AN INTEGRATED ASSESSMENT FRAMEWORK FOR ENERGY GOVERNANCE: TOWARD A SUSTAINABLE, EQUITABLE, AND DEMOCRATIC ENERGY TRANSITION

by

Jeongseok Seo

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Energy and Environmental Policy

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Writing a dissertation has been a long journey. I understand that one of the key objectives for writing a dissertation is to create a piece of my life embodying important ontological, epistemological, and intellectual experiences and lessons learned during this journey.

I would like to take this opportunity to express my sincere gratitude to the people who have walked with me during this invaluable journey. First, I owe a debt of gratitude to my wife, Hyejeong, and two kids, Ahram and Minjoon. Without my wife’s support and patience, I wouldn’t be here today. My precious Ahram and Minjoon were the sources of our true happiness and hope. I am also extremely grateful for my parents for their love and sacrifices for supporting me.

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The dissertation is not just my private intellectual property. It is a commons that has been crafted together with my committee members, colleagues, friends, and my family. It is my hope that this piece of the commons can be a useful tool to realize a deep, equitable, and democratic energy transition.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREIVATIONS

ACEEE	American Council for an Energy-Efficient Economy
AFOLU	agriculture, forestry and other land use
BER	Berlin Energy Roundtable
CAGR	compound annual growth rate
CDD	cooling degree day
CEEP	Center for Energy and Environmental Policy
CHP	combined heat and power
CO_2	carbon dioxide
CSE	costs of saved electricity
DEDET	Deep, Equitable, Democratic Energy Transition (DEDET) Framework
DOE	US Department of Energy
ECEM	energy conservation and efficiency measure
EIA	Energy Information Administration
EPA	US Environmental Protection Agency
ESCO	energy service company
ESV	Energy Self-Sufficient Village
EU	European Union

EU ETS	EU Emissions Trading System
FIT	feed-in tariff
GDP	Gross Domestic Product
GHG	greenhouse gas
GLA	Greater London Authority
GW	Gigawatt
GWh	gigawatt hour
HDD	heating degree day
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IOU	investor-owned utility
IPCC	International Panel on Climate Change
KHNP	Korea Hydro and Nuclear Power Corporation
LCOE	levelized cost of energy
LCSE	levelized cost of saved energy
LED	light emitting diode
LMI	low-to-moderate income
INDC	Intended Nationally Determined Contribution
kW	Kilowatt
kWh	kilowatt hour
MTOE	million tonnes of oil equivalent
MW	megawatt
MWh	megawatt hour
NEA	Nuclear Energy Agency

NOAA	National Oceanic and Atmospheric Administration
OECD	Organization for Economic Co-operation and Development
OLNPP	One Less Nuclear Power Plant initiative
PV	photovoltaic
RGDP	Regional Gross Domestic Product
SCS	Solar City Seoul
SEC	Seoul Energy Corporation
SEU	Sustainable Energy Utility
SMG	Seoul Metropolitan Government
tCO_2e	ton of carbon dioxide equivalent
TEPCO	Tokyo Electric Power Company
TOE	tonne of oil equivalent
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organizations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
WHO	World Health Organization

ABSTRACT

Despite decades of efforts to promote greater socio-ecological sustainability, global society is failing to meet three important challenges in the context of energy and climate change: 1) the sustainability challenge posed by climate change; 2) the demand for equitable distribution concerning the benefits and burdens arising from climate change and high-risk energy technologies; and 3) the demand for democratic governance of energy systems.

First, global society is failing to address the sustainability challenge posed by climate change. Currently, the resilience of the biosphere and the stability of human society are under an imminent threat of climate change. Largely caused by anthropocentric activities since pre-industrial times, the substantial release of carbon emissions has changed the chemical composition of the Earth's atmosphere and, as a result, led to far-reaching consequences, such as global warming and sea level rise. The Intergovernmental Panel on Climate Change (IPCC) and other researchers have found that global average temperature increased by 0.85℃ and global sea level rose by 19 centimeters over the last century. Under these circumstances, a deep decarbonization of global carbon emissions has been urged by many. Yet, current business-as-usual approaches to carbon reductions are failing to meet the required reduction of GHG emissions. Currently, the globally averaged carbon abundances and temperature are continuing to increase.

Secondly, global society is failing to meet the demand for equitable distribution with respect to issues of benefits and burdens from climate change and

high-risk energy technologies. An example of the problem is that many forms of energy are mined in rural areas, but it is urban areas that most of the energy is consumed. Often rural areas are exposed to the harms of toxic byproducts released from mining and power plants. In a similar vein, greater burdens from climate change are born by those who are least responsible. Global energy systems are the most responsible for global warming. Yet, the accountability for global carbon emissions and radioactive wastes generated by contemporary energy systems is not equitably shared among countries, regions, or people. Besides, the actions of present generations are imposing heavy, or unbearable, burdens on the next generations.

Thirdly, global society is failing to meet the demand for democratic governance of energy systems. Contemporary energy institutions and policies are molded typically in a closed and hierarchical manner and shaped predominantly by experts and bureaucracies. On the other hand, voices of the public, especially parties disproportionately affected by policies, are not properly reflected in the decision-making process. The questions of democratic governance, such as who governs, are not generally addressed in modern democracies. Yet, critical inquiry of these issues is important as energy systems are configured by negotiations among competing interests, framings, and power relations.

This dissertation proposes an integrated framework to address the challenge of deep decarbonization in an equitable and democratic manner. This dissertation argues that the current governance approaches to climate change are largely based on prevailing epistemological and institutional paradigms, like elitist technocracy and market liberalism, and are not capable of solving the challenge of deep decarbonization. Instead, an integrated framework, coined here as a Deep, Equitable, and Democratic Energy Transition (DEDET) Framework, needs to be developed to guide analysis, assessment, and development of energy transition alternatives.

Why is an integrated assessment framework needed? There exist a diverse and growing number of studies offering alternative approaches crafted to respond to the challenges of deep decarbonization of energy-based emissions, equitable distribution of the risks and the burdens, and democratic governance of energy systems. Yet, most studies examine pieces of the challenges or sometimes present a partial analysis of policy options. For instance, IPCC (2014) analyzes the existing integrated models defining issues of sustainability and, to some extent, equity while not attending to issues of democratic governance. But, persistent challenges of sustainability and energy justice make the case for why we require new ways of thinking, inquiring, and policy-making other than the conventional approaches.

There are several reasons for the persistence of the research problem. One reason is that there is a serious analytical challenge. For instance, sustainability and, to some extent, equity are treated as measurable variables while democracy is recognized to be a question of values, principles, and critical thinking that cannot be readily quantified. Consequently, the democratic character of deep decarbonization is frequently examined as a separate problem. Similarly, quantitative and qualitative research methods are often treated as separate approaches. While issues of deep decarbonization and, to some extent, equity can be addressed by quantitative studies, democratic governance requires qualitative study. But it is obvious that the definitions of sustainability and equity are, in some degree, political matters and need democratic discussion and action to be successfully implemented. Lastly, the design of an integrated assessment framework for energy systems is often recognized to be a daunting task partly due to the heterogeneity of spatial and temporal characters of the challenges arising from energy systems (Pietzcker, et al., 2017). In brief, modern challenges require *integrated* assessment and implementation.

This dissertation, I hope, serves as a basic platform to build an integrated assessment tool. In other words, this dissertation does not aim to provide a definitive model encompassing all relevant issues and detailed guidance on assessment metrics, such as scoring methodologies. The focus of this dissertation is to argue for the need of a new approach that could address the interrelated challenges of deep decarbonization, equitable distribution, and democratic governance in an integrated manner and to embark on this initiative by offering the guiding principles and the assessment criteria. They are proposed as a potential basis for further investigation into the development of a multi-criteria framework.

DEDET is proposed for two audiences: (1) interdisciplinary research communities seeking to research integrated approaches to address the interlinked challenge of the modern era; and (2) policy-makers and citizens seeking to shape energy transition policy in a manner that can address the three challenges. This dissertation targets interdisciplinary research as the first audience and is intended to add a more integrated research approach to the ongoing scholarly endeavor to develop sustainable, equitable, and democratic policy options. A second and equally important audience of this dissertation is the body of policy planners and policymakers, and citizens. The new framework presented in this dissertation can be used to provide them with conceptually sound and empirically assessed metrics to develop a new energy strategy that is sustainable, equitable and democratic.

This dissertation analyzes large cities against DEDET to explore the potential of the framework. Large cities are considered important institutional hosts for this experimentation. Large cities arguably present the greatest challenge to the application of the DEDET framework. Large cities are important sites for policy innovation and democracy. From the early work of Lewis Mumford (1961) to the recent work of Bulkeley (2014), scholars have described the historical role of large cities in incubating new ideas, new policies, and new economies. The role and importance of large cities in tackling the interrelated challenges posed by modern energy systems are underscored by a growing body of research on the potential of polycentric governance approaches (Ostrom E., 2009; Taminiau, 2015; Byrne et al., 2017). Some have further argued that the distributed nature of sustainable energy transition makes cities more feasible and appropriate than centralized forms of nations (Rohracher & Spath, 2014).

To test the potential of the DEDET framework in an urban context, this dissertation carries out a preliminary comparative analysis of London, Austin, and Freiburg and an in-depth case study of Seoul, South Korea. The three cities, often considered “leaders” in urban sustainability, are briefly reviewed against DEDET to show the applicability of the DEDET framework at several levels. The city of Seoul has experimented with a range of energy policies, notably One Less Nuclear Power Plant (OLNPP) initiative, to counter issues of climate change, energy justice, and energy democracy. The dissertation deploys both qualitative and quantitative assessment approaches to evaluate OLNPP against DEDET if Seoul is on track to achieve an energy transition that is sustainable, equitable, and democratic.

The dissertation concludes with implications of this study for interdisciplinary research and for the development of integrated policy strategy. It is hoped that the research pursued here will encourage greater investigation of integrated frameworks and feasible strategies to tackle the core challenges of our time – sustainability, equitable distribution, and democratic governance.

Chapter 1

INTRODUCTION

1.1 Key Challenges Posed by Energy Systems[1]

Despite decades of efforts to promote greater socio-ecological sustainability, global society is failing to meet three important challenges in the context of energy and climate change: 1) the deep decarbonization challenge posed by climate change; 2) the demand for equitable distribution concerning the benefits and burdens arising from climate change and high-risk energy technologies; and 3) the demand for democratic governance of energy systems.

These three challenges are recognized in this dissertation as core issues facing global society (Figure 1). But this does not mean that there is no other challenge posed by modern energy systems. There may be other urgent challenges unique to some countries or cities. The three challenges of deep decarbonization, equitable distribution, and democratic governance are chosen and extensively discussed in this dissertation because these challenges, if not addressed in a proper and timely manner, could have far-reaching social and ecological impacts. Besides, the three challenges are considered major issues commonly applied to and shared by global society. The

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[1] An energy system can be understood in many ways according to heterogeneous perspectives (see Araújo, 2014 and Kuzemko et al., 2016). Here, it refers to a socio-technical system of energy production, delivery, consumption, and disposal, involving actors, technological artifacts and materials along with institutions shaping energy rules, laws, policies, regulations and practices.

subsequent subsections briefly talk about these cases (see Chapter 2 and Chapter 3 for further discussion).

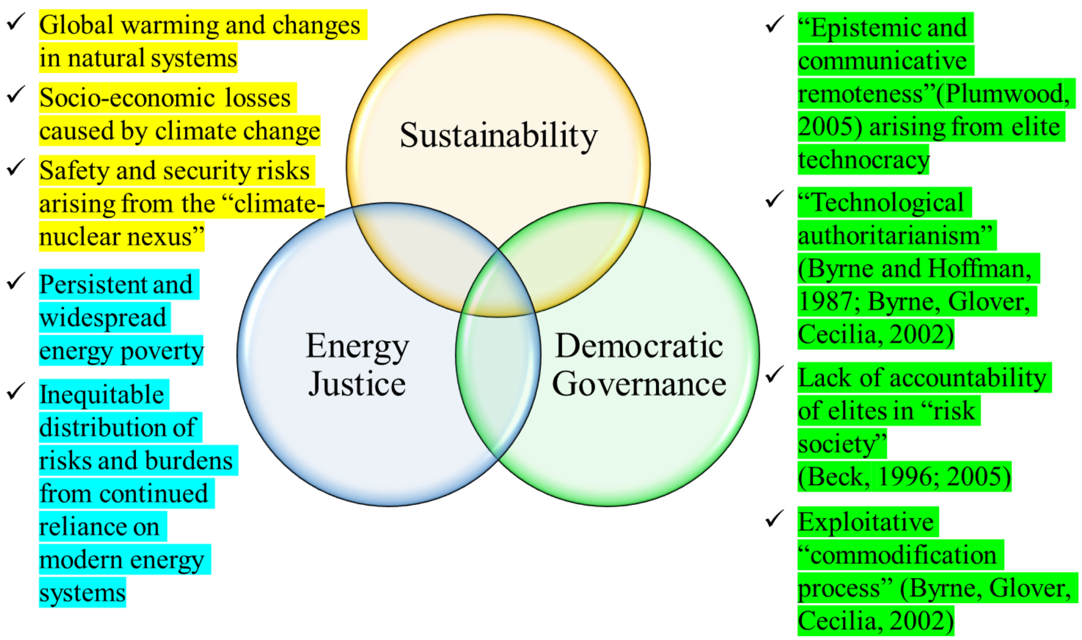

Figure 1. Key Challenges Posed by Modern Energy Systems
Note: The list of challenges in the figure is not intended to be exhaustive.

1.1.1 Sustainability Challenges

Global society and ecosystems are under an imminent threat of climate change (Steffen, Broadgate, Deutsch, Gaffney, & Ludwig, 2015; Huss, et al., 2017; Sarfaty, Gould, & Maibach, 2017; Postel, 1994). Through persistent rises in the global average temperature, so-called global warming, climate change is transforming the earth's climate system (IPCC, 2014a; Bruckner, et al., 2014; Allen, et al., 2009). Global warming is changing the Earth's natural systems and causing severe economic, ecological, and social problems, such as rising sea levels, mass distinction of species, severe droughts, intensified wildfires, and health risks (Brown, et al., 2013; Sarfaty, et al., 2017; IPCC, 2014a). Concerns about global warming are rapidly growing worldwide.

It is widely recognized that a substantial reduction of the total amount of GHG emissions over the next decades could only stabilize global temperatures that have continuously been increasing (IPCC, 2014a; Allen, et al., 2009; Meinshausen, et al., 2009; Bruckner, et al., 2014; Bataille, et al., 2016; Matthews & Caldeira, 2008). In other words, the global GHG emissions must decrease by more than 40 percent by 2050 compared to 2010 and to nearly zero by 2100 if global society is to limit the global mean temperature to the minimum threshold established by scientific communities. These long-term goals, which were endorsed by more than 175 nations as of 2017, are recognized by climate scientists that, if the goals are achieved, the global mean temperature rise would be limited to less than 2℃ above pre-industrial levels by 2100 (UNFCCC, 2018). International research communities are, therefore, calling for a rapid and immediate or "deep" decarbonization (IPCC, 2014a; IEA, 2016a; Byrne & Lund, 2017a; Geels, Sovacool, Schwanen, & Sorrell, 2017).

Yet, recent studies have found that current business-as-usual approaches to reduce global GHG emissions are failing to address the challenge of deep decarbonization required to meet the 2℃ target (IPCC, 2014a; Raftery, Zimmer, Frierson, Startz, & Liu, 2017; Bataille, et al., 2016). These studies have revealed that globally averaged atmospheric abundances of GHG emissions have continued to increase in recent decades. In 2016, the total amount of global GHG emissions reached about 49.3 billion tons of CO_2 equivalent (tCO_2e). Carbon dioxide (CO_2), the largest source of GHG emissions, amounted to about 73% of the total global GHG emissions (Janssens-Maenhout, et al., 2017). Other major GHG emissions – methane (CH_4) and nitrous oxide (N_2O) – have increased during the last decade by 6.8 parts per billion (ppb) per year and 0.9 ppb per year, respectively (WMO Global Atmosphere Watch Programme, 2017). An analysis of Friedlingstein et al. (2014) shows that global society has already used more than 60% of the CO_2 emissions quota, i.e., an estimate that global society is allowed to produce to meet the 2℃ target. The research team finds that the remaining quota will be exhausted in about 30 years without stronger mitigation measures (Friedlingstein, et al., 2014).

Energy sector emissions, including fossil fuel combustion to support electricity use, transport and the end-use sectors, are estimated to be the largest source of GHG emissions. The latest IEA study shows that global energy-related CO2 emissions reached "a historic high of 32.5 gigatonnes, accounting for about 70% of the total CO_2 emissions from human activity (IEA, 2018). It implies that the global energy system is a major driver behind the continued increases of global GHG emissions, calling for a deep decarbonization of energy-based carbon emissions.

1.1.2 Justice Challenges

The modern energy system is considered by many as a key vehicle to expand the economy and enhance the relative convenience of many individuals (Yoo, 2005; Stern & Kander, 2012; Ayres & Voudouris, 2014). But it has become a major source of engendering a range of divisive issues concerning inequity. For instance, the parties who are often cited as most responsible for global warming, such as multinational corporations in energy, steel, or semiconductor industries, have reaped considerable private gains from carbon-intensive business activities. On the other hand, residents and ecosystems located near power plants and the manufacturing sites run by these corporations can be easily exposed to an array of pollution. Likewise, those least responsible for global warming often end up bearing the heavier burdens, such as flooding, drought, high-intensity storm damage (see Cheney & Disparte, 2017 and UNDP, 2012). These inequitable practices and results can become key sources of social conflicts and potential barriers to maintaining community trust (Glover, Postmodern Climate Change, 2006).

Indeed, there is a growing demand for equitable approaches to these problems. Often referred to as energy justice, this discourse traces the origin to environmental justice and is closely associated with other concepts of justice. Justice discourses seek to apply justice principles to various fields of study other than energy including, but not limited to, the environment (Bullard, 2005; Schlosberg, 2013), ecology (Baxter, 2014), climate (Pettit, 2004; Bulkeley, Edwards, & Fuller, 2014), sustainability (Agyeman, 2013), and water (Zwarteveen & Boelens, 2014). In general, the concept of energy justice seeks to apply justice principles to energy policy and is comprised of three tenets – distributional, recognition, and procedural justice – which are often cited as useful tools to analyze various equity issues arising from modern energy systems (Jenkins, McCauley, Heffron, Stephan, & Rehner, 2016). It is argued that the principles of energy justice must be integrated into the institutionalization of energy systems and the design of energy policies (Jenkins et al., 2016; Bullard, 2005; Agyeman, 2013; Klinsky & Dowlatabadi, 2009).

The need for energy justice is further underscored because of ongoing cases where burdens from energy systems are shifting to other regions or future generations. High-risk energy facilities, such as nuclear reactors, coal-fired power plants, and high-voltage power transmission towers, are located in rural areas while these artifacts are largely intended to meet energy needs of urban areas (Lee & Lee, 2015). Residents in the rural areas tend to be exposed to higher health and safety risks posed by the facilities. Similarly, children including unborn generations will inevitably endure far-reaching consequences of climate change. They are expected to cope with a range of issues concerning nuclear power. For example, the lifetime of a nuclear reactor is generally 40 years and, if an extension is approved, 60 years (NEA and IEA, 2015), implying that the current generation, particularly children and adolescents, will have to bear potential disastrous risks from these reactors. Even though the current fleet of nuclear power plants was shut down today, the unresolved issues of nuclear radioactive wastes, which is estimated to be stored for more than 10,000 years (Verbruggen, Laes, & Lemmens, 2014), will likely remain a big challenge to many generations to come.

So-called energy-poverty nexus is another challenge of energy justice. There are various terminologies characterizing energy-poverty nexus. The definitions of these terminologies differ mostly depending on an array of factors. For instance, fuel poverty is a concept that is most widely used in the global North. This concept is generally defined as the inability to pay energy services, especially heating, and characterizes fuel poverty as a situation where a household's fuel expenditure on all energy services exceeds ten percent of their income (Moore, 2012; Boardman, 1991). IPCC (2014a) also defines fuel poverty as "a condition in which a household is unable to guarantee a certain level of consumption of domestic energy services (especially heating) or suffers disproportionate expenditure burdens to meet these needs" (p. 123). In the global South, the dominant terminology is energy poverty which describes a human condition in which people lack access to clean and safe energy service for basic needs, such as cooking, heating, lighting, etc. (IEA, UNDP, and UNIDO, 2010).

This concept often extends to encompass social and economic perspectives that basic energy services are a prerequisite to human and economic development (Day, Walker, & Simcock, 2016). There exists growing scholarship that attempts to offer alternative models of conceptualizing energy-poverty nexus challenges. For example, Bouzarovsky and Petrova (2015) criticize the dominant "fuel-energy poverty binary" (p. 33) and emphasize the importance of integrating "vulnerability thinking" (p. 35) into the analysis of energy-poverty nexus challenges.

Many people in both high-income and low-income countries are persistently in energy poverty. They do not have access to electricity or cannot afford sufficient heating and cooling while experiencing extreme weather conditions. For instance, over half the population in Sub-Saharan Africa does not have access to electricity (IEA and World Bank, 2015; IEA, 2017b). High-income countries are facing similar challenges. For example, a sizeable number of people in high-income countries including the United States (Byrne & Yun, 2017a), western European countries, like France and the United Kingdom (European Parliament's Committee on Industry, Research, and Energy, 2015), and East Asian countries, such as Japan (Okushima, 2016) and South Korea (Byrne & Yun, 2017a), are classified as energy poor.

The last important issue of energy justice issue arises from an effort to address the challenge of deep decarbonization. For instance, high-income countries are obligated or expected to take more active measures to cut their emissions than low-income countries (Article 3.1 of the United Nations Framework Convention on Climate Change). So-called "Common but Differentiated Responsibilities" (UNFCCC, 1992), this principle was formalized in 1992 and agreed by all parties to the United Nations Framework Convention on Climate Change (UNFCCC). But a growing number of empirical studies show that high-income or large countries are contributing to global warming substantially greater than their counterparts (Byrne et al., 1998; Byrne, Kurdgelashvili, & Hughes, 2008; Gignac & Matthews, 2015; Robiou du Pont, et al., 2017). The volumes of energy-related CO_2 emissions from these countries are estimated to be far greater than the threshold required to limit unacceptable levels of global temperature increase (IPCC, 2014a; Byrne et al., 1998). The latest estimate reveals that the world's six largest emitters – China, the United States, EU28, India, Russia and Japan – produced in 2016 nearly 67% of the total global CO_2 emission or 65% of the total global GHG emissions (Janssens-Maenhout, et al., 2017).

1.1.3 Democratic Governance

It is widely recognized that modern political systems are not much dictated by key democratic principles, such as civil liberties, political participation and equality (Cammack, 1998; Beder, 2010; Miller, 2009; Wolin, 2010). In general, community members, or citizens, are not allowed to participate in the decision-making process. Their rights to be represented by elected officials are often ignored or misused.

Modern political systems and energy systems share many characters in common. Like political systems, democratic principles are not much applied to the general decision-making processes of the modern energy system, often for professed reasons of security (e.g., nuclear power planning), economic efficiency (e.g., the regulation of electricity), and technology management (e.g., transmission and distribution networks). Typical governing approaches of the modern energy system, as commonly observed in other fields of modern society, are shaped primarily by a group of experts and high-level bureaucrats. Other important stakeholders are, on the other hand, frequently "represented" by the decisions of experts and planners. Their rights to choose energy sources and technologies are often disenfranchised in the context of the modern energy system.

As global warming illustrates, modern society's anthropocentric activities have altered the chemical composition of the Earth atmosphere and geophysical processes, creating an unprecedented epoch in human history, often called Anthropocene (O'Brien & Sygna, 2013; Steffen, Crutzen, & McNeill, 2007; Steffen, et al., 2011). But current approaches to problem-solving appear to be insufficient or ineffective in addressing such a far-reaching challenge. Under this circumstance, a growing body of energy research identifies the shortcomings of current approaches to analyzing the sustainability challenges and argues that the governance conditions of energy system are needed to democratically design and implemented (Angel, 2016; Byrne & Taminiau, 2015; Harvey, 2012).

It is also worth noting that there is a growing need for critical inquiries about the democracy-technology relation on the brink of an emerging new social order (Byrne & Toly, 2006; see also Hager, 1995 and O'Brien 2012). Trends in artificial intelligence (AI), automation, and machine learning, can exert a profound influence upon a vast range of our society's values and goals. For example, approximately 30 to 50% of the existing jobs are estimated to be displaced by the ongoing computerization (Smith & Anderson, 2014; Frey & Osborne, 2013; Manyika, et al., 2017). Job losses can lead to a massive unemployment, particularly among the poor, perhaps exacerbating issues of income inequality. This, in turn, may create a social condition where authoritarian regimes could gain the majority support of voters in liberal democracies (West, 2018). The politics and social conditions of high-tech countries can be particularly affected by this new socio-technological trend. For example, unemployment is currently a big issue in South Korea. But the country has the highest robot density in the world, reaching 631 installed robots per 10,000 employees in the manufacturing industry as of 2016 (IFR, 2018). Yet, major discourses and debates in many nations, including South Korea, are not actively engaging in systemic inquiries about the political and social implications of the advent of new technologies.

1.2 Aims and Research Design of the Dissertation

Figure 2 outlines the aim and the conceptual framework of the dissertation. As discussed in the previous section, global society is failing to meet the three important and interrelated challenges (see also Chapter 2). This failure can be traced in part to our lack of research on integrated modeling of deep decarbonization, energy justice, and democratic governance. A growing body of research has offered alternative approaches to the challenges of deep decarbonization, energy justice, and democratic governance of energy systems, in isolation or sometimes in a partial analysis of policy options. Global society has largely focused on tackling the challenges step-by-step or incrementally, running the risk of requiring a deeper reduction in carbon (due to the non-linear character of their atmospheric concentration) and higher risks of triggering disasters (IPCC, 2014a). In this context, the dissertation proposes a new integrated framework that is sustainable, equitable, and democratic. Coined here as a Deep, Equitable, and Democratic Energy Transition (DEDET) Framework, this integrated model is proposed to guide analysis, assessment, and development of policy alternatives.

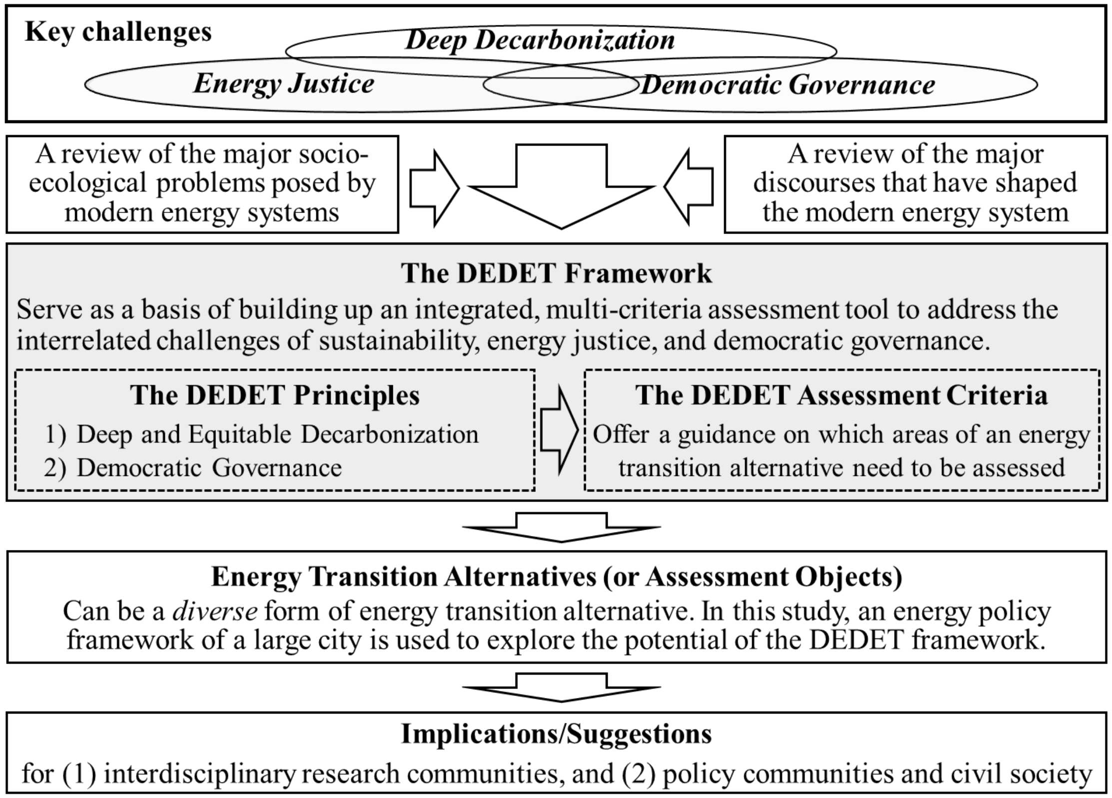

Figure 2. A Conceptual Framework of the Dissertation

This dissertation conducts a review of major discourses of the energy-society relation, along with a discussion of socio-technical and socio-ecological problems posed by energy systems, as captured in Figure 2. Largely defined as a way of understanding the world, a discourse plays a significant role in shaping our beliefs, norms, institutions, social practices and so forth (Dryzek, 2013). In this sense, Wolin (1968) defines a discourse as a paradigm (p. 139), and discourses and paradigms are used interchangeably in this dissertation. Byrne and Toly (2006) point out that energy systems are the artifacts of political and social discourses, suggesting that energy systems are politically and socially constructed. O'Brien (2012) criticizes major strands of studies on climate change for their failure to question "…the assumptions, beliefs, values, commitments, loyalties and interests that have created the structures, systems and behaviors that contribute to anthropogenic climate change, social vulnerability and other environmental problems in the first place” (p. 668). The dissertation highlights that current analytical and governing approaches are largely based on prevailing epistemological and institutional paradigms, like elitist technocracy and market liberalism, and are incapable of solving the three interrelated challenges. This dissertation maintains that the challenges identified through a comprehensive review of major discourses, along with a discussion of a range of socio-ecological problems posed by energy systems (Chapter 2), can serve as a sound basis for identifying key principles underlying the DEDET Framework. The key principles are elaborated in Chapter 4.

DEDET is proposed for two audiences: (1) interdisciplinary research communities seeking to research integrated approaches to address the interlinked challenges of the modern era; and (2) policy-makers and citizens seeking to shape energy transition policy in a manner that can resolve the three challenges. There exist numerous studies offering alternative approaches to the challenges of deep decarbonization, energy justice, and democratic governance of energy systems, in isolation or sometimes in a partial analysis of policy options. That is, there are a growing number of models seeking sustainability and equity. Others examine equity and democracy. But a review of major studies, including the syntheses prepared by IPCC, do not show significant research on models to address all three challenges in an integrated manner (see the introduction part of Chapter 4 for further explanation). This dissertation targets interdisciplinary research as the first audience and is intended to add a more integrated research approach to the ongoing scholarly endeavor to develop sustainable, equitable, and democratic policy options. A second and equally important audience for the dissertation is the body of policy planners and policymakers, and citizens. The new framework presented here can be used to provide conceptually sound and empirically assessed metrics to develop an energy strategy that is sustainable, equitable, and democratic.

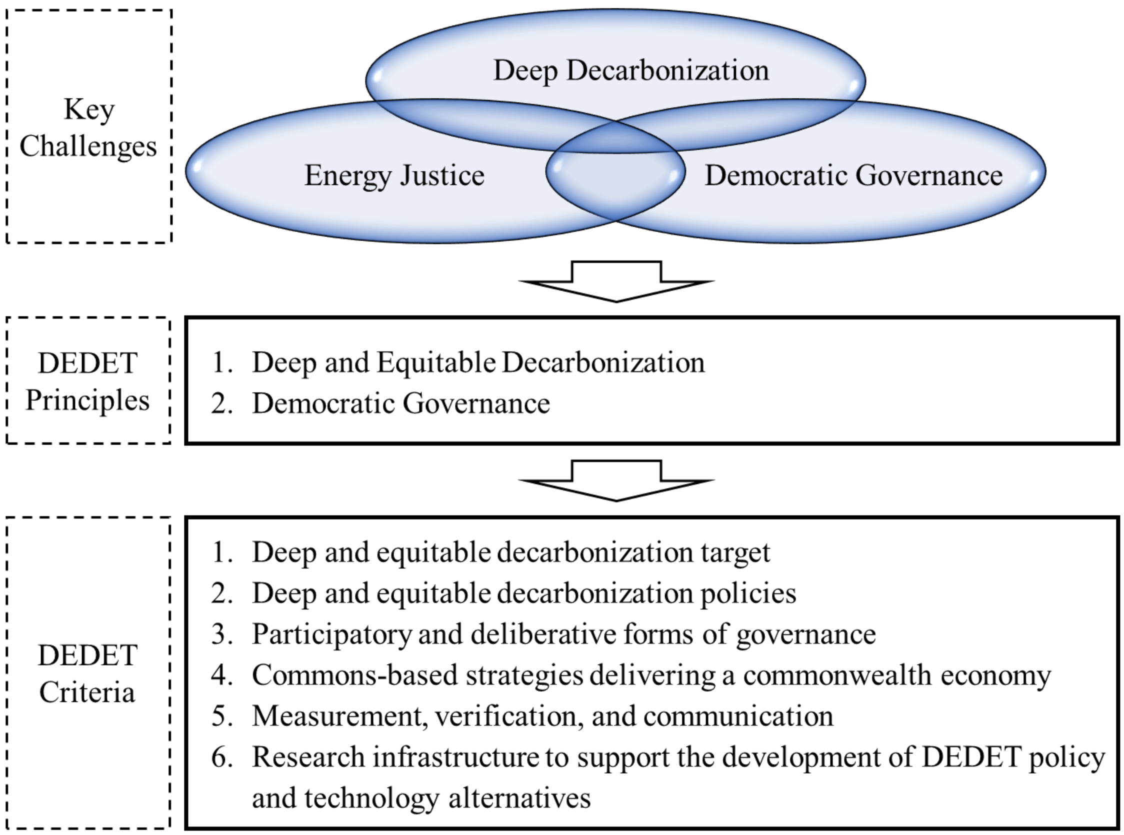

Figure 3. Scope of the Dissertation Concerning the Development of DEDET Framework

The goal of DEDET is to offer guidance at a conceptual level for building an integrated framework that can resolve the interrelated challenges of deep decarbonization, energy justice, and democratic governance (see Figure 3). DEDET is not a definitive model encompassing all relevant issues or detailed guidance on assessment metrics, like scoring methodologies. While it is hoped that a multi-criteria framework can be organized to complement DEDET, this dissertation is intended to create a basic platform as a starting step to build an integrated tool.

The potential of the DEDET Framework for use in actual cases is examined in the dissertation. Referred to as DEDET Criteria, a set of questions are proposed here as the basis for indicators to assess if an energy alternative meets the principles of the framework (see Chapter 5). Large cities are analyzed as important institutional hosts for this experimentation. The largest and busiest cities arguably present the greatest challenge to the achievement of deep, equitable, and democratic decarbonization (see Chapter 5 for further discussion). On the other hand, large cities are important sites for policy innovation and democracy. From the early work of Lewis Mumford (1961) to the recent work of Bulkeley (2014), scholars have described the historical role of large cities in incubating new ideas, new policies, and new economies. The role and importance of large cities are further underscored by a growing body of research on the potential of urban "commoning" (Harvey, 2012) and polycentric governance approaches (Ostrom E., 2009; Taminiau, 2015) in tackling the dual challenges of climate change and the persistent reliance on high-risk technologies. Some have further argued that the distributed nature of sustainable energy transition makes cities more feasible and appropriate than centralized forms of nations (Rohracher & Spath, 2014).

To test the potential of the DEDET framework in an urban context, this dissertation carries out an in-depth case study of Seoul, South Korea, along with a preliminary comparative analysis of London, Austin, and Freiburg. The three cities, often considered "leaders" in urban sustainability, are briefly reviewed against DEDET to offer a glimpse idea of the framework's applicability. The city of Seoul has experimented with a range of energy policies, notably One Less Nuclear Power Plant (OLNPP) initiative, to counter issues of climate change, energy justice, and energy democracy. Focusing on OLNPP, the dissertation deploys DEDET to demonstrate the usefulness of integrated assessment.

The dissertation concludes with implications of this study for interdisciplinary sustainability research and for the development of integrated policy strategy. It is hoped that the research pursued here will encourage greater investigation of integrated frameworks and feasible strategies to tackle the core challenges of our time – deep decarbonization, energy justice, and democratic governance.

1.3 Outline of the Dissertation

In this opening chapter, the three major challenges posed by energy systems were briefly discussed. Details of these challenges are elaborated in the next chapters (see Chapter 2 and Chapter 3). The aim and the research design of the dissertation were also explained. Including Chapter 1, this dissertation consists of seven chapters, as elucidated in Figure 4.

In the next two chapters, the research background is elaborated to critically understand the major challenges posed by energy systems. Chapter 2 discusses defining ecological and social conditions caused by contemporary energy systems. Focusing on issues of sustainability and equity arising from climate change and the continued reliance on high-risk technologies, the chapter characterizes energy systems as the largest and most problematic source of climate change. Key challenges with respect to energy systems from an equity point of view are also discussed in this chapter. The focus of Chapter 3 is to understand major governance challenges posed by energy systems. This chapter discusses theoretical backgrounds and empirical evidence supporting the argument that the prevailing discourses of the modern era, like elite technocracy and market liberalism, have significantly shaped the epistemological and institutional paradigms forming global energy systems. Drawing on a review of the existing scholarship, this chapter identifies institutional arrangements and practices attributable to these discourses. This chapter concludes with major governance challenges within or posed by global energy systems in relation to the dominant discourses.

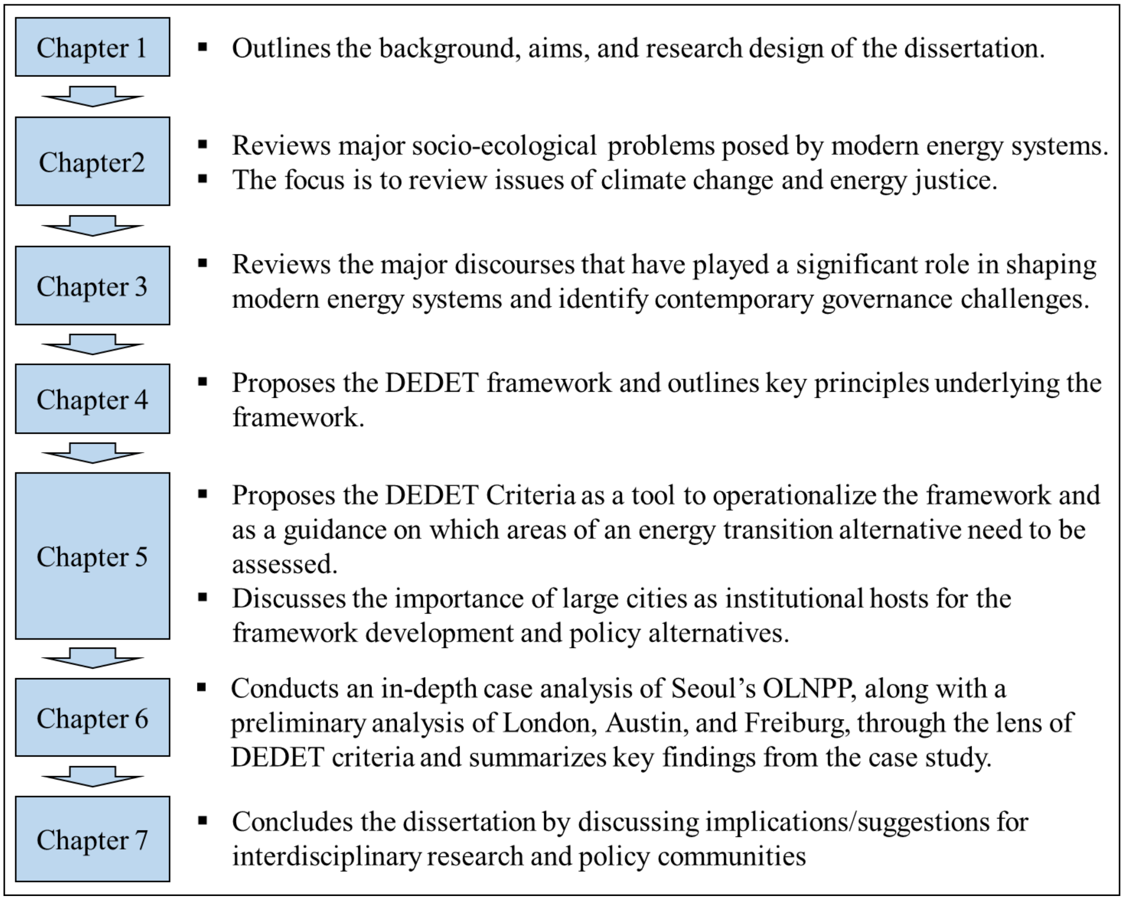

Figure 4. A Summary of the Outline of Chapters for This Dissertation

Chapter 4 develops the DEDET Framework, calling for new principles that need to be embedded in the development of sustainable energy alternatives. The framework identifies 1) deep and equitable decarbonization and 2) democratic governance as key principles. Energy sources and technologies that can be considered for DEDET are also discussed.

Chapter 5 extends the discussion by introducing potential six criteria that can be used as an integrated tool to assess an energy transition alternative. Large cities are identified as important institutional hosts for the development of the DEDET framework. Major motives and reasons of why large cities are selected are explained.

Chapter 6 carries out a preliminary comparative analysis of London, Austin, and Freiburg, followed by an in-depth case analysis of Seoul, South Korea. Based on the DEDET Criteria, Seoul's One Less Nuclear Power Plant (OLNPP) initiative is analyzed. Based on the key findings from the case study, this chapter discusses the potential of the framework as well as quantitative and qualitative gaps that Seoul needs to address to meet the DEDET requirements.

Lastly, Chapter 7 concludes the dissertation by identifying research limitations and offering suggestions to the target audiences for further research.

Chapter 2

SUSTAINABILITY AND JUSTICE CHALLENGES OF ENERGY SYSTEMS

The modern energy system can be characterized as a centralized socio-technical system of energy provision and consumption, typically comprised of large and high-risk technologies and non-renewable sources of energy (Kuzemko, Lockwood, Mitchell, & Hoggett, 2016). These technological artifacts include, but are not limited to, electricity supply systems relying on nuclear and coal-fired power generation and fossil fuel-based transportation systems.

A growing body of research points out that a vast range of social, ecological, or socio-ecological problems are attributable to the conventional production and consumption modes of the modern energy system, calling for a change in the means to produce, deliver and consume energy services. Often referred to as energy transition, this change may begin with a clear understanding of diverse socio-ecological problems posed by modern energy systems (Rauschmayer, Bauler, & Schäpke, 2015). A review of these challenges can also be useful in decoding the complexity of modern energy systems (Cherp, Jewell, & Goldthau, 2011) and building a better framework for energy governance (Kuzemko et al., 2016).

In this context, Chapter 2 reviews major socio-ecological problems caused by or arising from modern energy systems, focusing on major socio-ecological issues of climate change and the inequitable distribution of the benefits and burdens of energy systems.

2.1 Major Challenges of Deep Decarbonization

There is a myriad of and a wide range of evidence showing that climate change is an objective reality and the consequence of an anthropocentric production and consumption system. IPCC and many research bodies offer numerous problems caused by climate change and important challenges facing the international community. This section discusses some of these problems and challenges that are seriously threatening the sustainability of human society and ecosystems.

2.1.1 Global Warming and Changes in Natural Systems

The global average surface temperature has increased by 0.85℃ over the period from 1880 to 2012 (IPCC, 2014a). The 1983-2012 period is estimated as the warmest thirty-year period of the last 800 years (IPCC, 2014a). All analyses of several major datasets point out a rapidly increasing trend of global mean temperature over the last century (see Figure 5). The earth's surface temperatures in 2014, 2015, and 2016 were the warmest since 1880 (NASA, 2017). The latest analysis reports that 2017 was the second highest global average temperature on record (Schmidt & Arndt, 2018).

The IPCC clearly states that global warming and climate change are man-made and anthropogenic crises (IPCC, 2014a). Largely driven by a combination of economic growth, population increases, carbon-based industrialization and rapid urbanization, energy-related GHGs account for nearly half the total global GHG emissions (US EIA, 2009; IPCC, 2014a)..

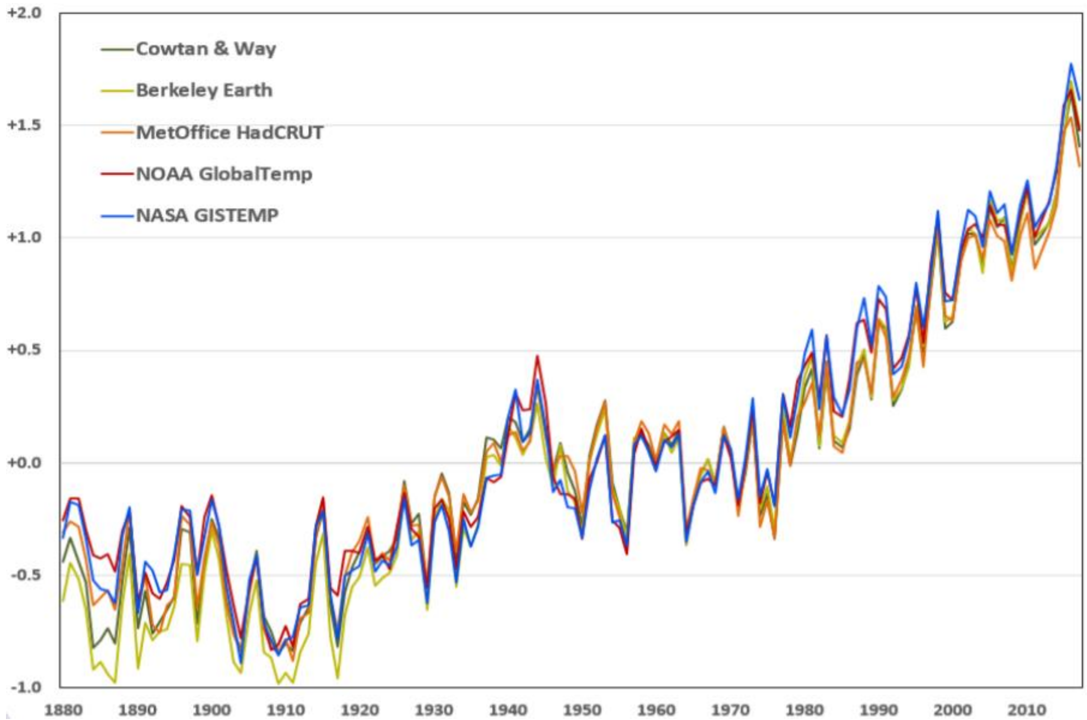

Figure 5. Global Temperature Time Series (difference from 1951-80 average, in °F)
Source: Annual Global Analysis for 2017 (Schmidt and Arndt, 2018)

One of the most recent analyses shows that the energy supply sector alone was responsible for approximately thirty-five percent of the total global anthropogenic GHG emissions in 2010 (Bruckner, et al., 2014). By GHG type, the atmospheric abundances of carbon dioxide (CO_2) and methane (CH_4) – main GHGs released from energy systems – have increased by thirty percent (287 ppm to 399.5 ppm) and sixty-one percent (722 ppb to 1834 ppb), respectively, since 1750 (Blasing, 2016). The latest analysis reports that the monthly average CO_2 concentration in April 2018 exceeded 410 ppm (Monroe, 2018). The US National Oceanic and Atmospheric Administration (NOAA)'s Annual Greenhouse Gas Index (AGGI), which measures how much long-lived greenhouse gases (LLGHGs) influence global warming on an annual basis, also indicates that LLGHGs have constantly increased since 1750 (Butler & Montzka, 2017). As Figure 6 shows, both the empirically measured carbon dioxide equivalent (CO_2e) concentration and the AGGI have constantly gone up since 1990, which was designated as the baseline year for mandatory GHG reduction targets for Annex I countries under the Kyoto Protocol.

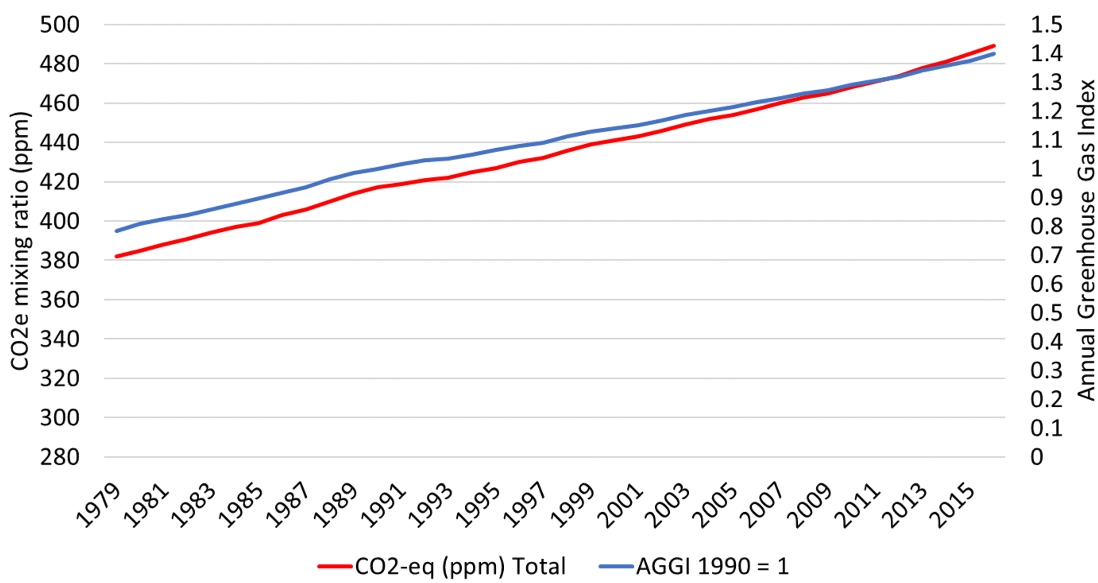

Figure 6. Changes in Carbon Dioxide Equivalent Concentration and the NOAA Annual Greenhouse Gas Index (AGGI)

Note: The graph above is created based on the dataset provided by NOAA (available at https://www.esrl.noaa.gov/gmd/aggi/aggi.html).

These changes in the chemical composition of the atmosphere are ascribed to a range of alterations in climate and natural systems at global levels. For example, the earth's cryosphere, including the ice sheets, ice caps, glaciers, areas of permanent snow and permafrost, is rapidly declining. Coupled with the thermal expansion of the ocean, it leads to rising sea levels. Mass distinctions of species are also pointed out as a far-reaching consequence of global warming (IPCC, 2014a; Huss, et al., 2017). At regional levels, the frequency of heat waves has increased in many parts of Europe, Asia, and Australia (IPCC, 2013). The frequency and intensity of heavy precipitation events, including hurricanes, has also increased in North America and Europe (IPCC, 2013). Some regions including developed countries, Australia and US for example, are experiencing super droughts, causing fresh water shortages and wildfires. Figure 7 and Figure 8 capture some of the fundamental causes of global warming and marked changes in the ecosystem, respectively.

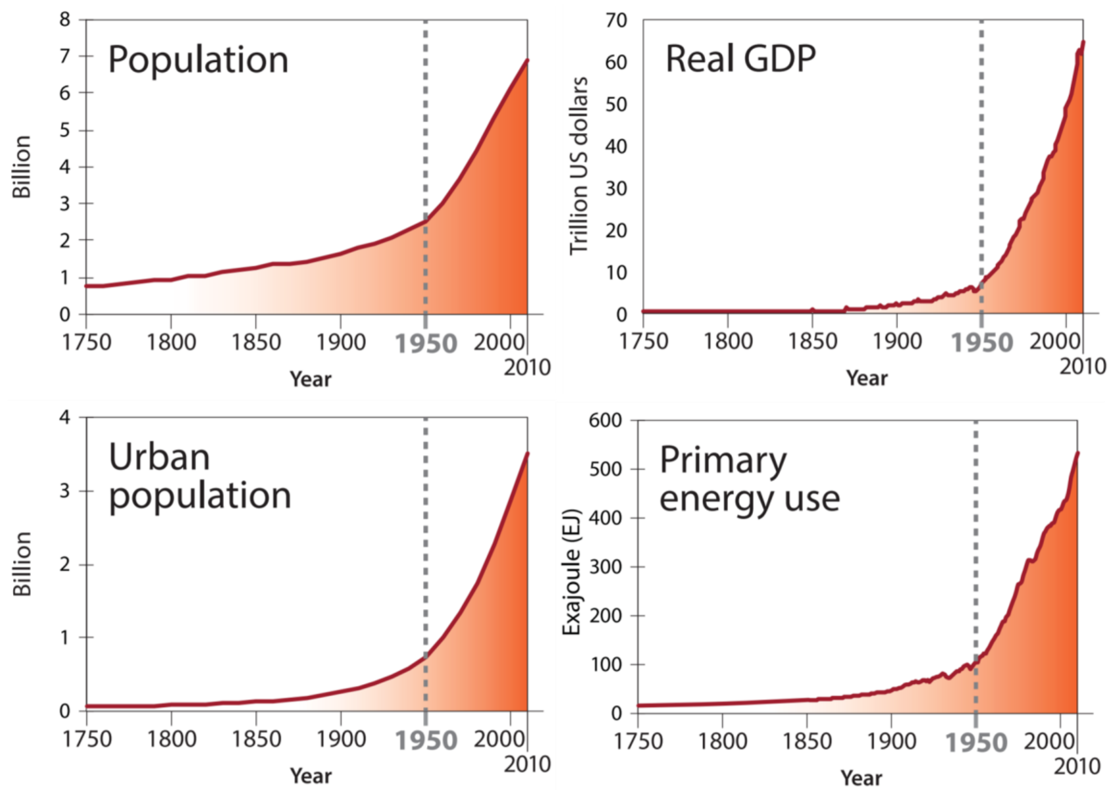

Figure 7. Major Causes of Climate Change
Source: The Trajectory of the Anthropocene: The Great Acceleration (Steffen et al., 2015)

It is also important to note that climate-related impacts could be unexpectedly far-reaching with compounding effects. In natural systems, in which an isolated non-material event is rarely noticed, weather-related factors can influence one another, which could intensify extreme weather events and in turn exacerbate the consequences. For instance, the landfall of a hurricane coinciding with high sea levels increases the risk of flooding, as evidenced by Superstorm Sandy in 2012. Sandy made landfall at high tide on the Atlantic Ocean and in New York Harbor (City of New York, 2013). With rising sea levels, the compounding effects of a strong hurricane can be disastrous.

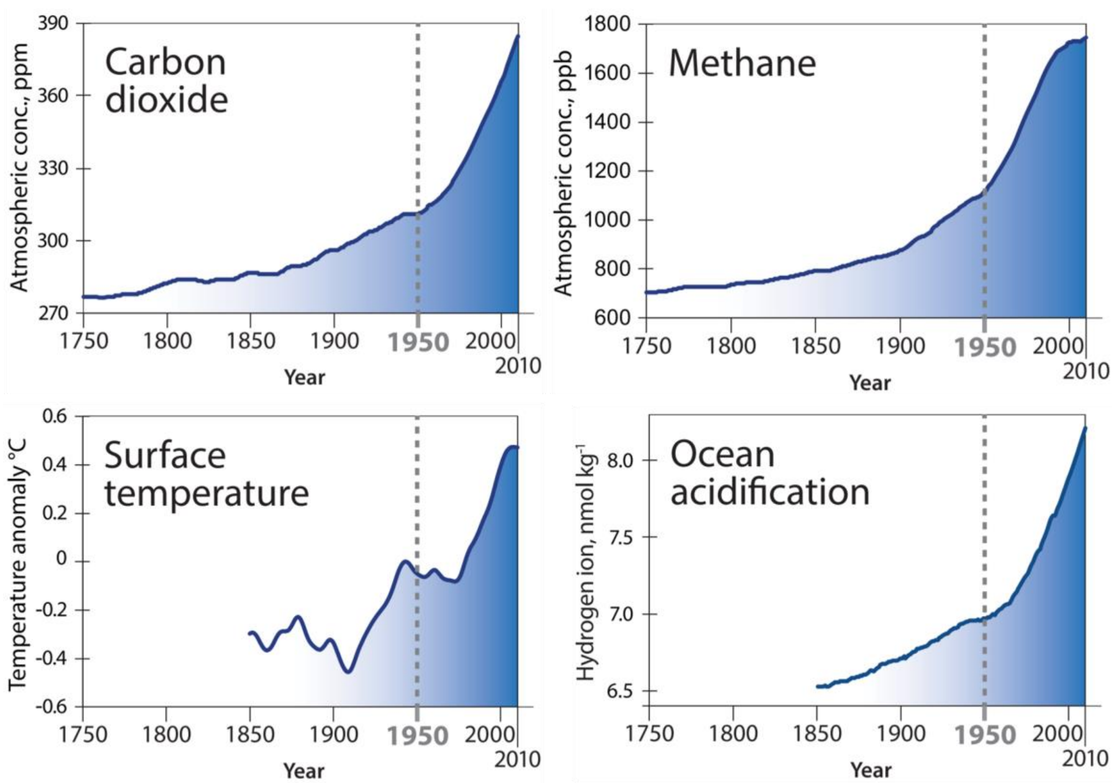

Figure 8. Obvious Changes in the Atmospheric and Oceanic Systems
Source: The Trajectory of the Anthropocene: The Great Acceleration (Steffen et al., 2015)

2.1.2 Socio-Economic Losses Caused by Climate Change

The accurate quantification of the socio-economic impacts of climate change is considered challenging as it involves an array of assumptions and uncertainties (IPCC, 2014a). With the recognition of this challenge, IPCC and other research bodies predict that the aggregate economic losses associated with climate change continue to grow. For instance, IPCC claims that "global annual economic losses for warming of ~2.5℃ above pre-industrial levels are 0.2 to 2.0% of income" (IPCC, 2014a). Munich Re, a German global reinsurance company, estimates a loss of $163 billion in 2016 due to meteorological, hydrological, and climatological events (Munich Re, 2017). Swiss Re, a Swiss global reinsurance company, estimates that insured losses from weather-related events have grown from 0.018% of global GDP between 1974 and 1983 to 0.077% of global GDP between 2004 and 2013 (Bevere & Mueller, 2014). A recent report estimates that the US alone has lost fifty-two billion US dollars for the last decade due to weather events. When combined with health costs caused by fossil fuel power generation, they argue, the annual economic cost associated with current energy systems reaches $240 billion (Watson, McCarthy, & Hisas, 2017).

Modern energy systems are considered inefficient in some senses. For example, a substantial portion of primary energy is wasted during energy conversion and transmission (Sovacool, 2012). During the lifecycle of electricity, including long-distance transmission and distribution, two-thirds of primary energy is estimated to be wasted, indicating that final usable energy is generally about thirty percent or forty percent of primary fossil energy. Indeed, the US EIA found that the average efficiency of an electricity generator by energy source is thirty percent for coal-, oil-, or nuclear-powered plants and forty-three percent for natural gas plants in the United States (US

EIA, 2016). Barely have these efficiency rates grown over the last ten years since 2005 (US EIA, 2016).

As discussed earlier in this section, IPCC has found that weather-related extreme events have increased in many regions since 1950, including warm temperature extremes, high sea levels, and heavy precipitation events (IPCC, 2014a, p. 53). The socio-economic consequences of these extreme events are typically widespread and far-reaching. For instance, pest and disease outbreak is rising in both developed and underdeveloped countries, causing health risks and mortality to increase (IEA, 2016b; Sarfaty et al., 2017). Tropical cyclones, including hurricanes and typhoons, have killed many people and caused severe property damages in many parts of the world. The total costs spent to recover damages from Hurricane Katrina was about $120 billion (Milman, 2017). The 2017 hurricanes, such as Harvey, Irma, and Maria, have devastated urban centers like Houston in Texas and islands like Puerto Rico, and are expected to require more than $120 billion to rebuild. For instance, the governor of Texas said that the recovery cost from Hurricane Harvey could reach $180 billion (Parraga & McWilliams, 2017). Hurricanes Irma and Maria destroyed 55% of Puerto Rico's transmission towers and damaged 100% of the distribution system, leaving the entire population without power and the majority without water (Cheney & Disparte, 2017; Vives & Hennessy-Fiske, 2017). The satellite night images of Puerto Rico before and after Hurricanes Irma and Maria show the catastrophic consequences on the island and its neighbors in the Carribean Sea, such as St. Thomas, St. Croix, and Tortola (Figure 9).

In addition, IPCC has warned that climate change can exacerbate water stress and scarcity problems in dry regions as the frequency and severity of droughts will likely increase (IPCC, 2014a, p. 64). These water shortage problems can be worsened by current energy supply systems partly due to the amount of freshwater required for operation of conventional power plants and production of fossil fuels and biofuels (Glassman et al., 2011; Macknick et al., 2012; Meldrum et al., 2013). Spang et al. (2014) compared the total freshwater consumption in more than 150 countries and found that 52 billion cubic meters of freshwater was used for energy production on an annual basis. This volume is almost sixty percent of the 2014 total water withdrawal in South Korea (World Bank, 2017b). IEA (2016c) estimates that currently 10% of global water withdrawals are used for the energy sector (p. 28).

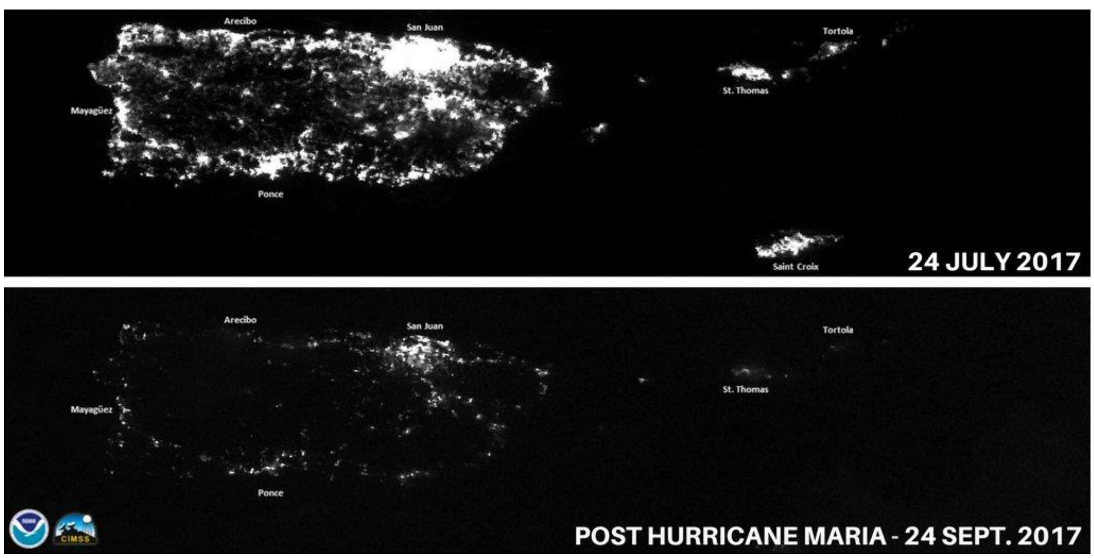

Figure 9. The Satellite Night Images of Puerto Rico Before and After Hurricane Maria
Source: The US NOAA National Environmental Satellite, Data and Information Service (NESDIS), 2017

The water sector is closely interrelated with energy. Various processes in the water sector, including the provision of freshwater and the treatment of wastewater, require energy. IEA (2016c) estimates that the water sector used approximately 120 million tons of oil equivalent (Mtoe) of energy in 2014, which is "almost equivalent to the entire energy demand of Australia" (p. 370). These circumstances indicate that the interlinked challenge posed by so-called water-energy nexus can grow due to the adverse consequences of climate change. Relatedly, it is also worth noting that the "fracking" approach used to extract shale gas is harming local water systems. Howarth et al. (2011) found that fracking for each well requires an average of 21 million liters of water (p. 273). This technical option also contaminates the water sources, particularly groundwater, by using toxic chemicals during fracking processes.

2.1.3 Potential Safety and Security Risks Arising from the "Climate-Nuclear Nexus"

Citing the nuclear industry journal *Nucleonics Week*, David Elliot (2006), an expert in technology policy, offers an intense but ongoing debate over whether nuclear power is a "green" energy technology. With growing threats of climate change to the modern civilization, the discussion of this issue is increasingly evident (Saul & Perkins, 2014). Yet, a burgeoning body of research on the so-called "climate-nuclear nexus" has found that nuclear power, coupled with climate change, could induce disastrous results, including unintended nuclear power accidents and regional security problems due to military conflicts. For instance, IPCC argues that current energy systems, including nuclear power plants, can be exposed to "accidental events" due to natural hazards (IPCC, 2014a, p. 549). IEA and the OECD's Nuclear Energy Agency (NEA), who has endorsed nuclear power as a low-carbon option, admittedly are acknowledging the potential risk of sea level rise on nuclear power operations (IEA and NEA, 2015).

The problems of climate change may threaten local and regional security. As evidenced by the nuclear disasters in Chernobyl and Fukushima Daiichi, a failure of a nuclear power station can result in social and ecological security crises through radioactive contamination and the displacement of many residents. Countries that are both vulnerable to climate change and reliant on nuclear power are particularly exposed to potential risks arising from the "climate-nuclear nexus." These countries may experience an unexpected technological failure of a nuclear power plant and/or a dangerous military conflict due to melting snows and ice, droughts, or rising sea levels. India and Pakistan, for example, have both nuclear power plants and are vulnerable to climate change. They are in conflict over shared water resources and, sometimes, trade nuclear threats and deadly attacks (Kugelman, 2016). In general, a nuclear power plant requires freshwater for cooling much more than other energy technologies. According to an estimate by the International Atomic Energy Agency (IAEA), cooling water requirements are typically greater than coal-fired or natural gas-fired power plants by twenty to twenty-five percent (IAEA, 2012). As of July 2017, India and Pakistan, respectively, have twenty-six and five nuclear reactors in operation. In addition, Pakistan is constructing two new reactors. Under these circumstances, Mian (2016) attributes the conflict between India and Pakistan to the melting snow and glacial in the Himalayas. What makes this conflict a regional and global security issue is that these two countries own nuclear warheads. It is reported that India and Pakistan have approximately 120 and 130 nuclear warheads, respectively, as of early 2017 (Kristensen & Norris, 2017).

In the United States, many electricity facilities, including power generations and substations, are exposed to potential threats from sea level rises. A recent report shows nearly 100 electricity facilities along the coast of the country are within four feet of high tide (see Figure 10) (Davis & Clemmer, 2014). Due to rising sea levels, there will be a greater possibility for any of these facilities to be affected by storm surge and floods.

Figure 10. Electricity Facilities Reportedly Vulnerable to Rising Sea Levels in the United States
Source: Power Failure – How Climate Change Puts Our Electricity at Risk and What We Can Do (Davis & Clemmer, 2014)

South Korea is exemplified in delineating a potential security risk arising from the "climate-nuclear nexus." South Korea is a small-sized country, but the population density is very high. With respect to the number of nuclear reactors, it is ranked fifth in the world. As of July 2017, the country has twenty-four nuclear reactors in operation with the installed capacity of 22.5 GW (Office for Government Policy

Coordination, 2017). There are also five new reactors under construction. The density of nuclear power reactors to the total land area is far higher than the rest of the top five countries in terms of the number of nuclear power reactors (Table 1). Any technical failure of the Kori Nuclear Power Plant (consisting of nine reactors – six reactors in operation and three reactors under construction) can be especially disastrous. It is located near two large cities, Busan and Ulsan. Roughly four million people are residing within a thirty-kilometer radius of the power station, which makes it almost impossible for the population to evacuate in time. Especially, the vulnerable population, such as the handicapped, the elderly, and the young, can be the first victims of any unexpected accident.

Table 1. The Number of Nuclear Reactors and Nuclear Power Plants Density by Country

Indicators	Rank				
	1	2	3	4	5
Number of reactors (unit)	USA	France	China	Russia	*S. Korea*
	99	56	37	35	24
Generating capacity (GW)	USA	France	China	Russia	*S. Korea*
	100	61	32	26	23
Land area (km^2)	Russia	China	USA	France	*S. Korea*
	16,376,870	9,388,210	9,147,420	547,557	97,480
Density (unit/1,000 km^2)	*S. Korea*	France	USA	China	Russia
	0.246	0.102	0.011	0.004	0.002

Note: There are other countries which are ranked higher than France in terms of density. They include Belgium, Taiwan, Switzerland, and Slovakia. The United States, China, and Russia are ranked 21st, 26th, and 27th, respectively, among 33 countries which are operating a nuclear power plant or constructing the first nuclear power plants (i.e. the United Arab Emirates). The sources used in the table above are: (Schneider, 2017) for nuclear power data as of July 1, 2017; (World Bank, 2017c) for land area in 2016

Rising sea levels are of another concern to South Korea. Sea levels surrounding the country have risen by ten centimeters over the last forty years (Ministry of Oceans and Fisheries, 2015). Particularly, the sea levels of the eastern coast of South Korea, in which there are twenty-three nuclear power reactors including five reactors under construction, have recently been increasing by 2.53 millimeters per year (Ministry of Oceans and Fisheries, 2015). Korea Environment Institute (KEI) analyzed future socio-economic impacts of sea level rise on South Korea and found that 3.96% of the national land area could be inundated due to rising seas (KEI, 2012).

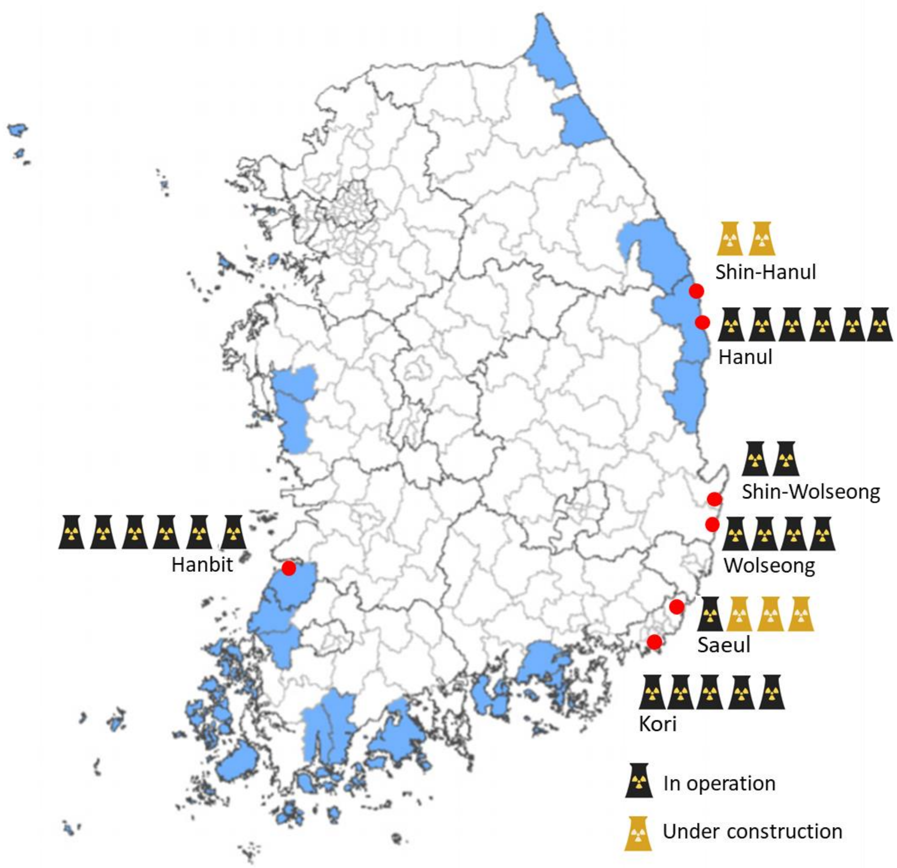

Figure 11. Nuclear Reactors and the Areas Expected to Be Inundated in 2100
Note: The blue shaded areas are forecast to be significantly affected by sea level rises (KEI, 2012). Nuclear reactor information is retrieved from the Korea Hydro and Nuclear Power Corporation (KHNP) website (KHNP, 2018).

As Figure 11 illustrates, three coastal areas hosting at least one nuclear reactor are exposed to seawater inundation due to sea level rise. This alludes to the possibility for nuclear power reactors, especially located at low-lying sites, in South Korea to be intruded upon or flooded by seawater, which can lead to system failure and, on some occasions, an explosion of a reactor (Hutchins, 2014; Kopytko & Perkins, 2011). The 2011 Fukushima Daiichi nuclear accident demonstrates how seawater intrusion could lead to far-reaching consequences (Nunes, 2015).

2.2 Challenges of Equitable Distribution of the Benefits and Burdens of Energy Systems

Despite an unprecedented economic growth and social progress, modern society is experiencing a widespread income and wealth inequality. Likewise, even though energy systems have contributed to the economic growth and social progress, the benefits and risks from energy systems are distributed largely in an inequitable manner. This section discusses some of the obvious problems and challenges posed by these inequitable practices under modern energy systems.

2.2.1 Persistent and Widespread Energy Poverty

The United Nations (UN) and several international research bodies, like IEA and the World Bank, have found that a sizeable number of people in the world are persistently in energy poverty. These people do not have access to electricity or cannot afford sufficient heating or cooling in extreme weather conditions. While estimates differ among studies, in general over one billion people – about 20% of the global population – still lack access to electricity (IEA and World Bank, 2015; UN AGECC, 2010; IEA, 2017b). As illustrated in Figure 12, more than 50% of the people in low-income countries and regions, particularly countries in the Southern Hemisphere, are estimated to have no or very limited access to electricity.

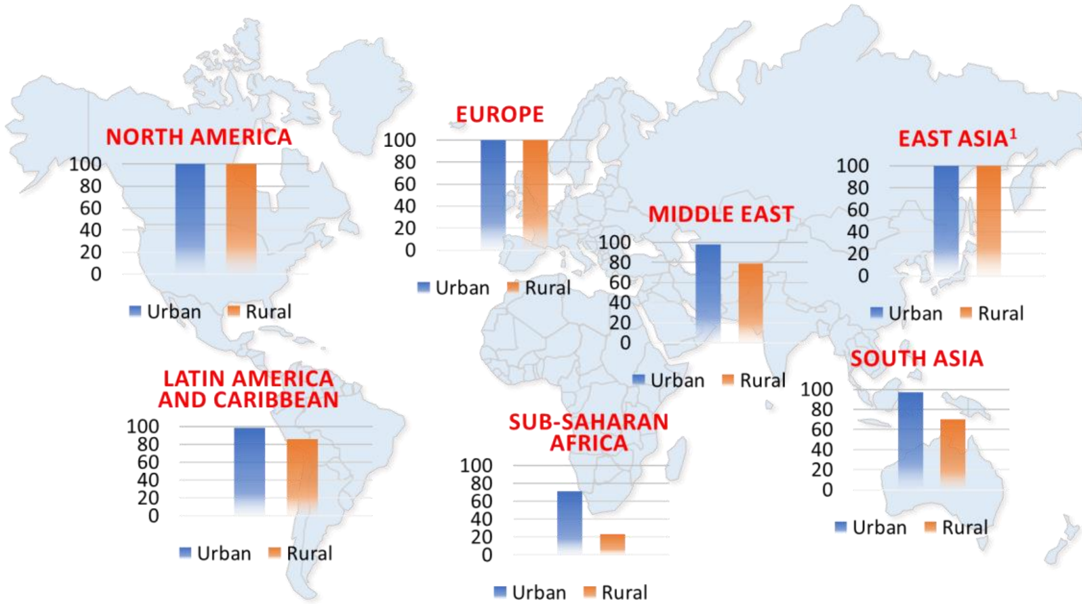

Figure 12. Access to Electricity (% of the population) in 2016

Note: Data used to create this figure is retrieved from IEA (2017b) and IEA & World Bank (2015). Democratic People's Republic of Korea (so-called North Korea) is not included. IEA (2017b) estimates that the 2016 rate of access in North Korea was 36% and 11% for urban and rural areas, respectively.

Many countries in Sub-Saharan Africa and South Asia also show a large gap of electricity access between rural and urban areas (refer to Figure 13). For instance, only eight percent of Ethiopians in the rural areas have access to electricity while 100% of the urban counterparts do. Only half rural areas in Bangladesh have access to electricity while more than 90% of the urban areas do. Due to the lack of access to modern energy services in these regions, three billion people (roughly 40% of global population) – rely on traditional biomass, such as firewood, charcoal, and crop residues, for cooking and heating (IEA and World Bank, 2015; UN AGECC, 2010).[2]

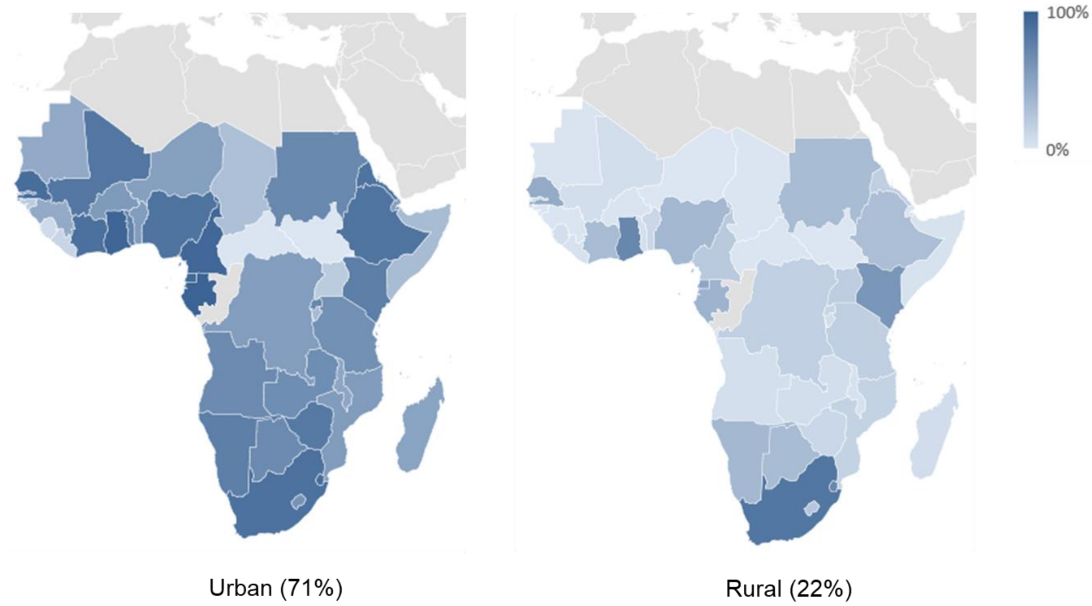

Figure 13. The Access-to-Electricity Gap between Urban and Rural Areas in Sub-Saharan Countries
Note: The map is created based on data retrieved from IEA (2017b).

A considerable number of people in high-income countries often cannot afford sufficient heating or cooling in extreme weather conditions. It is found that thirteen percent of the households in France were identified as energy poor in 2012 (European

2 There is no consensus on the definition of (modern) energy access or modern energy access. For instance, UN AGECC (2010) defines “universal energy access” as “access to clean, reliable and affordable energy service for cooking and heating, lighting, communications and productive uses” (p. 13). IEA (2016d) defines “modern energy access” as “a household having reliable and affordable access to clean cooking facilities and to a minimum level of electricity consumption which is increasing over time (p. 3)”

Parliament's Committee on Industry, Research, and Energy, 2015). The energy poverty rate in Japan has steadily increased from 4.7% in 2004 to 8.4% in 2013 (Okushima, 2016). Byrne et al. (2017a) found that the people in the lowest income quintile in the United States, United Kingdom, and South Korea pay more than 10% of their income for energy bills while those in the highest income quintile pay only 2 or 3% of their income (Figure 14).

These deficits of reliable and affordable energy services create so-called "energy poverty" or "fuel poverty" among the vulnerable (see Section 1.1.2 for a list of definitions of energy poverty or fuel poverty). These circumstances indicate that many people in both rich and poor nations do not have access to sufficient energy services for their basic needs and human development. This energy deficiency may further exacerbate their overall quality of life by depriving them of moving up the socioeconomic ladder.

So-called "gender-energy nexus" studies have found that females in low-income and vulnerable households bear heavier burdens than male counterparts with respect to energy poverty due to socially-determined gender roles (Tolemariam & Mamo, 2016; Mutasa, 2016). It is evidenced by the World Health Organization (WHO)'s estimate that more than 4.3 million people, mostly women and young girls, died in 2012 from household air pollution from inefficient biomass combustion (WHO, 2016). Females in these regions spend much time cooking and walking a considerable distance to collect and carry fuel resources, such as biomass. These roles may not only deprive females of opportunities for education and socioeconomic activities but also expose them to physical harm and human assault (IEA, UNDP, and UNIDO, 2010; UNDP, 2012).

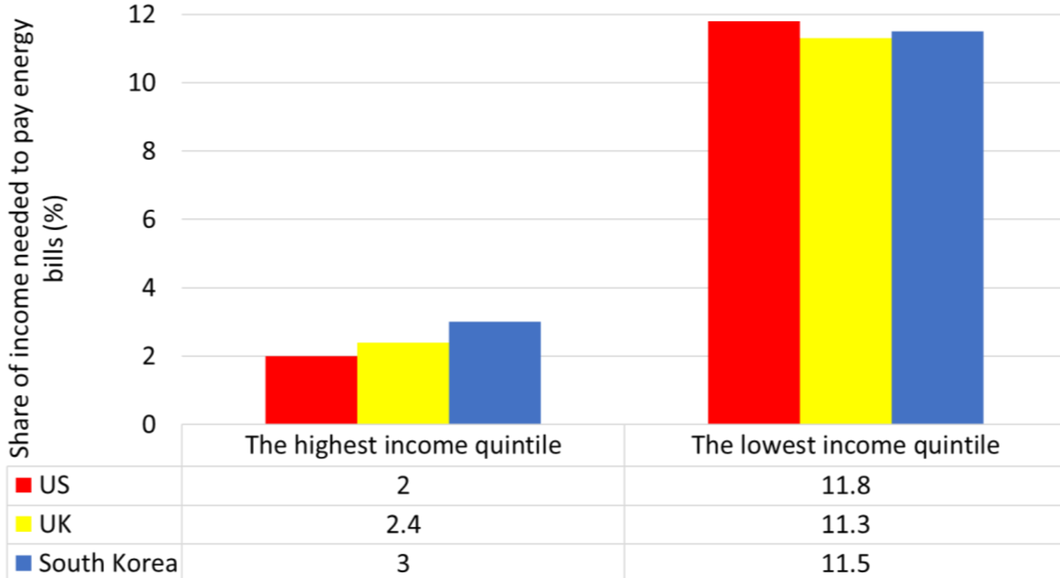

Figure 14. The Share of Income Needed to Pay Energy Bills by the Highest and Lowest Income Quintile in the United States, the United Kingdom, and South Korea

Note: The energy bills in the figure above include heating fuel and electricity. Source: Achieving a Democratic and Sustainable Energy Future: Energy Justice and Community Renewable Energy Tools at Work in the OLNPP Strategy (Byrne & Yun, 2017)

2.2.2 Inequitable Distribution of the Benefits and Burdens Arising from Persistent Reliance on High-Risk Energy Technologies

Climate change is apparently imposing a greater danger on the vulnerable of our society. As a result, it will continue to widen the wealth gaps between high-income nations and low-income nations and between the rich and the poor within a country. These widening chasms may accelerate global warming and ecological degradation, as pointed out by Sandra Postel. In her journal article entitled “Carrying Capacity: Earth’s Bottom Line (1994),” she explains how inequality can be a major driving force of ecological degradation (p. 5):

> [l]nequity is a major cause of environmental decline: it fosters overconsumption at the top of the income ladder and persistent poverty at the bottom .... [P]eople at either end of the income spectrum are far more likely than those in the middle to damage the earth's ecological health-the rich because of their high consumption of energy, raw materials and manufactured goods, and the poor because they must often cut trees, grow crops, or graze cattle in ways harmful to the earth merely to survive from one day to the next.

It is universally agreed that high-income countries should reduce their GHG emissions more than low-income countries (UNFCCC, 1992). However, high-income countries are contributing to global warming substantially greater than their counterparts. Some studies have found that ten largest economies in the world are emitting almost 75% of the global GHG emissions (Gignac & Matthews, 2015; Robiou du Pont, et al., 2017).[3] Some may argue that, given current sizes of population and economy, it is unfair to criticize the high-income countries only based on their gross GHG emission levels. From an equity point of view, however, no country has the privilege to use global biosphere intensively (Byrne et al., 1998).

Major energy technologies tend to be high-risk from the health and safety perspective. For instance, toxic chemicals from coal-fired power plants, such as sulfur dioxide (SO_2), nitrous oxide (NOx), particulate matter (PM), cause health and environmental problems in the areas near the plants (Koplitz, Jacob, Sulprizio, Myllyvirta, & Reid, 2017). Nuclear power plants release radioactive emissions into the

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[3] As of 2016, the largest ten economies are the United States, China, Japan, Germany, the United Kingdom, France, India, Italy, Brazil, and Canada (World Bank, 2017a). Depending on the point of view, some of these countries may be classified as a non-heavy GHG polluter and, for this reason, allowed to generate more GHG emissions. In this vein, Byrne and his colleagues (1998; 2008) are useful sources to understand these points.

biosphere. Consequently, the residents near the plants are exposed to adverse health consequences, such as thyroid cancer, or a potentially catastrophic accident (Kazakov, Demidchik, & Astakhova, 1992; Takamura, et al., 2016).

Sometimes, some rural areas are forced to accept a government- or investor-owned company-led decision to build a high-voltage power transmission tower or a large-scale power generation facility. Typically, these facilities are constructed in rural areas to transport electricity to large cities or large industrial complexes. This implies that urban areas benefit from high-risk energy facilities at the expense of rural residents. Some have noted that this type of policy-making practice is a consequence of so-called “peripheralization,” which refers to a phenomenon which planning authorities tend to designate communities which have historically been marginalized from a political, social and economic perspective (Blowers & Leroy, 1994; Sovacool, 2016). This pattern, in turn, creates a vicious cycle of inequitable distribution.

A rural-urban conflict is also found in South Korea. Seoul accounts for 0.16% of the country’s total electricity generation while consuming 9.4% (Table 2). This implies that the city only produced 1.9% of the total electricity consumed in 2016. When it comes to per capita electricity generation, each citizen in Seoul only produced 88 kWh in 2016. Issues of energy inequity become more obvious when it comes to nuclear power plants. For instance, when nuclear accidents occurred in Chernobyl in 1986 and Fukushima Daiichi in 2011, nearly 340,000 and 160,000 residents within a radius of 30 km or 20 km from these nuclear power stations, respectively, had to leave their house (IAEA, 2015, p. 158; Chernobyl Forum, 2006). Their houses and nearby lands virtually became uninhabitable. Some may justify these issues of inequity on the premise that large cities, like Seoul, do not have a place suitable to install a large-scale power plant. Yet, there exists no right for any region to reap the benefits at the expense of other regions.

Table 2. Key Energy Indicators and Gaps between Electricity Production and Consumption in 2016: Seoul vs. South Korea

City	Total electricity generation (GWh)	Total electricity consumption (GWh)	Electricity self-reliance (%)	Population (1,000 persons)	Per capita electricity production (kWh/person)
Seoul	874	46,493	1.9	9,930	79
South Korea	540,441	497,039	109.0	51,696	10,169
Share (%)	0.16%	9.4%		19.2%	79

Source: Energy and electricity data is retrieved from KEEI (2017); Population data is accessed at Korean Statistical Information Service (KOSIS) at http://kosis.kr/.

Contemporary high-risk energy technologies impose both expected and unexpected burdens on future generations. From a decision to construct a new nuclear power plant to the shutdown, it takes more than 40 years or 70 years, depending on the lifespan of a nuclear power reactor. This implies that a decision-making of the present generation to construct a new nuclear reactor could substantially affect the well-being of the next generations. Radioactive wastes generated from nuclear power reactors must be stored for more than 10,000 years, shifting economic and environmental burdens to future generations. It will be them who must bear the consequences of a potential nuclear accident.

2.3 Need for an Integrated Framework that Can Address the Challenges of Deep Decarbonization and Equitable Distribution

As described in this chapter, we are facing a wide range of socio-ecological problems posed by modern energy systems. A list of selected problems is presented in Table 3. Although this chapter focused on major challenges of climate change and equitable distribution of the risks and opportunities from modern energy systems, it must be pointed out that there are more issues than those presented here.

As illustrated in Figure 1 (see Section 1.2), a discussion of socio-ecological problems, along with a review of key modern discourses about the energy-society relationship (in Chapter 3), is intended to serve as a basis for identifying key principles underlying an integrated framework of energy governance that is sustainable, equitable and democratic. The challenges posed by modern energy systems described in this chapter clearly demonstrate the need for integrated frameworks that can address the issues of deep decarbonization and equitable distribution.

Table 3. Selected Deep Decarbonization- and Equitable Distribution Challenges Posed by Modern Energy Systems

Category		Key Challenges
Challenges regarding major issues of deep decarbonization	Global warming and changes in natural systems	• Driven by rapid increases in GHG emissions, the global average surface temperature has increased by 0.85℃ over the period from 1880 to 2012, experiencing a more rapid increase in the last decade. • Changes in the chemical composition of the atmosphere caused by the continued accumulation of GHGs are ascribed to a range of alterations in climate and natural systems at global levels, including a rapid decline in the ice sheets, ice caps and glaciers, rising sea levels and mass distinctions of species (see Section 2.1.1 for more details).
	Socio-economic losses caused by climate change	• IPCC and other research bodies predict that the aggregate economic losses associated with climate change continue to grow. • There exist substantial economic losses arising from inefficiencies in some of the conventional forms of energy conversion and consumption. • There is a growing concern about socio-economic consequences from extreme weather events, like warm temperature extremes, high sea levels, and heavy precipitation events, including pest and disease outbreak which increases health risks (see Section 2.1.2 for more details)

	Potential safety and security risks arising from the "climate-nuclear nexus"	• A burgeoning body of research on the so-called "climate-nuclear nexus" has found that nuclear power, when coupled with climate change, could induce disastrous results, including unintended nuclear power accidents ("accidental events") and regional security problems due to military conflicts (see cases of India-Pakistan, the United States, and South Korea illustrated in Section 2.1.3)
Challenges of equitable distribution	Persistent and widespread energy poverty	• Over one billion people – about 20% of the global population – still lack access to electricity. More than 50% of the people in low-income countries and regions, particularly countries in the Southern Hemisphere, are estimated to have no or very limited access to electricity. • In low-income countries, the so-called "rural-urban divide" in energy access and "gender-energy nexus" are evident. • In high-income countries, there are a sizeable people in energy poverty (see Section 2.2.1 for more details).
	Inequitable distribution of the risks and burdens arising from our continued reliance on modern energy systems	• High-income countries are contributing to global warming substantially greater than their counterparts • There are diverse patterns of energy injustice, such as "rural-urban divide" and "urban splinterism", causing the risks and burdens from modern energy systems not to equitably distributed among social and political classes (see Section 2.2.2 for more details).

Chapter 3

DEMOCRATIC GOVERNANCE CHALLENGES OF ENERGY SYSTEMS

Interdisciplinary scholars seeking to address the challenges posed by modern energy systems point out the importance of systemic inquiries about dominant political and social discourses (Byrne & Toly, 2006; Hager, 1995; O'Brien, 2012).[4] They argue that systemic social inquiries can serve as a point of departure for understanding the epistemological and institutional barriers that make it difficult to govern energy systems in a democratic manner. For example, Byrne and Toly (2006) argue that energy systems are politically and socially constructed, calling for a systemic understanding of major political and social discourses about the energy-society relationship.

As illustrated earlier (see Section 1.1 and Chapter 2), global society is failing to address the challenges of deep decarbonization, equitable distribution, and democratic governance of energy systems. Key challenges posed by modern energy systems concerning these issues were discussed in Chapter 2. What remains is to further investigate the issues of democratic governance. Democracy is largely recognized to be a question of values, principles and critical thinking. Hence, the

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[4] Discourses are generally defined as ways to understand the world and are recognized as a powerful tool to shape our beliefs, norms, institutions and social practices (Dryzek, 2013). Wolin (1968), in this sense, characterizes a hegemonic discourse as a paradigm. Discourses and paradigms are used interchangeably in this dissertation.

means of social inquiry can be a useful tool to understand the issues of democratic governance.

In this context, the chapter reviews major political and social discourses. The discourses presented here are acknowledged as important and are primarily cited in the discussion about the politics of the energy-society, or more specifically, technology-environment-society (TES) relationships (Dryzek, 2013). A focus of this chapter is to disassemble two discourses – elitist technocracy and market liberalism – because these discourses are widely recognized to be hegemonic to shaping modern energy systems (Dryzek, 2013; Huesemann & Huesemann, 2011).

3.1 Major Discourses That Have Shaped Modern Energy Systems

This study examines elitist technocracy and market liberalism to understand key challenges of modern energy systems concerning democratic governance. These discourses are recognized to be essential bases for shaping the theoretical and epistemological perspectives of the society-energy relationship and for providing useful tools to form institutions and policy positions within modern energy systems (Byrne & Toly, 2006; Dryzek, 2013).

Other discourses, along with elitist technocracy and market liberalism, are also briefly reviewed in this Chapter. A review of the other discourses may serve as a useful source for understanding the complex and interlinked nature of modern energy governance and the epistemological, and to some extent, institutional barriers that need to be addressed in order to build an integrated framework for energy governance.

3.1.1 Elitist Technocracy

3.1.1.1 Theoretical Backgrounds and Perspectives of Elitist Technocracy

An earlier idea of elitist technocracy may trace back to the 18th century. Social theorists, such as Marquis de Condorcet (1743-1794) and Henri de Saint-Simon (1760-1825), argued that the advent of scientific prediction and technological progress would allow humans to control nature and "tame the future," highlighting that science and technology was essential to social and political progress and that scientists and government administrators had to play central roles in the planning of important public policies (Saint-Simon, 1975, p. 36; Kumar, 1978, p. 25). They opined that humans can engineer nature (Saint-Simon, 1975, p. 38; Kumar, 1978, p. 41) and environmental problems can be fixed if science and technology are sufficiently advanced (O'Riordan, 1981). In a similar vein, it is argued that scientific and technological progress is central to problem-solving.

Elite technocracy is defined in many ways. In general, it can be construed as a discourse that stresses the role of the experts, such as scientists, policy planners, economists, in the design of social, environmental, and technological policies rather than the role of citizens (Dryzek, 2013, p. 75). There are at least three reasons for supporting elitist technocracy as a form of energy governance. First, it is argued that the public or citizens are not capable of addressing global crises. According to this argument, the existing global problems, such as climate change, require highly technical expertise that the public, or non-experts, cannot understand the nature of the problems and cannot deliver the most desirable solutions because they do not have the required expertise and skills. Therefore, the role of citizens in policy making, they argue, needs to be limited.

Secondly, elitist technocracy is preferred to other modes of governance due to the belief that centralized and top-down approaches are the most feasible ways to govern modern problems. It is argued that the existing governing approaches of liberal democratic nations often have difficulty in mobilizing human and capital resources needed to resolve contemporary problems and address potential risks largely because these challenges are highly complex while requiring immediate actions (Hare, Stockwell, Flachsland, & Oberthur, 2010; Cherp, Jewell, & Goldthau, 2011). The path-dependent nature of a socio-technical system makes it more difficult to address modern challenges. Some scholars also point out that hierarchical approaches create a condition where policy-makers and planners can have psychological stability and confidence in their role because the roles and responsibilities are predefined (Cajot, Peter, Bahu, Koch, & Marechal, 2015).

In a similar vein, some scholars endorse elitist technocracy due to the shortcomings of liberal democratic systems. For instance, some pundits, such as Shearman and Wayne-Smith (2007) and Lovelock (2010), argue that the technocentric (and hierarchical) approach to problem-solving is the only means that can effectively address global problems. Contemporary western democratic countries, they argue, cannot solve climate change due to serious limitations inherent in the incumbent political, social and technical institutions, such as a series of political gridlock between competing political parties and ideologies. Instead, they argue, authoritarian and expert-led governance forms such as those found in communist nations, like China, are more efficacious institutional approaches to tackle problems that need bold and immediate measures. Table 4 summarizes key ideas or beliefs that are often found in the advocates of elitist technocracy.

Table 4. Key Theoretical Ideas and Beliefs Underlying Elitist Technocracy

Key Ideas or Beliefs	Description
Scientific and technological progress can solve global problems.	Central to problem-solving is scientific and technological progress. Scientists and technocrats need to play a key role in addressing global problems and making social progress.
Experts are superior to lay people in making policies.	Experts have the knowledge and skills needed to make policy decisions. On the other hand, the public (or non-experts) are not capable of understanding modern problems and developing sound policies because they do not have the required technical expertise and skills. Therefore, the role of citizens in policymaking needs to be limited.
Centralization and hierarchy is a more feasible way to governing modern problems.	Consisting of an array of interests, modern democratic nations often have difficulty in addressing problems and potential risks in a concerted manner. The path-dependent nature of a socio-technical system makes it more difficult to address modern problems. On the other hand, a centralized and top-down approach can easily mobilize human and capital resources needed to solve modern problems. It also helps policy communities by offering psychological stability and confidence.

3.1.1.2 Major Policy Positions and Technological Choices of Elitist Technocracy

The decision systems in the energy domain are heavily affected by governance approaches based on elitist technocracy (Kim & Byrne, Centralization, Technicization and Development on the Semi-Periphery, 1990; Beck, 1996; Byrne & Toly, 2006; Beck, 2006; Gilley, 2017). Typically characterized by elite-centered and technocentric governance, elitist technocracy tends to underscore the roles of a few groups of high-level government administrators and technical experts, frequently rendering energy institutions and policies shaped in a centralized and hierarchical manner. Another character of elitist technocracy-based decision-making systems tends to prioritize technical and economic feasibilities over other important aspects. For example, social equity and long-term ecological sustainability are not virtually factored into in the design of energy strategies.

Technocentric policy tools often deployed by modern energy systems include, but are not limited to, technological innovation models, professional resource and pollution management programs, and rationalistic policy analysis techniques (Dryzek, 2013, pp. 76-88). It is worth noting that these tools are advocated by mainstream environmental groups. Often recognized as liberal democrats, they often display the propensity to rely on technocentric approaches to problem-solving, indicating that elite technocracy is being widely accepted regardless of political and social orientation.

These governance approaches of elitist technocracy are easily found in the arguments for nuclear power technology. During the birth of nuclear power technology, government administrators, scientists, and economists considered nuclear power technology one of the most sophisticated technologies. In general, a nuclear power system has the most complex fuel- and disposal cycle among energy technologies and is composed of more than 100,000 technical components. Byrne and Hoffman (1987) point out that these characteristics were so attractive that several authoritarian governments, such as the United States and the Soviet Union, began their first nuclear power program in the 1960s although there was no significant social and economic reason to do so. As Robert Oppenheimer (1904-1967), an American physicist and the so-called “father of the atomic bomb,” claimed, nuclear power was considered a logical step toward technological progress (Byrne & Hoffman, 1987, pp. 659-60):

> When I saw how to do it, it was clear to me that one had to at least make the thing. The [hydrogen bomb] program … was technically so sweet that you could not argue about that.

Nuclear energy is recognized by techno-fix belief often found in the paradigm of elitist technocracy. A sizeable number of elites endorse nuclear power as the best technological solution to climate change. They contend that nuclear power is an inevitable tool for realizing a rapid low-carbon transition. This argument in nuclear power is reinforced by an advanced type of this technology, such as small modular reactors (SMRs). Sometimes called Generation IV SMRs, these new fleets of nuclear reactor are endorsed by many as safer and more environment-friendly than the conventional nuclear reactors. Moreover, the cost of SMRs is estimated to be much lower compared to that of the conventional reactors (Brook & Bradshaw, 2014; Iyer, Hultman, Fetter, & Kim, 2014).

3.1.2 Market Liberalism

3.1.2.1 Theoretical Backgrounds and Perspectives of Market Liberalism

Central to the discourse of market liberalism are the concepts of economic optimality and free markets. Typically defined as a state where benefits are greatest at the least cost, the idea of economic optimality is endorsed by many as a guiding principle of modern decision-making systems. The concept of the free market has offered modern society an institutional means in which economic optimality can be achieved. The *modus operandi* of the free market is often recognized to be the most optimal way to address modern problems and realize a greater social progress.

In general, these ideas of market liberalism are based on two assumptions: *homo economicus* and “self-regulating” market. The assumption of *homo economicus* states that humans are rational and self-interested economic agents who can exchange goods and services to the point at which their satisfaction or benefits are maximized. Although this assumption provides a basis of a market system, it has led some to argue that there is an inevitable propensity for humans to overexploit the commons (Hardin, 1968; Hardin, 1985; Anderson & Leal, 1991). For instance, Garret Hardin (1985) argues that self-interested individuals can create a tragedy of the commons (p. 110):

> “[U]nder a system of private property, the men who own property recognize their responsibility to care for it, for if they don't they will eventually suffer. A farmer, for instance, will allow no more cattle in a pasture than its carrying capacity justifies. If he overloads it, erosion sets in, weeds take over, and he loses the use of the pasture. If a pasture becomes a commons open to all, the right of each to use it may not be matched by a corresponding responsibility to protect it. Asking everyone to use it with discretion will hardly do, for the considerate herdsman who refrains from overloading the commons suffers more than a selfish one who says his needs are greater. If everyone would restrain himself, all would be well; but it takes only one less than everyone to ruin a system of voluntary restraint. In a crowded world of less than perfect human beings, mutual ruin is inevitable if there are no controls. This is the tragedy of the commons.

Market participants, Hardin argues, have self-regarding preferences and strive to maximize their own benefits. As a result, they tend to exploit publicly-accessible properties and ecosystems as much as they could. The over-exploitation of natural resources and the degradation of the environment are inevitable. In response to these problems, Hardin and his followers contend that the commons must be privatized and failures to enforce private property rights can create serious environmental problems (Anderson & Leal, 1991). In fact, they point out that market failure is in part owing to the result of the government’s failure to clearly and comprehensively define private property rights. Hence, the existing private property rights, they argue, must be strongly protected, and the currently non-privatized areas must also turn into privatized properties. Some strict adherents of this idea have further argued that the privatization of every common pool resource, such as land, air, water, forest, and fisheries, are needed to avoid the tragedy of the commons (Anderson & Leal, 1991).

Several mechanisms of the free market or self-regulating market are recognized as useful tools for producing the optimal outcomes of economic activity. For example, free market, it is argued, enables the supply and demand of products and services to be determined and managed at the most optimal level, often defined as an equilibrium (Ventura, Cafiero, & Montibeller, 2016; van den Bergh, 2001; Dixon, Scura, Carpenter, & Sherman, 1994).[5] An equilibrium is conceptualized as a state where no one is better off without making anyone worse off. It can be described as a point where an incremental benefit arising from an increase in one unit of production (i.e. marginal private benefit) equals an incremental cost associated with the production increase (i.e. marginal private cost) (Point A in Figure 15) (Dixon et al., 1994).

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[5] Economists generally interpret Adam Smith's invisible hand as a supreme and distinct force (i.e. the market) that enables a society to achieve the most optimal level of social welfare. However, other scholars including economic historians, raise a question concerning Smith's idea, arguing that he used the phrase "invisible hand" as a metaphor to help readers understand his arguments. In fact, Smith used the phrase only once in his book, indicating that the phrase was not his main idea (Kennedy, 2009). Critics also point out that the actual meaning of Smith's invisible hand must be read in a historical context when he wrote his 1776 book. In fact, James Tobin, known for the "Tobin tax," notes that Smith wrote his 1776 book to "oppose protectionism and other regulations favoring special interests at the expense of the general public" (1991, p. 12).

This implies that any market interference by governments is not supported by market liberalism. The so-called laissez-faire is extensively endorsed by most schools of this thought. They argue that government intervention must be very limited if social benefits are to be maximized. Any market interference by governments can, they argue, infringe on economic liberties, leading the free market to fail (Mitchell & Simmons, 1994, p. 148).

Table 5 summarizes key ideas or beliefs that are often found in the advocates of market liberalism.

Table 5. Key Theoretical Ideas and Beliefs Underlying Market Liberalism

Key Ideas or Beliefs	Description
Economic optimality and free markets as underpinning principles	Generally defined as a state where benefits are greatest at the least cost, economic optimality is recognized as a key principle guiding decision-making systems. The concept of free market offers an institutional means in which economic optimality is realized because it enables the supply and demand of products and services to be determined at the most optimal level.
Strong privatization can prevent a tragedy of the commons.	Self-regarding nature of individuals tends to over-exploit common-pool resources, creating a tragedy of the commons. Privatization of common-pool resources and a strict enforcement of private property rights are required to prevent the degradation of the environment and to maintain the Earth's carrying capacity.
Laissez-faire can help market or market participants achieve the most optimal social benefits.	The market is self-regulating and is designed to achieve the most optimal social benefits. Any interference by governments into market activities infringes on economic liberties and proper market functions. Thus, the government's intervention into market activities must be very limited.

3.1.2.2 Major Policy Positions and Technological Choices of Market Liberalism

Over the last two centuries, the discourse of market liberalism has played dominant roles in shaping the politics, economy, culture, and social arrangements (Kenworthy, 1995; Fraser, 2014). The principle of economic optimality and the belief in the free market have exerted predominant power upon all levels of the sphere and manifested in various patterns (Huesemann & Huesemann, 2011). Many individuals, for instance, strive to improve their labor efficiency to make a living and revamp their competitiveness. The most important goal of businesses is to maximize profits by enhancing their productivity and managerial efficiency. A defining goal of many governments is to achieve a higher economic growth by enhancing national productivity, often measured in economic metrics such as Gross Domestic Product (GDP) per capita.

The principle of economic optimality and the belief in free market equally applies to modern energy systems. These values are recognized to be overriding elements in the design of energy policies (Dryzek, 2013). Global socio-ecological problems, such as climate change, are frequently perceived as so-called externalities caused by the lack of proper market mechanisms or as a market failure. For example, climate change is considered by this school of thought an externality from the absence of an efficient market where economic agents can freely trade their carbon emissions (Heller and Starrett, 1976).

Primary policy tools endorsed by market liberalism, even though this discourse in theory objects any government intervention to market activity, often depend on some levels of government engagement. For instance, carbon emissions trading, recognized as one of the most popular tools to address climate change, requires an extensive support from government authorities (Grubb, 1989; Stern, 2008; Hare et al., 2010; European Commission, 2017; Knight, 2010). So-called green taxes are another policy tools advocated by market liberal scholars such as Pigou (1877-1959), the first economist who introduced the concept of externality. They argue that externalities can be fixed by the imposition of a tax (t_x) on the producer of negative externalities (the area of welfare loss) and the pollution itself (Pigou, 1920; Paavola, 2007). The so-called Pigovian tax shifts the original market equilibrium (A) to a socially optimal equilibrium (B), removing the social (welfare) loss created by negative externality.

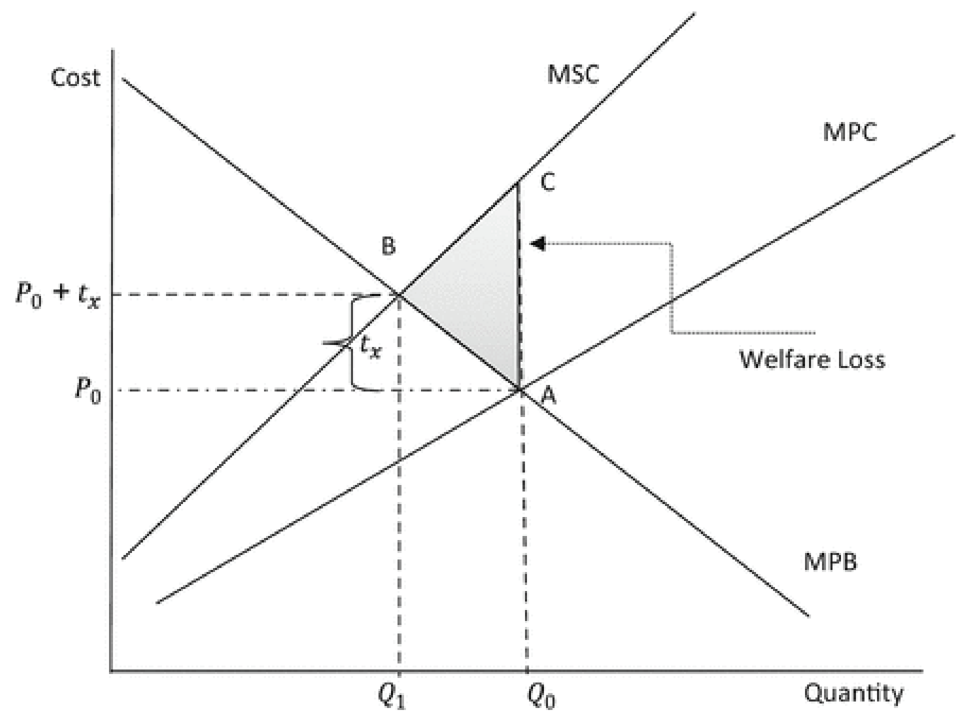

Figure 15. Pigovian Tax on Negative Externalities.
Note: The graph above is retrieved from the following reference. Source: Pigouvian Carbon Tax Rate: Can It Help the European Union Achieve Sustainability? (Nerudová & Dobranschi, 2016).

Market liberalism and elitist technocracy have something in common. Government administrators and technological experts, who are recognized as dominant actors in the elitist technocratic system, also play hegemonic roles in the market liberalism-based policy systems. But there are clear differences between the two systems. For example, citizens are treated as policy consumers in the market liberalism system whilst subordinates or subjects in the elitist technocratic system.

3.1.3 Other Discourses that May be Helpful to Understand the Complex Nature of the Energy-Society Relation

As indicated in the opening section of this chapter, the focus of this Chapter is to understand major challenges of modern energy systems concerning democratic governance. A review of dominant discourses – elitist technocracy and market liberalism – is conducted as an analytical tool to achieve the objective. Yet, it must be pointed out that, although these two discourses are conceived highly pertinent to and the most dominant forms of the energy-society debates, there is an array of other discourses that have had influential in the configuration of modern energy institutions and policies (Dryzek, 2013). Hence, a brief discussion of these discourses may help to understand different perspectives and to formulate a more interdisciplinary approach to address the major challenges of deep decarbonization, equitable distribution, and democratic governance. This discussion is also to assure the readers that this dissertation is not to argue that elitist technocracy and market liberalism are the only forms of discourses that have shaped modern energy systems. Even though the list of other discourses that can be reviewed can be extensive, this section discusses key ideas and critiques of five discourses that are often presented as ways to interpret and solve the emergent social and environmental problems.

3.1.3.1 The Neo-Malthusian Perspective

Population and resource exhaustion have been considered as key factors shaping the political economy and public policies of the modern era. Their relationships with social and ecological conditions have been extensively investigated since Thomas R. Malthus, an English reverend and political economist (1766-1834), revealed his idea in Essay on the Principle of Population (Malthus, 1798). Malthus argues that population increases exponentially whilst the arithmetic growth in food production, leading to a point beyond which population surpasses food availability. This unbalance must return to an equilibrium to avoid social instability arising from poverty, crimes, or wars. His proposal to curving the exponential growth of population within resource limits are either to reduce birth rate or to increase death rate. The measures to reduce birth rate, so-called preventive checks, include the postponement of marriage or contraception. Increases in death rate occur when a massive famine, epidemic, or war erupts (so-called positive checks).

Theoretical and philosophical underpinnings of the neo-Malthusian perspective are perhaps ascribed to the belief that human civilization will experience lack of resources and consequently ecosystem collapse unless some bold (and authoritarian) measures are immediately tackled. Advocates to this belief contend that the carrying capacity of the earth is unable to cope with the ("exponential") rate of population growth (especially in economically poor countries), and therefore measures (e.g. population control, limits to resource use, or "efficient" resource allocation) should be urgently tackled to save human civilization. For instance, Garret J. Hardin, an American biologist and philosopher (1915-2003), urged overpopulation as a major cause of global social and ecological problems. Particularly, his idea of lifeboat ethics (Hardin, 1985) and the tragedy of the commons (Hardin, 1968) have been widely considered as key concepts to understand the neo-Malthusian perspective on how to address global challenges. Hardin used the metaphor of the earth as a "lifeboat" to emphasize that the earth has limited resources, which are insufficient to support every human being in the world (Hardin, 1985). A lifeboat has a capacity to accommodate a certain number of people. It should limit the number of passengers to avert any catastrophe (e.g. sinking of the lifeboat). Likewise, he asserts that the resource-constrained earth can only house a limited population. People in the "lifeboat" (i.e. people in high-income nations) need to have this ethics to protect the earth and human civilization from catastrophic consequences. His lifeboat ethics can be inferred from the following paragraph (Hardin, 1985, p. 109):

> Some say they feel guilty about their good luck. My reply is simple: "Get out and yield your place to others." This may solve the problem of the guilt-ridden person's conscience, but it does not change the ethics of the lifeboat. The needy person to whom the guilt-ridden person yields his place will not himself feel guilty about his good luck. If he did, he would not climb aboard. The net result of conscience-stricken people giving up their unjustly held seats is the elimination of the sort of conscience from the lifeboat.

His idea of the tragedy of the commons starts with the premises that humans are self-interested beings who strive to maximize their benefits (so-called rational actor model) and the commons are non-excludable but rivalry (Paavola, 2007). Thus, individuals (i.e. rational actors) exploit resources as much as they could. This situation (so-called free-rider problem) causes over-exploitation and the depletion of the resource in the end. Likewise, rational individuals pollute common-pool resources (e.g. water, air, ocean, etc.) as much as they could, inducing environmental degradation. This situation (so-called negative externality) along with the free-rider problem leads to “the tragedy of the commons” as he notes in his writing (Hardin, 1968, p. 1245):

> (W)e are locked into a system of fouling our own nest, so long as we behave only as independent, rational, free-enterprisers.

His solution is to rescue high-income nations by fostering lifeboat ethics among their citizens and enclosing (or privatizing) the commons. Accepting immigrants from and sharing resources with low-income countries exacerbates poverty in low-income nations by increasing their population and expedite the depletion of resources and ruin the environment in high-income nations, leaving the future generations of high-income nations at risk (Hardin, 1968). Unlike futurists or cornucopias, he contends that there is no technical panacea concerning overpopulation problems. Instead, a type of coercion (what he describes as “mutual coercion, mutually agreed upon by most of the people affected”), is required to stop population growth and prevent from “the tragedy of the commons” (Hardin, 1968, p. 1247). Under this mutual agreement, individual’s freedom to breed or self-interests can be eventually controlled. He admits that his lifeboat ethics and “mutual coercion” sound to be undesirable but maintains that it can overcome the uneasiness of conscience and, more importantly, is the only means to sustain human civilization (Hardin, 1968, pp. 1247-48):

> Coercion is a dirty word to most liberals now, but it need not forever be so. As with the four-letter words, its dirtiness can be cleansed away by exposure to the light, by saying it over and over without apology or embarrassment… The only kind of coercion I recommend is mutual coercion, mutually agreed upon by most of the people affected… The most important aspect of necessity that we must now recognize, is the necessity of abandoning the commons in breeding. No technical solution can rescue us from the misery of overpopulation. Freedom to breed will bring ruin to all… The only way we can preserve and nurture

> other and more precious freedoms is by relinquishing the freedom to breed, and that very soon.

Neo-Malthusian arguments, which can be understood by Hardin's lifeboat ethics and the tragedy of the commons, have been challenged on various grounds. Barry Commoner, an American ecologist (1917-2012), argues that high fertility in low-income countries cannot be explained by a single factor (e.g. human nature to breed) but that this is the product of complex social and cultural factors (Commoner, 1985). Based on comparative analysis of several countries, he demystifies that human fertility is highly associated with the quality of life or the standard of living. While high-income nations have met the level of living standards and entered "population-balancing phase of the demographic transition", he concludes, low-income nations were not able to reach the required level due to resource exploitation through colonialism (Commoner, 1985, pp. 67-68):

> In the colonial period, western nations introduced revamped living conditions (roads, communications, engineering, agricultural and medical services) as part of their campaign to increase the labor force needed to exploit the colony's natural resources. This increase in living standards initiated the first phase of the demographic transition. But most of the resultant wealth did not remain in the colony. As a result, the second (or population-balancing) phase of the demographic transition could not take place.

From Commoner's perspective, Hardin's objection against foreign aid is not only reasonable but also unfair approach. Instead, he urges that the best way to reduce population in low-income countries is to "help them develop – and more rapidly achieve the level of welfare" (Commoner, 1985, p. 69). He further proposes that a means to addressing global overpopulation is to tackle poverty in low-income nations by distributing global wealth more equally among and within the nations.

The idea of the tragedy of the commons has also been refuted by several scholars including ecologists and commons scholars. These critics urge that the source of social or environmental tragedy is not the commons and elucidate that there are many cases in which commons-based governance approach results in successful management of natural resources or common-pool resources (e.g. land, water, fisheries) (Byrne & Glover, 2002; Ecologist, 1993; Ostrom, et al., 2003; Agrawal & Ostrom, 2001). Some criticize Hardin for his seemingly oversimplified idea, noting that it regards two centralized and coercive institutional arrangements (i.e., central government and private property) as sole vehicles capable of solving the common-pool resource problems (Dietz et al., 2003). Instead, they attribute "the tragedy of the commons" to the modern cornucopian political economy which enables individuals and collective bodies to seek economic profits at the expense of the environment and social values (e.g. community trust) (Byrne et al., 2009).

3.1.3.2 The Idea of Sustainable Development

Sustainable development originally began as a discourse of resistance based in the Third World (Carruthers, 2001; Dryzek, 2013). Neo-Malthusian discourses popularized in the Western countries in the 1960s and 1970s had prompted some to critically reconsider old development models and propose new development models that could address ecological degradations and the "limits" of the earth carrying capacity. As a result, they introduced new concepts, such as sustained yield or maximum sustainable yield, which sets a maximum threshold of yield and use that could sustain natural systems indefinitely. Indeed, the original logic of sustainable development, as quoted below, appears more radical than the contemporary discourse of sustainable development:

> (Sustainable development) refers to the ensemble of life-support systems, and seeks perpetual growth in the sum of human needs that might be satisfied not through simple resource garnering, but rather through intelligent operation of natural systems and human systems in combination (Dryzek, 2013, p. 148).

A new logic of sustainable development prevailing in contemporary policy domains is quite different from the original definition. In general, this new discourse of sustainable development attributes persistent social and ecological problems to the conventional approaches to problem-solving which tend to downplay other aspects, such as poverty, pollution, and loss of biodiversity. Instead, this logic of sustainable development claims that environmental sustainability and social equity can be achieved without compromising perpetual economic growth. The most widely cited definition of sustainable development is that of the Brundtland's Commission, formally known as the World Commission on Environment and Development (WCED) (WCED, 1987, p. 43):

> Humanity can make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits – not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth.

This discourse of sustainable development challenges the dominant growth-oriented model (so-called industrialism) by recognizing the limits of environmental resources, and the resiliency of biosphere (WCED, 1987). It also addresses the needs of future generations (often referred to as intergenerational equity) and the gap between poor and rich countries (often referred to as "North-South divide") (WCED, 1987). The responsibility of rich countries for poor countries and ecology is also specified (WCED, 1987). In addition, it reorients the directions of investment and institutional change as well as the orientation of policy and technological development (WCED, 1987, p. 46). Specifically, it calls for "political systems that secure effective citizen participation in decision making and by greater democracy in international decision making" (WCED, 1987, p. 8). The goal of sustainable development is arguably to achieve economic growth, environmental sustainability, and social equity at the same time. This means that these values are not only compatible with each other but also achievable altogether. These three dimensions – i.e. economic, social and environmental – are often referred to as the three pillars of sustainable development.

Yet, there are still a wide range of definitions of sustainable development. These definitions have been proposed by scholars and organizations in various academic disciplines and professional fields, including environmental and ecological economists, scientists, environmentalists, international development organizations, business interest groups (Pezzey, 1992; IUCN, 1980; Goodland & Ledec, 1987; Pirages, 1977; Repetto, 1985; Lafferty W. M., 1998; Rockwood, Stewart, & Dietz, 2008; Schmidheiny, 1992). The multitude of definitions are often pointed out as one of the major criticisms of sustainable development. The critics contend that it creates ambiguity in terms of the goals of sustainable development and meanings of its key ideas. In this context, some have concluded that sustainable development is "a complex and contested concept" (Meadowcroft, 2007, p. 300). Critics of sustainable development range from economic rationalists (e.g. Anderson & Leal) to radical environmentalists (e.g. Carruthers) (Anderson & Leal, 1991; Carruthers, 2001). On the other hand, others have noted that the proliferation of definition can be partly explained by the popularity or dominance of this discourse (Dryzek, 2013, p. 148). In a similar vein, some critics of sustainable development argue that the discourse of sustainable development creates an ambiguity concerning policy priority, especially for ecological concerns. While it is ideal for the three pillars to be balanced in policy making, typically environmental values are taken less important. In this regard, some scholars have proposed the concepts of “strong” sustainability and “weak” sustainability (Foster, Clark, & York, 2009; Hay, 2002, pp. 214-17). Proponents to strong sustainability recognize ecological limits while those to weak sustainability deny. Supporters of weak sustainability believe that the total sum of social welfare can be maintained by substituting human-made capital for natural capital through technological progress (Solow, 1974; Barbier, 2007). Some scholars also point out that sustainable development strategies have not been successful in addressing many global challenges, in contrast with what the discourse of sustainable development has promised. Although these critics acknowledge that sustainable development helps raise an awareness of environmental degradation and global poverty, it is conceptually ambiguous and structurally flawed and, as a result, incompetent to address many challenges with respect to ecological resilience and social justice (Lélé, 1991; Byrne & Glover, 2002; Foster, 2008).

Some critics of sustainable development strategies also point out that there are obvious gaps between the rhetoric of sustainable development and the results of sustainable development strategies. The rhetoric urges that the so-called “three pillars” of sustainable development – economic, social, and environmental dimension – be equally considered; yet in practice, social and environmental values are often treated less important or put aside. In fact, the Brundtland’s definition of sustainable development explicitly points to economic growth as an indispensable element for sustainability. It argues that global problems such as environmental degradation and widespread poverty can be alleviated through material wealth accrued from constant economic growth (p. 3). Indeed, the Brundtland report points to "a new development path" (p. 4) and "a new era of economic growth" (p. 1) as a key aim of sustainable development. Relatedly, some scholars point out that there are epistemological weaknesses inherent in the sustainable development discourse given that the strategies based on this framework are perceived as new projects of the West. Redclift (1987) notes in a similar vein that geopolitical and historical accounts between the Western and the non-Western are largely left out of the debates over global challenges. This problem has been often cited as a major barrier to an international agreement on a bold GHG reduction target.

Lastly, it is impossible for the global economy to grow indefinitely, as sustainable development advocates claim, due to the limited earth's carrying capacity. For instance, Daly (1990) challenges sustainable development arguments, citing that the concept of sustainable development is "a bad oxymoron." Economic growth, he argues, cannot grow endlessly as the economy is a subsystem of the Earth ecosystem which is a finite, non-growing and materially-closed system (p. 45). As knowns as Impossibility Theorem, Daly contends that sustainable development is impossible unless the Earth's carrying capacity keeps growing. In a 2013 paper, he maintains that global society is reaching towards a point where "the rising marginal costs of growth equal the declining marginal benefits", noting that "further growth ceases to be economic and becomes uneconomic" (p. 22). This argument appears to be true. For instance, a ton of shale gas adds an economic value to the national and global real

GDPs; at the same time, it adds extra carbon emissions to the atmosphere. Under the current pricing metrics, the latter (i.e. marginal cost) is worth less than the former (i.e. marginal benefit). Yet, their prices can be reversed if the current level of carbon abundance is near a so-called tipping point. The same logic applies to nuclear power. An extra kWh of electricity produced from a nuclear reactor (i.e. marginal benefit) may be considered more valuable than a marginal cost under a certain economic analysis. However, the marginal benefit and cost of the construction of a nuclear reactor may differ based on a range of factors, notably the costs associated with nuclear wastes or an accident. In the end, the accumulative cost to handle energy-related problems such as climate change and nuclear wastes could be prohibitive to global society. If these costs were reflected in the current GDP metrics, it is uncertain that the current GDPs at national and international levels are truly growing or positive (Daly, 2013).

3.1.3.3 The Approaches of Environmental Economics

Environmental economics (EE) can be defined as a sub-field of economics discipline that focuses on the valuation of environmental services[6] and environmental problems caused by economic activities. A theoretical framework of EE is built upon the principle of efficiency (or cost-effectiveness) and the theories of "rational agent" model (i.e. human beings and firms behave rationally) and the "invisible hand" model (i.e. the pricing mechanism in the market economy is key to reach economic

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[6] It is perceived that Harold Hotelling (1947), known for his work on the travel cost method[6], is one of the first theorists who contributed to the theoretical foundation of EE (Heal, 2007). See (Hotelling, 1947).

equilibrium where social welfare is maximized) (Ventura et al., 2016; van den Bergh, 2001; Dixon et al., 1994).

A main goal of EE is to find the level where individuals' satisfaction (or "utility") and firms' profits are maximized while attempting to take environmental problems into consideration. In EE, such a level is described as the "socially optimal level" or a Pareto efficiency point. For an economy to reach that level, environmental problems (namely, negative externalities) should be addressed.[7] A "socially optimal" level is sought by comparing an incremental benefit by increasing one unit of production (i.e. marginal social benefit) with an incremental cost associated with the production increase (i.e. marginal social cost). The "socially optimal level" is reached when a marginal benefit equals a marginal cost (Dixon et al., 1994).

Several market-based instruments have been proposed to fix externalities and thus to maximize social welfare. Widely known for introducing the concept of externality, A.G. Pigou (1920), a British economist (1877-1959), pointed out that the externality problem can be intervened by the government through the imposition of a tax, so-called a Pigovian tax, on the producer of negative externalities (Pigou, 1920; Paavola, 2007). This Pigovian approach emphasizes the role of public policies (e.g. taxation) since it considers externalities as an example of market failures. Ronald H. Coase, a British economist (1910-2013), opposed the Pigovian approach as

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[7] In EE, externalities refer to external costs or social costs induced by economic activities. It is argued that externalities are central to EE (Dixon et al., 1994). These costs are external to the internal pricing system of the market so that these are not incorporated into the price or costs of commodities or products. Typically, externalities occur in the form of pollution released during the extraction and use of natural resources and manufacturing of tradable products, of agents (i.e. firms or individuals).

“inappropriate” and undesirable (Coase, 1960, p. 2) since Pigou and his followers do not rightly comprehend the nature of problems which they are dealing with. Coase argues that any physical harms or environmental damages are the result of mutual interaction, not a unilateral action of one party against another party. The most important problem, he stated in his writing, is to choose the less serious harm or the larger benefit (Coase, 1960, p. 2):

> The traditional approach has tended to obscure the nature of the choice that has to be made. The question is commonly thought of as one in which A inflicts harm on B and what has to be decided is: how should we restrain A? But this is wrong. We are dealing with a problem of a reciprocal nature. To avoid the harm to B would inflict harm on A. The real question that has to be decided is: should A be allowed to harm B or should B be allowed to harm A? The problem is to avoid the more serious harm.

Coase urged that government intervention is costlier and less efficient in addressing social or environmental problems. Instead, the market pricing system supported by well-defined property rights is the most desirable social arrangement that can address harmful effects or inefficient allocation of resources. In this social arrangement, parties bargain or make a transaction based on their marginal benefits and marginal costs (i.e. they choose cases where a marginal benefit is greater than a marginal cost), which would make them better off.

Critics have pointed out that the utilitarian approach of EE (i.e. Coasian bargaining) fails to capture distribution and equity dimensions by only factoring efficiency into its problem-solving formula (van den Bergh, 2001). Environmental damages that are allowed by “efficient” bargaining could have a significant impact on other parts of the world and future generations. Therefore, it is argued that the utilitarian approach adopted by EE does not fully account for equity issues, including intergenerational welfare.

Some have also noted that underpinning approaches of EE to problem-solving (e.g. equilibrium analysis) are based on the “weak sustainability” hypothesis (Foster et al., 2009). EE maintains that the total sum of social welfare, even after a natural resource is depleted or an environmental damage occurs, can be maintained by substituting alternative resources for the depleted ones (and fixing the damages) through technological innovation (or technological progress) (Solow, 1974). However, critics point out weak sustainability approaches as unsustainable in that neither substitutability of natural resources can be sustained in the long run due to the dual challenges of ultimate constraints of natural resources and population growth. Nor can it be ensured at present that human civilization could reach the stage of technological progress capable of solving an environmental crisis.

Some critics contend that traditional economists including environmental economists focus heavily on the efficient allocation of natural resources or optimal level of pollution and ignored scale issues. They argue that scale problems (e.g. sustainable level of throughput and optimal level of resource use) should be determined by “a social decision reflecting ecological limits” (Daly, 1992, p. 188), not solely by private bargaining based on utilitarian, mathematical equilibrium analysis. Some scholars further raise potential risks arising from evaluating the monetary value of nature or the ecosystem (e.g. through cost-benefit analysis primarily by experts). For instance, John B. Foster (1993) and Ulrich Beck (2005) contend that either a miscalculated (or intentionally distorted) monetary value of the ecosystem and its services could be misrepresented in formulating policy which assumes a wrong estimated value of a critical ecological factor. This could deteriorate the ecosystem and worsen the existing ecological problems (Foster, 1993; Beck, 2005).

3.1.3.4 The Perspective of Political Economy

It is generally perceived that political economy (PE) is a discipline concerned with social (or economic) production and distribution. Central to this school of thought are global capitalism and states. In this regard, the following definition offered by Gorz presents what PE is and for what purpose PE can be useful (Gorz, 1980, p. 274):

> Political economy begins only where free cooperation and reciprocity cease. It begins only with social production, i.e., production founded upon a social division of labor and regulated by mechanisms external to the will and consciousness of individuals – by market processes or by central planning (or by both).

Scholars in political economic approaches criticize the capitalist economy itself due to the intrinsic flaws of its logic (O'Connor, 1994) or policies derived from the ideology due to its exploitative nature and disastrous consequences (Stiglitz, 2016). PE is predicated on values other than economic rationality when analyzing the current system and proposing solutions. For instance, PE "begins only where free cooperation and reciprocity cease", as seen in the above quotation by Gorz (Gorz, 1980, p. 14). Karl Polanyi's (1886-1964) "double movement" theory, which maintains that there have existed forces trying to curb seemingly insatiable global capitalism (Polanyi, 1944, p. 76), also entails the idea that PE recognizes non-market values (Bakker, 2010; Vail, 2010).

In general, PE scholars criticize of the modernity's approach to problem-solving that tends to neglect broader and more fundamental issues (e.g. power relations, economic structure, wealth distribution) (Polanyi, 1944; Gorz, 1980). They argue that dominant belief systems and institutional arrangements in capitalist market regimes have an inbuilt tendency to interpret the society-nature relations and address global problems within a narrow system like economy or markets (O'Connor, 1994). That is, these discourses (including eco-managerialism like the logic of sustainable development) fail to deconstruct the power relations and potential destinations of capitalization embedded in the contemporary political and economic system.

Focusing on environmental problems, Byrne et al. (2002) conceptualizes a new political economy as a complement to the traditional political economy. According to them, the traditional political economy generally predicts patterns of environmental risks as outcomes of the logic of capital and explains demands for environmental justice as phenomena of class struggle. Instead, they propose that social and political power structure along with class issues, be factored into when it comes to unequal distribution of environmental risks (Byrne et al., 2002). They also offer practical definitions and requirements of the alternative political economy that focuses on changes in ecological structure as well as social relations (Byrne et al., 2002). In addition to such efforts in the reconceptualization of PE, some scholars suggest that we reduce “the scope and influence of the market in everyday life” by replacing technology and fostering decentralization (Gorz, 1980: 40-42; O’Connor, 1994: 146) or through ‘decommodification’ as suggested by Vail (Vail, 2010, p. 312). Indeed, there is a growing number of social and environmental movements and community-based cooperatives across the world, including ethical consumption and fair-trade movements, local exchange trading systems, renewable energy cooperatives, and public benefits companies (Vail, 2010). Some scholars, especially those who study low-carbon or sustainability transition, find political economic approaches more important than previously since a climate or energy regime or a paradigm transition requires a holistic analysis of an ever more intertwined socio-technical networks in relation to climate and energy issue (Bulkeley & Betsill, 2013).

3.1.3.5 The Idea of Social Constructionism

Our experience and understanding of nature have a significant implication on how to build our relationship with nature. Depending on our relationship with nature, our governance approach to energy can take heterogeneous paths. Indeed, some scholars argue that the nature that we perceive is greatly shaped by our decision and action. They raise concerns about how our society has perceived and treated nature by arguing that the current approach to constructing nature-society relations is problematic (Evernden, 1992; Byrne et al., 2002; Glover, 2006, p. 224).

These scholars contend that our understanding of nature is predicated on images or ideologies of nature constructed by society. For instance, Neil Evernden argues that “a false or socially constructed nature” can emerge when nature rests on history or culture (Evernden, 1992, p. 24). Furthermore, he warns of how ecology is being conceptualized and used. As a discipline, ecology admittedly studies nature and ideally presents strategies to conserve it. However, it can be deployed as a vehicle to support some interest groups wanting to maintain the existing power structure. He is critical of some of key instruments that ecologists employ with the aim of conserving nature. These include environmental impact assessment, wildlife management, and land reclamation. He argues that these tools can be partially useful in achieving their purpose but will end up reinforcing the roles of “technological and bureaucratic interventions” (Evernden, 1992, p. 9). Similarly, he charges mainstream ecologists with their use of appropriate technology as an alternative form of technology that this approach is “to identify niches for human to appropriate” (Evernden, 1992, p. 9).

Some scholars pay attention to the influence of the capitalist economy on the social creation of nature. They argue that nature is conceptualized as a supplier of natural resources or commodities mostly through capitalist economic systems (Byrne et al., 2009; O'Connor, 1994). According to this perspective, nature that we currently see is the images produced by capitalist’s vested interests. Nature as a form of a commodity is manufactured and sold at the marketplace. Especially some industries have been successful in this regard. For instance, cosmetic and food companies have created a market niche for profits by branding their corporate identities and their products as ‘natural’ or ‘organic’. These images of Nature are consumed and spread across the world through globalization. The case of Disney World offered by Cypher and Higgs (1997) indubitably illustrates how nature is manufactured. They argue that people’s perceptions and experiences of nature-society relations are shaped by the images and artifacts designed and manufactured by entertainment and tourist industries like Disney (Cypher & Higgs, 1997, pp. 108-109):

> As part of a larger tourist industry, Disney is in the business of constructing, organizing and selling experience; in so doing Disney is intimately involved in the production of landscapes and the selling of stories about nature. Disney World uses space to create and reinforce ideologies, particularly ideologies which are supportive of capitalism and consumption.

In addition, these scholars criticize that this modernity’s tendency to create artifacts of nature exhibits an ideology that nature can be controlled and even modified (Evernden, 1992, p. 9; Norgaard, 2006, p. 159; Glover, 2006, p. 226). This idea has recently become more obvious since we have accumulated knowledge of nature that leads us to believe that human beings can manage nature. According to this belief system, nature is confined to the laboratory and treated as data that will be used for analysis, such as cost-benefit analysis of conserving wildlife. The analysis generates a model, largely putting greater weights on economic criteria, that simulates a range of possible outcomes. These virtual scenarios serve as a basis for decision-making. Furthermore, some scholars cautiously predict that human society's enduring pursuit of the progress of hyperintelligence (or superintelligence) will lead us to fulfill the long-sought goal of technological progress that nature is completely controlled and mastered (Borgmann, 1992, p. 104).

The critics of these systems believe that most human beings can't apprehend nature per se and only perceive superficial or false realities. It may make society indifferent and inert to the issues of environmental degradations and injustice (Norgaard, 2006, p. 165). This is problematic since the appreciation of the reality (e.g. 'real' nature) is the first step toward social criticism (Gare, 1995). Furthermore, a few interest group, with the assistance by the development of new technologies (e.g. media and the Internet), have become capable of controlling messages and creating images to reinforce their ideologies at the expense of the loss of collectivity among general public and local culture (Gare, 1995, pp. 28-29).

In response to these problems, some scholars emphasize the importance of self-consciousness of the modernism's project of alienating human beings from nature. Especially the awakening of local communities may be promising in that they are spatially closest to nature (Norgaard, 2006, p. 165). Some scholars find a source of the problem in knowledge regime. For instance, Flyvbjerg (2001) criticizes the contemporary epistemological and methodological approaches taken by social scientists by arguing that they have emulated the deterministic and reductionist approaches (e.g. prediction and approximation based on quantitative abstraction and modelling) to social issues where a ‘thick’ analysis of the context is often more desirable. Instead, he opines that social analyses recover *phronesis* that emphasizes the importance of “practical knowledge and practical ethics”, so-called praxis, in overhauling political economies of global crises (Flyvbjerg, 2001: 55-57). Phronesis is one of the intellectual virtues – *epistme*, *techno*, and *phronesis* –proposed by Aristotle. *Episteme* concerns “universals and the production of knowledge which is invariable in time and space, and which is achieved with the aid of analytical rationality” (Flyvbjerg, 2001, p. 56). It is scientific knowledge and “corresponds to the modern scientific idea as expressed in natural science.” *Techne* is “craft and art” and its “objective is application of technical knowledge and skills according to a pragmatic instrumental rationality.” *Phronesis* is translated as prudence or practical common sense, phronesis is ethics in relation to social and political praxis. Byrne (1980) reiterates the importance of social scientists who presumably stands at the forefront of addressing social and environmental crises. He contends that they create alternative theory and present it in a language that the public can understand by playing a role “as an arbiter between possible conjectures and social facts” who are “sorting out those conjectures which correspond to the facts from those which do not” (Byrne, 1980, p. 234).

3.2 Major Governance Challenges of Energy Systems

There is a growing and diverse concern that global society is failing to meet the demand for democratic governance of energy systems. Scholars have criticized the underlying principles of elitist technocracy and market liberalism (see the previous sections) of a major source of the failure (O'Connor, 1994; Byrne, Glover, & Martinez, 2002). Some have also argued that hierarchical and cornucopian governance approaches of these discourses are not sustainable enough to address highly complex socio-ecological risks, such as climate change and issues of energy justice, and are less capable of capturing rapidly changing demands for low-carbon and distributed energy systems (Westley, et al., 2011; North, 2010, p. 586). This section reviews widespread criticisms of elitist technocracy and market liberalism and discusses major challenges posed by modern energy systems with respect to the issues of democratic governance.

3.2.1 "Epistemic and Communicative Remoteness" Arising from Elitist Technocracy

Critics of elitist technocracy contend that decision systems relying on a few cadres of elites, such as techno-bureaucrats, often face epistemological and communicative weaknesses in addressing modern challenges. This is problematic because substantial public support is required to address the modern challenges of sustainability and equity, such as climate change and energy justice. Frequently, this mode of decision-making approach does not sufficiently reflect the actual needs of the public. As discussed in Section 3.1, energy policies are typically designed by elites, such as government administrators and technical experts, while the parties negatively affected by the policy are rarely given the opportunity to engage in the decision-making process.

These elites are in general both spatially and socially distant from the people and the regions. Often, they do not have a scope and dimension of knowledge required to understand the multifaceted social, cultural, and political complexities of the communities adversely affected by public policy (Cajot et al., 2015). To borrow a phrase of Plumwood (2005), there exists an “epistemic and communicative remoteness” between elites and the public when it comes to policy-making and problem-solving (p. 615). As a result, the decision by elites “are not necessarily widely accepted as legitimate” (Stern, 2011, p. 227).

3.2.2 Technological Authoritarianism

Elitist technocracy generally hinges on the principles of technological feasibility and technological authoritarianism as key guidance to decision making. This tendency can reduce the plurality of values and issues, such as community trust, social justice and ecological sustainability, into a simply technical and economic dimension (Ellul, 1964; Kim & Byrne, 1990; Stirling, 2014; Byrne & Taminiau, 2015; Byrne & Hoffman, 1996; Byrne & Hoffman, 1987).

But safety is recognized by some as an overriding concern. They are unwilling to accept a government’s proposal to construct a high-risk energy facility, such as a nuclear power plant, in their area or anywhere. Even though government officials and experts insist that the probability of an accident from a nuclear power plant be less than 0.1% and that a proposed construction project can offer them a sizeable level of economic benefit, those who regard safety as a prime value will very likely reject the government’s proposal to build a high-risk energy facility, such as a nuclear power plant.

Likewise, some people may believe that ecological sustainability is the most critical factor when it comes to public policy (Cajot et al., 2015). In these days, the principle of ecological sustainability is increasingly recognized as one of the most important values that need to be reflected in the design of energy policy. Some have further argued that this principle must take precedence over technical or economic dimensions (Dryzek, 2013).

Figure 16. Owners of TEPCO Holding a Press Conference After the Fukushima Nuclear Accident
Note: The picture is retrieved from the Telegraph (Telegraph, 2011).

The 2011 disastrous accident in Fukushima, Japan, clearly displays an unyielding belief of modern society in technological authoritarianism. Before 2011, nuclear engineers and government administrators in Japan appeared to be confident in their knowledge of nuclear power and the safety of the reactors. They did not report some technical problems that arose at the nuclear power station as far as safety is controlled. Besides, Tokyo Electric Power Company (TEPCO) has played down and ignored warnings from some scholars who had repeatedly warned that a massive tsunami could hit the Tohoku region (where Fukushima is situated) prior to the accident (Gundersen, 2012: 40).

Since the Fukushima accident, nuclear power is still advocated by many, including the incumbent prime minister of Japan. They maintain that this technology must be encouraged because it is the most efficient solution to reducing GHG emissions, the safety is under control, and other challenges, such as the disposal of nuclear wastes, will be tackled by technological innovation (Bekku, 2018). The belief that regards technological progress as a panacea remains unchanged.

3.2.3 Liberal Democracies in the 21st Century: Democracy or Elitist Technocracy?

The technological authoritarianism of elitist technocracy is often found in most liberal democratic countries where community members are institutionally allowed to participate in the decision-making process. In liberal democratic systems, community members can have their voices heard through representatives that they elect. Generally called representative democracy, this institutional system is cited as the most "efficient" political product of modern society (Fung & Wright, 2001). But it is widely found that representative democracy does not properly "represent" the voices of citizens (Byrne & Yun, 1999; Wolin, 2003; Callon, Lascoumes, & Barthe, 2009). Under the existing forms of representative democracy, many community members tend to be invisible in the political sphere or are generally "indifferent" to politics (Wolin, 1983, p. 6). Often, they cannot afford to active engagement in politics because political participation means a greater opportunity cost for them (Lee & Lee, 2015). Consequently, elected politicians often tend to "represent" a certain interest group. To the contrary, community members, including the marginalized frequently exposed to significant risks posed by policy failure) are often disenfranchised. That is, democratic procedures, such as public control and political equality, are often found to be constrained or completely absent in liberal democracies.

Similarly, key policy tools advocated by mainstream environmental groups and environmental studies, such as ecology, tend to reinforce technological authoritarianism. Environmental studies are largely recognized as a scholarly discipline where privileged citizens or experts can explore nature and offer strategies to address environmental problems facing modern society and conserve nature for future generations. However, key instruments often deployed by them have in effect reinforced the dominant paradigm built upon elitist technocracy (Evernden, 1992). For example, Evernden (1992) chides environmental studies, along with mainstream environmental groups, that major environmental policy tools, such as environmental impact assessment, wildlife management, and land reclamation, often end up strengthening the roles of "technological and bureaucratic interventions" (p. 9).

Championed by mainstream environmental groups and environmental studies, carbon emissions trading is deployed as a useful tool for addressing climate change. But this policy instrument, some critics argue, can delay a level of change required to achieve the 2℃ target because public attention and resources can be diverted away from the required level of decarbonization (Byrne & Glover, 2001; Lohman, 2005, p. 364).

3.2.4 Is Elitist Technocracy Viable in Risk Society?

The theory of risk society posits that many types and patterns of modern risk cannot be fully understood and controllable by anyone, including scientists and engineers. Ulrich Beck (2005) characterized them as risks that "nobody knows" (p.

589) unlike the claims by many politicians and some experts that every risk is under control. Therefore, it is absurd to allow a few groups of elites to exert a significant, or often exclusive, authority for making technology policies even though they may be better positioned to offer useful theoretical explanations and scientific evidences.

It is also difficult to predict that elites will take full accountability for consequences of their decisions. There are, at least, three reasons for this concern. First, no one has an indubitable understanding of far-reaching consequences of modern risk. Experts on nuclear power may assert that they comprehend potential risks posed by nuclear power systems; yet, this assertion can be easily disproved by the accidents in Chernobyl and Fukushima. Secondly, modern policy and technological experiments are increasingly recognized to be unpredictable and uncontrollable. Beck (2005) depicted this situation by arguing: (modern society) “has become a laboratory where there is absolutely nobody in charge” (p. 587). The controllability of contemporary technologies, such as nuclear power, is perceived as an ability that modern society cannot hold because these technologies must be applied to the real world in order to prove their effectiveness and find possible shortcomings. A single mistake or a minor accident in a laboratory could be considered a trial and error. But it means an unprecedented and far-reaching disaster in modern society, as Beck (2005) succinctly describes: “nuclear reactors leak or explode, test-tube babies are born deformed, people are killed by CJD” (p. 590).[8] Lastly, experts in the existing

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[8] Referred to Creutzfeldt-Jakob Disease, CDJ is “a rare, degenerative, invariably fatal brain disorder” (NINDS, 2018). It belongs to the transmissible spongiform encephalopathies (TSEs), which includes bovine spongiform encephalopathy (BSE) often referred to as “mad cow” disease.

political and economic arrangements often face a situation that motivates them to distort or hide information that is important for public safety and environmental protection. For example, a range of experts, including academics, scientists, and engineers in both public and private sectors, often "need the support of the politicians and the public to finance their research" (Beck, 2005, p. 590). As a result, there exists a powerful incentive for them to assert that "everything is under control and nothing can go wrong" (Beck, 2005, p. 590).

Risks arising from climate change also display key characteristics of risk society. It suggests that climate change has been "manufactured" by human society as 97 percent of climate scientists maintain that climate change is man-made and largely attributed to human activities. Potential impacts of climate change are arguably unpredictable and probably uncontrollable.

3.2.5 Putting Economic Optimality over Public Safety and Long-Term Ecological Sustainability

As discussed in Section 3.1.2, economic optimality is recognized to be an overriding principle for making energy policy. The principle of economic optimality is intended to choose a policy that can create higher benefits or less harms, as Coase (1960) articulated in his influential paper, *The Problem of Social Cost*, (p. 2):

> The real question that has to be decided is: should A be allowed to harm B or should B be allowed to harm A? The problem is to avoid the more serious harm.

Often, economic optimality is recognized to be a principle that should be prioritized over other values, such as fairness or ecological sustainability (Huesemann & Huesemann, 2011, p. 113; Fraser, 2014; Byrne & Taminiau, 2015). Modern society's preoccupation with economic optimality has frequently created circumstances where economic activities are preferred to non-economic activities. Inhumane or ecologically disturbing activities, such as human trafficking, contract killing, and deep-water drilling, may be attributed to this modern society's obsession for economic optimality. On the other hand, non-economic or non-market activities are largely treated as "inefficient" or "time-consuming". These activities are, as a result, ignored or avoided in spite of their societal functions, such as strengthening community trust and maintaining social solidarity.

There are many accounts illustrating that, in the energy domain, economic optimality is put ahead of other important values, such as the health and safety of the public, community trust, and long-term ecological resilience. For instance, the 2011 Fukushima Daiichi nuclear accident could have been avoided, it is argued, if public health and safety were prioritized (Gundersen, 2012). Over the years prior to the accident, TEPCO had been accused of falsifying safety inspection records and failing to disclose "cracks" in the reactors (Japan Times, 2002). The company has neither taken proper protection measures against potential earthquake and tsunami that scientist had warned long before the accident. In fact, a major cause of the accident is known as a failure of the emergency backup diesel generators located under the ground and flooded with seawater (Hollnagel & Fujita, 2013). It all implies that the Fukushima disaster could have been avoided if TEPCO either took a stricter contingency measure that could protect the emergency generators, installed extra emergency generators in a safer place before the accident or, desirably, did both. As Ellul warned in his 1964 book, *The Technological Society*, the Fukushima accident demonstrates that important decisions are often ruled by modern society's belief in economic optimality while other crucial factors, such as justice and public safety, are consumed as a political rhetoric (p. 282).

Environmental problems, as discussed in Section 3.1.2, are often conceptualized as externalities or market failures. It suggests that long-term ecological costs of any economic activity are not accurately, if any, reflected in mainstream economic analyses. For example, key tools deployed in cost-benefit analysis, such as discounting, are by nature unable to accurately and fully capture the plural and long-term values of ecosystems (Hodbod & Adger, 2014). Any minor change in ecosystems such as diverse forms of stress, like water stress, could have significant implications on their dynamic webs or could lead the whole ecosystem to collapse (Hodbod & Adger, 2014, p. 227)

3.2.6 Can the Tragedy of the Commons be Avoided through Privatization?

Hardin (1968) concluded that an enclosure or privatization of a commons is the most effective tool to avoid an overexploitation or a collapse of the commons (see Section 3.1.2 for further discussion). This argument has indeed been touted by many scholars and professionals and deployed as an underlying logic to support the ideas of market liberalism, such as self-regulating market (Heller & Starrett, 1976; Anderson & Leal, 1991). In modern society, privatization is widely recognized as a preferred approach to governing the commons. But one of the major criticisms lies in an arguably simplistic logic for privatization behind Hardin's model. Critics argue that Hardin's model does not fully account for both complex nature of the commons and a wide range of interactions taking place between the property-rights system and outcome postulated by Hardin. For example, Feeny et al. (1990) point out that Hardin's argument "overlooks the important role of institutional arrangements that provide for exclusion and regulation of use" and "cultural factors," such as "the nature of resources" and "the whole array of decision-making arrangements" (p. 13)

Hardin's model also fails to recognize the possibility that people, although they are characterized as self-interested, can cooperate with each other for a certain objective. The theory posits that leaving commons to open to the public is a bad idea because humans are self-interested and pursuit their own interests. Yet, there are many evidences that people often act based on altruistic motives rather than self-regarding preferences (Helbing, 2013). A growing number of scholars and activists document the cases where communities successfully manage their commons (Becker, Naumann, & Moss, 2017; Byrne and Taminiau, 2015; Harvey, 2012; Eizenberg, 2012; Ecologist, 1993; Ostrom, et al., 2003; Agrawal & Ostrom, 2001; Feeny, Berkes, McCay, & Acheson, 1990). This argument for the potential of the commons is not intended to say that human beings are born altruistic. Likewise, it is also unfair to confirm that human beings only act for their own interests.

Similarly, the theory of the tragedy of the commons is criticized of the strict premise that privatization is the only approach to sustainably or effectively govern the commons (Dietz, Ostrom, & Stern, 2003). There is no clear evidence that the quality of the environment or our ecosystems have been improved because of a more deployment of privatization policies (Feeny et al., 1990). To the contrary, there are several incidents where privatization of the commons has caused disastrous consequences, such as the 2010 Deepwater Horizon oil spill in the Gulf of Mexico. As shown in the picture below (Figure 17), it is difficult to say that BP, the operator of the Deepwater Horizon, has sustainably managed the area of the Gulf of Mexico where they were entitled to do business.

Figure 17. Clotted Oil and Fresh Crude Float Nine Miles from the BP Deepwater Horizon Oil Well Spill in the Gulf of Mexico in 2010

Note: The picture above is retrieved from Guardian (2015).

3.2.7 The Principle of Economic Optimality and Exploitative Commodification

The principle of economic optimality is recognized as a catalytic tool to encourage the belief system that nature is subordinate to economic development (O'Connor, 1994, p. 126). In mainstream economics, natural resources are treated as key inputs for economic development and can be exploited so long as the economic activity is profitable. In this context, normative questions are often considered no longer imperative. Many forms of commons are commodified and exchanged in the marketplace for private economic gains. Byrne et al. (2002) define commodification as (p. 288):

> (A) social process by which phenomena (social and natural) are transformed from their intrinsic and autonomous existence into a social, political, and/or economic value. This transformation from

> phenomenon to value delivers a thing, person, etc., to society as a fungible object available for use and exchange.

Other key elements of modern society, such as labor and money, concern the issues of commodification because the nature of the relationships between these topics with economic optimality is closely related to a critique of modern energy systems. In his book entitled *The Great Transformation: The Political and Economic Origins of Our Time* (1944), Karl Polanyi describes the history and political economy of the commodification of labor, money and nature:

> "(L)abor, land, and money are obviously not commodities; the postulate that anything that is bought and sold must have been produced for sale is emphatically untrue in regard to them. In other words, according to the empirical definition of a commodity they are not commodities. Labor is only another name for a human activity which goes with life itself, which in its turn is not produced for sale but for entirely different reasons, nor can that activity be detached from the rest of life, be stored or mobilized; land is only another name for nature which is not produced by man; actual money, finally, is merely a token of purchasing power which, as a rule, is not produced at all, but comes into being through the mechanism of banking or state finance. None of them is produced for sale. The commodity description of labor, land, and money is entirely fictitious" (p. 72).

A discussion of carbon emission trading can serve as a perfect example for articulating how nature can be commodified. Carbon emissions trading is a popular market-based policy instrument to address climate change and is endorsed by many environmentalists, including international bodies (Knight, 2010; UNFCCC, 2014). A central mechanism of carbon emissions trading is to put a price on carbon or GHGs. The priced unit of carbon is exchanged in the so-called carbon markets. This mechanism of carbon emissions trading implies that the atmosphere is translated into saleable pieces of property and, as a result, that the rights of the public to hold the atmosphere in trust are violated (Ott & Sachs, 2000; Byrne et al., 2002). Along with this normative constraint, carbon emissions trading has several practical problems that could have adverse implications on our long-term sustainability goals. For example, grandfathering and free allowances, which are main tools of carbon emissions trading, have incentivized businesses (particularly, heavy polluters) not to focus on reducing their GHG emissions (Lohmann, p. 363). Heavy GHG polluters have historically used natural resources intensively and, as a result, have excessively damaged the biosphere more than others. Yet, these tools of carbon emissions trading allow them to conceal their historical contributions to environmental degradation. Sometimes, those who meet the requirements of a certain carbon emissions trading program are recast as "green" companies (Lohmann, 2008). This practice is unsustainable as heavy polluters will continue to damage the atmosphere as long as they are allowed to participate in carbon emissions trading (Young & Tilley, 2006, p. 404).

Market-liberal institutions and strategies for globalization over last decades, often cited as neoliberalism, have reinforced the commodification process of nature (Newell & Paterson, 2010; Glover, Postmodern Climate Change, 2006). Market-based policy instruments, such as carbon markets, are being often deployed as political vehicles that high-income countries and transnational corporations can exploit wealth from the rest of the world. While the most responsible for climate change are benefitting from these market-based instruments, burdens and risks posed by global crises (e.g. climate change) are typically born by those who are "least well defended by suitable social, political, knowledge, and judicial institutions" (Glover, 2006, p. 232).

These exploitative practices of commodifying nature are greatly found and are, often, promoted in many liberal democracies (Vázquez-Arroyo, 2008). There have been several cases where elected officials and public agencies in liberal democracies represented special energy industries who have practiced exploitative activities at the expense of local health and ecological sustainability. community members, including citizens and employees, are often deprived of their rights to participate in the decision-making process and share equitable benefits from the economic activities. In fact, a series of studies have argued that the historical performance of liberal democracy has not met either "the central ideals of democratic politics" (Fung & Wright, 2001, p. 5) or the standards of sustainability that liberal democracies have promised (Wurster, 2013, p. 89; Ward, 2008). This mode of liberal democracy is considered inadequate to socio-economic transitions deemed necessary to rectify major environmental and ecological challenges (Lafferty, 2004, p. 2; Byrne & Yun, 1999).

3.3 Need for an Integrated Framework that Can Meet the Demand for Energy Democracy

Chapter 3 reviewed major discourses of the society-energy relationship. A focus of the review was elitist technocracy and market liberalism largely due to their dominant roles in shaping modern energy systems (Dryzek, 2013; Byrne et al., 2002). A key intention of the review is to decode key elements shaping the governance approaches of the global energy system and to identify major challenges stemming from the approaches. Although numerous factors and challenges can be discussed, key findings of the review can be summarized as below (see Table 6).

Table 6. Key Findings from A Review of Modern Major Discourses

Major Discourses	Key Theoretical Ideas and Beliefs	Major Challenges
Elitist Technocracy	• Scientific and technological progress can solve global problems. • Experts are superior to lay people in making policies. • Centralization and hierarchy is a more feasible way to governing modern problems.	• "Epistemic and communicative remoteness" (Plumwood, 2005) • "Technological authoritarianism" (Byrne and Hoffman, 1987; Byrne, Glover, Cecilia, 2002) • Lack of accountability of elites in "risk society" (Beck, 1996; 2005)
Market Liberalism	• Economic optimality and free markets as underpinning principles • Strong privatization can prevent a tragedy of the commons. • Laissez-faire can help market or market participants achieve the most optimal social benefits.	• Putting economic optimality over public safety and long-term ecological sustainability • Can privatization prevent the tragedy of the commons? • Exploitative "commodification process" (Byrne, Glover, Cecilia, 2002)

The challenges identified in this chapter are often treated as unimportant or unnecessary by conventional assessment frameworks. This tendency is particularly pertinent to a discussion of democratic governance. The principle of democracy, albeit the growing roles and importance in the so-called technological society or risk society, is frequently left out because it is largely recognized as a question of belief, values and critical thinking. The qualitative nature of these questions makes it difficult for social scientists to develop an integrated framework that could assess the governance challenges presented in this chapter. Byrne et al. (2002) notes (p. 264):

> Few efforts are made to develop social analyses which can both characterize the commodification process and challenge its hegemony over social and ecological relations. Even several of the more comprehensive social frameworks conceive only the possibility of social activities which degrade the environment.

But a discussion of key challenges of modern energy systems concerning the issues of democratic governance may offer a sound basis for the development of an integrated framework that integrates democratic values. Particularly, an emerging idea of energy democracy is increasingly recognized by interdisciplinary scholars seeking integrated approaches to address the challenges of deep decarbonization and equitable distribution. Along with the values of deep and equitable decarbonization, the demand for energy democracy needs to be fully reflected in the development of an integrated framework.

Chapter 4

DEEP, EQUITABLE, AND DEMOCRATIC ENERGY TRANSITION (DEDET) FRAMEWORK

4.1 Introduction

There exist a diverse and growing number of studies offering alternative approaches crafted to respond to the challenges of deep decarbonization of energy-based emissions, equitable distribution of the risks and burdens, and democratic governance of energy systems. Yet, most studies still examine pieces of the challenges or sometimes present a partial analysis of policy options.

For instance, IPCC (2014) reviews 31 decarbonization models and 1,184 decarbonization scenarios in its Fifth Assessment Report (AR5) based on published integrated assessment models (IAMs) and suggests a range of policy pathways to limit the global temperature rise to less than 2 ℃ by 2100 (p. 1308-11). All models attempt to define decarbonization, mostly based on techno-economic paradigms. The models include, but are not limited to, BET (Basic Energy systems, Economy, Environment, and End-use Technology), iPETS (integrated Population-Economy-Technology-Science), and WITCH (World Induced Technical Change Hybrid) model. The IPCC report acknowledges that AR5 recognizes the importance of equity in formulating decarbonization policy more than the Fourth Assessment Report (AR4) and, indeed, discusses the issues of equity throughout the report. But it appears that, among 31 models, only one model – GEA (Global Energy Assessment) transition pathways (Riahi, et al., 2012) – reviewed by AR5 addresses challenges and responses concerning equity. However, these models barely recognize democratic governance as a variable or principle in formulating deep decarbonization strategies. Scenario analyses reviewed by IPCC include deep decarbonization options and frequently explore pathways to deep decarbonization that embed equity principles related to "Common but Differentiated Responsibilities and Respective Capabilities" (UNFCCC, 1992). But the governance conditions needed to democratically design and implement pathways are acknowledged as important, but these conditions are not embodied in the models.

The DEDET framework, which is intended to serve two target audiences (interdisciplinary research communities and policy groups) seeking to address the interrelated challenges, recognizes the usefulness of the existing IAMs. A diverse and growing demand for reliable and affordable energy services, along with an urgent need for a deep decarbonization, requires technically apt and socially appropriate configurations of an energy system. Some of the existing IAMs, including the models cited by IPCC (2014), can offer the target audiences useful sources for the design of the needed measures to achieve the objective. For example, Pietzcker et al. (2017) argue that an integrated framework for a low-carbon energy transition needs integration of variable renewable energies into modeling and review the existing seven IAMs with a focus on the challenges of integrating variable renewable energies (VREs). They develop a framework that assesses 18 elements of power sector dynamics and VRE integration and apply the framework to the existing models to assess the framework's merits and shortcomings in addressing the deep decarbonization challenge.

There are several reasons for the persistence of this research problem. One reason is that there is a serious analytical challenge. For instance, sustainability and, to some extent, equity are treated as measurable variables while democracy is recognized to be a question of values, principles, and critical thinking that cannot be readily quantified. Consequently, the democratic character of deep decarbonization is frequently examined as a separate problem. Similarly, quantitative and qualitative research methods are often treated as separate approaches. While issues of deep decarbonization and, to some extent, equity can be addressed by quantitative studies, democratic governance requires qualitative study. Lastly, the design of an integrated assessment framework for energy systems is often recognized to be a daunting task partly due to the heterogeneity of spatial and temporal characters of the challenges arising from energy systems (Pietzcker, et al., 2017).

But, persistent challenges of sustainability and energy justice make the case for why we require new ways of thinking, inquiring, and policy-making other than the conventional approaches. It is obvious that the definitions of sustainability and equity are, in some degree, political matters and need democratic discussion and action to be successfully implemented. In brief, modern challenges require *integrated* assessment and implementation.

This dissertation, I hope, serves as a basic platform to build an integrated assessment tool. In other words, this dissertation does not aim to provide a definitive model encompassing all relevant issues and detailed guidance on assessment metrics, such as scoring methodologies. The focus of this dissertation is to argue for the need of a new approach that could address the interrelated challenges of deep decarbonization, equitable decarbonization, and democratic governance in an integrated manner and to embark on this initiative by offering the guiding principles and the assessment criteria. They are proposed as a potential basis for further investigation into the development of a multi-criteria framework.

4.2 Guiding Principles That Need to Be Embedded in the DEDET Framework

Guiding principles provide clear signposts pointing at the goal(s) of a framework. Guiding principles dictate directions in the course of the life-cycle of the framework – i.e. design, implementation, monitoring, and evaluation. A certain action can be allowed or, sometimes, constrained by guiding principles. For instance, economic and technological feasibilities are perceived as hegemonic decision-making principles in contemporary energy systems, as discussed in Chapter 3. Decision-making approaches heavily relying on a few groups of experts and policy planners are considered another central principle. Yet, these approaches are considered either major sources of current social-ecological problems or not nimble enough to tackle highly interlinked challenges of our time, as noted in Chapter 2 and Chapter 3.

As suggested by the previous section, a new integrated framework needs principles that have the potential to address the challenges of deep decarbonization, energy equity, and energy democracy in an *integrated* manner. This dissertation identifies deep and equitable decarbonization and democratic governance as the key principles of the DEDET framework.

4.2.1 The First Principle: Deep and Equitable Decarbonization

> Halting the current experiment in warming risk requires all industrialized societies to transform their social and economic structures in a manner that is consistent with the carbon cycle and social justice. Without transformation along both dimensions, it is unlikely that a global commitment to significantly and rapidly reduce greenhouse gas emissions can be mounted (Byrne et al., 2008, p. 47).

As discussed in Chapter 2, global warming is already causing a rapid decline of ice sheets, glaciers, and permafrost along with rising sea levels and mass distinctions of endangered species (IPCC, 2014a; Huss, et al., 2017). Coupled with weather-related extreme events, these changes in natural systems could lead to socio-economic and socio-ecological, often catastrophic, consequences through, for example, pest and disease outbreak, tropical cyclones, water shortage, and wildfires. IPCC and other research bodies have found that 450 ppm of atmospheric GHG concentrations is a minimum threshold capable of stabilizing global warming and, thus, the rise of global average temperature must be limited to less than 2℃ above pre-industrial levels by 2100 to avoid disastrous consequences or, at least, lessen adverse impacts (IPCC, 2014a; IPCC, 2007; Allen, et al., 2009). Oppenheimer and Petsonk (2005) have warned that ecosystems could be in danger if GHG concentrations surpass 450 ppm (Oppenheimer & Petsonk, 2005). Hansen et al. (2008) have also warned that "a CO_2 amount of order 450 ppm or larger, if maintained over a substantial period, would push Earth toward the ice-free state" (Hansen, et al., 2008, p. 12). It is also worth noting that a deep decarbonization implies the actual reduction of the total GHG emissions from the estimated global carbon emission budget given that global warming has, at least, temporally irreversible impacts on our climate system (Stern P. , 2011). Friedlingstein et al. (2014) finds that global society has already used more than 60% of CO_2 emissions quota allowed under the 2℃ target.

To sum, the stabilization of global temperature needs a deep reduction of the total global GHG emissions. This implies that the total amount of GHG emissions must be reduced by more than 40 percent by 2050 compared to 2010 and to nearly zero by 2100. It calls for strategies to realize a rapid and deep reduction of GHG emissions. This study, as discussed in Section 1.1, argues that energy-based emissions can be the primary focus to meet the goal as they are the largest source of global GHG emission.

Equity is another prong of the properties that should be ingrained in the first principle of the DEDET framework. Based on climate (and energy) justice discourses, the equity principle urges that no human has the privilege to pollute or exploit the commons, like the earth's biosphere or the atmosphere (Byrne et al., 2008). Here, equity is not necessarily confined to issues of historical responsibility for global GHG emissions, although the so-called polluter-pays-principle must be embedded in the design of equitable GHG mitigation strategies. Issues of historical responsibility often cause gridlock in reaching a political consensus among nations, especially between the South and the North. In sum, the equity principle refers here to a fundamental right and a universal responsibility of every person (Byrne, Hughes, Toly, & Wang, 2006, p. 87):

> [A]n international commitment to equity must include a principle recognizing that the biosphere belongs to all living things, so that no human being can claim entitlement in using its carrying capacity more intensively than another.

A wide range of low-carbon governance approaches are in place or under discussion. Techno-economic models, often relying on nuclear power, shale gas, or large-scale renewable development, are endorsed by many as the most plausible approaches to govern the deep-decarbonization challenge. Yet, the approaches that coopt nuclear power can create a condition where benefits and burdens from nuclear power systems are inequitably distributed among social classes and regions (see Section 2.2.2). In a similar vein, there are social and environmental challenges related to a large-scale deployment of renewable energy systems. For instance, large-scale renewable power plants often require a large-sized portion of land or ocean and, as a result, indigenous communities are displaced during the construction process and the resilience of ecosystems can be disturbed. Sometimes, large-scale renewable power plants require an extension or a new construction of high-voltage power transmission towers. Such projects can profoundly affect the livelihoods of indigenous communities. Other “low-carbon” energies, such as shale gas, clean coal and large-scale geothermal power, also raise various issues of inequity. For example, some studies show that the main production methods on which these energy technologies depend heavily (hydraulic fracturing for shale gas extraction, CO_2 geological sequestration for “clean” coal production, and hydraulic simulation of geothermal fields for geothermal power) can create so-called “induced seismicity” (Grigoli, et al., 2017). It implies that there is possibility that local communities near these energy production sites are under threat of earthquakes. Hence, it is highly uncertain whether deep decarbonization approaches based on these energy technologies can meet the demand for energy justice and equity.

Incumbent governing approaches, including those described above, tend to focus on quantitative properties; yet, it is important to embody both technical and equity dimensions into the development of deep decarbonization strategies. Long failure to curb GHG emissions at international levels indicate that global society has been unable to find efficacious approaches to govern GHG emissions (Byrne & Lund, 2017a). Reaching an effective global climate agreement appears virtually impossible in the lack of or absence of equitable sharing of benefits and burdens from climate change. In short, this study identifies ‘deep and equitable decarbonization’ as the first principle of the DEDET framework.

4.2.2 The Second Principle: Democratic Governance

As discussed in Chapter 3, contemporary modes of energy governance, largely characterized by techno-authoritarian and elite-centered approaches, are failing to address socio-ecological challenges and fulfill growing needs for diverse and decentralized energy services. The chapter also pointed out that market liberal (or neoliberal as a more recent form of market liberalism) political economies based on discourses of economic optimality have created a condition where everything can turn into a marketable commodity for the sake of profit-seeking or profit-maximizing interests.

This dissertation proposes democratic governance as a second principle of the DEDET Framework. This principle arises from the recognition that the failure to resolve deep and equitable decarbonization is in part due to our lack of research on integrated modeling of three values – that is, deep decarbonization, equity, and democratic governance.

Central to democratic governance is energy democracy. The concept of energy democracy traces the origin to climate justice movement which aims to overcome challenges arising from climate change and energy issues (Kunze & Becker, 2014). Advocates of this movement seek to apply fairness principles to various fields of research related to energy provision and use, including the environment (Bullard, 2005; Schlosberg, 2013), ecology (Baxter B. , 2014), climate (Pettit, 2004; Bulkeley et al., 2014), sustainability (Agyeman, 2013), and water (Zwarteveen & Boelens, 2014).

Inherently, the nature of energy democracy is to grapple with inequity and justice issues posed by energy systems.

Some scholars emphasize energy democracy as the means to support deep decarbonization. For example, Strachan et al. (2015) define energy democracy as an "idea of linking decarbonization with social control of energy" (p. 105). Similarly, Angel (2016) conceptualizes energy democracy as "struggles that seek to keep fossil fuels in the ground, while developing alternative ideas and practices of low-carbon energy provision that eschew the market in favor of collective control, universal access, and social justice" (pp. 557-58). Other scholars highlight the values of communal relations and political participation underlying the notion of energy democracy. For instance, Morris and Jungjohann (2016) argue that energy democratic movements render "stronger communities" and create "better personal relationships." Koira et al. (2016) argue that energy democracy can "open up new opportunities, create a wider basis of support as well as mobilize participation and contributions" (p. 738).

While energy democracy can be conceptualized in various ways, the guiding ideas can be summarized as: first, the right of community members to choose and produce energy and secondly, the right of community members to participate in the design of energy institutions and policies. Typically, citizens are treated as consumers of energy goods and services mostly provided by sizable private or public companies. But the idea of energy democracy specifies that community members have the right to choose the source of energy for own use. Households or small businesses have become to own on-site power generation technologies, such as rooftop PV, or join community energy initiatives, like community solar or energy cooperative. The community initiatives have the potential to create an opportunity where community members can learn, study, and practice democratic ways of producing and consuming energy. This space can also open a space where informed members of societies are mobilized for campaign to exert pressures on local authorities and to identify locally appropriate solutions (Blanchet T. , 2015, p. 253). Increased levels of interactions among locals could also nurture a culture of sharing and community trust (Kalkbrenner & Roosen, 2016). These social properties can be further enhanced by sharing not only information about the source of electricity generated by the community but also surplus electricity with energy poor households within the community (Yu, 2009; Kalkbrenner & Roosen, 2016). Lastly, community energy initiatives are also conducive to the psychology and behavior change of commoners, providing the locals with an opportunity to experience tangible and positive results for local economy and environment and, consequently, empower them while overcoming a sense of helplessness. Energy democracy also recognizes that community members participate in the design and implementation of energy policy (Byrne & Toly, 2006; Hoffman & High-Pippert, 2010; Daly & Cobb, 1994; Foster, Clark, & York, 2009). A democratic participation approach is based on the premise that political dialogue and policy engagement are civil rights (Cunningham, 2002) and, to some extent, citizens' social responsibilities (Dzur, 2012, p. 121; Kaufman, 1969, p. 189). Every community member is empowered to openly and freely offer their perspective and idea in policy design and decision-making processes. Primary roles of elected representatives, public agencies, and experts are to facilitate these procedures to deliver equitable and viable policies that enhance the welfare of community members (Dzur, 2012, p. 122). The last but not least, the principle of energy democracy ensures that burdens and benefits from energy systems are actively balanced among community members. This principle is intended to grapple with the emergent challenges of social justice, like urban splinterism or rural-urban conflicts.

The demands for energy democracy are closely connected with the underlying idea and tools advocated by the energy-as-a-commons scholarship. Both of them focus on social control of energy as the means to counter global commons problems, e.g. climate change, and to strengthen community trust. But, energy-as-a-commons can complement to the notion and tools of energy democracy. In addition to conceiving community members as prosumers or empowering them to control energy systems, the DEDET framework underscores the property of commonwealth underlying energy-as-a-commons. The idea of commonwealth specifies that energy is not a mere private property or a commodity, but a commonwealth owned and created by community. Here, community is not just defined by a certain spatial scale, such as a small town, a country, or global society. In fact, there can be many overlapping communities in a place (Walker et al., 2010); community can be defined by a wide range of criterium, such as a place, relationships, shared interests, or collective political power (Chavis & Wandersman, 1990). In this study, community is conceptualized by all these aspects. This implies that rural and urban areas can be connected by community. This also means that communal spirits and responsibilities for commons should be shared among the current and future generations.

In general, commons are referred to as natural resources (e.g., forests, fisheries, water bodies, ocean, or atmosphere). Yet, commons can be defined and conceptualized in a broader manner. For instance, it can include social or cultural resources (e.g. local knowledge, academic knowledge, culture, genetic materials, like seeds) (Ostrom, 2015; Buck, 1998). Human settlements, like large cities, can also be considered commons (Harvey, 2012). As these characteristics imply, along with a lexicon of commons-associated terms, commons or commoning underscores so-called relations or the understanding of the nature-society relation. Hence, the values, like community trust and commonwealth, are recognized as the most important elements in the concept of commons.

Contrary to dominant ideas of market liberalism, commons-based approaches seek "noncommodified means to fulfill social needs" (De Angelis, 2003, p. 5). Discourses and practices based on market-liberalism have displayed a steady and intensive exploitation of ecosystem services and social knowledge (e.g. cultural heritage, indigenous knowledge). Often people, especially the vulnerable, are displaced or their lands are dispossessed under the guise of national economic development or for the sake of benefits for the privileged. To the contrary, commons-based approaches recognize so-called common-pool resources (or natural resources) as a commonwealth held or created by community members or communities. This implies that the commonwealth needs to be equitably shared by community members or communities. In this context, commons-based approaches have the potential to promote participation of community members or, more broadly, participatory and, to some extent, deliberative democracy (De Angelis, 2003). Hence, many scholars have emphasized that commons-based approaches have the potential to provide useful analytical and strategic means to address contemporary governance challenges arising from energy systems and enhance both ecological sustainability and social equity (Ostrom, et al., 2003; De Angelis, 2003; Byrne, Martinez, & Ruggero, 2009;

Eizenberg, 2012; Byrne & Taminiau, 2015; Moss, Becker, & Naumann, 2015; Becker, Naumann, & Moss, 2017; Harvey, 2012).[9]

The notion of commons does not just refer to a static or specific space, material, knowledge, relation; but, it also indicates dynamic and ongoing social practices. There exist constant struggles and contestations over commons. In the incumbent political and economic realm, there are powerful forces seeking to commodify commons and gain private gains solely for themselves. On the other hand, there are also forces against such activities. Sometimes, the latter groups take a further step to create some new commons or open a space for the commons. In this sense, the politics of commons is construed as social practices of "commoning" (Harvey, 2012, p. 73). These "commoning" practices are constantly competing with so-called commodification measures. This nature of commons can create a condition by which communities engage in the processes of social production of the common good. Particularly, commons can provide a platform on which the socially marginalized and/or the economically poor can mobilize themselves or join community groups to demand for a commonwealth economy. In this vein, commons can also play a viable role in addressing issues of inequity and democracy (Eizenberg, 2012, p. 779).

All things considered, energy-as-a-commons can be a useful tool to democratize energy systems and address issues of inequity. Indeed, it is often cited in a good portion of the research literature on energy democracy as a useful tool for that

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[9] There are heterogenous strands of research on the commons. Becker and his colleagues (2017) offer a literature review of commons research and, thus, can be a useful source for understanding various conceptual and methodological similarities and differences of these studies.

purpose. Scholars seeking potential alternatives to contemporary crises (e.g. climate change) have maintained that energy issues be governed from a commons standpoint (Byrne et al., 2009; Byrne & Taminiau, 2015; Moss et al., 2015; Becker et al., 2017). Contrary to dominant ideas of commodification and privatization, the notion of energy-as-a-commons is predicated on the standpoint that energy is a non-commodified resource open to all and, thus, should be controlled by communities for the sake of the common good. Community members, especially the vulnerable, have been virtually disenfranchised their democratic rights to choose and use energy. Yet, the DEDET Framework embodying the principle of energy-as-a-commons may provide them with epistemological and pragmatic means to reclaim their rights to energy.

4.3 Energy Resources and Technologies Which Can Be Considered for DEDET

A successful energy transition requires substantial public engagement. Some have pointed out that technological artifacts and materials (or resources) could play an important or critical role in creating and expanding public support for a certain issue or policy. For example, Ryhaug et al. (2018) argue, drawing the theory of material participation, that sustainable energy technologies, like solar panels, can serve as an intervening tool for building new energy practices which could foster the creation of energy citizenship and, as a result, the realization of energy transition. Kuzemko et al. point out that the nature of energy governance is highly associated with the choice of energy resources along with the modes of political institutions (Kuzemko et al., 2016).

Keeping this in mind, this study identifies technological options that can supply low-carbon energy and reduce energy consumption, including renewable energy supply (RES) technologies and energy conservation and efficiency measures

(ECEM)s. However, some of these options – e.g. nuclear power, clean coal and large-scale renewable power generation – are being debated over whether they must be included in a portfolio of alternative energy supply technologies.

In this study, ECEMs and distributed renewable energies, often cited as sustainable energy, are considered as energy sources applicable to the DEDET framework. Sustainable energy is considered much cleaner and safer than fossil fuels and nuclear power. The lifecycle GHG emissions from sustainable energy sources are much lower than those from conventional counterparts. Sustainable energy systems can also provide several social and economic benefits to local communities. In conventional energy systems, community members typically pay bills for energy services to IOUs. Here, community members do not generally have opportunities to accrue economic gains in line with revenues of these private utilities. In sustainable energy systems, community members can have greater access to power generation and distribution. For instance, community members can also join local cooperatives or subscribe to community solar projects. Economic benefits from these activities are expected to grow due to continuously falling costs of PV. Levelized costs of electricity (LCOEs) studies show that PV has become cost-effective compared to conventional energy counterparts (Lazard, 2016; US EIA, 2018).

As illustrated in Figure 18, which several low-carbon and low-risk energy technologies, including PV, have lower or competitive LCOEs compared to conventional energy technologies. The latest EIA report (2018) shows that the cost competitiveness of PV has continuously enhanced. The LCOE of PV reached $49.9/MWh (2017 USD), down from $66.8/MWh (2016 USD) a year ago. The cost competitiveness of PV is expected to grow further due to several factors, such as lower module price spurred by technological innovation and soft cost reduction through streamlining so-called PII (permitting, inspection, and interconnection) processes.

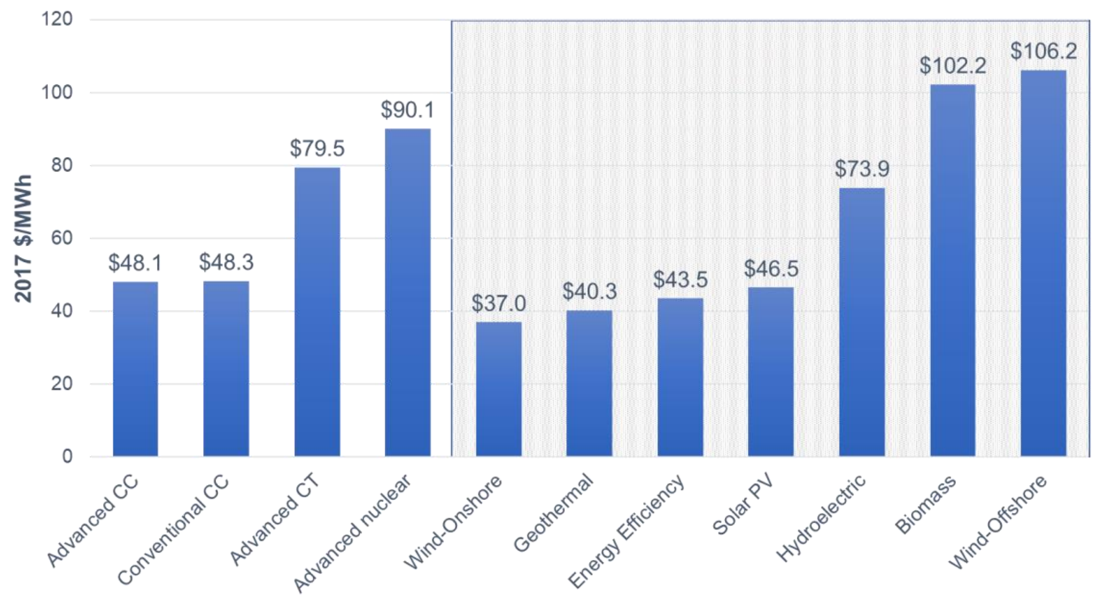

Figure 18. Estimated LCOE (2017 $/MWh) for New Generation Sources Entering Service in 2022

Note: The graph is adapted from Byrne et al. (2018) who used the 2017 EIA report. Byrne et al (2018) calculated the LCOE for energy efficiency by referencing Hoffman et al. (2017) which estimate the weighted average total cost of saved electricity as $0.046/kWh for 20 states in 2009–2013. Byrne et al. (2018) corrected the energy efficiency data with an Automatic Energy Efficiency Indicator (AEEI) of 0.75%.

ECEMs are another important sustainable energy sources. Energy conservation can be referred to as “reducing or going without a service to save energy” (U.S. EPA, 2017). whereas energy efficiency can be defined as “a way of managing and restricting the growth in energy consumption” (IEA, 2016a). ECEMs, as implied by the definition, have the potential to significantly contribute to deep and equitable decarbonization. Falling energy intensity (i.e. energy consumption per unit of GDP) is cited as a major cause of the recent flattening of global energy-related GHG emissions (IEA, 2017a).

ECEMs are also considered the cheapest energy sources. The LCOEs or the costs of saved electricity (CSE) for ECEMs is estimated to be close to \$0/MWh (low end) or \$50/MWh (high end) (Molina, 2014; Lazard, 2015; Hoffman, et al., 2015). ECEMs remain vastly untapped energy sources as can be supported by an array of potential assessment studies.[10] For example, the US DOE has compiled more than 70 state and local energy efficiency potential studies. Having been published between 2007 and 2015, 84% of these studies have found that average annual potential savings rates, either economic or achievable potentials, are higher than 1% (US DOE, 2016). The American Council for an Energy-Efficient Economy (ACEEE) carried out a meta-analysis of 45 electric and natural gas energy potential studies, which were published between 2009 and 2014, and found that the median values of average annual achievable savings for electricity and natural gas were 1.3% and 0.9%, respectively (Neubauer, 2014).

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[10] In general, there are four types of energy efficiency potential analysis, including the three types mentioned above and program potential. According to the US National Action Plan for Energy Efficiency Leadership Group's guidance report on energy efficiency potential studies facilitated by the US EPA and DOE, technical potential refers to "the theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures", while economic potential is defined as "the subset of the technical potential that is economically cost-effective as compared to conventional supply-side energy resources" (US DOE, 2016). Achievable potential refers to "the amount of energy use that efficiency can realistically be expected to displace assuming the most aggressive program scenario possible" whereas program potential is defined as "the efficiency potential possible given specific program funding levels and designs" (US DOE, 2016).

ECEMs are also widely considered that they can bring positive impacts on communities' economy and environment (Ribeiro, et al., 2015). Table 7 summarizes some of the major benefits of ECEMs identified by recent studies.

Table 7. Major Benefits of ECEMs

Type	Benefits
Energy Security	Enhance energy independence or self-reliance by reducing exposure to energy price volatility
	Increase the capacity of supplying energy when emergency or disasters occur by securing backup power from efficient electric power system (e.g. CHP and microgrid)
Environmental	Reduce carbon emissions by helping communities use less or avoid carbon intensive energy
	Reduce air, land and water pollution that could help local ecology more sustainable
Social and economic	Spend less money on energy and use the money saved for investment in efficiency improvement and/or on-site renewable energy generation installations
	Create jobs and local businesses (e.g. ESCOs), which tends to retain economic values within the community involved
	Improve indoor air quality that could reduce health risks

ECEMs encompass a diversity of activities and technological measures and can be applied to every socioeconomic sector. They include, but are not limited to, energy efficient transportation, transit-oriented regional or urban development, energy efficient buildings, district energy systems, and green infrastructure. Table 8 lists possible measures and activities that can be applicable to many forms of institutions, including large cities.

Table 8. Examples of ECEMs that Can be Applicable to DEDET

Measures	Key Characters and Expected Benefits
Energy-efficient transportation	▪ Efficient- and conservation-oriented transportation modes (e.g. public transit, shared cars, community bicycles, etc.) can save costs. The costs saved can be used for other purposes (e.g. infrastructure improvement or social welfare). ▪ Can reduce carbon emissions and other air and water pollutants. ▪ Various transportation modes help communities cope with emergencies during human-made or natural disasters.
Transit-oriented development	▪ Transit-oriented development (TOD) is an approach to development and land use planning that involves mixing housing, retail, and other amenities in walkable areas within a half mile of public transit facilities or hubs (MPC 2015). Communities can become more location-efficient, thereby reducing the transportation-related energy use.
Energy-efficient buildings	▪ The buildings that have highly insulated and air-sealed envelopes create more livable and comfortable indoor conditions during hot and cold weather seasons, helping occupants spend less money on energy. Particularly, these measures help low-income households save money on energy and instead use the saved money on other vital daily necessities. ▪ These improved indoor conditions can help vulnerable populations (e.g. elderly and infants) stay healthier.
District energy systems	▪ Help reduce electricity peak loads by using waste heat and/or heat energy storage ▪ These systems can use local fuels including biomass or waste materials (especially, tree trimmings and other waste wood) to supply heating, cooling, and electricity.
Green infrastructure	• So-called green infrastructure can save energy while carrying out routine tasks. For instance, combined sewer systems are designed to cut the amount of storm-water typically being processed at conventional water treatment facilities, as a result reducing energy consumption (CNT 2010). Evaporative cooling from vegetated forms of green infrastructure can lower indoor or surface temperatures, as a result saving energy (CNT 2010).

Battery storage may also be considered a means to support the resilience of urban energy systems. Large urban areas, such as Seoul, are vulnerable to power outages. Urban infrastructure networks cannot properly operate without a stable supply of electricity. In case of outages, battery storage can help maintain, at least, critical infrastructure. The role of battery storage in this regard can further be expanded as the likelihood of occurring a power outage is expected to grow due to worsening climate change (Michelle & Clemmer, 2014).

Hybrid forms of solar panels and storage can address several challenges that large cities face. As indicated in the previous paragraph, large cities can enhance the resilience of their power systems by balancing the supply and demand of electricity through battery storages. Unused electricity generated from solar arrays during the day can be saved into batteries and discharged for night-time power consumption or, sometimes, during outages. Storage can also help large cities reduce their peak consumption levels, thus contributing to grid balancing or reliability.

Households and small-scale businesses can save their electric bills through small-scale solar-plus storage. Unused electricity generated from solar panels can be saved into a storage, thus lowering electric bills. Large power consumers in urban centers can save their electric bills through battery storages since it allows them to avoid peak demand charges (Park & Lappas, 2017).

Storage prices are experiencing rapid declines. The cost of lithium ion batteries is down to less than $200/kWh in 2017, compared with almost $2,000 in 2008 (Sunrun, 2018). The costs of solar panels and lithium ion storage both have substantially declined over the last decade (Sunrun, 2018).

Lastly, microgrids can be a useful electricity infrastructure for urban energy systems. Microgrids referred to "local power grids that connect selected buildings and facilities to distributed energy supplies, such as district heating and cooling, solar photovoltaic systems, and energy storage devices" (Ribeiro, et al., 2015, p. 13). One defining benefit of the microgrid is its capability to backup conventional grid systems during power outages. It allows microgrid to play a pivotal role in urban centers by supplying power to critical facilities and infrastructures (e.g. hospitals, wastewater treatment facilities, or fire stations) without any disruptions.

4.4 The Need for an Operationalization of the DEDET Framework

Chapter 4 outlined the key principles underlying the DEDET Framework and discussed possible sources and technologies applicable to the DEDET framework. This chapter argued that deep and equitable decarbonization and democratic governance could be the guiding principles that can form alternative approaches to socio-ecological problem-solving and governing energy systems. Figure 19 provides a summary of the two principles and the key elements underlying them.

As indicated in the opening section of this chapter, the DEDET framework is intended to offer a basic platform as a starting step to build up an integrated tool. It serves as a basis of moving toward an integrated, multi-criteria framework that can address the interrelated challenges of deep decarbonization, equitable distribution, and democratic governance. The dissertation does not intend to provide a definitive model encompassing all relevant issues or detailed guidance on assessment metrics, such as scoring methodologies.

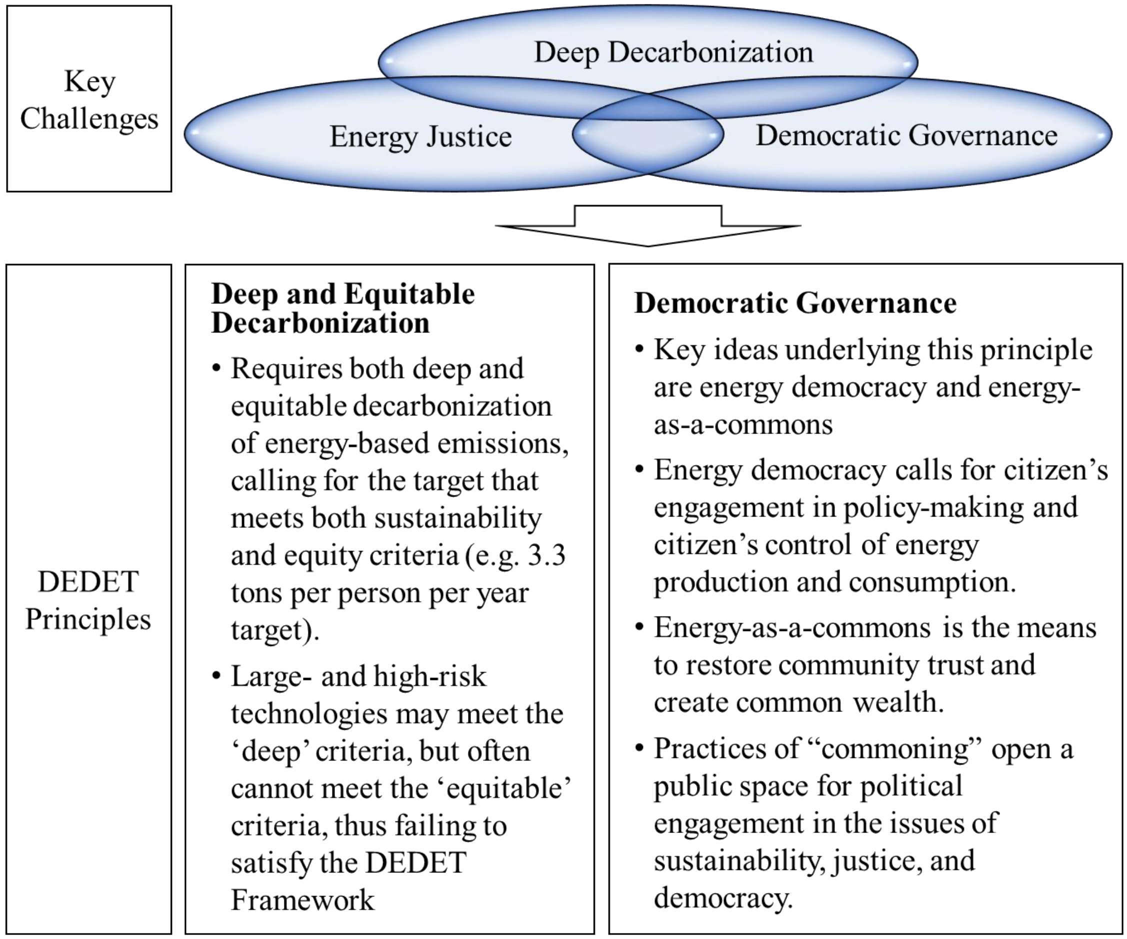

Figure 19. Principles Underlying the DEDET Framework

The next chapter explains a way to operationalize the DEDET framework. An operationalization of a conceptual framework is important, or even pivotal, in the development of an integrated tool because it can serve as a useful evidence showing conceptual soundness and, to some extent, empirical verifiability of the framework.

There are, at least, two aspects that should be considered in a discussion of the operationalization. First, a success of the DEDET framework can be measured by its applicability or acceptability. The framework needs to be applicable to or acceptable by a large and diverse form of energy transition alternatives and institutions. The target institutions can be geographical regions, such as countries, states, cities, or specific agencies, such as inter-governmental organizations or multinational corporations.

Secondly, a set of assessment criteria need to be developed if the framework has broad, or even universal, applicability. The guiding principles identified in this chapter should play a central role in the assessment of an energy strategy or a policy framework. But a more detailed set of assessment criteria or questions are needed to effectively capture the details of the energy transition alternative. As indicated above, this dissertation does not intend to offer a final and definitive version of an energy governance framework. The development of an integrated framework would rather need a deliberate and systematic engagement by a wide range of stakeholders. The major role of the DEDET framework is to serve as an open source that can be used by key stakeholders, such as interdisciplinary research communities, policymakers, and citizens seeking to research integrated approaches or shape energy transition policy to address the three challenges, in building up an integrated assessment tool. In this context, this dissertation offers six DEDET criteria in the next chapter as a starting step.

Chapter 5

OPERATIONALIZING THE DEDET FRAMEWORK

Chapter 5 proposes six criteria that can be used as a tool for assessing sustainability, equity and democratic governance in the pursuit of deep decarbonization. These criteria are referred to here as the DEDET Criteria. The criteria are not regarded complete or sufficiently specific. They are intended to explore the potential of the DEDET framework for further investigation into the possibility toward an integrated framework.

The dissertation identifies large cities as important institutional hosts for the DEDET framework development. As a form of key modern institutions, large cities are arguably most responsible for a range of global problems posed by energy systems while being important sites for policy innovation and democratic movements. The expected roles of large cities are further highlighted by a growing body of research on the potential of urban commoning and polycentric governance approaches in addressing the interlinked challenges of energy and climate change (see Section 5.2).

5.1 DEDET Criterion, Possible Questions, and Performance Benchmarks

Figure 19 presents a list of DEDET Criteria and possible questions that can be used to assess the governance framework and policy progress of urban energy strategies. In this section, further explanations about the question are explained.

DEDET Principles	1. Deep and Equitable Decarbonization 2. Democratic Governance
DEDET Criteria and Possible Questions	**1. Deep and equitable decarbonization target** "Is there a GHG reduction target? If so, does it meet the principle of deep and equitable decarbonization?" **2. Deep and equitable decarbonization policies** "Is there a sufficient diversity of policy and technology alternatives to address the challenge of deep and equitable decarbonization?" **3. Participatory and deliberative forms of governance** "Are there systematic forms of institutional transparency and openness that enable community members to be clearly informed of the benefits and costs of proposed measures and participate in the decision-making process?" **4. Commons-based strategies delivering a commonwealth economy** "Is there a sufficient diversity of policy and technology alternatives to enable citizens to control their energy needs and create a commonwealth economy?" **5. Measurement, verification, and communication** "Is there a comprehensive system to measure, verify, and communicate the implemented policy or technology measures?" **6. Research infrastructure to support the development of DEDET strategy** "Is there a research infrastructure to support the design, implementation, and evaluation of DEDET policy and technology alternatives not using conventional energy?"

Figure 20. DEDET Principles, Criteria, and Questions

5.1.1 The 1st Criterion: Deep and Equitable Decarbonization Targets

The first criterion of DEDET seeks to assess whether an energy strategy has at least one target to reduce energy-based emissions in a *sustainable and equitable* manner. Some studies can be identified as useful references in this vein. For instance, Byrne and his colleagues (1998) have estimated a sustainability- and equity-based GHG emission rate – 3.3 tCO_2e of GHGs per person per year. This target, they argue, embodies both “climate sustainability” and “carbon equity” in that it requires every country or person to reduce the current level of GHG emissions to 3.3 tCO_2e per person per year (Byrne et al., 1998, p. 337). Byrne and his teams have also pointed out in the subsequent studies that the rate must fall to 2 tons per capita per year by 2050 as the world population is expected to increase (Byrne et al., 2008; 2012).

Other studies, which integrates the equity principle in the development of GHG reduction targets, also show targets close to those of Byrne et al. For instance, C40 (2017), a network of the world’s largest cities which aim to address climate change, uses the contraction and conversion method and integrates the principles of equity, responsibility, and capacity in the development of the GHG reduction targets for C40 cities. They estimate that the per capita emission of a C40 member city must drop from over 5 tCO2e in 2015 to 2.9 tCO2e by 2030.

The comparative analysis between the sustainable GHG emission rate (3.3 tCO_2e) and the 2015 global per capita GHG emissions (4.9 tCO_2e) illustrates that the world falls behind with respect to long-term sustainable levels of GHG emissions. When it comes to top GHG emitting nations, this gap widens dramatically. For instance, the per capita GHG emissions of the two largest GHG emitting nations, the United States and China, in 2015 were 16.07 tCO_2e and 7.73 tCO_2e, which are far greater than 3.3 tCO_2-e per capita[11]. As these two countries account for 43% of the

11 Per capita emissions for both the United States and China are available at Emissions Database for Global Atmospheric Research operated by the European Commission Joint Research Center (EDGAR, 2017).

total global GHG emissions[12], the wide gaps in per capita GHG emissions indicate that the global GHG emissions will not decrease enough to address climate change in a timely manner. Under this framework, some countries must reduce their GHG emissions significantly. To the contrary, some countries may be allowed to increase their GHG emissions. This mechanism ensures every country to make an equitable contribution to the global fight against climate change. At the same time, the deep decarbonization target can be met in a concerted manner.

In brief, this criterion seeks to understand if an assessment object has multiple absolute GHG reduction goals. Here, multiple goals can include a short-, medium-, and/or long-term goals. The geographic scope of the goals (at least, two of them) should cover the entire area of an assessment object. It is also important for the emissions reduction goals to be on track to meet the 3.3-tons requirement.

5.1.2 The 2nd Criterion: Deep and Equitable Decarbonization Policies

This criterion asks whether there is a sufficient diversity of policy and technology alternatives designed to reduce energy-based GHG emissions in a sustainable and equitable manner. In general, energy saved from energy conservation and efficiency measures (ECEM)s and renewable energies are referred to as sustainable energy.[13] ECEMs are recognized as nearly zero-emission energy sources.

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12 As of the end of 2015, China and the United States account for approximately 29% and 14%, respectively (Olivier, Janssens-Maenhout, Muntean, & Peters, 2016).

13 Here, sustainable energy refers to energy sources and technological options that can be applicable to the DECET Strategy Framework. It must be noted, however, each large city has unique conditions and, thus, can design a site-specific policy and program that can support the goals of deep and equitable decarbonization.

In effect, they save energy consumption and, as a result, cut energy-based GHG emissions. IEA has found that energy efficiency improvements since 2000 have avoided energy consumption by approximately 12% in 2016 and points out that it is one of the major sources for the reduction of GHG emissions (IEA, 2017c). As shown in Table 9, GHG emissions during the lifecycles of renewable energy technologies, such as solar or wind power, are much lower than those of conventional energy technologies, such as coal- or gas combined cycle technologies. This indicates that a large deployment of sustainable energy technologies has a significant potential to reduce GHG emissions.

Table 9. Lifecycle GHG Emissions of Selected Energy Sources

	Selected energy source	Lifecycle emissions (gCO_2eq/kWh)
Non-renewables	Coal	820
	Gas Combined Cycle	490
	Nuclear	12
Renewables	Solar PV – rooftop	41
	Solar PV – utility	48
	Wind – onshore	11
	Wind – offshore	12
	Geothermal	38
	Hydropower	24

Note: Lifecycle emissions can vary depending on measurement assumptions and methodologies. The author used IPCC data to create the table above. This table only includes selected information and further information is available at IPCC website (Schlomer, et al., 2014). Lifecycle emissions in this table represent median values (Minimum and maximum values are also included in the IPCC report.

Solar city strategy can be considered as a useful means to help achieve a deep and equitable decarbonization in an urban context. Byrne et al. (2016; 2017b; 2017c) have shown that the solar city development can be an efficacious measure for a large city to realize the goal of deep and equitable decarbonization. Figure 21 illustrates that the city-scale deployment of PV in large cities can produce a sizeable amount of electricity, reducing the use of carbon-intensive electricity. For instance, Los Angeles can meet more than 60% of the total annual electricity consumption through a city-wide deployment of rooftop PV. This solar city strategy can also allow citizens to financially invest in the project development. It provides them with an opportunity to not only share the responsibility for GHG reduction. It also allows them to reap economic benefits from the power generation activity that has been almost exclusively monopolized by a few companies.

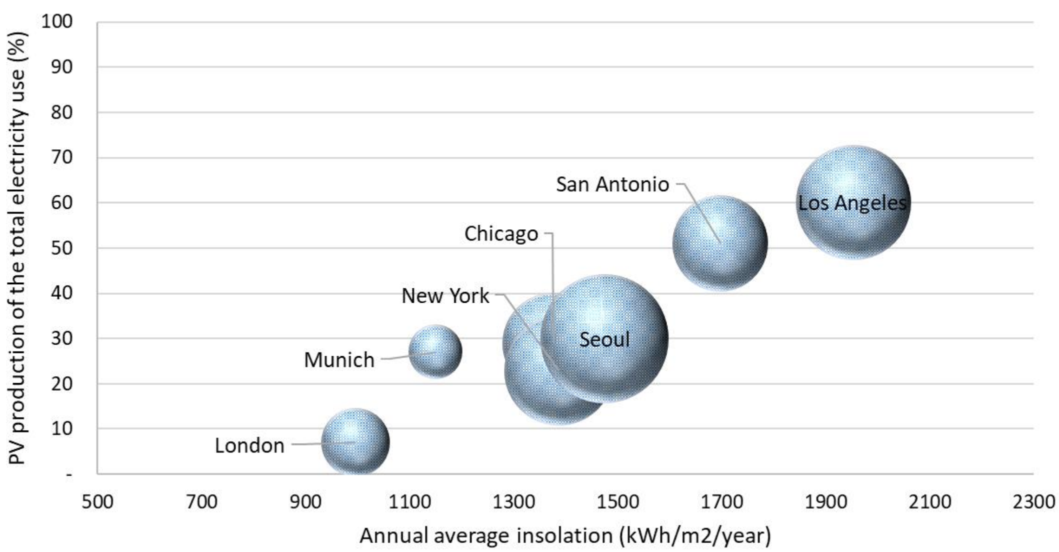

Figure 21. PV Electricity Production of the Total Electricity Use by Selected Large City

Note: The graph above is re-created from the following reference. Source: Are solar cities feasible? A review of current research (Byrne, Taminiau, Seo, Lee, & Shin, 2017c).

Under the right policy conditions, solar city strategies are considered a means to support energy needs of low-to-moderate income (LMI) households. In general, these households cannot afford to solar energy partly due to the types of residential buildings, housing tenure as well as upfront installation cost. Yet, a recent study reports that solar technical potential from the LMI income group in the United States accounts for 42% of the total US residential potential (Sigrin & Mooney, 2018). More importantly, the study finds that rooftop solar generation can offset 33% of LMI electricity consumption. With proper incentives and business models, the study offers, such technical potential may be realized to support both LMI households and, to some extent, rental-property owners.

In brief, the second criterion seeks to understand if an energy transition alternative, or an assessment object, has a diversity of actions, such as public policy or technological measure, to reduce GHG emissions. Besides, all the actions need to use sustainable energy as the key tools in the pursuit of deep decarbonization. Sustainable energies include, but are not limited to, the provision or use of renewable energy or energy conservation and efficiency measures. This requirement seeks to understand whether sustainable energy is considered a preferred option to conventional energy when it comes to the challenge of deep and equitable decarbonization.

5.1.3 The 3rd Criterion: Participatory and Deliberative Forms of Governance

This DEDET criterion asks about whether there are systematic forms of institutions within which community members, or citizens, can actively participate in the decision-making process and can be informed of the benefits and costs of proposed polices. The modern political and institutional arrangement tends to highly constrain human rights to participatory and deliberative democracy. It often prohibits the community members from engaging in the decision-making process, not offering an appropriate procedure enough to integrate their needs and concerns. But, it is important that the members exercise their political rights to decide energy provision and use.

There are several reasons that participatory approaches must be ensured in the decision-making process. First, the conventional governance approach is conceived as rigid and, thus, not responsive enough to adequately address contemporary social-environmental problems such as climate change. Several contemporary global problems are characterized by high uncertainty, complexity, and pervasiveness. These problems are often very site-specific as well. For example, climate change affects every country while the type and magnitude of its impact is often heterogeneous among countries and regions. Modern problems are also highly interrelated. Due to these characters, modern challenges can be more effectively tackled by flexible and polycentric approaches rather than centralized and one-size-fits-all approaches.

Secondly, the importance of participatory democracy is underscored by the nature of sustainable energy technologies. Characterized by ICT-based, distributed, and modular systems, sustainable energy technologies would need the role of the community members. The members can install PV panels on their rooftops and balconies. Buildings in one block or district can be connected through a microgrid, which enables them to share electricity within the network. The reliability of the microgrid can be further enhanced by ICT because it allows a collective gathering and distribution of information on energy supply and demand.

Thirdly, the participatory decision-making can address issues of energy justice more nimble than hierarchical approach. There is much evidence that the benefits from energy systems are mostly reaped by certain interest groups while the burdens and risks are mostly borne by the politically and economically powerless. Typically, these powerless rarely could offer their voice. There is less possibility that their choice is accepted or integrated into policy. Hence, it is important to ensure that the members, especially those most affected by the policy, participate in the decision-making process.

Lastly, the participation of community members is critical in achieving policy goals. A growing body of researchers find that civil society play an important role in the transformation of energy infrastructure through support for and pressure on governments' policy (Rohracher & Spath, 2014). In the domains of energy and climate change, community members are accountable for global GHG emissions as their daily activities are highly reliant on carbon-intensive sources of energy. C40, who analyzed the GHG inventories of 30 large cities in the world, found that more than 50% of a large city's GHG emissions originate from its residential and transportation sectors (C40 and Arup, 2017). This suggests that the members play a significant role in adding GHG emissions into the atmosphere. It also means that their participation is the central element to addressing the challenge of deep decarbonization.

There are various means that can be considered when it comes to participatory approaches in the design and implementation of an energy strategy. For example, it is important to ensure the presence of the representatives of the members in the highest decision-making body such as an advisory board or a steering committee. The members can also work with policymakers and professional auditors in monitoring and verifying the procedure and results of an energy measure.

In brief, this criterion seeks to understand if there is a systemic decision-making system within which participatory and deliberative process is ensured. A decision-making system can be considered systematic if there are systematic forms of institutional transparency and openness that enable the community members to be clearly informed of the benefits and costs of proposed measures and participate in the decision-making system. There should also be at least one policy that community members have played a key role in designing it, or them if more than two policies, to reach the outstanding level. This requirement seeks to understand whether the decision-making system works. Community members can take part in the policy-making through a diversity of approaches. But, it is crucial to make a policy that can serve for public good and community members, which requires incorporating the needs of community members in the design of the policy. Lastly, the third criterion requires if there is a mechanism where the needs of the energy poor are systemically reflected into policy making.

5.1.4 The 4th Criterion: Commons-Based Strategies Delivering a Commonwealth Economy

This criterion asks about whether there is a sufficient diversity of policy and technology alternatives to enable community members to control their energy needs and create a commonwealth economy. Under the dominant modes of energy systems, community members or citizens are largely treated as energy consumers. Produced mostly by monopolistic or oligopolistic energy companies as commodities, energy products and services are delivered to them through an extensive infrastructure network. Within this system, there is rarely a space for them to choose a source and type of energy. Energy companies, to the contrary, tend to choose the source of energy and technological artifact that could bring them the highest profits, not a way to protect the Earth and the future generations.

The DEDET framework, to the contrary, identifies the idea of energy-as-a-commons to be a useful tool to address the challenges of climate change and equitable distribution. This idea suggests that community members be accountable for issues of environmental degradation and social inequity arising from energy provision and use. As a growing number of people recognize energy as a commons and embrace the sense of accountability for the Earth and the future generations, the possibility to enhance the long-term social-ecological sustainability will likely increase.

Recognizing energy as a commons, not a commodity, can enhance social trust (Melville et al., 2017; Byrne & Taminiau, 2015). Profit-seeking energy companies, often under the auspice of the central or local government, tend to develop energy projects, such as construction of a large-scale power plant or high-voltage transmission towers, without obtaining informed consent from indigenous residents. It often creates distrust of the governments as well as the companies. Sometimes the indigenous town is split over monetary incentives offered by the governments or energy companies, slipping into a feud among neighbors. To the contrary, community trust or social solidarity can be enhanced if energy is recognized as a commons, not a commodity provided often exclusively by large energy companies.

Besides, the idea of energy-as-a-commons can create a space where the members of societies collaborate with each other to produce energy for themselves. Especially with the advent of cost-competitive sustainable energies, such as solar power, a group of citizens can install a solar array and produce electricity. There are already commons-based strategies, such as solar cooperatives and community solar, that have flourished in many parts of the world.

Community-owned transport schemes may also be considered to enhance community trust and create a commonwealth economy. It is argued that a primary means to reducing GHG emissions in the transportation systems is to change the individual use of privately-owned motor vehicles to less polluting transport options, such as using public transport or active transport (e.g. walking or bicycling) (Glover, 2016). In this sense, modes of community-owned transport can be useful in making such a change as they can play roles in the substitution of the private use of motor vehicles. So-called democratic financing tools, such as citizen funding, can be leveraged to procure funding for community-based energy conservation and production projects. Policies or incentives to support the poor, such as retrofit programs, can be an important vehicle to enhance community trust, thus facilitating participation in a community project.

In some parts of the world, alternative utility models were tested for their potential to realize the ideas of citizens' control of energy systems and the creation of a commonwealth economy. For instance, Sustainable Energy Utility (SEU) has been successfully experimented in several jurisdictions in the United States, including several cities in Delaware and Pennsylvania and Washington D.C. (IEA, 2016; Byrne & Taminiau, 2015). Conceptualized based on commonwealth economics and community utility, SEU seeks commons-based and community-oriented energy strategies. Particularly, its financing model, so-called Sustainable Energy Financing, leverages the wealth saved through conservation measures and innovative financing tools, such as Guaranteed Savings Agreement, to expand energy conservation projects and create a new renewable energy project at local levels. As a result, economic benefits largely remain locally owned through forms of money savings and local jobs.

Founded in Berlin, Germany, the *Berliner Energietisch* (Berlin Energy Roundtable; hereinafter BER) called for the re-municipalization of utilities through the direct engagement of citizens in the decision-making process. To that end, they proposed a *Bürgerstadtwerk* (Citizens' Power Utility) and drafted a bill that incorporates a number of speculations for empowering citizens to engage in the decision-making process. In a referendum that the Roundtable succeeded in holding through petition, over 600,000 people voted in favor of the bill, but the referendum could not meet the required quorum by 21,000. Although it failed by a narrow margin due to various factors, such as the challenge of path dependency supported by mainstream actors, it is recognized that the Roundtable's efforts played an important role in raising public awareness of energy democracy as well as climate change and social inequity (Moss et al., 2015).

In brief, this criterion seeks to assess if an energy transition alternative has a diversity of policies or technological measures that could help the members of a society control their energy needs by owning the means to produce energy for themselves. It is also important to have a diversity of policies that help community members, including the energy poor, participate in any community energy project. Sustainable energies should be used as the key tools.

5.1.5 The 5th Criterion: Measurement, Verification, and Communication

This criterion asks whether there is a comprehensive system of measurement, verification, and communication (MVC) in place. The fifth criterion is intended to assess whether policy performance is monitored and verified on a regular basis. Wang et al. (2012) point out that monitoring and evaluation is a critical procedure to assess the effectiveness of energy planning implementation. This process ensures whether the target is on the right track and offers guidance for future planning direction (Wang, Chen, & Park, 2012). Equally importantly, the monitoring and verification results need to be publicly disclosed. Public scrutiny is important to gain the credibility of the assessment results and bolsters the legitimacy of the policies. Often, major challenges need to be publicly disclosed to secure public support and come up with the best approaches to problem-solving.

An effective MVC can facilitate a sharing of best-practices. From a long-term sustainability perspective, the goal of energy transition is to achieve a regional, and even global, sustainability. Hence, it is important to create regional and global platforms where communities at multiple levels can collaborate on this issue. Using these platforms, communities can support each other by various means, such as exchanging the best practices.

In brief, the fifth criterion seeks to understand if there is a system in place that measures, verify, and report the progress of the implemented policy or technological measure. Besides, the measured progress must be verified by an independent third-party. These activities also need to be done on a regular basis.

5.1.6 The 6th Criterion: Research Infrastructure to Support the Development of DEDET Strategies

The last criterion of DEDET seeks to understand if there is research infrastructure to support the development of policy and technology alternatives that can resolve the interlinked challenges of deep decarbonization, equitable distribution, and democratic governance. Research infrastructure can include, but is not limited to, research institutes (or at least divisions within a research institute) dedicated to these challenges and interdisciplinary degree programs that offer future scholars and professionals the opportunity to earn advanced degrees in sustainability. A multi-stakeholder forum where all relevant parties can discuss and evaluate policy alternatives can also be an important element of research infrastructure.

In brief, the sixth criterion seeks to assess if there is an institutional form of research infrastructure that has a sufficient body of researchers seeking to research the interrelated challenges of deep decarbonization, equitable distribution, and democratic governance. The institutional form of research infrastructure can be a research institute, a higher education institution, or an in-house research unit. Furthermore, the researchers must produce at least two publications per year on the interrelated issues of deep decarbonization, equitable distribution, and democratic governance. This requirement can be a useful indicator to assess if the research infrastructure works.

5.1.7 Summary of the Six Criteria and Potential Performance Benchmarks

The six criteria presented here are developed as a tool to assess sustainability, equity and democratic governance in the pursuit of deep decarbonization although it is worth reiterating that the criteria and questions are not designed to be complete or sufficiently specific in this dissertation. Table 10 offers a list of the six criteria and summarizes key examples or indicators that can be considered performance benchmarks for each criterion. The benchmarks are deployed in Chapter 6 to assess Seoul's OLNPP. The assessment is intended to explore whether the DEDET framework can be used as an integrated tool to evaluate a diverse types of energy transition alternatives.

Table 10. The DEDET Criteria and Potential Performance Benchmarks

DEDET Criteria	Possible Performance Benchmarks/Indicators
1. Deep and equitable decarbonization targets	• Multiple GHG emissions goals that meet the sustainability- and equity-based emissions rate (e.g. 3.3 tons GHG emissions per person per year)
2. Deep and equitable decarbonization policies	• Has a diversity of activities to reduce GHG emissions. • The action, if there is only one action, (or all actions, if there are more than two) uses sustainable energies as key tools to reduce emissions in a deep and equitable manner (e.g. infrastructure-scale deployment of energy conservation, efficiency, and/or renewable energies).
3. Participatory and deliberative forms of governance	• A systemic decision-making structure and process in place that ensures participatory and deliberative approaches. • There is at least one policy that community members have played a central role in designing it (or them). • A systemic mechanism that incentivizes the needs of the energy poor to be incorporated into policy making.
4. Commons-based strategies delivering a commonwealth economy	• Has a diversity of activities using sustainable energy that help community members, including energy-poor households, own the means to produce energy (e.g. creation of citizens' utilities, community solar, Sustainable Energy Utility). • Has a diversity of activities that help the members, including energy-poor households, participate in a community project using sustainable energy (e.g. efficient- and conservation-oriented transportation modes such as public transit, shared cars, community bicycles)
5. Measurement, verification, and communication (MVC)	• Has a system in place to measure, verify, and discloses the progress of the implemented major policies. • Measures, verifies, and discloses the progress of the implemented major policies on a routine basis. • Has the measured progress of the major policies verified by an independent party on a routine basis.

6. Research infrastructure to support the development of DEDET strategy	• There is an institutional form of research infrastructure, such as research institute and university, that has a sufficient body of researchers seeking to research the interrelated challenges of deep decarbonization, energy justice, and democratic governance. • The researchers produce more than two publications on the issue on an annual basis.

5.2 Large Cities: A Key Institutional Host for the DEDET Framework Development

Large cities are analyzed in this dissertation to explore the potential of the DEDET framework for use in actual cases. It does not mean that DEDET is designed or used for cities only. DEDET is proposed as an integrated framework that may be applicable to an array of geographical scales, such as global society, countries, or communities. It can also be a useful analytical tool at organizational levels. An international body or national research institute seeking to address the interlinked challenges of the modern era can be analyzed. The main approaches to governing their organizations can be assessed through the lens of DEDET.

Yet, large cities arguably present the greatest challenge to the application of the DEDET framework. They are also recognized to be crucial sites for policy innovation and democracy. The role and importance of large cities are further underscored by a growing body of research on the potential of urban "commoning" (Harvey, 2012) and polycentric governance approaches (Ostrom E., 2009; Taminiau, 2015) in tackling the dual challenges of climate change and the persistent reliance on high-risk technologies. For instance, several cities in the world establish a municipal utility to facilitate their sustainability goals. These cities chose to create a municipal utility or expand its roles to address climate change partly because national governments are not meeting the needed decarbonization targets. The city of Seoul also launched a municipal utility named Seoul Energy Corporation in an effort to fill the areas that its national counterpart, Korea Electric Power Corporation (KEPCO), cannot or does not sufficiently address.

In this sense, this section elaborates key characters of large cities to help understand why they are chosen as important hosts for DEDET framework. To begin with, a brief discussion of historical relations between large cities and modern energy systems is offered in the first section.

5.2.1 A History of Large Cities and Its Relationship with Modern Energy Systems

There have been close relationships between cities and energy systems for centuries (Mumford, 1934). British cities in the early 1800s and other regions of the world in mid- to late-1800s were transformed by coal-powered steam engines (Mumford, 1934). Coupled with new metals, such as iron, it had shaped not only energy infrastructure within cities but also other critical infrastructures, such as transportation systems. It had enlarged the size of cities by driving urban communities to "coalesce along the lines of transportation and travel" (Mumford, 1934, p. 161). The expansion of this urban configuration, in turn, induced growing consumption of coal and, later, natural gas and oil.

The early version of fossil fuel-based energy systems also changed social and cultural norms and practices. For instance, the energy system enabled factories to run for 24 hours per day, altering labor practices. The spread of rapid transportation powered by steam engine changed the time-keeping method. The widespread coal- and oil-based urbanization (and industrialization) had led modern society to form a "mining civilization" or "the coal-iron régime" (Mumford, 1934, p. 153; 163). Consequential features of early modern urbanization (and industrialization) based on the "coal-iron regime" were explosive increases in urban dwellers or "purely physical massing of population" (Mumford, 1934, p. 163). By the mid- and late 20th century, these phenomena had, once again, transformed modern cities into so-called "mega-cities" (Droege, 2008).

Energy systems have profoundly shaped the modern urban metabolism, which in turn has reinforced the institutions and practices of energy systems. This interaction between urbanization and energy systems has exerted an enormous influence upon the current social order and ecosystems. Due in part to this interdependence, so-called mega-cities, or large cities, have emerged. These big cities have played a significant role in maintaining modern energy systems by burning fossil fuels and using electricity generated by steam-electric power stations.

5.2.2 Large Cities as Main Sources of Contemporary Socio-Ecological Crises

Cities are considered one of the most responsible for global socio-ecological problems. Cities, including large cities, account for more than 50% of total global primary energy consumption and energy-related carbon dioxide emissions (IPCC, 2014a). Research estimates indicate that cities account for almost 70% of the total global energy-related carbon dioxide emissions (UN-Habitat, 2016). Considering that large cities typically consume more energy than small- or medium-sized cities, these findings imply that large cities are major contributors to climate change. In addition, large cities in emerging countries such as China and India (e.g. Shanghai, Mumbai, Delhi, Beijing, Wuhan, Guangzhou, Chongqing, Chengdu, Tianjin, Kolkata, Bangalore, Shenzhen, Harbin, Chennai) are expected to consume growing amounts of energy due to population growth and the improvements in living standards (UN, 2017; Lund, Mikkola, & Ypyä, 2015). While several large cities in high-income countries are reducing their consumption from some conventional energy sources, such as coal-fired electricity and gasoline, and are also slowing GHG emissions, it still holds true that large cities in the world continue to contribute significantly to global warming. Large cities are also contributing to the failure of energy systems to meet the demand for energy justice. Energy systems provide energy services to urban centers through an extensive energy supply chain replete with an array of carbon-intensive and high-risk infrastructure, such as thermal power stations (e.g. coal-fired or nuclear power plants) and extra-high-voltage power transmission lines. For instance, coal-fired power plants pollute toxic chemicals – e.g. sulfur dioxide (SO_2), nitrous oxide (NOx), particulate matter (PM) – into the atmosphere, as a result causing health risks to many people, especially locals residing near those power stations (Koplitz et al., 2017). Extra-high-voltage power transmission lines (e.g. 765,000V) and transmission towers (e.g. 140 meters tall) are constructed to transport electricity mostly generated from the power plants in rural areas to large cities. These cases elucidate that the energy demanded by large cities is being met largely at the expense of rural health and the health of surrounding ecosystems.

5.2.3 Large Cities as Key Venues for Democratic and Justice Movements

Large cities have also considerably proven experiences and capacities in promoting democratic values. They have traditionally played important roles as laboratories of democracy. Their cultural, demographic, political, and spatial characteristics can create opportunities for municipal planners, often together with civil society, to experiment with new policies (Byrne et al., 2017c). Large cities have also a comparatively strong presence of civil society and are a focal point in which competing political and economic ideologies are contested (Gerometta, Haussermann, & Longo, 2005, p. 2010; Betsill & Bulkeley, 2006). There is an additional factor for focusing on cities: diffusion. Demands for civil rights and democracy, for example, have been mobilized in cities and developed as municipal policies or laws. Some are emulated by other cities, adopted by national governments, and reproduced in the regional or global networks (Taminiau, 2015).

5.2.4 Large Cities as Laboratories for Commons-Based and Polycentric Governance Strategies

These characteristics of large cities make them important venues to experiment with sustainable energy transition (Droege, 2008; Bulkeley, Castan Broto, & Maassen, 2014; Rutherford & Coutard, 2014; Monstadt, 2007; Byrne et al., 2017c). It is further justified by growing interests in the notions of commons and polycentricity. Construed as alternatives to conventional governance approaches, these ideas have significant potentials to provide powerful analytical and pragmatic means to identify key sources of contemporary global problems and allow urban centers to develop feasible strategies to address challenges that are forbidding a sustainable and equitable energy transition at local, regional, and international levels.

The development of a typical large city is greatly financed by public entities (e.g. governments) and private capitals (e.g. construction and financial capitals); yet, the roles of community members in the formation and operation of the large city should be recognized. In other words, large cities are the results of joint efforts and should be owned and managed by all stakeholders, including citizens. In this context, large cities are ideal venues where commons-based strategies can be effectively developed and, thus, a vast commonwealth can be created (Hardt & Negri, 2009, p. 153; Harvey, 2012). Some have demonstrated that commons-based urban energy strategies, such as a large-scale deployment of PV panels within city (so-called Solar City strategy) and citizen-led movements for utility re-municipalization, have significant potentials to help cities to deeply decarbonize energy-based emissions and enhance social-ecological sustainability of the city and beyond (Byrne, Taminiau, Kim, Seo, & Lee, 2016; Byrne et al., 2017c; Byrne & Taminiau, 2015; Becker et al., 2017; Moss et al., 2015).

Polycentric governance approach underscores the importance of urban commons and bolsters the possibility of commons-based urban strategies as feasible alternatives to conventional approaches to address global challenges. Advocates of polycentric governance contend that this approach is more capable of addressing the dual challenges of climate change and energy transition (Goldthau, 2014; Abbot, 2012; Cole, 2011; Byrne & Taminiau, 2015; Andrews-Speed & Shi, 2015; Hooghe & Marks, 2003; Ostrom, 2010). The main feature of polycentric governance approaches is the multiplicity of scales and stakeholders, allowing various stakeholders at multiple levels – particularly actors at local scales – to engage in strategy development and problem-solving (Abbot, 2012). This nature of polycentric governance renders energy systems more local specific and democratic. Polycentric governance is also more capable of creating innovative policies as it may stimulate various policy experimentations at multiple levels, foster collective action, and revamp learning networks (Goldthau, 2014; Abbot, 2012; Cole, 2011). Hence, these properties are arguably more capable of addressing the interrelated challenge posed by modern energy systems in an equitable and democratic manner.

Lastly, it should be noted that there are some concerns about the polycentric approach to addressing global commons problems, like climate change. Some scholars are worried about the feasibility of polycentric governance approach, arguing that various agencies at sub-national levels often do not have sufficient knowledge and resources to initiate and maintain a strong climate mitigation action.

In fact, this argument was one of the key criticisms of the Berlin's citizen-led movements for re-municipalizing energy provision (see Moss et al., 2015). Although this may be true for some local governments or private sectors, there are many municipal governments, civil movements, and businesses that have successfully achieved their targets to reduce GHG emissions. For example, Byrne et al. (Byrne, Taminiau, Seo, & Lee, 2017d) demonstrate that a city's decarbonization ambition (see Figure 22) and performance (see Figure 23) often exceed those of its national counterpart. More importantly, the criticism of polycentric governance approach can be overcome by the fact that large cities have sufficient resources and means that can contribute to global environmental governance as well as their local environmental problems.

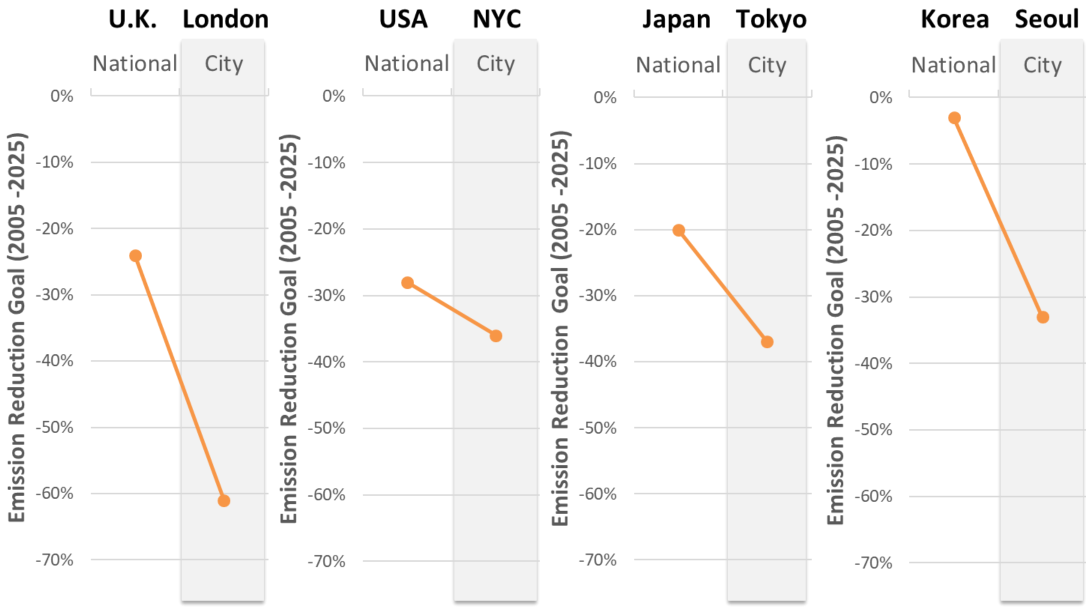

Figure 22. A Comparison of GHG Reduction Targets Between Four Large Cities and Their National Counterparts

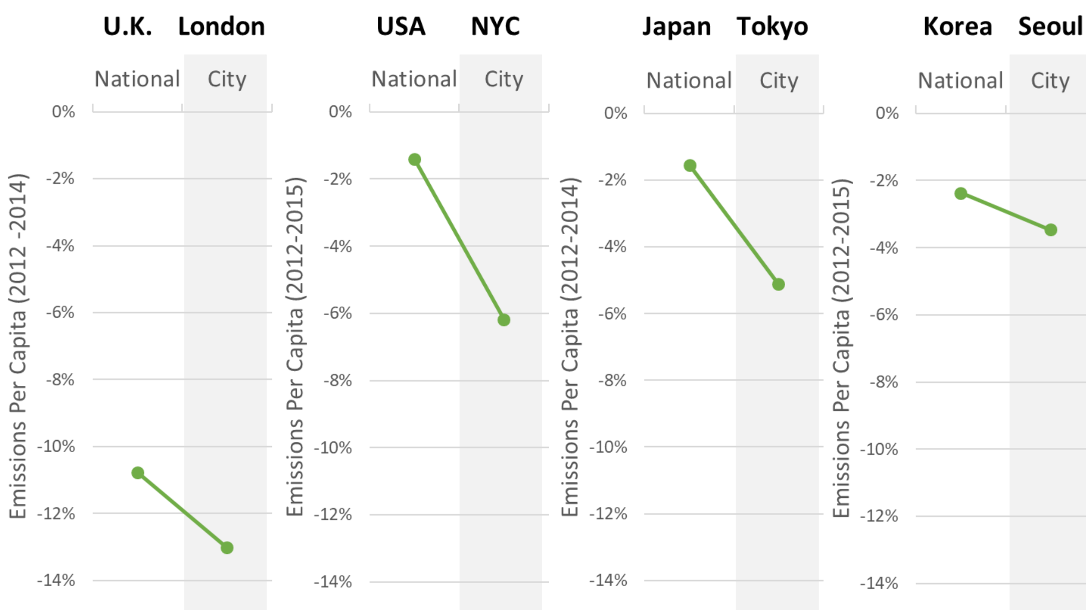

Figure 23. A Comparison of GHG Reduction Performances Between Four Large Cities and Their National Counterparts

5.3 Case Study as a Research Methodology to Assess the Potential of the DEDET framework

The dissertation chooses case study as a useful research method to explore the potential of DEDET Framework. In general, a case study can be defined in many ways. Even the term ‘case’ is not confined to a single definition. Under these circumstances, this study defines a case within the context of focus of inquiry (Patton, 2015; Stake, 2006). Yet, it is also important to note that there is a minimum requirement that a case should be bounded in a physical and temporal manner and/or by definition and context (Stake, 2006; Baxter & Jack, 2008; Patton, 2015). In this context, this study identifies Seoul, South Korea particularly the city’s One Less Nuclear Power Plant (OLNPP) initiative, for a case study. OLNPP initiative was designed to address the issues described in Chapter 2, which are endemic throughout the country. A case study can also provide an appropriate method to explore an emergent phenomenon, like urban energy transition, as it allows the researcher to investigate the complexity and uniqueness of the phenomenon or initiative from multiple perspectives (Van der Schoor, Van Lente, Scholtens, & Peine, 2016).

As the largest metropolitan cities in South Korea, Seoul has experimented with a range of energy policies to address issues of climate change, equitable distribution, and energy democracy. Notably, the OLNPP initiative is assessed through the lens of the DEDET framework proposed in Chapter 4 and the DEDET Criteria outlined in Section 5.1. Since launched in 2012, OLNPP has been positioned as the central energy strategy in Seoul. Several scholars have reviewed and analyzed the institutional design and/or key performance of OLNPP and/or its program(s). Although the foci of these studies vary, they are generally in agreement that OLNPP is an innovative urban strategy for a sustainable, equitable, and democratic energy transition (Byrne & Yun, 2017; Kim, 2017; Lee et al., 2014). This case study also discusses a recent initiative called Solar City Seoul (SCS). Publicly announced by SMG in November 2017, SCS aims to install 1GW of solar PV in Seoul by 2020. The discussion of SCS will heavily rely on three peer-reviewed papers that I co-authored and a technical report for which I was the primary author. In short, the logic of choosing Seoul are threefold. First, it is one of the largest and energy-intensive large cities in the world. Second, the city has been active in trying to integrate the principles of energy justice and democratic governance into its energy framework. Third, the new government of South Korea frequently turns to Seoul to understand what National governments need to do.

Key sources of the case study consist of an array of grey literature, scientific journals, and site-visit observations. Numerous phone or email communications that I have had with SMG (mostly the OLNPP team) are also used for data collection. These methods helped obtain information publicly unavailable. The details of the city's energy strategies, notably One Less Nuclear Power Plant (OLNPP), are well documented in grey literature including technical reports, conference proceedings, books, and web-based information published by Seoul Metropolitan Government (SMG) and its affiliated bodies, such as OLNPP advisory boards or Seoul Institute. Some of the information gathered through this process was triangulated through phone or email communications. This study also depends on scientific and peer-reviewed studies related to the city's energy strategies. Here, previous analyses that I have conducted with my colleagues are referred to or integrated into this case study. These include, but not limited to, peer-reviewed journal articles, conference proceedings, technical reports.

Lastly, site-visit observations and informal discussion helped gain insights and triangulate some information garnered from literature. I have had several opportunities to interact with the high-level officers, including the Mayor, CEO of Seoul Energy Corporation (SEC), and some managing directors, and several staffs responsible for daily operations regarding the city's energy strategies. These people have played key roles in the design and implementation of the energy strategies including OLNPP. I met them in person, by email, and/or by phone. I have worked with Dr. John Byrne, a member of Seoul International Energy Advisory Council (SIEAC), in the response to consultation requests made by SMG on an annual basis as well as an ad-hoc basis. SIEAC is an advisory body to the City of Seoul (and the Mayor of Seoul) consisting of 12 internationally recognized scholars and field experts in the energy and climate domain. I have also had face-to-face meetings with key stakeholders involved in Seoul's energy strategies, including some Korean members of the Citizen's Council and the Working Committee for OLNPP. The answers to the questionnaire that Dr. Byrne and I created are also very helpful for the case study. Composed of ten questions, this questionnaire is formulated to understand the key achievements of OLNPP over the first five years (April 2012 – April 2017) of OLNPP. A full version of the questions and answers is available in Appendix A.

Chapter 6

APPLYING THE DEDET FRAMEWORK

This chapter explores the potential of the DEDET framework through a general application of DEDET to three cities and an in-depth case study of Seoul. Three cities – London, Austin, Freiburg – are selected to show the applicability of the DEDET framework at several levels. These cities are widely recognized as leading examples of sustainable energy transition (Bulkeley, Castan Broto, & Maassen, 2014; Hughes, 2009; Rohracher & Spath, 2014). The energy strategies or policy frameworks of these cities are briefly reviewed whether and how extensively their guiding principles are aligned with the principles of DEDET, i.e. deep and equitable decarbonization and democratic governance, and vice versa. The brief review will provide a sense of whether DEDET is applicable to cities.

An in-depth study of Seoul is conducted to supplement the brief review of the three cities and understand the potentials of the DEDET framework in a more comprehensive and in-depth manner. The existing energy policy framework, OLNPP, is analyzed against the DEDET Criteria which are built upon the principles of deep and equitable decarbonization and democratic governance. The first two sections of this chapter present background information on Seoul and the OLNPP strategy. These sections are intended to help an understanding of the contextual circumstances behind the launch of OLNPP and provide site-specific information relevant to this study. The first section briefly discusses an overview of OLNPP. The next section delineates the major characteristics of Seoul pertinent to this study, including overall patterns and trends of energy supply and consumption. It also discusses major socioeconomic and climatological factors that can affect various issues of energy supply and consumption, followed by a review of previous studies on OLNPP. In the last two sections, an analysis of OLNPP against the DEDET Criteria is carried out and, then, policy implications are identified as the attempt to understand the potential of the DEDET framework as an integrated assessment model.

6.1 General Application of DEDET to Cities

6.1.1 Background on London

As the capital of the U.K., London consists of 33 local government districts, including 32 boroughs and the city of London. Comprised of the Mayor of London and London Assembly, Greater London Authority is administratively responsible for London. The city's total population is estimated to be 8.6 million as of 2015 and the total GHG emissions were 33.9 million tons.

London has been active in responding to the dual challenges of climate change and energy. Numerous studies have assessed the city's energy and climate policies and generally recognized the city as a leading exemplar in these fields. For instance, Newman (2009) notes that London was the first major metropolis in the world that imposed a city-wide tax on car use, so-called congestion tax. Bulkeley et al. (2014) analyze energy policy experiments – London ESCO and municipal PV projects – conducted during the previous two Mayors of London, Ken Livingstone and Boris Johnson, and show their potential as key agents facilitating an urban low-carbon transition.

London has a solid target to reduce city-wide GHG emissions by 60% from 1990 levels by 2025. In 2015, London reduced city-wide GHG emissions by 25%

compared to 1990 level and 33% compared to 2000 level. The city's per person GHG emission rate has rapidly decreased since 2005. During 2013-2015, London reduced per person emission rate by 24%. If the current declining rate continues or accelerates, partly due to the incumbent Mayor Kahn's zero carbon city initiative, London's per person emission rate could reach less than the sustainable- and equitable GHG emission rates in the next few years (Figure 24).

Figure 24. Per Person GHG Emissions for London (2005-2015)
Note: The data for London is retrieved from London Energy and Greenhouse Gas Inventory (LEGGI) (GLA, 2018b).

The current government of London initiated a comprehensive set of measures called Energy for Londoners (EfL) to achieve the zero carbon target (GLA, 2018a). One of them is to deploy 1 GW of installed solar capacity by 2030 and 2 GW by 2050. London also has Fuel Poverty Action Plan that assesses the issues of fuel poverty and provides activities to support the energy poor in the city (GLA, 2018c). These measures can be considered activities to reduce GHG emissions in a sustainable and equitable manner. The performance of these programs, once a concrete set of data is available, can be assessed against the second criterion of DEDET.

GLA developed London Zero Carbon Pathway Tool shows possible scenarios that can meet the 2050 zero carbon target (GLA, 2018d). London grouped decarbonization pathways into six categories – demand reduction, heat pump uptake, new heat networks, solar installations, gas decarbonization, and electricity decarbonization. The tool displays potential carbon emissions or energy demands based on select scenarios by each category (Figure 25). While it needs to be scrutinized, the tool implies that London is measuring and disclosing policy progress, which suggests that London's efforts for the fifth DEDET criterion could be highly appraised.

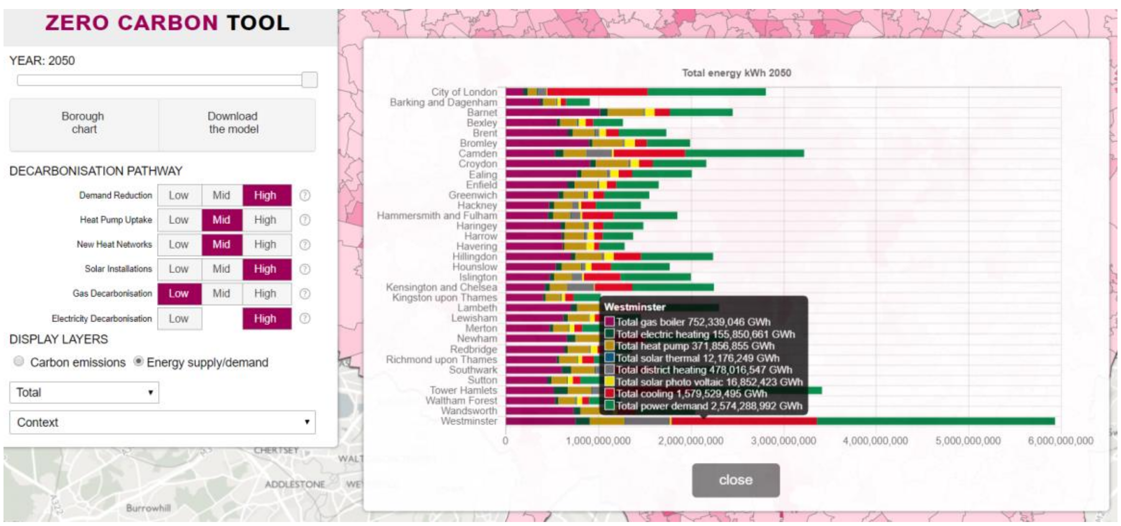

Figure 25. A captured image of London Zero Carbon Pathway Tool

6.1.2 Background on Austin

Located in the central area of Texas, the U.S., Austin is a mid-sized city with the population of 920 thousand as of 2016 (City of Austin, 2018a). Austin is recognized as a leading city in addressing the challenges of climate change and energy during the 1990s and the 2000s. From the 1990s, the municipal government of Austin established ambitious goals to reduce the city-wide GHG emissions, such as 20% below the 1990 levels by 2010. It created a RPS in 1999, which requires 5% of the city's electricity to come from renewable sources. The standard reinforced in 2003, though which renewable sources and energy efficiency were to meet 20% and 15%, respectively, of the energy demand in 2020 (Hughes, 2009).

The City of Austin has reinforced their efforts in recent years. For instance, the City Council of Austin approved a resolution, adopting the Austin Community Climate Plan in 2015. One of the plan's key goals is to achieve net-zero GHG emissions by 2050 (City of Austin, 2018b). Austin also has the interim targets to 2020, 2030, and 2040. The 2020 target is to reduce the city-wide GHG emissions to 11.3 million tons of carbon dioxide equivalent. Yet, neither the current level of GHG emissions nor the interim targets do meet the sustainable- and equitable emissions level (Figure 26). The 2050 goal is, if successful, to be below than the 3.3 ton per capita, but it cannot meet the first DEDET criterion.

Yet, there are positive signs that Austin can not only achieve its 2050 target but also meet many of the DEDET criteria. Although a detailed analysis is needed, an overview of the positive signs can be described here. First, the City of Austin is required to regularly monitors and reports policy progress, including its GHG emissions data. The resolution that adopted the Austin Community Climate Plan requires the City of Austin to issue semi-annual progress reports to the city council

(City of Austin, 2017), which can greatly increase the possibility to meet the fifth DEDET criterion. Second, the city has a municipal utility called Austin Energy. Established in 1895, Austin Energy is officially a municipal department of the city of Austin (Austin Energy, 2018a). Recognized as a “community-owned” utility, it has served the residents and businesses in the city by meeting their needs of electricity services (Hughes, 2009, p. 111). The fact that there is a municipal utility suggests that the city of Austin has a certain degree of institutional capacity and infrastructure to carry out the city’s implementation plans, enhancing the possibility to achieve the policy goals.

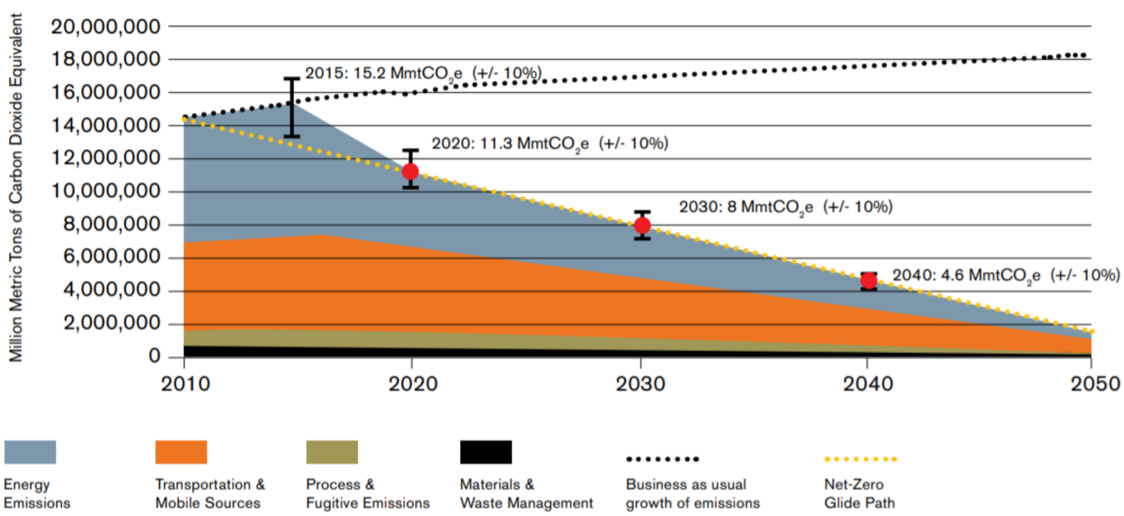

Figure 26. The City of Austin’s Climate Plan Target Path to Net-Zero By 2050
Source: City of Austin (2015), Austin Community Climate Plan, p. 5

Indeed, Austin Energy is recognized as a forefront of deploying sustainable energy. For instance, it supports 6,250 residential solar energy systems, 335 commercial projects, 44 school projects, and 60 municipal projects as of October 2017 (Austin Energy, 2018b). They currently operate two community solar projects: a 185-

kilowatt solar array located atop Palmer Events Center in Central Austin and a 2.6-MW La Loma solar farm located adjacent to Austin Energy's Kingsbery substation in East Austin. Palmer community solar array was built and owned by Austin Energy while La Loma solar farm was built by developer PowerFin. The community solar program supported by Austin Energy can offer the City of Austin a greater possibility to meet various dimensions of the third and fourth DEDET criteria.

6.1.3 Background on Freiburg

Located in the southwestern Germany, Freiburg has a population of around 220,000 (as of 2014) and is known for the first community-led resistance to the construction of Wyhl nuclear power plant during 1970s. Since then, it has been regarded as a frontrunner in sustainability and urban energy transition (Buehler & Pucher, 2011; Rohracher & Spath, 2014; Fastenrath & Braun, 2018).

The city has established ambitious GHG reduction targets from the 1990s. For instance, in 1996 it established a 25 percent reduction goal by 2010 compared to the 1992 level (City of Freiburg, 2011). It currently has two targets, as shown in Figure 27: a 50 percent reduction by 2030 against the 1992 levels and Climate-Neutral City by 2050 (City of Freiburg, 2018a), which can meet one of the requirements of the DEDET first criterion. The city reports that, due to a multitude of measures, the per capita GHG emissions have decreased by almost 30% compared to the 1992 level (11.38 tCO_2e per capita). Yet, the latest data shows that the per capita emission was 7.97 tCO_2e per capita in 2014 (City of Freiburg, 2017a). It is estimated to be 5.5 tCO2e by 2030 and 2.4 tCO2e by 2050, if the targets were to be achieved (Hertle & Dünnebeil, 2017). What is impressive is that the city reports that it will not be able to meet the previous target, which was a 40% reduction by 2030, and therefore establishes a more stringent target. Another strength that often cannot be found in other cities is that the targets were approved by the municipal council of Freiburg, suggesting that there is a greater possibility that Freiburg could achieve the targets.

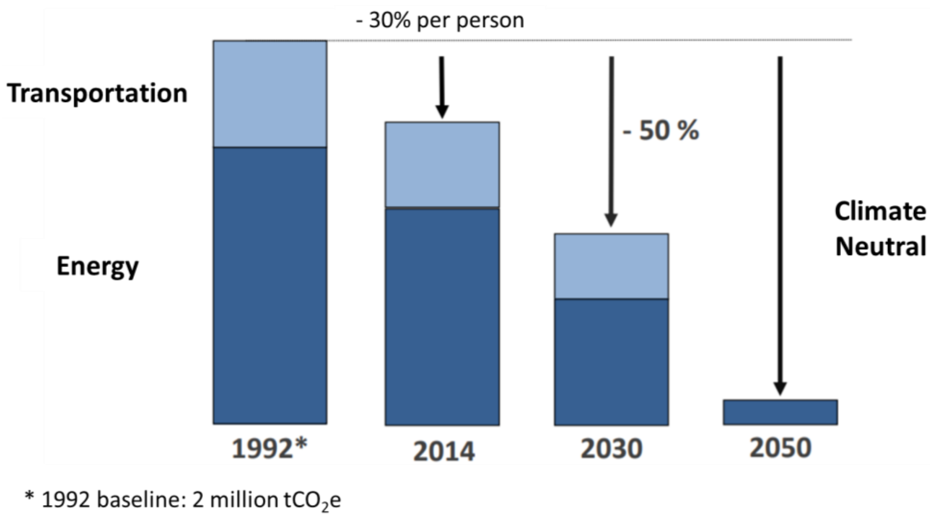

Figure 27. Historic GHG reduction achievement and the long-term targets in Freiburg
Source: City of Freiburg (2018b), Was kann Freiburg für den Klimaschutz tun? (What can Freiburg do for climate protection?)

The key tools deployed by the City of Freiburg are sustainable energy sources. For instance, the city reports that energy conservation and efficiency measures are “of great importance” (City of Freiburg, 2017b). It has a diversity of activities to promote this agenda. For instance, the city estimates that it has reduced CO_2 emissions from its building stocks by 48.7 percent since 1990 (City of Freiburg, 2018b). It initiated “city of short distances” in 1989 and then adopted “CO2-free mobility” as one of the six action fields for its long-term goals (City of Freiburg, 2018c). Freiburg has expanded the public transport and cycling networks within the city. The city is recognized as a “leader in sustainable transport and land-use” (Buehler & Pucher, 2011).

6.1.4 Key Findings from Preliminary Studies of Three Cities and the Next Step

The preliminary studies of the three cities – London, Austin, and Freiburg – were carried out to enable a review of the general applicability of the DEDET framework to cities. The review shows that the three cities, which are broadly recognized as so-called leaders in sustainability, are meeting most of the DEDET criteria (Table 11). The test of DEDET's applicability was conducted using a checklist method that is widely used to evaluate performance appraisal or the nature of impacts, such as environmental impact assessment.

Table 11. A preliminary DEDET analysis of London, Austin, and Freiburg

DEDET Criteria	London	Austin	Freiburg
Deep and equitable decarbonization targets	V	V	V
Deep and equitable decarbonization policies	V	V	V
Citizen participatory and deliberative forms of governance	N/A	V	V
Commons-based strategies delivering a commonwealth economy	N/A	V	V
Measurement, verification, and communication (MVC)	V	V	N/A
Research infrastructure to support the development of DEDET strategy	N/A	N/A	V

Note: This table shows preliminary analyses of applying the DEDET framework to the three cities. The results do not provide a complete picture of the institutional capacity and measures of each city. It is advised to be understood that the results above are illustrative purposes only. The check symbol (V) indicates that a city meets the DEDET criterion while N/A means that either there is no information publicly available or relevant information could not be found for the purpose of this preliminary analysis.

It must be pointed out that this comparative study is preliminary. Further analysis would be needed to capture the institutional forms and activities of each city as comprehensively and in-depth as possible in order for DEDET to fully analyze each city's activity on behalf of the principles of deep and equitable decarbonization and democratic governance. Quantitative analyses would also need to be conducted. To fill the gaps, this dissertation carries out an in-depth case study, using Seoul, South Korea, in the next section.

6.2 In-Depth Study of Seoul

6.2.1 Introduction of OLNPP

Seoul, as the largest and busiest city in South Korea, exhibits similar characteristics typically found in other large cities whose extensive infrastructure network have heavily reliant on conventional modes of energy provision and consumption. In this context, Seoul is accountable for many global challenges as it has contributed to the configuration of conventional energy systems by not only using a significant portion of the total produced energy and, as a result, generating carbon emissions. Political and economic powers are also highly concentrated in Seoul considering that Seoul is the capital of and the most populous city in South Korea.

On the other hand, it is important to understand that prevailing modes of energy provision and consumption in Seoul have also been configured by conventional energy systems. South Korea's energy systems are characterized by highly centralized governance approaches and vertically integrated technological network. Under these circumstances, there has been no substantial energy policy designed by local governments, including SMG. Major roles of local governments were to support national policies at administrative levels. As a result, institutional arrangements and infrastructure within Seoul are largely shaped by nation-wide conventional energy systems.

In January 2012, the newly elected mayor of Seoul, Mr. Park Won-soon, initiated a meeting among SMG, civil society, and experts to address major issues of energy that Seoul was facing. These issues were particularly pertinent to two major accidents that both occurred in 2011 – the Fukushima Daiichi nuclear disaster in Japan and nation-wide rolling blackouts in South Korea. Several types of the public session were followed, such as workshop and public discussion. In April 2012, Seoul launched the so-called One Less Nuclear Power Plant (OLNPP). Conceptualized as an urban energy strategy to replace the existing nuclear power reactor with sustainable energies, OLNPP was developed to address inequity issues imposed by Seoul's energy provision and consumption modes and reduce Seoul's GHG emissions as well as reduce high technological risks posed by a growing number of nuclear reactors in South Korea (SMG, 2014a).

Consisting of two phases, OLNPP has been continuing over the last six years (Figure 28). Key goals of the first phase were to reduce the city's energy use by 2 million tons of oil equivalent (TOE) and increase the city's electricity self-sufficiency rate to 5% by 2014. SMG set out 78 projects in the areas of renewable energy, energy efficient buildings and transportation system, job creation in the energy sectors, low-carbon urban restructuring, and citizen-led creation of an energy saving culture. In June 2014, SMG declared that Seoul accomplished the reduction of energy use by 2 million TOE. Considering the target year was the end of 2014, it indicated that Seoul achieved the goal six months earlier than originally planned. The self-sufficiency rate reached 5% by the end of 2014.

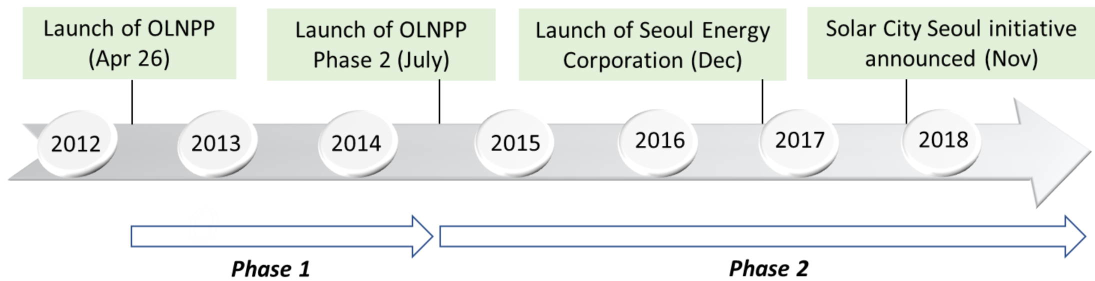

Figure 28. Key Milestones of OLNPP

In July 2014, SMG announced the second phase of OLNPP. SMG identified four issues and challenges that must be addressed in the design process for OLNPP 2: 1) Seoul's long-term energy vision and core values, 2) a sustainable and participatory governance framework for OLNPP, 3) institutional challenges posed by the existing arrangements, and 4) administrative capacity and inter-governmental cooperation within the city government. Accordingly, the second phase of OLNPP set out a vision, "Seoul, an Energy Self-Reliant City," and three core values or principles – energy self-reliance, energy sharing, and energy participation. The vision embodies Seoul's commitment to both its citizens and others, including other regions and future generations (SMG, 2017a, p. 13). The three core values specify the vision: 1) energy self-reliance enhances Seoul's energy self-sufficiency and, as a result, reduces the burdens born by other regions and future generations; 2) the energy sharing principle underscores that energy saved through OLNPP be shared with the energy poor and future generations; energy participation seeks to realize energy democracy by building an energy governance where citizens are main actors. The second phase extended the quantitative targets, including electricity self-reliance rate and the energy savings target, to 20% and 400 million TOE, respectively, by 2020. OLNPP-2 also set a GHG reduction target of reducing 10 million tCO_2e of GHG emissions by 2020 compared to the 2005 level. During the second phase, SMG established a municipal utility, Seoul Energy Corporation (SEC), in December 2017 and launched a new ambitious initiative called Solar City Seoul in Nov. 2018.

6.2.2 Major Characteristics of Seoul[14]

With a population of 10 million, Seoul is the most populous and densest city in South Korea. Its population accounts for approximately 20% of the national population and its population density stood at 16,364 people per square kilometer in 2015 (Figure 29). Seoul is ranked one of the highest in terms of economic indicators. The regional gross domestic product (RGDP) of Seoul accounts for over 20% of the GDP of South Korea. Seoul has the highest personal income and consumption expense at capita level. These characteristics indicate that Seoul is the largest and the most powerful metropolis in demographic and economic points of view.

At the same time, Seoul has played a catalytic role as a central venue where civil movements for democracy and commonwealth are mobilized including a series of protests against any types of dictatorship.

[14] This study assumes that OLNPP took effect from 2013. In this vein, most characteristics of Seoul in this section, especially quantitative data associated with energy provision and consumption, are depicted up until FY2012. More recent data is, when available, used in the section that analyzes OLNPP.

- Population (2016) – 9.93 million (19.2%)
- RGDP (2016) – $331 billion (21.8%)
- RGDP per capita (2016) – $33,000
- TFEC (2016) – 179,497 gigawatt hour (6.8%)
- Electricity consumption (2016) – 46,493 gigawatt hour (9.4%)
- GHG emissions (2015) – 47.6 million tCO_2e (7%)

Figure 29. Map of South Korea and Key Characters of Seoul
Note: The numbers in parentheses represent the proportion of Seoul against the national statistics. The image is accessible at https://www. worldatlas.com/webimage/ countrys/asia/koreanpn.htm

Relatedly, there is, among citizens, a growing recognition of the problems with institutional arrangements and socioeconomic practices based on predatory capitalism and elitism. As a response, some citizens or grassroot activists organized community-based activities to recover commons, such as brownfields and retired sites. For instance, Gyeongui Line Commons Civil Movement was formed to reclaim the retired lands for one of the railroads in Seoul, Gyeongui Line, as a public space owned by community members (Kim, 2016). In the energy domain, one of the most popular activities has been to organize forms of energy conservation action and community solar. For instance, residents in some apartment complexes have implemented retrofit programs in their common property to save energy (Yun & Park, 2017). The energy saved from the programs is characterized by a commonwealth as it is created and owned by the community.

When it comes to energy provision and consumption, a substantial amount of energy is needed to maintain the urban metabolism of Seoul. From 2005 to 2012, Seoul had consumed more than 15 million TOE of energy on an annual basis (see Figure 30). This level of consumption amounts to approximately 8 percent of South Korea's total energy consumption. Over this period, however, Seoul's total energy consumption has almost stayed the same (see the red line with square marker) while the national counterpart has increased by over 20% (CAGR=2.9%) (see the blue line with triangle marker). The bar graphs show a two-fold increase of energy consumption in the public sector (CAGR=8%) (the top area in yellow) but a 26 percent decrease in the industry sector (the bottom area in blue). In the residential, commercial, and transportation sectors, which accounts for over 85% of Seoul's total energy consumption, there have been no significant change in energy consumption (the middle areas of bar graphs where the upper area represents the residential and commercial sector and the lower area the transportation sector).

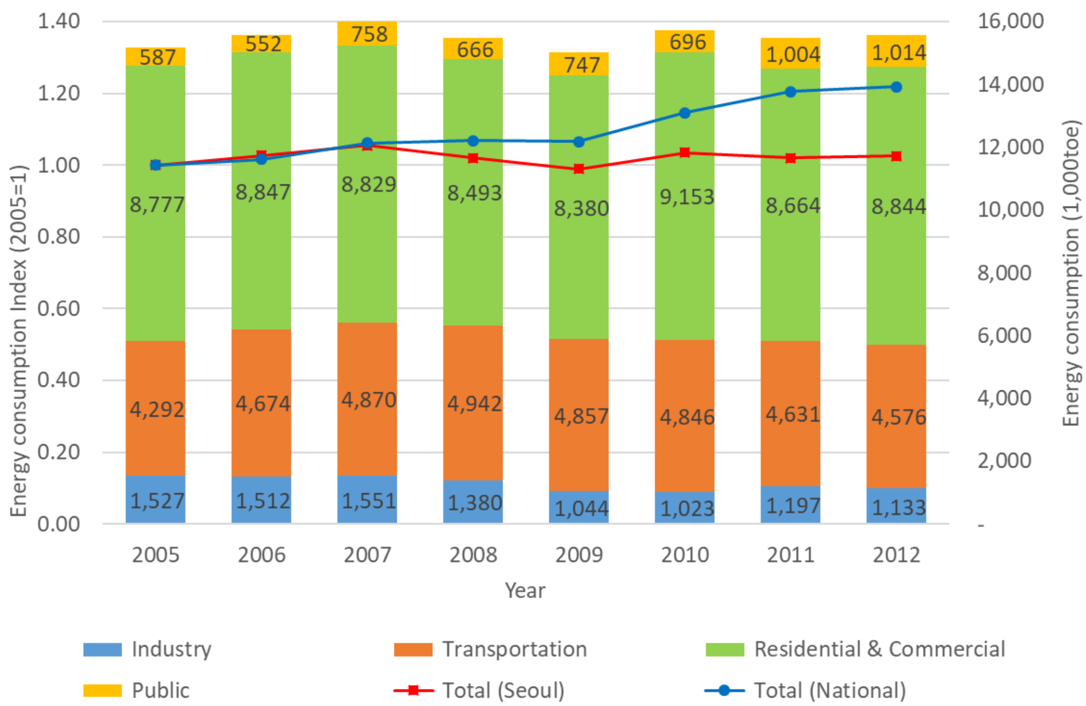

Figure 30. Seoul's Total Energy Consumption by Sector and the Energy Consumption Trends in Seoul and South Korea from 2005 to 2012
Note: The bar graphs represent Seoul's total energy consumption by sector and the indexed line graphs show the energy consumption trends in Seoul and South Korea.

Contrary to the total energy consumption, the electricity consumption of Seoul has significantly increased. As shown in Figure 31, it has increased by 17 percent from 2005 to 2012 (CAGR = 2%). However, the share of Seoul to national electricity consumption has narrowed from 12.2 percent to 10.1 percent largely due to higher electricity consumption growth at the national level. Every sector overall shows a continued growth in electricity consumption. Compared to the 2005 levels, the public, commercial, and residential sectors have experienced increases in electricity consumption by 35% (CAGR=4%), 19% (CAGR=3%), and 16% (CAGR=2%), respectively. The industrial sector is the only one that shows a decline in electricity consumption (20% decline compared to the 2005 level).

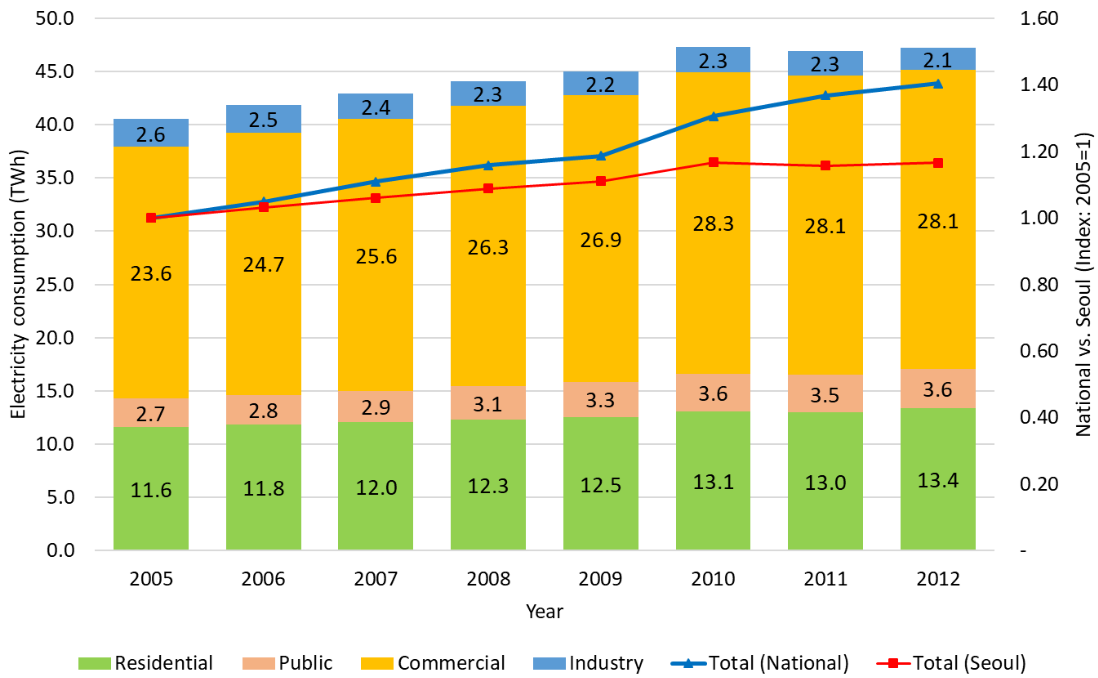

Figure 31. Seoul's Total Electricity Consumption by Sector and the Electricity Consumption Trends in Seoul and South Korea from 2005 to 2012

Note: The bar graphs represent Seoul's total electricity consumption by sector and the indexed line graphs show the electricity consumption trends in Seoul and South Korea.

The final energy that the city consumes is largely produced from non-renewable resources, such as coal, oil, and natural gas. Figure 32 illustrates sources of energy used in Seoul from 2005 to 2012. Oil and natural gas (here, noted as city gas) amounted to 72% and 69% of the total energy consumption in 2005 and 2012, respectively. When combined with the use of electricity, these rates could reach around 90%. Renewable energy has played a very insignificant role in Seoul's energy consumption trends (less than 1 percent). It was 2011 when the rate reached over 1 percent. In 2012, it went up to 1.4% (KEEI, 2017a).

These characteristics associated with energy consumption indicate that Seoul heavily relies on other regions for energy required to maintain its infrastructure network and daily operation. This situation is further highlighted by the level of electricity consumption by the city. Seoul procures approximately 25% of its final energy consumption through the national power grid in which 25% of electricity is produced from nuclear power reactors. Indeed, 18 out of 24 nuclear power reactors in operation are located in the red dotted area in Figure 29. Seoul's electricity demand is partly met by these nuclear power plants, implying that the city is being operated or growing at the expense of the residents in this red dotted area. Along with the heavy reliance on fossil fuels, Seoul's energy consumption has a significant implication on other regions of South Korea.

It can also be said that Seoul is a major contributor to the design and development of current energy systems at a national level and, to some extent, at international level. One important implication is its contribution to global warming. Seoul, as described earlier in this section, burns a substantial amount of oil (e.g. gasoline and diesel) on the streets and uses electricity produced from coal- or gas-fired power plants, as a result adding a substantial amount of carbon emissions to the global atmosphere. From 2005 to 2012, Seoul has generated on average 49.3 million tCO_2e of GHG emission.

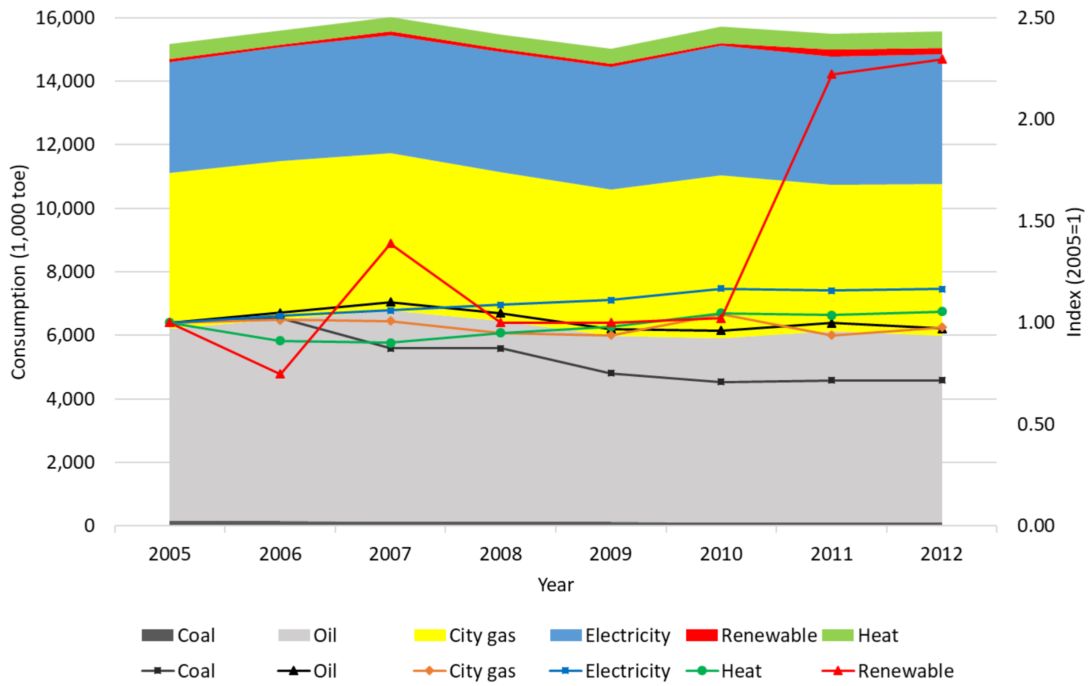

Figure 32. Energy consumption by energy source in Seoul from 2005 to 2012
Note: An area represents the annual total energy consumption of an energy source and a line graph is an indexed energy consumption.

Lastly, it is important to understand climatological conditions in Seoul when it comes to energy provision and consumption. Figure 33 illustrates three major climatological information – atmospheric temperature, heating degree days (HDD), and cooling degree days (CDD) - in Seoul from 1997 to 2016. Although there has been a string of fluctuations, these climatological factors show tendencies to gradually increase, at least, over this period. Yet, it should be noted that the focus of this study is not related to the long-term (here 20 years) climate trend; rather, these sets of climatological information are useful when analyzing the impact of OLNPP on energy conservation.

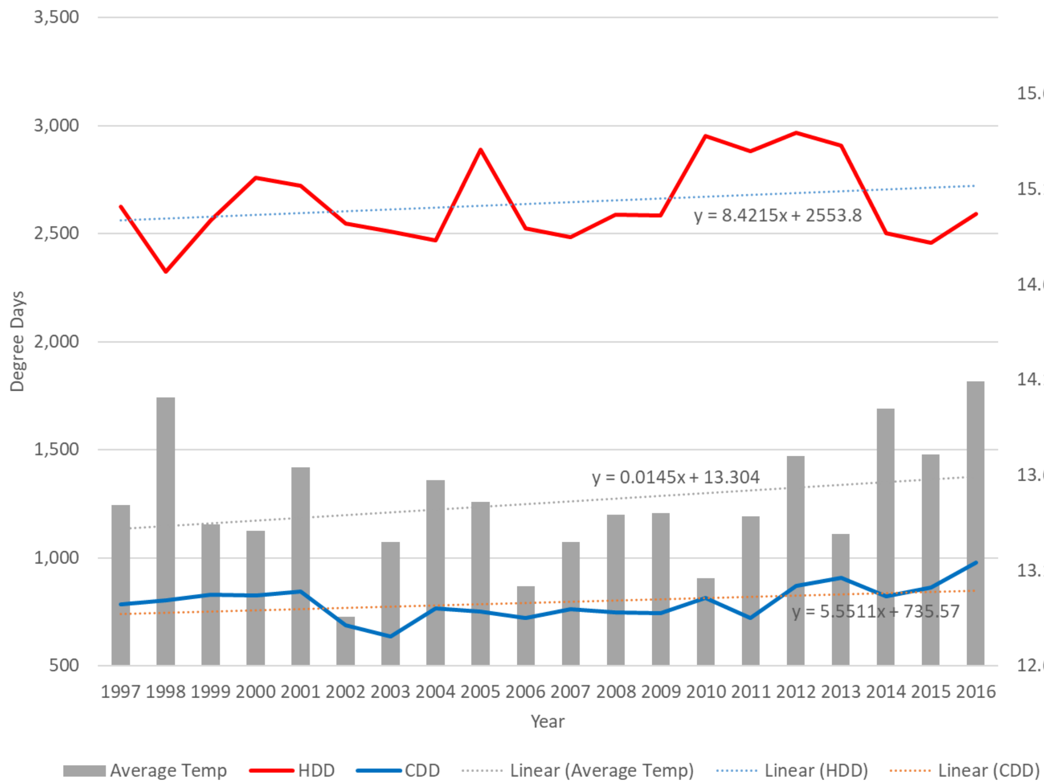

Figure 33. Average Temperature, HDD, and CDD in Seoul from 1997 to 2016
Note: The bar graphs represent Seoul's average temperatures and the line graphs (red and blue) represent heating degree days and cooling degree days, respectively.

6.2.3 Previous Studies

There is a growing body of research on OLNPP. As of Feb 2018, at least 11 peer-reviewed studies can be identified. Table 12 offers a list of these studies.

Table 12. Peer-Reviewed Journal Articles that Assess or Discuss OLNPP

Title of study	Author (year)
Explaining One Less Nuclear Energy Policy from Governance Perspective: Energy Transition and Effectiveness of Urban Energy Policy (*In Korean*)	Lee (2017)

A Community Energy Transition Model for Urban Areas: The Energy Self-Reliant Village Program in Seoul, South Korea (*In English*)	Kim (2017)
Multivariate analysis of solar city economics: impact of energy prices, policy, finance, and cost on urban photovoltaic power plant implementation	Byrne et al. (2017)
The Expansion of Apartment Energy Transition Movements from a Viewpoint of Spatiality: Focusing on the cases of Energy Self-sufficient Village Initiatives by Apartment Complexes in Seoul (*In Korean*)	Yun & Park (2017)
The Factors of Local Energy Transition in the Seoul Metropolitan Government: The Case of Mini-PV Plants (*In English*)	Lee & Kim (2017)
A solar city strategy applied to six municipalities: integrating market, finance, and policy factors for infrastructure-scale photovoltaic development in Amsterdam, London, Munich, New York, Seoul, and Tokyo	Byrne et al. (2016)
An analysis of Seoul`s energy transition from an integrated multilevel governance perspective (*In Korean*)	Kim (2016)
Possibilities and Institutional Limits of Citizens' Solar Power Cooperatives as a Strategic Niche for Energy Transition: Focusing on the Case of Seoul (*In Korean*)	Yun & Sim (2015)
Energy Politics and Civil Governance of Mayor Park Wonsoon in Metropolitan Seoul (*In Korean*)	Lee (2015)
A review of the solar city concept and methods to assess rooftop solar electric potential, with an illustrative application to the city of Seoul (*In English*)	Byrne et al. (2015)
An experiment for urban energy autonomy in Seoul: The One 'Less' Nuclear Power Plant policy (*In English*)	Lee et al. (2014)

Note: The parentheses in the first column (Title of Study) refer to the language used for publication.

The existing studies assess major achievements of and important barriers to a sub-program of OLNPP from energy transition perspectives. Kim (2017) explores the achievements of Seoul's Energy Self-Sufficient Village (ESV) program and the role of the Seoul Metropolitan Government in realizing such results. Through a literature review of both published and unpublished documents and semi-structured interviews with SMG and leaders of ESVs, she finds chief achievements of the ESV program, such as energy savings, increases in locally-produced energy, or enhancement of community trust. Her study also identifies major factors that have enabled the positive outcomes of ESVs, notably administrative, financial, and technical support of SMG. Yun and Park (2017) also investigate the ESV program in urban energy transition movements. Particularly, they analyze the functions and roles of the ESV program in the context of the spatiality of apartment complexes. By conceptualizing spatiality by boundedness, commonality, and compactedness, they identify that the ESV program helps raise awareness of energy transition and enhancing community trust among the residents in two apartment complexes selected for this study. Lee and Kim (2017) analyze the number of mini-photovoltaics (PV) installed in each of 25 districts of Seoul to explore important factors of encouraging or discouraging a sub-program cited as Mini-PV Plant throughout the city. Relying largely on descriptive statistics, they identify 13 explanatory indicators grouped in 4 categories – administrative and financial capacity, political context, public awareness, and geographical diffusion – and conduct correlation analyses between the explanatory indicators and the number of mini-PVs installed in each district. As a result, they find that higher rates of mini-PV installation are highly associated with administrative capacity, financial capacity, and political context. Specifically, their results show that three indicators - an ordinance on climate change, financial dependence on SMG, and district mayor's leadership or will – have greatest correlations with the number of mini-PVs installed. Yun and Sim (2015) examined the potential of citizen-led energy cooperatives as a strategic niche for energy transition. While it is difficult to recognize citizen-led energy cooperatives as an OLNPP initiative, Seoul provides an array of incentives to support energy cooperatives. Through a case study of six energy cooperatives, Yun and Sim found that, although energy cooperatives can play a contributing role in energy transition movements, their potential has been constrained by the existing institutional arrangements, such as lack of financial and regulatory support, that discourage small-scale energy cooperatives to flourish and make this business model unviable.

Byrne et al. (2015, 2016, and 2017b) explore the electricity technical potential and financeability of city-wide solar PV deployment in six megacities across the world, including Seoul and point out that this infrastructure-scale solar energy development has a transformative power for a sustainable urban metabolism. They find that such a large-scale solar PV deployment can generate more than 60% of the electricity needed for Seoul during daylight hours and more than 30% during all day. Although the financial feasibility of the project for Seoul is less attractive than those of other case cities, such as Amsterdam, Munich, and New York, due to lower electricity price, their findings suggest that a large-scale solar city strategy for Seoul can become feasible "when combined with well-designed policy incentives and financing instruments (Byrne et al., 2017c, p. 251).

Some studies have focused on issues of governance. These studies find that the governance arrangements of OLNPP play critical roles in achieving the positive outcomes. Lee et al. (2014) characterize OLNPP as an urban energy experiment and argue that it was formulated as "a purposive intervention" for urban energy transition (p. 311). To examine the contributions of OLNPP to urban energy transition, they develop a framework consisting of 11 central themes. Grouped into three components of policy background, governance, and policy content, the four central themes (under policy background) include economic, environmental, social, and political contexts; the next three key themes (under the governance component) are policy aims, the decision-making process, and leadership; the last four main themes (under the policy content component) include renewable energy supply, energy efficiency measures, energy demand management policies, and the evaluation and monitoring of policy performance. Based on an analysis of OLNPP through the lens of the framework, they identify the leadership of Seoul's Mayor and the moral dimensions embedded in OLNPP as particularly significant contributions of OLNPP. Lee (2017) also notes Seoul's governance capacity as a central factor for highly positive outcomes of OLNPP. He contends that Seoul has been able to maintain epistemological consistency of key procedural elements of energy policy system, such as policy goals, tools, and evaluation. Lee points out, however, that Seoul's policy evaluation framework is still largely based on conventional approaches to assessing the achievement of its policies. This indicates that there is a mismatch between the epistemological and normative system of OLNPP and the evaluation system of OLNPP. This gap, he argues, creates a high possibility to not only distort evaluation results but also undermine the sustainability of energy policy system.

Lee's criticism of Seoul's current governance framework underscores the timeliness of a new framework to assess energy policies, particularly in the context of energy transition. In this regard, the DEDET framework may provide a useful tool to assess the achievements of OLNPP in realizing the three goals of deep decarbonization, equitable distribution of the risks and opportunities, and democratic control of energy systems.

6.2.4 In-Depth Analysis of OLNPP Against the DEDET Criteria

6.2.4.1 Deep and Equitable Decarbonization Targets

Possible question: Are there a multitude of GHG reduction targets? If so, do they meet the principle of deep and equitable decarbonization?

Seoul has been a heavy consumer of carbon-intensive energy. As illustrated in Figure 34, Seoul's GHG emissions had remained near 50 million tCO_2e during eight years before OLNPP. On average, 15 million tCO_2e of annual excess GHG emissions were generated by Seoul from 2005 to 2012 when compared to the sustainability- and equity-based GHG emission rate (Byrne et al., 1998). It is equivalent to an excess of 1.53 tCO_2e per person per year. In the initial design stage of OLNPP, it was recognized that Seoul had imposed the burdens and potential risks arising from the city's energy consumption on other regions of South Korea and the world. SMG explicitly states that some of the OLNPP's aims are to transform Seoul into an "energy-responsible city" and to make the existing patterns of energy provision and consumption as equitable as possible between Seoul and other regions (SMG, 2017a, p. 13).

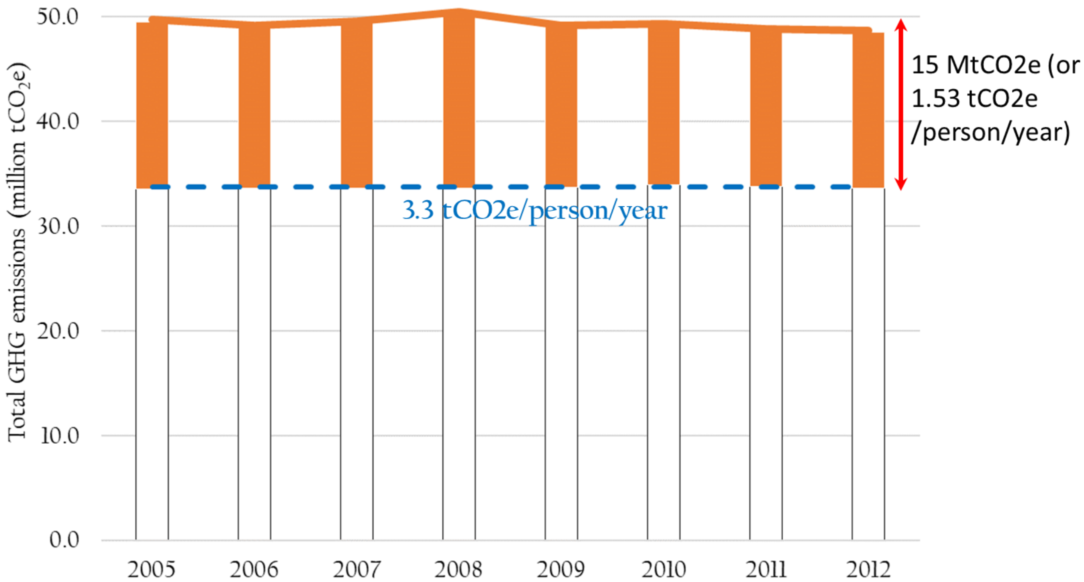

Figure 34. Sustainable- and Equitable Emissions Levels Versus Observed GHG Emissions for Seoul from 2005 to 2012

Note: If Seoul had met this benchmark rate, it should have generated GHG emissions at an annual average of 33.7 million tCO_2e. The bottom blank areas of the stacked bar graphs represent the amount of GHG emissions at the sustainable- and equitable levels (i.e. 33.7 million tCO_2e). The top red areas show the exceeded GHG emissions each year, which is as much as 15 million tCO_2e. This emission level amounts to the latest annual GHG emissions of the City of Phoenix (US), Lima (Peru), or Manchester (UK) (CDP, 2018).

As Figure 35 shows, the annual GHG emissions and the per person rate have decreased during 2013-2014, which was the first two years of OLNPP. Nevertheless, these results are still greater than the sustainability- and equity-based GHG emission rates, such as 3.3 tCO_2e per person per year target (the blue dot, horizontal line in Figure 31). The city's near-term target is to reduce GHG emissions by 25% compared to the 2005 level by 2020 (SMG, 2017b). To achieve this target, Seoul needs to reduce more than 12 million tCO_2e or 1.7 MtCO2e per year from 2015 to 2020. As a result, Seoul's total GHG emissions will be no less than 37.1 million tCO_2e in 2020 or 3.85

tCO$_2$e per person on the premise that the population of Seoul will be 9,635,124, which is the national population projection. But it is still larger than the sustainable- and equitable level of the annual total GHG emissions by 3.4 million tCO$_2$e or 0.55 tCO$_2$e per person.

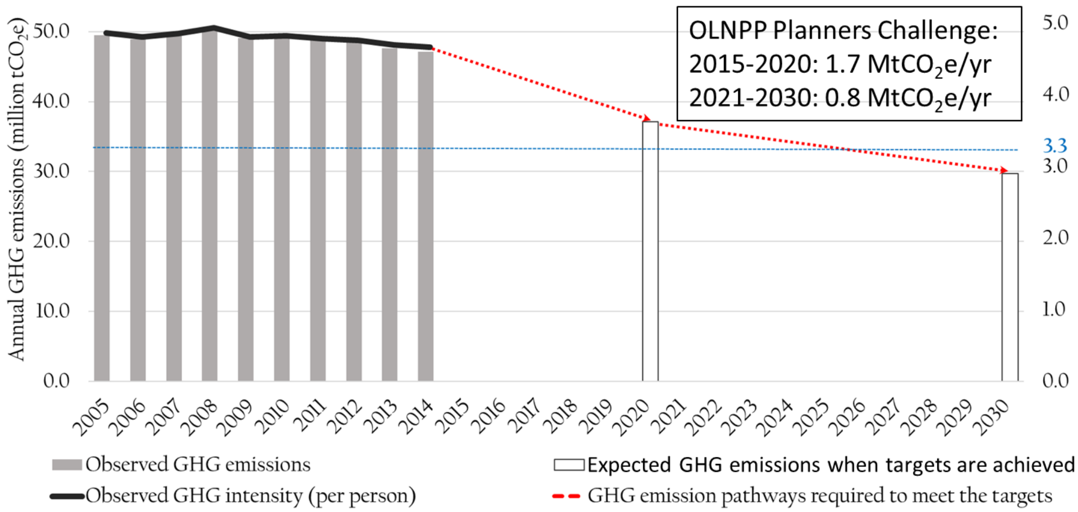

Figure 35. Observed GHG Emissions (2005-2014) and Emission Pathways to Meet Seoul's 2020 and 2030 Targets
Note: The white bars represent Seoul's GHG emission targets for 2020 (25% reduction) and 2030 (40% reduction) against the 2005 level.

Seoul also has a long-term target, aiming to reduce the city-wide GHG emissions by 40% compared to the 2005 level by 2030 (SMG, 2017b). To meet this target, the city needs to reduce its total GHG emissions to 29.7 MtCO$_2$e or 0.8 MtCO$_2$e per year from 2021-2030 in addition to an annual reduction of 1.7 MtCO$_2$e per year for 2015-2020. Using the projected population of Seoul in 2030 (9,428,800), the per person rate is estimated to be 3.15 tCO$_2$e. It means that Seoul's 2030 target can be considered a GHG reduction target that is sustainable and equitable. But the level of reduction required to meet the target, although it is less than the annual reduction that Seoul achieved during the first two years of OLNPP (2 $MtCO_2e$), presents OLNPP planners with substantial challenges as more ambitious measures, which often requires a greater portion of the city's budget, will likely be needed.

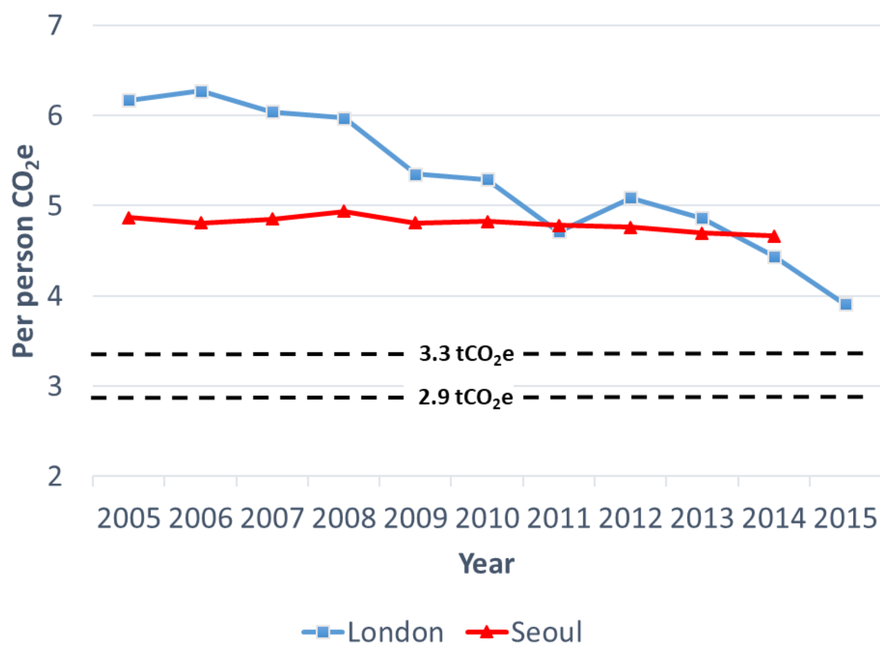

Figure 36. Per Person GHG Emissions Comparison between London and Seoul (2005-2015)
Note: The data for London is retrieved from London Energy and Greenhouse Gas Inventory (LEGGI) (GLA, 2018e).

In sum, Seoul has a GHG reduction target that is designed to meet the sustainability- and equity emission rate. Seoul's long-term target (40% reduction compared to the 2005 level by 2030) could decrease the per person emission rate to 3.15 tCO_2e (see Figure 31). Yet, the city is currently failing to meet the sustainability- and equity-based emissions rate (i.e. 3.3 tCO_2e per person per year). Although the average per person emission rate since the launch of OLNPP (2013-2015), is lower than that of the previous years (2005-2012) by 0.13 tCO_2e, the current level (4.7

tCO_2e) is still much higher than 3.3 tCO_2e. When compared to other major cities, Seoul appears to lag behind. For instance, during 2013-2015, London (see Section 6.1.1 for more details), had reduced per person emission rate by 24% while Seoul reduced by 2.4% (Figure 36). If the current declining rate continues, London's per person emission rate can reach less than 3.3 tCO_2e by 2017 and 2.9 tCO_2e by 2018. This study finds that Seoul must reduce city-wide GHG emissions by 15.6 million tCO_2e to meet the GHG reduction target that is sustainable and equitable.

6.2.4.2 Deep and Equitable Decarbonization Policies

Possible question: Is there a sufficient diversity of policy and technology alternatives to address the challenge of deep and equitable decarbonization?

During the first two years (2013-2014) since the launch of OLNPP, the city's annual average GHG emission had decreased by 2 $MtCO_2e$ (or 0.1 tCO_2e per person) compared to the level of the previous years. SMG reports that it has avoided 5.63 million tCO_2e from April 2012 to June 2014 (OLNPP Phase 1) (SMG, 2017a). A main reason behind the difference between 5.63 million tCO_2e and 1.7 million tCO_2e is that the former (SMG's estimate) represents a sum of combined GHG emissions avoided by all energy-related activities (e.g. energy conservation measures and renewable energy production) while the latter (this study's estimate) is solely based on GHG statistics for Seoul. This amount of reduction is equivalent to 3.5% of the city's GHG emissions in 2014. Indeed, a preliminary analysis of energy saved during the first three years of OLNPP shows that Seoul has avoided a significant amount of energy consumption (Figure 37).

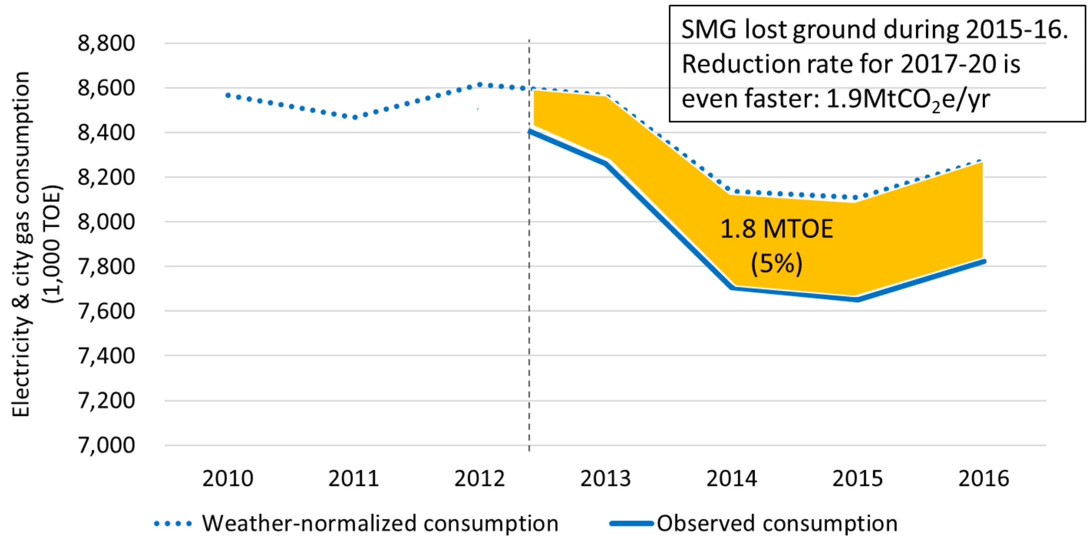

Figure 37. Avoided Electricity and Natural Gas Consumption from the Launch of OLNPP to 2016

Note: Regression analyses were run to predict LNG and electricity consumption over 2013-2015. The following equations are the results of the analyses: for electricity, $C_{electricity} = 293.0736 + 0.1295*HDD + 0.3282*CDD – 13.9232*D$ (R^2 = 74%) where HDD and CDD represent heating degree days and cooling degree days in Seoul and D represents a dummy variable when HDD>CDD is 1; for LNG, $C_{gas} = 164.36 + 0.86*HDD$ (R^2=95%) where HDD represents heating degree days in Seoul. Note that the analysis above starts from 2010 because of the issue of data availability for city gas consumption.

This analysis compares the observed (blue solid line) with weather-normalized (blue dotted line) electricity and natural gas consumption. The observed consumption before 2011, although it is not illustrated in the graph, was greater than the weather-normalized consumption. From April 2012 to 2016, the total amount of electricity and city gas saved amounts to 1.8 million TOE (yellow shaded area), which is about 5% of the total observed consumption during this period. Indeed, the city reports that by June 2014 it had achieved the 2 million TOE target of OLNPP Phase. The latest report shows that the saved energy reached 4.2 million TOE in September 2017 (SMG, 2017b). This amount of energy is equivalent to annual electricity that can be generated from two nuclear reactors or 30% of Seoul's annual energy consumption.

There are more than 200 measures taken from 2012 to 2016 to support OLNPP (SMG, 2017a). Some of them clearly show that the principle of deep and equitable decarbonization is engrained. For example, SMG's weatherization program had provided a low-interest loan to 143,487 households from 2012 to 2016. It is reported that the program saved energy consumption by 20,778 TOE and reduced GHG emissions by 45,000 tCO_2e (SMG, 2017d). SMG's LED replacement program for low-income households can also be considered as a means that has contributed to deep and equitable decarbonization of energy systems in Seoul. The city has replaced inefficient light bulbs with LED bulbs in 40,600 low-income households and 1,120 community service centers at no cost from 2014 to 2016 (SMG, 2017d). By 2020, it plans to distribute 580,000 LED bulbs and estimates that 9,019 TOE of energy will be saved. There are also other programs which, at least partially, reflect the principles of deep decarbonization and equity, such as Eco-Mileage program and Mini-PV program (these two programs may be more relevant to other Criteria are discussed in the following sections).

But Seoul needs more ambitious measures to achieve its 2020 target and, more desirably, the target that is sustainable and equitable. For instance, Seoul's 2020 target requires an additional reduction of 10.3 $MtCO_2e$ or 0.18 ton per person per year (see Figure 38). Similarly, a reduction of 15.6 $MtCO_2e$ (or 0.27 tons per person per year) is needed to meet the sustainable- and equitable emission target.

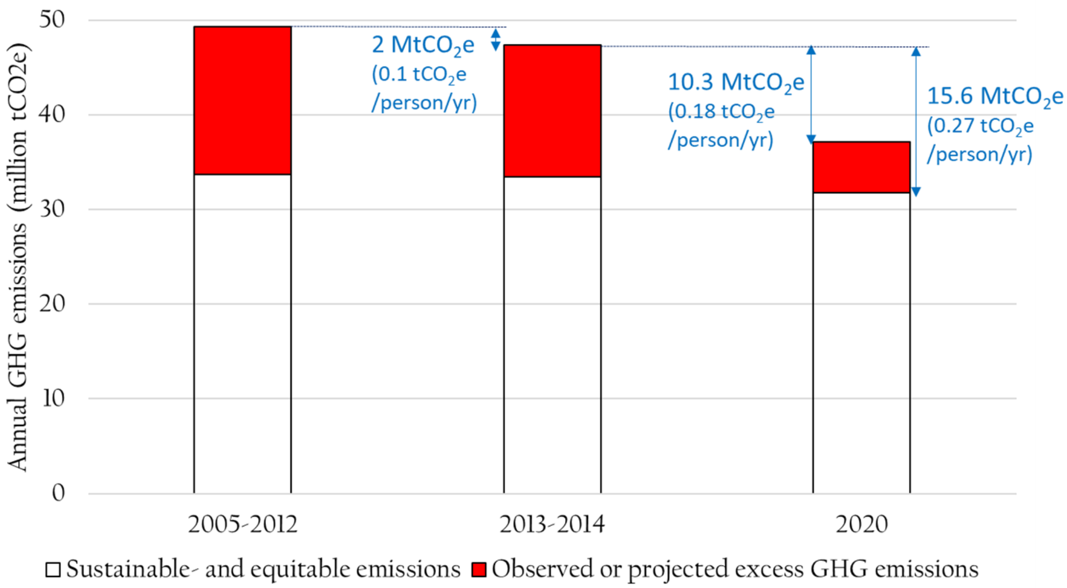

Figure 38. Reduced GHG Emissions During 2013-2014 and the Amounts of Reduction Needed to Achieve Seoul's 2020 Target

Note: This study compares 2005-2012 with 2013-2014 as Seoul's GHG emissions for 2015-2017 are still not publicly available.

The upward trend of energy consumption shown in 2016 (see Figure 37) presents OLNPP policy planners with greater challenges. Due to the increase, the reduction rate for 2017-2020 needs to be much faster (1.9 $MtCO_2e$) than the required amount of annual GHG reduction for this period (1.7 $MtCO_2e$).[15]

Seoul's new initiative, Solar City Seoul, may be considered a promising strategy in that regard. Since the launch of OLNPP in 2012, SMG has maintained a city-wide solar energy development as a vehicle for a sustainable reconfiguration of the city (SMG, 2017a, p. 33). During the Phase 1, this strategy was called "Sunlight City Seoul" and aimed to install the total PV capacity of 320MW in the rooftops of

[15] This change, although a further analysis is needed, seems to be attributable to weather. Indeed, there were increases in both heating and cooling degree days in 2016.

10,000 buildings by 2014 (SMG, 2014; Yun, 2012). Seoul could not meet their target; yet, SMG has promised a far more ambitious goal for Phase 2. In November 2017, the mayor of Seoul announced “2022 Solar City Seoul”. The aim of this initiative is to deploy a total installed solar capacity of 1 GW by 2022. Some of the key measures proposed by Seoul are to deploy miniature solar panels to 1 million households (a total installed solar capacity of 551MW) and solar arrays to all developable public buildings (a total installed solar capacity of 243MW) by 2022 (SMG, 2017c).

SMG has taken an array of activities to support these strategies (“Sunlight City Seoul” and “Solar City Seoul”). SMG estimated the total rooftop area of all buildings in Seoul and created “Seoul Solar Map,” which provides information on the electricity technical potential of buildings and the existing solar power plants. The color of each building in Figure 35 represents electricity technical potential (kWh/m^2) of installing a solar array on the rooftop of the building. The circles with green, yellow, and red sun symbol indicate a brief information on the existing solar array on the building rooftop. For example, the pop-up window on the right, bottom corner of Figure 39 shows a brief information on the solar array installed on the rooftop of Seoul City Hall. SMG created financial incentives, such as lowering the cost of renting a public space, low-interest loan for installation cost, and so-called Seoul-type feed-in tariff (FIT) which provided small-scale PV power systems (less than 50KW) with 50 Korean won (approximately 4 US cents) for 1 kWh generated from the system during the last one year of OLNPP Phase 1. Through FIT, SMG invested 104 million won (approximately 100,000 US dollars) into 89 PV systems (SMG, 2017a, p. 231). The incentive increased to 100 Korean won for 1 kWh (approximately 9 US cents) in the second phase of OLNPP.

Figure 39. A Captured Image from Seoul Solar Map
Note: Retrieved from http://solarmap. seoul.go.kr/main/mainMap.do# (March 29, 2018).

6.2.4.3 Participatory and Deliberative Forms of Governance

Possible question: Are there systematic forms of institutional transparency and openness that enable community members to be clearly informed of the benefits and costs of proposed measures and participate in the decision-making process?

Before 2012, Seoul had plans to reduce energy consumption and GHG emissions, such as 'Seoul Eco-friendly Energy Declaration.' Announced in 2007 by a former Mayor Oh, this energy strategy aimed to increase renewable energy production and use. The growth rate of Seoul's installed solar capacity has accelerated since 2009. Yet, the 2007 energy strategy was mainly developed and controlled by SMG (Lee, 2017).

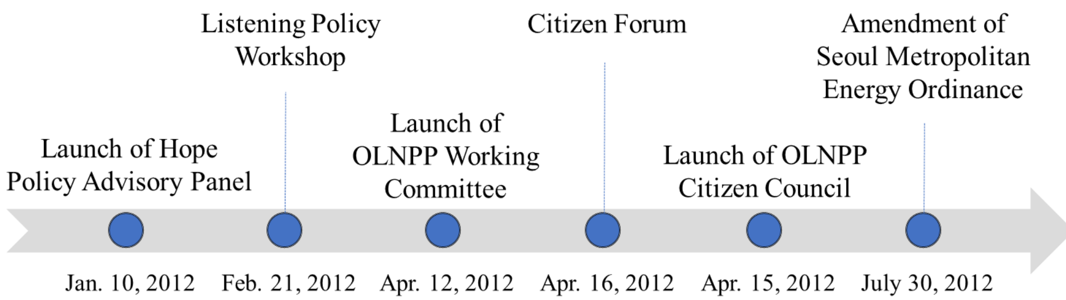

Figure 40. Key Developments of OLNPP Governance Structure

Since 2012, the focus of Seoul's energy policy has extended to issues of citizen participation. In January 2012, the newly-elected mayor of Seoul, Mr. Park Wonsoon, formed Hope Policy Advisory Panel mostly composed of civic group activists and scholars (see Figure 40). Since his mayoral inauguration in October 2011, Park Wonsoon increased the number of advisory committees from 103 in 2011 to 127 in 2012 to 139 in 2013 (Cho, 2014). A key characteristic of this change is to have increased the number of citizens and civic groups in these councils. As Table 9 shows, the proportion of civic groups and citizens accounted for 12.2% (351 people) and 12.2% (348 people), respectively, in 2014. Yet in 2011, the figure for civic groups and citizens was merely 7.6% and 5.4%, respectively (Cho, 2014).

SMG hosted 16 meetings with the Panel's Environment and Culture Subcommittee and civic groups to produce a draft of an urban energy transition strategy, called OLNPP. This draft OLNPP plan was proposed to citizens through public forums. Then, SMG hosted a Citizen Forum in which approximately 400 citizens participated to review the plan. Although this number of participants is not significant when compared to the city's population, it can be recognized as a meaningful effort to build a participatory policy-making system. The forum served as a platform where the members of the community could make policy recommendations, proposing 109 ideas and some of which were in effect integrated into the OLNPP plan (Ahn, 2017).

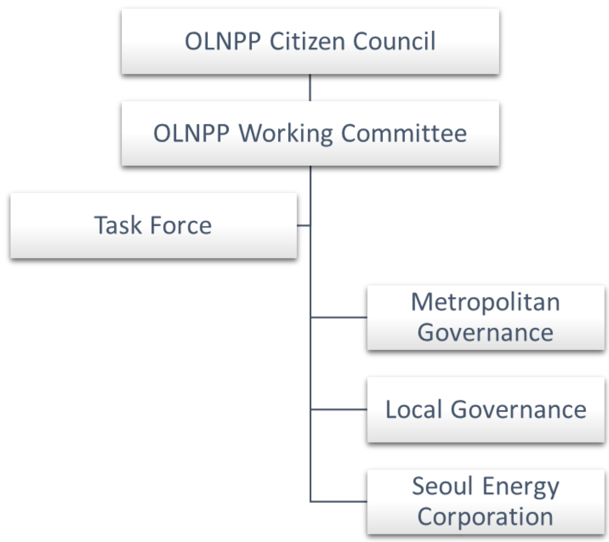

Figure 41. OLNPP Organizational Structure

Examples of citizen engagement can also be evidenced by two decision-making committees for OLNPP (see Figure 41). First, a Citizen Council was formed as the highest-level decision-making body (Lee, 2017; Ahn, 2017). Their main roles are to take the lead a transition of Seoul into an energy producer and decide overall policy directions of OLNPP. Major business plans for OLNPP and changes in important plans must be approved by Citizen Council (SMG, 2012). Co-chaired by the Mayor of Seoul and a representative of the community members, the council consists of an array of stakeholders, including environmental advocates, religious leaders, educators, researchers from public and private research institutes, and business people.

Citizen Council consists of some members who do not necessarily have technical expertise or prior experience in the energy policy domain (see Table 13).

This nature of Citizen Council is one of the major differences from typical governance structure where the highest decision-making body is composed exclusively of technical experts and high-level officers from governments. Sometimes energy non-experts are appointed as board members, yet their roles and responsibilities in the decision-making process are generally very limited. Under this form of governance, often cited as bureaucratic governance, governments or bureaucrats tend to take the lead while non-experts (and often policy experts) cannot exert any significant influence on the design of final policy (Cho, 2014).

Table 13. Founding Members of the OLNPP Citizen Council

Total	SMG (mayor)	Civic group	Religious leaders	Busi-ness	Edu-cators	Academic scholars	Writer & Journalist
21	1	6	4	1	3	2	2

Source: OLNPP Committee Plan (SMG, 2012),

Created as a central implementation unit for OLNPP, the OLNPP Working Committee exhibits a similar governance approach embedded in Citizen Council. Launched on April 12, 2012, the main role of Working Committee is to identify and develop policies and programs to support the goals of OLNPP. It also evaluates policy performance (SMG, 2012). The Working Committee consists of two joint chairs – the Head of Climate and Environmental Headquarters of SMG and one of the committee members. Voted by committee members for a chair in April 2012, Mr. Ahn Byung-ok was leading an environmental NGO. As shown in Table 14, more than one third of the committee (15 people) were filled with civic activists while only four city officials from SMG participated in the committee as members (SMG, 2012).

Table 14. Founding Members of the OLNPP Working Committee

Total	SMG	Civic group	Religious leaders	Busi-ness	Edu-cator	Scholars	Jour-nalists	Central gov't
42	4	15	4	6	1	5	3	4

Source: SMG (2012), OLNPP Committee Plan

To ensure the stability and continuity of the Working Committee and the Citizen Council, SMG amended Seoul City Energy Ordinance to create a new provision (Article 12) on July 30, 2012. Article 12 (5) permits the mayor of Seoul to form an energy advisory board and a working committee. Before the amendment, the mayor of Seoul and SMG are entitled to develop the city's energy policy. Citizens' roles and responsibilities were very limited only to policy beneficiaries. However, the amended ordinance allows SMG to form these committees in which important stakeholders, including civic groups, can participate to represent citizens. Particularly, Article 12 (4) specifies citizen participation as one of the major issues on which the committee can advise (Seoul Metropolitan Council, 2012).

In line with the change in the ordinance, the Working Committee was tasked to prepare a master plan for OLNPP Phase 2, so-called Seoul Sustainable Energy Action Plan in 2014. The Working Committee had 23 meetings and one forum to identify major challenges and develop key values for the city's energy future. They proposed several values to the public, and three values – self-sufficiency, sharing, and participation – were finally selected by popular vote in which citizens participated. Lee (2017) notes that it was "an experiment of the city-level democracy" (p. 331).

Major OLNPP indicators and sub-programs demonstrate that Seoul's energy strategy has significantly shifted from a government-led to a citizen participatory governance approach (Lee, 2017). The total count of people having participated in any

OLNPP activity has reached 3.37 million by the end of 2016 (SMG, 2017a). This does not mean that 3.37 million citizens of Seoul have participated. Some citizens have participated in more than one program and were counted more than once. Hence, when it comes to assessing quantitative citizen participation, it may be more appropriate to refer to the program in which the highest number of citizens are participating under the assumption that many of these citizens are involved in more than one program.

One program that may be worth noting is an eco-points program called Eco-Mileage. Introduced in 2009, Eco-Mileage program is designed to help citizens to save their energy consumption and the city to reduce GHG emissions. A central mechanism of this program is to provide a monetary incentive to a household that saves energy consumption against a baseline for comparison. As Figure 42 shows, the number of subscription to this program increased more than two times from 2012 to 2013. This big gap may be explained by the launch of OLNPP in April 2012. Although the growth rate is not significant in the years that follow, the latest number of subscription is reported to be 1.97 million as of September 2017 (SMG, 2017b).

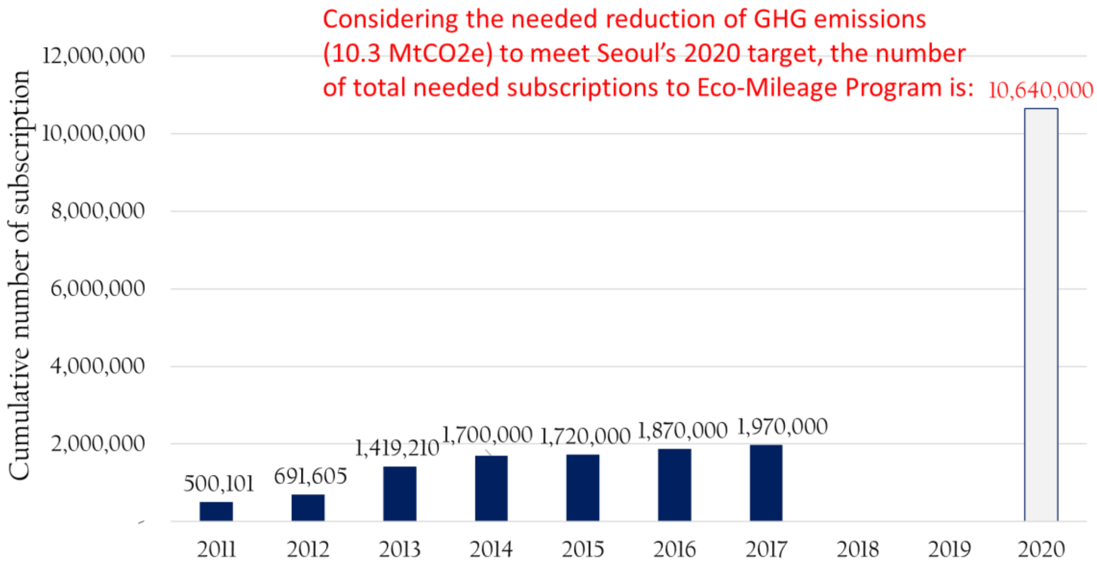

Figure 42. The Number of Subscription to Eco-Mileage Program

Note: The number of subscription for 2017 represents the data garnered up to September 2017. This estimate is drawing from the assumption that Eco-Mileage program is the only OLNPP measure which actively reflects the values of citizen participation in decarbonizing energy-based emissions. One additional subscription reduced 1.15 tCO_2e per year during the first two years (2013-14) of OLNPP, indicating that more than 10 million people need to subscribe to this program to meet the city's 2020 target.

However, the graph above shows that the number of total needed subscriptions to this program is over 10 million to meet the 2020 target. Since the total population of the city is less than 10 million, the needed number appears to be implausible. It means that Eco-Mileage program needs a greater reduction of per person GHG emissions, such as doubling the observed reduction of per person emissions during the first two years (2013-14).

A couple of shortcomings or challenges can be identified from the analysis of this program. First, citizens' roles need to be expanded beyond the design and implementation of OLNPP policies. They can also work with experts in monitoring and evaluating the procedure and policy results of pertinent activities. It is unclear whether citizens can play any roles in that regard. It is also important to understand the needs of the energy poor so that energy measures, like Eco-Mileage program, can have the potential to address issues of energy equity. There is no indication as to whether energy poor households are participating in this program. Considering lack of their ability to save energy, a measure that integrates this factor would be needed.

6.2.4.4 Commons-Based Policies Delivering Commonwealth

Possible question: Is there a sufficient diversity of policy and technology alternatives to enable community members control their energy needs and create a commonwealth economy?

A key goal of Seoul's OLNPP is to increase the rate of energy self-reliance from 4.2% in 2013 to 20% by 2020. As major means to achieve the goal, the city launched a series of solar initiatives, such as Sunlight City Seoul and Solar City Seoul, as noted in Section 6.4.2. Some vehicles designed to support these initiatives include solar cooperatives and the Mini-PV program, as introduced in Section 6.4.2. These tools may be considered commons-based policies partly because they have been useful in creating public spaces where citizens can reclaim their rights to own the means to produce energy.

There has been a significant growth of solar energy cooperatives in Seoul since the launch of OLNPP. There are more than ten citizen-led energy cooperatives (a total installed solar capacity of 824 kW) that has at least one solar power plant within Seoul (Choi, 2018; SMG, 2017d). These citizen participatory cooperatives have been established mostly in late 2012 and 2013 and have developed more than one PV power plant in Seoul. The number of participating members varies among these cooperatives, ranging from 50 to 1,145 (Choi S.-G. , 2017). Formed in April 2013, Solar & Wind

Energy Cooperative has the largest total installed solar capacity of 288 kW. These cooperatives were begun by citizens who understood the importance of energy democracy or energy independence after the Fukushima Daiichi nuclear accident in 2011. Awakened by potential risks arising from South Korea's heavy reliance on nuclear power, the citizens started exploring "specific energy alternatives customized for their local communities" (Choi S.-G. , 2017, p. 239). By owning their solar power plants, they could generate locally-sourced energy and create community wealth. Although the growth of these cooperatives has been constrained by various challenges, they have been able to develop some economically feasible projects with the support of OLNPP incentives, such as Seoul's FIT. Particularly, SMG and the association of solar cooperatives closely collaborated to find public spaces, such as rooftops of the city-owned buildings, for the development of solar power plants (SMG, 2014a).

The city's Mini-PV Program has also been useful in providing citizens with the means to produce energy. Each household in Seoul can install a miniature solar panel (the installed capacity of 250W) in their house. They had been provided a subsidy of, on average, 300,000 Korean won (approx. 280 US dollar) until 2016. This value is currently equivalent to 75% of the total installed cost for a mini-PV system (SMG, 2017b). In 2017, SMG increased the subsidy to 490,000 Korean won (approx. 450 US dollar) (SMG, 2017a, p. 116). SMG estimates that a mini-PV system can generate 15-24 kWh of electricity each month and, as a result, can save a household's electricity bill by, on average, 8,000 Korean won (approx. 7 US dollar) (SMG, 2017a, p. 115). Since 2014, SMG has continued to increase the amount of the subsidy. As a result, the annual installed solar capacity has doubled in 2016, reaching up to 7MW. By September 2017, the cumulative installed solar capacity stood at 32.6MW (Figure 43).

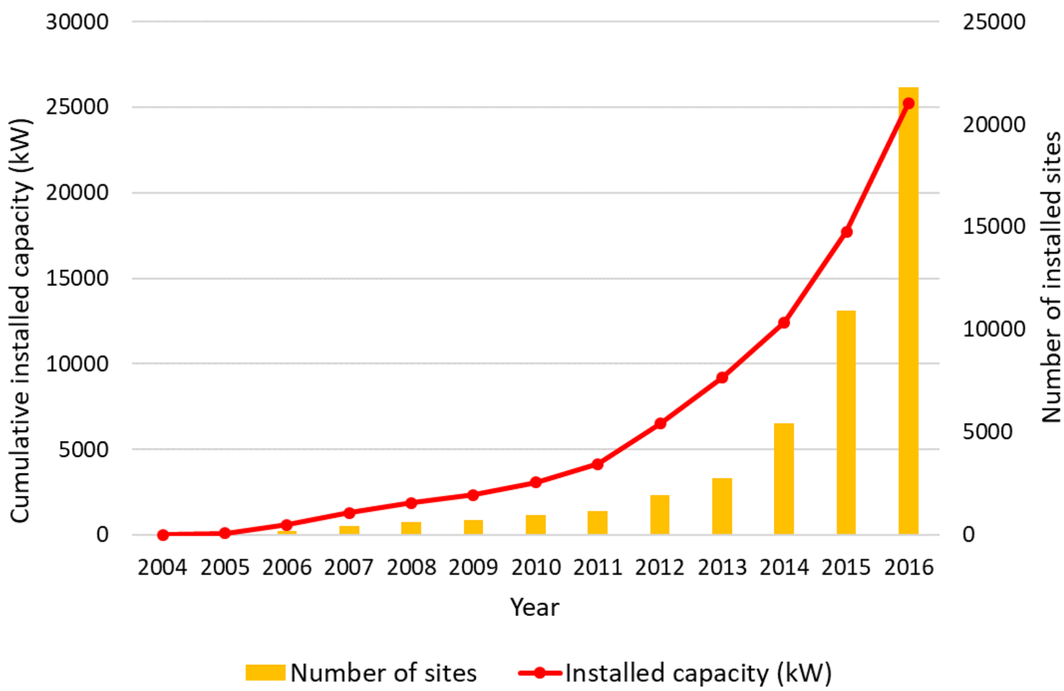

Figure 43. Installed Capacity of Mini PVs and the Number of Installed Sites by Type from 2004 to 2016
Source: 2016 Energy White Paper (SMG, 2017d)

A positive effect of Mini-PV program can be illustrated by comparing the cumulative installed solar capacity total with the cumulative installed solar capacity for self-consumption by South Korean large city. Figure 44 delineates the total installed solar capacity by South Korean large city. Like many other large cities, Seoul's total installed solar capacity had steadily increased until 2012. Since then, however, the city has experienced a rapid growth of total installed solar capacity. Compared to other large cities, Seoul had had the largest installed solar capacity until 2011. Since 2012, however, Busan and Gwangju have overtaken Seoul.

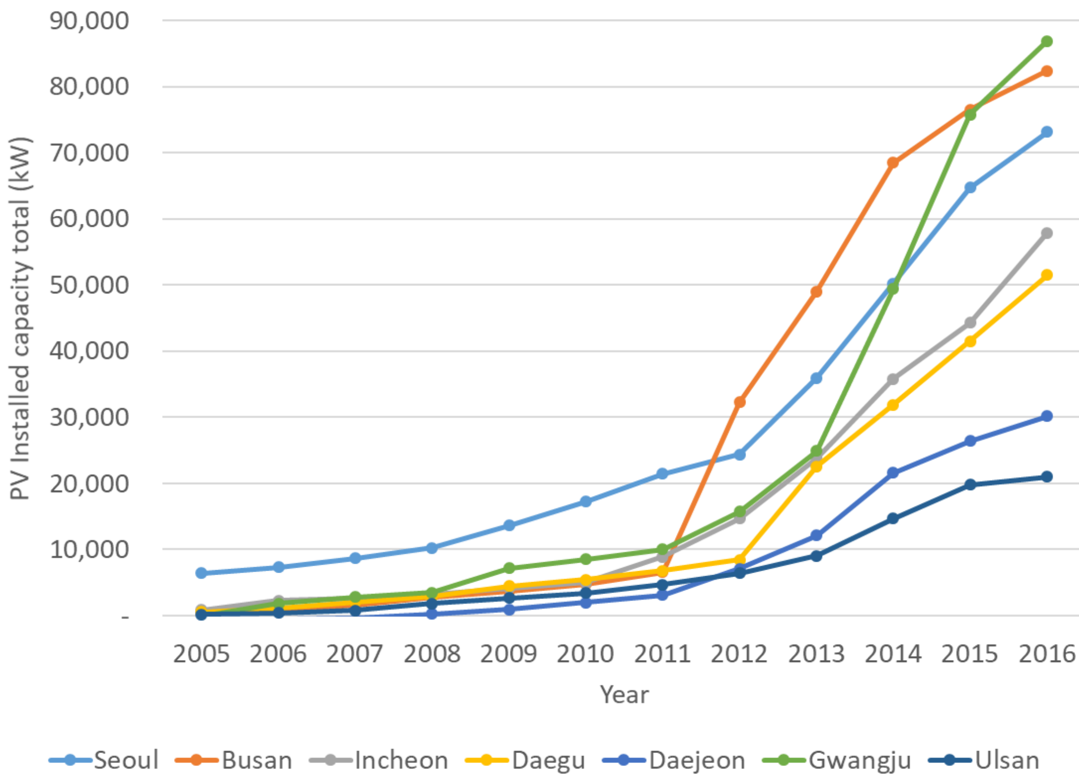

Figure 44. Total Solar Capacity Installed by South Korean Large City from 2005 to 2016[16]

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[16] The data used for the graph above is retrieved from the annual statistics reports from 2006 to 2017, Yearbook of Regional Energy Statistics, published jointly by the Ministry of Trade, Industry and Energy and the Korea Energy Economics Institute. There is a significant difference in total installed solar capacity numbers between KEEI and SMG. A major reason for the difference is that SMG's solar statistic includes solar panels installed to meet the city's own regulations. Every new public building (total floor space greater than 3,000 m^2) and residential and commercial buildings (total floor space greater than 100,000 m^2) are required to supply 19% and 16%, respectively, of total energy consumption from renewable sources as of 2017 (SMG, 2014b; SMG, 2017e). SMG reports that the total installed solar capacity is 131.7MW as of Nov. 2017 (SMG, 2017f). According to KEEP, the 2016 total installed solar capacity for Seoul is 73.1MW. The comparative analysis to create the figure above uses KEEI's statistic as it provides the total installed solar capacity for other metropolises.

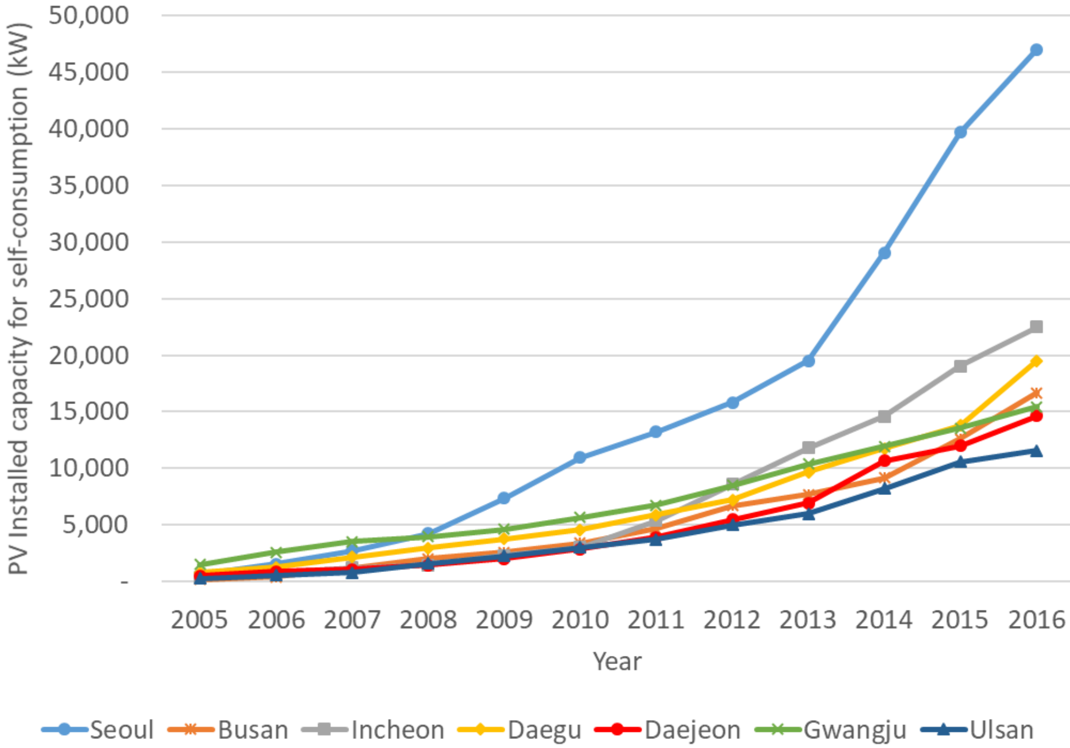


Figure 45. Total Solar Capacity for Self-Consumption Installed by South Korean Large City from 2005 to 2016.[17]

Seoul's installed solar capacity for self-consumption, however, has been continuously largest among these large cities. Its growth rate of installed solar capacity for self-consumption has sharply accelerated since 2013, enlarging the cumulative gaps among the large cities (see Figure 45). In 2008, Seoul's installed solar capacity was greater than the second highest large city, Gwangju, by 1.07 times. The gap has widened to 1.84 in 2012 and to 2.09 in 2016 (both compared to Incheon which had the

[17] The data used for the graph above is retrieved from the annual statistics reports from 2006 to 2017, Yearbook of Regional Energy Statistics, published jointly by the Ministry of Trade, Industry and Energy and the Korea Energy Economics Institute.

second highest installed solar capacity). The added capacity in the first nine month of 2017 was much greater than that of 2016. Hence, there is high possibility that the gap may further broaden in 2017.

The Mini-PV program also shows a positive implication concerning energy equity. Lee and Kim (2017) find a high negative correlation (− 0.4246 with p-value less than 0.01) between the number of mini PVs installed in each district of Seoul ("Gu" in Korean) and each Gu's financial independence from SMG. This result indicates that the Mini-PV program allows the poorer Gus to actively seek and, in effect, gain higher economic benefits.

Despite these meaningful outcomes, some issues need to be addressed from the perspectives of the DEDET framework. For instance, it is argued that Seoul's Mini-PV program is failing to contribute to an OLNPP's central goal of transforming citizens into energy prosumers. For example, Park (2018) points out that the Mini-PV program is serving as a business means for private installers. Currently, SMG selects private installers and pays them as a form of subsidy for the installation of mini PVs. A household can install a mini PV system in their house through private installers selected by SMG or Korea Energy Agency. As competition among these installers intensifies, there is a strong tendency for the installers to lower the installation cost of a mini PV system to attract more customers. It creates a situation where citizens are treated as consumers of mini PV system, not producers of energy. While the households installing a solar system are producing electricity, their interest in this program becomes the consumption of cheap energy, not the production of energy. In fact, there is a growing concern among citizens in Seoul that a mini PV is "free" when it is installed by a private installer (Park, 2018). This may tarnish the policy intention behind this program, that is, helping citizens to become energy prosumers and to provide them opportunities to share the wealth created by locally-owned power systems.

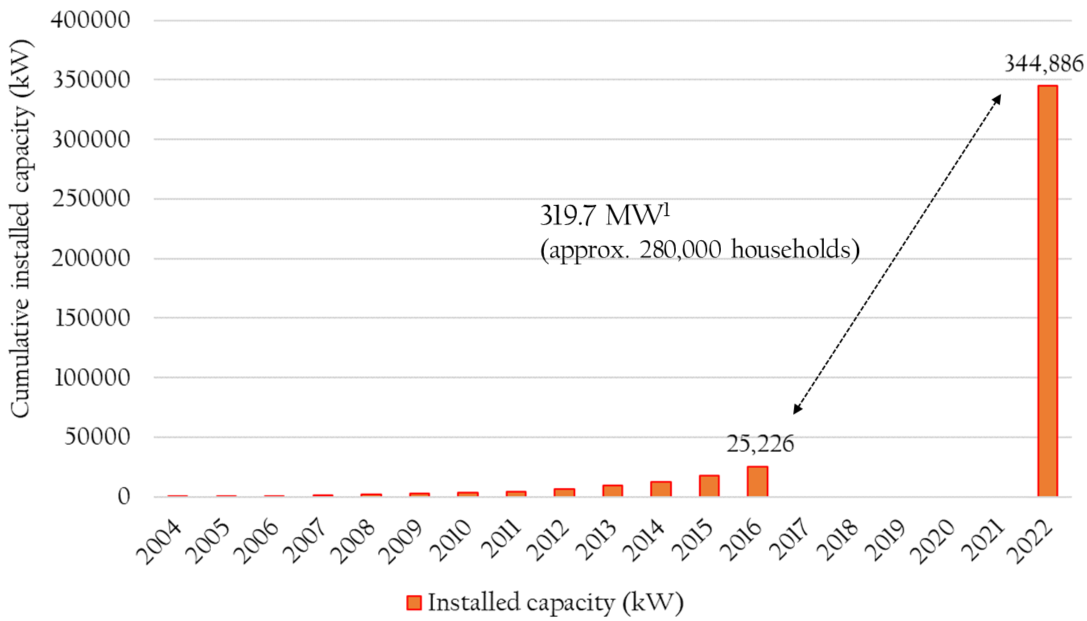


Figure 46. The Installed Mini-PV Capacity Needed to Meet the 2022 Target
Note: This capacity is estimated by assuming that the share of installed mini-PV capacity to total solar capacity in 2022 is in proportion to that in 2016 (35%). Seoul's total installed solar capacity in 2016 is 73.1 MW.

This study also finds that Seoul needs to install more than 300 MW of installed Mini-PV capacity in about 280,000 households to meet Seoul's 2022 Solar City target (Figure 46). It implies an annual addition of 53 MW and 46,000 households, which appears to be implausible. While this program has been a useful commons-based strategy, it is recommended that Seoul, to meet its 2022 target, consider taking stronger action in deploying solar arrays through different means, such as infrastructure-scale solar development project, solar cooperatives, and/or community solar.

Citizen engagement is integral to the success of urban-based energy strategy in achieving deep and equitable decarbonization. In this regard, there are some solar business models that may be useful for Seoul to achieve the dual targets of the 40% reduction of GHG emissions by 2030 and the 1 GW installed solar capacity by 2022.

One example is community solar. Also known as shared solar, community solar is a business scheme that allows residential households and small businesses to participate in the production of clean electricity from a small- to medium-scale solar array installed offsite. While community solar can be developed in various ways, a simple three-step mechanism can be illustrated as a typical business model (see Figure 47). A group of households and small business owners (or participants) in one utility's service territory are a key stakeholder in a typical community solar project. They pay for a portion of the investment made to develop a solar array (or solar farm). Electricity generated from the solar farm is integrated into the grid. In return, utilities credit electricity generated from the solar farm to the bill of participants in accordance with participant's subscription (or ownership). A community solar project can be led entirely by a utility (e.g. investor-owned or municipal), led jointly by a utility and a third-party serving a specific role (e.g., project developer, customer interface), or led by a third-party developer (Chwastyk & Sterling, 2016).

In the United States, community solar has experienced a rapid growth over the last five years, with the annual installed capacity surpassing 400 megawatts in 2017. The US National Renewable Energy Laboratory (NREL) estimates that the cumulative community solar capacity will reach 11 gigawatts by 2020 (Feldman, Brockway, Ulrich, & Margolis, 2015). Key drivers behind the growth of community solar can be explained by various factors. First, this emerging model has shown that it could meet the demands of a growing number of households and small businesses for energy independence and “greening” the grid. Despite rapid decreases of PV installation cost, those who want to install solar panels in their houses or stores often do not have space suitable for this power generator. A recent study finds that almost 50% of households and small business owners in the United States do not have solar suitable roofs (Feldman, Brockway, Ulrich, & Margolis, 2015).

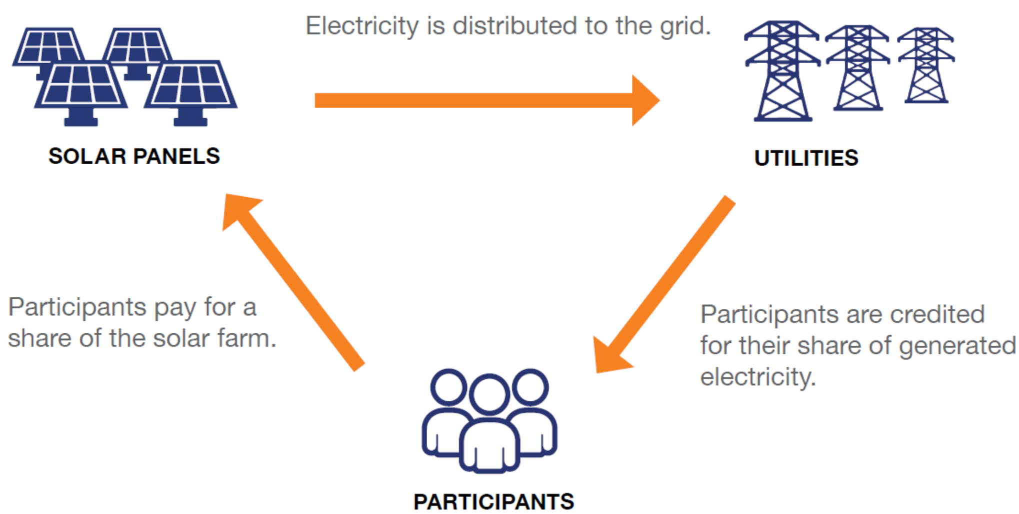


Figure 47. General Schematic of Community Solar Model
Source: Community Solar: Program Design Models (Chwastyk & Sterling, 2016)

As noted earlier (see Section 6.1.2), citizens (or participants) in Austin can subscribe a portion of any community solar project. They can also opt out at any time but must wait 12 months when wanting to re-subscribe. Unlike conventional rate systems, the rate for community solar subscribers is fixed for 15 years (see Table 15). Community solar subscribers pay 4.27 cents per kilowatt-hour for 15 years under the

Community Solar Adjustment (CSA) term while non-subscribers are subject to the Power Supply Adjustment (PSA) term. Although the current PSA rates are lower than the CSA rate, PSA rates are expected to increase. The city's community solar program also offers a discount rate to low-income households in its jurisdiction through Customer Assistance Program (CAP). Half of La Loma's capacity is dedicated to low-income households. CAP alleviates the energy burden of low-income households by providing a reduced rate by 1.5 cents per kilowatt-hour.

Table 15. Comparison of Traditional Electric Power and Community Solar

	Traditional Electric Power	Community Solar
How to choose	▪ Automatic, with no other enrollment selection	▪ Must enroll to receive CSA rate for community solar while capacity is available
Term of rate	▪ Adjusted seasonally and annually based on market prices ▪ Currently \$0.02936/kilowatt hour (winter) and \$0.03007 (summer)	▪ 15-year fixed ▪ \$0.0427/kilowatt hour (\$0.0277/kilowatt hour for eligible CAP customers)

Community solar can provide the opportunity for them to virtually net meter from an off-site solar array. This implies that participants have more than one source of electricity supply, mitigating potential risk of being exposed to power outrage and enhancing energy independence. By subscribing a community solar farm, participants can also help decarbonize energy systems and reduce local pollution. Secondly, community solar provides participants with various tangible economic benefits. Being a subscriber to a community solar far offers participants the opportunity to diversify energy sources. It implies that community solar can be a useful hedge against the rising electricity rate. Community solar can also help the local economy by creating on-site jobs and procuring local products and services. Particularly, these economic benefits can, directly and indirectly, fulfill the needs of low-income households.

In the United Kingdom, London Community Energy Fund (LCEF) was created to counter key challenges that community solar groups face and, thus, facilitate installation of PV arrays throughout the city (GLA, 2017). This fund is cited as an important financing strategy to help achieve the city's goal to deploy 1 GW of installed solar capacity by 2030 and 2 GW by 2050 (GLA, 2017). Seoul has a financing program like LCEF. Seoul offers lower-interest loan (1.45%) up to 150 million Korean won ($140,000 in USD) as of February 2018 to a community solar project with the installed capacity less than 100kW (Mayor of Seoul, 2018). This program is recognized as a major financing source for community solar groups in Seoul (Choi S.-G. , 2017). On the other hand, London's financing program (LCEF) supports community solar groups in the form of grants. LCEF provides a community solar group with grants up to £15,000 in 2017/18 fiscal year (GLA, 2017). This grant can be used for a wide range of preliminary and scoping activities, such as technical and financial feasibility studies, and costs associated with any legal and financial advice. It cannot be spent for capital expenditure. In some senses, LCEF may provide Seoul with some insights that can be helpful to support community solar activities. The LCEF grant is a sort of seed money for community solar groups. With this grant, community solar groups can carry out (or ask legal, policy, or financial experts to carry out) technical and financial feasibility studies and, thus, make a well-informed decision. It can help enhance the possibility of a successful solar development project. It can also provide community solar groups with opportunities to unearth innovative ideas that can overcome the existing challenges and make community solar projects financially more viable.

The last example is the Sustainable Energy Utility (SEU) model. Designed as a clearinghouse for energy service delivery programs, the SEU model has been effectively implemented in several jurisdictions in the United States, including Delaware, Pennsylvania and Washington D.C. (IEA, 2016a).

The basic financing strategy of the SEU model is based on a premise that saving a unit of energy (e.g. through energy conservation measures) costs less than retail price that a household pays for the unit of energy service. This financing strategy enables communities to leverage future energy savings to pay up-front costs to develop a solar project. Figure 48 illustrates the monetization mechanism of SEU financing strategy. The monetized savings (in red) from energy conservation measures can be directed to support community solar projects. Indeed, the SEU has effectively financed energy efficiency and sustainable energy projects. For example, the Sustainable Energy Bond issued by the DE SEU, a non-profit agency in Delaware, financed a $72.5 million investment in sustainable energy and a net-savings after paying off all costs amounted to $37 million (Byrne and Taminiau, 2015).

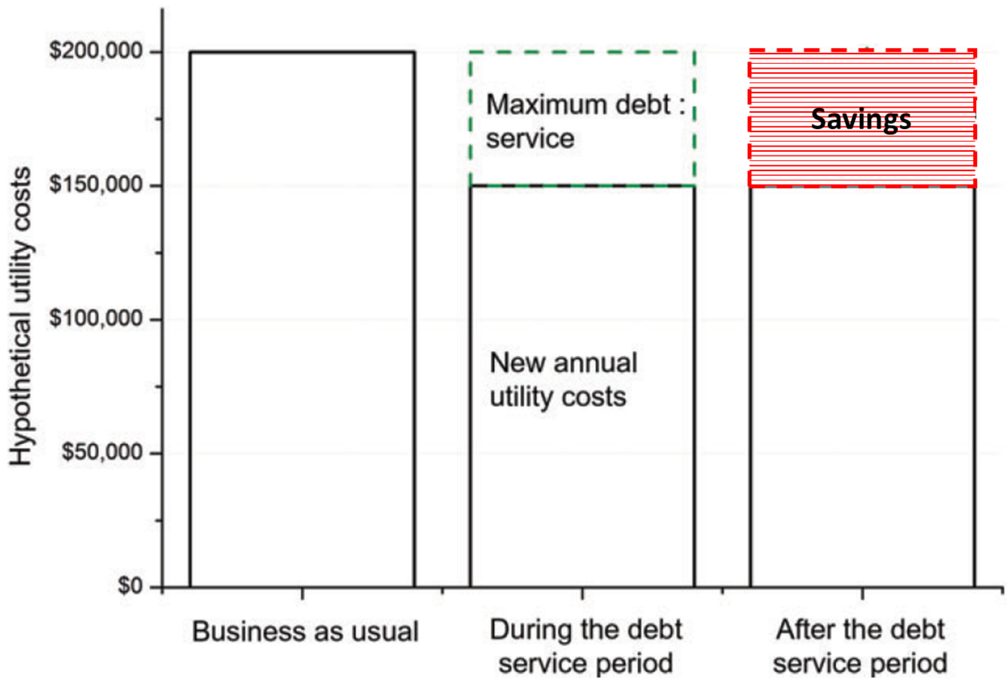


Figure 48. Self-Financing Model of SEU

Source: A Review of Sustainable Energy Utility and Energy Service Utility Concepts and Applications: Realizing Ecological and Social Sustainability with a Community Utility (Byrne & Taminiau, 2015).

6.2.4.5 Measurement, Verification, and Communication

Possible question: Is there a comprehensive system to measure, verify, and communicate the implemented policy or technology measures?"

Various forms of publications identified in this dissertation imply that SMG is measuring the city's progress concerning OLNPP. Particularly, SMG reports the annual outcomes of key performance indicators, such as energy savings and renewable energy production through an array of media, including websites (see Figure 49). Indeed, a range of data analyses done in the previous sections, such as the analysis of avoided electricity and natural gas consumption, would not have been possible in the absence of relevant datasets.

Figure 49. The Official Website for OLNPP

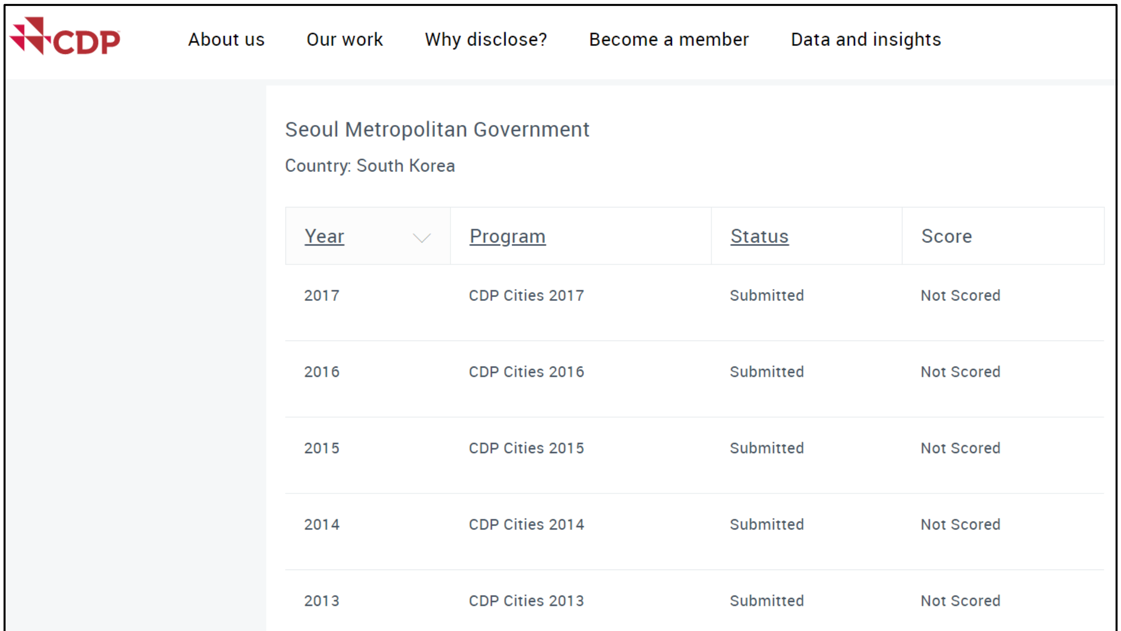
But it is uncertain whether the monitoring or measurement results are being independently verified on a routine basis. Lee (2017) points out that building energy performance from the city's building retrofit program needs to be verified. SMG argues that the city's GHG emissions are verified by a third-party on an annual basis but it is required by a national regulation (Greenhouse Gas Target Management System for the Public Sector).

The city has been very active in exchanging or sharing the best practices and major challenges arising from OLNPP with key stakeholders. First, it has provided them with detailed information with respect to OLNPP through online and offline means. SMG has also produced a number of publications on OLNPP in an effort to share the best practices with stakeholders. Table 16 shows a list of selected books and reports on OLNPP that SMG has published.

Table 16. A List of Selected Publications on OLNPP Published by SMG

Title	Year
One Less Nuclear Power Plant 2012 *(Korean and English)*	Aug. 2013
One Less Nuclear Power Plant: A Hopeful Message of Seoul's Energy Policy (*Korean and English*)	Nov. 2014
One Less Nuclear Power Plant, Phase 2: Seoul Sustainable Energy Action Plan (*Korean and English*)	Nov. 2015
Citizen White Paper (*Korean*)	June 2017
Reframing Urban Energy Policy: Challenges and Opportunities in the City Seoul (*Korean and English*)	Aug. 2017
Energy White Paper (*Korean*)	Nov. 2017

Many evidences can be found that SMG has actively engaged in providing the best practices and lessons learned from OLNPP to other cities in both Korea and other countries. SMG reports that there have been more than 20 cases where either SMG or OLNPP Working Committee was asked to provide lectures or consultation (SMG, 2017a, pp. 236-237). It is also reported that SMG has hosted representatives or journalists from other countries, including Taiwan, Mongolia, France, Hong Kong, the United States, who visited Seoul to learn or cover the city's energy policies, notably OLNPP.



CDP About us Our work Why disclose? Become a member Data and insights

Seoul Metropolitan Government

Country: South Korea

Year	Program	Status	Score
2017	CDP Cities 2017	Submitted	Not Scored
2016	CDP Cities 2016	Submitted	Not Scored
2015	CDP Cities 2015	Submitted	Not Scored
2014	CDP Cities 2014	Submitted	Not Scored
2013	CDP Cities 2013	Submitted	Not Scored

Figure 50. A Captured Image from CDP Cities Showing SMG is Disclosing Their Climate-Related Information, Including GHG Reduction Targets.
Source: Retrieved on March 30, 2018, from CDP Website (CDP Cities, 2018).

SMG discloses GHG emissions-related information on an annual basis through various means, including the city's annual reports and international disclosure platforms. It has published over ICLEI's Climate Registry (see ICLEI, 2017). As shown in Figure 50, SMG has been disclosing their climate-related information, including GHG reduction targets and measures to achieve the targets, to the CDP Cities program. These pieces of evidence indicate that SMG monitors and evaluates the progress of GHG reduction targets and relevant policies.

In sum, Seoul has some procedures and mechanisms in place to monitor policy progress and communicate the monitoring results with stakeholders, including municipal governments in Korea and other countries (see Section 6.4.5). Yet, there are some areas that Seoul can improve for a more systemic policy monitoring, verification and communication.

First, this study finds that several pieces of information are not consistent by source. In other words, there are some discrepancies on some information between publications. For example, the cumulative installed solar capacity varies between major sources. SMG reports that the cumulative installed solar capacity was 131.7MW as of Nov. 2017 (SMG, 2017f). However, the number reported by KEEI, a main source of national and regional energy statistics, was 73.1MW as of December 2016. SMG has published a series of publications on OLNPP, including reports, books, white papers, and webpages. Scholars and practitioners need to depend on these publications for their research. Besides, reliability and consistency of data must be ensured to make sound policies. Thus, it is advised that KEEI and SMG address this data inconsistency to ensure data reliability.

Secondly, GHG emissions information is neither readily available nor, to some extent, publicly accessible. One of the main policy goals of OLNPP is to reduce GHG emissions in Seoul. The first step to achieve this goal would be to accurately and comprehensively measure GHG emissions by scope, source, and type. Along with measurement, a set of GHG emissions data need to be more transparently disclosed and publicly accessible.

Table 0.1 Historical overview, MtCO2 (pre 2010) and MtCO2e (post 2010)

	CO2 Emissions (MtCO2)											GHG Emissions (MtCO2e) [1]				
	1990	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Weather corrected and CO2											Non-weather corrected and CO2e				
DOMESTIC	E	C	C	E	C	C	C	C	C	C	C	C	C	C	C	C
Gas		10.13	11.96	11.10	10.24	9.88	9.83	9.42	8.98	9.25	8.31	9.09	7.38	8.12	8.25	7.35
Electricity		7.36	5.65	6.67	7.68	6.92	7.25	7.57	7.63	7.43	6.70	6.69	6.47	7.14	6.56	5.93
Other		0.05	0.18	0.18	0.19	0.06	0.23	0.23	0.23	0.24	0.24					
Coal												0.05	0.04	0.04	0.05	0.04
Oil												0.06	0.05	0.05	0.05	0.05
SUB-TOTAL	**15.84**	**17.54**	**17.79**	**17.95**	**18.11**	**16.85**	**17.31**	**17.22**	**16.84**	**16.93**	**15.25**	**15.88**	**13.94**	**15.34**	**14.91**	**13.38**
Reduction from 2000			1%	2%	3%	-4%	-1%	-2%	-4%	-3%	-13%	-9%	-20%	-13%	-15%	-24%
INDUSTRIAL AND COMMER	E	C	C	E	C	C	C	C	C	C	C	C	C	C	C	C
Gas		6.38	6.16	5.67	5.17	6.52	5.08	4.81	4.39	4.63	4.15	4.62	3.83	4.17	4.20	3.62
Electricity		15.33	13.17	13.79	14.42	12.97	13.40	15.12	14.76	14.51	12.66	12.90	11.66	13.61	12.50	11.56
Large industrial							0.13	0.10	0.10	0.10	0.10	0.07	0.02	0.03	0.03	0.02
Other		2.35	2.43	1.64	0.86	0.57	0.62	0.59	0.60	0.61	0.47					
Coal												0.02	0.02	0.02	0.01	0.01
Oil												0.59	0.54	0.53	0.50	0.56
Waste												0.02	0.04	0.04	0.04	0.21
SUB-TOTAL	**19.74**	**24.06**	**21.76**	**21.10**	**20.45**	**20.05**	**19.23**	**20.62**	**19.85**	**19.85**	**17.38**	**18.22**	**16.12**	**18.40**	**17.29**	**15.99**
Reduction from 2000			-10%	-12%	-15%	-17%	-20%	-14%	-18%	-18%	-28%	-24%	-33%	-24%	-28%	-34%
TRANSPORT	E	C	C	E	C	C	C	C	E	C	E	C	E	E	E	C
Road Transport	7.22	6.62	7.00	7.24	7.48	7.43	7.32	7.26	7.26	6.98	6.98	6.39	6.39	6.39	6.36	6.62
Rail_diesel	1.39	0.24	0.70	0.84	0.98	0.19	0.19	0.19	0.19	0.28	0.28	0.11	0.11	0.11	0.13	0.08
Rail_electric		0.98	0.84	0.88	0.92	0.83	0.98	0.98	0.98	1.24	1.24	1.12	1.18	1.18	1.20	0.91
Aviation	0.86	0.86	0.76	0.91	1.07	1.20	1.36	1.36	1.36	1.39	1.39	0.87	0.87	0.87	0.98	0.93
Shipping	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03
SUB-TOTAL	**9.47**	**8.71**	**9.31**	**9.88**	**10.45**	**9.65**	**9.86**	**9.79**	**9.79**	**9.90**	**9.90**	**8.52**	**8.58**	**8.58**	**8.68**	**8.57**
Reduction from 2000			7%	13%	20%	11%	13%	12%	12%	14%	14%	-2%	-2%	-2%	0%	-2%
TOTAL	45.05	50.31	48.86	48.93	49.01	46.56	46.40	47.64	46.48	46.67	42.52	42.62	38.64	42.32	40.87	37.94
Reduction from 1990		12%	8%	9%	9%	3%	3%	6%	3%	4%	-6%	-5%	-14%	-6%	-9%	-16%
Reduction from 2000			-3%	-3%	-3%	-7%	-8%	-5%	-8%	-7%	-15%	-15%	-23%	-16%	-19%	-25%
Population	6,798,800	7,236,700	7,322,400	7,376,700	7,394,800	7,432,700	7,519,000	7,597,800	7,693,600	7,812,400	7,942,500	8,061,495	8,204,407	8,308,369	8,416,535	8,538,689
CO2 per capita_all	6.63	6.95	6.67	6.63	6.63	6.26	6.17	6.27	6.04	5.97	5.35	5.29	4.71	5.09	4.86	4.44
CO2 per capita_excl. workplac	3.72	3.63	3.70	3.77	3.86	3.57	3.61	3.56	3.46	3.43	3.17	3.03	2.75	2.88	2.80	2.57

00 Summary | 01 Energy | 02 CO2 | 03a Data_Elec&Gas | 03b Data_Residual | 03c Data_Transport | 04 Emissions Factors | 05 Dat

Figure 51. A Captured Image of the LEGGI Showing a Historical Overview of GHG Emissions in London

Yet, GHG emissions data for Seoul is not easily reachable or publicly accessible. While SMG has a website where a myriad of datasets is provided, so-called Seoul Open Data Square, GHG emissions data is not available as of April 16, 2018. In a few reports published by SMG and Seoul Institute, Seoul's think-tank, a summary of annual GHG emission inventory can be found. For example, a latest 285-page-long report on OLNPP only provides a table showing Seoul's annual GHG emissions by source from 2005 to 2013 (SMG, 2017a, p. 50). Another latest report, *2016 Energy White Paper*, includes the same table, in which 2014 data is added (SMG, 2017d, p. 166).

Table 1.1 **Energy consumption by borough, 2014 (kWh)**

Total Energy Consumption	Sector											
	Domestic					Industrial and Commercial						
	Electricity	Gas	Coal	Oil	Total	Electricity	Electricity w/o rail	Gas	Coal	Oil	Waste and Renewables	Total
Year	2014	2014	2014	2014		2014	2014	2014	2014	2014	2014	
Barking and Dagenham	272,901,888	762,016,168	4,992,336	2,496,911	1,042,407,304	314,089,618	269,588,177	229,834,760	12,786,787	149,536,114	71,081,767	732,827,604
Barnet	633,063,075	2,263,044,923	4,763,232	8,356,284	2,909,227,514	643,095,500	563,791,492	573,065,325	139,614	41,000,418	39,815,632	1,217,812,482
Bexley	391,796,731	1,150,908,191	5,850,720	5,830,791	1,554,386,434	493,875,254	473,171,387	689,984,266	215,315	142,192,027	79,232,322	1,384,795,317
Brent	435,615,822	1,592,866,623	3,434,433	5,002,787	2,036,919,665	920,652,157	822,388,983	577,864,939	0	77,482,990	29,046,828	1,506,783,740
Bromley	571,978,417	1,897,789,196	6,365,688	13,434,995	2,489,568,297	464,817,683	415,671,756	370,230,135	31,804	73,050,026	49,494,827	908,478,549
Camden	360,200,451	998,574,266	1,169,176	9,502,041	1,369,445,934	1,437,742,521	1,333,121,718	1,349,210,579	0	41,104,748	9,105,447	2,732,542,491
City of London	27,922,851	29,955,414	4,429	345,005	58,227,699	2,074,873,155	2,029,901,177	673,061,406	0	35,527,701	39,635	2,738,529,919
Croydon	609,710,901	1,898,155,631	7,948,345	8,559,739	2,524,374,616	613,317,979	553,461,259	386,212,491	657,551	31,808,907	65,110,921	1,037,251,130
Ealing	488,911,573	1,737,906,645	5,403,124	6,312,711	2,238,534,053	893,535,421	832,494,619	778,404,429	109,556	88,302,140	43,540,156	1,742,850,900
Enfield	507,761,004	1,607,318,496	6,456,190	6,110,718	2,127,646,408	583,160,755	540,164,433	549,421,380	583,358	82,949,681	103,754,527	1,276,873,378
Greenwich	381,339,957	1,054,566,840	4,817,745	4,578,115	1,445,302,656	492,522,720	460,875,687	937,432,787	307,846	41,761,632	40,427,974	1,480,805,926
Hackney	353,880,744	1,015,328,518	1,894,499	3,046,346	1,374,150,107	694,558,037	670,571,855	324,627,682	84,652	15,699,507	15,083,770	1,026,067,467
Hammersmith and Fulham	292,328,692	921,956,928	1,837,589	3,681,732	1,219,804,942	665,763,396	620,229,487	532,195,607	0	38,083,026	15,776,586	1,206,284,707
Haringey	371,811,672	1,313,634,147	3,685,225	3,059,380	1,692,190,424	399,106,720	338,285,028	325,054,145	4,467,640	24,716,570	31,128,700	723,652,084
Harrow	361,520,850	1,474,745,796	3,586,122	5,242,777	1,845,095,546	326,677,307	281,316,233	380,809,079	512,363	20,867,983	30,234,453	713,740,111
Havering	418,900,902	1,389,912,004	6,078,088	7,407,705	1,822,298,700	406,286,226	360,794,611	227,163,363	649,930	47,738,634	45,486,757	681,833,295
Hillingdon	438,208,798	1,492,604,543	5,023,445	8,912,107	1,944,748,893	1,180,886,539	1,128,733,645	852,540,371	1,592,398	438,246,100	345,169,907	2,766,282,421
Hounslow	389,598,632	1,088,250,886	4,215,199	6,926,878	1,488,991,595	1,018,968,794	976,510,823	579,815,189	159,899	70,791,918	63,116,852	1,690,394,680
Islington	325,578,848	941,318,754	1,364,149	3,192,668	1,271,454,419	837,081,633	782,419,121	645,308,732	47,029	32,725,615	11,105,175	1,471,605,672
Kensington and Chelsea	382,532,447	920,690,099	1,113,209	8,146,532	1,312,482,287	1,281,781,900	1,224,776,335	961,002,468	28,217	7,157,291	8,853,856	2,201,818,168
Kingston	273,830,838	836,584,619	2,914,164	3,277,864	1,116,607,485	359,797,653	342,527,003	222,375,082	18,812	36,710,268	23,427,848	625,059,013
Lambeth	449,639,777	1,295,344,714	3,323,647	6,046,409	1,754,354,546	729,483,167	619,505,839	724,220,351	0	10,072,996	27,792,110	1,381,591,295
Lewisham	422,788,873	1,233,460,736	5,193,101	3,990,906	1,665,433,617	344,916,540	295,151,239	248,364,566	0	9,083,763	43,577,709	596,177,277
Merton	324,869,037	995,228,109	4,772,543	4,299,264	1,329,168,951	388,316,158	335,740,827	296,769,535	24,903	27,076,101	41,038,474	700,649,839
Newham	385,780,136	1,126,016,170	5,355,796	1,849,367	1,519,001,469	1,082,522,810	981,090,835	963,587,779	2,241,313	118,042,065	45,196,217	2,110,158,209
Redbridge	415,733,311	1,490,587,980	5,188,135	4,651,485	1,916,160,911	328,422,935	284,092,159	241,774,471	9,406	23,031,493	43,550,958	592,458,487
Richmond	349,048,205	1,126,064,410	3,652,157	6,307,257	1,485,072,030	412,314,446	389,902,257	326,733,547	0	22,468,155	29,591,356	768,695,315
Southwark	453,195,186	967,500,986	2,625,622	8,346,401	1,431,668,194	1,030,571,350	962,462,055	784,472,797	1,002,200	18,995,604	21,967,577	1,788,900,234
Sutton	337,958,129	973,279,860	4,170,068	4,977,646	1,320,385,702	351,972,311	341,810,748	201,072,458	3,769,571	27,319,646	33,157,439	607,129,863
Tower Hamlets	410,966,618	718,063,876	1,298,902	4,563,237	1,134,892,633	2,529,080,112	2,433,937,499	647,353,703	243,078	29,191,514	44,552,772	3,155,278,566
Waltham Forest	362,124,945	1,248,663,649	5,623,596	2,899,900	1,619,312,089	410,147,451	378,979,379	307,402,369	0	31,789,200	47,133,419	765,304,366
Wandsworth	506,578,437	1,425,210,422	4,029,238	5,588,893	1,941,406,991	550,536,359	454,192,506	560,544,056	0	18,841,987	34,670,325	1,068,248,875
Westminster	496,298,778	973,293,812	1,183,328	11,896,700	1,482,672,618	3,492,194,920	3,338,592,793	2,221,992,338	1,979,496	211,955,435	8,985,804	5,783,505,865
Unapportioned							-52,551,435	106,061,965				53,510,530
Grand Total (kWh)	13,204,376,524	39,960,843,414	129,333,242	188,841,550	53,483,394,730	27,753,069,527	25,783,701,531	19,795,964,149	31,662,736	2,085,321,256	1,541,248,100	49,237,897,774
Grand Total (GWh)	13,204	39,961	129	189	53,483	27,753	25,784	19,796	32	2,085	1,541	49,238

00 Summary | 01 Energy | 02 CO2 | 03a Data_Elec&Gas | 03b Data_Residual | 03c Data_Transport | 04 Emissions Factors | 05 Data_Sources

Figure 52. A Captured Image of LEGGI Showing the Energy Consumption by Borough in London

It is important for GHG emissions data to be publicly accessible as comprehensively as possible. Indeed, some large cities disclose the details of GHG emissions on an annual basis. For instance, London, the United Kingdom, publicly discloses a comprehensive dataset of GHG emissions and energy consumption within the Greater London Area. Called the London Energy and Greenhouse Gas Inventory (LEGGI), the datasets report annual GHG emissions and energy consumption by sector and source. A main purpose of the LEGGI is cited as measuring "progress against the Mayor's carbon reduction targets for London" (GLA, 2018b). As Figure 51 shows, GHG reduction progress is measured on an annual basis (red and dotted rectangle). The LEGGI also includes GHG emissions and energy consumption by borough (see Figure 52).

6.2.4.6 Research Infrastructure to Support the Development of DEDET Strategies

Possible question: Is there a research infrastructure to support the design, implementation, and evaluation of DEDET policy and technology alternatives not using conventional energy?

The city of Seoul has some forms of research infrastructure that are supporting the city government and citizens in addressing issues of sustainability, equity, and democratic governance. For example, Seoul Institute, a city's think-tank, has a division, such as Safety and Environment Research Department, dedicated to supporting the city's energy and climate policy by evaluating the city's progress and offering best-practices (see Figure 53). The division consists of 32 senior and junior researchers as of June 2018 focusing on a range of issues concerning safety and the environment. The city has recently established a municipal utility called Seoul Energy Corporation (SEC). It characterizes itself as "environmental-friendly energy corporation," seeking to develop "new energy" that helps citizens in Seoul. While SEC serves as a central executing agency for implementing the city's energy policies and carrying out daily businesses, it has an in-house unit dedicated to research. It consists of six researchers, including the director who is a professor at a renowned university in South Korea.

But the roles defined in their websites and the existing studies produced by these two agencies do not appear to have a sufficient body of researchers dedicated to a growing and diverse issues of sustainability that the city faces (Seoul Institute, 2018; Seoul Energy Corporation, 2018). More importantly, it is unclear that, while it needs to be verified, there is no one in these institutes seeking to research the interrelated challenges of sustainability, equitable distribution, and democratic governance. It is not evident that there is any collaboration between the two agencies with respect to the challenges of sustainability, equity, and democratic governance.

Figure 53. Key SMG-affiliated Research Infrastructure Focusing on Issues of Energy and Climate Change

SMG, often in collaboration with OLNPP Working Committee, has hosted various forms of venues where citizens, government officials and experts can exchange new ideas and the best practices and discuss the challenges facing the city. For example, SMG has hosted forums where key stakeholders discuss important energy challenges that Seoul need to address as well as the performances of Seoul's energy policies, including OLNPP. Begun in January 2016, Seoul Energy Forum has served as a venue through which key stakeholders routinely meet and discuss important topics, such as local energy governance, energy welfare, and energy decentralization (Table 17). The forum proceedings are made publicly accessible at the official website for OLNPP (SMG, 2018).

Table 17. A List of Selected Proceedings from Seoul Energy Forums

Title	Year
Energy efficiency: green remodeling and urban regeneration	Feb. 23, 2016
How to improve urban energy welfare system in Seoul	Apr. 29, 2016
How to strengthen local energy cooperation and what are challenges to be addressed?	Aug. 29, 2016
How to expedite solar power deployment for an urban energy transition	Sep. 26, 2016
Assessing the first year of Local Energy Transition Declaration	Nov. 29, 2016
School solar power plants for Sunshine City Seoul	Aug. 31, 2017
Local governments' proposal to promote energy decentralization in the energy transition era	Sep. 27, 2017
What should local governments prepare for an energy decentralization era?	Oct. 26, 2017
An energy transition through urban regeneration and building retrofits	Nov. 14, 2017
How to Succeed OLNPP through Education and Citizen Engagement?	Nov. 11, 2017
Know-how of citizen cooperation for OLNPP	Dec. 13, 2017
'Renewable Energy 3020' and 'Solar City, Seoul'	Mar. 7, 2018

Note: All proceedings are in Korean and, thus, are translated by the author of this thesis.

However, this study finds that the city needs more spaces where citizens and prospective researchers can study and conducts research on interrelated challenges of sustainability, equitable distribution, and democratic governance. One of the potential tools can be to help universities create an advanced degree in sustainability.

6.3 Key Findings from the In-depth Case Analysis and Discussion

In the previous section, Seoul was selected as a case city to explore the potential of the DEDET framework. The city's OLNPP was analyzed against six DEDET Criteria, which are defined as vehicles to operationalize the framework, and the city's progress concerning the principles of deep and equitable decarbonization and democratic governance was assessed.

While the case analysis showed that OLNPP has met some objectives of the framework, it also revealed that OLNPP is failing to meet others, notably a deep and equitable decarbonization target and the institutionalization of MVC and research functions. The case study exposes quantitative gaps and qualitative shortcomings that need to be improved to meet the requirements of deep and equitable decarbonization and democratic governance. Table 18 summarizes key strengths of OLNPP or positive policy outcomes that can be identified from the case analysis. A list of important quantitative gaps or qualitative shortcomings are also presented in Table 19.

Table 18. Key Strengths of OLNPP or Positive Policy Outcomes that Are Identified from the Case Analysis

Criteria	Key findings
1. Deep and equitable decarbonization targets	▪ Seoul's long-term target to 2030 is estimated to meet the 3.3 tCO_2e target.
2. Deep and equitable decarbonization policies	▪ Seoul reports that more than 4.3 million TOE are saved through OLNPP. ▪ This study's weather-normalized analysis shows that, since the launch of OLNPP, Seoul has saved citywide consumption of electricity and natural gas by 1,863,000 TOE by 2016.

	▪ Seoul has ambitious deep decarbonization measures, such as Solar City Seoul which aims to deploy 1 GW of PV panels throughout the city by 2020.
3. Citizen participatory and deliberative forms of governance	▪ Various stakeholders, who are better positioned to represent the needs of citizens, took important positions, such as the chair or a joint chair of Hope Advisory Panel, Citizen Council, and Working Committee. ▪ The total count of people having participated in any OLNPP activity has reached 3.37 million by the end of 2016. Particularly, approximately 2 million citizens are members of Eco-Mileage Program as of Dec. 2017.
4. Commons-based strategies delivering commonwealth	▪ Seoul has introduced some measures to support commons-based strategies, such as solar cooperatives. These measures have been useful in creating public spaces where citizens can reclaim their rights to own the means to produce energy. ▪ The city's Mini-PV program is recognized to have been a useful tool to help citizens understand the importance of locally-sourced energy and reclaim their rights to own the means to produce energy.
5. Measurement, verification, and communication (MVC)	▪ SMG measures the progress of OLNPP, including the annual results of key performance indicators, such as energy savings and renewable energy production. ▪ The city discloses key information in relation to climate change and GHG emissions to open platforms, such as CDP and ICELI's Climate Registry.
6. Research infrastructure to support the development of DEDET strategy	▪ Seoul Institute, a city's think-tank, and Seoul Energy Corporation, a city's utility, has a division, such as Safety and Environment Research Department and Energy Research Center respectively, dedicated to supporting the city's energy and climate policy by evaluating the city's progress and offering best-practices.

Table 19. Important Quantitative Gaps or Qualitative Barriers that Are Found from the Case Analysis

Criteria	Quantitative Gaps or Qualitative Shortcomings
1. Deep and equitable decarbonization targets	▪ Seoul's per person average GHG emission rates are 4.83 tCO_2e (2005-2012) and 4.70 tCO_2e (2013-2015), much greater than the sustainability- and equity-based emission rate (3.3 tCO_2e per person per year). ▪ The current level of Seoul's average annual GHG emissions exceeds the expected total emissions in terms of the sustainability- and equity-based emissions level by 15.6 million tCO_2e. ▪ The city's target to 2020 is not sufficient to meet the sustainability- and equity-based GHG emissions target.
2. Deep and equitable decarbonization policies	▪ Although Seoul has deployed several policies that can be regarded to be sustainable and equitable, it needs to consider more ambitious policy and technology alternatives. ▪ For example, the weather-normalized analysis shows that the absolute consumption of electricity and city gas increased in 2016 although it had decreased over the first 3 years since the launch of OLNPP. ▪ Seoul needs bolder policies to reduce about one third (15.6 $MtCO_2e$) of its 2014 emission level (approx. 47 $MtCO_2e$) by 2020 to meet the sustainable- and equitable emission level or at least 10.3 $MtCO_2e$ to meet its GHG target.
3. Citizen participatory and deliberative forms of governance	▪ Citizens' role is not just confined to the design phase. They can also work with experts in monitoring and evaluating the procedure and policy results of pertinent activities. ▪ The analysis of Seoul's Eco-Mileage program shows that SMG needs additional bolder measures that can significantly increase the number of subscriptions or can, at least, double the observed reduction of per person emissions during 2013-14 (2.3 tCO2e). ▪ It is also important to understand the needs of the energy poor and reflect the understanding into formulating energy

	policy, calling for a more systemic form of governance that can sufficiently capture the needs of the poor.
4. Commons-based strategies delivering commonwealth	▪ While the Mini-PV program helps citizens understand the importance of locally-sourced or distributed source of energy. The analysis shows that Seoul needs bolder action to meet the 2020 target. It has qualitative shortcomings that it only supports the households who can afford to PV installation and that a primary beneficiary is private installers, not citizens or communities. In this context, it may be timely to evaluate the qualitative characters of this program. ▪ Seoul needs a further investigation into developing commons-based measures to create the commonwealth for citizens. The roles of Seoul Energy Corporation in this regard need to be revamped and strengthened.
5. Measurement, verification, and communication (MVC)	▪ It is uncertain whether the monitoring or measurement results are being independently verified on a routine basis. ▪ SMG needs the institutionalization of MVC and an integrated system that can measure, verify and communicate its policy progress.
6. Research infrastructure to support the development of DEDET strategy	▪ It is unclear whether the two core research agencies, Seoul Institute and Seoul Energy Corporation, have a sufficient body of researchers who are dedicated to a growing and diverse issues of sustainability that the city faces as well as who are researching the interrelated challenges of sustainability, equitable distribution, and democratic governance. ▪ It is not evident that there is any collaboration between the two agencies with respect to the challenges of sustainability, equitable distribution, and democratic governance. ▪ The city of Seoul needs more spaces where citizens and prospective researchers can study and conducts research on interrelated challenges of sustainability, equitable distribution, and democratic governance.

The tables above show that there are several gaps and shortcomings that need to be addressed for Seoul to meet the DEDET requirements. The findings may prove a usefulness of DEDET framework. At the same time, the case analysis implies that a further investigation of applying DEDET to other cities is needed because universality or acceptability is central to any framework.

In this context, this section drew on the best practices from other cities and regions, such as a state, and compared them with Seoul in the previous sections (see Section 6.4.1, Section 6.4.4, and Section 6.4.5). The comparative assessment shows that some cities have already met or are almost to meet a certain DEDET criterion. But it does not necessarily demonstrate if they can meet every DEDET criterion, calling for a further analysis of applying DEDET to these cities.

Chapter 7

CONCLUSION

We are facing three challenges posed by modern energy systems: deep decarbonization of energy-based emissions, equitable distribution of the risks and opportunities, and democratic governance. In an effort to address these challenges, this research offers a new framework for both interdisciplinary research and policy communities to consider DEDET. This framework is intended to serve as an open source where these groups can grapple with the challenges of the modern era and the drawbacks displayed by current piecemeal approaches to address them.

Central to DEDET are the principles of deep and equitable decarbonization and democratic governance. Key tools to operationalizing these principles include sustainability- and equity-based policy design, the adoption of community trust decision systems, and the pursuit of a commonwealth energy economy. These tools are introduced in DEDET as pragmatic strategies to address the interrelated challenges of deep decarbonization, equitable distribution, and democratic governance. Their success, though, is ultimately measured by a society's ability to realize a fundamental shift in its technics, politics, and economics. The empirical form of these principles, such as the target of 3.3 tons per person per year of CO_2 equivalent emissions and commoning practices, can catalyze social and economic innovation and open a political and moral space for democratic and just pursuit of a sustainable energy future.

In an attempt to operationalize the framework, large cities were identified and analyzed as an important institutional host for transformative change. Six DEDET Criteria were defined as vehicles to operationalize the framework in order to assess a city's progress. A case study of Seoul was carried out to investigate the conceptual soundness of the framework and the empirical validity of the Criteria. The case study revealed that Seoul's OLNPP initiative has met some objectives of the framework while failing to meet others, notably a deep and equitable decarbonization target and the institutionalization of MVC and research functions. Methodologically, the case study indicates that the OLNPP framework has the potential to inform governance approaches to be taken by various stakeholders in the pursuit of an integrated DEDET strategy. The case analysis exposes quantitative gaps and qualitative shortcomings that need to be improved to meet the requirements of deep and equitable decarbonization and democratic governance.

7.1 Limitations of the Research

This study has several limitations that must be pointed out. First, the in-depth case analysis of Seoul, and the preliminary study of London, Austin, and Freiburg, largely relied on government publications as the source of information and data for the analysis. While the in-depth study of Seoul used non-governmental publications, such as peer-reviewed papers, it must be noted that independent sources of information and data are not widely available due to the lack that OLNPP has only been in practice for a few years. But non-governmental publications are appearing, and future analyses should incorporate them.

While meetings with SMG staff and some members of the OLNPP Working Committee were organized by the author and were used for the case study, in-depth interviews with officials would improve the analysis. The use of online communications and direct engagement with citizen groups would likewise advance the quality of the research. Data availability is central to an accurate assessment and the author was able to acquire only limited quantitative information for this study.

Secondly, the DEDET framework must pursue quantitative data if the goal of integrated assessment is to be achieved. The DEDET Criteria, by their very nature, underscore this point. But there is a well-known challenge in doing so. For example, DEDET adopts a specific quantitative threshold (e.g. 3.3 tCO_2e per person per year) to evaluate deep decarbonization. Such a quantitative indicator can be useful in measuring some aspects of energy alternatives. For instance, quantitative indicators may enable key stakeholders (e.g. citizens and policy planners) to closely monitor whether policy progress is on track, helping to achieve policy goals. Quantitative indicators can also provide a means to analyze comparative performance among large cities. Energy strategies of each large city can be evaluated in terms of standardized indicators. Based on the benchmark resulted from the assessment, large cities can identify the areas to be revamped, learn best practices from other large cities, or do both. But governance processes and some attributes of equity are not easily assessed quantitatively. How, then, are qualitative representations of governance, as an example, to be combined with quantitative measures of emissions to produce an integrated assessment? For the OLNPP case study, a simple procedure of co-reporting was used with the assessment of OLNPP being based on the extent of its inclusive performance of quantitative and qualitative measurements. However, at some point, the weighting of performance measures will need to be examined if DEDET is to offer a multivariate analysis of our progress.

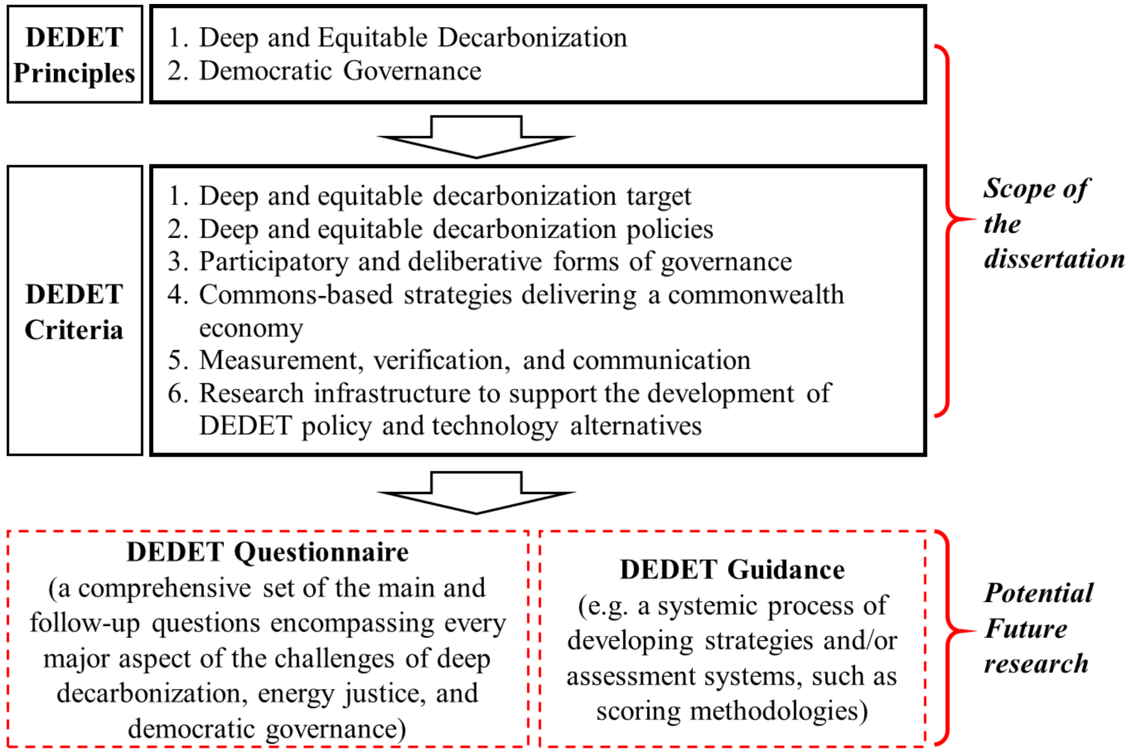


Figure 54. The Scope of this Dissertation and Potential Future Research

In a similar vein, the third limitation is that this study does not offer a clear guidance on how a DEDET assessment can be summarized and presented in an integrated manner. A key objective of this study is to develop an integrated assessment framework that can address three important challenges of the modern era (i.e. deep decarbonization, energy equity, and democratic governance). In that regard, this study proposes two principles that must be integrated into decision-making systems and six criteria that can be useful for assessing the existing policy models while not offering a guidance for key stakeholders to present the assessment results in an integrated manner. For example, the analysis results of this study are not either scored or quantified. Yet, it is important for the assessment result to be presented in an integrated manner because an integrated form of assessment results can help understand policy progress in a clearer manner.

Finally, the dissertation reviewed dominant discourses (or paradigms) of the modern era to identify major challenges that need to be addressed for a transition to a sustainable energy system that is equitable and democratic. But, there are other discourses that are worth discussing in the issues of energy transition and which receive only brief attention here. For example, the theory of material participation is noted as a basis for the discussion of why it is important to properly identify energy sources and technologies in the debates of energy transition (Ryghaug, Skjølsvold, & Heidenreich, 2018). This theory needs further attention as part of an effort to improve DEDET. Likewise, use of actor-network theory (ANT) may further shed light on the complex relationships between human and technical values, behaviors and choices. For example, Holifield (2009), citing Latour's version of ANT, argues that actor-network theory can be leveraged as a critical perspective to identify issues of energy justice and energy democracy. Wong (2016) has further noted that ANT can serve as a theoretical framework for interdisciplinary energy research aiming to analyze socio-technical and socio-ecological phenomena. Likewise, a review of other concepts and ideas of explaining the barriers, mechanisms, and/or processes of energy transition may be useful in comprehending the contemporary debates over energy transition and in underscoring the need for the DEDET framework. These include, but are not limited to, theories of systems change, such as technological innovation system modeling (Köhler, Grubb, Popp, & Edenhofer, 2006; Tokimatsu, et al., 2018), strategic niche management (Schot & Geels, 2008; Yun & Sim, 2015), interpretive and micro-focused perspectives on personal decisions and actions (Vandenbergh &

Steinemann, 2007; Devine-Wright, et al., 2017), and research on sustainable management, such as corporate social responsibility (Porter & Kramer, 2006; Post, Rahman, & Rubow, 2011), green management (Molina-Azorín , Claver-Cortés, López-Gamero, & Tarí, 2009; Siegel, 2009) and green growth (Dale, Mathai, & Puppim de Oliveira, 2016).

7.2 Suggestions for Further Research

As noted earlier in this dissertation, the framework was developed with the hope that it could be useful for two audiences: (1) interdisciplinary research communities seeking to research integrated approaches to address the interlinked challenges of the modern era; and (2) policy-makers and citizens seeking to shape energy transition policy in a manner that can resolve the three challenges (Figure 55). Hence, it may be proper to conclude this dissertation by offering suggestions to both audiences.

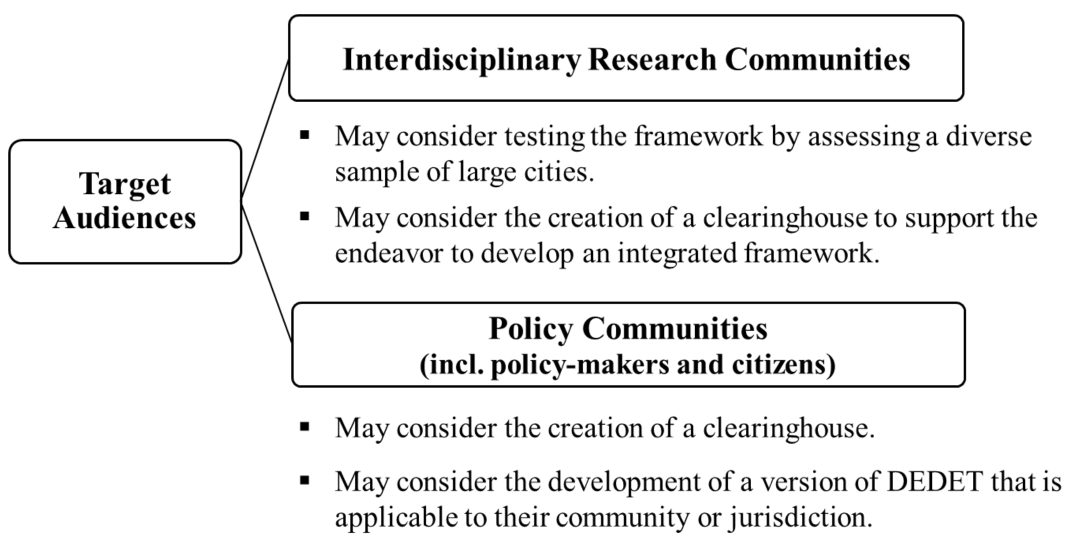


Figure 55. Suggestions to Target Audiences for Further Research

7.2.1 Suggestions to Interdisciplinary Research Communities

DEDET is specifically developed for interdisciplinary research communities as a key audience with the intention to add a more integrated research approach to the ongoing scholarly endeavor to develop sustainable, equitable, and democratic policy alternatives. In this context, I would like to offer specific suggestions for interdisciplinary research communities who are seeking to develop integrated approaches to assessing the interlinked challenges of sustainability, fairness, and democracy in the modern era.

First, this study conducted one in-depth case study of Seoul, although the preliminary study of London, Austin, and Freiburg was also carried out. These case studies were offered as tools to demonstrate the conceptual soundness and empirical feasibility of DEDET-informed assessments. But the usefulness of the framework needs to be tested by assessing a diverse sample of large cities in other regions. This concern must be addressed because of the global character of the challenges that it tackles. In-depth case analyses of London, Austin, and Freiburg may serve to fulfill this research goal. There are globally-recognized metrics already in use and DEDET must be benchmarked against them. As an attempt to address this issue, a range of heterogeneous questions can be developed to complement the standard set of DEDET Criteria.

Secondly, I would like to propose the creation of a clearinghouse to support the endeavor to develop an integrated framework assessing the sustainability, fairness, and democratic governance of the energy transition. This clearinghouse can include quantitative studies, case studies, and relevant theoretical or conceptual studies. A model for this purpose might be IPCC’s Working Group III work but with detailed assessment to qualitative studies on governance and qualitative-quantitative assessment integration.

7.2.2 Suggestions to Policy Communities and Civil Society

Planners and policymakers, and citizen groups seeking to shape energy transitions are also key sources of critical thinking about DEDET. The framework as it was presented in this dissertation offers a measure of conceptual and empirical guidance for government and civil society efforts to build a new energy order. But critiques from government and civil society are needed if DEDET is to adapt to the changing challenges that we will face throughout the century.

Suggestions I can offer for these communities are, in some senses, closely related to those for interdisciplinary research communities. They may also need a clearinghouse which documents a growing and diverse range of practices and implementation results. Political and social practices at municipal and grassroots levels, which have been largely undocumented thus far, can be recorded and shared through such a commons-based platform.

Perhaps most important, DEDET is developed to support policy-making and planning for a sustainable energy transition pathway for cities, communities, and nations. In this regard, DEDET can only be a useful tool if it is the subject of ongoing critique. Good frameworks need criticism and are improved by responding to criticism. In this respect, it is my responsibility to actively seek opportunities to apply DEDET and to elicit criticism of its principles and questions in policy and planning circles. In this vein, it is my goal to develop a version of DEDET for submission to the OLNPP Committee as a first step in searching for social and political criticism of the framework, which can be followed by submission of in-depth analyses to policy planners and civil society of London, Austin, and Freiburg.

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Appendix A

Q&A BETWEEN FREE AND SMG CONCERNING OLNPP

As indicated in Chapter 5 (see Section 5.3), the author of this dissertation has had several occasions to meet with high-level officers and have phone calls with staffs responsible for OLNPP. I could ask them several questions concerning OLNPP. These occasions have provided me with useful sources for writing this dissertation. One example is Q&A emails that Dr. John Byrne and the author of this dissertation sent to SMG. Below are the answers provided by SMG on April 28, 2017, to our questions. The original texts are kept while some formats, such as tables, are changed to meet the dissertation standards:

1. Please describe specific impacts of OLNPP on the local economy (in particular, job creation, private investment in sustainable energy, new industry development) over the last five years. Please indicate how each indicator was measured (including the source of the data).

    - The impact of OLNPP on the local economy is hard to analyze. For example, when we look at its LED replacement project, most of LED manufacturers are located outside Seoul and it is hard to locate where the materials for LED are produced, thus the impact on the local economy is hard to identify.

    - However, according to the study on the economic impact of the 1st phase of OLNPP (from January to June 2014) calculated with several inducement coefficients and analyzed by the Seoul Institute, the total budget was estimated to be about KRW 2.197 trillion including private investment and its nation-wide production inducement effect was KRW 1.2659 trillion and employment inducement effects was 20,116 persons.

- Using the above method, the production inducement effect on Seoul was KRW 2.1358 trillion; the income inducement effect was KRW 835.8 billion; and job inducement effect was 19,112 persons.

2. Please describe specific impacts of OLNPP on the local environment (in particular, air quality, water quality) over the last five years. Please indicate how each indicator was measured (including the source of the data).

- The OLNPP initiative results in GHG emissions reduction led by energy generation and conservation efforts and it helps improve air quality by reducing pollutant emissions.

- From January 2012 to December 2016, it has achieved an annual GHG reduction of 8.19 million tons, and it is expected to reduce about 14.52 million tons of GHG by 2020.

- Several projects under OLNPP, including promotion of EVs and retiring aged diesel vehicles as part of its plan to curb fine dust, are assumed to have contributed to improving air quality. However, the "study on the characteristics of fine particulate matter through close monitoring on fine dust in Seoul" conducted by the Seoul Institute and six universities from 2007 to 2010 shows that air pollution sources affecting fine dust levels of Seoul are largely affected by transboundary pollution from china and only 50% are affected by domestic pollution, among which the contribution of vehicle combustion and fuel use to air pollution was only 17.3%. Thus, it is assumed that the OLNPP's contribution to air pollution is limited. (Vehicle combustion: 11.4%, fuel use: 5.9%)

Table 20. Contribution of domestic pollution sources to fine dust in Seoul

Group	Pollution Source	Emission Source	Domestic
Group 1	Car combustion	On-road mobile source, gasoline cars, two-wheeled vehicles and construction equipment	11.4%
	Biomass burning	Barbecuing, incineration in the open air, charcoal burners, furnaces and firewood stoves	4.1%

	Combustion of fossil fuels	Combustion from energy and manufacturing industries, non-industrial combustion, gas heat pumps, non-road mobile sources (excluding construction equipment)	5.9%
Group 2	Fugitive dust	Scattered dust on the road, construction activities, recycling of construction waste, agricultural activities, vacant land and animal husbandry	17.9%
Group 3	Industrial Process	Production process, waste treatment	0.9%
Others		Other emissions source (Energy transport and storage, use of organic solvents, agriculture, area source, natural source, etc.)	10.7%
Total			50.9%

3. Please describe specific impacts of OLNPP on citizen awareness and participation over the last five years. For instance, has citizens' awareness of issues such as climate change, nuclear safety, or energy justice enhanced? Has citizens' participation in energy efficiency and conservation programs or installation of specific measures increased? Has OLNPP helped improve energy welfare among citizens? Please indicate how each indicator was measured (including the source of the data).

- OLNPP has led a sharp increase in citizen's awareness on energy policy. According to the survey on citizen's awareness on OLNPP conducted in March 2014, 71% of respondents said they were well aware of the policy and 59% of among them evaluated highly of it. This shows that many citizens have good awareness and perception of OLNPP.

- Since citizens are increasingly aware of energy policy issues, such as anti-nuclear power activities, the Fukushima Daichi nuclear disaster and global efforts for GHG emissions reduction, a social consensus has been formed on the necessity of implementing OLNPP, which has become its driving force.

- As for SMG's energy welfare project which kicked into gear since the phase 2, SMG formed an energy welfare fund management committee and raised KRW 7.56 million in in-kind and cash donations from 31 businesses, 3,868 citizens and 20 civic groups until 2016, and 27,370 citizens have participated in SMG' energy welfare projects. Given this, SMG's energy welfare projects are assumed be to be in full swing.

- The energy welfare projects which began in 2016 include BRP projects for residential housing, promoting the installment of solar panels, provision of goods to help the energy poor to cope with heat wave and cold snap, and in-kind donation for the local community, all of which benefited 37,065 households.

4. Please describe impacts of OLNPP on other local governments and regions in South Korea over the last five years. Especially, we would like to learn if OLNPP has had a positive impact on the residents in the towns where nuclear power plants are located. Has any energy policy instrument developed by SMG been adopted by other local governments?

- Since the launch of OLNPP, other local governments, including Gyeong-gi, South Chungcheong and Jeju, devised energy policies modeled after OLNPP, and many other cities and companies visited SMG to learn about OLNPP. In addition, several local governments requested information about the comprehensive plan for OLNPP.

- Also, the foundation ceremony of Seoul Energy Corporation held in February 2017 was joined by Gyeong-ju and Yeonggwang where nuclear power plants are located; Mirayang where there were a strong opposition against the construction of a power transmission tower; and Samcheok where the government plans to construct a new nuclear power plant, and discussed how to apply the OLNPP model to their local communities.

Table 21. Visit to Other Organizations and Information Request regarding OLNPP

No	Date	Type	Organization	Description
1	Sep.19, 2014	Provision of information	Incheon City (Bupyeong District)	Benchmarking OLNPP
2	Sep.29, 2014	Provision of information	LG Chemicals	OLNPP Phase 2 projects and performance measurement methods, etc.
3	Oct.6, 2014	Visit	Suncheon City Govt.	Benchmarking OLNPP

4	August 2014	Provision of information	Samcheok city, Gangwon Province	Comprehensive Plan for OLNPP Phase 1
5	Nov.3, 2014	Provision of information	Jeonju city, Jeon-buk province	Information request regarding mini-solar PVs, LED for multi-family housing
6	Oct. 2014	Provision of information	Suwon city	SMG's plan to increase the uptake of LED lighting
7	Nov.18, 2014	Lecture	Incheon City (Bupyeong District)	Presentation at climate change forum
8	Dec.8, 2014	Visit	Gwangju Mega City	Benchmarking OLNPP
9	Dec.15, 2014	Forum	Seongnam City Govt.	Presentation at Seongnam city's energy policy forum (OLNPP Executive Committee)
10	Nov.20, 2014	Lecture	Ulsan Development Institute (Environmental Safety research office)	the 2nd Ulsan Climate Change Symposium at Ulsan MBC Convention
11	Jan.22, 2015	Provision of information	Jeonju city govt. in Jeon-buk province	Information regarding the plan to build an energy self-sufficient city
12	Jan.27, 2015	Provision of information	National Agency for Administrative City Construction	Measurement of impacts of GHG reduction (commissioning completion report)
13	Feb.2, 2015	Provision of information	Korea Energy Agency (IEA)	posted an op-ed about OLNPP
14	Feb.11, 2015	Provision of information	Eumseong County Office	Support for energy saving programs
15	Apr.29, 2015	Visit & briefing	Ansan City officials, Ansan City Council mebers, etc.	OLNPP Briefing

5. Has there been an impact of OLNPP on national government policy in South Korea? For instance, has OLNPP contributed to national GHG reductions? Please indicate how this was measured (including the source of the data). Has

any energy policy instrument developed by SMG been adopted by the national government?

- OLNPP projects, such as promotion of solar PV, BRP and energy efficient building design, resulted in an annual GHG reduction of 8.19 million tons until December 2016 and plans to achieve an additional GHG reduction by 6.34 million tons by 2020.

- Considering the limited urban space in Seoul, SMG developed and has been promoting the installment of mini solar power plants for apartment buildings and provided a subsidy that covers 50% of the installment costs. Accordingly, the central government has adopted SMG's policy since 2017 and began providing subsidies to increase the uptake of mini-solar PVs.

- Mini-solar subsidies: KRW 490,000 for 260w (Government subsidy: KRW 670/w, KRW 174,200 for 260W)

6. Please describe whether OLNPP has contributed to global efforts in addressing climate change and energy justice. And if so, how?

- Under OLNPP, SMG has been carrying out various programs to encourage renewable energy generation; to reduce energy demand through BRP; and to promote energy-saving practices in daily life.

- Through the above efforts, SMG is fully committed to global efforts in addressing climate change and energy justice by achieving a GHG reduction of 8.19 million tons, and SMG's decentralized energy generation and energy demand reduction serve as a catalyst to alleviate local conflicts over nuclear power plants and coal-fired power plants.

7. Please describe the barriers SMG had encountered over the last five years in the design, formation, implementation, monitoring, or evaluation of OLNPP. What were the most challenging barriers? How has SMG addressed these challenges?

- In the new and renewable energy generation sector, poor geological conditions, densely populated urban space and relatively low power rates were major obstacles. In the energy efficiency sector, the high up-front cost was the most challenging barrier. In the energy conservation sector, it was difficult to come up with ways to encourage greater participation from citizens.

- The size of Seoul is approximately 605 ㎢, but buildings are densely populated in most areas except mountainous ones. Also, three sides except the west are surrounded by mountains

- The average wind speed is 2.4m/s which makes it hard for wind power generation and the physical condition of densely populated buildings is unfavorable to the installment of solar PVs. Also, most streams except the Han River become dry except the rainy season, which make it impossible to use hydropower generation. Also, the relatively low power rates becomes a barrier to encouraging renewable energy generation. To top it off, as the central government abolished Feed in Tariffs, a government subsidy paid to renewable energy generators, renewable energy businesses are put in a tough situation.

- To address the challenges, SMG made the most use of public spaces, such as car depots, water recycling centers and water treatment centers to construct solar PVs and fuel cell power plants.

- Feed in Tariff was a government subsidy program which began in October 2001 and the government compensated the difference between the base price of electricity and traded power prices to encourage investment in new and renewable energy. However, since its abolition in 2012, SMG used its climate change fund and implemented its own "FIT" program to promote new and renewable energy generation.

- Meanwhile, to compensate for the poor hydropower resources, SMG carried out a pilot program to assess the effectiveness of a small hydropower plant which can generate power at low head sites. To this end, it built small hydropower plants and installed them at water and sewage treatment centers.

- In the energy efficiency sector, the high up-front cost associated with building retrofitting discouraged civic participation and the cheap consumer prices for electricity extended the payback period. So, there was little incentive for building owners to participate in the retrofitting program.

- To entice BRP, SMG lowered its BRP loan interest rate to 1.45% (as of 2016) to encourage greater participation from citizens. Also, SMG commissioned research projects on global energy policies and technology trends and on ways to reduce building energy consumption in order to find ways for cost-effective and energy-efficient building retrofitting.

- In the energy conservation sector, citizens had little knowledge about how to save energy, which prevented them from engaging in the program and most citizens were too busy with their work to put their time and efforts in learning about ways to conserve energy. Against this backdrop, many agreed on the need for energy saving campaigns but didn't know how to act on it, which discouraged further promotion of energy saving programs.

- In our effort to encourage energy-saving practices for citizens, SMG nurtured about 50,000 citizens as energy consultants, green leaders and the Energy Guardian Angel Corp. composed of young students, to conduct and expand the energy saving movement among citizens.

- SMG also invested its public budget in conducting energy audits for small-sized buildings which have no obligation to report their energy consumption to entice retrofitting, thereby bringing about increasing citizen's interest and participation in OLNPP

8. Please describe the lessons SMG has learned from Phase 1. How have the lessons been integrated into the second phase of OLNPP?

    - The success of the Phase 1 increased stability in the city's energy supply and brought about a change in citizen's perception about energy use, thus increasing sustainability. Also, to address the problem of limited existing resources, SMG expanded new and renewable energy generation and reduced its dependency on fossil fuels, thus reducing its GHG emissions.

    - Also, OLNPP contributed to alleviating citizen's concern over unstable energy supply by enhancing stability in energy supply, and it demonstrated the fact that energy policies governed by the central government can be decentralized to the local level of governments, thus promoting decentralized energy policy to other local governments.

- The experiences and lessons learned from implementing OLNPP showed a possibility for local energy governance and help us realize the importance of citizen governance in enhancing policy impact.

- So far most energy has been generated from fossil fuels and nuclear power. Accordingly, the social discussion on energy policy has been mostly about limited energy resources and the treatment of nuclear waste. During the first phase, SMG promoted new and renewable energy generation and saw the outcomes. Based on this experience, SMG gained confidence in new energy sources and this was reflected in the second phase, which was a meaningful gain in both environmental and economic aspects.

- In addition, through the first phase, SMG was able to find the direction for institutional improvements and reviewed its energy consumption habits. It clarified the need for urban redesign, institutional improvements and the next direction for SMG's energy policy.

- Also, the A/C temperature during the summer was set at the summertime temperature limit of 28℃ for the public sector and 26℃ for the private sector. Also, the heating temperature limit during the winter was set at 18℃ for the public sector and 20℃ for the private sector. Thanks to this measure, SMG was better able to respond to a sharp rise in energy demand during the summer and winter.

- This process gave an important social lesson that although this measure might cause a little discomfort, but it did not prevent people from leading a normal life and helped prevent an energy crisis.

- Also, it served as a catalyst to rapid technological development. To reduce building energy demand which takes up the largest share in Seoul's energy consumption, it has reinforced green building design standard since 2013 and yielded considerable results. It led to technological development in energy efficient building design.

- To maintain the amount of energy consumption per unit area below a certain level, it required technology to reduce the heat transmission coefficient to the outside and to improve thermal insulation and air tightness performances of doors and windows, which prompted technological development in building design.

9. Please describe if and how OLNPP can be tangibly identified as a vehicle to redefine future urbanism in Korea.

    - One of the most crucial elements in future energy policy design is to build a broad consensus and a practical and pragmatic governance structure. Most of the successful energy-saving projects involved active community engagement, which was based on extensive consensus-building among citizens.

    - As there was a citizen-wide consensus about the need for OLNPP, many citizens participated in the Eco-Mileage program and Energy-Saving Model Shops to practice energy-saving lifestyle and joined for Green Leader and Energy Consultant programs to encourage more people to engage in energy saving.

    - Such extensive consensus building was possible as the OLNPP initiative was led in cooperation with citizens since its beginning. Particularly, the OLNPP Executive Committee played a major role in discussing individual projects and the future direction of OLNPP. Though this process, SMG built a broad consensus that it established a practical governance framework.

    - Future energy policies should include projects that are agreeable and actionable among citizens and a thorough review is needed to explore ways to improve the effectiveness of policy implementation.

10. Overall, what does SMG consider the two most innovative features of OLNPP?

    - One of the most innovative features of OLNPP is that it provided a successful model of decentralized energy policy tailored to local situations which moved away from a centralized and supply-side oriented one that often provokes conflicts with local residents.

    - Another innovative feature of OLNPP is that citizens took the lead in most of the projects. Compared to the existing policy approach that forced citizens to reduce energy consumption in response to a temporary change in energy demand in case of important difficulties in energy supply, OLNPP set concrete policy objectives that promote new and renewable energy generation and low-energy citizen lifestyle. In other words, OLNPP took a long-term approach and set annual targets for energy demand reduction and energy saving, thereby ensuring sustainable outcomes.

- To address the disadvantageous natural geographic conditions, OLNPP aimed to obtaining sustainable energy sources by expanding Solar PVs and other new and renewable energy generation and using biogas and sewage sludge as fuels. This allowed SMG to build its capacity to better respond to an energy crisis and ensure a sustainable supply of energy.