the time when the decision must be made. An ideal decision environment would include all possible information, all of it accurate, and every possible alternative" (p. 1777).*

According to Herath and Prato (2006) the disadvantages of AHP are its long and demanding questionnaire and its high degree of subjectivity. I nevertheless chose AHP because it is the most common form of MCDM used in academia today (see Dyer, 2000) and entails its very own consistency ratio.

2.10. **Gaps in the Literature**

The absence of a comparative analysis on the terminology, typology and implementation of brightfields constitutes a gap that this study aims to fill. There is also no academic study that explores the brightfield concept from a policy perspective. While several studies have assessed the barriers to the development of renewable energy in general, as well as barriers to brownfield redevelopment, no one has investigated the barriers to implementing brightfields. Furthermore, AHP has never been used in combination with renewable energy on brownfields. In order to appreciate chapter 4, 5, 6 and 7, it is vital to provide a detailed assessment of the definition and scale of brownfields and brightfields. Chapter 3 is therefore key to deliver the necessary context.

Chapter 3: DEFINITION AND SCALE

3.1. **Definition of the term Brownfield**

The 1992 U.S. Congressional Field Hearing hosted by the Northeast Midwest Congressional Coalition who initiated the *Revitalizing Older Cities Task Force* is generally attributed to be the first to use the term *brownfield* in a legal context (Nathanail, Thornton and Millar, 2003). The term has since gained popularity and acceptance in America, mainly due to the White House's 1993 Brownfield Initiative[16], and has since evolved from an urban planning jargon to a widely known terminology. The term has found its way into countless state and federal statutes, policies, programs and as well as common parlance in North America, although the term, '*contaminated land'* continues to be used predominantly in legislative contexts at the federal level[17] in Canada (Adams, De Sousa, and Tiesdell, 2010). Still the most common definition of brownfields is the one formulated by the United States Environmental Protection Agency (EPA), who defines them as, "abandoned, idled or underused industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination" (1996). This 'old' (1996!) definition stresses the urban, industrial character of such sites that are likely polluted due to past activities. The newer definition of 2002 under the U.S. Small Business Liability Relief and Brownfields Revitalization Act on the other hand contains an updated version and defines brownfields as "real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant" (U.S. EPA 2002). This revision not only reduces the emphasis on contamination, but also constitutes a wider site typology to encompass sites in a more rural environment for example.

The brownfield literature has adopted this broad, (almost-) all-encompassing definition and regards brownfields as potentially contaminated sites that are currently underused or abandoned, afflicted by either real or perceived contamination, but with an active potential for redevelopment (see Wernstedt, Meyer, Dixon, Yount and Basu 2007; Yount, 2003; Coffin, 2003; De Sousa, 2000; De Sousa and Spiess, 2014). A common academic definition comes from Alker, Joy, Roberts and Smith (2000) that echoes the breadth of brownfields by describing them as:

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[16] http://clinton5.nara.gov/ WH/Accomplishments/additional.html

[17] Provinces like Ontario and British Columbia have adopted the term brownfield to conform to the industry jargon and differentiate from truly contaminated sites (such as oil spills). These two provincial governments have also introduced the most comprehensive brownfield policies in Canada, largely motivated by the potential of economic stimulation resultant of redevelopment.

"any land or premises, which has previously been used or developed and is not currently fully in use, although it may be partially occupied or utilized. It may also be vacant, derelict or contaminated. Therefore a brownfield site is not available for immediate use without intervention" (p. 64).

Table 3.1 provides an overview of the typology of brownfields pertaining to size, location, ownership as well as the degree of contamination. This information is compiled based on the review of the brownfield literature, along with a survey of (mostly U.S., German, Canadian, Czech and U.K.) brownfields that were systematically analysed based on size, location, ownership and degree of contamination of brownfield types. 19 distinct types of brownfield types were found and their common characteristics are represented here.

	Size		Location			Ownership		Degree of Contamination		
	Small-scale	Large-scale	Urban	Suburban	Rural	Private	Public	None	Medium	High
Abnd.* Gas Station	✓		✓	✓	✓	✓			■	■
Abnd. Parking Lot	✓		✓	✓		✓	✓	■	■	
Abnd. Warehouse		✓	✓		✓	✓		■	■	■
Abnd. Repair/Work Shop	✓			✓	✓	✓			■	■
Abnd. Railway (Yard)		✓	✓		✓		✓		■	■
Abnd. Commercial Complex	✓	✓	✓	✓	✓	✓		■	■	■
Dockyard / Shipyard		✓	✓			✓	✓		■	■
Abnd. Foundry			✓		✓	✓				■
Landfill**		✓			✓		✓			■
Abnd. Mining Site		✓			✓	✓				■
Abnd. Military Site		✓			✓		✓		■	■
Abnd. Power Plant / Station		✓		✓	✓	✓	✓		■	■
Abnd. Paper Mill		✓			✓	✓			■	■
Junkyard		✓			✓	✓			■	■
Ex-Excavation Site	✓	✓	✓	✓	✓	✓			■	■
Reserve Land	✓	✓			✓	✓		■		
Abnd. Factory	✓	✓	✓		✓	✓		■	■	■
Derelict Waterfront		✓	✓				✓		■	■
Abnd. Housing Units or Complex	✓	✓	✓	✓	✓	✓	✓	■	■	

*Abnd. = Abandoned, ** Closed landfills are preferred, but active ones can and are still used for brightfields, **Bold** = Properties which have been used for brightfields

Table 3.1. Typology of brownfields: Size, Location, Ownership and degree of Contamination of various types of brownfields.

3.1.1. Geographical Differences

3.1.1.1. Canada

In Canada, the 1998 National Roundtable on the Economy and the Environment (NRTEE) report defined brownfields as “underutilized sites with real or suspected contamination, […] a subset of contaminated sites […] with a potential for redevelopment” (p. 5). The phrase ‘subset of contaminated sites’ stigmatized brownfields tremendously, suggesting that all sites are contaminated. The 2003 NRTEE definition addressed this by describing brownfields as “abandoned, vacant, derelict or underutilized commercial and industrial properties where past actions have resulted in actual or perceived contamination and where there is an active potential for redevelopment” (p. 2). The 2003 definition is very close to the 1996 EPA definition, stressing the economic potential of a largely untapped resource. However, the more narrow Canadian reference to development potential and to commercial and industrial property is likely to change over time to conform to the newer (2002) U.S. definition (Adams, De Sousa, and Tiesdell, 2010). This trend towards a broader definition with less of an emphasis on contamination can already be seen in Ontario, where the Ministry of Municipal Affairs and Housing (MAH) describes brownfields as “vacant or underused sites with potential for redevelopment [acknowledging that] they may be contaminated, often due to former industrial or commercial use […] and are found in all types of communities across the province” (MAH, 2014).

According to the NRTEE (2003) there are three types of brownfields in Canada, the bulk (middle tier) of which requires costly remediation, but has high redevelopment potential due to the urban location. 15 to 20 % centrally located brownfields have a market value that exceeds costs of remediation; while around the same percentage of sites have “no realistic development prospect”. Table 3.2 illustrates this distribution.

Site Category	Percentage of Total Canadian Sites	Location	Properties
Top Tier	15-20%	• Centrally located former industrial site	• Market values exceed costs of remediation • Redevelopment driven by market forces due to profitability
Middle Tier	60-70%	• Established urban areas along transport corridors	• High cleanup costs • High potential for redevelopment • Market value of cleaned land equal the combined cost of land and cleanup • Sit idle due to market obstacles
Bottom Tier	15-20%	• Rural or remote areas or smaller urban areas	• Cost of cleanup far exceeds the value of the land after remediation • High cleanup costs and uncertainty dampen market interest • No realistic development prospects

Table 3.2. The three tiers of brownfield types in Canada. (NRTEE, 2003)

3.1.1.2. Germany

The term brownfield translates to *Brache*, meaning fallow land, which originated from the crop rotation system. In the 1990's the German Ministry of the Environment (or *Umweltbundesamt)* formulated its own definition, designating all land that has no intended urban reuse as brownfields, because they are underutilized. Colloquially, such sites were also called *Rumpelflächen*, which can be translated to limbo lands. Later on the *Umweltbundesamt* defined them as "inner city buildings not under use and inner city areas for redevelopment and refurbishment" demonstrating an unmistakably urban character (see Oliver, Ferber, Grimski, Millar and Nathanail, 2005). The prefix *Industrie* (or '*Industriebrache')* on the other hand, describes the vast tracts of rural land in the Ruhrgebiet, Germany's former hearth of the coal industry and represents marginalized rural lands. According to Tomerius (2000) "the [newer] German definition of a *Brachfläche* is broader and includes sites where no contamination is suspected" (p.5). *Flächenrecycling* (land recycling) is the reuse of already sealed land and has long been a key priority in urban and rural land use legislation in Germany (Höhmann, 1999; Tomerius, 2000). This phenomenon promotes the reuse of *Brachflächen* (Reiss-Schmidt, 1997). The main impetus for *Flächenrecycling* in Germany is to revitalize the country's *Industriebrachen* in order to increase sustainable land use and protect greenfields and hinterlands.

3.1.1.3. European Union

While early European legislation and European Union Commission Directives employed a different language, using *contaminated sites* or *derelict land* instead of brownfields, the increased adoption of the latter term speaks to a broader concern about land reuse in general and soil management in particular. Guglielmi (2005) confirms that the EU [did] not use the word "brownfield" in most of its legislation or policy [but] instead, "derelict" or "contaminated" land (p. 1282). This seems to have changed, and is reflected in the transition from the 1998 **C**LARINET (**C**ontaminated Lands Rehabilitations Network for Environmental Technologies) project to the newer (since 2002) CABERNET (Brownfield!) project. Subsequent projects use the term '**b**rownfield' in their acronyms such as the 2007 TIM**B**RE[18] and HOM**B**RE[19] project, et cetera. Crucially, the European concern with brownfields is not just an urban planning and economic issue, but carries a more holistic approach in which ecological considerations are as equally important as compacted development (Grimski and Ferber, 2001).

The updated version of the 2002 U.S. EPA definition closely resembles the European understanding of the term, which according to CABERNET[20] defines brownfields as "sites that have been affected by the former uses of the site and surrounding land; are derelict and underused; may have real or perceived contamination problems; are mainly in developed urban areas; and require intervention to bring them back to beneficial use". Siebielec (2012), thinks that the European understanding of brownfields describes properties that are abandoned; often but not always contaminated; that require reclamation/revitalization and that are relicts of industry, construction, agriculture, military or other anthropogenic activities.

3.1.1.4. Elsewhere

CABERNET's catch-all definition is also closer to the traditionally loose interpretation of brownfields in the United Kingdom, where they are most commonly described as previously developed land, encompassing a wide range of site characteristics. Although British scholars are

[18] Tailored Improvement of Brownfield Regeneration in Europe.
[19] Holistic Management of Brownfield Regeneration.
[20] Concentrated Action on Brownfields and Economic Regeneration Network

using the term brownfield more and more, legislative writings and naturalist organizations continue to use the term 'previously developed land' (Tang and Nathanail, 2012). This, Adams, De Sousa, and Tiesdell (2010) found, emphasizes the desire to create a semantic counterpart to the term greenfield. Coffin (2002) confirms that "these urban eyesores were given the term 'brownfields', with their counterpart undeveloped real estate referred to as 'greenfields' " (p. 15). Since greenfields are defined as lands that have never been developed, then by definition brownfields must have been formerly developed.

Brownfields are predominantly urban sites in the Chinese understanding of the term, defined via their previous economic activity (Li, 2011). The literature suggests that the main reason for the existence for brownfields is not so much decline of the manufacturing industry (like in many developed countries), as much as the relocation of its plants (Li, 2011; Gong, 2010). Relocation occurs due to the unstoppable sprawling of cities, the need to relocate the major environmental polluter and to make space for new housing developments (Wu and Chen, 2012). In the Chinese context, Cao and Guang (2007) define brownfields as "industrial and commercial lands, sites and facilities in urban areas, which are abandoned, idled or underused due to real or perceived environmental threats and other developing obstacles, and cannot be immediately put into use without treatment." Furthermore, China is home to a unique type of brownfield that exists nowhere else in the world. So-called Mountain Brownfields, are manufacturing plants that, during the Planned Economy era, were built in mountainous regions for security reasons and are now being relocated for a better integration into the country's trade and transportation infrastructure (Zhu, Peng and Hipel, 2008).

There is no distinction in the French terminology between fallow land, industrial brownfield or urban wasteland. Andres and Grésillion (2013) point out that "the word '*friche'* is used for all" (p. 42). Although the term *friche* is still in use today, adjectives such as '*industielle'* or '*urbaine'* are added to underscore an urban or industrial character.

In Australia, brownfields tend to have an urban flavour as well, despite the country's rich mining history. Newton (2010) defines them as "urban sites which were large parcels of land, owned by a single party, usually government or an industry, currently unoccupied and depending on previous use, contaminated to some extent" (p. 52). The urban nature of brownfields in Australia may be the result of the country's decline of the shipbuilding industry since the 1970's, leaving many waterfront properties and dockyards (like the Docklands and Federation Square in Melbourne, Darling Harbour and Barangaroo in Sydney, Newport Quays in Port Adelaide and Southbank in Brisbane) unoccupied (Newton, 2010). The urbaness is also reflected in a more recent definition by Wu and Chen (2012), who describe Australia's brownfields as "inner-city sites with industry heritage e.g. contamination or other environmental problem which have been or are being rapidly developed or transformed into higher-density residential or commercial uses"(p. 612).

3.1.2. Remarks on Definitions

The definition of what constitutes a brownfields is somewhat of a moving target and often dependent on local economic needs. Yount (2003) for example calls for a broad definition for inventory purposes and several more detailed ones to distinguish various properties regarding eligibility to funding programs.

While in the United Kingdom, any type of previously used land maybe considered a brownfield, in North America the notion of previous industrial and commercial development is what defines a brownfield (Adams, De Sousa, and Tiesdell, 2010). Thus, the term brownfield was created largely to address the negative connotation associated with contaminated industrial land. De Sousa (2000) notes that "although the terms' brownfield site' and 'contaminated site' were often used interchangeably in the scientific literature, a brownfield site is characterized by several key differences with respect to a contaminated site. A contaminated site is generally one that has soil, groundwater or surface water containing contaminants at levels that exceed those considered safe by regulators" (p. 832). By contrast a brownfield need not be contaminated. Thus, the distinction can be made between sites with a known contaminated media and potentially contaminated sites, which are suspected of being contaminated because of their previous land use or sites that are not contaminated (De Sousa, 2000).

The emergence of these broad-brush definitions are a result of the interdisciplinary nature of brownfields, and the desire to increase the flexibility of policy-makers and practitioners to address both the economic and environmental problems of redevelopment (see Yount, 2003). It will be noted later on in this dissertation how this broadening has also occurred for brightfields, insofar as the initial narrow focus on solar energy on necessarily contaminated lands now encompasses a wider range of renewable energy technologies on a wider range of properties.

3.2. **Definition of the term "Brightfield"**

3.2.1. The United States

The Clinton-Gore administration's Brightfield Initiative introduced the concept in 1999, defining it as "the conversion of contaminated sites into usable land by bringing pollution-free solar energy and high-tech solar manufacturing jobs to these sites, including the placement of photovoltaic (PV) arrays that can reduce cleanup costs, building integrated[21] solar energy systems as part of redevelopment, and solar manufacturing plants on brownfields"[22]. Admittedly, the terminology has not gained a lot of traction after its initial implementation in Chicago and has remained more or less dormant for a decade. The 2006 Brockton Brightfield project was truly a game changer, in that it brought the issue to the attention of lawmakers, utilities and most notably, urban planners and brownfield redevelopers and municipal property owners. The initial and preferred technology at the time the initiative was launched was solar, hence the use of the term *bright*. The originally narrow scope has widened in recent years to encompass solar thermal power, wind power, geothermal and the cultivation of energy crops for biofuels. Insofar, the EPA has broadened the brightfield definition describing it as "an effort to encourage productive use of brownfields and advance the use of clean and climate-friendly energy technologies"[23] (n/a).

This broadening is not only apparent in the technologies used, but also regarding site typology, which according to the RE-Powering America's Land Initiative can include lands that need not be contaminated. The Initiative defines brightfields as "renewable energy development on suspected current and formerly contaminated lands, landfills, and mine sites" (EPA, 2015). Thus at least in the United States, one can observe a broadening of the definition similar to brownfields.

3.2.2. Canada

The reuse of brownfields for renewable energy installations has no official, government-issued definition in Canada, nor is there a term that is used particularly to describe this concept. Although, the Federation of Canadian Municipalities (FCM) acknowledges brightfields as an

[21] It is important that retrofitting of buildings on brownfields or residential, commercial or industrial brownfield redevelopment with building integrated renewable energy systems are not considered brightfields. The latter is reserved for the purpose of producing electricity.
[22] U.S. Environmental Protection Agency, http://epa.gov/brownfields/partners/brightfd.htm
[23] http://www.epa.gov/oswercpa/

alternative to traditional brownfield redevelopment, yet it too does not provide a definition.

NRTEE has thus far produced two notable publications on brownfields in general, namely 'Greening Canada's Brownfield Sites' (2005) and 'Cleaning up the Past, Building the Future' (2003). While neither document explicitly defines the brightfield idea, the NRTEE briefly demonstrates the accrued benefits of renewable energy siting as an alternative to traditional brownfield development, at least in theory. The lack of popularity of brightfields in Canada is reflected by the absence of scholarly work on the matter and would be totally non-existent if it was not for the efforts by Angus Ross to build momentum for brightfields. Ross, in his capacity as former national spokesman for the Canadian Brownfields Network (CBN) has written several articles on the benefits of using brownfields for the siting of renewable energy. Alas, they remain largely void of academic merit.

The Canadian brownfield situation is, apart from the number of sites, by and large comparable to the United States with respect to the desire for urban revitalization, high-tech job creation, as well as a growing interest in renewable energy (despite the relative abundance of natural gas and oil in either country) along with the economic impetus.

3.2.3. Germany

In Germany this development is often defined as *Energetische Nachnutzung von Brachflächen (*or 'energetic' reuse of brownfields), while the term *Konversionsfläche* is used more and more to distinguish brightfields from conventional renewable energy developments. Originally, *Konversionsflächen* exclusively described the reuse of abandoned military sites for green energy purposes; this term however is now being used to describe a larger range of brightfields to include non-military properties.

3.3. **Brightfields Defined in Academia**

To date, academia has produced a scant amount of literature; as a result the concept has only a handful, yet still somewhat diverse definitions of what brightfields are. The definitions below are all taken from the academic literature describing the concept of brightfields.

- "*A brightfield is an abandoned or contaminated property (brownfield) redeveloped to use solar* *technology"* (Ribeiro, 2007)

- "*Brownfield land (post -industrial, -mining, - military, etc.) converted into a newly usable and productive land by implementation of renewable energy technologies*" (Osman and Frantal 2013)

- "*Brownfield redevelopment for the needs of solar energy projects*" (Klusáček et al., 2014)

- "*These circumstances in the brownfield redevelopment and renewable energy industries create the potential opportunity to achieve some of the brownfield redevelopment goals of communities, while addressing the need for renewable energy in post- industrial regions of the country*" (Adelaja et al., 2010)

- "*Renewable energy development on marginalized land*" (Milbrandt et al., 2014)

Although there are only a handful of articles on the subject (see above), there is some evidence supporting that this broadening also manifests itself in academia (i.e. from Ribeiro's *contaminated property for solar use* to Milbrandt's extended understanding of all *renewable energies on marginalized lands* seven years later). Milbrandt et al. (2014) definition is the closest to the EPA definition and in the absence of an official Canadian definition, is also the one used to examine brightfields in Canada.

3.4. **The Scale of Brownfields**

Despite a notable redevelopment effort over the last two decades, the sheer scale of the brownfields has, according to Siikamäki and Wernstedt (2008) burdened rural and urban communities all across North America and Europe, and dwarfs the number of redeveloped sites.

3.4.1. The United States

One of the first assessments came in 1987 by the US General Accounting Office (GAO) who estimated there to be between 130'000 and 450'000 potential hazardous sites (GAO, 1987). Later estimates have placed this figure in the range of 500'000 to 600'000 (see Simons, 1998). Still other (academic) approximations of scale put the number of brownfields in a range of between 400'000 and 600'000 properties (see Bartsch and Collaton 1994; Edelstein, 1988). The U.S. Conference of Mayors produced a study that describes approximately 75'000 formerly industrial brownfield sites in 31 U.S. central cities on 93'000 acres, representing approximately 5 % of all industrial properties in the United States (U.S. Conference of Mayors, 2003). Brownfields in the United States seem to be concentrated in the Northeast and along the Eastern seaboard. Simons (1998) finds that while the large mining sites and the rust belt in the north-eastern parts of the U.S. account for the bulk of the brownfield sites in the country, about 20 % of the total sites in the U.S. can be found in the 11 Rocky Mountain and western states.

Although the EPA at one point had estimated the number to be as high as 1 million sites[24], the federal agency revised this estimation in 2011, stating that there are a total of 500’000 brownfields in the United States. However, the EPA also recognizes that the amount of brownfield land is still growing, due to the slow economic recovery and on-going abandonment of both residential and commercial/industrial units in struggling cities like Detroit.

3.4.2. Canada

The earliest assessment of brownfields in Canada came by Sisson (1989), who estimated that there are about 30’000 brownfields in the country. However, Benazon (1995) projected that in fact as much as 25 % of urban land in Canada is contaminated in one way or another (see De Sousa, 2002), suggesting that Sisson’s (1989) assessment had been too timid. In fact, the estimated 30’000 brownfields in Canada does not seem to be an adequate assessment nowadays due to the 25 year period that has elapsed since then. Interestingly however, the National Roundtable on the Economy and the Environment (NRTEE) adopted the 30’000 estimate as recent as 2003 (Chalifour, 2004). This number has not been updated, in part because of the termination of the NRTEE, in part due to the still fluid definition. The most recent, although not widely known (or accepted) estimate comes from an environmental labour market research conducted by Environmental Careers Organization (2010), who conjectures that Canada is home to 64’046 properties, identified as potentially contaminated. According to this estimate, up to 40 % of all brownfields in Canada are located in Ontario.

Further, Hogan and Tremblay (2006) believe there to be around 10’000 abandoned or orphaned mining and petroleum sites in Canada, and one can assume that this number has grown (considerably) in the past 2 years, given the recent downturn in the mining and oil & gas industry.

A common measure of brownfields is the Federal Contaminated Site Inventory (FCSI). However, this inventory it is often only seen as a proxy, because its intention is not to list brownfields in the larger sense, which includes only potentially or even non-contaminated sites. In 2013, the

[24] www.epa.gov/compliance/resources/faqs/cleanup/brownfields

Treasury Board of Canada Secretariat - the federal custodian of the inventory - has identified and classified over 22'000 contaminated sites in urban, rural and remote areas across Canada. After Phase I assessments, a total of 5'032 sites were classified as not significantly contaminated and have a low or no priority for action. Further, the FCSI does not list privately owned properties.

Strangely, the public regards brownfields as a minor problem, a perception that is sometimes attributed to the fact that Canada has fewer sites, no singular catastrophic event like in the U.S., and a 'we-have-enough-land attitude' (De Sousa, 2001). Although brownfields are integral to the study of brightfields, developing a framework and assessing the 'true' amount of brownfields in Canada today is beyond the scope of this study. Table 3.3 below is a representation of existing estimates for brownfields in Canada.

Location	Suspected/known contaminated sites (# of sites)
Canada	20 000–30 000[a]
Provinces and Territories	
Ontario	3900[b]
Quebec	1600[c]
British Columbia	4200[d]
Alberta	10 000[c]
Nova Scotia	1000[c]
New Brunswick	NA
Manitoba	1500[c]
Saskatchewan	71[c]
Newfoundland	NA
Prince Edward Island	70[c]
Northwest Territories	NA
Yukon Territories	40–50[c]

Table 3.3. Brownfields (known or suspected contaminated sites) in Canada. (De Sousa, 2001).

3.4.3. Germany

In 2000 the Ministry of the Environment reported that Germany is home to an estimated 362'000 brownfields, totalling an approximate 128'000 ha (Oliver et al., 2005). Juckenack, Kurch and Wittemann (2002) produced a very similar estimation of 1.3billion m^2 or 130'000 ha of brownfield land (see also Juckenack, Barczewski and Schrenk, 2000). The *Umweltbundesamt* stated that brownfields are 'growing' by approximately 8-10 ha per day[25]. At the same time the average daily greenfield consumption in Germany was 93 ha in 2003, but is targeted to drop to 30 ha a day by 2020 (Dosch and Schultz, 2005). These numbers suggest that the number of brownfields and their cumulative area are still growing despite notable cleanup and redevelopment efforts. Ex-military sites especially are growing in number. According to data collected from the German Archive for Military History and the Bundeswehr there are an estimated 895 *Konversionsflächen* with an estimated 160'400 ha of land (on top of the 128'000 ha o brownfields).

3.4.4. Elsewhere

In 2004 there were around 100'000 brownfields in the United Kingdom with a cumulative total of around 66'000 ha (Thornton, Franz, Edwards, Pahlen and Nathanail, 2007). Greenfields are being consumed at a rate of around 16 ha per day (Thornton et al., 2007). In 2010 the Homes and Communities Agency indicated that local authorities identified an estimated 62'130 ha of brownfield land in England. One year later this number was up 2.6 % to a total of 63'750 ha, of which an estimated 32'400 ha or around half was completely vacant. From 2001 to 2007 the total area of brownfields in use went from 24'000 ha to 28'000 ha (ibid). Similar to Germany, Canada and the United States, the number and total area of brownfields in the United Kingdom remains fluid.

One of the first assessments of brownfields in Chinese cities came in a 2005 study by the World Bank's East Asia Infrastructure Division, who estimated there to be around 5'000 sites (World Bank, n/a). Although the study only assessed urban sites, this number is believed to be a gross underestimation, given that over 98'000 enterprises have been closed or relocated between 2001 and 2009 alone (Aecom, 2013). According to Teng, Wu, Lu, Wang, Jiao and Song (2014), the "Chinese policy of withdraw two, forward three', referring to the effort to suppress the second industry and develop the third industry in well developed areas in China was issued as a result of rapid urbanization and industrial transfer a few years ago" (n/a). In an effort to account for all brownfields (not just urban ones), the Ministry of Environmental Protection of China found that this policy has led to the closure and relocation of many large and medium-sized enterprises nationwide, resulting in more than 500'000 potentially contaminated sites in well-developed areas and industrial bases (Teng et al., 2014). Given the size of the country and its 51 % urbanization rate, even this order of magnitude greater estimation may not capture the entire scale of brownfields in China. In accordance

[25] http://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3051.pdf

with the Chinese Land Management Act (1986, revised 2004), the Land Administrative Department and the Statistics Department are responsible for statistics of brownfield sites (Cao and Guang, 2007). However, as reported by AECOM (2013) only 9 out of 22 provinces have carried out even preliminary monitoring work.

There are an estimated 2.9 million brownfields in Europe (EU 27) of which approximately 81'000 have seen remediation (Holstenkamp and Degenhart, 2011) (see Figure 3.1). Based on Vanheusden's (2007) assessment, well over 500'000 sites have significant contamination and require remediation. Adding the estimated 500'000 sites in the U.S. and the well over 30'000 sites in Canada, North America (Mexico not included) and Europe have approximately > 3.5 million sites. However, this number needs to be taken with caution, since other estimates for the U.S. and Europe provide a significantly lower range of 380'000 site and 750'000 sites respectively (see Table 3.4).

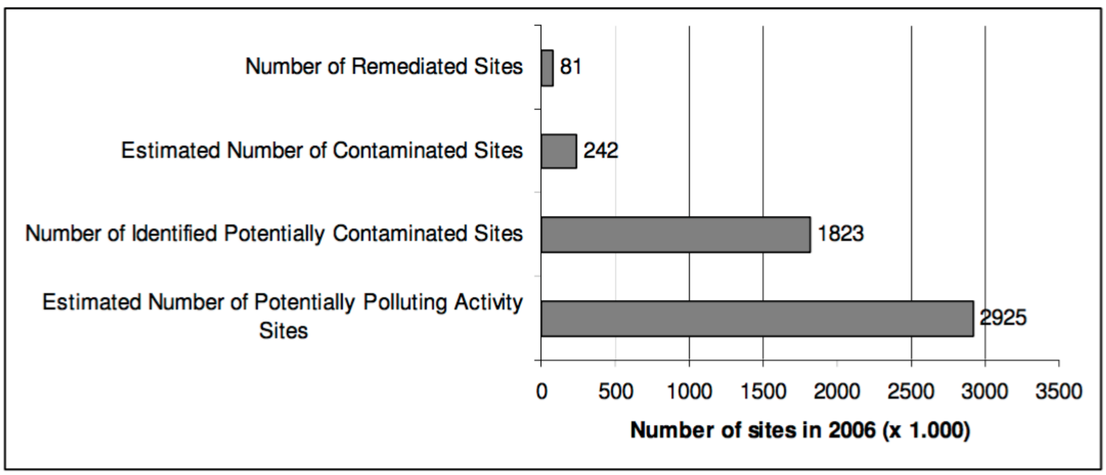

Figure 3.1. Overview of number of potentially contaminated land in Europe. (Holstenkamp and Degenhart, 2011)

Country	Brownfield Area (ha)	Estimated Number	Data Description	Data Source
Canada	n/a	22’000	Contaminated sites	*FCSI, 2014*
		30’000	Brownfields	*NRTEE, 2003*
		64’046	Brownfields	*ECO, 2010*
		10’000	Abandoned or orphaned mines	*Hogan and Tremblay, 2006*
Ontario	n/a	4’000	RSC properties	*RSC (MOE) 2015 and FCSI, 2014*
Germany	528,000	362’000	Brownfields	*Bundesumweltamt, 2000*
United Kingdom	65,760 (England)	100’000	Brownfields	*NLUD, 2004*
		23’859	Brownfields	*HCA, 2011*
		50’000-100’000	PDL	*Kraemer, 2000*
China	n/a	5’000	Brownfields	*World Bank, 2005*
		500’000	Brownfields	*Song, 2014*
United States	2,023,428	130’000-450’000	Brownfields	*GAO, 1987*
		500’000-600’000	Brownfields	*Simons, 1998*
		500’000	Brownfields	*EPA, 2011*

Table 3.4. Scale of brownfields in a selected number of countries. Adapted from CABERNET, 2006

3.5. Brownfield Legislation

3.5.1. The United States

In the United States, as in Canada, constitutional jurisdiction over environmental laws is bifurcated between federal and provincial responsibility. In the U.S. however, strong federal leadership has facilitated an extensive national initiative despite the existence of State-level programs. The United States Environment Protection Agency launched its Brownfields Action Agenda in 1995. According to Hara (2003) the “Action Agenda outlined four key areas of action for returning brownfields to productive use: (1) awarding brownfields pilot grants; (2) clarifying liability and cleanup issues; (3) building partnerships with all brownfields stakeholders; and (4) fostering local workforce development and job training initiatives" (p.9). Two years later, the resources of more than 15 federal agencies were combined to expand the Brownfields Initiative and create the Brownfields National Partnership Action Agenda. This partnership laid the foundation for an unprecedented degree of cooperation among governments, businesses and non-governmental organizations. The U.S. EPA introduced a pilot program known as Brownfields Prevention Initiative Pilots with the hope of preventing future brownfields and to ensure remedial work was being done on facilities under the mandate of the Resource Conservation and Recovery Act that dates back to 1976.

The most significant statute concerning brownfields is the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA, also referred to as "Superfund", established a federal program to identify and remediate active or abandoned contaminated sites that pose a threat to human and environmental health and safety. The Superfund program oversees long-term ("remedial") cleanups at National Priorities List (NPL) sites, short-term cleanups ("removal actions") and responses to chemical and oil spill emergencies. Superfund cleanup starts when anyone discovers or reports a waste site or the possible release of hazardous materials. In most cases, the degree of contamination is not enough to prompt federal involvement and state cleanup programs are sufficient to address remediation and do not warrant federal programs (i.e. CERCLA). The primary trigger for liability under this legislation is a release, or the threat of a release, of a CERCLA hazardous substance on a site, which requires a remedial response. Because of the *threat* was sufficient cause; rather predictably, CERCLA did not decrease the number of brownfields, as it imposed extended liability for current and past site owners via its joint-and-several-liability. Bartsch and Munson (1994) confirm that the Act had various adverse effects on redevelopment because of its strict environmental laws. Under CERCLA, liability is strict, joint, and several as well as retroactive. The result was a plethora of litigation, estimated to have consumed between 30-70% of the $40 billions spent under the Superfund (Aecom, 2013). To remedy this situation a number of flexible liability regulations and incentive-based approaches were introduced. The Superfund Amendments and Reauthorization Act (SARA) can issue so-called 'No further Action' or 'Not to Sue' certificates to prevent future liabilities due to changing compliance standards, as well as buyer protection programs.

The Small Business Liability Relief and Brownfield Revitalization Act (2002) limits the liability for contiguous property owners and bona fide prospective purchasers, and expedites settlements with potentially responsible parties that demonstrate that they cannot pay the full costs of remediation (Bannon, 2009). Although it does not fully exempt past polluters from their liability, it limits it for future developers of the site. The Act also decreases the exposure to the so-called *de micromis*[26] and *de minimis*[27] principles protecting parties from liability due to their miniscule contribution to the contamination and limited time of ownership during which they could have influenced the amount of contamination, respectively. The Small Business Liability Relief and Brownfield Revitalization Act also amended the Superfund law to exempt a "bona fide prospective purchaser" from liability as an "owner" under CERCLA as long as the purchaser meets certain specified conditions. The 2002 amendment also include a contiguous property owners and a provision for "innocent landowners". CERCLA does not preempt state regulation and most States have developed their own voluntary cleanup programs. The latter is an agreement between a developer and a state that once a site has been remediated according to state regulations, that the state will not require cleanup in the future. To promote the numerous environmental, public health, and economic benefits associated with cleaning up and reusing previously developed property, EPA and states developed brownfields and land revitalization programs. Accordingly, many state and federal laws and policies were changed to address, and in certain situations provide protection against, the liability risk associated with the reuse of contaminated properties, particularly for parties who wish to reuse property that they did not contaminate. These protections may be applicable to address the potential liability concerns of a developer of renewable energy on contaminated property. EPA has also developed a variety of mechanisms, including policy and guidance and property-specific documents to address potential liability concerns and uncertainty. Generally, only contaminated properties with significant actual or potential public health and/or environmental impacts or those needing immediate attention are likely to warrant federal cleanup. The majority of cleanups are performed under state authority and do not require EPA involvement.

3.5.2. Ontario

Prior to 1970, Ontarians were by and large free to pollute their immediate environment, so long as common law obligations were observed and pollution did not take place on someone else's property. However, Fishlock (2010) points out that "most of this polluting activity was not serious enough at the time to give rise to common law legal proceedings that might have required such

[26] Miniscule contributor to contamination.
[27] Minimal power to influence contamination due to short time of ownership.

activities to stop, but by today's standards, the resulting soil and groundwater conditions are unacceptable and require remediation before the land can be redeveloped for a new use" (p. 3). "Such is the dilemma of brownfield lands: not bad enough to have attracted remedial action at the time, but sufficiently dirty or contaminated to present an obstacle to redevelopment today" (ibid, p. 3).

The combining of the Air Pollution Control Act (1967) and the Waste Management Act (1970) resulted in the 1971 enactment of an early Environmental Protection Act and marked the beginning of Ontario's regulatory effort aimed at protecting the province's land, air and water resources. This Act prohibited discharge of a contaminant into the natural environment that may cause a number of adverse effects, including property damage, and provided the Ministry of the Environment (MOE) with the power to issue pollution control, stop, repair and preventative measures orders to address such contaminant discharges. Later provisions to the EPA stipulated the requirement of an immediate cleanup of spills that emitted harmful substances into the air, water or land along with the monetary recompense to anyone who bares either personal or economic harm as a result of the pollutant spill.

In spite of these legislative provisions, the majority of spills never did receive proper legal attention. "This was due to the fact that most land contamination results from the gradual accumulation of chemicals escaping onto and into the ground from small or unseen contaminant spills or leaks (particularly in the case of underground chemical storage tanks) and until the late 1980s, environmental law enforcement was sporadic and the penalties that were available against offenders were relatively small" (Fishlock, 2010, p. 4). The realization of these regulatory failures together with scientific improvement in testing lead to the development of Ontario's first set of remediation standards and site cleanup policies. This meant that the MOE became involved in the approval of site remediation plans as well as post remediation plans. The lengthy process of back and forth ideally led to a MOE letter of concurrence that would to some degree assure the property owner that the site had passed remedial standards and that no future remedial work would be necessary. Crucially, no provision did in fact guarantee that a MOE letter of concurrence exempted a property from undergoing additional remedial efforts in the future in the event where either the standards changed or further contaminates become evident. This of course then provided almost no certainty neither for property owners or potential creditors that would provide financial support.

In 1996, Ontario introduced the Guideline for Use at Contaminated Sites, which substantially expanded the list of contaminants. "In addition, the MOE now recognized the need for different environmental standards for sites where the groundwater was considered potable or non-potable; where full depth remediation was not required or desired; or where site-specific land uses and characteristics did not present any of the human health or environmental risks assumed in the development of generic soil and groundwater standards or criteria" (Fishlock, 2010, p 4). The MOE became not only the authority for environmental legal oversight, but also very much involved in the actual remedial process of contaminated properties. Overrun and largely not equipped with the proper resources to manage its growing mandate, the MOE made the decision to discontinue its concurrence letters, which still offered little legal certainty. Instead, the Ministry stipulated that, since it has provided the guidelines for acceptable remediation standards, it is the responsibility of the landowner to meet said standards by getting the site inspected and passed by private environmental consultants. The MOE also developed a form known as a record of site condition (or RSC) that a landowner and his or her principal consultant could complete, certifying their compliance with the MOE contaminated site guidelines. The RSC is a form of report card on the environmental condition of a property at a particular point in time, based on the condition of the property and its intended use. Unfortunately, while one could file a RSC with the MOE, the government did not accept any responsibility for the statements contained in the document and was not bound by the fact that the remedial work complied with the Ministry's standards at the time. In addition, the MOE's enforcement activities were increasing and during the 1990s it was granted the power to impose remedial liability on past owners, occupiers and other persons having charge, management and control of contaminated sites. As a result, "landowners, developers and their lenders sought legislated liability limits under the EPA and related environmental legislation, before they were prepared to commit large sums of money to clean up contaminated sites" (Fishlock, 2010, p. 4).

The Ontario government began the process of amending brownfield law and policy in 2001 and made further changes in 2007, 2009 and most recently in 2011. The goal was to establish clearer requirements for site assessments, provide some protection from environmental liability, and establish municipal planning tools and financial incentives. These amendments improved the RSC process making it more predictable and transparent, and the strengthening of the environmental site condition standards (Ontario Ministry of the Environment, 2011a). In 2004, the Brownfields Statute Law Amendment Act and the Ontario Regulation 153/04 (Record of Site Condition Regulation) came into force and a year later, the Minister of Municipal Affairs and Housing announced the creation of the Office of Brownfields Coordinator. The RSC and the Brownfields Environmental Site Registry are without doubt the centrepiece of this new brownfield legislation. The RSC is seen as voluntary form of property assessments. However, the filing of an RSC becomes prescriptive when land use changes from industrial, commercial or community use to agricultural, institutional, parkland or residential use. The rationale being that industrial, commercial or community current property uses have a greater likelihood of being areas of potential environmental concern.

A Record of Site Condition establishes the environmental condition of a given property at a particular point in time, based on the intended use of the site. Under the RSC, a Qualified Person (or QP) prepares a RSC. The property owner must hire such a QP to complete a Phase One Environmental Site Assessment (ESA). The latter investigates if it is possible whether one or more substances present on the property have contaminated all or part of the property. If the Phase One ESA shows that contaminants may have affected a property, a Phase Two ESA is required to determine the location and concentration of the contaminants present in soil, groundwater and/or sediment and whether they exceed provincial site condition standards. The RSC then must be filed to the Brownfields Environmental Site Registry in the event that the intended property use changes the sites current property use. Before filing an RSC, the property must meet the soil, sediment and groundwater standards applicable to the intended use. Submitting an RSC to the Brownfields Environmental Site Registry provides the owner of the property protection from some environmental cleanup orders for property owners who want to redevelop a brownfield site.

Generally the MOE has established two standards when assessing contaminated sites; generic standards and site-specific ones. First, Generic, numeric, soil-quality criteria: (cleanup level is land-use specific). These are numerical indices that can be used for both assessment and cleanup activities derived from (eco) toxicological studies that identify levels according to a tolerable health risk. These indices tend to vary with the risks of contamination based on the proposed land use (e.g., agricultural, residential/parkland, industrial). Second, Site-Specific Risk Assessment (SSRA or risk-based, corrective action, RBCA): (cleanup level is project-specific) These are procedures for developing soil and groundwater criteria that consider tolerance and risk exposure levels associated with a specific site and/or land use to be implemented as part of the corrective action process to ensure that appropriate and cost-effective remedies are selected (De Sousa, 2013).

Thus, under the new legislation, property owners have the option of doing a Risk Assessment (RA) when their brownfield does not meet the generic site condition standards, but meets alternative standards that have been specified in a RA that has been accepted by the Ministry of the Environment. In this case, a risk assessment must be accepted the MOE in order for an RSC to be submitted. Where the Ministry of the Environment has accepted a RA, it may issue a Certificate of

Property Use (CPU) that requires the owner to take specified actions to prevent, eliminate or improve any adverse effect identified in the RA, or refrain from using the property in certain ways. A CPU includes a summary of risk management measures identified by the RA. Since 2011, owners have the option of a more streamlined risk assessment process – called a Modified Generic Risk Assessment – intended to allow brownfield redevelopment to proceed more quickly. This modified RA assessment can be prepared using a web-based "approval model" which can be adjusted to reflect the site conditions of a specific brownfield.

Examining the legislative evolution of Ontario's contaminated sites policy, it becomes evident that most matters related to the actual site cleanup today escape the authoritative reach of government. In lieu of government-controlled remediation, the MOE has opted to outsource most remedial efforts to the private sector. This transition was justified since the government had created clear cleanup guidelines which are to be followed by private remediation and engineering companies without public intervention. The creation of generic standards meant that the government need not be involved in the actual approval of the remediation work. This responsibility now falls to the QP. Further, it is the responsibility of private companies to apply for the RSC.

One difference among jurisdictions throughout North America is the role played by government in the review and approval of site assessments and cleanup activities. In the U.S., state agencies take an active role in virtually all technical assistance and review activities, usually evaluating and approving work plans and cleanup objectives which the responsible party puts forward at the beginning of the remediation process, and then reviewing the cleanup work for acceptability at the end. In Ontario, the responsibility is largely deferred to the private sector.

CHAPTER 4: TYPOLOGY OF BRIGHTFIELDS: AN OVERVIEW OF THE UNITED STATES, CANADA AND GERMANY.

Abstract: The concept of brightfields combines the generation of renewable energy and the reuse of abandoned and marginalized lands. Although the literature is rather scant thus far, this development can help reconcile the plea for green energy with the desire to curb the energy sprawl and augmented distributed generation. This study explores the brightfield concept by comparing the terminology and typology (i.e. former land use) of properties used for this type of green energy development in Canada, the United States and Germany. The study found that landfills and brownfields are the most common type of brightfields in the U.S., where current capacity exceeds 1 GWp due to the federal RE-Powering America's Land Initiative. In Germany, ex-military sites and abandoned airfields are the most common brightfield types, where installed capacity of so-called Solar Parks has likely surpassed 4 GWp. Absent political support, brightfields have very little momentum in Canada; there are few concrete examples and a subsequent dearth of academic interest. Ontario, Canada's leader in green energy, has, despite a few examples, overall missed the opportunity to implement a quota of projects on such marginalized lands, as the majority of future projects are proposed on agricultural land. The study contributes to the emerging brightfield literature by providing a comparative overview of brightfield typology, terminology and capacity in these three countries.

Keywords: brightfields, brownfields, land reuse, marginalized land, renewable energy, typology.

4.1. **Introduction**

The brownfield literature shows that by and large researchers have assessed properties based on two main attributes; site based and context based (Dasgupta and Kwan Lap Tam, 2009). As a result the literature began classifying brownfields via four main criteria that are either site based or context based, but rarely both; (1) degree of contamination, (2) functionality, (3) economic value, and (4) spatial distribution.

(1) Although classifying a brownfield based on its degree of contamination makes sense from both a legal and engineering perspective, accurately determining the degree of pollution (if any) is a daunting undertaking for a given property, let alone for all suspected properties within a designated area. Furthermore, contamination and pollution is most commonly a function of thresholds and by how much a given pollutant exceeds them. This then does (as much in this research) depend on the jurisdiction that defines environmental standards, legal limits and maximal thresholds. In

Canada for example previously developed lands can be classified via the degree of aquatic contamination or a scoring system fixed by the federal contaminated site program. The latter system then assigns scores to sites after they have been assessed and are either classified as 'no-priority-for-action sites' or sites with various degrees of priority for cleanup. Similarly, properties in the United States can be analysed via a hazardous ranking system first launched with CERCLA. In both instances, the process requires Phase I and/or II/III assessments in order to determine the source of contamination, its pathway and its receptors. Such assessments are expensive and time consuming for governments or academic investigators alike. As result, only few studies have attempted to categorize brownfields based on degree of contamination (see Schoenbaum, 2002; Howland, 2002, 2004).

(2) With regard to functionality, brownfields have been examined pertaining to their current derelict state (Kirkwood, 2001; Nathanail, Thornton and Millar, 2003; Doick, Sellers, Mofat and Hutchings, 2006), or their genesis and decline of former functionality (Krzysztofik, Kantor-Pietraga, and Spórna, 2013). The functionality of brownfields can also be defined via their former use such as *blackfields* (paved surface), *greyfields* (economically obsolete) and so on. CABERNET's assessment of former functionality and current use (or lack thereof) is representative of research on brownfield typology (see Figure 4.1). The diagram illustrates the complexity and broad range of brownfield types.

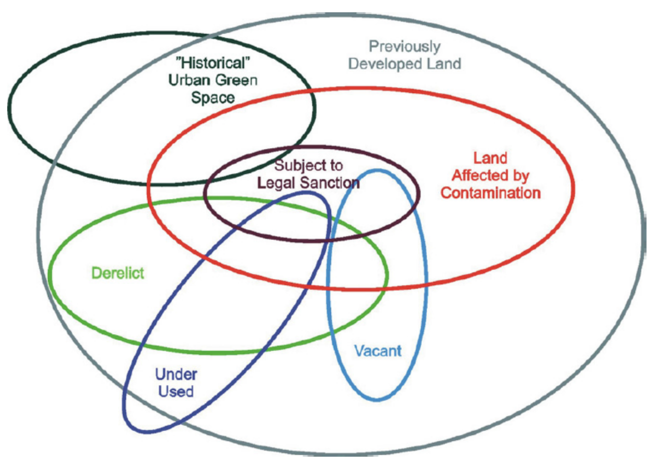

Figure 4.1. Relationship between brownfield-related definitions. (Adapted from Sustainable Brownfield Regeneration CABERNET Network Report, 2005).

(3) The third classification system examines the current potential of brownfields for the reintegration into the urban fabric, a categorization, which is largely based on economic viability. In that regard CABERNET (2005) provided the so-called 'ABC model', which divides brownfields into

(A) viable sites (private-driven projects), (B) marginally non-viable sites (public-private partnership), and (C) non-viable sites (public-driven projects) (Tang and Nathanail, 2012). Franz, Güles and Prey (2006) combined the economic viability model with the derelict functionality (see Figure 4.1) and added a "D" category (or ABCD-model) for sites that remain permanently derelict.

(4) The fourth classification system – spatial distribution – has gained a lot of attention in recent years and has profited immensely from free data and advancements in Geographic Information System (GIS). Spatial distribution of brownfields was conceptualized by researchers who were not satisfied by simply categorizing brownfields based on form or function and who believe that the redevelopment effort would benefit from understanding the spatial distribution of sites (Leigh and Coffin, 2000; Tomerius, 2000; Frantál, Kunc, Nováková, Klusáček, Martinát and Osman, 2013; Boott, Haklay, Heppell and Morley, 2001; Thomas, 2002). Josef, Kunc, Martinat, Tonev and Frantal (2014) for instance examined the density of urban brownfields via spatial patterns and perceived consequences of post-socialistic deindustrialization. Most recently Špirić (2015) and Frantál, Greer-Wootten, Klusáček, Krejčí, Kunc, and Martinát (2015) explored the possibility of using spatial criteria for the evaluation of abandoned or underused industrial complexes during their urban renewal and spatial patterns regarding urban brownfield regeneration. Despite the dearth of the brightfield literature, some of the most seminal studies focus on understanding the spatial differences regarding renewable energy potential and density, namely Adelaja et al. (2010) and Milbrandt et al. (2014).

It is clear then that classifying brownfields has a long tradition in the extensive corpus of brownfield literature and has already been used to spatially analyse brightfields. To the current state of knowledge however, no study has explored the functionality of brightfields, let alone compared them across multiple jurisdictions. Here, the investigation of site typology aims to be 'site-based' and 'context-based', meaning that the analysis is quantitative by trying to estimate the number of sites, the total peak installed capacity, as well as qualitative by determining the functionality or former site use of brightfields.

4.2. Objectives and Research Questions

To date, there exists no scholarly work that examines the typology of abandoned properties that are being used for brightfields. Thus there is no answer to the question of whether this type of development truly is exclusive to the U.S. or whether other countries with similar brownfield problems also produce brightfields? How many? How? What type of land is being used?

The objective of this chapter is to explore brightfields in Canada, Germany and the United States by analysing site typology/functionality, in order to gain a better understanding of this type of brownfield redevelopment and explore the geographical differences. The overall goal is to help academics from a wide range of disciplines and backgrounds to familiarize themselves with the concept of brightfields and encourage additional multidisciplinary research on this multifaceted topic in order to better understand the land (re) use implications of brightfields.

- **Q 1:** How many brightfields are there and what is their estimated nameplate capacity?
- **Q 2:** What types of sites are being used most frequently for brightfields
- **Q 3:** What are the differences or similarities between the three countries in terms of definition of brightfields, typology and number of sites?

4.3. **Research Methods**

This study is based on an extensive review of the literature on brownfields, brightfields, renewable energy and land use, and marginalized lands. Data and background information are also drawn from primary and secondary sources. Pertinent case studies, assessment and feasibility reports, regulatory documents and policies pertaining to the above issues are systematically examined in Canada, the United States, and Germany regarding former land use, current number and capacity of brightfields. The current brightfield situation in the United States is by and large a derived from the U.S. EPA's RE-Powering America's Land Initiative and data from the National Renewable Energy Laboratory.

The Canadian situation presented the difficulty of finding pertinent data on renewable energy projects and former land use. An extensive and systematic search for all types of renewable energy (excluding hydro) on brownfields (including landfills) was undertaken in all provinces combing through a vast amount of government-issued primary sources on renewable energy projects and land use. The lack of consistent information on previous land use *and* projects size capacity made it difficult to estimate the number of brightfields and calculate the total installed capacity in Canada. Therefore the Canadian Solar Industry Association, the Canadian Wind Energy Association as well as a number of solar and wind energy developers were contacted in order to establish a more reliable picture. These sources were asked how many brightfields they know to exist in Canada and whether they could provide an estimate regarding their peak installed capacity. The estimated number of brightfields in Canada is largely their assessment and is not backed by primary data.

While not representative of the country as a whole, Ontario is used to observe all approved and/or operational renewable energy projects (>500kWp for solar), listed by the government of Ontario (since ~2012), with regard to previous land use. The Ministry of Energy lists all renewable energy projects that, under the Feed in tariff regulation, require a government overseen approval process. To date 180 projects are listed. While the Ministry does list these projects, their location and project proponent, primary data had to be collected online for each project. This was done by examining so-called land consideration reports which are standardized reports containing information on the property that hosts a renewable energy installation. Alas, other provinces do not have data on renewable energy projects *and* land use.

Germany is studied in a similar fashion; the wealth of resources in Germany (despite the absence of a federal program) allows for a compilation of the brightfield potential as well as completed projects, but posed a challenge due to the large amount of data available. Existing databases on renewable energy projects were analysed regarding former land use and whether so-called *Konversionsflächen* were used. The capacity of brightfields was evaluated based on project information found online. The total number of true *Konversionsflächen* (ex-military sites) is largely examined with the help of *Naturstiftung David* and the Archive for Military History. The format of former land use is very similar to Canada, which allows for a comparison (i.e. industrial, commercial, agricultural et cetera).

4.4. **Results**

4.4.1. The United States

In the United States a brightfield is defined as an “abandoned and/or potentially contaminated property - better known as brownfield - redeveloped to use renewable energy technology” (Riberio, 2007). The RE-Powering America’s Land Initiative employs an equally broad definition, describing brightfields as renewable energy development on current, suspected and formerly contaminated lands, landfills, and mine sites.

In 2010, out of the over 500’000 brownfields in the United States, some 11’000 were screened for their wind, solar, biomass and geothermal potential. This totals over 14 million acres (Outka, 2010). In 2014 this number rose to 66’000 sites (due to a increased scanning effort), equating to nearly 35 million acres with over 185’000 (concurrent) renewable energy opportunities and over 1 million MWp of potential capacity (EPA, 2014). Under the tutelage of the EPA’s, the RE-Powering

America's Land Initiative, launched in 2008, converted over 151 marginalized sites in 31 States into brightfields (EPA, 2015). The total amount of installed capacity 1'046MWp and counting. The number of installations along with total installed (peak) capacity has grown steadily over the past 8 years, significantly so in the last three years and is projected to grow further still. Figure 4.2 represents this growth of both numbers of installation and cumulative capacity.

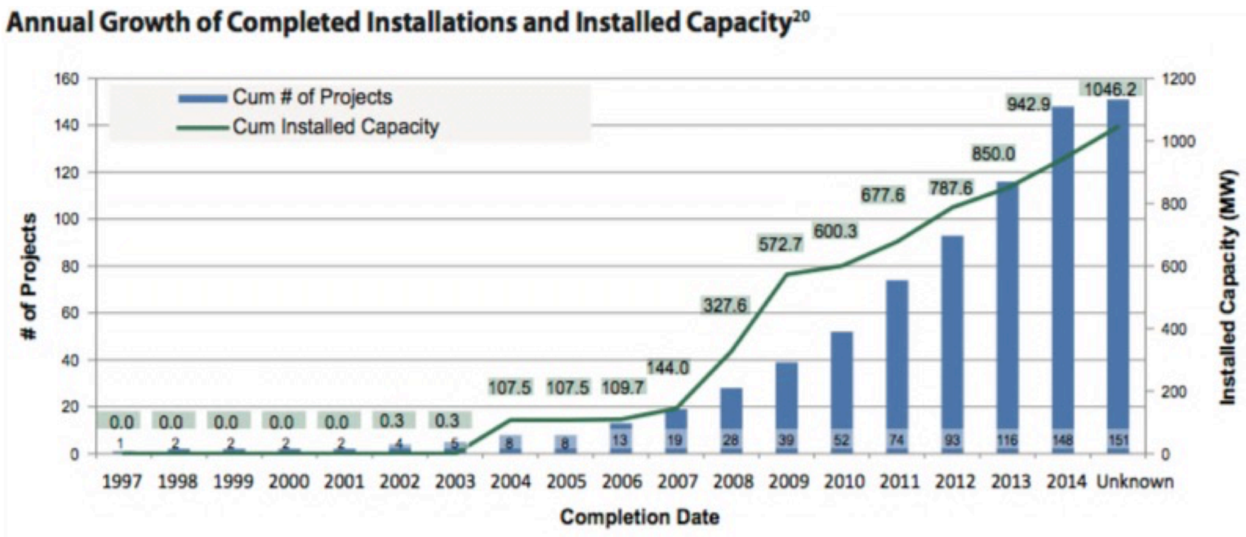

Figure 4.2. Illustration of the rapid growth of installed capacity of brightfields completed under the supervision of the EPA's RE-Powering America's Land Initiative. (EPA, 2015).

Around 40 % of RE-Powering America's Land brightfields are owned by municipalities, followed by private ownership at approximately 30 %, and federal ownership at about 8 %. At 62.5 % municipalities also make up the bulk of installed capacity. This, based on an assessment by to one EPA Regional Director, is because "municipalities can sell the triple-bottom-line benefits to its taxpayers" (personal communication, 2015) Furthermore, a vast majority of installations (and the biggest cumulative capacity) generate wholesale electricity. By contrast, only around 23/151 installations use the produced electricity on-site for so-called green remediation. Unsurprisingly, solar PV makes up around 82 % of all installations. As of September 2015 there are 151 brightfield projects on 144 sites classified as being brownfields, landfills, mining sites or Superfund sites. Table 4.1 illustrates the spatial distribution of brightfields. One notices that Massachusetts almost makes up half of the total number of sites. Bolinger et al. (2001) found that this is due to very favourable conditions in the state regarding financial incentives, but more importantly Renewable Energy

Portfolio Standards (RPS). The RPS began with an obligation of one per cent in 2003, and then increased by one-half per cent annually until it reached 4 % in 2009 with an annual obligation set to increase by one per cent annually after that. Similar provisions are in place in states that are also at the top of the list below. Note that Wyoming has the largest installed capacity, yet only five brightfield projects; this is due to two very large wind installations.

State	Number of Installations	Installed Capacity (MW)	State	Number of Installations	Installed Capacity (MW)
MA	50	105.9	TX	3	11.6
NJ	14	69.5	NC	2	0.6
CA	11	97.4	DE	2	0.7
NY	9	71	NM	2	3
CO	7	6.5	IL	2	10.9
OH	6	11.7	OK	2	0
PA	6	178.5	WI	2	0.6
WY	5	295.8	OR	1	100
TN	4	10.1	Rest of U.S	20	52.3
AZ	3	20	**TOTAL**	**151**	**1,046.20**

Table 4.1. RE-Powering America's Land Initiative: A geographic overview

A closer look at the previous use of sites reveals however that landfills, not brownfields are the most common type used in the Initiative with 76 properties, followed by resource extraction (18) and ex-industrial facilities (16). Utility lands or properties owned by power generation companies, host 13 installations, while (ex-) military properties make up 8 properties. Table 4.2 shows that landfills and buffer zones around landfills make up about half of all properties. Brightfields in the Untied States seem to have a type. Unlike ‘conventional’ landfill-gas-capture, the projects listed below are solar PV installations, using thin-film solar that is rolled out on the slope of the landfill. The table also shows the acreage of all the sites, totalling 13’444 acres. It is important to note that mine sites are the largest sites whereas brownfields ‘only’ account for about 1’000 acres.

Site Type* according to the EPA assessment	Number of Installations	Project Acreage
Solar and wind projects on landfills/landfill buffer	80	701.9
Renewable energy projects on brownfield sites	33	1’007.7
Renewable energy projects on Superfund sites	25	1’917.5
Renewable energy projects on current/former federal facilities and contaminated properties	17	12
Renewable energy projects on RCRA corrective action sites	14	1’143
Renewable energy projects on mine sites	10	8’662
Total	**179**	**13’444.1**

Detailed former Land Use	Number of Properties
Landfill	76
Military Use	8
Resource Extraction	18
Commercial	3
Industrial	16
Utility	13
Mixed	2
Federal Facility	2
n/a	4
Total	**144**

*Some installations can be considered multiple “site types.” For example, a Superfund site on a federal facility would be counted both as a Superfund site and as a federal facility for the purposes of this table; however, sites that are considered to be multiple site types are counted only once when calculating the total number of sites.

Table 4.2. Typology of brightfields developed under the RE-Powering America's Land Initiative. The data on the right show more specific previous usage.

It is important to note that there are brightfield projects that were completed outside the EPA led Initiative. Tracking these however would be beyond the scope of this research given the sheer amount of new renewable energy projects completed in the United States in the last 5 years across 50 States and the scant amount of information on previous land use. Furthermore, the EPA Initiative Regional Directors have stated that the EPA aims to keep track of all brightfields being developed in the country and that the amount of ‘outsiders’, in terms of number and capacity, is likely not very substantial. There exists no other database for brightfields in the United States. Furthermore, the efforts made by the RE-Powering Initiative must be examined in the broader context of the rising green energy development in the United States. The NREL (2015) estimates that the total installed renewable energy capacity (excluding hydro) is around 92.4 GW (18 GW are solar PV), representing around 8 % of the total installed energy capacity in the United States. Compared to the ~ 1GWp of installed capacity on brightfields, the latter make up 1.13 %. The discussion part of this chapter will to put this number into perspective.

4.4.2. Canada

There is no accepted definition of brightfields in Canada and to the current state of knowledge the term ‘brightfield’ (or any synonym) does not appear in any federal or provincial policy, program or legislation.

In spite of an abundance of natural gas and oil in Canada, like the United States, the country is experiencing an unprecedented increase in its renewable energy capacity. In 2013, the total installed renewable energy capacity in Canada - excluding hydroelectricity - was an estimated 12.5 GW (cieedac.sfu.ca, June 2015). According to the National Energy Board (NEB), “on a percentage basis, non-hydro renewables such as wind, solar and biomass have been the fastest growing source of generation in both countries. Government incentives, such as federal tax credits and state-level policies in the U.S. and renewable energy targets and standards in Canada, contributed to this growth” (NEB, 2013). Furthermore, Canada has equally diverse types of marginalized lands compared to the United States, yet so far the country has only a handful of brightfield installations, largely confined to Ontario. At first glance then, it seems that brightfields are not (yet) established as an alternative to greenfields for the siting of renewable energy, nor provide an alternative to conventional brownfield redevelopment. The investigation below shows that there are renewable energy installations on previously developed land in Canada (Ontario), however such installations are not being labelled *brightfields* (or a similar terminology) to distinguish themselves from ‘conventional’ renewable energy projects. My research illustrates (see also chapter 5), that it is not only a labelling issue (or lack thereof) since the very concept of ‘brightfields’ continues to be largely unfamiliar to both scholars and industry north of the border. Similarly political interest is lacking as well as outlined in chapter 5 that addresses this matter in more detail.

So far the only prominent example of a veritable *brightfield* in Canada is British Columbia’s *SunMine*. Located on a former mine in Kimberly British Columbia, the *SunMine* project is by far Canada’s most notable brightfield (see Figure 3.3.). The 1.05 MWp solar project is the province’s first grid-connected solar facility, as well as being Canada’s largest project to use solar so-called trackers.

Figure 4.3. *SunMine* in Kimberly, British Columbia. (www.sunmine.ca, 2015)

After an extensive review of renewable energy projects in all provinces and Territories only B.C's SunMine has been called a *brightfield*. Because previous land use data for renewable energy applications are often of poor quality if they exist at all, Canada could no be analysed nationwide. Alas, land use information for renewable energy projects is not available in all provinces, making it difficult to gauge this postulation and estimate a capacity figure. Due to this lack of consistent data across the country the author reached out to renewable energy organizations such as Canadian Solar Industry Association (*CanSIA*) and private companies like *Canadian Solar*, *ArcStar Energy* and others. Based on their estimation[28], Canada has fewer than 30 renewable energy projects on brownfields or otherwise marginalized lands. It is known however, that ArcStar Energy has secured investment for 70 MWp of brightfield capacity in Canada. So far none have been approved.

4.4.2.1. Ontario

Since the province started collecting information on renewable energy projects that require a renewable energy approval (REA) in 2012, 180 projects have received a notice to proceed or are already in operation. This means that there are 180 renewable energy projects in Ontario with a peak capacity greater than 0.5MW that have been approved by the provincial government and the Ontario

[28] Note that 30 was the highest estimation, others estimated the total number to be (much) lower

Energy Board since [29]. These 180 projects of solar, wind and biomass installations are listed on the Ministry of Energy website. Data prior to 2012 do not exist to our knowledge.

Out of the 180 projects, 113 are solar, 57 wind and 10 are biogas installations. From the 113 solar farms a total of 10 installations are planned on land that could be described as marginalized or brownfield (see Table 4.3). This includes vacant lands, aggregate resource areas and ex-industrial lands. Table 4.3 shows the total combined capacity of these solar "brightfields" at around 95 MWp (Source: Ministry of Energy, 2015).

Previous Land Use	**Number of Installations and (%)**	**Installed Capacity in MW and (%)**
Agriculture	45 (~40%)	564.5 (~44%)
BROWNFIELD (Abandoned, vacant, industrial)	10 (~8.8%)	95 (~7.4%)
Mixed Use or not specified	22 (~19.5%)	296 (~23%)
Residential	1	0.5
Wetland	1	1
Agriculture, Rural and Woodlands	34 (~30%)	326 (~25.5%)
Total	**113**	**1'283**

* Solar energy only

Table 4.3. Previous land use of large solar PV power installations and peak capacity (approved installations since ~ 2012). The majority of sites (45) are on lands previously used for agriculture with a capacity of 564.5 MW.

The data show that out of the 57 wind farms, 3 are located on land previously used for resource extraction (i.e. mining) and 4 out of 10 biogas facilities are located on landfills. Biogas or in this case landfill gas capturing is not strictly speaking considered a brightfield, thus 13 brightfields are counted here not 17. The 13 renewable energy facilities have a combined installed peak capacity o 263.5 MW. This represents ~ 7.22 % (13/180) of the total number of approved renewable energy installations in the province (since 2012) and around 6.45 % (263.5/4076) of the total installed renewable energy capacity of those 180 projects. Table 4.4 illustrates these findings. However,

[29] This does not represent all renewable energy projects in the province, but only the ones large enough automatically requiring an approval process. Further, these are projects that have been applied under the FIT program.

according to the latest Independent Electricity System Operators (IESO) data[30] on electricity, in 2015 solar provided approximately 0.25 TWh, or less than 1 per cent of the total electricity output, making the 'brightfield' contribution further negligible.

	Total # of projects	Total MWp	Previous Land Use: Marginalized land*	MWp of "brightfields"	Percentage of brightfields of total renewable energy projects	Percentage of brightfields of total renewable energy MWp
Solar PV	113 projects	1'283	10 projects	95	9%	7.40%
Wind	57 projects	2'760	3 projects	168.5	5.30%	6%
(Biogas)	(10 projects)	(24)	((4 projects))	((13.3))	((40%))	((55.50%))
Total	180 projects	4'076	13 projects	263.5	7.22%	6.45%

* Abandoned agricultural land, ex-industrial land, resource or aggregate extraction and logging

Table 4.4. Representation of the assessed renewable energy projects in Ontario and their previous land use.

The province of Ontario is Canada's leader in solar installation, mainly due to its Feed-in tariff scheme, which is in part managed by the IESO. However, the province is moving towards so-called capacity markets where the projects will be auctioned off. Further, under the IESO's Large Renewable Procurement (LRP) Program[31], non-rooftop solar projects will no longer be allowed in 'prime agricultural areas' that are designated as such in the current 'Official Plan'. Non-prime agricultural land - that is still being used for crops and livestock management - is still largely eligible however (see section 5.7).

According to the IESO (2015) the targets for this first procurement process include up to 300 MW of wind, 140 MW of solar, 50 MW of bioenergy and 75 MW of waterpower[32]. There are a total of 110 solar PV, wind power and biomass energy projects that have applied for the LRP process[33]. All 110 LRP project applications were read, specifically the sections pertaining to previous land use. After this analysis, only 4 out of the 110 applications are proposed on aggregate pits or otherwise marginalized lands. The applicants of these 4 proposed projects were contacted to confirm the former land use. Only one applicant was familiar with the term brightfield.

[30] http://www.ieso.ca/Pages/Media/Release.aspx?releaseID=7286, retrieved on January 13th, 2016.
[31] The IESO oversees the Large Renewable Procurement (LRP), a competitive process for procuring large renewable energy projects generally larger than 500 kilowatts. The LRP represents a key step in the province's 2025 target for renewable energy to comprise about half of Ontario's installed capacity
[32] These are projects that will be (if approved) starting construction around 2017.
[33] As well as 9 waterpower projects

4.4.3. Germany

Unsurprisingly, the term 'brightfield' is not known in the common parlance and does not appear on government websites or in legal documents (both in German and English). Further, based on personal conversations with planners, brownfield redevelopers, and renewable energy developers the term is largely unknown to them. The author was also able to correspond with brownfield scholars in Germany and although they have heard the term, they have not seen it in academic writings in Germany nor used it themselves. Brightfields in Germany that use solar PV are more commonly referred to as *Solar Parks* (see Frantal and Osman, 2013; Kunc, Klusáček, Martinát and Tonev, 2011) and are semantically distinguished from *Solar Anlagen* (i.e. conventional solar farms). There is no semantic distinction for wind energy installations on brownfields.

The type (i.e. previous use) of land (or brownfield) that is most often associated with brightfields in Germany is referred to as *Konversionsflächen*. Originally, the term referred exclusively to ex-military properties that are abandoned or partly abandoned and either still owned by the government or available for lease. Today the term may also include other forms of brownfields such as ex-industrial or ex-commercial lands that are now abandoned. *Konversionsflächen* in the original sense (ex-military lands), are and continue to be the most likely type of brownfield for the development of brightfields in Germany. The size, abundance and underutilization - especially the former Soviet military bases in East Germany – render these lands very suitable for large-scale wind and solar installations. Legally and strictly speaking, in order for these sites to be considered a *Konversionsfläche,* 51 % of the total area must be ecologically damaged; otherwise they are considered greenfields, arable lands or similar, thus forgoing feed-in tariff support (see Clearingstelle EEG, 2010).

Frantal and Osman (2013) found that renewable energy development is the preferred reuse for urban brownfields and the second most preferred reuse for rural brownfields (after agricultural production). This is not to say that that renewable energy development is the most common form of actual site reuse, but is at the top of stakeholder preference.

Brightfields fit into Germany's tradition of land reuse, and the country's desire to increase renewable energy and halt the sprawl of energy infrastructure into green spaces. Although Germany's *Freiflächen* (i.e. open space and arable lands) potential is with 230'000 ha still very substantial (see Photovoltaik, 2015), feed-in tariffs for *Freiflächen* ceased altogether in 2010. The feed-in tariff for *Konversionsflächen* on the other hand currently remains at 18.76 €ct/kWh and has thus surpassed compensation for all other types of land, like for instance the 17.94 €ct/kWh for ground-mounted PV installations (see Table 4.5).

	2008	2009	2010	Mid 2010	2011	2012
Brownfields (“Konversionsflächen“)	35.49	31.94	28.43	26.16	22.07	18.76
Other	35.49	31.94	28.43	25.02	21.11	17.94
Arable lands	35.49	31.94	28.43	--	--	--

Table 4.5. German feed-in-tariffs for solar electricity in €ct/kWh. (Adapted from Osman and Frantal, 2013)

After an extensive analysis of databases on renewable energy projects in all 16 Bundesländer, a total of 250 ‘brightfields’ were found with a peak nameplate capacity of approximately 4’000 MW. The 250 installations have a greater than 0.5 MWp capacity and a previous land use that could be described as marginalized in general or brownfields (or *Konversionsflächen*) in particular. The majority of installations are solar (195) with around 1’800 MWp, while 55 brightfields are wind installations with a total of around 2’200 MWp.

Unlike the brightfields in the RE-Powering America’s Land Initiative, where the type of land is described by the EPA itself, here it important to examine these brightfields more closely, in particular the abandoned military properties, in order to establish the role they play in the brightfield development in Germany. In 2013, the German Archive for Military History listed a total of 744 decommissioned sites of the *Bundeswehr* (MGFA, 2013). Starting in 2014, an additional 151 sites were suspended or completely decommissioned (Bundeswehr, 2013). This brings the total to 895 properties, which according to the Bundeswehr occupy an estimated 160’400 ha. However, it would be an oversimplification and outright erroneous to simply assume that the estimated 250 (+/-) brightfields (Solar Parks) make up an astounding 27 % if compared to the 895 abandoned military sites. That is due to the fact that not all brightfields (Solar Parks) are *Konversionsflächen* in the original meaning of the term (i.e. ex-military) and that the typology is broader and not restricted to ex-military lands. This claim is substantiated by the *Naturstiftung*[34] *David*, which estimates that there are ‘only’ about 51[35] completed renewable energy projects on ex-military sites strictly speaking (45 solar and 6 wind). However, the study completed by the author does find another 39 sites, which brings the total to 90 or around 36 % of all 250 brightfields. According to one estimate by ‘Hidden-

[34] Nature Institute David
[35] The study (2015) by Naturstiftung David is not completed yet and the total number of renewable energy projects on Konversionsflächen may be higher.

Places' (2015), abandoned airfields in East Germany converted into *Solar Parks* have a combined nameplate capacity of approximately 870 MWp[36]. Furthermore, all of Germany's top 10 solar farms are either located on ex-mining sites (2 projects with a total of 314MW) or abandoned airfields (8 projects with a total of 688MW) and the *Naturstiftung David* does expect more of such installations on abandoned military sites in the near future.

Crucially, the estimated 4'000 MWp of already installed brightfield capacity compared to Germany's total renewable energy capacity (hydroelectricity not included) of approximately 80 GWp (ISE Fraunhofer, 2015), represents around 5 %. This is roughly four times as much as the 'brightfield share' in the United States. Germany has in fact more brightfields than the United States, while Canada seems to have but a few. By contrast, Ontario's estimated 13 brightfields make up about 6.5 % of the province's proposed renewable energy project capacity (since 2012), whereas the United States and Germany's brightfields represent around 1.13 % and 5 %, respectively. Table 4.6 summarizes these findings.

Country	Estimated number of brownfields	Estimated number of brightfields	Brightfields as a % of all brownfields	Total renewable energy capacity*	Estimated brightfield capacity	Percentage of total renewable energy capacity
United States	> 500'000	> 151	~ 0.03%	92'400 MW	~ 1'046MW	~ 1.13 %
Germany	~ 362'000	~ 250	~ 0.07%	80'000 MW	~ 4'000MW	~ 5 %
Canada	> 30'000 ~ 22'000 (FCSI)	< 30	~ 0.10% ~ 0.14%	12'500 MW	n/a	n/a
Ontario	4'000 (De Sousa, 2001)	~13	~ 0.325%	4'076 MW**	263.5MW	~ 6.46 %

* in MWp for completed renewable energy projects (without Hydro) in 2014. ** Approved without LRP for Ontario.

Table 4.6. Comparison of all three countries regarding estimated number of brownfields, number of brightfields, total renewable energy capacity and brightfield capacity.

[36] http://hidden-places.de

4.4.4. Other Notable Countries

According to Frantal et al. (2015), two per cent of all large solar installations (with capacity of 1 MW or more) in the Czech Republic and almost 12 % in the South Moravian Region are located on brownfields. The South Moravian Region of the Czech Republic has a total of 22 PV plants (> 1 MWp) located on former brownfields (ibid.).

In the United Kingdom, a country 40 times smaller than the United States, the reuse of previously developed land (PDL) has become a national priority, given the country's high population density. Curbing the urban sprawl is thus far the main impetus for brownfield redevelopment in the U.K., in concert with the protection of greenfields and natural habitat (Ganser and Williams, 2007). Protecting the latter has a long history of support in the U.K. More recently, the government has made brightfields a priority as well, in an effort to curb the increasing energy sprawl. The Energy Minister demanded that PDLs are preferred over agricultural lands for larger PV arrays and according to the planning guidance for the development of large-scale ground mounted installations, solar systems should utilize previously developed land, brownfield land, contaminated land, industrial land and not greenfields. In 2013 however, this notion was dismissed as unrealistic by *Kronos Solar*, who published the first major study of the viability of brightfields in the United Kingdom. The study claims that of the 23'859 brownfield sites (based on the Homes and Communities estimate) listed in England, a mere 21 sites have potential to be transformed into brightfields. Despite the Kronos Solar report, the very first of the 10 commitments of the *Solar Trade Association of Britain* is that non-agricultural land or any land that is of low agricultural quality is to be preferred. Similarly, the *National Solar Centre* continues to advocate the use of PDL (brownfields) for the development of large-scale ground mounted solar systems.

4.5. **Discussion**

As seen in chapter 3, the definition of brownfields (or *Brachflächen*) and their meaning in all three countries is converging insofar as it is becoming broader, encompassing a wide range of sites. The emphasis on the potential of redevelopment is also shared among the three countries. By contrast, the term brightfield is not as well defined or understood[37]. Although one also witnesses a broadening of the meaning – including more and more site types and technologies – the term is not popular outside

[37] Broadening the scope seems to confuse meaning and succinct definition.

the United States. The United States is so far the only country in which the term brightfield is consistently being used to describe renewable energy on marginalized lands. By contrast, it is largely unknown in Canada and Germany. The latter country uses the term Solar Park to describe a similar phenomenon for solar installations on *Konversionsflächen*.

The analysis of the EPA initiative illustrates that a wide range of sites are being used for brightfields, which in tune with the broadened definition and evolution since its originally narrow focus. While solar remains the most common technology, landfill sites are the most frequent type in terms of previous use. In fact, landfilling sites make up more than half of all RE-Powering America's Land brightfields. Interestingly, from a semantic perspective, landfills were originally not considered brightfields since landfill gas capture is not considered a green form of energy. However with the advent of thin film solar cells that can be rolled onto and cover a sloped landfilling site, such installations are of course considered brightfields.

In the United States only around 5 % of all brightfields are located on (former) military sites, whereas ex-military sites such as abandoned airfields have emerged as the favoured form of brightfield in Germany making up just under 40 % of the total. The majority of brightfields on (ex) airfields in Germany are made up of solar farms, since large wind turbines would be quite dangerous if the airfield is still being used.

There is no clear type of brightfield in Canada, because there are very few examples of renewable energy being generated on marginalized lands, apart from landfill gas capturing, which again does not 'count' as brightfields. Although, Canada's rich mining history has left behind around 10'000 abandoned and orphaned mines (Tremblay and Hogan, 2006), there are only around four examples of renewable energy installations located in former resource extraction areas. Mining sites could indeed be a superb opportunity for brining renewables to rural communities without disturbing more land. Overall, it would be desirable to examine all current renewable energy projects in Canada based on former land use, in order to determine whether they were greenfields, Brownfields, or Greyfields, (and Blackfields) (see Krzysztofik, Kantor-Pietraga and Spórna, 2013). This would be beneficial from an ecological as well as from a planning perspective.

Like the United States, the brightfield concept in Germany is becoming more and more common, as the number of installations grows every year. In 2013 alone, a total of 30 *Konversionsflächen* were transformed (or have received approval to be transformed) into mostly Solar Parks. Six Bundesländer produced brightfield assessment reports which when analysed stipulate that their potential for renewable energy on *Konversionsflächen* is over 7'600 MWp for solar alone. Other Bundesländer have so far produced no similar assessments.

Based on the NREL predictions in the United States, the trend of brightfields is not going anywhere but up. The potential for this type of renewable energy infrastructure remains largely untapped and as Milbrandt et al. (2014) suggest that the total amount of renewable energy produced on marginalized land in the United States could produce as much as 4.5PWh of electricity.

While Germany does have an abundance of brownfields and despite its preference for ex-military sites, it will be interesting to see whether the *Atomausstieg* (the nuclear power phase out process) translates into even more Solar Parks or wind energy on Konversionsflächen. On the one hand, brightfields could compensate for the soon to be lacking nuclear energy, while on the other hand make use of the soon to be abandoned and otherwise not useable nuclear plant properties. For comparison, the estimated 4'000MWp of installed brightfield capacity is the equivalent of around 2 large-capacity nuclear reactors or enough to provide electricity to roughly 1 million households. In comparison, the ~ 1'000MW of brightfield capacity in the United States 'only' provide approximately 200'000 households with electricity. This of course is largely due to the fact that the average American household consumes about 3.5 times as much as a German one.

The conditions for brightfields to succeed such as the number of marginalized properties, the technical know-how and desire for renewable energy as well as the natural resource availability (i.e. solar irradiance and wind speed) are similar in all three countries, yet in reality there are substantial differences regarding implementation. Alas, there is no indication that brightfields will become a priority for Canadian governments in the near future.

One can argue that it is just a matter of actively pursuing this idea via political and industry support that drives this concept in Germany and the United States. By this logic, it appears that politicians and renewable energy developers in Canada do not see brightfields as an alternative to residential redevelopment, which may be attributed to a housing market some say is the most overvalued in the world (Huffington Post, 2015). Nevertheless, the renewable industry and the Canadian governments jointly hold the key to unlock the brightfield potential in this country via private-public partnerships. Whether brightfields will become a more common alternative to greenfields and traditional brownfield redevelopment in Canada depends on the political will and manifestation in the form of programs similar to the EPA, as well as on the growing renewable industry and how much they pressure the government. Policies designed to curb the urban sprawl such as the Golden Horseshoe Growth Plan and the Green Belt mainly prohibit larger subdivisions on arable lands. Such policies do not apply to renewable energy via similarly imposing restrictions. On the one hand, the decision to discontinue FIT for large-scale ground-mounted solar farms in Ontario could have an adverse effect on the solar industry as a whole, since economic incentives may disappear. On the other hand, if grid parity does (and it will) become a reality, such incentives are no longer needed. This has several implications, most important of which is that renewable energy projects need no longer abide by the FIT rules, which could mean that the existing restrictions (weak as they may be in Ontario) regarding installations on certain lands worth protecting[38] no longer apply.

The Large Renewable Procurement process in Ontario has had a chance to increase the number of renewable energy projects on brownfields by setting aside a quota for marginalized lands, but it did not take this opportunity. As a result, conventional greenfields and lands that are still agriculturally valuable continue being used for green energy installations. Absent political leadership, it seems unlikely that the private sector would want to deal with the potential added difficulty of contaminated lands. Further the IESO has not issued preferential pricing for brownfields, even though numerous stakeholders have requested this since the onset of the Green Energy Act in 2009 and again in the FIT review 2011 by Pembina Institute.

The future of brightfields in Canada also depends on whether developers and policy-makers alike see the value in reusing lands with potentially troubled pasts or whether the liability and cleanup efforts are outweighing such benefits (more on this in chapter 5). Well-defined regulatory cleanup standards and procedures as well as brightfield best practices are needed, an issue that will be addressed in detail in the following chapter.

From a semantic perspective, the brightfields in Germany and the United States are starting to converge insofar as the type of marginalized property is beginning to broaden. From a typological point of view, the most common types of brightfields pertaining to former land use remain different in the two countries. Further, the main impetus for brownfield reuse in the United States has, for the longest time, been economic stimulation, whereas Germany had always advocated its brownfield reuse in terms of contribution to sustainability, greenfield protection and urban and *landschaft*

[38] Specialty Crop Areas, CLI Class 1 Lands, CLI Class 2 Lands, CLI Class 3 Lands and CLI Organic Lands (source: http://fit.powerauthority.on.ca/faqsFIT3/non-rooftop-solar-project-completeness-eligibility#3, retrieved on January 11, 2016).

revitalization. With the reuse of marginalized lands for the generation of green electricity, the United States is becoming more aware of the benefits of brownfield reuse not only to the economy, but also to the environment. One can argue that the United States is starting to pay closer attention to the sustainability aspect of brownfield reuse and is thus converging towards a German or European approach. The development of brightfields is the conveyor of this convergence. The dearth of information in Canada just does not allow for an objective conclusion regarding convergence, but is a good indication that the country is not at the same stage compared to the other two.

4.6. **Conclusion**

This study offers a comparative overview of the brightfield situation in America, Canada and Germany and provides answers as to how many brightfields there are and what their previous land use is. The comparison is centred on typology and former functionality of marginalized lands used for the generation of renewable electricity. The United States has so far 151 brightfields; Germany has around 250 and Canada less than 30. Germany also has the largest capacity (4'000MWp), followed by America's 1046 MWp and likely less than 300MWp in Canada. The concept of brightfields is most manifest in the United States. This is largely due to the backing by one of the country's largest federal agency; the EPA and its RE-Powering America's Land Initiative. Apart from successful implementation, the initiative's accomplishments and the growing popularity of the concept must also be attributed to a good marketing strategy, which advertises the benefits and consequently draws additional (e.g. private) financial support. A total of 151 brightfields have been implemented under the tutelage of the EPA with a capacity of 1'046 MWp. This represents around 1.13 % of the country's total renewable energy capacity. The United States is so far the only country with a federally implemented brightfield program.

In Germany this type of brownfield reuse is not as widely or successfully broadcasted compared to the United States. Nonetheless, the country has been converting *Konversionsflächen* into brightfields for a longer period of time. Brightfields in Germany are often refereed to as Solar Parks (if solar is the technology used), as it does not make sense to use an English term (i.e. 'brightfield') in Germany, although it would fit in nicely with the already common use of the term 'brownfield'. While Germany is the original creator of the Feed-in Tariff program, which helped transform Germany into a global green energy leader, the brightfield industry has relied less on government intervention. However the phase out of FIT support for arable lands has helped the brightfield development. Germany's *Konversionsflächen* have an estimated combined capacity of around 4'000

MW or around 2.5 % of the countries total renewable energy capacity. It is clear that Germany's brightfields are predominantly found on ex military sites, whereas the majority of installations in America are located on landfills. No clear type can be identified for brightfields in Canada.

CHAPTER 5: POLICY COMPARISON BETWEEN THE UNITED STATES, CANADA AND GERMANY REGARDING BRIGHTFIELD SUPPORT

Abstract: The United States Environmental Protection Agency's (EPA) RE-Powering America's Land Initiative has thus far converted over 150 marginalized lands into so-called brightfields using renewable energy. Outside the United States, the conversion of brownfields into brightfields seems less of a national priority. This study examines whether Canada and Germany, countries similar in scale vis-à-vis brownfields and the desire for more renewable energy, also offer federal brightfield programs. In the absence of federal policies, this study investigates whether individual economic and regulatory policies can support this novel concept. A comparative framework was created comprising three 'pillars'; (i) brownfield redevelopment, (ii) renewable energy development, and (iii) industry support. Each pillar contains several components, such as liability regime, remediation standards, financial incentives, etc. While neither country has a federal brightfield program à la United States, Germany's individual policies regarding the three pillars are applicable to renewable energy on brownfields and the country has produced a large number of brightfields already. Canada has yet to connect the dots between renewables and brownfield redevelopment and although some policies could be applied for this development, few have been used in practice. Despite these disparities regarding the marriage of brownfield and renewable energy, one can witness convergence of individual brownfield and renewable energy policies, in particular regarding funding mechanisms. These similarities can be attributed to transnational communication and lesson-drawing

Keywords: brownfield redevelopment, brightfields, renewable energy, policy review, multinational comparison.

5.1. **Introduction**

While there are numerous studies examining policies promoting a greener redevelopment of brownfields (see De Sousa, 2003, 2004, 2006; Schilling and Logan, 2008; Dorsey, 2003; Dair and Williams, 2006) or its merit regarding sustainability (Wedding and Crawford, 2007), brightfields policies have thus far gained little academic attention. In general, the concept is scarcely known and academia has produced little to explore it, especially outside the United States[39]. The brightfield concept has certainly not been given any academic attention in Canada, limitedly so in Germany and certainly not regarding policy support. Such a comparison is needed for two reasons. First, it highlights the strengths and weaknesses of a given country's capacity to advance the concept of

[39] With the exception of the Czech Republic where a dedicated group of researchers are producing a great amount of work on brownfield in general and brightfields in particular; most notably Frantal, Osman, Klusáček, Krejčí, Martinát, Kunc, Nováková, Pavlovič, Mahutová and Tonev.

brightfields through policy-making and industry support, and second, by doing so, it allows policy-makers to learn from the experiences of other jurisdictions, adopt new ones, and adapt existing ones. Lachapelle, Borick and Rabe (2012) attest that "comparison is a fundamental tool for political scientists, allowing researchers to situate their analyses in a broader context in order to reveal broad patterns and suggestive dissimilarities across cases" (p.3).

Comparative studies are a frequent method of analysis in the brownfield literature. Adams, De Sousa, and Tiesdell (2010) compared the British and the North American approach to brownfield redevelopment, remarking that industrial revival and economic stimulus have been seen as priorities in the United States, while the United Kingdom emphasizes the need for residential rather than economic redevelopment. The study also found that European and American brownfield policies are more and more convergent (both intra and internationally) - due to the similarity of incentives encouraging and stimulating the private market in order to undertake the costly and risky redevelopment effort. Guglielmi (2005) compared brownfield policies in Europe and the U.S. in light of the decline in industrialization and manufacturing. He found that "Germany and Europe are committed to preserving city life and the interests of the community through government funding, while the U.S. is committed to private property and aspirations of the individual through tax incentives" (p. 1312). Similarly, Oliver et al., (2005) analysed the European brownfield market via multi-country comparisons regarding policies and definitions. Frantal and Osman (2013) compared policy-frameworks and public attitudes regarding brightfields across the Czech Republic, Germany, Poland and Romania) and found that policies, practices and public attitudes remain largely divergent. Although Osman and Frantal (2013) work "*Renewable energy development on brownfields: Some evidence on diverging policies, practices and public attitudes from the USA, Germany and Czech Republic*" is noteworthy in that it compares the number of brownfields and the growth of renewable energy installation in the respective countries, the study does not actually analyse the selected countries' policies[40].

On the surface then it seems that the U.S. is alone in spearheading this development via the EPA's RE-Powering America's Land Initiative. While the latter has already been explored in chapter 4 (specifically its outcomes), here the goal is to examine more closely how the program works and

[40] The study does draw on a stakeholder survey pertaining to preferences regarding different brownfield redevelopment options, but it fails to assess the policies and investigate the cause of divergence/convergence.

what its components are. The analysis of this EPA Initiative will later on serve as a benchmark[41] against which the brightfield policies (or separate brownfield and renewable energy policies) in Canada and Germany can be compared.

5.2. Objectives and Research Questions

This chapter examines the efforts made in Canada and Germany juxtaposed to the EPA initiative and aims to determine whether Canada and Germany have federal brightfield policies of their own. Absent such national brightfield policies, this chapter investigates whether existing brownfield and renewable energy policies seem to suffice to support brightfields in lieu of specific federal policies directly targeting brightfields. Further, the objective is to find out whether there is convergence among these countries and what may be the cause of it. Canada and Germany are chosen for their scale of brownfields, their redevelopment efforts as well as socio-economic similarities to the United States.

This chapter aims to address the following research questions:

- **Q1:** Have Canada and Germany developed federal policies that support brightfields?
- **Q2:** What are the pillars and components that make up a brightfield support framework?
- **Q3:** Are these pillars and its components present in Canada and Germany and do they apply to brightfields?
- **Q4:** Is there convergence between these countries and what may explain the similarities or differences?

5.3. RE-Powering America's Land Initiative

This section studies the RE-Powering America's Land Initiative and examines and reports on how it supports renewable energy developers (private and public) and owners of marginalized lands (private and public) in the facilitation and development of brightfields. For that purpose, all RE-Powering America's Land Initiative documents and pertinent policies were analysed. Further, the author also attended numerous EPA and National Renewable Energy Laboratory workshops and has had personal communication with Regional EPA Directors responsible for the Initiative.

Based on the agency website, the current EPA initiative's main goals are to offer programmatic assistance regarding the feasibility of brightfields as well as provide funding for site assessment, site cleanup and renewable installations. Furthermore, the EPA has developed various

[41] It is important to note that although the U.S. brightfield strategy is the measure against which other countries are compared, the U.S. program is however not to be understood as a normative ideal.

polices and best practices in order to foster a knowledgeable brightfield industry and its success is based on a variety of partnerships with multiple stakeholders, including other federal agencies and innumerable state governments. This study finds that the initiative is built around the following principles and objectives: (1) offer technical assistance; (2) provide financial incentives; (3) promote policies and best practices for renewable energy on brownfields; and (4) partner with stakeholders and levy agency efforts.

(1) The technical assistance is offered via a variety of federal agencies such as the Office of Solid Waste and Emergency Response (OSWER) and the National Renewable Energy Laboratory (NREL), who provide free mapping and site screening tools (e.g. Google Earth applications) aimed at helping to determine the resource potential for a specific location (see Figure 5.1). There are also state inventories - such as the one in Ohio for example - and marginalized land databases that vary in comprehensiveness. The most complete federal resource for brownfield information is also maintained by the EPA, in what is called the *Comprehensive Environmental Response, Compensation, and Liability Information System*, or CERCLIS. The latter provides an electronic list of properties that have been flagged as potentially contaminated and could thus become brightfields. Despite these inventories and the estimates they provide (see chapter 4), Leigh and Coffin (2005) admit that one cannot know how many brownfields there truly are.

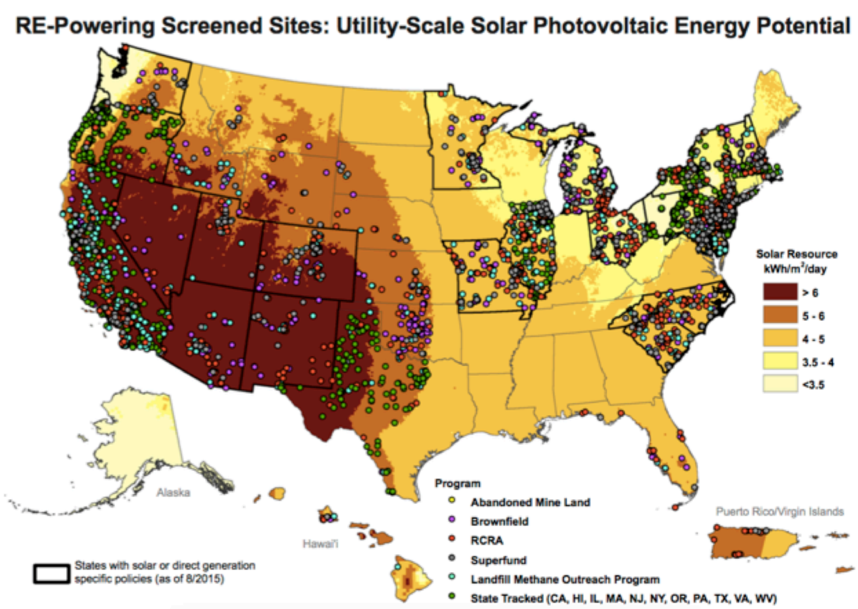

Figure 5.1. RE-Powering Screened Sites: Utility-Scale Solar PV Energy Potential in the U.S. The map is part of a larger effort to provide technical assistance and feasibility tools. This maps shows the amount and spatial distribution of sites. Similar maps exist for wind, geothermal and bio-energy (EPA, 2015).

(2) The initiative's financial aid offers a wide spectrum of resources such as direct funding via grants and revolving loans; tax incentives via deductions and credits; and cost recovery programs. There are many funding avenues and resources in the United States both for brownfield cleanup and brightfield projects via project banks, EPA loans, the Department of Housing and Urban Development, and Economic Development Administration or the Small Business Administration loans. The EPA initiative helps coordinate the various funding programs and offers assistance in the application process. The '*Technical Assistance to Brownfields Program*' funds technical brownfield assessments in communities with the goal of increasing the community's understanding and involvement in the brownfield cleanup and revitalization process, and ultimately helping communities expedite site cleanup and reuse. Crucially, this program underwent a policy change in order to apply to brightfields as well. However, the EPA also offers brightfield specific funding opportunities under its '*Federal Incentive for Achieving Clean Energy Development on Contaminated Lands Program*'. The latter is divided into three categories: (a) funding; assessment and cleanup grants, job training grants, et cetera, (b) tax incentives; renewable electricity production tax credit, investment tax credits, and (c) consultation; modified accelerated cost-recovery system and best practices.

(3) Although scholars like Wernstedt et al. (2007) believe that the United States contaminated land liability system is still unpredictable, adversarial and litigation-fraught, the efforts made by the RE-Powering America's Land Initiative have somewhat reversed this trend according to Tomberlin and Mosey (2013). The initiative uses brownfield and contaminated site regulations and is therefore able to offer a wide range of liability relief programs and financial resources that increase project viability. In fact, the EPA began issuing renewable energy comfort or status letters in 2012, specifically intended for lessees involved in renewable energy development on contaminated property. The letters are intended to provide the lessee with information the EPA currently has about the property and applicable Agency policies to help the lessee make informed decisions as they move forward with renewable energy development on their property. This is a good example of a federal policy that has been amended in order to apply specifically to brightfields.

Crucially, the cooperation between State and Federal authorities (the lack thereof often slowing down, even halting brownfield reuse efforts) has been - somewhat uncharacteristically - productive and for the most part void of litigations pertaining to brightfields. State authorities can impose cleanup procedures and prepare sites for reuse, while the federal initiative then helps owners and developers with the facilitation of renewable energy installations (Hunsberger and Mosey, 2014).

This has resulted in a high degree of coordination, responsibility-sharing and ultimately augmented numbers of successfully implemented brightfields. While the RE-Powering America's Land Initiative is a collaborative effort by the EPA, OSWER, NREL and other agencies, it has also been well received by the private sector and the broader public such as Non-Governmental Organizations, insofar as many utilities are engaged in the process and collaborative in their approach. While the literature has demonstrated that there is a positive spill over effect regarding brownfield redevelopment (see Howland, 2007; De Sousa, 2008), the development of brightfields promises an even higher economic multiplier since the concept is coupled to the thriving renewable energy industry.

(4) Industry support is essential in creating a workforce knowledgeable to deal with both renewables and brownfields. The solar industry in the U.S. is backing this idea and even utility companies are starting to redevelop some of their own brownfield 'asset lands' with green energy (see previous chapter). Furthermore, there are a host of organizations such as the Union of Concerned Scientists (UCS), the Sierra Club, the Audubon Society and others, promoting the idea of recycling such lands for green energy. The UCS states as early as 2009 that "land that has already been disturbed should be given preference for [renewable energy] development. Whether in private or public ownership, land that has been used for industrial, agricultural, or other intensive human purposes is generally superior to 'greenfield' sites in term of reduction of environmental degradation [...] redevelopment of disturbed sites offers opportunities to improve lands that may not otherwise be reclaimed" (p.4).

The RE-Powering America's Land Initiative wants to be understood as a facilitator rather than an implementer. The brownfield/brightfield market still holds inequalities compared to conventional renewable energy projects (see chapter 6), which these federal policies aim to address. Further, the involvement of the EPA, one of the largest federal agencies in the United States, demonstrates a political commitment and government-oriented support. The complexity of brightfield development requires a mix of private, municipal, state and federal government stakeholders. This mix of actors and supporters for a common goal can be described as a cooperative technology policy paradigm (Bozeman, 2000). The United States brightfield program is the most targeted and coordinated effort anywhere in the world that aims to convert contaminated (or potentially contaminated) lands into green electricity facilities. According to several high-level RE-Powering

America's Land Initiative personnel, the United States would not be where they are now regarding brightfields if it was not for federal policy intervention (Personal Communication, 2015).

5.4. **Framework and Methodology**

Any multilateral policy comparison sooner or later has to address the question of convergence. Policy convergence is a sub-field of the broader theory of convergence in public policy, which is defined by Kerr (1983) as the tendency of societies to grow alike, to develop similarities in structures, processes and performances" (p. 23). One of the more established theories suggests that convergence between nations is the product of technocratic and economic forces of industrialism, since industrialized and technocratic societies tend to adopt progressively similar infrastructures, which in turn shape comparable social dispositions, political processes, legal and administrative structures (see Bell, 1960; Bennett, 1991). According to Bennett (1991) "convergence should also be seen as a process of 'becoming' rather than a condition of 'being' more alike: Convergence means moving from different positions toward some common point" (p.219). Holzinger and Knill (2005), find it is crucial to discern between degree, scope or direction of convergence. Here, the focus is on the direction, which is indicative of an upward or downward trend regarding a given issue. That is, whether the development of brightfield policies is becoming more and more common (upward trend) as a result of the concept itself becoming a more common form of brownfield redevelopment across these countries. Further, the objective is to determine the main impetuses for this type of development in each country as well as the causes of directional convergence or lack thereof.

Together with the renewable energy and brownfield literature, the EPA Initiative serves area benchmark against which Germany and Canada can be compared. To that end, the United States RE-Powering America's Land Initiative (see section 5.3 above) is dissected into its individual components such as liability relief, technical assistance, et cetera. In concert with the literature, three main pillars are constructed that are desirable to have for the support and facilitation of brightfields. The term 'pillars' is chosen deliberately for it represents the individuality of various policies (chiefly renewable energy and brownfield) as opposed to the more cohesive U.S. federal initiative that brings all these pillars under one hat, or foundation as it were. Figure 5.2 illustrates the analytical framework. These three pillars are; (1) brownfield redevelopment pillar, (2) renewable energy development pillar, and (3) an industry support pillar (see Table 5.1).

A comprehensive review of the literature helps determine the components of each pillar with regard to brownfield redevelopment policies/programs and renewable energy policies/programs. The literature shows (see McCarthy, 2002; Heberle and Wernstedt, 2006; Coffin, 2003; Coffin and Shepherd, 1998; Bartsch and Collaton, 1997; De Sousa, 2000), that a brownfield redevelopment framework (pillar 1) should include; a measure of stock via a (1) *site inventory*; clear and uniform (2) *remediation standards*; a robust (3) *liability regime;* and (4) *financial incentives* for redevelopment. The Canadian Brownfield Manual by Chalifour (2004) as well as the work by Hara (2003) on 'Meeting the Challenges of Brownfield Redevelopment' are instrumental in determining the applicability of this pillar in Canada. The literature (see Ramachandra and Shruthi, 2005; Tansel et al., 2013; Mosey et al., 2007; Sawin, 2006 and others) also suggests that a renewable energy development framework (pillar 2) should be comprised of (5) *regulatory instruments*, and (6) *financial incentives*. The seventh component is the third pillar or (7) *industry support*. The three pillars and their individual components are illustrated in Table 5.1.

Pillar 1:Brownfield Redevelopment	**Pillar 2: Renewable Energy Development**	**Pillar 3: Industry Support**
(1) Site inventory *(2) Remediation standards* *(3) Liability regime* *(4) Financial incentives*	*(5) Regulatory instruments* *(6) Financial incentives*	*(7) Industry Support*

Table 5.1. The foundation of brightfield support. Canada and Germany are investigated pertaining to the existence and applicability of these three pillars.

The analytical comparative framework is based on the existence and applicability of the 7 components to the development of brightfields. Birkmann (2007) uses a similar approach, comparing risk and vulnerability indicators across various countries, by using a model based on the existence and applicability of polices. The two selected countries are analysed - based on the above pillars - investigating the existence *and* applicability of each of the seven components in the two countries. To that end, around two hundred primary data sources such as national legal documents, government-issued reports and web-content was surveyed, and substantiated by the academic literature where available. Applicability is defined as follows; a government policy not necessarily specifically intended for brightfields, but that could technically (or in theory) apply to brightfields either via the wording of the policy or practice (e.g. a policy has been used for brightfields in the past). Finally, several brownfield and renewable energy experts were contacted in order to substantiate its applicability. Although, this applicability may lack objectivity and repeatability, each policy was studied comprehensively enough to determine whether it could apply to brightfields or whether it has already been applied. Finally each country's industry support is examined. Industry support is determined by exploring the presence of domestic renewable energy or brownfield redevelopment companies, non-governmental and not-for-profit organizations that recognize the benefits of brightfields, provide resources, training, funding, or have already implemented brightfield projects. Such organizations and companies often conduct case or feasibility studies that are used here to establish whether there is support for the brightfield idea by the renewable energy installation and manufacturing, brownfield development and remediation industry. The author examined all available industry-issued material regarding brightfields, renewable energy on brownfields or contaminated sites. Several experts from the brownfield and renewable energy industry were engaged (informally) in order to gauge their sentiment regarding industry support. These industry experts were asked whether their respective industry (renewables or brownfield) supported the brightfield idea and whether there may already be a brightfield capacity or not. Figure 5.2 provides an overview of the analytical framework of this chapter.

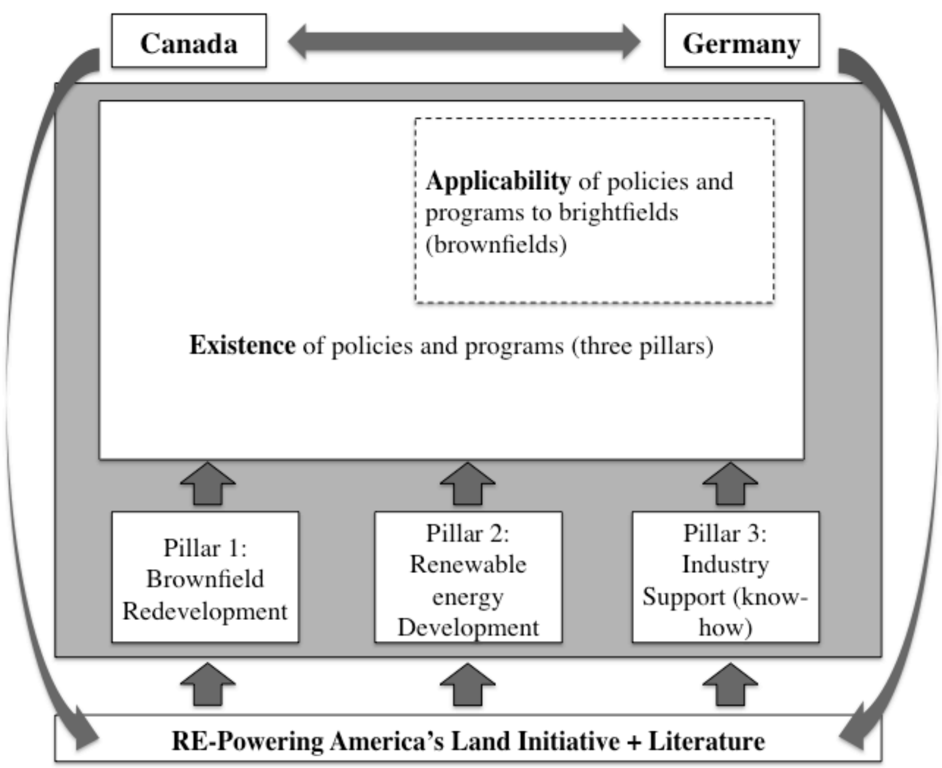

Figure 5.2. Illustration of the analytical framework. Canada and Germany are compared to the pillars that make up the foundation of a brightfield support framework, which is derived from the U.S. brightfield strategy and the literature.

5.5. **Explanation of Pillars**

The following paragraphs describe the pillars of brightfield development, their individual components, and their importance regarding the support and implementation of brightfields. These separate pillars are in lieu of federal brightfield policies and serve as a basis with which to compare Canada and Germany to the United States.

5.5.1. Site Inventory

Because one 'can't manage what can't be measured', a site inventory is an important component of any brownfield redevelopment program and consequently crucial to brightfields. An inventory helps understand the scale and scope within a jurisdiction and track the progress of redevelopment of individual sites in relation to the entire extent and national stock (see Leigh and Coffin, 2000). An inventory ideally includes (a) geophysical data such as location and size; (b) site classifications such as status (active/inactive); and (c) the degree of contamination. Such an inventory should be free of charge and publicly accessible so that anyone who seeks to unlock the potential of brownfields can make use of such inventories, searching for sites or assessing the suitability of their own sites (e.g. a municipality).

5.5.2. Remediation Standards

Remediation standards are a crucial part of brownfield/brightfield (re)-development polices. Traditional generic standards[42] are more and more being complimented with site-specific and/or risk-based ones that tailor remediation efforts to end-uses. While the author does not advocate one over the other, the literature shows that standards need an unambiguous legal language and are ideally uniform intranationally. Such policies should be clear on where and when remediation is and is not required. In practice (as seen in the U.S.), often times remedial work is not mandated by the regulator for interim or long-term renewables, because of a smaller path-receptor risk than other end-uses such as residential.

5.5.3. Liability Regime

Based on the brownfield literature, liability continues to be the single greatest barrier to brownfield redevelopment (Murphy, 1996; De Sousa, 2002; McMorrow, 2003; Alberini et al., 2005;

[42] If contaminants are present at concentrations higher than the generic standards for an intended use or certain physical characteristics of the property, remedial action may be required.

Siikamäki and Wernstedt, 2008). According to Hara (2003) "a myriad of regulatory requirements and potentially infinite civil liabilities impede progress in brownfields redevelopment" (p.10). A liability regime is important because it determines the bearer of responsibility for site cleanup and additional costs or damages. It requires a legal foundation that is enforceable by law and punitive in cases of non-compliance. Although the Polluter Pays Principle (PPP) has been established as the primary form of assignment in all three countries, governments have begun to put forward several relief or exemption policies that exempt owners (and/or polluters) from certain liabilities, such as in the case of remedial compliance, or the *de micromis* or *de minimis* principle. There are also exemptions on prospective liability in the form of certificates, 'comfort letters' or 'covenants-not-to-sue' (Alberini et al., 2005). Moreover, in some instances, the government assumes the cleanup costs or part of it, in order to stimulate the development of a brownfield and its surroundings. Again, the author does not advocate a liability regime over another, but simply compares the three countries' liability policies (on the provincial and where available on the federal level) and their applicability to brightfields.

5.5.4. Financial Incentives for Brownfields/Brightfields

The majority of brownfield redevelopment projects require a substantial amount of capital for potential remediation and due diligence, leaving many investors and developers to opt for the 'easier' (and often cheaper) greenfield. Bartsch (1996) calls on governments to level the playing field regarding the disadvantage of brownfields over greenfields via financial incentives. Absent such intervention, most projects are not economically viable without economic incentives such as funding and tax schemes that will finance gaps beyond the market value or allow for cost recovery (see Kurdila and Rindfleisch, 2007; Kushner, 2005).

5.5.5. Regulatory Instruments for Renewable Energy/Brightfields

Regulatory instruments pertaining to renewable energy policies include pricing policies and renewable energy quotas or targets (see Menanteau, Finon and Lamy, 2003). Regulatory instruments are at least as important for renewable energy technologies as economic ones, as they require any party to produce or buy a certain amount of electricity from eligible renewable sources to fulfil a quota (Sawin, 2006). Without regulatory instruments, demand for, as well as supply of renewable energy would be considerably less. Generally speaking, Feed-in-tariffs (FIT), Standard Offers Programs (SOP) or Net Metering Programs (NMP) apply for most renewable energy projects, including brightfields. Quotas and other renewable energy targets can be met via Renewable Energy

Portfolio Standards (RPS) and Renewable Energy Certificates (REC) or other means.

5.5.6. Financial Incentives for Renewable Energy/Brightfields

In order to address high capital costs of renewable energy in general, and potentially added costs for brightfields in particular (i.e. remediation) governments offer also economic instruments directed towards renewable energy installations. These tools can encompass some form of tax relief (such as investment and production credits), rebates alongside funding schemes such as loans, grants, bonds, et cetera. It is important to note that FIT, SOP and the like are primarily regulatory instruments and not financial ones, despite their financial nature.

5.5.7. Industry Support

The abovementioned regulatory and financial instruments are largely inept without proper application and implementation. Thus, industry support is of crucial importance in order to establish the necessary know-how for this type of development and advance the implementation of standards and best practices. While the RE-Powering America's Land Initiative is a collaborative effort by the EPA, OSWER, NREL and other agencies, it has also been well received by the private sector and the broader public (see page 72). Coffin and Barbero (2009) correctly point out that private-public-partnerships are key to successful brownfield revitalization by building capacity for redevelopment and it can be argued that this also applies to brightfields. Since (most) renewable energy projects undergo a public review process, overseen by the authorities, this partnership is also invaluable when it comes to brightfields.

5.6. **Results**

5.6.1. Site Inventory

Canada does not have a national brownfield inventory. Apart from land use data such as the Canadian Land Inventory (that does not list current or past industrial or commercial use), the country's only federally run inventory of properties is the Federal Contaminated Site Inventory (FCSI)[43]. The FCSI lists concrete or potentially adverse impacts, status (active, inactive), location,

[43] The Federal Contaminated Sites Inventory includes information on all known federal contaminated sites under the custodianship of the Crown corporations as well as those that are being or have been investigated to determine whether they have contamination arising from past use that could pose a risk to human health or the environment. The inventory also includes non-federal contaminated sites for which the Government of Canada has accepted some, or all financial responsibility.

size, source and degree of contamination, priority for cleanup and required action. It also provides, exporting and mapping tools for and accessible by the public. The FCSI, while comprehensive, does not list sites with no apparent contamination and thus does not include all brownfields in the larger sense of definition. More importantly, it does not list privately owned sites.

Ontario, Quebec and B.C. have inventories of lands that could be classified as brownfields. These inventories range in comprehensiveness and accessibility and mostly include properties already slated for (mostly residential) reuse. In the case of Ontario, the province's Record of Site Condition (RSC) program is used for properties suspected of contamination whose owners wish to reduce their liability. It is not an inventory of (all) brownfields strictly speaking. Under the current law, the RSC records are available to the public, alas are not very user-friendly from personal experience. Apart from the provinces, most Canadian municipalities have inventories of their landfills and to some degree vacant properties.

Other provinces have contaminated site inventories, but as reported by De Sousa (2001) they differ extensively with regard to how they: (1) compile information; (2) determine which sites qualify as contaminated; and (3) make data available to the public. To the current state of knowledge no federal brightfield or brownfield inventory policy is being planned in Canada, although the Public Sector Accounting Board called for municipal contaminated site inventories in 2014. Compared to the United States (both on the federal and state-level), Canada does not maintain as comprehensive records of its brownfield stock[44], thus not making a real difference regarding the support and implementation of brightfields and does therefore not contribute nor truly apply to brightfields as of yet.

To the current state of knowledge there is no federal brownfield inventory in Germany. However, the country is part of several Pan-European initiatives aimed at assessing brownfields on a regional rather than a national scale; such as TIMBRE's online brownfield database. Further, almost every Bundesland has its own '*Brachflächenkataster'* or brownfield catalogues, which are often very detailed inventories comprising current use, present infrastructure, location and source of contamination. Several Bundesländer and most regional or municipal authorities also possess a so-called *Entwicklungsplan*, a master development plan that often includes inventories of brownfields as well as contaminated sites (so-called *Altlasten*). Compared to Canada, Germany has a more comprehensive and more updated inventory of its brownfields (see Table 3.2). According to primary

[44] Although Municipalities are soon to be obligated to maintain an inventory of all contaminated sites.

data analysed (in chapter 4), it is evident that solar and wind energy developers have made use of the various inventories available for the development of *Konversionsflächen*. Thus, the existing inventories and databases are helpful in the development of brightfields.

5.6.2. Remediation Standards

In Canada, most provincial and municipal approval processes require brownfields to be remediated to meet a set of quality standards (NRTEE, 2003). Federal guidelines and protocols are put forward under the *Canadian Environmental Assessment Act* and *Canadian Environmental Protection Act* to provide risk assessment measures regarding contaminated or potentially contaminated sites. However, these are mere guidelines for *ad hoc* (i.e. emergency) cleanup and do not apply to the "reclamation or restoration of land" (NEB, 2013), adding to the inconsistency of federal guidelines regarding remediation. What's more, the provinces are not obliged to abide by these guidelines. Therefore, provincial governments in Canada may require different cleanup criteria. The provinces are divided in that regard, in that about half of them have generic standards and half have site-specific ones (World Bank, 2010). Some municipalities (and provinces) may even set up additional requirements for environmental approvals in case of their potential exposure to the legal liability (NRTEE, 2003). Saskatchewan for instance has introduced Risk-based Corrective Action (RBCA) for petroleum hydrocarbons (PHC) impacted sites for remediation and management standards. The Ontario Ministry of the Environment advocates two standards for brownfield assessments, a generic and site-specific one. Site-specific standards could in theory apply to any type of potential brightfield requiring cleanup, although there are no concrete examples yet, as there are no brightfield specific standards. The Renewable Energy Approval (REA) process in Ontario addresses mitigation measures, stating that "for each negative environmental effect that will or is likely to result from construction and installation, the applicant is required to describe any mitigation measures proposed" (REA, 2013). Containment structures such as siltation fencing or storm water management measures are simply recommended in the REA application and are by no means set standards. Due to the lack of experience, there are also no brightfield generic standards, complicating the matter for the generic-only provinces. By contrast, the country's most famous brightfield - British Columbia's SunMine - did not need remediation, suggesting that under certain circumstances brownfields are allowed to be transformed into brightfields without expensive remediation. This however depends on provincial policies and likely the nature of contamination. In Ontario for instance, solar is not deemed a suitable use for aggregate sites, but a new policy, expected in 2016, is going to change that.

A further failure to tackle remediation criteria on a federal level comes from the vague language of the National Energy Board. While the National Energy Board (NEB) has developed the *Remediation Process Guide* for industry to follow in case of a contamination, the responsibility for developing cleanup criteria lies with the provinces. The *Remediation Process Guide* de facto only applies to facilities that are already in operation and as such addresses spills or contamination events concurrent to energy operations. Even though, the NEB states that remediation is necessary for 'most energy infrastructure', it fails to specify whether this applies to solar and wind energy as well or only conventional energy plants.

Canada's intranational incoherence creates inequalities and complications for developers of brightfields. Thus far there is no clarity regarding regulatory remediation standards that apply for brightfields. Absent legal clarity and further examples, it is difficult to determine when brightfields require remediation or not and how current policies (e.g. standards) may apply to brightfields.

The German Federal Soil Protection Act and the Federal Soil Protection Ordinance include three types of risk-based brownfield cleanup standards: (1) trigger values (concerning soil-to-human, soil-to-plant, and soil-to groundwater pathways), (2) action values (concerning soil-to-human and soil-to-plant pathways) and (3) precaution values (to prevent new soil pollution). When trigger values are exceeded, further investigation and assessment is necessary whether the site is contaminated or not (World Bank, 2010). "When action values are exceeded, it is usually an indication of the presence of a contaminated site, meaning that corrective measures are required to meet the provisions to prevent harmful soil changes" (World Bank, p. 23). The Soil Protection Act is congruent with the E.U. Directive 2004/35/CE on environmental liability. Interestingly, the main European piece of legislation addressing the problem of contaminated soils is the same Directive as the one covering liability.

Despite this congruence, there are no specific guidelines or standards for remediating brightfields specifically, only ad-hoc assessments – similar to Canada - with the exception of PV installations on closed landfills, where federal quality standards demand that no substantial disturbance to the integrity of the cap shall occur. However, according to the *Bundesumweltamt*, brightfields can make use of existing brownfield site-specific standards to remediate the site if necessary. Despite being rather stringent, the standards in Germany are uniform across the country and apply to brightfields, if not (yet) by language, then by practice, as demonstrated by hundreds of completed brightfield sites.

5.6.3. Liability Regime

The Canadian Council of Ministers for the Environment (CCME) agrees that the Polluter Pays Principle (PPP) "should be paramount in framing contaminated site remediation policy and legislation" (1993, p. 4). While the federal government promotes the PPP, which has been adopted by all provinces, the latter still hold primary responsibility pertaining to liability. In the case of brownfield remediation, private companies are usually responsible for the costs to restore the land contaminated by their past or on-going activities that left a property contaminated. Generally, provinces can use two approaches in determining liability and financial responsibility for cleanup and/or damages done to the human and environmental health; (1) joint and several liability[45] and (2) allocated liability[46] (De Sousa, 2001). While these two approaches are at the government's disposal vis-à-vis private responsible parties, De Sousa (2001) pointed out that there is a "general unwillingness across the country for governments to impose liability on those responsible for contamination and force a clean up, except when the contamination at a site imposes a severe risk to human health or to the environment" (p. 139). Governments rather allow responsible parties to clean up sites voluntarily when they are transferring or developing brownfields.

For contaminated properties, where the government is the responsible party, there is a new federal legislation (PS3260) that addresses liabilities for remediation related to sites, or parts of a site no longer in active or productive use (Church, 2014). PS3260 does not specify standards for renewable energy end use and more critically continues with the strict retroactive and prospective liability. Some provinces offer liability relief programs. Ontario's 2001 *Brownfields Statute Law Amendment Act* provides limited liability from further regulatory orders for property owners who clean up contaminated sites to acceptable standards. It also provides protection for municipalities, secured creditors, receivers, and trustees in bankruptcy, fiduciaries, and property investigators (Gerrard, 2008). British Columbia provides for liability to be shared among site owners, former site owners and producers, disposers, transporters and handlers of contaminating substances, with exemptions for secured creditors, authorized contractors, governmental bodies and remediation contractors and advisors. Under the province's regulation liability is absolute, retroactive, joint and separate. B.C. also has a limited innocent purchaser exemption (similar to the U.S.) for purchasers who buy land not knowing it is contaminated, provided they exercise due diligence (Gerrard, 2008).

[45] In cases of joint and several liability, a person who was harmed or wronged by several parties could be awarded damages and collect from any one, several, or all of the liable parties (Cupp, 2003).
[46] Under an *allocated* or *apportioned liability* system, the different parties are held liable for clean up in accordance with their individual contribution to the pollution problem (De Sousa, 2001).

Compared to Germany, there is no limit on time in Canada for liability, meaning that liability can become both retroactive and prospective often hindering redevelopment out of fear for future costs and tort (World Bank, 2010). Adding to the confusion is the fact that '*caveat emptor'* is still in effect in most provinces, despite innocent buyer exemptions. However, there is no specific liability exemption policy for the development of brightfields in Canada, because there is little experience with brightfield end-use specific standards. Absent governmental intervention or support, it is doubtful whether more contaminated or potentially contaminated lands will become brightfields in the near future in Canada.

Unlike the United States, many European countries including Germany have opted to exempt polluters from liability of past contamination that was considered legal at the time, thus placing a time limit on retroactive liability (Auer et al., 2001; Larson, 2006). The abatement of retroactive liability responsibilities was also sanctioned by the European Commission's White Paper on Environmental Liability Regime[47]. The federal liability Act implements the provisions of the Directive 2004/35/EC of the European Union concerning environmental liability. Germany's PPP holds financially liable the operator whose activity has caused environmental damage (strict approach) or damages to biodiversity (fault-based approach). Paccagnan and Turvani (2007) confirm that the German Liability Act is uniform across all *Bundesländer*. Again, to the current state of knowledge there exists no specific liability exemption scheme for the development of renewable energy on brownfields. This may explain the use of government-owned ex-military sites where governments themselves are liable or where liability and its costs may be deferred.

5.6.4. Financial Incentives for Brownfields/Brightfields

According to De Sousa (2001) there was great variability in the early 2000's in how funding incentives for brownfield redevelopment were established within Canada. While there still is no federal funding program for remediation, brownfield redevelopment projects can now benefit from a number of general federal funding avenues such as tax and rebate schemes under the federal infrastructure and economic stimulus program. However, financial incentives are more frequently offered provincially and municipally through community improvement plans, tax increment financing or brownfield remediation tax assistance, or via advocacy groups such as the Federation of Canadian Municipalities (FCM). Edmonton for example offers financial assistance for the construction of

[47] The Environment Liability Directive (2004/35/CE)

infrastructure to support interim renewable energy installations. The Green Municipal Fund[48] (GMF) initiated by the FCM, allows for brownfields in every province to apply for 'planning grants'[49], remediation and redevelopment loans[50]. Planning grants are up to 50 % of eligible costs with a maximum grant of $175'000, while remediation and redevelopment loans are up to 80 % of eligible costs. More importantly, since 2014 brightfields can explicitly profit from the GMF. However, no brightfield has yet received funding from the GMF. Quebec, Ontario, and British Columbia (among other provinces) have their own funding programs that are either specifically for brownfields or can apply for funding by incorporating their redevelopment into the broader context of sustainability. Ontario's greenbelt legislation provides stimuli for brownfield development, while B.C. announced in 2008 a $10 million remediation fund to create green opportunities on brownfield land (Adams, De Sousa, Tiesdell, 2009). The B.C. government in part funded SunMine for instance; although this was a 'one-time-only' funding and no standing financial support for brightfields exists anywhere in Canada. There is no federal policy that directly financially supports renewable energy on brownfields.

The most significant financial incentive for sustainable brownfield development is the European Union Structural Fund (EUSF); without it, regeneration activity in Europe would have been almost exclusively restricted to brownfields with high viability and marketability, so called 'A' sites (see Thornton et al., 2007). The EUSF chiefly flows into pan-cooperative research programs like JESSICA, HOMBRE, URBANSMS, SAFIRA, REFINA and so on. To the current state of knowledge there is no standing federal funding scheme explicitly for the development of brightfields in Germany. However, the German Government does fund brownfield redevelopments (specifically *Flächenrecycling*) insofar as it provides grants and money for the removal of waste, which include grants from the *German Communal Transport Financing Act* and loans by the *Kreditanstalt für Wiederaufbau (KfW)*. As part of the reunification effort, site cleanup and redevelopment became the responsibility of the federal government and as a result, the bulk of federal resources were directed to high-profile pilot projects (Paccagnan and Turvani, 2007).

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[48] N.B The GMF comes from the federal government but is administrated by the FCM.
[49] 50% of eligible costs with a maximum grant of $175,000.
[50] Up to 80% of eligible costs.
N.B Private investment funds (e.g. equity funds) are available and sought after given the previous reluctance of banks to finance brownfield redevelopments. The Kilmer Brownfield Equity Fund is the first private equity fund in Canada dedicated exclusively to the redevelopment of brownfields and has $100 million set up as a limited partnership with both institutional and private investors. Apart from retrofitting (i.e. LEED), Kilmer has so far no brightfield in its portfolio.

5.6.5. Regulatory Instruments for Renewable Energy/Brightfields

Although Canada already produces around 60 % of its electricity from renewables[51], the country thus far has no federal Renewable Energy Portfolio Standard. Like most brownfield regulations and incentives, regulatory instruments for renewables are more abundant provincially and municipally through Standing Offer Programs (SOP), Net Metering Programs (NMP) or FIT programs. The latter system is available in Ontario through the Green Energy Act, modelled after the German *Stromeinspeisungsgesetz*. Some provinces provide similar offers but are more restricted such as for instance the Community FIT in Nova Scotia.

Advantageously, the Ontario FIT program does not allow installations on prime agricultural land[52], thus somewhat opening the door for brightfields in the province. Furthermore, the latest FIT regulation (FIT 4.0) states that non-rooftop solar must not be located on Class 1, 2 or 3 land unless the property is (i) a closed landfill, (ii) a federal military installation or (iii) a contaminated property. Class 1, 2 or 3 lands represent the most agriculturally productive lands. Alas, despite these seemingly advantageous conditions, the number of renewable energy installations on brownfields remains if not negligible then certainly unsubstantial (see chapter 4). In short, there are no explicit federal regulatory instruments directly supporting the development of brightfields, such as quotas or land use moratoria for energy projects on greenfields.

*The A*ct on Feeding Renewable Energies into the Grid of 1990, better known as the *Stromeinspeisungsgesetz* promoted the generation of renewable energy for over two decades and made Germany the world's single biggest producer of solar energy along the way (Schiereck and Trillig, 2014). The Act was passed because Germany had very ambitious renewable energy targets[53]. At its core is the FIT program, which it is expected to be replaced soon by Tradable Green Energy Certificates (Nielsen and Jeppesen, 2003). There have been special provisions in the FIT regulation for *Konversionsflächen* that offer higher tariffs (see chapter 4); in fact since 2010 solar PV on any arable land does not receive any Feed-in tariffs, thus levelling the playing field in comparison to conventional electricity generation (Frantal, 2013). This restriction is a lot stricter than the one in Ontario, where renewable energy installations are still receiving feed-in tariffs on non-brownfield lands. The overall reduction of FIT in Germany is a result of a successful FIT program and a soon

[51] The majority of which comes from hydroelectricity.
[52] Canada Land Inventory (CLI) Class 1,2 or 3 soils, CLI Organic Lands or Specialty Crop Areas
[53] Germany has set the following federal RPS; 35 % Renewable electricity by 2020, 80% by 2050; and 18% Renewable energy by 2020, 30% by 2020, and 60% by 2050 (EIA, 2014).

largely incentive-free solar and wind economy. To the current knowledge there is no other regulatory mechanism that directly supports brightfields, the way the German FIT does.

5.6.6. Financial Incentives for Renewable Energy/Brightfields

Funding for renewables in Canada is available through a variety of federal channels aimed at economic stimulation including Accelerated Capital Cost Allowance for green electricity, Renewable and Conservation Expense**,** in concert with various programs from Natural Resources Canada, such as the Clean Energy Fund and *ecoENERGY*. Canada's Gas Tax Fund, for example, continues to drive improvements in municipal infrastructure. As of April 2014, the eligible categories that communities could use the funding for was broadened to not only highways, and broadband development, but also brownfield redevelopment. Again the majority of economic incentives are provincially issued, (such as the refundable and/or non-refundable investment tax credits available in all provinces). Thus far there is little precedent of such instruments being used for brightfields, although the *SunMine* project is testament to the fact that such monies exists and are theoretically applicable to brightfields. Thus far they are only given out on an ad hoc basis.

In Germany, renewable energy is backed by a series of robust federal direct funding and to some degree fiscal mechanisms, offering tax-based incentives like the *Eco-Tax Reform*. By far the most important funding stream comes from the Renewable Energies Programme and the Energy Turnaround Financing Initiative under the umbrella of the *Kreditanstalt für Wiederaufbau*. These programs and initiatives do apply to renewable energy on brownfields, however they are not specifically designed for brightfields. *Konversionsflächen* are favoured in the FIT program and thus attracted a great deal of additional investors (using FIT as guarantees), but since the future of the FIT is unclear, so too is the financial support for brightfields, experts say. Albeit the degression of financial incentives, commercial solar has reached grid parity[54] in Germany (PV Tech, 2014), which leads to what Nakata (2014) calls a 'soft-landing' for the end of FIT.

[54] Grid Parity occurs when an alternative energy source can generate power at a levelized cost of electricity that is less than or equal to the price of purchasing power from the electricity grid.

5.6.7. Industry Support

Canada has long been a leader in sustainable energy (mostly hydro) and is starting[55] to become a leader in solar and wind energy via augmented technical know-how, installed capacity all the while creating a world-class green energy workforce. Canada is ranked 3rd in the world for hydroelectricity, 7th for wind energy and is in the top 15 for solar.

By all accounts, the Canadian brownfield sector is thriving, especially amidst a housing boom and urban intensification (prompted by Green Belt growth restrictions or similar provisions). The dichotomy between urban and rural brownfields however remains, making the Canadian market very selective insofar as urban brownfields see a much quicker turnaround compared to rural ones. The competitiveness of urban brownfields, will generally render them less suitable for renewable energy developments. Overall, the brownfield industry is well established and has a wealth of expertise and resources.

By contrast, the brightfield industry is more or less non-existent, which means that Canada has not yet connected the dots between renewables and brownfields. Canada's Green Building Council's LEED Program does award credits for renewable energy and brownfield redevelopment but has so far not made the connection and leap to brightfield development. Further, despite the fact that multiple non-governmental organization such as the FCM have for instance requested to raise FIT rates for ground-mounted PV on brownfields, few changes have been implemented so far and industry support and interest has stalled as a result of the status quo. A notable exception is ArcStar Energy, a private company that is investing in and consulting stakeholders (e.g. site owners) on brightfield developments. ArcStar Energy claims to have secured investments for 10 brightfields in Ontario totalling 70 MWp in capacity and are looking to expand into Alberta and Quebec. In ArcStar Energy's view, the Green Energy Act provides Ontario with a unique opportunity to address two environmental problems for Ontario; Brownfield redevelopment and electricity from renewable energy (IESO, 2009). However, the IESO is not committed to carve out a quota for brightfields in their Large Renewable Procurement (LRP I.). Overall, industry support for brightfields is a lot less significant in comparison to both the United States and Germany.

In Germany, industry support for the reuse of *Konversionsflächen* for Solar Parks and wind installations on Brachflächen manifests itself in a much more concrete fashion, given that a myriad of

[55] However, Canada's 0.95 % of global installed renewable capacity pales in comparison to Germany's 21 %.

green energy companies have already implemented a substantial number of brightfields, more than the U.S. and Canada combined. This expertise is rooted in a collective shift away from conventional energy production to more sustainable power generation called *Energiewende*. According to industry experts, the original enthusiasm for green energy has spilled over into the development of brightfields, albeit the lack of an official federal policy. Germany can rely on a great industry support for brightfields as illustrated by numerous renewable energy developments on marginalized lands.

So far, the bulk of the findings compared Canada and Germany, thus it is important to compare these results to the United States. We have already discovered that the U.S. EPA brightfield initiative is accelerating the development of brightfields via a broad range of financial and regulatory instruments, specifically designed for brightfields, or by adapting existing brownfield or renewable energy policies. Liability and remediation regimes in particular were adapted to fit the needs of brightfields. Despite the federal initiative, it has to be recognized that state authorities in the U.S. still hold primary responsibility in most cases, from issuing voluntary action, to RPSs. Paccagnan and Turvani (2007) confirm that such voluntary agreements are quite common in the management of brownfield both in the European Union and the United States. Because of the federalism in Canada and the United States, regulations, incentive programs and other pertinent policies regarding energy and natural resources are the responsibility of the provinces and states and therefore not always uniform across the country. Whereas the United States has adapted its policies to allow their application to brightfields, and has a better coordination with federal agencies regarding the support of the brightfield idea, Canada has thus far not adapted any federal and provincial policies specifically for brightfields. This is all the more surprising considering that Canadian provinces have the 'right to adopt *and* modify' federal guidelines (De Sousa, 2001).

It stands to reason that this has little to do with the organization of government, but with political support and industry pressure, or the lack thereof. Germany, although similarly organized politically speaking, benefits from the 'imposing' E.U. mandate aimed at supra- and intranational uniformity of laws. This sacrifice of independence is a result of international institutions, which in terms of convergence can be expressed as international cooperation and regulatory pressure (Holzinger and Knill, 2005). Table 5.2 offers a summary regarding the 7 components that form the basis of this comparison between Canada and Germany and also the United States.

	Canada	Germany	REPAL Initiative
Site Inventory	*FCSI* / CLI some Provinces have brownfield Inventories In theory applicable but no practice	*Altlasten* and *Brachflächenkataster* (subnationally) Have been used for *Konversionsflächen*	State (CERCLIS) and Federal databases / Tracking matrix and 'tools' Applicable to brightfields
Remediation Standards	No federally consistent standards No brightfield specific standards	Federal standards and EU Directive Applicable to brightfields	Federal and State Voluntary Applicable to brightfields
Liability Regime	No federally consistent liability regime. Exemptions available but different across the Provinces Unknown due to lack of precedence	Liability Act and EU Directive, uniform across the country (and EU) Applicable to brightfields	CERCLA and RCRA with possible exemption Applicable to brightfields
Financial Incentives for Brownfields/Brightfields	Federally and subnationally available In theory applicable to brightfields	No specific federal funding for brightfields but federal, EU and subnationally available brownfield funding and sustainable uses Applicable to brightfields	Good federal and State funding available Applicable to brightfields
Regulatory Instruments for Renewables	Not federally uniform, but available subnationally (FIT, RPS, etc.) In theory applicable but little practice	Federal Feed-in tariff program Specifically for *Konversionsflächen*	Not federally uniform, but available subnationally (FIT, RPS, etc.) Applicable to brightfields
Financial Incentives for Renewables	Federally and subnationally available In theory applicable to brightfields	Federally and subnationally available Applicable to brightfields	Federally and subnationally available Applicable to brightfields
Industry Support for Brightfields	Minor interest, but largely absent Examples of brightfield applications	Brightfields are well established and supported by private industry with good political support Applicable to brightfields	Brightfields are well established and supported by private industry with good political support Applicable to brightfields

Table 5.2. Overall summary of comparative findings. The grey shaded cells illustrate the applicability of each policy to the development of brightfields.

5.7. **Discussion**

There is convergence but there is also the absence of convergence[56]. This discussion aims to explain why this is, as well as what it means for the future of brightfields particularly in Canada. Having compared the two countries to an ideal brightfield support framework (largely a copy of the U.S. EPA Initiative), it is clear that there continues to be variability regarding the implementation of and support for brightfields.

However, as far as the individual brownfield and renewable energy policies are concerned, the degree of variability is beginning to diminish. When taken separately, renewable energy and brownfield policies show a good deal of similarity or convergence among all three countries, since more and more similar regulatory and financial policies are being used to promote the installation of renewable energy and the redevelopment of brownfields independently. Specifically for the latter, the so-called private-public partnership approach that - includes the sharing of risk and the provision of financial incentives - can be found in all three countries. It can be argued that Canada and the United States are converging towards a European (i.e. German) renewable energy model that includes FITs, Standard Offer Programs, and (planned) carbon tax schemes (Mabee et al., 2011). While the political obligation to green energy targets, GHG emissions reduction and the commitment to nuclear energy for instance remain dissimilar on the national stage; [57] policies and funding schemes are becoming more and more convergent in the three countries.

It must be noted that this convergence is not homogenous intranationally across the three countries. That is due to the fact that energy policies are chiefly the responsibilities of the provinces, the states and Bundesländer. It is however interesting to note that this convergence can be witnessed among a host of other countries like for instance Spain and France (see Jacobs, 2012) and that global green energy policies are becoming increasingly similar to the European (i.e. German) model (Markandya et al., 2006). Similarly, Kitzing, Mitchell, and Morthorst (2012) examined the renewable energy policies in Europe and concluded that there are indications of a bottom-up convergence regarding renewable energy policies, meaning that they are formed or at least coincide with top-down policy approaches.

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[56] The absence of convergence does not necessarily mean divergence, not in this case.

[57] The United States and Canada famously lack federal renewable energy standards according to a KPMG report (https://www.kpmg.com/Global/en/IssuesAndInsights/ArticlesPublications/Documents/taxes-incentives-renewable-energy-v1.pdf, retrieved May, 2015).

In contrast, pertaining to the marriage of renewable energy and brownfield policies on a federal (as well as provincial) level, the United States continues to stands alone as having brightfield specific policies and there is no indication that Canada is converging on to this path in the near future. On the *Bundesebene* (or State level) Germany is expected to create a more concerted effort for brightfields, insofar as the moratorium for greenfields is becoming ever more stringent beyond the FIT program in order to curb greenfield consumption.

Regarding brightfield support in Canada, it seems that top-down or federal to lower-tier governments convergence (see Kitzing, Mitchell, and Morthorst, 2012) is slower and less comprehensive intranationally. This means that Provincial and especially municipal authorities are often better-equipped, quicker and more willing to support new ideas. This has been true for a long time when it comes to brownfield policies.

This begs the question whether or not it matters if policies are being created by federal governments as opposed to Provincial ones? Having examined Germany, and the success of brightfields in some Bundesländer, one can reasonably argue that it matters not. However, a federal brightfield agenda could act as a catalyst in Canada, where no Provincial government has assumed leadership so far. The U.S. is an example where a federal program acted as a catalyst – despite good state-level brownfield policies - and one witnesses more and more State-level spinoff programs[58] across the country in concert with private sector initiatives. It can be argued that it is this private-public partnership that is the true reason for the brightfield success in the United States and Germany. Prior to the 2008 EPA initiative, there were but few examples of brightfields and the concept was largely unknown.

In Ontario, this private sector approach has been successful for brownfield redevelopment, but has yet to be adopted on the federal level. De Sousa (2015) explains that the "shift from an enforcement-driven approach focusing on soil remediation, to a facilitation-oriented one fostering private-sector investment, has made it necessary for governments to get a better sense of what is required to attract private investment" (p. 17). The same cannot be said about brightfields. The private

[58] California Energy Commission (CEC) for examples issued a Bill, in consultation with the Department of Resources Recycling and Recovery (DRRR), Department of Toxic Substances Control (DTSC), and the Department of Conservation (DOC), to (1) establish criteria for identifying closed disposal sites, brownfields, and degraded agricultural lands that have high potential for use as sites for renewable generation facilities and (2) prepare a list of lands that meet this criteria. Authorizes CEC to prepare a program environmental impact report (PEIR) to facilitate the siting of renewable energy projects on the listed sites.

sector is not taking matters into their own hands, largely due to the uncertainty that exists via liability and the lack of federal support.

Sadly, as a whole, De Sousa (2000) noted that - regarding brownfield policies - the convergence process in Canada is occurring more slowly than in the United States (and the United Kingdom). Canadian brownfield policies have traditionally evolved slowly because the federal government did not take up this mandate, but left it to the provinces instead. This lack of urgency may be attributed to the following; (a) fewer brownfields compared to the U.S.; (b) the fact that Canada is less densely populated compared to its European counterparts, thus giving its inhabitants a feeling that there is enough land; (c) the absence of a single catastrophic Love Canal-like disaster; and (d) a largely unknowledgeable public as a result of it (De Sousa, 2001). It is fair to say that regarding brownfields, Canada has since entered the risk/costs sharing as well as the harmonization stage, the absence of which was lamented by De Sousa (2000) at the turn of the new millennium. Because of the general lack of interest in and support of renewable energy on brownfields, the same cannot be said for brightfields.

The (emerging) convergence regarding renewable energy strategies among the three countries and to a lesser degree regarding brownfields may be caused primarily by transnational communication. As seen in the methodology section of this chapter, this includes, ‘transnational problem-solving’ and ‘lesson-drawing’. While the former characterizes a more active approach of policy-makers seeking out one another at conferences or international gatherings for instance, lesson drawing is a simpler form of policy emulation that implies the simple copying of policy decisions seen elsewhere (Holzinger and Knill, 2005). Lesson-drawing is an approach in which, one functional system or program in one jurisdiction is used in the development of policies, programs, administrative arrangements, institutions, or ideas in another system or program in a different jurisdiction (Dolowitz and Marsh, 2000; Spaans and Louw, 2009). According to Holzinger and Knill (2005) “the mechanism of lesson-drawing refers to constellations of policy transfer in which governments rationally utilize available experience elsewhere in order to solve domestic problems” (p.783). Lesson-drawing may be one of the major causes for the convergence of brownfield and renewable energy policies in the three countries. Lesson-drawing is the result of the similarity of the domestic problems; in this case brownfields and contaminated lands as well as the want for augmented renewable energy. It can be argued that this has made governments receptive to adopt policies that were successful elsewhere. This is certainly the case with regard to the FIT system, which is being adopted the world over based on the German model. Similarly, one can see the introduction of cap and trade schemes in multiple jurisdictions, often on the State or Provincial level. Interestingly, one can also witness the dissipating importance of national policy making, in the case of the Western Climate Initiative, which includes among others California, Quebec and Ontario.

Crucially, lesson-drawing in the international context is not limited to federal governments but more often than not entails second-tier governments and more importantly, the private sector. Holzinger and Knill (2005) point out that lesson-drawing is not restricted to bilateral policy transfer, but can be undertaken by transnational networks or professional communities. De Sousa (2015) points out that "there is an on-going convergence in policy-making, both within Canada and within the U.S. and Western Europe, as governments become more sensitive to the types of costs and risks (i.e., environmental, economic, and management) which they must share with the private sector to solve the problem effectively" (p. 16). It will be interesting to see whether this lesson-drawing is going to extend in the future to encompass brightfields.

Regarding liability relief, all three countries promote the Polluter Pays Principle. Yet, whereas responsibility can still become retroactive in most U.S. jurisdictions and Canadian provinces, Germany (as most European countries) has put a time limit on liability. In reality however, governments in all three countries have started to share some of the costs and risks associated with liability, as governments in many jurisdictions are no longer compelling landowners to remediate low-risk sites until their property is redeveloped or sold or until it is economically feasible to do so, thus allowing activity to continue on site despite risks from contamination (De Sousa, 2001). Funding schemes also have become similar not just regarding brownfields and renewables, but for a wide range of infrastructure and developments that aim to be more sustainable, be it water treatment, green transport et cetera. Although it has to be said that by and large Germany – much like the European Union as a whole - is more prone to support such developments via direct funding, whereas the United States and to some degree Canada continue to favour tax related instruments.

It would be incorrect not to attribute the want for and success of renewable energy deployment to economic viability. Due to (approaching) grid parity, the scale of economic viability is tipping in favour of renewables and soon no more incentives will be needed. As a result of it, developers in the three countries (and elsewhere) are rushing to make hay while the sun shines (i.e. developing green energy projects sooner rather than later) in order to still benefit from remaining incentive programs, thus driving the renewable sector. It will be interesting to see what will happen once FIT programs dry up.

It could be argued that Germany and Canada are similar simply due to the lack of federal brightfield policies/strategies and the similarity of provincial FIT provisions on discontinuing tariffs on arable lands. This however is an incomplete picture. Firstly, the Canadian, that is the Ontario FIT system (as well as in other provinces), is a lot more forgiving regarding renewables on arable lands compared to the strict prohibition in Germany. The Ontario FIT restriction is that non-rooftop solar may not be installed on Specialty Crop Areas[59], CLI Class 1, 2 and 3 Lands (municipalities are exempted) and CLI Organic Lands. This means that out of the 7 CLI classes, only 3 limited the development of solar. More interestingly, FIT regulations state that even commercial and industrial zones are not wanted, as the FIT *Non-Rooftop Solar Project Completeness and Eligibility Regulation* states: "A Non-Rooftop Solar Project is permitted on property zoned commercial or industrial as long as the Project is not the main, primary or only use of the Property". It has already been shown that the IESO has missed an opportunity to reverse this trend and call for more projects on marginalized lands. FIT rules 4.0 allow non-rooftop solar on closed landfills, military installations and contaminated properties, but there seems to be no uptake of these potential brightfield lands given the lack of preferential pricing.

Secondly, below the surface of policies (or lack thereof on the federal level), it is apparent that Germany has produced a great number of brightfields, while Canada has not. Thirdly, and most importantly, Canada has so far never produced policies that were intended to support brightfields, thus there are no brightfield policy outputs. While Germany's brownfield and renewable energy policies (the first 6 components) may not always apply to brightfields legally speaking (e.g. policy intention), they are being applied in practice.

Owing to a renewable energy expertise and collective public support for renewable energy and sustainable land reuse, Germany possesses an overall sound capacity to implement the development of brightfields, since it has always had a strong focus on sustainability and holistic reintegration of brownfields. Germany has a successful brownfield redevelopment framework as well as a renewable energy development framework. Similarly to Canada, each *Bundesland* maintains a great deal of autonomy with regard to its natural resources, including energy policies and a push in

[59] Specialty Crop areas where specialty crops such as tender fruits, grapes or other fruit crops, vegetable crops, greenhouse crops and crops from agriculturally developed organic soil (http://www.neptis.org/publications/agriculture-central-zone/chapters/definition-significant-agricultural-land, visited on Dec. 28, 2015).

brightfield policy is more likely to occur on the State level, as opposed to a federal mandate from Berlin (as long as it is congruent with European Union law). Brownfield policies only exist provincially in Canada.

However, convergence is a process and not a state. According to Bennett (1991) "convergence should also be seen as a process of 'becoming' rather than a condition of 'being' more alike; convergence means moving from different positions toward some common point" (p. 219). Similarly, Adams, De Sousa and Tiesdell (2010) as well as Andres, (2010) mention the temporal aspect of policy formation via learning in different stages. Germany is more likely to lean towards a more deliberate and supportive brightfield policy, thus 'becoming' convergent to the U.S. Furthermore, Germany's trend toward convergence may be substantiated based on industry support, know-how and number of brightfields. The same cannot be said for Canada at the moment. However, priorities and agendas may change suddenly and brightfields may become more of a priority in the future.

Adams, De Sousa and Tiesdell (2010) speak of policy maturity regarding their assessment of brownfield policies in the United States and the United Kingdom. Their maturity model involves (1) grasping and under-standing the brownfield problem; (2) recognizing the potential it contains and securing political commitment to action; and, (3) generating engagement from the private sector (p. 76). The three stages are congruent with a perceptional shift from 'problem to opportunity' (Adams, De Sousa and Tiesdell, 2010). Applying this framework to brightfields, it is apparent that Canada has not grasped the potential and opportunity of siting renewable energy on marginalized lands, whereas the other two countries have. Hoberg (1992) found that America has historically had a great deal of influence on Canadian regulations regarding environmental policy-making, which can be seen in the adoption of some RBCA for instance. Further, Canada has in the past copied the American generic criteria and site-specific procedures for assessing soil pollution levels (although American approaches are in general much more stringent than Canadian ones). This may suggest that a brightfield policy could become a reality in the near future.

5.7.1. Policy Implications and Recommendations for Canada

In Canada, like in the United States, matters related to energy and the environment are the responsibility of the provinces. The U.S. experience has shown that this must not prevent federal initiatives from advancing the brightfield idea through federal policies and tiered-partnerships.

According to the literature, the lack of federal legislation in Canada has created both uncertainties and inequalities for the redevelopment of brownfields (Hara, 2003; Davies, 2000). The development of brightfields would benefit if liability and remediation standards were to become more aligned across the different provinces and territories and provide clearer guidelines on cleanup requirements for renewable energy reuse. Harbell (in Davis 2000) states that the varying degrees of different jurisdictions across Canada prevent certainty over applicable standards, legislated liability provisions and lack of direct financial funding. Further the "wide scope of liability, the lack of predictable cleanup goals and inconsistent regulatory decisions" are also considered barriers to brownfield redevelopment based on Harbell (see Davis, 2000, p. 443).

Hara (2003) found that a "[Canadian] federal liability management regime is desirable for two principal reasons. First, federal legislation would enable parties to allocate, cap or terminate risk of environmental liability under federal legislation or in respect of lands coming within federal jurisdiction. Liability transfers caps and terminations for qualifying brownfield projects can be made available in respect of liabilities or responsibilities arising under the Canadian Environmental Assessment Act, the Canadian Environmental Protection Act and the Fisheries Act. Second, a federal brownfield liability management model can serve as an example for similar integrated provincial programs, and the establishment of an analogous regime by the provinces can be made a condition of federal financial assistance for brownfield projects" (p.18). Brightfields would further benefit, if FIT programs were available across the country and would be as prohibitive as Germany's FIT system regarding the use of greenfields. It is also recommended that the pricing schedule reflects the type of lands being used like in Germany.

According to De Sousa (2001) "stakeholders in Canada generally decry the complexity, uncertainty, and variability of the regulatory systems in place to oversee remediation and redevelopment issues, favouring a simplification and harmonization of the current ways in which environmental laws and standards are enacted throughout the country (NRTEE, 1996, 1997). The latter are considered pivotal because they would provide an expectation of consistency to lenders, investors, and businesses with national activities and they would ensure that a 'level playing field' exists throughout the country" (p. 136). Hara (2003) believe that "while the federal government cannot single-handedly remove the obstacles to brownfields redevelopment in Canada, it can play a key role in initiating a national program [and that] a federal program can serve as the catalyst for much-needed provincial initiatives and can provide important tools to encourage and support provincial and local efforts" (p. 19). The same can be said for brightfields. A federal program is a momentum-starter, but requires strong industry support, in order to keep the momentum. According to EPA regional managers, the industry support is what helps sustain the success of brightfields in the U.S. Political support for the idea is poor in Canada at the moment and industry support is struggling to gain momentum because of it, despite a growing domestic renewable energy industry. With that in mind, the private sector and appropriate professional organizations need to step up and build a similar capacity than the one regarding brownfields (see Record of Site Condition in Ontario). This coincidentally, can also be done via transnational communication!

So why has environmental law making been such a slow process in Canada? According to Harrison (1996 as cited in De Sousa, 2001), "Canadian environmental policymaking can be characterized as heterogeneous in both style and outcome for the following two main reasons: (1) although both the federal and provincial levels of government tend to value their jurisdiction over environmental matters most during periods of heightened environmental awareness, at other times, the federal government is especially ill-inclined to exercise its constitutional jurisdiction in this domain, downloading it typically to the provinces. (2) In order to compete for investments, provincial governments tend to bend easily to the interests of industry, declining to strengthen, and even lowering, environmental standards" (p.134).

It must be said that the brownfields that are being redeveloped in Canada are chiefly found in an urban environment where residential redevelopment makes more sense compared to renewables (see market barriers chapter 5). That said there are many examples of urban brightfields (see Brockton, Exxelon, etc.) in the U.S. and the lacking interest north of the border can in part be attributed to the absence of political support. Overall, it can be argued that regarding brightfields, Canada is not yet at the cost/risk sharing or harmonization stage, to use De Sousa's (2000) terminology.

5.8. **Conclusion**

This study has identified three pillars with which brightfields have to be supported, namely brownfield redevelopment, renewable energy development and industry support. The study also describes to what degree and how all three countries are supporting the development of renewable energy on brownfields based on these pillars and its components.

In summary, the three countries are as of now at different stages. The United States has the most comprehensive and concerted effort to turn marginalized lands into brightfields, manly due to the federal reach of the EPA program. The federal leadership and initiative is aided by supportive State legislation and the green energy sector and utility industry, who have embraced the brightfield idea. Even though Germany has seen an impressive uptake of solar infrastructure especially on ex-military sites - and it is estimated that the total capacity exceeds that of the United States both in project numbers and installed capacity – there is no federal effort similar to the U.S. one. Canada on the other hand has seen little uptake (as described in chapter 4) and there is no indication that (with a few notable exceptions) there are deliberate efforts being made, provincially or federally, to specifically use brownfields for the generation of renewable energy.

Despite these differences, there is a good deal of similarity or convergence among all three countries, since they are (at times) using similar regulatory and financial policies to individually promote the installation of renewables and the redevelopment of brownfields. However, pertaining to the marriage of renewable energy and brownfield policies on a federal as well as provincial level, the United States stands alone as having brightfield specific policies and there is no indication Canada is converging on to this path in the near future. On the *Bundesebene* (State level) Germany is expected to do so in the opinion of experts, insofar as the moratorium for renewable energy on greenfields is becoming even more stringent beyond the FIT program.

The emerging convergence regarding renewable energy strategies among the three countries and (to a lesser degree) regarding brownfields may be primarily the result of transnational problem solving, particularly lesson-drawing. There is no evidence that Canada is adopting a policy similar to the United States regarding brightfields in the future. However, Germany's has implemented over 250 brightfields and has good industry know-how and political support. The same cannot be said for Canada at the moment where brownfield and renewable energy policies remain separate.

CHAPTER 6: BARRIERS TO RENEWABLE ENERGY DEVELOPMENT ON BROWNFIELDS

Abstract: Brownfields that are reused for the generation of renewable energy are called brightfields. This rapidly emerging idea advocates the combination sustainable site reuse and the generation of electricity from renewables. While programmes like the RE-Powering America's Land Initiative herald its benefits, academia knows but little of its barriers and challenges. This study aims to examine the technical/environmental, regulator/financial/institutional, and social barriers to this type of development, along with measures that may address them. The barriers and measures were predominately identified via a qualitative and quantitative survey sent to brightfield developers (experts), along with a review of case studies and the emerging brightfield literature. The study found that environmental/ technical barriers only differ from 'conventional' renewable energy projects (e.g. on greenfields) in the event of site contamination. The latter then is what makes brightfields unique and is the source for a myriad of challenges concerning risk and liability, which cause financial problems and investment hesitance. However, evidence conjectures that there is less contextual public opposition to brightfields compared to conventional renewable energy.

Keywords: renewable energy, brownfield redevelopment, contaminated land, brightfields, survey, barriers.

6.1. **Introduction**

It was demonstrated early on in this dissertation how most renewable energy facilities require large parcels of land and are thus contributing to the so-called energy sprawl. That is, energy infrastructures - especially large footprint solar energy plants - sprawl into (semi-) pristine or other ecological asset areas, infringing on wildlife habitats. The use of brownfields or any other marginalized property claims to curb this sprawl, conserve greenfields and preserve the land carbon sink. Oftentimes brown-/brightfields are already adequately zoned for renewable energy installations and are according to Neuman and Hopkins (2009) generally "situated in areas where aesthetic opposition is minimized" (p. 298) and located near existing roads and energy transmission or distribution lines. It is suggested that placing renewable energy on brownfields provides an economically viable reuse for sites that have potentially significant cleanup costs, low real estate value that are difficult to redevelop (see Bardos et al., 2008). Brightfields are alleged to create further synergies by providing job opportunities in sub/urban and rural communities, and generally advance cleaner and more cost-effective green energy technologies. Overall, brightfields are heralded as being able to reduce the environmental impacts of energy systems and have so-called triple-bottom line benefits (see Table 6.1).

Environmental	Reduced development pressure for greenfields Potential contamination is being addressed Protection of public health and safety Renewable energy generation Reduced Greenhouse gas (GHG) emissions
Social	Neighbourhood renewal, revitalization Disappearance of eyesore, nuisance and blight Elimination of social stigma of derelict property
Economic	Leveraging of existing infrastructure Restoration of tax base and job creation

Table 6.1. Professed Triple-Bottom Line Benefits of Brightfields.

The purported advantages of using brightfields over greenfields are well documented – although be it by developers and brightfield proponents - but these advantages have not been exposed to any academic scrutiny. This chapter addresses this concern, as it constitutes a vital gap in the literature. The objective is not per se to dispute or disprove the very real benefits of brightfields.

It is crucial to examine the ramifications of brightfield development and why many conventional renewable energy projects face obstacles not primary legal and financial in nature, but due to public opposition. While public resistance is commonplace for nuclear power plants (see Burton and Pushchak, 1983), petrochemical facilities (see Morell and Singer, 1980) or even hydroelectricity infrastructures, the barrier of public opposition for renewable energy is a rather new angst. Academics like O'Hare (1977) produced early work on this phenomenon, even though renewable energy technologies in the 1980's, especially wind, had a very high social acceptance level. However, non-technical factors have since become exposed to a variety of apprehension from all stakeholders, including policy-makers and investors, not just the public (Wüstenhagen, Wolsink and Bürer, 2007). Slovic (1987) argues that this apprehension is often consequential of miscommunications between lay people, experts and policy-makers and their perceived risks. According to Devine-Wright (2011), miscommunication can also lead to public-value failures due to "insufficient means of ensuring articulation and effective communication of core values" (p. 179). Opponents are in principle in favour of renewables, but in practice oppose a particular development, a phenomenon called ‘Not In My Back-Yard’ or NIMBYism. Devine-Wright (2011) explains the emergence of public resistance by the presence of imperfect monopolies, imperfect public communication, an unfair distribution of benefits and suspicion of the developer’s motives that can have people up in arms (also see Boholm and Löfstedt, 2004). Van der Horst (2007) and Wüstenhagen et al. (2007) analyse the effectiveness of renewable energy siting through the lens of NIMBYism and public participation, emphasizing the importance of social issues when conceptualizing such projects. The social contextualization of knowledge and barriers is also an important theme in Shove’s (1998) work on barriers of technology transfer. Social or public opposition does pose a significant challenge to renewable energy and has been the topic of countless studies (see Kasperson and Ram, 2013; Cohen, Reichl and Schmidthaler, 2014; Wolsink, 2000), most prominently the work by Devine-Wright (2005, 2010, 2011).

Because brightfields are placed in a liability-laden environment, the concept has been the topic of several legal studies, such as Outka’s legal review on renewable energy footprint (2011) and regulatory analysis (2010), Alberini et al. (2005) analysis of the role of liability, or Collins and Savage (1998) review of the regulatory liability landscape. Conventional renewable energy, especially solar is seen as having little to no risk in the traditional sense (see Beck 1992); whether site contamination may change that is one of the goals of this study.

Neuman and Hopkins (2009) focus on the assessment of risk of renewable energy projects, but ‘only’ taken site contamination into consideration and not further expounded on other barriers of siting renewable energy on contaminated land as they may pertain to socioeconomic obstacles. Inhaber’s (1979) controversial work went even further and lists a number risk sources pertaining to energy production in general; raw materials, component production, plant construction, operation and maintenance, public health, transportation and finally waste disposal and deactivation for all sources of energy including solar. There are great many studies that have assessed the barriers to renewable energy development. Some of the more prominent ones are Painuly (2001), Mirza Ahmad, Harijan and Majeed (2009), Beck and Martinot (2004), and Richards, Noble and Belcher (2012) and Kahn (2000). Vajjhala (2006) for instance, examined the barriers of energy siting regarding its geography and location. Most notable is the work by Neuman and Hopkins (2009) on managing the risk for renewables on contaminated lands. While the latter work focuses largely on entrepreneurial risk, Reddy and Painuly (2004) examined a wider taxonomy of barriers for conventional renewables (not brightfields!), such as: (1) awareness and information, (2) financial and economic, (3) market barriers, (4) technical, (5) institutional and regulatory and finally, (6) behavioural.

Academic work on barriers to the redevelopment effort has become an important part of the brownfield literature. Coffin (2002) notes that, "as early as 1991, researchers were considering these barriers, trying to understand why brownfields were so difficult to redevelop" (p.25). McCarthy (2002), Davis (2002), Bartsch and Collaton (1994) along with Coffin and Shepherd (1998), produced some of the earliest work on the subject, the latter finding that legal liability, limited information, limited financial resources, and limited demand for the properties pose major barriers for brownfields. Similarly, work by Hudak (2002), Brachman (2004) and McCarthy (2002) as well as Hara (2003) find that uncertain and unacceptable civil and regulatory legal liability regimes, inconsistent and unclear remedial requirements imposed by the various levels of government, the absence of adequate and consistently accessible expertise and the requirement for large capital investments pose some of the largest barriers for brownfield redevelopment.

Studies by Lord et al., (2008), Bardos et al., (2008) and Heerten and Koerner (2008) examined technology-specific barriers to renewable energy on marginalized lands by examining technical feasibility of solar energy on landfills or the cultivation of energy crops. Adelaja et al. (2010) commented on the traditional barriers of market and remediation costs for conventional brownfield redevelopment, but did not explore such barriers for brightfields in much detail.

Thus far, the work by Spiess and De Sousa (2016) constitutes the only academic work that has combined the study of barriers to renewable energy and brightfields from technical, regulatory, financial and social perspective or has focused exclusively on brightfield implementation barriers.

6.2. **Objectives and Research Questions**

The purpose of this study is to identify the barriers and challenges to the development of brightfields, but also provide measures that address them. The goal is not to disprove the benefits of brightfields (as they certainly exist), but to critically review, thus filling an important gap in the otherwise comprehensive literature on brownfields and expand the emerging brightfield literature.

- **Q1:** What are the barriers and challenges for brightfield developers?
- **Q2:** What measures can be used to overcome these barriers and challenges?

6.3. **Research Methods**

This study has been developed within the emerging brightfield literature, which is largely positioned at the intersection of the brownfield and renewable energy literature. Furthermore, it is tangentially situated in the theory of public opposition to renewable energy and the identification of barriers via expert surveys, as reflected in the literature review. This study employs mixed methods research (MMR), using questionnaires with open-ended and quantitative questions, as well as qualitative case study analysis and a literature review. MMR can be used to give numerical power to words and give context and meaning to numbers (Johnson and Onwuegbuzie, 2004).

6.3.1. Taxonomy of Barriers

Even though Shove (1998) differentiated between barriers and non-technical obstacles, here barriers and challenges are defined as obstacles both physical (technical and economic) as well as social ones. Barriers are obstacles that could contribute to the failing of a project. Challenges are defined as elements of concern that may or may not become a barrier but that could hinder the implementation of renewable energy on brownfields. An examination of EPA feasibility studies with regards to barriers and challenges along with a survey of the appropriate literature (Kahn, 2000; Reddy and Painuley, 2003; Chalifour (2004); Coffin and Sheppard, 1998; Coffin and Barbero, 2009) helped provide the three categories of barriers and challenges: (1) technical and environmental, (2) financial, regulatory and institutional, and (3) social. Figure 6.1 illustrates the three main categories of barriers identified.

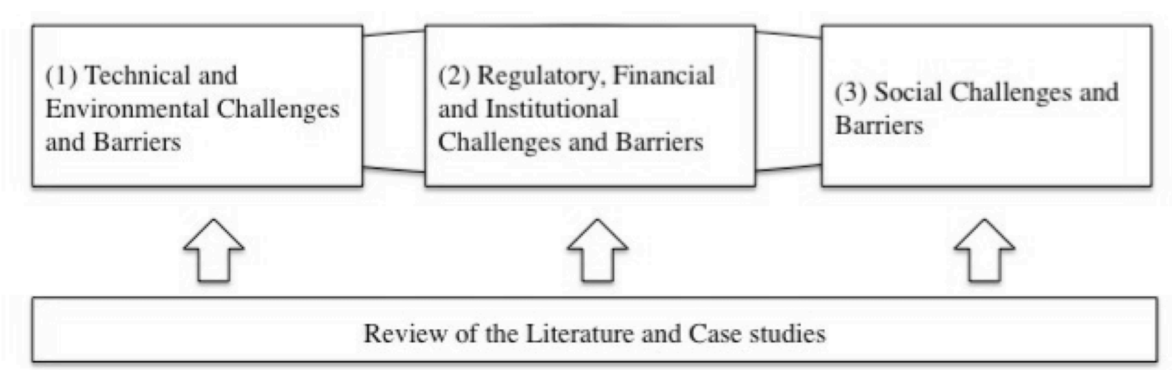

Figure 6.1. Three main categories of barriers fall neatly, yet somewhat unsurprisingly (although not intentional), into the triple-bottom line categories. This juxtaposition makes for an interesting comparison of benefits and barriers and challenges. Again, the categories are derived from the literature and case studies and form the basis of the categories used in the expert survey.

6.3.2. Expert Survey

The survey was sent to over 100 experts[60]; experienced brightfield developers or consultants, who were identified via the literature and feasibility studies, both in North America and Europe. Expert surveys have been used before in brownfield research (see De Sousa, 2002; Sherk, 2002; Thornton, Vanheusden and Nathanail, 2005). Especially, stakeholder surveys have examined liability issues (Alberini et al., 2005), post remediation property values (De Sousa, Wu and Westphal, 2009) or regarding the effectiveness of public policies and private decisions (Sherk, 2002). Osman and Frantal (2013) used a stakeholder survey to examine the preferred brownfield reuses. Osman and Frantal (2013) as well as Alberini et al. (2005) specifically targeted brownfield developers.

After several automated reminder emails, a total of 28 agreed to participate. While a comparable study by Buchholz, Luzadis and Volk (2009) on bioenergy systems had 45 expert participants, it has to be recognized that the brightfield community (i.e. developers) is much smaller, given the small amount of brightfields compared to 'conventional' renewable energy projects. Several individuals that did not fill out the survey online opted for a phone interview instead.

Several individuals from Canadian, American, the U.K. and the German governments (agencies) provided additional information and context that helped support the findings, but are not part of the survey results (i.e. frequency) due an expired ethics approval. Alas, there is no equal geographic distribution as the majority of participants came from the U.S. This makes it impossible to make cross-country comparisons. Albeit this failure, the purpose of the developer survey is to bring to attention the general obstacles that so far the literature has not addressed and this study represents the opinions and experiences of 28 such developers. According to the survey, the total number of projects the 28 participants have been involved in overall ranges from a minimum of 75 to over 135, which is sizable considering the comparable newness of brightfields.

6.3.3. Data Analysis

The survey consists of qualitative and quantitative questions pertaining to the barriers and challenges. The experts were also asked to recommend some measures to address these barriers via open-ended questions. In total, the survey contained 23 questions. Qualitative questions are analysed through thematic/content analysis. Thematic analysis consists of searching for themes that emerge from collected data that is important to the description of the phenomenon or occurrence (Daly,

[60] Experts (e.g. Brightfield professionals, consultants etc.) were asked to participate in this survey, as opposed to the public, due to the technical nature of the matter.

Kellehear, and Gliksman, 1997; Joffe 2011). The process involves the identification of themes through "careful reading and re-reading of the data" (Rice and Ezzy, 1999, p. 258). Every answer is recorded in Excel. The data are viewed several times prior to coding. The latter is used only minimally, because most answers are short, concise and often in bullet form. Nevertheless, such keywords and meanings of a response are put into themes and sub-themes for each of the three main categories. These themes also produce the sub-categories for each category (see Figure 6.1). Content analysis is used to count the occurrence or frequency of keywords (i.e. barriers). Content analysis can be described as a quantitative analysis of qualitative data, focusing on counting the frequency of specific words or content (Kondracki and Wellman, 2002).

The expert survey answers provide the more detailed themes or specific barriers for each category, as well as the suggested measures. By and large, the responses clarified whether a given expert considers a particular issue a barrier or a challenge. In general, every barrier mentioned within each of the three categories is represented in one of the sub-categories (e.g. land & resource constrains; load & transmission barriers; etc.). Frequency counts are also used to represent the quantitative questions with regards to how many experts have encountered a given type of public opposition for instance or a technical challenge. The frequency is generally given at the beginning of each section (e.g. 6.4.1.1.) as well as in table 6.2. In the event where the survey responses remained vague and general, feasibility studies (mostly EPA) and additional literature are consulted to further investigate and substantiate a barrier/challenge or measure that was simply mentioned by an expert but not clarified further. In other words, some of the concrete barriers/challenges or measures described hereafter were only vaguely referred to by the surveyees and needed investigation outside the survey. Forty-three of the 150 completed brightfield projects under the RE-Powering America's Land Initiative produced either feasibility studies and/or post-completion reports[61]. Together with EPA's Handbook on Siting Renewable Energy Projects While Addressing Environmental Issues (EPA, 2009), they are instrumental in providing context to these barriers. The literature also provides the appropriate academic context for much of the discussion and critical review of the survey responses, especially Kahn (2000) and Neuman and Hopkins (2009).

[61] For more information on the brightfield feasibility studies used in this study, visit: http://www.epa.gov/oswercpa/rd_studies.htm

6.4. **Results**

Note that 15 experts have each had experience with 1 to 5 brightfield projects, 5 experts between 6 and 9, and 3 experts have been involved in over 10 brightfield projects at the time of taking the survey.

6.4.1. Technical & Environmental Challenges and Barriers

6.4.1.1. Site Contamination

Unsurprisingly, 20 out of 28 experts find that the chief technical and environmental concerns pertain to site contamination. However, the survey shows that the main barrier is not remediation itself, but the difficulty of accurately determining the scale of contamination and its associated costs and duration of cleanup (also see Leigh and Coffin, 2000). According to the survey, there are three challenges: (1) determining the nature and degree of contamination for safe reuse; (2) determining whether remediation is necessary legally speaking or technically even possible; and (3) determining how contamination/remediation will affect renewable energy capacity, output, operation and maintenance (O&M). It is key to point out that remediation refers to the removal or containment of contaminates within the soil (or water), whereas mitigation measures refer to above ground actions such as fences. Even though site cleanup may not be legally necessary, mitigation measures are almost always required if a brightfield is contaminated. The latter barrier/challenge is unique to most brightfields.

6.4.1.2. Disturbance of Remedial Work & Spread of Contamination

Nine experts think that depending on the type of remediation - if necessary or legally required - there is still a risk associated with the installation of renewable energy due to site disturbances. If a contaminated medium is still present yet controlled either via solidification, stabilization, or encasing (e.g. liners, slurry walls, sarcophagus, etc.), it is important not to compromise it via underground construction, aboveground installations and their operation. According to Tansel, Varala and Londono (2013) "maintaining the integrity of the cap is both an engineering and regulatory concern" (p.5). The following three operations could compromise this integrity: (1) deep ground penetration (i.e. wind turbine foundation) or geothermal drilling; (2) shallow ground penetration (i.e. building foundations, trenches for electrical wiring); and (3) heavy load of solar trackers, transformers et cetera, potentially causing sinking. However, the migration of pollutants can happen during the construction and/or installation, as well as the O&M stage. Naturally, contaminated sites that have not undergone remediation are especially susceptible to the risk of dissemination, as traffic leaving a contaminated site as well as heavy precipitation or flooding can also cause the spread of contaminants together with the problems mentioned above. This then, according to the experts, constitutes barrier/challenge that is unique to brightfields.

6.4.1.3. Land & Resource Constraints

Some experts (six) find that land and natural resource (solar[62] irradiance, wind speed, etc.) constraints constitute a challenge for the developments of brightfields. This is consistent with the literature, whereby most renewable energy projects are constrained by key site attributes that should to be fulfilled (see Lopez, Roberts, Heimiller, Blair and Porro, 2012; Milbrandt et al., 2014). They include technical and economic constraints such as size and slope, distance to the existing grid, roads and access to water (for cleaning) and suppliers, and resource availability (e.g. m/s; $W/m^2/y$). Regulatory constraints (also called setbacks) include the protection of wildlife habitat, wetlands and the proximity to schools, airports and other sensitive areas. Land and resource constraints are generally not unique to brightfields, but are true for every renewable energy project, or as one participant put it: "I do not see any significant technological problems, all is about legislation, finances and public and policy-makers attitudes (acceptance)". However, site contamination may alter regulatory constraints thus potentially reducing the number of suitable locations by having to increase buffer around wetlands for instance.

6.4.1.4. *Load & Transmission Constraints*

According to the survey, four experts say that brightfield projects can also face a variety of challenges related to electrical loads, its quality as well as connecting to transmission or distribution lines. These challenges can include: (1) large grid extension and transmission and distribution (T&D) costs or refurbishment costs, (2) transmission losses, (3) power output fluctuations (e.g. night-/downtime), (4) displaceable load disturbances (e.g. harmonic, over- or undervoltages), and (5) protection malfunctions (e.g. power continues to flow into an off-line) (see Vajjhala and Fischbeck, 2007). In Ontario in particular, grid capacity poses a main challenge (more in the discussion). These challenges are not unique to brightfields or as one survey participant put it: "Although it is not unique

[62] According to the survey, solar is by far the most popular type of renewable energy technology with 20 experts saying it is the most common in their opinion. Only 2 experts think that wind is more common and 1 expert believes bio-energy is most frequently used.

to brightfields but all renewable energy projects lack the steadiness of conventional power output which can cause a lot of dirty power and lead to supply problems". In fact, existing infrastructure and previous connections may actually alleviate such concerns.

6.4.2. Financial, Regulatory & Institutional Challenges and Barriers

6.4.2.1. Securing Capital

According to the survey, financial issues are not only the main barrier, but also the main cause for project failure. Twenty-four out of 28 experts cited the securing of capital as a barrier or challenge to the development of brightfields. The majority of which would categorize it as a barrier. Known as lender hesitance, investors are reluctant to deal with potential legal liability caused by a brightfield's environmental baggage. Together with fluctuation of power output, system downtime, benchmark changes, and cleanup costs, experts find calculating a project's return on investment and net present value difficult. Practice shows that, as a result, many investors and renewable energy developers opt for the more predictable and potentially cheaper greenfield. Out of the 8 surveyees that say that at least one of their projects had failed (note that 13 say this never happened to them), financial reasons are cited as the most common cause for project failure. Further, five experts say that there are too few or not high enough incentives and grants for assessments and cleanup for brightfields that would allow these developments to compete with conventional renewable energy projects. It has to be noted that lender hesitance is not unique to brownfields however, as Yount and Meyer (1994) pointed out by postulating that the lending community would effectively 'brownline' funding for redevelopment efforts, although this has largely changed for the better in recent years (for brownfields at least). This barrier is vastly exacerbated if contamination is present and thus unique compared to most greenfields.

6.4.2.2. Risk & Liability

According to the survey, 18 experts say that the attempt to reduce risks and liabilities continues to be a barrier. Developers face these barriers due to actual or perceived site pollution, often during all phases of a project's life cycle. Seeking to minimize present and future environmental and civil liability is key, especially for impaired lands, as it may reduce or exempt owners of certain responsibilities and damage reparation costs. From the literature and the survey, it is evident that risk and liability (even of only suspected) can have a negative impact on project financing. Risk and liability, and financing are closely related barriers; the former being the main cause for the latter. Liability continues to be the single greatest barrier for brownfields (McMorrow, 2003; Siikamäki and Wernstedt, 2008; De Sousa, 2001) and consequently represents a large barrier for environmentally impaired brightfields. This barrier is again exacerbated if contamination is present.

6.4.2.3. Regulatory & Institutional

Surprisingly, only four experts make reference to challenges and barriers that can be categorized as regulatory or institutional. These experts express concerns that there is less legislative and regulatory support compared to conventional renewable energy projects. Specifically, they lament that licensing, permitting, zoning and approval processes continue to constitute a major challenge in developing brightfields. All these processes require consultation, review and appeal periods from multiple agencies and levels of government with no or little streamlining. According to the survey and the literature, these so-called 'transaction costs', can become an unfair barrier for brightfields because many transaction costs are essentially 'fixed'. That is, they are roughly the same irrespective of project size. This creates a competitive disadvantage for smaller projects compared to fossil fuel plants (Mirza, Ahmad, Harijan and Majeed, 2009). Brightfields have high transaction costs and less regulatory and institutional backing mainly because of the relative novelty and lack of experience for dealing with the combination of renewable energy and contamination. These challenges seem to be intensified if contamination is present, but are not unique to brightfields.

6.4.2.4. Market Barriers[63]

Four experts are also making reference to barriers on a larger scale, such as market penetration, lack of brightfield capacity and unfair (non-regulatory) market conditions. Some of these market or diffusion barriers can include: (1) residential[64] brownfield redevelopment is a priority to the detriment of renewable energy, (2) lack of capacity such as little technical know-how and support from utilities, (3) high capital costs for renewable energy and few incentives, (4) low performance

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[63] A market failure exists, when the incentives experienced by participants in the market place do not reflect all of the relevant costs and benefits to society as a whole, it can be shown that markets will not produce the result that maximize the common good.

[64] Three of the four experts are from the UK, where 60% of new housing developments are to be located on brownfields, creating end-use competition (see Alker et al., 2000).

and reliability of renewable energy, and (4) cheap (fossil-based) electricity and lack of cost competitiveness of solar/wind. ArcStar Energy, a Toronto based consulting and solar developing firm for instance would very much like to expand their bids into Alberta and Quebec, but the low electricity rates in the respective provinces prohibits project viability.

Federal initiatives like the one in the U.S. are facilitating market penetration, while Canada, a country similar in size and solar and wind resources, does little to reduce market barriers. However, the United States is not free of market barriers either, as Adelaja et al. (2010) suggests; "[brightfields] require their own unique expertise including project design, a thorough knowledge of state and federal renewable energy incentives, the grid connection process, resource assessment, site design, and regulatory approval from multiple federal and state agencies" (p. 7024). Regarding the suitability of marginalized lands for green energy, one survey participant states: "Often, renewable energy projects on brownfield sites are a bit of a 'force fit'. In other words, someone wants to do something with this available land, but it might not be a great site for that particular application". Some elements of this barrier are unique to brightfields, but are dependent on geography. Market barriers are a combination of brownfield related obstacles and renewable energy deployment barriers.

6.4.3. Social Challenges and Barriers

According to the survey and personal exchanges with brightfield developers, social barriers are largely synonymous with public opposition. Whereas a total of 19 survey participants admit to having encountered 'public opposition', only 9 say they have encountered or would label it as NIMBYism. According to the survey, the most common form of opposition[65] is a group of residents (frequency: 11) followed by a neighbourhood or community group (7), and a single non-resident (6). Further, 10 experts say that an agreement had always been reached. Eight experts say this did not always happen. However, 16 experts, who have had experience with conventional renewable energy and brightfields, find that there is less public opposition against brightfields compared to conventional renewable energy projects or as one participant states: "There is typically less opposition to projects on brownfield sites, provided that the level of contamination is low to moderate". Two experts think that opposition against brightfields is greater and five find it equal.

[65] For any reason

The qualitative survey answers are divided into the following three categories of reason for public opposition:

- *Physical and Contextual* (e.g. type of technology, scale, or location);
- *Socio-economic*; and
- *Institutional* (e.g. health and safety standards or decision-making process).

6.4.3.1. Opposition for Physical & Contextual Reasons

Based on the survey, physical and contextual issues are the main reasons for opposition against brightfields, as a total of 11 experts find this to be the case. The top reason for public opposition is fear of the dissemination of contaminates (frequency: 15 for solar; 11 for wind), followed by fear of disturbance of remediation (14/10) and finally the creation of new eyesores (7/7).

6.4.3.2. Opposition for Institutional Reasons

The survey shows that 10 experts have encountered opposition for reasons that can be categorized as institutional. Such opposition arises from a lack of public participation and involvement in the decision-making process. Further, there can be a lack of trust in the developer with regards to the accuracy of information on the severity and extent of noise, glare and health impact caused by contamination or dissemination of contaminants. There are also cases of distrust in the regulator regarding remediation or lack thereof, if cleanup is not legally required even though some degree of contamination present. Some survey participants confirmed this, one stating that "there are those who reject all change by an outside developer". It is important to note that remediation is not needed in certain cases if renewable energy is the sole end or interim use.

6.4.3.3. Opposition for Socio-Economic Reasons

Only four experts mention socio-economic fear as a cause for public opposition. Facility siting in general can be accompanied by socio-economic disadvantages, of which a common manifestation is the decrease in surrounding property value. While this often is a reality for hazardous facilities, amplified by risk (see Kasperson and Kasperson, 1996), findings by De Sousa, Wu and Westphal, (2009) show that brownfield redevelopment for example has a positive spillover effect for property value (also see Leigh and Coffin, 2005). Ihlanfeldt and Taylor (2002) suggest that as brownfields are redeveloped, surrounding properties within as much as a 2.4 Km radius may rise in value by an average of 10%. On the other hand, still contaminated sites have an adverse effect beyond the hedonic value, because of their stigma (Coffin 2002). Safety concerns such as theft and vandalism are also common among residents. Nevertheless, four experts say they have encountered project opposition due to residents fearing a decrease in property value because of such negative externalities as noise, glare, smells, traffic et cetera.

Technical and Environmental	Frequency
Site Contamination	20/28
Disturbance of Remedial Work & Spread of Contamination	9/28
Land & Resource Constraints	6/28
Load & Transmission Constraints	4/28
Financial, Regulatory and Institutional	
Securing Capital	24/28
Reducing Risk and Liability	18/28
Regulatory & Institutional Ineptitude	4/28
Market Barriers	4/28
Social	
Opposition for Physical & Contextual Reasons	11/28
Opposition for Institutional Reasons	10/28
Opposition for Socio-Economic Reasons	4/28

Table 6.2. Frequency of survey answers (e.g. mentions or more elaborate answers) related to Barriers and Challenges.

6.5. Measures

These measures are to be understood as methods that try to overcome barriers and remove challenges. The term solution is eschewed because it is not always possible to remove a barrier (for example risk) or challenge nor does a measure apply for every brightfield project. The measures presented here are derived from the survey, and substantiated by the literature (including case studies) and personal exchanges with a myriad of brightfield experts.

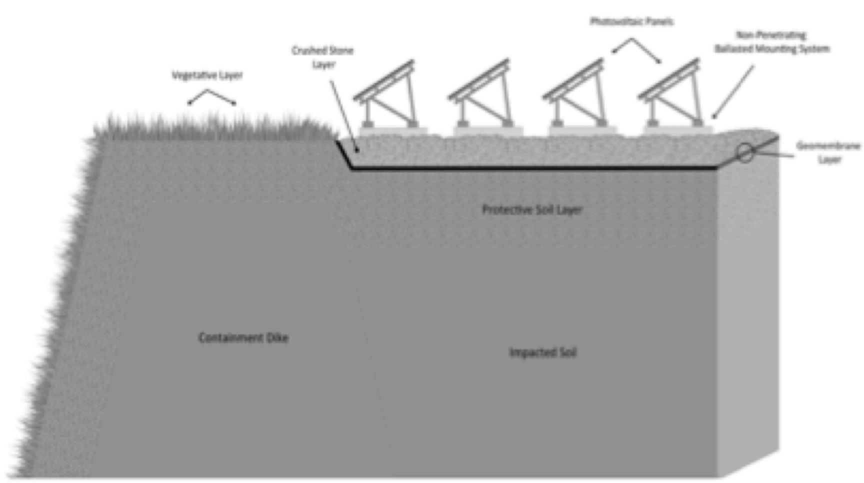
6.5.1. Measures for Technical and Environmental Challenges and Barriers

6.5.1.1. Site Contamination

The issue of site contamination cannot simply be removed, as remediation is a complex undertaking, but the survey shows that the true barrier here is determining its scope and consequences. One survey participant states: "I don't what to spend time and resources on a site that later turns out to be too contaminated". In this regard, surveyees find it advisable to evaluate its extent prior to launching an official environmental site assessment and therefore prior to site purchase. Prospective brightfield owners/developers are urged to examine the history of a given site, its present state and whether renewable energy installations will exacerbate existing conditions. So-called 'reasonable steps' (EPA) are due diligence and good faith procedures undertaken by the (future) owner/developer and recognized by the authorities. In any event, an eventual remedial process for brightfields can be quite different from conventional brownfield redevelopment. According to the survey, the following four items need to be considered to increase its success: (1) remedial work/final site conditions need to be tailored to the proposed type of renewable energy technology, (2) dimensions and locations of future infrastructure (e.g. racking and foundations, electrical wiring, auxiliary buildings etc.) need to be known to the party undertaking the remediation process and vice versa, (3) provide remedial contractor with all future system layouts and designs and (4) choose only experienced contractors, if possible only one.

6.5.1.2. Disturbance of Remedial Work & Spread of Contamination

The survey shows that equally important to site remediation, is not to compromise or disturb any remedial work or to spread the contamination. These disturbances often depend on the proposed technology and on the brownfield type. From a renewable energy technology and system design perspective, wind turbines or geothermal electricity can be ideal if contamination free pockets are present. Their small footprints allow ground penetration. On the other hand, the modular configuration of solar can also avoid certain areas (i.e. pockets of contamination) and can make use of smaller, lighter racking system placed on top of an existing cap without ground penetrating foundations. To prevent sinking, lightweight, flexible roll up solar (i.e. thin film) can be used for landfills, provided there is a protective membrane. Auxiliary systems can be fastened to ballast systems and wires can be run aboveground to prevent trenching. From a site layout and construction perspective dissemination can be mitigated via the installation of fences or walls, wheel wash ramps and rubble shakers or grids, and protective layers consisting of crushed rocks (see Figures 6.2, 6.3, and 6.4). The more careful the remedial planning process and execution is, the smaller the risk of site disturbances during construction and O&M stages. The EPA for instance suggests the following considerations; Landfill soil caps, impermeable liners, containment covers, underground slurry walls, fences, soil vapour extraction, bioremediation, and ground water pump-and-treat and monitoring systems. One survey participant states that "solar projects usually increase the protectiveness of a remedy because they usually involve a perimeter fence that dissuades unwanted intruders like dirt bikers".



Figures 6.2. (3) and (4) Measures to reduce the risk of off-site mitigation of pollutants

6.5.1.3. Land & Resource Constraints

Land and resource constraints can be assessed and potentially overcome using site evaluation frameworks such as the so-called 'fatal flaw analysis'. The latter is a pre-feasibility study, where if any of a predetermined fatal flaw criterion is not met, the pursuing of a project becomes impractical. Similarly, a 'showstopper analyses' identifies issues that are 'halting' project progress partially and temporarily. Developed by the EPA/NREL, 'decision trees' are flowcharts for examining a site's suitability. Finally, there are mapping tools, shade and PV/Wind capacity calculators that help evaluate the power output of a given location. Alas, such tools are mainly designed for identifying large utility-sized sites that often eliminate smaller sites that could still have renewable energy potential.

6.5.1.4. Load & Transmission Barriers

Both the survey and the case studies uncover that there are no shortcuts for load and transmission impact assessments as they are mandatory for most large renewable energy projects and necessary to determine the cost and feasibility of connecting a system to the grid. Yet it is recommended, that in order to minimize surprises later on with regard to output reliability and financial return, it is prudent to include very basic load and transmission parameters such as distance and cost into site identification criteria. Any property identification should be undertaken with local utilities and in accordance with electricity codes and standards.

6.5.2. Measures for Financial, Regulatory and Institutional Challenges and Barriers

6.5.2.1. Securing Capital

In order to overcome financial barriers, several experts say that it is critical to eliminate lender hesitance and secure a power purchase agreement (PPA) by building trust. The latter can be achieved by providing realistic and accurate estimations of costs and projected revenue, by sharing any type of information, especially negative ones, or by hiring an independent estimator or consulting firm. According to Neuman and Hopkins (2009), any agreements such as PPAs, interconnection agreements, lease or purchase and sale agreements should entail early exit strategies in case of non-compliance, project halt, or failure. Prospective brightfield owners and renewable energy developers should be well informed not only of site conditions, but also of the (changing) legal situation before purchasing developing a potentially impaired property. In order to further reduce financial risks, so-called financial sensitivity analyses can be done. Apart from building trust by eliminating as much risk and uncertainties as possible, most renewable energy and brightfields would not be viable without capturing external incentives and grants. These come mostly in form of government loans or grants but increasingly also from private investor groups such as equity firms and banks. Ultimately, if there is money to be made, practice shows that investors are often not far.

6.5.2.2. Reducing Risk & Liability

While there are other liabilities (flooding, earthquakes, system failures etc.) the survey focused on potential damages causes by contamination or the disturbance of remedial works. Experts believe that it is essential to inquire any legal responsibilities prior to spending too much time and resources on feasibility studies. Engineering, procurement and construction (EPC) and O&M insurance agreements can mitigate the risk of system failure, underperformance, carbon credit risks and so on (Neuman and Hopkins, 2009). The outsourcing of O&M and equipment warranties can further defer such risks. By using a contractor responsible for site remediation, and a contractor for EPC, one can broker a contract that provides site owners and/or system operators with insurance, including professional liability and commercial general liability insurance, where any risks associated with error or omissions in design can be covered. Aside from financial ramification, liability assurance is a lengthy and toilsome regulatory process at the end of which - developers complain - assurance is anything but guaranteed. Survey participants omitted to speak to the ecological risk, a shortcoming addressed in the discussion.

6.5.2.3. Regulatory & Institutional Barriers

The survey did not offer concrete measures to institutional barriers. A review of case study reports reveals that developers are often rather powerless with regard to institutional barriers and cannot for instance speed up bureaucratic or regulatory processes (see Brockton). However, there are several measures that may help reduce the negative impact of these processes and help save time and resources. Such measures include: (1) having continuous internal work lined-up to avoid unproductive waiting periods, (2) bundling bulk applications and submissions to speed up process, (3) outsourcing certain processes to specialized third parties, and (4) staying mindful of new (or future) policies and procedural changes.

6.5.2.4. Market Barriers

Again, few survey participants offer any concrete measures to address market barriers, thus recommendations are derived from the literature (see Painuly, 2001; Menanteau Finon and Lamy, 2003; Meyer, 2003). Proposed measures for increased market penetration for renewable energy include: (1) internalizing negative externalities of fossil-based energy, (2) feed-in tariffs with a guaranteed market such as Renewable Energy Portfolio Standards (RPS), Renewable Energy Credits (REC) and other incentives, (3) economic subsidies, and (4) building human and institutional capacity and education. These measures are for renewable energy in general. Please see the discussion section for a critical examination of measures pertaining to brightfields.

6.5.3. Measures for Social Challenges and Barriers (e.g. Opposition)

6.5.3.1. Physical & Contextual

Apart from increasing setbacks and spacing of wind turbines for example, there are not a lot developers can do to reduce physical and contextual opposition against brightfields. By and large, brightfield owners or renewable energy developers are not responsible or able to change system designs and technologies. Renewable energy system manufactures on the other hand are aware of the negative externalities of certain renewable energy and aim to design less intrusive systems such as quieter wind turbines changing blade colour to reduce bird fatalities green and blue tower colour that fits into landscape; anti-reflection coating on solar panels or air filtration systems on bio-digesters (Gipe, 1995). However, there is evidence that there is generally less of a need for aesthetic improvement for brightfields if they are located in non-residential (i.e. industrial) and already unpleasant areas (Neuman and Hopkins, 2009; Wolsink, 2010).

6.5.3.2. Institutional & Socioeconomic

A total of 11 survey participants believe that the single greatest measure to address both socio-economic and institutional barriers is to educate the public on the benefits and safety of brightfields and administrators and regulators on how to facilitate their implementation. The literature suggests that this can be achieved via show-and-tell demonstration and hands-on workshops for the public as well as public participation and town hall meetings (see Kahn, 2000; Wolsink, 2010; Devine-Wright, 2005, 2007; Felten, 2005). This requires the existence of successful cases and best practices from which to learn. Owners and developers are also encouraged to educate the public about all financial aspects of the projects, including costs, financing and the ramifications (if any) pertaining to one's electricity bills. The literature provides some evidence suggesting that individuals seek greater levels of participation in renewable energy developments (see Devine-Wright, 2007). Johansson and Laike (2007) argue that social interventions and public participation are required to promote positive attitudes towards renewable energy. Yet, Brounen Kok and Quigley (2013) show that "energy literacy" and awareness is generally pretty low among [Dutch] residents and Turcotte, Moore and Winter (2012) demonstrate that the average [Canadian] lacks detailed knowledge about sources of energy fuels, as well as sources and linkages with environmental impacts. In the context of brightfields it may be advantageous to also improve 'contamination or remediation literacy'. That is, educating the public on the extent of a property's contamination, its cause (prior activity) and what the safe legal limits are. Adelaja et al. (2010) argue that "community involvement and consensus-building have been identified as two of the most important issues that could present barriers to brownfield redevelopment, especially those involving renewable energy projects" (p. 7023). Figure 6.5 is a visual representation of the barrier/challenge categories.

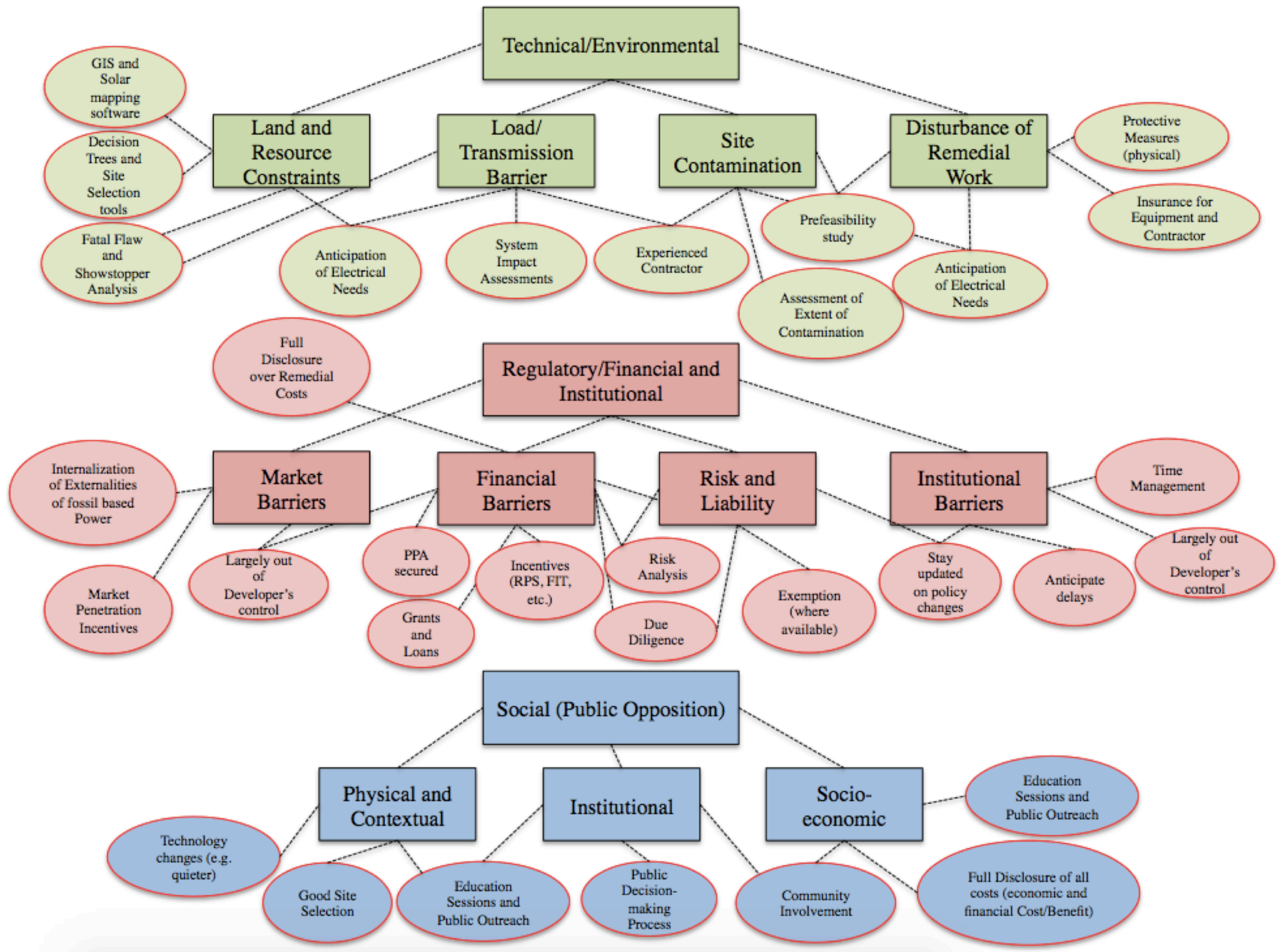


Figure 6.5. Summary of all challenges and barriers (rectangular) and their proposed measures (oval).

6.6. Discussion

The purpose of this discussion is to shed more light on the survey results by substantiating and critically reviewing some claims made by the surveyees and try to ground them in the literature where possible. Crucially, the effects and relationship between barriers and site attributes are also considered at the end of this discussion.

6.6.1. Technical & Environmental Challenges and Barriers

This research shows that site contamination remains a critical barrier to brightfields. Adelaja et al. (2010) profess that "although, the methods of assessing and cleaning up environmentally distressed properties have become more sophisticated, surprises are often encountered in the process of cleaning contaminated brownfield sites" (p. 7022). The degree of technical difficulty and duration of remedial work ranges from minimal (e.g. excavation), to medium (e.g. soil replacement), to high (e.g. solidification, soil recycling or capping). As Shove (1998) points out, it is false to assume that technical barriers can be solved outside the social realm. Especially concerning contaminated brightfields, where the distinction between technical and non-technical barriers cannot be drawn decisively. This assumption is to some degree supported by the survey, insofar as the experts describe that the real barrier is not contamination (ore subsequent remediation) itself, but instead accurately assessing its scope (in space, time and the legal landscape) and its socio-economic consequences. It is important to point out that most brightfields need no, or only limited, remediation in the event where renewable energy is the sole end or interim use. In the U.S. for example, only contaminated properties with significant actual or potential public health and/or environmental impacts likely warrant mandated cleanup. Similar provisions are (in theory) in place through Ontario's Record of Site Condition Program for example, although no such precedence is believed to exist.

In quite a lot of cases no cleanup is required even for contaminated sites, either because the levels of contamination do not pose unacceptable risk to human health or the environment, or remediation is not mandated for a renewable energy end-use. This double standard – when compared to residential redevelopment - is in large part due to risk-based and site specific assessments and end-use specific standards. Whether this is socially justifiable is up for discussion on a case-by-case basis (see discussion on social challenges). Engineering solutions to offset contamination and dissemination fears are valid technical measures, but may on the other hand reduce project viability since engineers will almost always find a solution given no financial restrictions. Site selection seems to be the best measure to prevent such challenges; meaning that a renewable energy developer or an owner of multiple brownfields is wise to choose the least contaminated one if possible.

Findings for load and transmission constraints are in line with the general literature, since renewable energy is not as consistent (from a power quality perspective) compared to conventional and more stable sources of energy, resulting in a less steady supply and lower quality electricity (Georgilakis, 2008; Hatziargyriou, 2002). Although power quality is mostly a concern for local distribution companies, renewable energy projects and subsequently also brightfield projects often bear the connection costs and responsibility of connection/load assessments. So-called System Impact Assessments [66] (SIA) are time consuming and can be disproportionally expensive for smaller projects due to (an inverse) economies of scale. In Ontario in particular, grid capacity constitutes a challenge. One of the province's largest solar developers, investigated the feasibility of, and submitted applications for 30 solar farms, 10 of which on aggregate pits (i.e. brightfields), but had to abandon most projects (and all on the aggregate pit ones) due to the lack of grid capacity. Under normal operating conditions, brightfields do not vary from other renewable energy projects in that regard and potential contamination is not known to have any further impacts with regard to these challenges. It is very likely that load and transmission assessments have disqualified numerous potential sites that never made it past the preliminary planning stage, which in itself can be viewed as a success when such flaws or showstoppers are identified early.

6.6.2. Financial, Regulatory & Institutional Challenges and Barriers

Most projects are not economically viable without economic incentives that will fill financial gaps beyond the market value or allow for cost recovery (Kurdila and Rindfleisch, 2007; Kushner, 2005). The survey describes that financial issues are the number one reason for project failure. Financing can become an insurmountable barrier, thus being the one barrier for which no rational solution may exist. Brownfields have long been burdened by lender hesitance and large up-front capital of green energy projects are making things worse, as it were. For brownfields in general, this seem to have changed, since there are now numerous funding schemes, and the viability of urban redevelopment is attractive to investors. Coffin (2002) notes that many researchers "point out that access to capital remains a primary barrier but, with demonstrated project demand, they have been able to surmount that barrier as well" (p. 31). However, regarding brightfields, Adelaja et al. (2010) state that "a primary barrier to brownfield redevelopment is that, even with incentives, the mitigation cost necessary to bring these sites up to safe standards may be more than the land would be worth after redevelopment […] this cost gap makes it difficulty for developers to embark on brownfield redevelopment projects, even in cases where the costs of cleanup and redevelopment are known with certainty" (p. 7022). It has to be recognized however that capital and contamination can be two sides of the same coin and are closely interrelated issues. On the one hand there are grants for brownfield clean-ups, yet on the other hand most general renewable energy funding avenues were (are) in favour of unimpaired lands. More recently however, in some jurisdictions financial incentive schemes such

[66] Also known as Transmission Availability Test (TAT) and Distribution Availability Test (DAT).

as the FIT programs are discontinued for wind and solar on greenfields in favour of *Konversionsflächen* for instance (see chapter 4 and 5). As stated earlier, grid parity and the breaking free of incentive related restrictions could mean that developers are starting to opt for straightforward greenfields again.

This phenomenon introduces the discussion on the plea for a moratorium of renewable energy on greenfields altogether, which could expedite the learning curve and increase technical and regulatory capacity for brightfields, but could go over the heads of those with concerns over safe-to-use practices and start a environmental justice debate. This would require a lot of legal work, time and resources to implement, as not to discriminate against 'conventional' renewable energy projects already in preparation. Whether, a moratorium is the best solution is questionable, and requires further research. An encouragement and incentive to use marginalized lands may be better than a punitive (against non-brownfields) and prohibitive moratorium on 'conventional' renewable projects. However, if contamination and liability is limited diligently, the operation of a renewable energy plant is comparable to conventional renewable energy projects.

Site pollution is unique to brightfields and presents both an ecological and a financial risk. To limit risk and liability, it must be assessed on a technical and regulatory basis that cannot be resolved outside the realm of state or federal legislations. Liability exposure is the result of an actual pollution condition on, at, or under a site arising out of historic, current of future operations (Neuman and Hopkins, 2009). Certain jurisdictions offer voluntary cleanup programs, no-further action letters and not-to-sue certificates, limited prospective liability, bona fide prospective purchaser exemptions, or other degrees of immunity from environmental orders. It is critical to try to capture these liability exemptions where possible. Alas, not all jurisdictions offer reduced environmental liabilities. Neuman and Hopkins (2009) found that "while some insurance products address risks presented by renewable energy projects, very few policies are specifically tailored to address both renewable energy project risks and brownfield remediation risks" (p.298). Neuman and Hopkins continue by saying that "if identifying and analyzing loss exposures is the most important step in risk management generally, it is all the more important—and more complicated—in managing the risks at a brownfields site" (p.298). Coffin and Sheppard (1998) postulate that perceived liability could compound legal liability as well as financial burdens, even in the absence of actual contamination. This is in line with social contextualization and seemingly 'irrational' amplification of contamination fears, economic angsts and risk. The latter[67] is defined as the sum of the probabilities of risk events and their consequences (Burton and Pushchak, 1984). As far as the risk of the actual infrastructure, Inhaber (1979) shows for instance, that solar uses the most amount of raw material per unit of energy produced and thus gives solar the highest occupational risk among all types of energy production. While this is largely seen as a disproportionate reflection (see Holdren, Anderson, Gleick, Mintzer, Morris and Smith; 1979), the siting of all types of renewable energy on contaminated lands does call for a sound assessment and management of risk.

Risk management is frequently defined as a five-step decision making process: (1) identifying an organization's exposures to accidental loss; (2) examining feasible alternative risk management techniques (risk control and risk financing) for dealing with these exposures; (3) selecting the best risk management techniques; (4) implementing the chosen techniques; and (5) monitoring the results of the chosen techniques to ensure that the risk management program remains effective (Head, 2002). The development of brightfields can and should not eschew risk analysis as part of the decision-making process. By using risk management, sites that are too risky may be eliminated early on in the site identification process in favour of less risky ones. Further, it has to be noted that the call (by some surveyees) for more liability exemption does not reduce the risk ecologically speaking, but only circumvents the legal barrier of financial responsibility. The continued ecological risk of contamination is not averted by liability exemptions, but begs the question of social responsibility. Can brightfield developers who advertise the protection of greenfields afford this type of social exposure? From an environmental justice point of view, this may not be the right thing to do (see also section 6.6.3).

Neuman and Hopkins (2009) refer to so-called risk transfer mechanisms that help defray the risks associated with the costs of brightfield projects. Arguably, social costs, a project's image and reputation need to become part of such mechanisms in the future since most existing management tools often "fail to consider risk in its full complexity and its social context" (Kasperson and Kasperson, 1996, p. 95). As Burton and Pushchak (1984) point out, "the acceptance of risk may be less dependent on the accuracy of risk analyses than it is on the nature of the decision-making process" (p.). This has some potentially far reaching consequences regarding environmental justice, if "most risks are likely imposed on imperfectly informed risk bearers who often lack the freedom to accept or reject the risk" (Kasperson, 1983, p. n/a). Thus the cost of green energy could (in theory) result in less remediation of contaminated land. A high-level EPA Regional Director confirms that

[67] It has to be noted that here risk refers to the potential damage caused by unknown or untreated contamination of soil or water present on a brownfield and only to a minor degree the risk of he actual renewable energy installation.

less than 50 % of all RE-Powering America's Land Initiative brightfields have undergone extensive remediation (pers. Comm., 2015). This is congruent with the 56 or so properties that are superfund sites, federal contaminated sites, or Corrective Action sites.

Market barriers are well reflected in the literature and the case studies, as well as other EPA resources. Market barriers identified by the survey consist of failures or distortions and institutional barriers in a larger sense (Painuly, 2001; Coffin and Barbero, 2009). Menanteau et al. (2003) state that, "because of the non-excludable and non-rival characteristics of [sunlight and wind], private actors are not prepared to invest in something which everyone can acquire free of charge" (p. 800). Practice shows that utility companies are often reluctant to engage in a Power Purchase Agreement (PPA) with a renewable energy producer as "distributed generation threatens the utility's bottom line, and PPAs provide a catalyst for this threat"[68]. At the same time, private landowners are often reluctant to lock up their land into a 20 or more year PPA contract and potentially forego a more lucrative investment in the future, thus holding out for a better opportunity (e.g. residential redevelopment). This presents a high opportunity cost for brownfield owners, especially urban ones. Alas, even municipalities that often own brownfields are not aware of this type of redevelopment and/or lack the necessary know-how, although this is starting to change. Market barriers for brightfields may differ from region to region and from country to country. In the U.S., brightfields have become a national priority, while Germany and the U.K. have had a long tradition of sustainable brownfield reuse and are developing brightfields in earnest, or are beginning to (U.K.). Alas, in Canada there is little industry and political support thus far for this type of development.

6.6.3. Social Barriers and Challenges

According to Swofford and Slattery (2010) "the basic theory [of NIMBY] is that people support renewable energy on an abstract level but object to specific local projects because of the expected consequences concerning primary noise and visual impacts" (p. 2509). Vajjhala (2006), finds that public opposition has now become so "commonplace that it is frequently disparaged as the primary barrier to any new development" (p.3). Since brightfields are using the same technologies than a 'conventional' renewable energy project, the concerns developers are dealing with are similar pertaining to social opposition.

[68] http://secuRETutures.us, retrieved May 2015

Compared to the 1980s, wind energy is now considered the most controversial renewable energy due to its impact on the landscape, making it “one of the most distinct energy landscapes in the world” (Pasqualetti, 2001, p. 692). Public opposition against wind is often due to tower height (average height has increased from 30-80m over the last 15–20 years); impact on landscape vistas; prolonged downtime and maintenance costs; avian mortality, and emission of noise and electromagnetic and radar interference. Solar PV is generally regarded as the most socially acceptable (even democratic) form of renewable energy, being perceived as less intrusive due to low array profile (Devine-Wright, 2010). However solar is not free of certain nuisances, such as panel glare/reflectivity or eyesore due to landscape blanketing (Riberio, 2007).

Just as the type of technology, the proposed location of a renewable energy site can become a concern. However, the survey shows that location related concerns, such as proximity to schools, houses et cetera, are minimal. Conjecturally, this may be because brownfields are often located away from such places, but in already industrial and therefore low residential density zones instead. The literature argues that the location of renewable energy installation can trigger ‘place-protective action’ due to place attachment and identity (Devine-Wright, 2009, 2010, 2011; Bonaiuto, Breakwell and Cano, 1996). Place attachment can be described as a positive emotional connection with a familiar location such as the home or neighbourhood (Devine-Wright, 2009). A similar concept is described in Casey’s (1999) research regarding the ‘home-place”. Researches talk about ‘disruption’ to this place attachment in the event of changes like the installation of a renewable energy facility. The location of a renewable energy facility may affect certain individuals personally even if they are generally in favour of say wind or solar energy. Place attachment need not be exclusive to a dwelling, but can extend to a former workplace, thus even including commercial and industrial zones. In that respect it is possible – although very rare - that former workers of a now abandoned factory for example still identify themselves with the brownfield, especially if they live nearby. More research needs to be done to find out if such individuals would oppose or welcome the transformation of a former workplace (now abandoned) into a meaningful reuse such as a brightfield. Furthermore, the literature shows that opposition is minimized for renewable energy locations in already aesthetically impaired environments (Neuman and Hopkins, 2009). Similarly, Wolsink (2010) found that members of an environmental movement in the Netherlands considered industrial areas and military training grounds, where the scenic value of the landscape could hardly be spoiled by turbines, to be suitable for wind power projects. He believes that spoiled and remote (to residential areas) areas could be more acceptable for wind turbines. Only 2 % of people rejected the installation of turbines on industrial lands and harbours and (only) 16 % for military grounds (ibid.). Similarly, Klusáček, Kunc and Nováková (2011) find that "[Brightfields] improve the public image of renewable energy sources because the development of alternative energy sources on brownfields usually does not spark intensive local NIMBY-type protests" (p. 518).

It can be argued that there is evidence that supports the claim that absent contamination, brightfields that are out of the public's sight, are out of the public's mind, because they are socially more acceptable compared to renewable energy on (semi-) pristine or unimpaired lands. Further, the generally lower population density (e.g. industrial area) may reduce public concern. One survey participant blatantly said: "Brightfields may have less of an issue there because there is no "backyard" for them". For conventional renewable energy projects public opposition has been a barrier that is difficult to overcome and one of the main reasons for project failure. Further research directly comparing brownfields versus greenfields would be very insightful. Whether greenfield protection is reason enough to offset the concerns about contamination (thus reducing opposition) cannot definitively be said and may be different from case to case. It may also be mainly due to the fact that brightfields are the better alternative to greenfields, the protection of which ranks high on the public's agenda. It stands to reason to speculate that the public may just be 'grateful' something is being done with a neighbourhood brownfield for example, that renewable energy installations seem better than the alternative (i.e. continued blight and vacancy) and close an eye on its 'normal' reasons for opposition against conventional renewable energy projects. Still, augmenting the public's comprehension of what remediation is, what pollutants are, and what they do is pivotal to the success of brightfields. The fear of pollutants entering the environment of people living in proximity to a brightfield is a real angst that must be addressed appropriately by disclosing all information and have the authorities confirm safe to use claims.

Physical and contextual fears are not the only concerns. According to the survey, institutional reasons for public resistance against brightfields do exist. Thus crucially, prospective brightfield owners/developers must be aware that they are facing more than just physical or contextual angsts. Wolsink (2000) states that "by labelling all protests as NIMBY one misses the multitude of underlying motivations" (p. 57). The public's desire for more involvement is due to 'value' factors such as land allocation, and public participation and can have nothing to do with physical fears (Devine-Wright, 2011; Wester-Herber, 2004). Pushchak and Rocha (1998) confirm that siting problems are often not technical in nature, but social and habitually also politically motivated. This can explain the occurrence of resistance that may be due to lack of participation in the decision-making process. Citizen participation (see Arnstein, 1969) in general and for the siting of renewable energy in particular (see Devine-Wright, 2005) is being more and more respected by developers and reflected in policies, such as public consultation and approval processes.

Whatever the reason for opposition may be, the challenge is to rapidly and cost-efficiently address and minimize public opposition in order to expedite the implementation process, but also and more importantly get community support for a given renewable energy project. Based on the survey as well as personal exchanges with senior EPA and NREL managers and advisors, every property brings new, unique challenges. The survey did not capture all barriers and did not present all measures. Some surveyees made it clear that their measures do not apply every time and may vary from property to property and from country to country. Every marginalized property is different and few are suitable for renewable energy due to remoteness (e.g. transmission issues), topography, land rights (i.e. ownership disputes), size, and of course resource availability (including shading). Each case must be assessed in tune with unique local conditions and within its unique social landscape. It stands to reason that macroscopic best practices and site evaluation methods are largely inappropriate. Even suitable properties compete with a host of other potential end-uses that may be better suited, more viable, and quicker to achieve. Urban vacant properties for instance seem a lot less likely to become brightfields because of the high value of urban real estate that is not suitable for 20 year return on investment contracts. The vast majority of vacant properties are being transformed for residential purposes, followed by commercial reuse, not renewable energy. Generally speaking, sites with a high economic viability are often redeveloped more quickly, whereas so-called 'hard-core' sites remain unused for much longer, making them more suited for renewable energy, given lower land costs. Renewable energy developers are encouraged to focus on these 'reserve' sites (see Oliver, Ferber, Grimski, Millar and Nathanail, 2005). Brightfields could be regarded as an interim use, during which time a property is producing revenue and green electricity. However, the installation of renewable energy infrastructure is a big commitment for the lifespan of a system. A brightfield could not only power green remediation work, but could provide on site/local energy to power multiple phase developments surrounding the brightfield concurrently.

Overall it is important to determine which barriers and challenges stem from brownfields and which from renewables. The question is whether brightfields really are at the intersection of the two and simply a sum of renewables and brownfields when it comes to barriers? Figure 6.6 illustrates the origin of barriers that exist between the two, as well as where such may overlap. Site contamination, remediation, disturbance of remedial work, securing capital, risk and liability, and end-use competition are brownfield barriers/challenges, whereas high capital costs, resource, load and transmission along with land constraints, and public opposition are renewable barriers/challenges. Both circles, share market barriers as well as regulatory and institutional challenges. Furthermore, it is the disturbance of potential remedial work by renewable energy infrastructure that is the truly unique elements for brightfields. It stands to reason that the barriers for the development of brightfields are not just the sum of its parts (brownfields and renewables), because not all brightfields are contaminated and even the ones that are, not always require remediation. Site contamination or the requirement to remediate, make all the difference. The crux of the matter lies in determining the effect and influence of different brightfield attributes on these barriers. Contamination, and if required remediation, are compounding already negative attributes of both 'circles', namely, financing, liability and social concerns. On the other hand the professed triple-bottom-line benefits (that do indeed exist!) may have a positive influence (or synergy) on some issues like physical and contextual angsts, as examined before. Figure 6.7 illustrates this relationship.

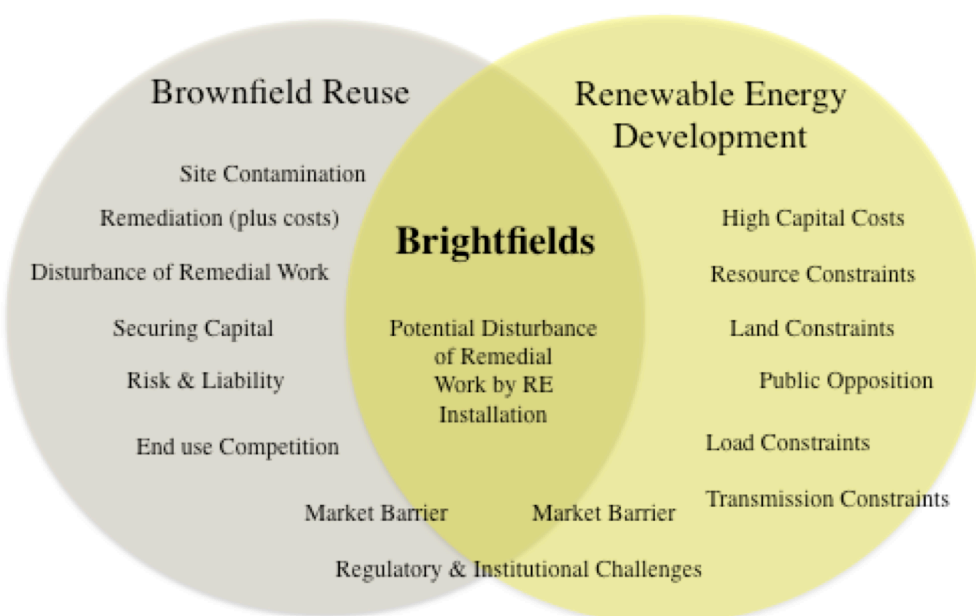


Figure 6.6. The intersection of Brownfield reuse and renewable energy development: Overlap of Barriers and Challenges.

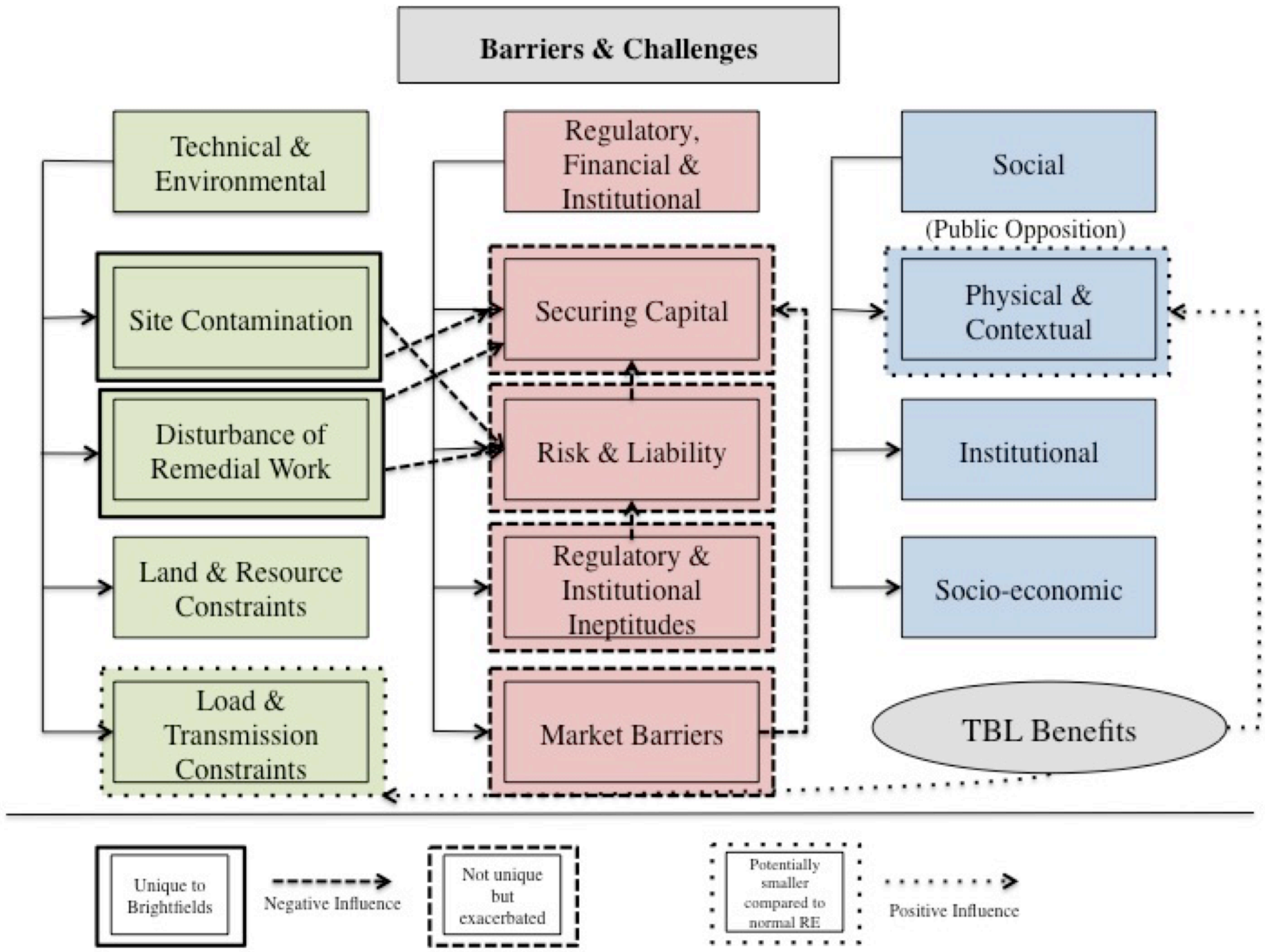


Figure 6.7. Overview of all barriers for renewable energy on marginalized lands. The main categories of barriers and challenges are (1) technical/environmental; (2) regulatory/financial/institutional, and finally (3) social. Each category contains several sub-categories. The arrows indicate negative or positive influence and the frames whether a given category is unique, exacerbated (compounded) or smaller compared to conventional renewable energy projects.

6.7. **Conclusion**

This chapter provides a comprehensive overview and detailed insight into the technical/environmental; regulatory/financial/institutional as well as social barriers and challenges to the development of brightfields. It is therefore a significant contribution to the still emerging brightfield literature.

Overall, the chapter shows that the common barriers and challenges for brownfield redevelopment are often carried over into the development of brightfields, questioning some of their professed benefits. The chapter finds that environmental/technical barriers only differ from 'conventional' renewable energy projects in the event of site contamination. The latter then is what separates brightfields from conventional renewable energy projects and is the source for a myriad of challenges concerning risk and liability, which cause financial problems and investment hesitance. Site contamination compounds these concerns. Despite the fact that brightfields can often be redeveloped without being first remediated, legal uncertainty pertaining to cleanup responsibilities seems to be a constant concern for brightfield developers. Alas, the majority of survey respondents are from the U.S., where litigation is commonplace[69]. It remains to be seen whether the bulk of developers in other countries share that concern with tort and liability.

Physical and contextual fears are likely to be smaller for brightfields compared to 'conventional' renewable energy projects, if no contamination is present. There is research that suggests that aesthetically unpleasant properties usually attract less public opposition because there is no view or natural beauty to begin with that may be ruined by renewable energy installations. Nevertheless, the barriers to this type of development should be as well understood as the suggested triple-bottom line benefits. This requires greater academic attention and a more careful and critical analysis of these benefits.

According to many experts surveyed, the best-case scenario consists of finding a brownfield that is not contaminated, thus limiting implementation challenges and avoiding crucial barriers. Thus, the study identified that site identification is arguably the most important step in developing a brightfield, able to avoid most barriers. Since there are thousands of properties to choose from, technical and particularly non-technical site identification criteria and prioritization methods are needed.

Putting renewables on brownfields is no guarantee for triple-bottom line benefits and each site/project must be scrutinized individually and taken in the context of its regulatory, financial and social environment. In the light of a more critical examination of its advantages and a better understanding of its barriers, the development of brightfields is certainly not without externalities and downsides.

[69] So much so that in the past, an estimated 30 to 70 % of the Superfund's $40 billion budget has already been consumed by litigation (De Sousa, 2008).

CHAPTER 7: SITE IDENTIFICATION PROCESS FOR BRIGHTFIELDS: A DECISION-SUPPORT SYSTEM USING AHP

Abstract: Brightfields, or the siting of renewable energy on marginalized and (potentially) contaminated lands is an increasingly popular reuse of brownfields and could become a viable alternative to residential redevelopment. Current site identification and decision-making (DM) tools for renewable energy on brownfields only assess technical feasibility and often fail to capture the uniqueness of both property and ownership with regard to contamination status, type of brownfield, land value etc. Here a more customizable decision support system (DSS) is proposed accounting for a variety of site criteria including non-technical and non-financial ones. By introducing Analytical Hierarchy Processes (AHP), this study aims to help the decision-maker in identifying potential candidate sites based on municipal or entrepreneurial agendas and preferences. Individual as well as group DM AHP is applied to 12 potential brightfields in the Port Land area in Toronto. The resulting ranking of sites is then compared to a cost-benefit analysis (CBA). The study shows that AHP can be used as a DSS tool for brightfield siting and that the results can differ significantly compared to a simple CBA. With some training brownfield owners may use this method for a more personalized (although subjective) and accurate site identification process and DSS. The tool is aimed at owners of multiple brownfields.

Keywords: brownfields, renewable energy, multi-criteria decision-making, AHP, brightfields, Toronto.

7.1. **Introduction**

So far this dissertation has found that site identification is the most essential step in minimizing challenges and barriers during the brightfield development process. Thus far the literature largely focused on the potential capacity (n-MWp) of brightfields on a State or national scale for large-scale power plants (see Adelaja, 2009; Milbrandt et al., 2014). Similarly, existing screening tools (e.g. EPA and NREL) provide help in finding utility-scale properties via a set of exclusion criteria such as technical feasibility and viability (economy of scale). This ignores the fact many municipalities and private companies alike own smaller properties and that they have their own agenda apart from these two admittedly important factors. In reality, brownfield owners are faced with a plethora of choices with regard to brownfield end-use. Leigh and Coffin (2000) remark that "cities need to be able to recognize their potential as well as their known brownfields problems" (p.4).

Screening procedures that identify candidate sites for energy siting is nothing new. Keeney (1980) describes the three formal approaches of *exclusion*, *inclusion* and *comparative* screening. There are a number of web-based site screening and evaluation tools available today, examining criteria such as size, shading, the distance to grid et cetera that aim to find suitable brightfields. These tools are largely exclusion screening tools using elimination of sites based on various factors. The underlying assumption of exclusion processes is that once all non-suitable sites have been eroded, what one ends up with must necessarily be suitable sites. This of course is a false assumption as well as a resource intensive undertaking. Apart from being too course and broad to be applied in a smaller jurisdiction, such tools lack non-technical decision-support mechanisms, and do not account for governmental or entrepreneurial agendas and development preferences. While Keeney (1980) sees [subjective] value judgments as an unfair and negative selection process, it has to be recognized that owners, in particular municipal brownfield owners, are not always subjected to rational decisions, but aim to meet socio-cultural goals as well as economic ones. This means that decisions are context dependent (see Kelman, Rottenstreich and Tversky, 1996; Wilson and Dowlatabadi, 2007). Shove (1998) states that the technical potential alone is an inappropriate (over-) representation of the overall capacity [for renewable energy deployment], generally too optimistic and without much relevance if analysed without accounting for social aspects of change and adoption. Thus, the aim of this chapter is to find out what the preferences are for brownfield owners in terms of selecting a property for a brightfield and create a model to facilitate the site identification process. A microscopic comparative site identification tool is proposed that accounts for the uniqueness of brownfield ownership in a spatially smaller decision-making environment.

The study is structured as follows. *First*, a survey on the motivation for brightfield conversions is analysed. The purpose of this survey is to gauge (on a high level) why brownfield owners may consider the development of brightfields and what criteria would be of importance to them. The survey was sent to private and municipal brownfield owners in Canada. *Second*, an AHP model is presented that encapsulates some of the motivating factors derived from the above-mentioned survey. *Third*, an AHP interview is presented, which was conducted with two decision-makers regarding the Toronto Port Land brownfields. The objective is to see how one could use AHP for the identification of candidate sites. The results of the AHP interviews are then applied to a case study including 12 brownfields in the Port Lands with the aim to identify the sites that meet the preferences of the two DMs. These AHP-ranked sites are then compared to a more traditional site identification based on a simple cost/benefit analysis.

7.2. **AHP and Brownfield Research**

This study introduces a so-called Analytical Hierarchy Process or AHP into the brightfield literature. AHP is used to help DMs in making a decision or finding a location, based on his or her preferences.

AHP employs mathematical and logical reasoning to turn human qualitative judgments into a quantitative support mechanism (Ṣandru, Constantinescu and Boscoianu, 2014). Multi criteria decision-making or MCDM is a sub-discipline of operations research that explicitly considers multiple criteria in decision-making environments (Köksalan, Wallenius and Zionts, 2011). AHP was developed by Saaty in the 1970s and is a MCDM tool that can be viewed as a structured technique for organizing and analysing complex decisions (see Belton and Stewart 2002; Saaty, 2008; Hummel, Bridges and Ijzerman, 2014). AHP "is used to derive relative priorities on absolute scales from both discrete and continuous paired comparisons in multilevel hierarchic structures" (Saaty and Vargas, 2006, p.2). Sandru, Constantinescu and Boscoianu (2014) find it is important to note that "the best option is the one which optimizes each single criterion, rather the one which achieves the most suitable trade-off among the different criteria" (p. 567). It reduces complex decisions to a series of pairwise comparisons that are subsequently synthesized to capture both subjective and objective aspects of a decision along with a technique for checking the consistency of the DM's evaluations, thus reducing bias in the decision-making process (Tavana and Sodenkamp, 2010).

Although AHP is a product of decision-making and operation literature, as well as mathematics, it has been a popular concept for many years in other disciplines, especially in the retail/wholesale and grocery sector for evaluating store and warehouse locations (see Kuo, Chi and Kao, 2011; Liand and Wang, 1991; Hsu and Chen, 2007; Tierno, Puig, Vera and Verdu, 2013). Özdağoğlu (2012) used fuzzy AHP and Chang, Parvathinathan and Breeden (2008) used GIS in concert with a multi-criteria decision-making methodology for the identification of landfill locations. Srdjevic, Kolarov and Srdjevic, (2007) employed AHP for finding a location for a pump station in Serbia in a group decision-making process using the geometric mean. AHP has also been used in hazardous facility siting. Hartman and Goltz (2001) for instance used this DM tool to select characterization and risk-based decision-making and management methods for hazardous waste sites. King and Pushchak (2008) attributed retrospective acceptability scores for the siting of marine aquaculture facilities in New Brunswick by amending existing decision support systems. MCDM and AHP in particular have been used in the context of renewable energy siting in studies by Nigim, Munier and Green (2004) and Aras, Erdoğmuş and Koç (2004) as well as finding locations for conventional energy plants (Akash, Mamlook and Mohsen, 1999). In fact, Pohekar and Ramachandran (2004) found that a total of 14 major studies used AHP in connection with renewable energy planning since 1990. Hobbs and Meier (2000) described how MCDM has been used to select locations for gas-fired plants and nuclear power plants in Indonesia and New York (see also Erol, Sencer, Özmen and Searcy, 2014). MCDM processes have also been used in the brownfield redevelopment literature. Chen et al., (2009) used Case-Based Multiple-Criteria Ranking and MCDM to rank 81 U.S. brownfield redevelopment projects based on available data and an accepted benchmark. Zavadskas and Antucheviciene, (2006) used multi-criterion techniques to develop an indicator model to rank sustainable brownfield redevelopment alternatives, while and Wedding and Brown (2007) used AHP to measure site-level success in brownfield redevelopments. Chen et al. (2007) developed a strategic decision support for brownfield redevelopment and two years later Chen et al. (2009) also developed a strategic classification support system for brownfield redevelopment using decision support system and multiple criteria decision analysis. Finally, Thomas' (2002) study on brownfield prioritization and selection process used multiple weighted attributes to "provide a model […] to help communities in selecting target sites for redevelopment" (p. 95).

Although MCDM has been used in the brownfield literature, strategic support for redevelopment decisions at the government and community level is still lacking due to "the absence of credible information about a city's situation" (Chen et al. 2009, p. 648). In other words, AHP has thus far not been used to locate candidate brownfield sites on a municipal level, but only in connection with decision-making regarding strategic reuse of already known sites. Coffin (2002) confirms that the benefit of knowing ones brownfield potential is great, yet hard to achieve absent inventory and accessible information. This study adopts proven decision support mechanisms and brownfield site identification models in a unique way by applying them to brightfields. To the current state of knowledge no study exists that employs AHP in brightfield identification and decision-support and will thus fill an important gap in the brown- brightfield literature and expand the use of AHP into a new and innovative field of research.

7.3. **Objectives and Research Questions**

Having identified the need for more microscopic site identification mechanism – including non-technical criteria - the objective of this study is to determine to what extent municipal and private brownfield owners have considered brightfields as an alternative to traditional brownfield redevelopment, what motivates them to undertake a brightfield transformation and what site criteria are most important to them. The goal of this survey is to see the differences as well as use the data for the creation a general AHP DSS. The objective of the AHP model is to provide private but especially municipal brownfield owners a decision-support model that helps DMs identify the properties according to their specific preferences and agenda. The model created can be customized by any jurisdictions to fit other local needs and more (or different) identification criteria can be added. To undertake an AHP, it is necessary to narrow down the list of criteria by finding out more objectively and more broadly (larger sample size) what some of the motivations are for brightfield development, as well as the preferences for companies and municipalities. Thus the AHP interviews build upon the above-mentioned survey.

This study aims to address the following research questions:

- **Q1:** What are the motivations for brightfield conversion for private and municipal brownfield owners?
- **Q2:** How can AHP be used to select brightfield property?
- **Q3:** What are the outcomes when applied to a case study?
- **Q4:** How may the results differ from a cost/benefit analysis?

7.4. Methods

The methodologies used for this study are best described as mix-method research (MMR). On the one hand, quantitative data are being collected together with numeric values assigned to personal preferences (i.e. pairwise comparisons). According to Yin (1994) case study research "investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" (p. 23). The paragraphs below present more detail on the methodology of this chapter.

7.4.1. Survey

The first step in this research is to determine the general motivation for brownfield owners both private and municipal pertaining to the development of brightfields. This is important as it helps narrow down (together with other case studies, evaluation tools and the literature) the site identification criteria used later on. To that end, two sets of surveys were prepared, one for municipalities and one for private companies that own brownfields. The closed survey questions only differed in the phrasing of the question ("municipality" or "your company"). The survey response options are derived from EPA rational for brightfield development (similar to TBL benefits). The online survey was sent to prospective participants via email. Municipal participants were identified via online searches for 'Municipal Brownfield Coordinator' (or similar) working for a given municipality. A total of 12 municipalities agreed to participate in the survey. A similar approach is undertaken for private companies, although this approach needed a lot of phone calls and 'blind' emails to determine who either is responsible for a company's brownfields or finding a DM willing to participate. Some participants (both private and municipal) were identified via the Canadian Brownfield Network, as individuals working for companies that are known to own brownfield properties or as a municipal brownfield coordinator. The survey participation selection was rigorous, in order to get the opinion of individuals with expertise, but also to determine whom to the best of their abilities could represent the views of their employer/municipality and thus be in a position to 'make a decision', as it were. Still, the text that accompanied the survey acknowledged that participants may not always fully speak on the behalf of their employer/municipality and that ultimate decisions - as to the reuse of such properties - may be made by others. The survey is analysed with descriptive statistics. A total of 8 companies and 12 municipalities participated. Thirteen survey participants filled the survey out online, 7 over the phone. The municipal brownfield owners that participated in the survey include; Windsor, Hamilton, Toronto, Kingston, Orillia, Guelph, Kitchener, Brantford, Vancouver, Moncton, Halifax and one other municipality that did not give permission to publish its name[70].

7.4.2. AHP Model

In general terms, AHP produces a weight (Wt) for each evaluation criterion based on to the DM's pairwise comparisons of the criteria (*Wt* (*w*) t = important). The criteria weights are combined and the options scores, thus determining a global score for each option, and a consequent ranking. The global score for a given option is a weighted sum of the scores it obtained with respect to all the criteria (Bunruamkaew, 2012; Şandru, Constantinescu and Boscoianu, 2014). AHP consists of three hierarchical elements; (1) a goal, (2) a set of criteria/sub-criteria and (3) a series of alternatives. The actual process employs three decision making steps: (1) Given $i = 1, \ldots, m$ objectives, determine their respective weights w_i, (2) For each objective i, compare the $j = 1, \ldots, n$ alternatives and determine their weights w_{ij} with respect to objective i, and (3) determine the final (global) alternative weights (priorities) W_j with respect to all the objectives by $W_j = w_{1j}w_1 + w_{2j}w_2 + \ldots + w_{mj}w_m$. The alternatives are then ordered by the W_j, with the most preferred alternative having the largest W_j (Forman and Gass, 2001). Thus, the process starts with the pairwise comparisons [$(n^2-n)/2$; 1-9 scale], followed by creation of the comparison matrix. The computation of the principal vector is next, which

[70] As per the Research Ethics Approval, the anonymity of all participants is guaranteed.

is the normalized *Eigenvector* of the matrix corresponding to the maximal *Eigenvector*. This process generated Wt for the evaluation criteria (and sub-criteria). The Consistency Index is determined [CI = (λmax-n)/(n-1)]. Finally, all alternatives are listed and ranked according to their overall scores. A general AHP model is created using various site identification criteria based on the literature, the aforementioned survey as well personal experience.

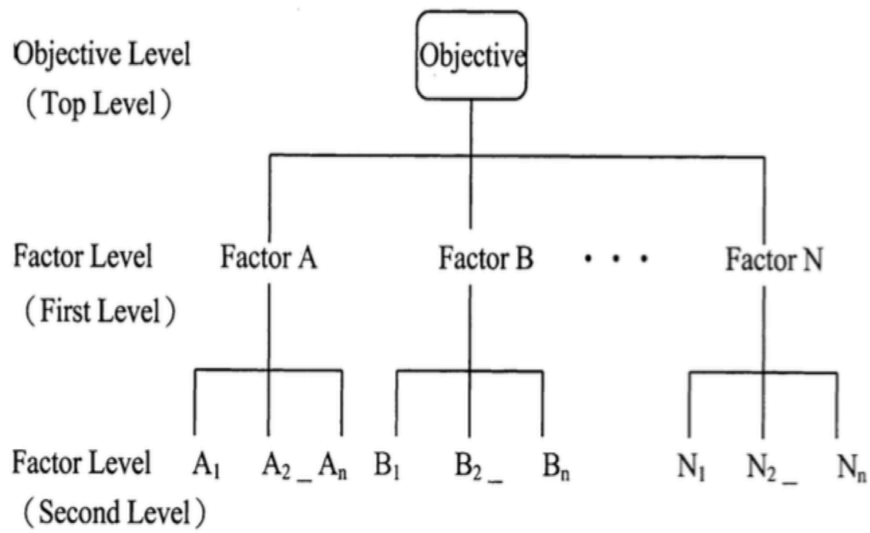
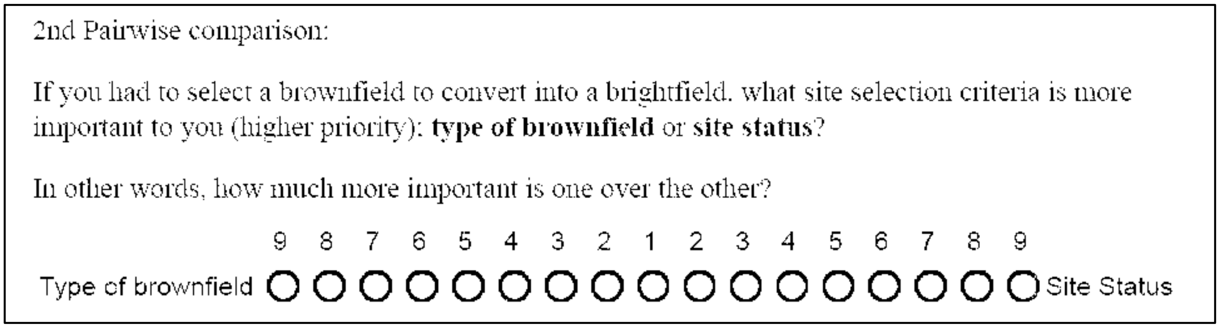


Figure 7.1. General schematic of AHP. (Source Kuo et al., 2002).

7.4.3. AHP Case Study Interview

It was decided to use the Toronto Port Lands as a case study because the solar resources are equal for all sites, thus providing a good case study to assess the non-technical factors. Further, the area is iconic and would appeal to a larger audience. The Toronto Port Land Company (TPLC) manages the majority of brownfields in the Port Lands, while Waterfront Toronto (WT) is the public advocate and steward of the waterfront and has a mandate to revitalize the area. The author was able to have the Director of the TPLC to participate in the AHP survey as well as the Chief Operating Officer of WT. Both DMs evaluated each criteria and sub-criteria in so-called pairwise comparisons (pwc). The number of pairwise comparison is calculated as follows (n^2-n)/2. Since seven main criteria are identified, a total of 21 first-level pwc were created [(7^2-7)/2 = 21]. Each of the seven main criteria has 3 sub-criteria equating to another 21 pwc. This means that the general AHP model has a total of 42 pairwise comparisons. The AHP style questions use the Saaty scale (9 – 1 – 9), and therefore would look like this example (see Figures 7.2a and 7.2b);


2nd Pairwise comparison:

If you had to select a brownfield to convert into a brightfield, what site selection criteria is more important to you (higher priority): **type of brownfield** or **site status**?

In other words, how much more important is one over the other?

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Type of brownfield	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Site Status

Figure 7.2a Example of AHP style question

Definition	**Value**
Equal importance	1
Moderate importance	3
Strong importance	5
Very strong importance	7
Extreme importance	9
Intermediate values	2,4,6,8

Figure 7.2b. Saaty Scale

During the interview, the DM is asked to 'answer' the questions by marking one of the circles on the scale. This is done for all 21 questions (pwc). Subsequently an AHP Matrix is populated with the results from the survey that will ultimately provide the weighted preferences upon which an informed decision can be made.

The entire AHP system requires the following steps:

1. Survey question
   a. Goal
   b. Site identification criteria
   c. Site identification sub-criteria (brownfield characteristics)
2. AHP matrix based on survey
3. Hierarchy matrix (or decision model)

The application of the AHP to the Toronto Port Lands case study follows these three steps.

7.4.3.1. Toronto Port Lands

Toronto is Canada's largest, most dense and built-up city with a rich industrial legacy. Thus, it provides an appropriate setting for the study of brownfield redevelopment. According to De Sousa (2002), the best brownfield estimate for the City of Toronto is from a study by Hemson (1998), which estimated that there are 865 acres in Toronto, although this is likely to be an underestimation. The Port Lands and the Waterfront have been the focus of several scientific inquiries with a focus on green enterprise (Desfor, 1990), ecological health (Evenson, 1997) or coastal assessments (Greenwood and McGillivray, 1978; McGillivray and Greenwood, 1978). The Toronto Port Lands (TPLs) were chosen because of the abundance of brownfields and variety of site typology and size (see Spiess, 2014). The TPLs are a largely abandoned industrial area located southeast of downtown Toronto with an expanse of around 988 acres (Hayek, 2012). Mostly created from reclaimed land, former marshes and sandbars, the area was once home to some of the city's largest manufacturers. Information about the sites such as their status (e.g. vacancy) is gathered via the TPLC, personal inquiries with owners, and Municipal Property Assessment Corporation (MPAC) databases. A total of 14 sites are managed by the TPLC and are part of the WT portfolio. No MPAC data (tax assessment data) were found for the two properties listed as 185 Cherry Street and 675 Commissioners Street. This analysis uses 12 properties whose MPAC designation is either 'derelict and vacant' or 'vacant with minor structures', and whose combined area totals 66 acres.

In a first step, site parameters such as size and land value et cetera are assessed for each vacant property in the Port Lands, using Geographic Information System (GIS), MPAC and site visits. This analysis focuses on ground-mounted fixed solar PV. The actual useable size is then used to calculate the maximum potential power capacity using *RETScreen* and *PVWatts* computations. The total size of a property is subtracted by the building footprint, legal setback requirements, shade and area for future auxiliary power and safety equipment and is calculated using Google Earth and GIS. *RETScreen* is also used to calculate GHG savings in tCO_2. *RETScreen* is a clean energy management software system for energy efficiency, renewable energy and cogeneration project feasibility analysis as well as ongoing energy performance analysis (http://www.retscreen.net). Every site is examined and site type (vacant open space, vacant abandoned building, etc.), and site location is determined together with power capacity. Proximity to transmission lines (Tx) is calculated in GIS using a perpendicular distance (m) from the site to the nearest Tx line. These site characteristics form the basis upon which each site (or alternative) will be judged (or ranked using scores). Please note that solar potential (irradiance) has been excluded from the analysis as well as population density since all sites are located in the same area. In actuality, an AHP model could be comprised of a lot more site characteristics and main identification criteria.

Figure 7.3. Aerial view of the Port Lands in 2012. (www.tplc.ca, 2016)

Figure 7.4. Collection of all 12 TPLC brownfields (aerial view). (www.tplc.ca, 2015).

Figure 7.5. Map of the Port Lands with all 12-study sites with addresses and potential maximum nameplate capacity. The blue line represents the Transmission line, to which the shortest distance to the sites is measured (without going over waterways).

7.5. **Results**

7.5.1. Survey on the Motivation for Brightfield Development

A total of 12 municipalities and 8 private brownfield owners (i.e. companies) were surveyed. The survey results suggests that municipalities consider developing a brightfield only marginally more compared to private companies, although municipalities seem to be considering the idea more seriously (see Table 7.1). By contrast the motivations for developing a brightfield seem somewhat divergent. While municipalities are chiefly concerned with redeveloping and reusing an otherwise underutilized piece of real estate asset, and creating green jobs, private brownfield owners admit that their prime objective is to have a greener image and to generate revenue either via the leasing of the land and/or the selling of power into the grid. Table 7.2 provides a summary regarding these motivations.

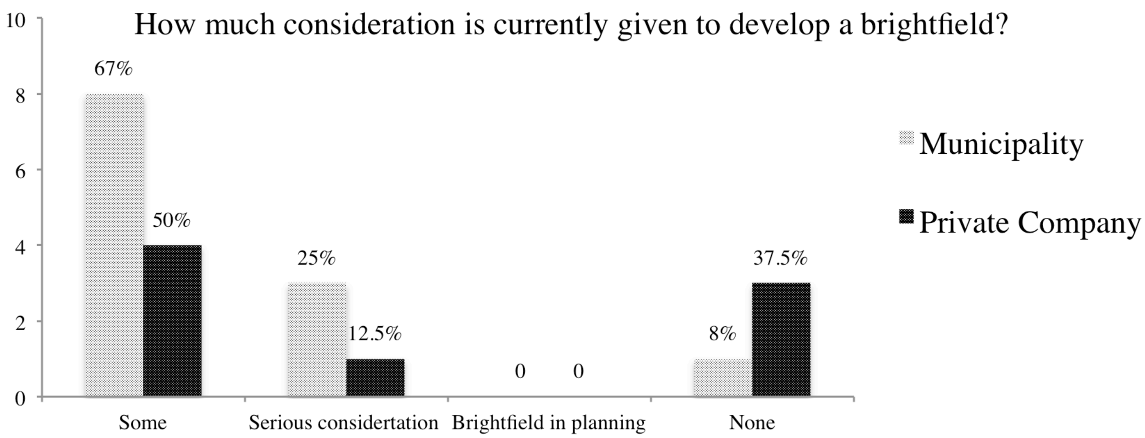


Table 7.1. This figure shows how much private companies and municipalities in Ontario consider developing a brightfield. Based on the survey most municipalities and half of the private owners have given some consideration, but none have implemented a brightfield or are planning to implement one.

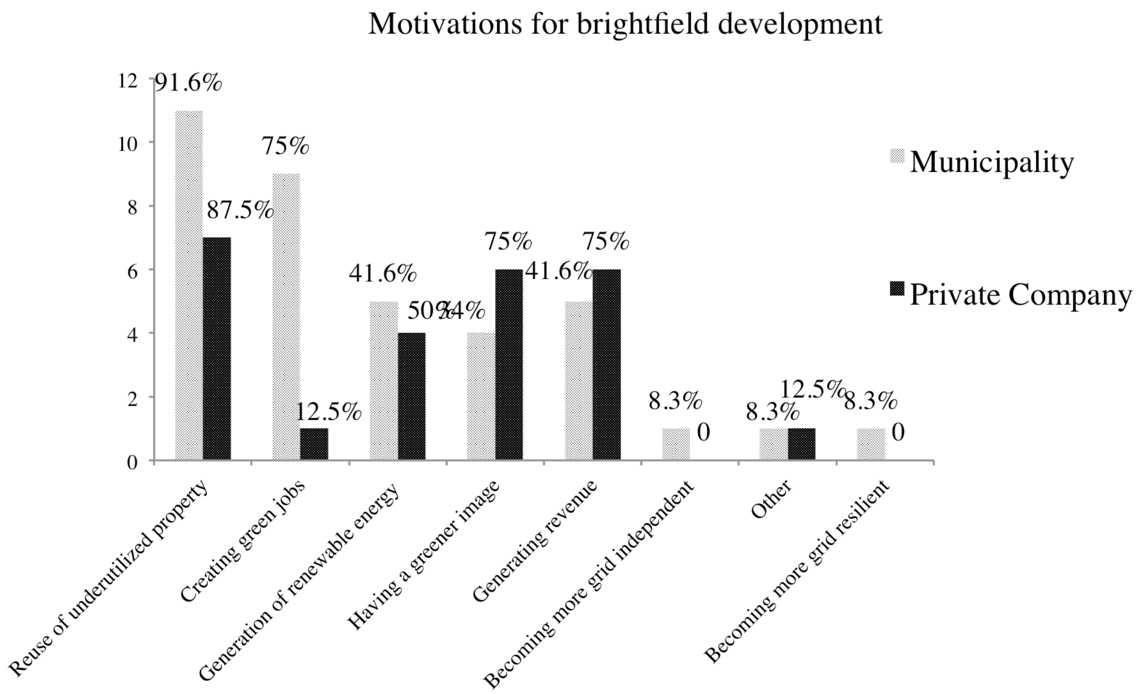


Table 7.2. Motivation for brightfield conversion. The reuse of a brownfield and the creation of green-tech jobs are the two main motivations for the surveyed municipalities. By contrast, private owners would like to see their image improved as well as for bottom-line considerations.

According to the survey, municipalities are motivated to redevelop a brownfield (!) for the following reasons; remediation, tax-base increase, neighbourhood revitalization and job creation (see Table 7.3).

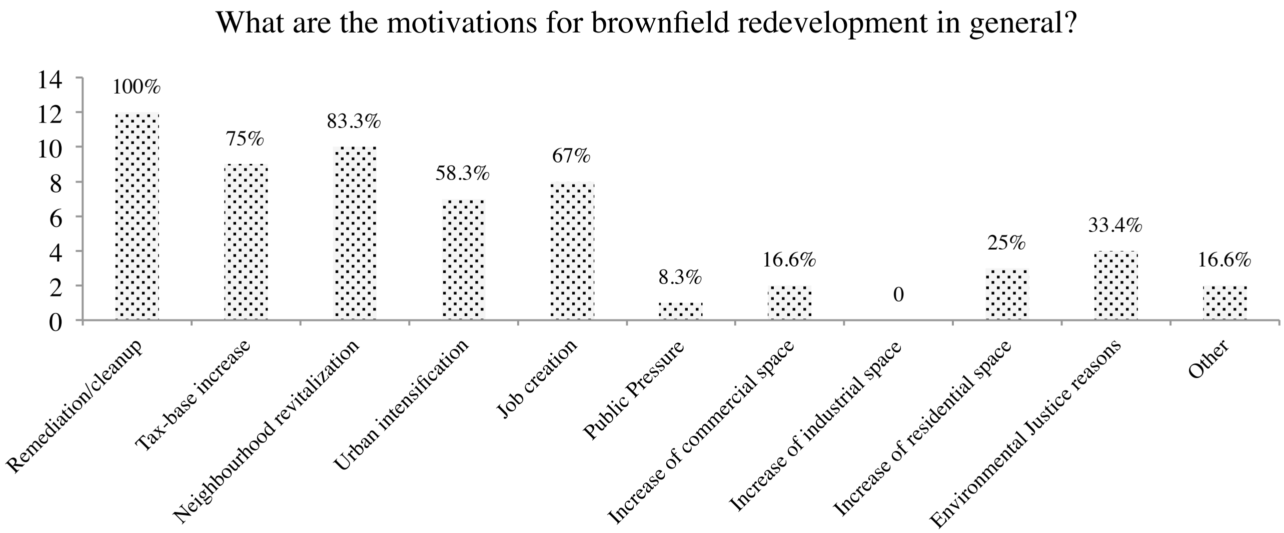


Table 7.3. Motivation for brownfield development for municipalities

Once a brightfield is (hypothetically) developed, both private companies and municipalities' favour keeping the land or leasing it, but would prefer not owning the renewable energy infrastructure themselves (see Table 7.4). Similarly, if they had to choose, both would prefer selling the power produced on the brightfield into the grid in lieu of using it 'in-house'/'on-site' or powering a so-called 'green remediation' process (see Table 7.5.).

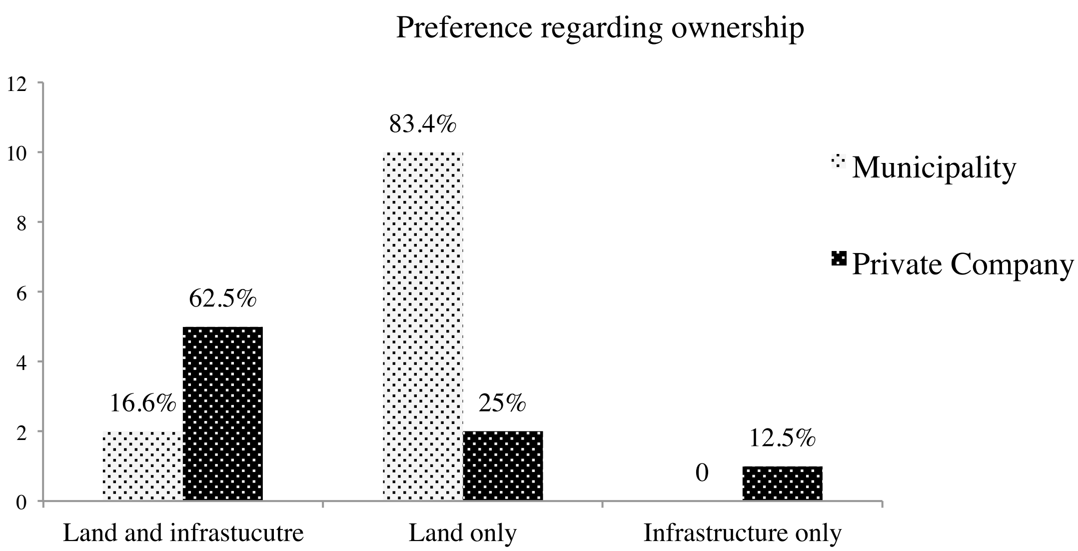


Table 7.4. Preference regarding ownership of land and/or infrastructure.

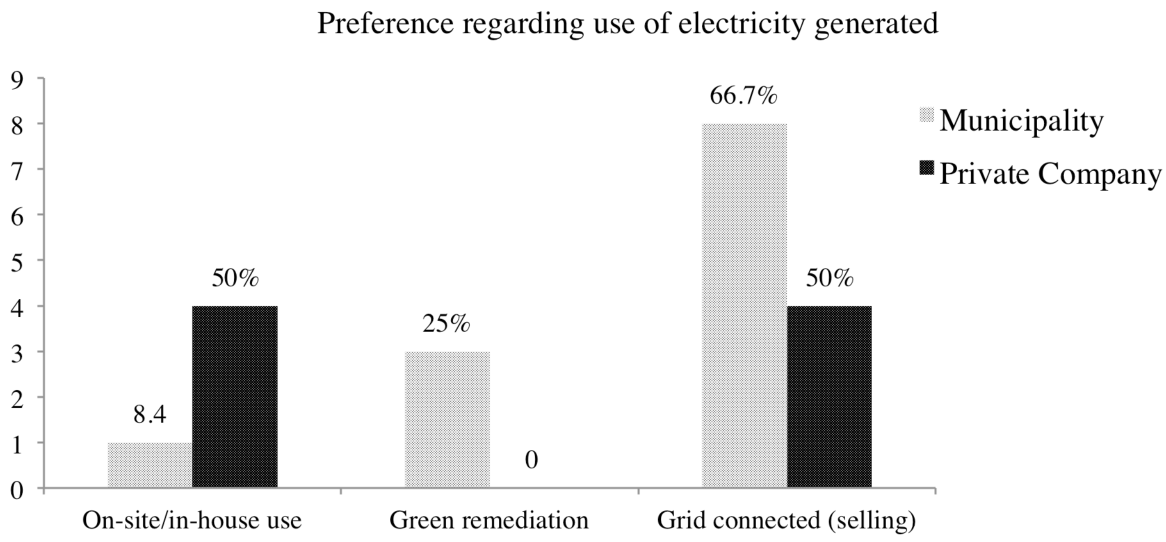


Table 7.5. Preference regarding use of electricity generated.

The following two tables (7.6 and 7.7) are the most pertinent ones, insofar as they capture the importance of the site identification criteria for the two groups of brownfield owners and directly link to the AHP style interview. By and large, the 'most important' criteria determined via this survey are later on used in the AHP model as well as the case study. While this is not an AHP model (no pairwise comparisons and no weights attributed), the survey questions are designed to determine the importance of a select number of site criteria by ranking them from "*No Importance - Extreme Importance*". This preference scale resembles the Saaty scale for that the results can be compared to the AHP case study.

According to the survey, brownfield size; land cost; and brownfield ownership are the three most important criteria for private companies when selecting a potential brightfield. By contrast, the location and type of a brownfield (future brightfield) seem to matter less. Similarly, population density (surrounding the brownfield) is less of a concern to private brownfield owners if they were to choose a site (see Table 7.6).

On the one hand, the survey suggests that site location, site status, and ownership are important decision-making factors for municipal brownfield owners. On the other hand, zoning and land costs are less of an issue if municipal brownfield owners had to select a site (see Table 7.7).

Preferences for Private Brownfield Owners

	No importance	Weak importance	Moderate importance	Strong importance	Very strong importance	Extreme importance
Site Type	1	**4 50%**	3	0	0	0
Site Location	0	**6 75%**	0	2	0	0
Site Zoning	0	**4 50%**	**4 50%**	0	0	0
Site Status	0	3	**4 50%**	1	0	0
Site Size (useable system size)	0	0	1	1	**4 50%**	2
Land value/cost	0	0	0	0	2	**6 75%**
Site Ownership	0	0	0	3	**5 ~63%**	0
Population density surrounding the site	3	**5 ~63 %**	0	0	0	0
Existing infrastructure (or proximity)	0	0	1	**7 ~88 %**	0	0
Type of current land use	1	**6 75%**	1	0	0	0

Table 7.6. Survey results for private company. Site size, land cost and site ownership are the most important criteria for private brownfield owners when selecting a potential brightfield property. Numbers indicate the number of private owners having selected a given importance scale for a given criteria.

Preferences for Municipal Brownfield Owners

	No importance	Weak importance	Moderate importance	Strong importance	Very strong importance	Extreme importance
Site Type	0		**8 ~67 %**	3	1	0
Site Location	0	1	0	3	1	**7 ~58%**
Site Zoning	1	**5 ~42%**	3	1	2	0
Site Status	0	1	2	3	**6 50%**	0
Site Size (useable system size)	0	1	3	**7 ~58 %**	1	0
Land value/cost	0	**6 50%**	3	2	1	0
Site Ownership	0	0	2	5	**5 ~42 %**	0
Population density surrounding the site	0	1	**7 ~58 %**	1	3	0
Existing infrastructure (or proximity)	0	1	3	**4 33%**	**4 33%**	0
Type of current land use	0	1	3	**5 ~42 %**	3	0

Table 7.7. Survey results for municipalities. Site location, status and ownership are the most important criteria for municipalities when selecting a potential brightfield property.

Please note that the following clarifications were provided to the survey participants, which are presented here; site type (open; open with topographic features; open with buildings less than 50%); site location (urban, rural, suburban); site zoning; site status (contaminated [low, medium, high), remediated, not contaminated, unknown); site size (total area as well as size of system); site ownership; population density surrounding the site; existing infrastructure (grid, roads, etc.)' type of current land use (how is the property used if at all?).

7.5.2. General AHP Model

The AHP site identification criteria used in creating this general AHP template are a hybrid between technical feasibility as well as non-technical considerations and is created based on EPA site criteria. Table 7.8 provides and overview of a list of possible AHP criteria and their sub-criteria (site characteristics).

Possible AHP criteria

Main criteria	**Sub-criteria (site characteristics)**
Brownfield Type	Vacant open land Vacant with topographical features; vacant with structures; vacant structure
Brownfield Location	Urban, rural, suburban, remote (e.g. Northern Community)
Brownfield Zoning	Industrial, commercial, residential, institutional
Brownfield Status	Contaminated, contaminated but sealed, not contaminated, remediated, unknown, on-going
Brownfield Area	Small, medium, large
Brownfield Power Output	Total potential power output considering solar radiance and shading and of course size; small, medium, large
Brownfield Cost/Value	Total value of land; low, medium, high
Proximity to Road	Distance to nearest paved road; close, medium, far
Proximity to Grid	Distance to nearest grid (Tx); close, medium, far
Proximity to Water	Distance to nearest access to water; close, medium, far
Proximity to residential area	Distance to nearest residential zoning; close, medium, far
Development pressure	Value of surrounding properties; going up, stable, going down
Available Lease (yrs)	Short, medium, long-term
Current Ownership	One owner, part owner municipal or private, co-op
Renewable energy technology	Solar PV, Wind, Geothermal
Public opinion	Favourable towards renewables, unknown, opposition
Legal situation	Cleanup required, not required, unknown.

Table 7.8. List of main criteria for general AHP as well as sub-criteria (site characteristics).

Rather than applying these criteria in an exclusion site selection process à la EPA (although the EPA process only includes a handful of technical ones), these 17 main site identification criteria are fed into an AHP model. However because the number of pairwise comparisons is given as; $(n^2-n)/2$, it follows that 17 criteria require 136 pwc (questions) and between 51 to 88 pwc for the sub-criteria for a total of 187 to 224 pwc or questions. Because the margin of error would be too great for someone unfamiliar with AHP, the above criteria can be clustered together in order to reduce the number of pairwise comparisons. Figure 7.6 is an example of how this can be achieved. Depending on the local situation one can choose to include as many or as little (as well as different) criteria and sub-criteria than the ones suggested in table 7.8 (or grouped in Figure 7.6)

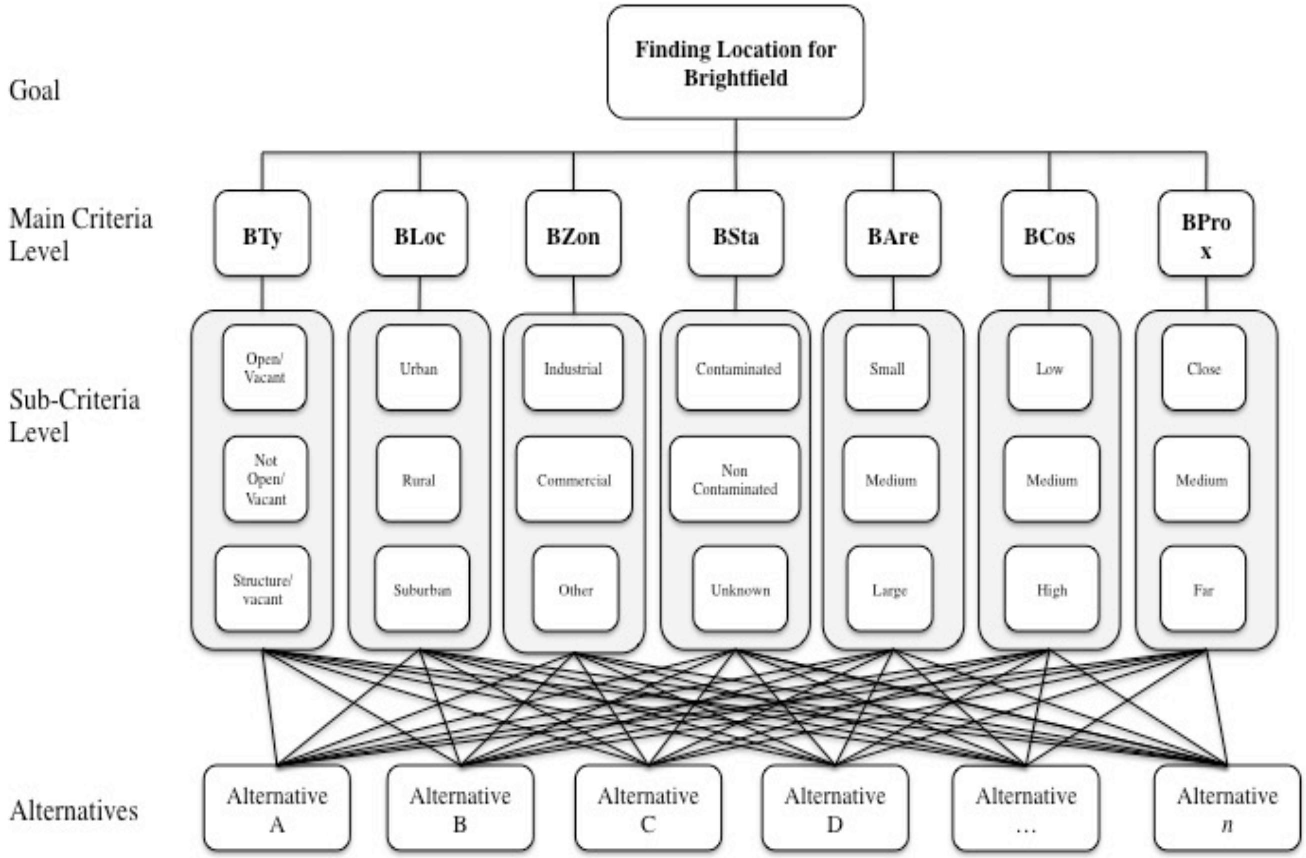


Figure 7.6. General brightfield AHP model. BTy = Type // BLoc = Location // BZon = Zoning // BSta = Status // BAre = Area (size) // BCos = Land cost (value) // BProx = Proximity to Tx.

7.5.3. AHP Case Study

While the above AHP model maybe applied more broadly and may serve as a template for future work, for the purpose of this study, an AHP survey is customized for the Toronto Port Lands case study. Compared to the above template (Figure 7.11). '*Location*' and '*Zoning*' are substituted with property '*Ownership*' and '*Capacity*' (potential installed nameplate capacity). This is done because all 12 brownfields or alternatives are located within the same neighbourhood and are all located in industrial zones. Compared to the survey sent to the municipal and private brownfield owners, '*Location*' and '*Zoning*' as well as '*Population Density*' are removed. Again, this is done because they are equal for all 12 brownfield properties.

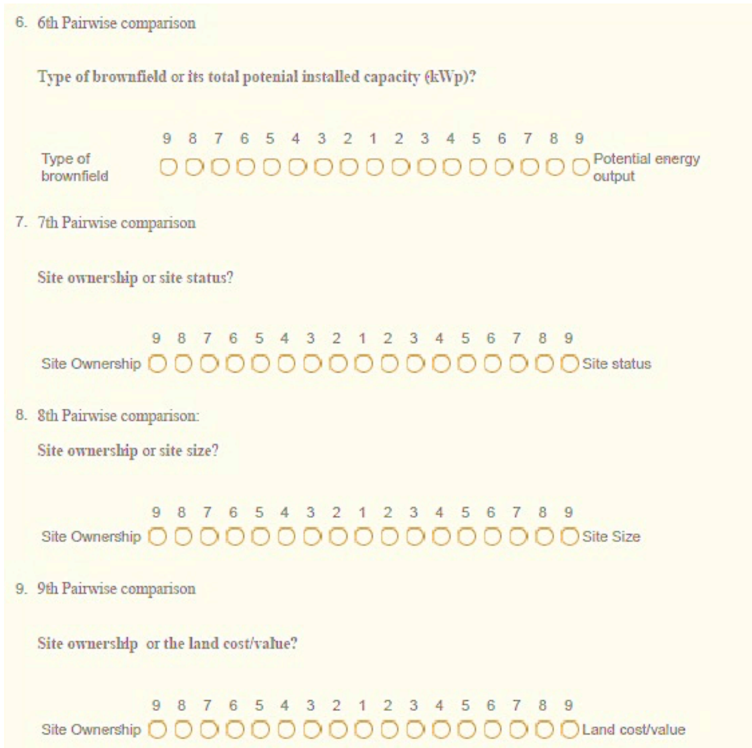


Figure 7.7. Example of pairwise comparisons; '*Ownership'* versus '*Site Status'*; '*Ownership'* vs. '*Site Size'*; and '*Ownership'* vs. '*Land Cost/Value'*.

As mentioned in the methodology section of this chapter, the AHP interview contains 21 pwc for the main site identification criteria and 21 for the sub-criteria (site characteristics). The answers on the Saaty scale are then put in an excel matrix (see Figure 7.8.) and the *Eigenvectors* are calculated. The averaged sum of the *Eigenvectors* for each criterion (x 100) gives us the weights for each criterion. In the case of the TPLC this looks as follows:

- *Brownfield Type* ~ 4.36 %
- *Ownership* ~ 6.45 %
- *Contamination Status* ~ 10.36 %
- *Size* ~ 3.75 %
- ***Land Cost*** **~ 22.34 %**
- ***Proximity*** **~ 21.19 %**
- ***Potential Capacity*** **~ 31.51%**

This means that '*Potential Capacity*', '*Land Cost*' and '*Proximity*' (to Tx) are the three most important criteria. The following two figures illustrate this computational iterative process. All calculations were performed in Excel.

AHP Model for Main Criteria WT

	Brownfield Type	Ownership	Cont. Status	Size	Land Cost	Proximity Tx	Capacity
Brownfield Type	1	0.2	0.333	0.25	0.125	0.167	0.125
Ownership	5	1	3	2	0.125	0.333	3
Cont. Status	3	0.333	1	0.25	0.143	0.167	0.25
Size	4	0.5	4	1	0.143	0.333	0.333
Land Cost	8	8	7	7	1	5	4
Proximity Tx	6	3	6	3	0.2	1	2
Capacity	8	0.333	4	3	0.25	0.5	1
Sum	**35**	**13.3666667**	**25.3333333**	**16.5**	**1.98571429**	**7.5**	**10.70833333**

Eigenvector

	Brownfield Type	Ownership	Cont. Status	Size	Land Cost	Proximity Tx	Capacity	Sum	Average	Wt	mmult
Brownfield Type	0.0286	0.0150	0.0132	0.0152	0.0629	0.0222	0.0117	0.1687	0.0241	2.4098	7.4757
Ownership	0.1429	0.0748	0.1184	0.1212	0.0629	0.0444	0.2802	0.8449	0.1207	12.0693	8.2917
Cont. Status	0.0857	0.0249	0.0395	0.0152	0.0719	0.0222	0.0233	0.2828	0.0404	4.0398	7.3000
Size	0.1143	0.0374	0.1579	0.0606	0.0719	0.0444	0.0311	0.5177	0.0740	7.3958	7.5132
Land Cost	0.2286	0.5985	0.2763	0.4242	0.5036	0.6667	0.3735	3.0714	0.4388	43.8777	8.6203
Proximity Tx	0.1714	0.2244	0.2368	0.1818	0.1007	0.1333	0.1868	1.2354	0.1765	17.6479	8.4223
Capacity	0.2286	0.0249	0.1579	0.1818	0.1259	0.0667	0.0934	0.8792	0.1256	12.5596	7.4844

100	55.107764	7.87254
	lamda max	7.87254
	RI	1.32
	CI	0.14542
	CR	**0.11017**

Brownfield Type	Ownership	Cont. Status	Size	Land Cost	Proximity Tx	Capacity
2.41	12.07	4.04	7.40	43.88	17.65	12.56

Figure 7.8. Example of the AHP matrix for Waterfront Toronto. The eigenvector matrix below is used to attribute the weights for the main criteria and compute the Consistency Ratio using the 'mmult' function.

AHP Matrix for Sub-Criteria Site Status

	Highly Cont.	Medium Cont.	Low Cont.
Highly Cont.	1	0.166666667	0.125
Medium Cont.	6	1	0.333333333
Low Cont.	8	3	1
Sum	15	4.166666667	1.458333333

Eigenvector Matrix

	Highly Cont.	Medium Cont.	Low Cont.	Sum	Average	Wt	mmult
Highly Cont.	0.066666667	0.04	0.085714286	0.19238095	0.06412698	6.41269841	3.01237624
Medium Cont.	0.4	0.24	0.228571429	0.86857143	0.28952381	28.952381	3.07309942
Low Cont.	0.533333333	0.72	0.685714286	1.93904762	0.64634921	64.6349206	3.13752456

100		9.22300021
	lamda max	3.0743334
	RI	0.58
	CI	0.0371667
	CR	**0.06408052**

Highly Cont.	Medium Cont.	Low Cont.
6.412698413	28.95238095	64.63492063

Figure 7.9. This figure shows the same kind of matrix as in figure 7.8, but for the sub-criteria

Figure 7.9 shows the matrix for the sub-criteria '*Site Status*'. By combining the main criteria matrix and the various sub-criteria matrices, one can build the final matrix with the weighted scores for the main criteria (Wt), the weighted scores for the sub-criteria (wt) and the normalized scores

(Wt/wt). Please note that sum Wt equals to 100 (%); the sum wt for each criteria category = 100 (%); and sum for all normalized scores across the entire matrix is also 100. The table below (Table 6.4) shows the finished weights for the main criteria as well as the normalized weights for the sub-criteria that are used to derive the ideal brownfield characteristics based on the DM.

Main Criteria	**Brownfield Type**	**Ownership**	**Cont. Status**	**Size**	**Land Cost**	**Proximity to Tx**	**Capacity**
Wt	4.37	6.45	10.37	3.75	22.35	21.20	31.52
Sub-Criteria	Open	Crown	Highly Cont.	Small	Low	Close	Small cap.
Sub-criteria Wt	73.91	32.78	6.41	9.05	69.05	69.05	49.05
Overall Wt	**3.23**	**2.11**	**0.66**	**0.34**	**15.43**	**14.64**	**15.46**
	Top. Feat.	Municipal	Medium Cont.	Medium	Medium	Medium	Medium cap.
	19.16	26.11	28.95	70.30	25.07	25.07	31.19
	0.84	**1.68**	**3.00**	**2.64**	**5.60**	**5.32**	**9.83**
	Build.	Private	Low Cont.	Large	High	Far	Large cap.
	6.94	41.11	64.63	20.66	5.88	5.88	19.76
	0.30	**2.65**	**6.70**	**0.78**	**1.31**	**1.25**	**6.23**

Table 7.9. This is the final table with weights (%) and normalized scores for all sub-criteria. This is also called the Hierarchy matrix or the Decision Model. This matrix is for TPLC.

The final matrix reveals that '*Land Cost*', '*Proximity'* and '*Capacity'* are the three most critical identification criteria. The emphasis on '*Land Cost*' and '*Capacity'* seems to be similar to the survey results for private brownfield owners. Based on the AHP and the attributed weights to both the criteria and sub-criteria, the TPLC would prefer (ideally) the following brownfield attributes;

Highest Score **60.74**	Lowest Score **11.78**	Medium Score **27.48**
Open (3.23)	With Build. (0.30)	Top. Features (0.84)
Private (2.65)	Municipal (1.68)	Crown (2.11)
Low Cont. (6.7)	Highly Cont. (0.66)	Medium Cont. (3.00)
Medium Size (2.64)	Small Size (0.34)	Large Size (0.78)
Low Cost (15.43)	High Cost (1.31)	Medium Cost (5.60)
Close (14.64)	Far (1.25)	Medium Prox. (5.32)
Small Capacity (15.46)	Large Capacity (6.23)	Medium Capacity (9.83)

Table 7.10. This figure represents the best, lowest and medium score for TPLC

Table 7.10 represents the highest, lowest and medium scores. It is surprising to see that the TPLC DM prefers a medium sized site to a larger site and a small capacity over a large capacity. The medium score represents the medium regarding cost, contamination, proximity and capacity, as well a large property with topographic features, sitting on crown land. These sub-criteria or brownfield characteristics are not as preferred as the ones in the highest score box, but still preferable over the ones in the lowest score box. In summary, table 7.10 is part of the decision model or the hierarchy matrix, as they provide answers to the question what brownfield characteristics are most and least important to the DM. Based on the Hierarchy matrix (Table 7.9) the alternatives can be evaluated. Each alternative receives a score in each of the seven categories. The cumulative score provides the final ranking of all alternatives (i.e. brownfields). Therefore, all alternatives will receive a score between 11.78 (lowest possible score) and 60.74 (highest possible score) for the TPLC and between 12.65 and 64.31 for the WT (see Appendix A). The alternative with the highest score is the brownfield that is best suited to become a brightfield (hypothetically) based on the DMs preferences.

In order to calculate the Consistency Index (CI), each column of the pair wise comparison matrix must be multiplied with the corresponding normalized vector, before the sum of the row entries are divided by the corresponding weight and the average of these values is computed:

$$a_{ij} = \sum_{k=1}^{n} b_{ik} c_{kj}$$

In Excel, this can be done with via the 'MMULT(array1, array2)' function;

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \end{bmatrix} \qquad B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \\ b_{31} & b_{32} \end{bmatrix}$$

The average of the MMULT gives us λ max.

CI = (λ max – n)/ (n-1)….or…. [λ max –7/6] for the 7 main criteria and [λ max –3/2] for the groups of 3 sub-criteria.

The Random Index (RI) is a constant and given as:

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.46	1.49

The Consistency Ratio (CR) is given as; CI/RI

The cumulative (main criteria and all sub-criteria) CR for the AHP TPLC is 0.094, which is acceptable as it is below the 0.10 threshold suggested by Saaty.

Based on the above results, the TPLC DM would ideally choose a brownfield that is (a) open, (b) private, (c) low contamination, (d) medium sized, (e) low cost, (f) close to Tx lines and that could have a small renewable energy capacity (g). The following paragraphs explore which brownfield properties or alternatives then would best suit the criteria set by the DM. In order to do that it is important to firstly determine the characteristics of these alternatives as accurately as possible regarding the seven sub-criteria. Secondly, because the AHP interview used language such as 'small', 'medium' and 'high', it is essential to determine delineations in order to categorize site characteristics into small, medium, large (etc.) categories. Only then can one subject these alternatives to the hierarchy matrix or decision model, determine the final score for all 12 alternatives and rank their overall suitability accordingly. Finally, it is crucial to compare the outcome of the decision model to a base case or a scenario in which a decision would be based solely on financial viability (i.e. cost/benefit). Therefore, the 12 sites will be ranked based on the total cost (land cost + system cost) and plotted against their benefit, in this case nameplate capacity, to simulate an EPA style approach.

All 12 sites are assessed according to the methods outlined in the methodology section of this chapter. The results, including the cost analysis are summarized in table 7.11 while table 7.12 contains the AHP pertinent data.

Site ID	Address	Assessed tax value 2014	Useable area (m2)	Nameplate (kWp)	Cost (without BOS)	Net annual GHG reduction (tCO2)	Pre-tax IRR equity (%)
A	284 Unwin Avenue	1412750	4249.20	150	3885000	94.5	28.6
B	185 Villiers Street	6133250	21189.34	748	18795000	411.1	26.8
C	673 Lakeshore Boulevard	737250	1980.13	70	1785000	34.4	28.5
D	625 Lakeshore Boulevard	2246500	6725.06	238.6	6054300	113.4	16.5
E	294/320 Unwin Avenue	5967000	16622.87	586.7	15267000	336.8	23.7
F	450 Commissioners	288901	195.46	7	178500	4.3	27.8
G	480 Unwin Avenue	2551000	5232.18	184	4788000	116.5	28.6
H	242/252 Unwin Avenue	1084500	9521.04	335.8	8619450	209.7	28.6
I	230 Unwin Avenue	1352500	4852.58	171.5	4410000	107.3	28.6
J	55 Unwin Avenue	8777500	32860.47	1158.6	29925000	560.4	16.6
K	95 Commissioners	3497000	2776.19	97.5	2467500	46.2	16.5
L	242 Cherry Street	21139500	50443.66	1785.8	46200000	1238.8	28.6

Table 7.11. This table shows the 12 currently vacant brownfield sites managed by the TPLC without a specific ranking (alphabetical only).

In order to apply the decision model, the properties must be categorized based on the seven site characteristics. Table 7.12 provides a visual representation of this categorization. Land Cost is categorized from low–medium–high; Size and capacity from small–medium–large, whereas proximity to Tx is measured as close–medium–far. Contamination status was provided by the TPLC. The categorization is done using the 'sort-function' in *Excel*. Proximity to the Tx line is an important factor, given the average cost of up to $400 per meter (IEA, 2015)[71].

[71] http://iea-etsap.org/web/Highlights%20PDF/E12_el-t&d_KV_Apr2014_GSOK%201.pdf, retrieved July 28th, 2015

Table 7.12. Representation of site characteristics and their categorization (small, medium, large, etc.).

Site ID	Cont. Status	Land Cost ($)		Size (m^2)		Capacity (kWp)		Ownership	Type	Proximity to Tx (m)	
A	High	1412750	Medium	4249.20	Medium	150	Small	Private	Minor temporary features	636.39	Medium
B	High	6133250	High	21189.34	Large	748	Medium	Municipal	Open (empty)	106	Close
C	High	737250	Low	1980.13	Small	70	Small	Municipal	Open (empty)	134.13	Close
D	High	2246500	Medium	6725.06	Medium	238.6	Small	Municipal	Open (empty)	37.47	Close
E	Medium	5967000	High	16622.87	Large	586.7	Medium	Municipal	Minor temporary features	495.78	Medium
F	Medium	288901	Low	195.46	Small	7	Small	Municipal	Minor temporary structures	526.88	Medium
G	Medium	2551000	Medium	5232.18	Medium	184	Small	Municipal	Open (empty)	604.23	Medium
H	Medium	1084500	Low	9521.04	Medium	335.8	Medium	Municipal	Minor temporary features	738.98	Far
I	Medium	1352500	Medium	4852.58	Medium	171.5	Small	Municipal	Open (empty)	891.34	Far
J	High	8777500	High	32860.47	Large	1158.6	Large	Private	Open (empty)	953.35	Far
K	Low	3497000	Medium	2776.19	Small	97.5	Small	Municipal	Building (abandoned Warehouse)	285.57	Close
L	Medium	21139500	High	50443.66	Large	1785.8	Large	Private	Mixed; Open and Building (abandoned Warehouse)	792	Far

Site ID	Contamination Status	Land Cost	Size	Capacity	Ownership	Type	Proximity		Sum	Sum	Rank	Site
					Normalized Wt (Score)							
A	0.66	5.6	2.64	15.46	2.65	0.84	5.32	➔	33.17	51.44	*1*	C
B	0.66	1.31	0.78	9.83	1.68	3.23	14.64	➔	32.13	44.72	*2*	K
C	0.66	15.43	0.34	15.46	1.68	3.23	14.64	➔	51.44	43.91	*3*	D
D	0.66	5.6	2.64	15.46	1.68	3.23	14.64	➔	43.91	42.07	4	F
E	3	1.31	0.78	9.83	1.68	0.84	5.32	➔	22.76	36.93	5	G
F	3	15.43	0.34	15.46	1.68	0.3	5.32	➔	42.07	34.67	6	H
G	3	5.6	2.64	15.46	1.68	3.23	5.32	➔	36.93	33.17	7	A
H	3	15.43	2.64	9.83	1.68	0.84	1.25	➔	34.67	32.86	8	I
I	3	5.6	2.64	15.46	1.68	3.23	1.25	➔	32.86	32.13	9	B
J	0.66	1.31	0.78	6.23	2.65	3.23	1.25	➔	16.11	22.76	10	E
K	6.7	5.6	0.34	15.46	1.68	0.3	14.64	➔	44.72	16.11	11	J
L	3	1.31	0.78	6.23	2.65	0.3	1.25	➔	15.52	15.52	12	L

Table 7.13. Final scores, sum of scores and ranking of sites.

Table 6 represents the values that correspond to the each site characteristic of the 12 brownfields. It is essentially the combining of tables 4 and 5. For instance property A is highly contaminated, which according to the TPLC DM corresponds to a score (wt) of 0.66. The 7 scores are added and the sum is subsequently used to rank the 12 properties. The property with the highest score is the one that fulfils the most criteria for either decision-maker. Properties 'C,' 'K' and 'D' score the highest. Site 'C' or 673 Lakeshore Boulevard scores a total of 51.44 while property 'L' (or 242 Cherry Street) scores the lowest with 15.52.

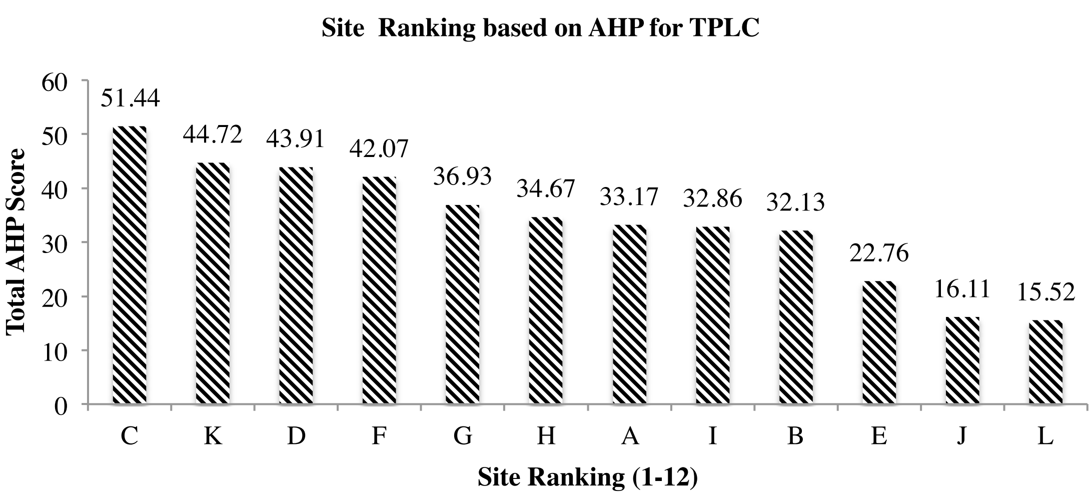


Table 7.14. Ranking of sites for TPLC.

Table 7.14 represents the site ranking for the TPLC. It shows that Site C is the preferred property, while Site L is the least preferred one. Toronto Waterfront undergoes the same analytical procedure. Table 7.15 shows the ranking of sites following the same AHP process as above, with 'C' scoring 55.54, 'F' 44.41 and 'H" 42.40. 'E' has the lowest score with 18.07. It becomes clear that there are differences, which will be addressed below. However, both render the same 'winner'; cite 'C' or 673 Lakeshore Boulevard.

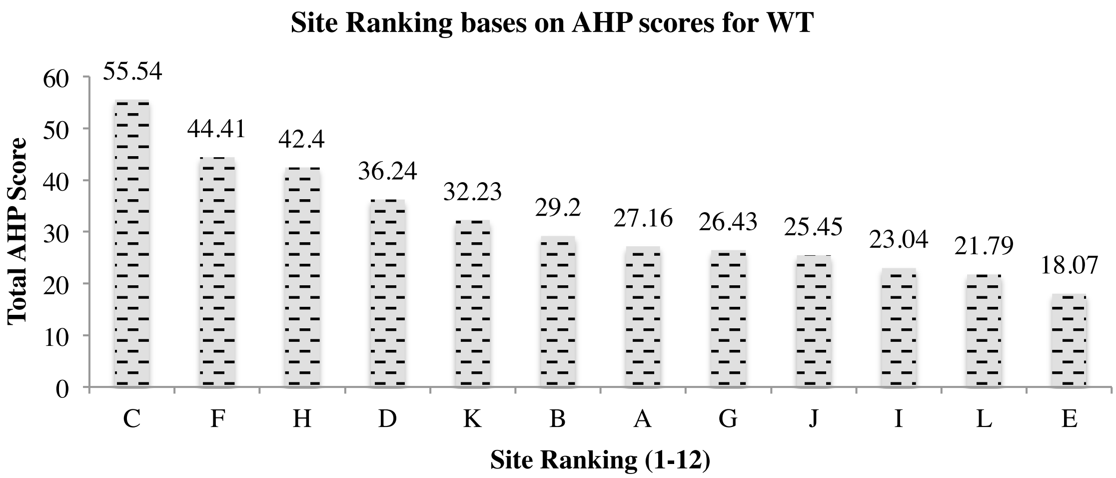


Table 7.15. Ranking of sites for Waterfront Toronto

While the two matrix evaluations result in different rankings, both list site 'C' as their preferred site overall. The two are relatively equal in their allocation of weights. The overall scores are subjected to a t-test (t = 1.6279) with a p-value equal to 0.1318. By conventional criteria, this difference is considered to be not statistically significant. The standard error of difference is 1.322. In actuality the two are relatively congruent as the average 'places off' in the ranking is 1.83 (see Appendix A). A significant difference in site evaluation is regarding property 'K'; the WT evaluation has site 'H' at 5th place, compared to 2nd place in the TPLC assessment with a total score difference of ~ 12.5 points. The average difference in site score is 6.99. The sensitivity analysis shows that WT "values" low land cost (which site 'H' has) approximately double (30.3 compared to TPLC's 15.43), making site 'H' the third best overall site in the eyes of Waterfront Toronto's CEO.

Using the geometric mean (GM) one can combine the two AHP matrices in order to expand the individual AHP into a group decision-making AHP (Srdjevic, Kolarov and Srdjevic, 2007). The GM is used between the normalized (final) scores, not the sum of scores and TPLC (α_1) and WT (α_2) are treated as equals: $\alpha_1 = \alpha_2 = 1/2$ (or $\alpha_1 + \alpha_2 = 1$).

The geometric mean is a ratio, given as follows (Forman and Peniwati, 1998):

$$\text{geometric mean} = \left(\prod_{n=1}^{k} x_n \right)^{\frac{1}{k}}$$

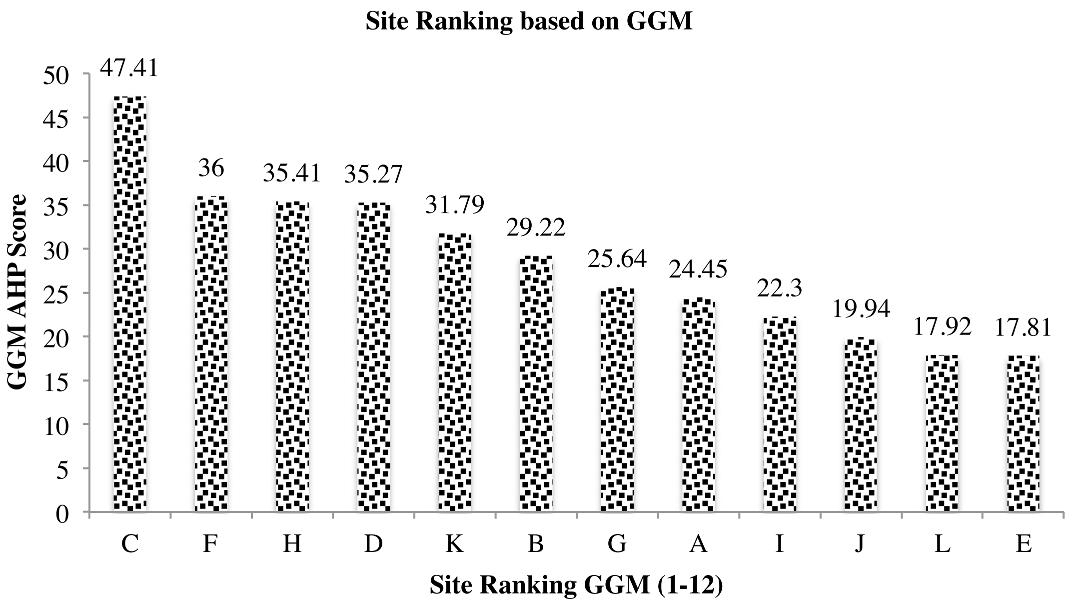


Table 7.16. Ranking of sites using the GM method

Interestingly, the final ranking of the geometric mean method is almost exactly congruent with the WT evaluation except places 7 and 8 and 9 and 10 are inverted. This may be due to WT's better overall CR of 0.069 compared to TPLC's 0.094. Further, the weights for the main criteria for the WT AHP is 1.1 points closer to the GM, or is other words, the TPLC is farther away from the geometric mean than WT (see appendix).

A sensitivity analysis was performed which showed that an increase of 10 % of the weighted scores (main criteria) of TPLC relative to the (unchanged) main criteria weights of WT is needed to make a difference in the GM method results. The only difference that can be detected is when TPLC (α_1) and WT (α_2) are not combined using the GM [$\alpha_1 = \alpha_2 = 1/2$], but a 1/3 to 2/3 ratio between the two [$\alpha_1 = 1/3$, $\alpha_2 = 2/3$]. This means that either TPLC or WT is 2/3 more 'important' compared to the other (1/3).

Because the GGM seems to be closer to the WT scores than the TPLC scores, the average [(wt TPLC + wt WT)/2] was calculated as well. The ranking of all 12 properties using the average is illustrated in table 7.16, showing a more ‘equal’ ranking between WT and TPLC. However the GGM is closer to the objective of the Saaty scale (Srdjevic, Kolarov and Srdjevic, 2007).

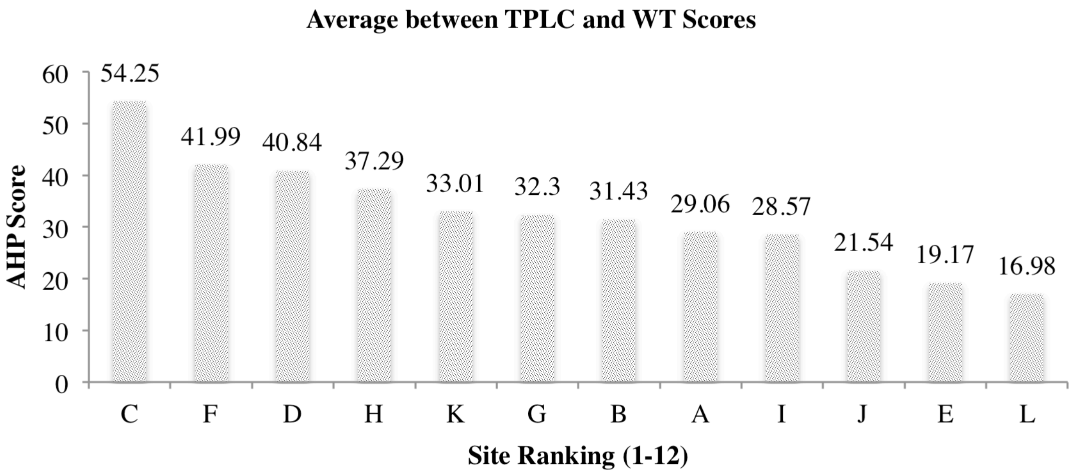


Table 7.17. Average between TPLC and WT scores (not GGM!)

Table 5 illustrates that 5 out of 12 (40 %) assessed brownfields are highly contaminated according to the TPLC, whereas 6 (or half) have a contamination categorized by the TPLC as medium. Only 1 brownfield (property ‘K’) has a low contamination status. Further, the largest brownfields are also the most expensive ones (more in Figure 2). Property ‘L’ is by far the most expensive one worth over $21 million according to MPAC assessment data. The 12 properties have a combined estimated value of over $55 million. Property ‘C’ is with just over $700’000 the second least expensive brownfield. The majority of properties are municipally owned (city of Toronto) and only three properties are owned by private landowners (although managed by the TPLC and WT). Similarly, the majority of brownfields are open space properties and have no or very minor temporary structures on them. The cumulative total area of 156648.18 m^2 (~39 acres) could theoretically host a total of 5.3 MWp of solar PV. This is corresponds to enough electricity to provide power around 700 households per year. If the total area of around 39 acres were not so fragmented, but one continuous property, this number would be significantly higher due to the economy of scale.

7.5.3.1. Comparison to Cost Benefit Analysis

Crucially, it is imperative to compare the AHP results to a more traditional site selection approach. Since technical feasibility and solar irradiance are treated as being equal across all sites, the traditional site identification could come down to a simple cost/benefit analysis (CBA). De Sousa (2002) uses a CBA for his study comparing the environmental, social, and economic costs and benefits of brownfield versus greenfield use. For the purpose of this case study, the simple CBA is defined as total cost over power output (provided that $/kW/h is equal for all sites and not dependent on quantity). Total cost = land cost + system cost. Both system cost (without Balance of System) and power output was computed using *RETScreen*. Land costs are derived from MPAC. The side-by-side evaluation of the two approaches is important as it allows for a comparison of the outcomes and where they align and where they diverge. This CBA is closer in nature to the RE-Powering America's Land Initiative and NREL approach and offers as such a comparison to their site selection tool largely based on the financial viability.

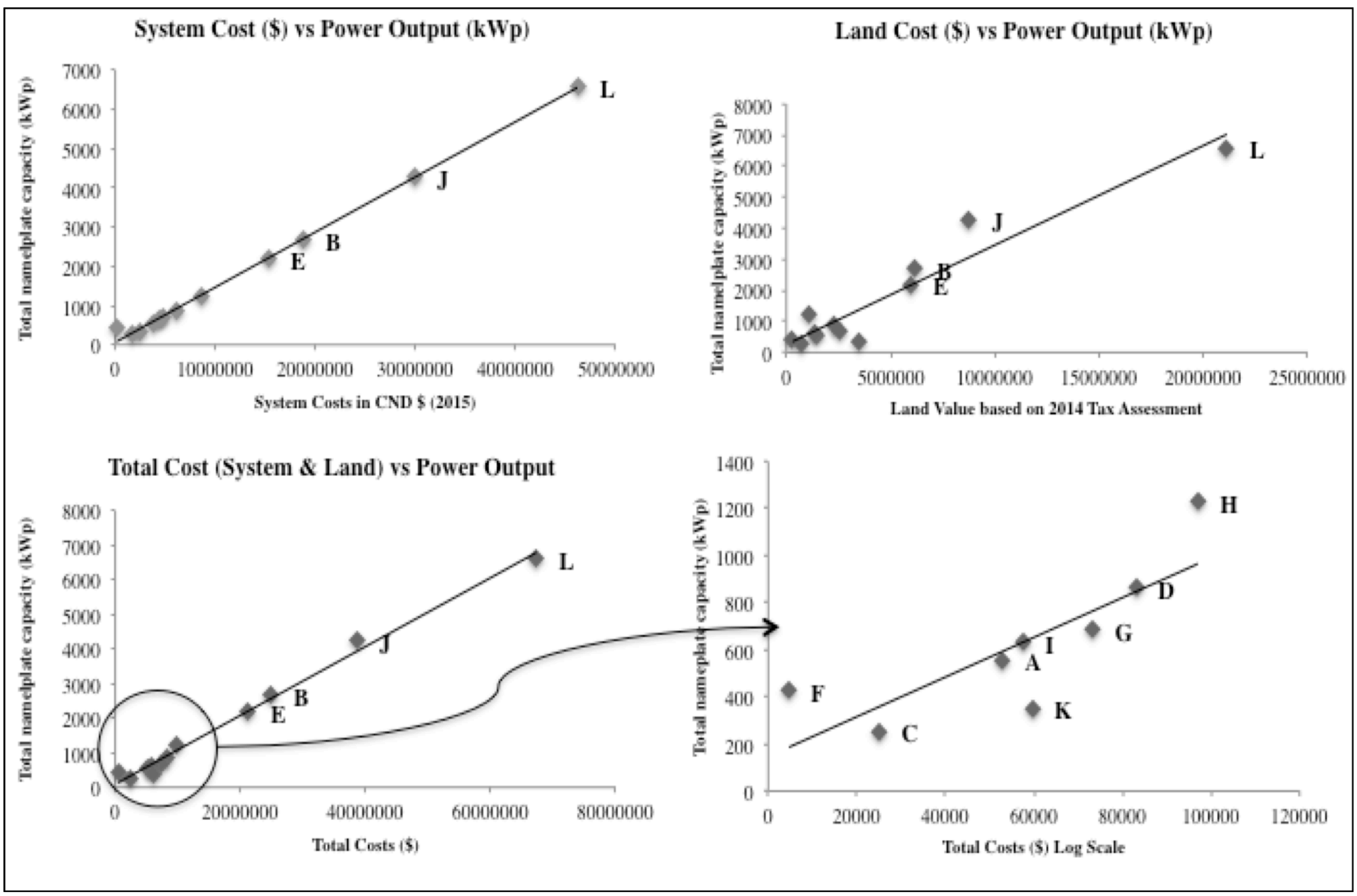


Figure 7.10. Cost/Benefit analysis for the 12 TPLC brownfields.

The first graph (top left) in Figure 7.10 represents the system cost compared to the power output. As expected this is a linear relationship. The second graph (Top right) shows the relation between land cost and power output. This is largely also a linear relationship since bigger properties and generally more and can host a larger system size. However, one can see that certain properties (F, B, J and H) are above the line. This means that they are cheaper relative to their size. The third graph (Bottom left) shows the combined costs of land value and system costs in relation to power output. Properties F and H are clearly above the line, while J is only just above it. The fourth graph (Bottom right) is a magnification of the cluster of smaller and small capacity sites. R^2 for Total cost vs. Power Output is: 0.98996.

The cost (land value) of the property by and large correlates to the size of a property. The size of a property also normally correlates to the system size, which influences the system cost. This relationship is illustrated by the first graph (top left) in figure 7.10. Thus, the best C/B ratio is a cheap yet large property. Based solely on the cost/benefit analysis, property F, H and J have the highest nameplate capacity relative to total costs as they are above the cost/benefit line.

Site ID	Address	Assessed tax value 2014	Useable area (m2)	Nameplate (kWp)	Cost (without BOS)	Net annual GHG reduction (tCO2)	Pre-tax IRR equity (%)
F	450 Commissioners	288,901	195.46	425.5	178,500	4.3	27.8
H	242/252 Unwin Avenue	1,084,500	9,521.04	1,231.35	8,619,450	209.7	28.6
J	55 Unwin Avenue	8,777,500	32,860.47	4275	29,925,000	560.4	16.6

Table 7.18. The three best sites based on simple C/B analysis

Comparing the base case to the AHP method (e.g. GGM) is interesting for two reasons (see Table 7.17). One, 2 of the three top-3 sites are the same, that is, ‘F’ and ‘H’. By contrast, while the simple cost/benefit analysis has site ‘F’ as the number one site, the AHP method shows site ‘C’ as the winner on both occasions. This is because ‘C’ scores a lot of points with its *Capacity* and *Proximity*, whereas ‘J’ (although marginally over the C/B line) has low AHP scores in particular due to the site’s far distance to the Transmission lines, its size (medium scores the highest) and its private current ownership. In fact ‘J’ ranks 3rd- and 2nd-last, respectively in the AHP method. This shows that the two DM did not simply choose the best value properties.

7.6. **Discussion**

The results from the survey indicate that different types of brownfield owners may have different priorities. While this may seem trite, this distinction is not well captured by existing site identification methods (e.g. EPA) as they simply assume that all brownfield owners are equal. The reuse of a brownfield and the creation of green-tech jobs are the two main motivations for the surveyed municipalities. By contrast, private owners would like to see their image improved, as well as care for bottom-line considerations. Similar to what can be observed in the RE-Powering America's Land Initiative, both municipal and private potential brightfield owners prefer to see the electricity generated being fed into the grid. Furthermore, there are differences regarding the site criteria. Private owners think that ownership, land cost and size are the three most important criteria, whereas municipal owners pay more attention to site location, status and ownership. This discrepancy is again not adequately represented in EPA tools.

It would be interesting to do this kind of survey for renewable energy developers as well, in order to see whether they too differ from one another and why. Likely this will however not be the case (or not so much), since developers may only care about the technical/financial aspects of implementation since they do not own the site. This begs the question of whether the EPA tools are mostly geared towards renewable energy developers as opposed to brownfield landowners. According the EPA, the latter target is a more accurate description of its intended audience. Having attended various webinars on the EPA RE-Powering tool, the author tends to agree with this, since webinar polling consistently showed a large contingent of brownfield owners, albeit it is not known whether they are private or municipal.

By far the most interesting result of this chapter is that contamination only seems to be moderately important. Put another way, not everyone feels that whether or not a potential brightfield is contaminated, plays a significant role. Meyer and Lyons (2000) confirm that developers often tend to prefer the problematic property because it may come at a discounted price.

While municipalities are concerned with site status, private owners tend to believe that putting renewables on potentially contaminated brownfields prevents costly remediation. Depending on the legal environment, they are often right. In the U.S. for instance, site remediation is often circumnavigated by siting renewables on a contaminated land, instead of residential redevelopment. The latter requires site cleanup. This is partly in contrast with the findings in chapter 6, where it is recommended that finding a contamination free brownfield helps eschew a host of barriers regarding financing and legal concerns over liability. Again, this is context dependent and financial hesitance can exist whether contamination is a legal issue or not, due to a negative image or perception. Chilton (1998) for instance argues that liability fears were nothing more than perception. Legal and regulatory know-how vis-à-vis brightfields is key in navigating these issues insofar as it can lessen such hesitance. Further, a contamination free ‘brownfield’ is likely to be more expensive than a contaminated one, and depending on the area (e.g. urban) this can make it a prime real estate property. Putting a solar array on it presents high opportunity costs (see chapter 6).

The very liberal approach taken by other studies (see Adelaja et al., 2010) in assessing the total possible potential of a region or State (see Figure 7.11) or even an entire country (Figure 7.12) (see Milbrandt et al., 2014) is not very telling for two main reasons. First, such assessments take every single brownfield site into consideration, skewing the results and ignoring alternative brownfield end-uses that make more sense in some (most) cases. The siting of renewable energy may not be the optimal alternative for a given site. Their screening is done solely on technical feasibility and does not account for other factors such as land value or ownership. Second, such assessments pay very little attention to the costs that would result if every site were to be converted into a brightfield.

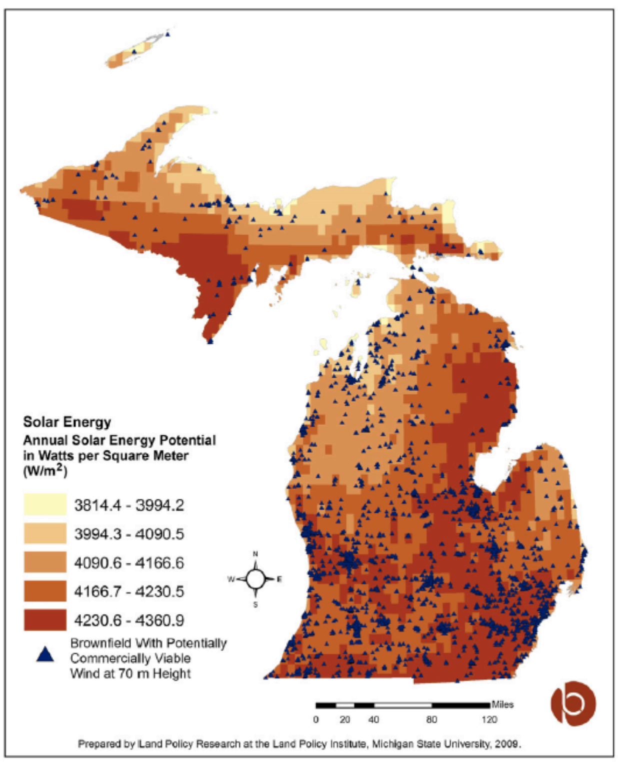


Figure 7.11. Solar energy potential on brownfields in Michigan. (Source: Adelaja et al., 2010)

To illustrate the point made above, similar calculations are performed, using the Port Lands as an example. The 12 TPLC sites have a combined total area of 94.96 acres, if one takes 10 waterfront properties (vacant) and the so-called Hearn (abandoned Toronto Hydro power station) into account (116 acres and 34 acres, respectively) the total area is ~245 acres.

- If one assumes that 1 MWp/7 acres (industry standard[72]), then 245 acres result in ~34.95 MWp. Using 90 % system efficiency; 100 % name plate capacity; and 20 % other system losses (environmental, distribution, etc.), the total efficiency of the entire system is ~ 70 % or 34.95 x 0.7 = **24.47 MWp capacity.**

- Given that 24.47 MWp x 5 hrs/day x 290 days/year = 35481.5 MWh/y x 1000 = **35'481'500 kWh/y. (***RETScreen* computations).

- If one assumes 11'000 kWh/y per household it follows that ~ **3'225 households** could be served by these brightfields. **(***RETScreen* computations).

- Based on RETScreen the total system cost would amount to $ 251,640,000 power system costs + $ 27'009'360 Balance of System costs = **$ 278'649'360 total costs. (***RETScreen* computations).

- Compared to a base (gas fired power plant) the whole system (244.68 acres) could **prevent ~8'831 tCO_2/year** from being emitted annually, which is the equivalent of ~2'000 cars taken off the road per year. **(***RETScreen* computations).

As one can imagine, this provides but very little tangible information, since the probability of all brownfields being used for solar PV is extremely low. Shove (1998) reminds us that the technical potential alone is an inappropriate (over-) representation of the overall capacity (for renewable energy deployment), generally too optimistic and without much relevance overall. Further, as was the assumption by both aforementioned authors, taking the size (area) of a brownfield at face value is misleading because such a property might contain topological features (water, hill, pit, etc.) that prohibit the use of the entire lot area. In other words, the given size of a brownfield is often different from the actual useable size.

[72] Values for this measure range from approximately 4 W/m^2 to 7 W/m^2.

The potential of brightfields can be assessed on a macroscopic level, in order to provide a general overview of a greater area's (state or province) potential. Yet realistically, only a fraction of those sites have a chance of becoming brightfields once they are assessed vis-à-vis their local uniqueness and ownership preferences. Most importantly however, such macro, broad-brush calculations do not take into account the priorities of brownfield owners, which is the main take-away message from this chapter; site identification tools must not be applied too broadly but take into account non-technical and non-economic agendas and individual (company) preferences. Decision-making trees and site selection tools (see EPA) are good for excluding sites from of a large pool of candidates, but not very helpful in making an informed decision based on the above mentioned factors. Proving whether the AHP method renders a better site compared to a more macroscopic approach is difficult. But one can imagine that AHP could be used to identify company or municipal intern goals that are to be met while pursuing the brightfield idea. Whether or not these site identification priorities or brownfield characteristics prevail over the undisputed importance of technical feasibility and viability remains to be determined on a case-by-case basis.

Interestingly, the cost-benefit analysis provided 2 of the 3 AHP top-3 candidate sites. This was of course because land cost is indeed an important factor. However, the 'best' site according to the AHP method did poorly in the cost-benefit analysis. By and large, private brownfield owners and municipal brownfield owners have sometimes very divergent ideas as to what constitutes a good brightfield and what their priorities and motivations are. Site identification tools should make note of this difference, by allowing for a high degree of customization as opposed to the cookie-cutter approach. However, the fact that the TPLC and WT AHP scores do not yield the same ranking of properties is in fact the essence and crux of such a microscopic approach in that it cannot be generalized.

7.6.1. Limitations of AHP

AHP is for the DM and not a tool that solicits the opinions of the public at large. That is not to say that a renewable energy project such as a brightfield is not subjected to a series of approval processes, during which time the public can express their opinion via public consultation. Municipal brownfields are often 'managed' by non-elected employees (i.e. brownfield coordinator), however the decision to 'do something' with a given brownfield can become the responsibility of an elected DM, who has been chosen in a democratic process. By contrast, private brownfield owners are much less subject to public opinion (apart from the required approval process). Thus certain concerns over environmental justice and risk or the perception of risk may arise, especially if no remediation is required. As Burton and Pushchak (1984) point out, the acceptance of risk may be less dependent on the accuracy of risk analyses than it is on the nature of the decision-making process. Since the public is excluded from the initial DM process, the brightfield proponents may influence public opinion by overemphasizing the benefits, whilst ignoring the potential risks. If brightfields were to become a more common practice in Canada, the regulator would have to address these issues. In the U.S. for instance, the Handbook on Siting Renewable Energy Projects While Addressing Environmental Issues (best practice) does recommend the engagement with local communities (especially Tribes) in order to fulfil their local needs. Legally, all brightfield projects need to undergo public comment periods and public scoping meetings during which an AHP process could be initiated. Furthermore, the literature shows that siting mechanism theory and practice are two very different things and that the theory can rarely be applied one to one.

The site identification tool proposed here does not encompass site impact evaluation. Site impact evaluation is an important part of facility siting, but since solar energy is largely void of hazardous implications (the same cannot be said for wind energy), impact evaluations here are limited to power system (grid) impacts.

Further, while AHP can be used for group decision making among both equal and unequal partners, this can only be done for one case at the time. In other words a municipality or a company can use AHP for its DM process within a small group of executives. However, the method fails in trying to find a consensus among different municipalities or companies[73] since the method inherently lacks objectivity. It is therefore futile to surmise generalities from AHP results. The AHP process is complex and can lead to errors when completing the questionnaire. While the consistency ratio for the sub-criteria is well within the accepted limits as well as the overall average CR, the main criteria AHP for both DM is marginally higher than 0.10. Follow-up interviews with both stakeholders show that the two DM feel that AHP is a useful tool, that they understood the process and goal and would consider using it for site identification. The author could envision that AHP could become useful in assessing not only corporate sustainability indicators (see Searcy, 2009), but also to determine municipal preferences. Searcy (2009) uses interviews in order to examine the role of sustainable development indicators in corporate decision-making structures. A closer look at decision-making of the two firms would have provided useful insights and could have allowed for a group decision-making method.

[73] The author does not suggest that TPLC and Waterfront Toronto are the same company.

7.7. **Conclusion**

The chapter demonstrated the potential of marginalized land from, of course, an energy perspective, but also through a lens of prioritization that takes into consideration less tangible non-technical, non-financial issues. It explored the different motivations of two different types of brownfield owners; municipal and private and showed that the two are not always alike. The study finds that the reuse of a brownfield and the creation of green-tech jobs are the two main motivations for the surveyed municipalities. By contrast, private owners would like to see their image improved as well as for bottom-line considerations. Similar to what can be observed in the RE-Powering America's Land Initiative, both municipal and private potential brightfield owners prefer to see the electricity generated being fed into the grid. Both groups also prefer leasing the land to a third party who owns and operates the infrastructure, rather than owning it themselves. Based on the survey, site location, status and ownership are the most important criteria for municipalities when selecting a potential brightfield property. Site size, land cost and site ownership are the most important criteria for private brownfield owners when selecting a potential brightfield property.

Further, the existing exclusion method for identifying potential brightfield candidates is inappropriate to capture the uniqueness of the jurisdictional environment and its owner. AHP can be used to incorporate less tangible decision factors such as ownership, contamination, size, development pressure, location, zoning et cetera. While more criteria (more *n*) may be more complicated, a smaller set of seven site identification criteria and their sub-criteria (21) is applied to a case study that is undertaken by two DMs. Individually, both AHP DMs chose the same 'number one' site. Comparing the base case to the AHP method provides several insights. Two of the three top-3 sites are the same, that is, 'F' and 'H'. By contrast, while the simple cost/benefit analysis has site 'F' as the number one site, the AHP method shows site 'C' as the winner on both occasions. This is because 'C' scores a lot of points with its *Capacity* and *Proximity*, whereas 'J' (although marginally over the C/B line) has low AHP scores in particular due to the site's far distance to the *Transmission lines*, its *Size* (medium scores the highest) and its *Private* current *Ownership*. In fact 'J' ranks 3rd and 2nd last, respectively in the AHP method.

The author believes that the MCDM and the context-based AHP system is a site identification mechanism that is worth pursuing further, for it can offer a more personalized search process. Going forward, it would be interesting to see whether or not there are marked differences regarding AHP and preferences among a set of international owners and firms across various economic sectors. Nevertheless, this study proves that AHP is a valid method for site identification for brightfields and is ideally used complementary to current selection tools since its results may very well differ from a cost benefit analysis for instance.

CHAPTER 8: CONCLUSIONS AND DISCUSSIONS

This chapter is dedicated to a final conclusion and discussion aimed at tying together the findings and significance of the four papers (chapters). The purpose of this debate then is to see if there are any surprising synergies, contradicting findings or other expected or unexpected relationships among the various chapters.

8.1. **Conclusions**

- The definition and meaning (also legally) of brownfields are becoming more and more similar in all three countries observed.
- By contrast, the term brightfield is not as well defined and understood. Broadening the scope of the brightfield definition seems to confuse its meaning and hinder a succinct understanding.
- The term is largely unknown in Canada and Germany. The latter uses the term Solar Park or Konversionsflächen to describe a similar phenomenon.

- The majority of brightfields in the United States are constructed on landfills using thin-film solar PV panels. The EPA initiative has installed a capacity of over 1'000 MWp.
- In Germany, ex-military sites such as abandoned airfields have emerged as the most common form of brightfield type. Both wind and solar brightfields in Germany have a peak capacity of around 4'000MW.

- The United States is so far the only country with a federal initiative specifically designed to support brightfields.
- Neither Canada, nor Germany has a similar program on the federal level.
- Individual policies and programs regarding the funding of brownfield redevelopment projects and renewable energy developments as well as some regulatory mechanisms (e.g. liability, remediation etc.) are becoming more and more alike.

- Environmental/technical barriers only differ from 'conventional' renewable energy projects in the event of site contamination.
- Site contamination can become the source of a myriad of barriers and challenges as it can negatively influence the ability to secure financing, the legal situation as well as prompt public opposition.

- AHP can be used to identify brightfield candidate sites based on the preferences of their owners.
- This is especially helpful for assessing non-technical and non-financial criteria.
- The method differs from a common cost benefit analysis and is best used complementary.

8.2. **Discussions**

Regarding the findings in chapter 3 and 4, one could argue that the definition of brightfields should be made broader still in order to include the siting of transmission lines and energy storage units (e.g. batteries, flywheels, etc.) on marginalized lands. Transmission lines run for thousands of kilometres through (over) often pristine areas such as wetlands. Although crisscrossing from one brownfield to the next is certainly not the solution, the deployment of renewable energy is going to increase the need for augmented energy storage capacity (see Ackermann, Andersson and Söder, 2001). Energy storage is not only desirable in terms of grid resilience in case of power outages, but is necessary to meet peak demand, allow off-peak generation to be stored, as well as counteract the fluctuations caused by unsteady green power production (i.e. harmonics). While the installation of PV or wind in urban environments does cause significant disadvantages as well as socio-economic drawbacks, brownfields could be used to house urban storage units instead. To the current state of knowledge there is very little research on this.

Canada in particular should pay more attention to the reuse of previously developed properties, given that the country lacks vast desserts (unlike the United States) that are feasible for solar or wind energy (note that Canada's arctic lands are not feasible for large-scale generation, due to their remoteness and sparse population density). The United Kingdom, a country roughly 40 times smaller than the United States, and already densely populated, is home to a series of discussion regarding the use of farmland for energy production and the reuse of marginalized lands for energy generation, the consensus leaning towards the latter.

Whether one will see more brightfields in Canada, in particular other than landfill gas capture (which here is not considered a brightfield), depends on the provincial and federal agenda, as well as on the growing solar and wind industry. Policies designed to curb urban sprawl, such as the Golden Horseshoe Growth Plan and the Green Belt, mainly prohibit larger subdivisions on arable lands. Such policy tools do not yet apply to renewable energy. Furthermore, the decision to discontinue the FIT program for large-scale (> 500kW) ground-mounted solar farms in Ontario could have an adverse effect on the solar industry as a whole. There is no indication that brightfields will become a priority in Canada in the near future and chapter 4 shows that the uptake for brightfields in Canada has been scant, whereas the United States and Germany can boast several hundred projects. From a typological perspective, the brightfields in Germany and the United States are starting to converge insofar as the type of marginalized property being used is beginning to broaden.

As mentioned in the discussion in chapter 3, on the one hand, I do recommend a more strict regulation regarding renewables on agricultural land in the FIT and beyond. On the other hand, it is important that such restrictions become FIT independent, in the event the latter is discontinued in the future. As it stands right now, renewable energy assessments (REA) address cultural heritage and natural heritage issues, as well as areas of natural significance such as the Greenbelt, Lake Simcoe Watershed, Niagara Escarpment, Oak Ridges Moraine. The latter areas are not prohibitive environments for renewables, but simply require additional documentation. Natural heritage for instance addresses bird and bat monitoring as well as water assessments, but by and large fails to mentioned land use in general. Development prohibitions for *significant*[74] or *provincially significant*[75] areas are stricter, but again not prohibitive for renewables. While the protection of ecological assets is the primary reason for setback requirements, the intrinsic value of undisturbed land is also important (as discussed in chapter 1). As mentioned previously, I am unsure whether a moratorium of

[74] Significant means in regard to w*oodlands* and *wildlife habitat*, a natural feature that MNR has identified as significant, or that is considered to be significant when evaluated using evaluation criteria or procedures established or accepted by MNR. (Natural heritage assessment guide for renewable energy projects Ontario, 2012).

[75] Provincially significant means in regard to *northern wetlands*, *southern wetlands, coastal wetlands* and *areas of natural and scientific interest*, a natural feature that MNR has identified as provincially significant or that is considered to be provincially significant when evaluated using evaluation criteria or procedures established or accepted by MNR. (ibid).

‘conventional’ renewable energy projects is the best solution or even feasible. I do not propose that all contaminated lands are transformed into brightfields, nor do I suggest that no renewable energy projects be allowed on agricultural lands or ecological assets such as Provincial Parks. Instead I envisage a more active encouragement and incentivized approach (by the governments) to use more marginalized lands, as opposed to the prohibitive manner of a moratorium. This would require a more thorough assessment and documentation of the previous land use for a proposed projects during a REA process; something that a regulator can easily impose.

One can reasonably argue that Canada, Germany and the United States are by and large comparable countries socioeconomically speaking. The question is then why does Canada not have the same interest in brightfields? The answer is, just as brightfields themselves, found at the intersection of brownfields and renewables. The fact that Canada has such vast land reserves may explain why rural brownfield redevelopment is not a priority; therefore brightfields are not one either. The perception that Canada has enough land can be misleading; yes, the country has a lot of land, but factually, its population is ‘confined’ to a proportionally small area. Within that area, Canada would do well to adopt a more conservative (as in land conservation) attitude. On the other hand, the country is already producing over 60 % of its electricity from hydro and the uptake of solar and wind (although generally impressive) is faced with low (in international comparison) electricity prices and a glut of oil and natural gas.

These are only excuses however, and not very good ones at that. The United States is remarkably similar in the two situations described above and has still managed to create a federal brightfield initiative. The hope is then, that Canada can pull of a similar feat. Chapter 5 has gone deeper into these issues.

Chapter 5 shows that the three countries are as of now at different stages. The United States has the most comprehensive and concerted effort to turn marginalized lands into brightfields, mainly due to the federal reach of the EPA program. Despite the lack of federal programs in Canada and Germany, one could argue that Canada and the U.S. are converging towards a European (i.e. German) renewable energy model that includes FITs, SOPs, and (planned) carbon tax schemes (Mabee, Mannion and Carpenter, 2011). Kitzing, Mitchell, and Morthorst (2012) examined renewable energy policies in Europe and concluded that there are indications of a bottom-up convergence of renewable energy policies, meaning that lower-tier governments are quicker to adapt and create new policies, which may later on then be adopted by federal governments. This is in line with the findings presented here, insofar as provincial or municipal governments are developing or have developed brightfield policies, while their federal governments have not.

So, does it matter whether brightfield (support) policies are being created by provincial and municipal governments as opposed to a federal government? Looking at Germany, and the success of brightfields in some Bundesländer one might argue that it matters not. However, a federal brightfield agenda could act as a catalyst in Canada, where no provincial government has assumed leadership in that regard. Federal leadership could lead to provincial and municipal spinoffs. The United States is an example of where a federal program acts as a catalyst and one can witness more and more state level spinoff programs across the country. Prior to the EPA Initiative, there were but very few examples of brightfields and the concept was largely unknown.

It seems that Germany and Canada are similar regarding brightfields, due to the lack of federal policies/strategies and the similarity of provincial FIT provisions on discontinuing tariffs on arable lands, this however is an incomplete picture. Firstly, the Canadian, that is the Ontario FIT system, is a lot more forgiving regarding renewables on arable lands compared to the strict prohibition in Germany; for instance, municipalities in Ontario are still permitted to lease CLI Class 3 lands to a solar developer. Secondly, below the surface of policies (or lack thereof on the federal level), it is apparent that Germany has produced a great number of brightfields, while Canada has not. Thirdly, and most importantly, Canada has so far never intended to support brightfields directly (no brightfield policy outputs).

The recommendations made here are mostly targeted towards the Canadian situation and how this type of development could be advanced and improved upon. Based on the above findings, I would recommend that the provincial governments in Canada pay closer attention to this type of sustainable brownfield reuse and renewable energy development found in other jurisdictions (U.S. or Germany). By doing so, it is the hope that policy-makers recognize the benefits of brightfields and implement programs similar to the RE-Powering America's Land Initiative, either federally or provincially. While the facilitation of such a program would probably be executed more effectively by Provincial or Municipal authorities, federal guidance would be able to kick-start policies such as marginalized land inventories, nation-wide site-specific remediation standards, uniform liability standards as well as funding and technical assistance, unequally distributed in Canada as of now. This could, over time, lead to a set of best practices. Such a momentum-starter requires the support of the brownfield and renewable energy industry, that could be facilitated by a forum or a committee comprised of policy-makers and individuals representing the industry. While it is essential to have private-public partnerships, the questions of whether the private sector pressures and the public authorities follow or vice-versa, poses a chicken and egg kind of situation. Regardless of what party initiates such a discussion, Canada would benefit from it! Reassuringly, the country has a history of adopting solutions 'invented' south of the border, and it can be expected that this will not be very different.

Overall, it is a question of learning from others. Lesson-drawing in particular, and transnational communication in general, can help policy-makers learn about this type of development. By the same token, brownfield and solar developers can learn from the experience and mistakes made by brightfield developers in the U.S. for instance.

Chapter 6 shows that there are a lot of barriers that exist for brightfields, which is surprising given that the survey participants were predominately American. This then shows that the RE-Powering America's Land Initiative is not without its flaws and that there are still barriers for brightfields in the U.S. While this may be attributed and to some degree forgiven because the initiative was only launched recently, it raised the question of whether it can serve as a benchmark with which to assess other programs (countries) as done in chapter 5. Interestingly, the so-called *Cleanfield Act*, a grant program to revitalize brownfield sites for the purpose of locating renewable electricity generation facilities on CERCLA properties did not make it passed Congress and 'died' in 2010. Whether this is disappointing or a testament to the success of the EPA initiative remains unanswered. Regardless, one may argue that, despite the EPA initiative being a work in progress, it is still the most direct federal initiative supporting this type of development, anywhere.

More importantly, the recommendation made in chapter 6 pertaining to the selection of a brownfield that is not contaminated may have been premature. That is, the subsequent chapter 7 has shown that contamination only seems to be moderately important. Put another way, not everyone feels that whether or not a potential brightfield is contaminated, plays a significant role. While municipalities are concerned with site status, private owners tend to believe that putting renewables on potentially contaminated brownfields prevents costly remediation. Depending on the legal environment, they are often right. In the U.S. for instance, site remediation is often circumnavigated by siting renewables on a contaminated land, instead of residential redevelopment, while in Ontario, contaminated sites require at minimum a Phase II ESA. One survey participant (from chapter 6) said: "I don't think any of the environmental challenges are major. No developer is going to build on a site that has major, uncontrolled contamination". Again, this is partly in contrast with earlier findings, where it is recommended that the best thing one can do is to find a contamination free brownfield to helps eschew a host of barriers regarding financing and legal concerns over liability. One needs to remember that barriers are context dependent and financial hesitance can exist whether contamination is a legal issue or not, due to a negative image or perception (see Chilton, 1998).

There is a difference between identifying a brownfield and making the decision to turn it into a brightfield. Originally I called chapter 7 'a site selection process', but I came to realize that it is closer to a site identification process that identifies a site as being preferred over another within a given set of sites. It does aim to make a final site selection, but choosing a site is only part of a larger process on whether to go forward with a brightfield conversion or not. Further, exclusion and elimination only work on a smaller scale and a given number of sites within a geographically limited environment or jurisdiction. The nationwide elimination process orchestrated by the EPA of over 66'000 sites identified some 185'000 possible renewable energy installations with a nameplate capacity of over 1 million MWp. Such a process, while rendering spectacularly high capacities, offers relatively little in terms of decision-making. A similar approach is used by Adelaja et al. (2010) and Milbrandt et al. (2014) claiming that siting renewables on brownfields and otherwise marginalized lands could produce 5855 MWp to as much as 13.1PWh[76].

Based on The Port Lands Acceleration Initiative and the Port Lands Planning Framework (Charrette Summary), all future buildings within the Port Lands must at least become LEED Gold Certified. Currently, new distributed generation (DG) in downtown Toronto and the eastern section of the City is limited to 10 MW for PV (and zero for synchronous DG) due to short circuit capacity limits at Leaside, Hearn and Manby stations, and transmission limits on the 230kV delivery system East to Cherrywood station in Pickering (Navigant, 2015). Yet, while the probability of a Brockton or Chicago style brightfield is very low in the case of the Port Lands, there is still a large capacity for solar in terms of microFIT rooftop installations. Based on Toronto Hydro tracking of microFITs, there is an apparent lack of solar installations in the Port Land area. This is due to the dearth of residential housing in the area, but given that some brownfields are home to warehouses with leases of up to 20 years, I could indeed envisage a sort of hybrid brightfield, where the lease may still operate while solar installations clad the roof. This is not a traditional brightfield, but the premise of

[76] According to the CIA Factbook (2010) the annual U.S. electricity consumption is 3.886 trillion kWh

this research is in essence to contribute to finding a solution to climate change, in which case compromises such as this will need to be part of the solution going forward.

The hope is that brightfields are not only seen as means to make a ‘buck out of muck’ and GHG emission reduction, but also for their potential for community improvement and more importantly empowerment. I do believe that this concept has the ability to remove the social stigma of brownfields by reusing them for the purpose of renewable energy siting, but only if the affected community is part of the decision-making process and has given its consent.

Most importantly however, I have learned that the site identification process, the barriers, the challenges, and also the solutions are context dependent. Catchall and broad-brush guidelines and current site-selection tools often fail to capture the unique context of a given project. This can lead to a simplification and falsely perceived standardization of brightfield implementation that may have brownfield owners believe that brightfield development is simple, while in reality it is anything but! This may especially be the case for potential Canadian brownfield owners, who look towards the U.S. and assume the legal environment in Canada is similar. While this may be the case in theory, the lack of experience and precedence is probably making implementation a lot harder compared to south of the border. While best practices are certainly helpful in creating a knowledgeable community of brightfield developers, they do not always reflect the local circumstances. I believe that a more context-based identification process is a stronger, more realistic and more applicable tool. I hope that my research shows that AHP may in some form or fashion become part of the solution.

Pertaining to the potential of brightfield properties and the decision-making process, I recommend that private and municipal brownfield owners assess their properties in a more microscopic fashion and do not simply follow the “run-of-the-mill” approach suggested by the EPA. That said, there are no such tools and decision-making trees in Canada and even small-scale identification measures must be developed first. Finally, I recommend that this type of research is explored further by the research community in Canada. Please see the paragraph below for more detail on this.

This dissertation represents original research in the area of brownfield redevelopment and renewable energy deployment. It contributes to the literature insofar as it addresses vital gap in the brownfield literature and expands the emerging brightfield literature via the exploration of international reviews, the analysis of typology, the examination of barriers and the use of AHP in a novel and original fashion. Its significance reaches beyond the literature and academia, but has ramification related to a more sustainable use of land and generation of electricity and therefore Climate Change.

8.3. **Future research**

Overall, the brightfield concept requires more academic attention. The fact that I am one of the few people doing research on brightfields in Canada is equally appealing as it is upsetting. The research presented here has introduced a variety of issues such as typology, political capacity, policy convergence, site identification as well as international comparison. However, I believe it is essential to assess the various types of marginalized properties in Canada such as mine sites for instance, for their potential, benefits and disadvantages regarding the siting of renewables. Having a more detailed assessment of renewable energy projects in all provinces is desirable as well and presents an opportunity for future research. Further, it is my conviction that policy-makers often are unaware of this concept. In order to examine their knowledge, I would recommend a survey that focuses not on developers but also on policy-makers and find a way to augment their understanding of brightfields. I believe that the MCDM and the context-based AHP system is a site identification mechanism that is worth pursuing, for it can offer a more personalized search process for those with a significant brownfield portfolio or operating at a municipal or district level of geography.

If I were to continue this research, I would expand the survey regarding the needs and agendas of brownfield owners sector by sector and develop an interface that could be used to identify candidate sites. As mentioned earlier, the use of brownfields for energy storage units similar to the one on Church Street in Toronto (developed by the Centre for Urban Energy) also demands more academic attention.

8.4. **Concluding Remarks**

This research has taught me not to always believe what I think. That is, at the onset of this research I was fascinated by the benefits and advantages of using brownfields for the siting of renewable energy. The promise of cheap and abundant land, economic multiplication through tax base increase and job creation, community improvement, not to mention increased green energy generation is what brought me into this research in the first place. Having examined the brightfield concept through a more critical lens as well as identified some of the barriers and challenges, I have learned that they are not a silver bullet and not the answer to all our problems. Even though I am even more enthusiastic about this type of research than when I started, I gained a more sober, objective and critical perspective. Put another way, and to quote Einstein, “The more I learn, the more I realize how much I don’t know”. Rather than seeing this as an impediment, it drives me to gain a deeper understanding of this development, which I would very much like to share and apply in the future. I have learned that Canada has very little to offer regarding brightfields, both academically speaking as well as concerning political and industry support. I find this challenging, yet exciting, since it presents an opportunity for a niche.

I would like to conclude by saying that I am grateful to have met so many great minds over the course of this journey and it is in large part due to those individuals that I can say that my interest in brownfields and renewable energy has grown into a passion and professional calling, since it is congruent with the desire to reconcile environmental health with the human need for energy.

Appendix

Brownfield Type	Ownership	Cont. Status	Size	Land Cost	Proximity to Tx	Capacity
2.41	12.07	4.04	7.40	43.88	17.65	12.56
Open 73.91 **1.78**	Crown 42.86 **5.17**	Highly Cont. 69.99 **2.83**	Small 33.33 **2.47**	Low 69.05 **30.30**	Close 69.05 **12.19**	Small cap. 6.34 **0.80**
Top. Feat. 19.16 **0.46**	Municipal 42.86 **5.17**	Medium Cont. 19.35 **0.78**	Medium 33.33 **2.47**	Medium 25.07 **11.00**	Medium 25.07 **4.43**	Medium cap. 17.36 **2.18**
Build. 6.94 **0.17**	Private 42.86 **5.17**	Low 10.66 **0.43**	Large 33.33 **2.47**	High 5.88 **2.58**	Far 5.88 **1.04**	Large cap. 76.29 **9.58**

Table A.1. Waterfront Toronto AHP matrix with final scores.

Best Score 64.31	Lowest Score 12.65	Medium Score 26.49
Open (1.78)	Build. (0.17)	Top. Feat (0.46)
No preference (5.17)	No preference (5.17)	No preference (5.17)
Highly Cont. (2.83)	Low Cont. (0.43)	Medium Cont. (0.78)
No preference (2.47)	No preference (2.47)	No preference (2.47)
Low Cost (30.30)	High Cost (2.58)	Medium Cost (11)
Close (12.19)	Far (1.04)	Medium (4.43)
Large (9.58)	Small (0.08)	Medium (2.18)

Table A.2. Highest, Lowest and Medium Score for Waterfront Toronto.

Site ID	Cont. Status	Land Cost	Size	Capacity	Ownership	Type	Proximity to Tx		Sum	Rank	
	Normalized Wt (Score)										
A	2.83	11.00	2.47	0.8	5.17	0.46	4.43	➔	27.16	55.54	C
B	2.83	2.58	2.47	2.18	5.17	1.78	12.19	➔	29.20	44.41	F
C	2.83	30.3	2.47	0.8	5.17	1.78	12.19	➔	55.54	42.4	H
D	2.83	11.00	2.47	0.8	5.17	1.78	12.19	➔	36.24	36.24	D
E	0.78	2.58	2.47	2.18	5.17	0.46	4.43	➔	18.07	32.23	K
F	0.78	30.3	2.47	0.8	5.17	0.46	4.43	➔	44.41	29.2	B
G	0.78	11.00	2.47	0.8	5.17	1.78	4.43	➔	26.43	27.16	A
H	0.78	30.3	2.47	2.18	5.17	0.46	1.04	➔	42.40	26.43	G
I	0.78	11.00	2.47	0.8	5.17	1.78	1.04	➔	23.04	25.45	J
J	2.83	2.58	2.47	9.58	5.17	1.78	1.04	➔	25.45	23.04	I
K	0.43	11.00	2.47	0.8	5.17	0.17	12.19	➔	32.23	21.79	L
L	0.78	2.58	2.47	9.58	5.17	0.17	1.04	➔	21.79	18.07	E

Table A.3. Final scores (wt) for Waterfront Toronto

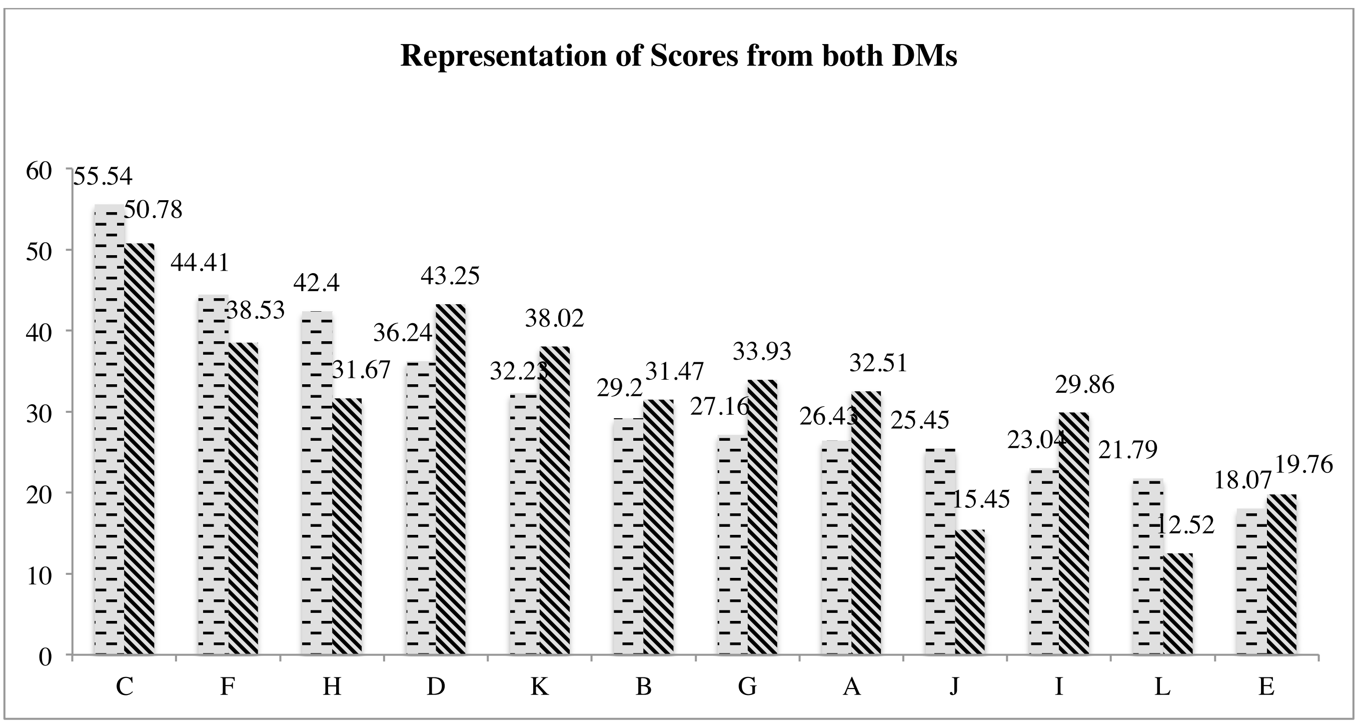


Table A.4. Scores from both decision-makers.

TPLC	Rank	WT	Place	Places "Off"
C	1	C	1st	0
K	2	F	2nd	2-3
D	3	H	3rd	1-3
F	4	D	4th	1-2
G	5	K	5th	3
H	6	B	6th	3
A	7	A	7th	0
I	8	G	8th	2-3
B	9	J	9th	2-3
E	10	I	10th	2
J	11	L	11th	1-2
L	12	E	12th	1-2

Average “Place-off”: **1.83**

Table A.5. This tables shows by how much (by how many ranks) the two DMs are ‘off’ in terms of site ranking. The average is 1.83. Eliminating the 3 rank difference outliers, the average is only 1.3.

Difference from GM to individual score for main criteria weights

	WT	TPLC
Brownfield Type	0.84	1.12
Ownership	3.25	2.37
Cont. Status	2.45	3.9
Size	2.13	1.52
Land Cost	12.56	8.97
Proximity to Tx	1.69	1.86
Capacity	7.34	11.62
SUM	**30.26**	**31.36**

Table A.6. Difference (WT score minus TPLC score or vice-versa) from GMM scores to individual scores for main criteria (Wt).

Geometric Mean Method

Brownfield Type	**Ownership**	**Cont. Status**	**Size**	**Land Cost**	**Proximity to Tx**	**Capacity**
10.53097872 **3.25**	77.8471703 **8.82**	41.89303898 **6.47**	27.73437272 **5.27**	980.6662846 **31.32**	374.1348583 **19.34**	395.8791163 **19.90**
Open	Crown	Highly Cont.	Small	Low	Close	Small cap.
5.752630196 **2.40**	10.91412155 3.30	1.866243119 **1.37**	0.838194375 **0.92**	467.4656717 **21.62**	178.3912177 **13.36**	12.31949343 **3.51**
Top. Feat.	Municipal	Medium Cont.	Medium	Medium	Medium	Medium cap.
0.387751041 **0.62**	8.689916685 **2.95**	2.345165827 **1.53**	6.508332797 **2.55**	61.61074175 **7.85**	23.54120223 **4.85**	21.43491158 **4.63**
Build.	Private	Low Cont.	Large	High	Far	Large cap.
0.050167951 **0.22**	13.70730906 **3.70**	2.884129901 **1.70**	1.922916508 **1.39**	3.379632555 **1.84**	2.29 **1.51**	59.69706548 **7.73**

Table A.7. Geometric mean scores (wt in bold).

RANK	Average		GGM		WT		TPLC	
1	C	54.25	**C**	47.41	**C**	55.54	**C**	51.44
2	F	41.99	F	36	F	44.41	K	44.72
3	D	40.84	H	35.41	H	42.4	D	43.91
4	H	37.29	D	35.27	D	36.24	F	42.07
5	K	33.01	K	31.79	K	32.23	G	36.93
6	G	32.3	B	29.22	B	29.2	H	34.67
7	B	31.43	G	25.64	A	27.16	A	33.17
8	A	29.06	A	24.45	G	26.43	I	32.86
9	I	28.57	I	22.3	J	25.45	B	32.13
10	J	21.54	J	19.94	I	23.04	E	22.76
11	E	19.17	L	17.92	L	21.79	J	16.11
12	L	16.98	E	17.81	E	18.07	L	15.52

Table A. 8. Overview of Average, GGM, WT and TPLC final scores and ranking.

Site ID	Properties	Contamination Status	Past activities
A	284 Unwin Avenue	HIGH	Fuel & Coal Storage
B	185 Villiers Street	HIGH	Former Tank Farm (Fuel Storage)
C	673 Lakeshore Boulevard	HIGH	Former Tank Farm (Fuel Storage)
D	625 Lakeshore Boulevard	HIGH	Former Tank Farm (Fuel Storage)
E	294/320 Unwin Avenue	MEDIUM	Coal Storage
F	450 Commissioners Street	MEDIUM	Former Hydro-substation
G	480 Unwin Avenue	MEDIUM	Coal Storage
H	242/252 Unwin Avenue	MEDIUM	Coal Storage
I	230 Unwin Avenue	MEDIUM	Coal & Salt Storage
J	55 Unwin Avenue	HIGH	Coal & Fuel Storage
K	95 Commissioners Street	LOW	Former paper recycling
L	242 Cherry Street	MEDIUM	Coal Storage & Recycling

Table A.9. Contamination status for all 12 brownfield. Data provided by TPLC environmental services.

Figure A.1. "Winning" Site. 673 Lakeshore Boulevard East.

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