Demystifying Climate Risk Volume II

Demystifying Climate Risk Volume II:

Industry and Infrastructure Implications

Edited by

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IN MEMORIAM

To Ed Helminski

Physicist, policy advisor, and publisher as well as a founder of the International Workshop on Solvent Substitution, central to the successful implementation of the Montreal Protocol in protecting the Earth's ozone layer. Always gracious; often funny.

To Dr. John Stemniski

Brilliant Draper Lab chemist, member of the Chemical Technical Options Committee (CTOC) of the Montreal Protocol, and individual recipient of the U.S. Environmental Protection Agency's Stratospheric Ozone Protection Award. My curmudgeon of a mentor and friend.

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PREFACE

On November 10, 2016, United States (U.S.) Senator Angus King, (Independent, Maine) presented, *Maine and Climate Change: The View from Greenland* as part of the Margaret Chase Smith Lectureship on Public Affairs. The Lectureship was endowed in 1989 by the Margaret Chase Smith Foundation in honor of Senator Smith's contributions to the state of Maine and to the nation. Senator King communicated much of the same information at a follow-up event at the University of Maine on November 16–explaining the causes and impacts of climate change over time; talking about what it was like to see Greenland's melting glaciers firsthand; and encouraging the student body to learn more about the science of climate change.

An advocate of climate science, the senator carries a 'climate change' card in his pocket, explaining that:

> "…the graphs on the card are the simplest and clearest way to show not only the unprecedented and growing amount of CO_2 <carbon dioxide> in our atmosphere, but also its close correlation to global temperatures in the past. As our climate continues to change and we strive to adapt…it is important that everyone appreciate the context of our situation with respect to data from the past."

While my family from Massachusetts often visited Maine, I'm a fairly new full-time resident of the state, having recently retired from many years of climate-related work. Maine is truly an exquisitely beautiful state, endowed with many environmental gifts throughout all of its seasonal changes. It comes as no surprise to me that native as well as 'newbies' to the state feel strongly about environmental issues and their consequences, both to human health and to nature.

On June 1, 2017 (just days before this book was finished), U.S. President Donald Trump, fulfilled a campaign promise by announcing his intention of withdrawing from the Paris Agreement. The agreement is the seminal global policy enacted to help ensure the world's retreat from ever-increasing temperatures.

On the same day, the U.S. Climate Alliance was announced. The alliance was spearheaded by the states of New York, California and

Washington, whose combined economies, according to the World Resources Institute, would be the fifth largest in the world. Entrance into the Alliance was swiftly followed by the states of Massachusetts and Vermont, both of which have Republican governors. At this writing, a total of 13 governors have joined the Alliance whose objectives include:

> "…achieving the U.S. goal of reducing carbon dioxide emissions 26-28 percent from 2005 levels by 2025 and meeting or exceeding the targets of the federal Clean Power Plan."

In addition, 17 U.S. governors have released individual statements in support of the Paris Agreement and 211 city mayors have adopted the Agreement's goals. To ensure that the U.S. remains a world leader in the reduction of carbon emissions, 125 cities, 9 states, 902 businesses and investors, and 183 colleges and universities have signed a similarly motivated declaration.[1] It is important to note that regionally enacted goals to reduce pollution may be easier to more accurately track and to monitor for progress.

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[1] The declaration represents 120 million Americans and $6.2 U.S. trillion economic power (www.wearestillin.com).

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The editor would like to thank workshop co-chairs Barbara Kanegsberg, President BFK Solutions, LLC and Edward T. (Tom) Morehouse Jr., National Renewable Energy Laboratory (NREL) as well as the presenters and attendees to the *First Annual International Technical Workshop on Climate Risk*.

A special thanks in memory of Piers Sellers, then Acting Director of the Earth Sciences Division at NASA Goddard Space Flight Center. A climate scientist for many years, British-borne astronaut Sellers' discussion with Leonardo DiCaprio in the National Geographic documentary, *Before the Flood*, was particularly moving, following his diagnosis of cancer. Having broken my leg in a nasty fall that required surgery and a year-long recuperative period, I was considering cancelling the workshop. Though I never met Dr. Sellers, he graciously and kindly responded to my emails during this extraordinarily difficult time. His courage inspired me to continue this work.

Finally, the editor also thanks Cambridge Scholars Publishing for making this treatise possible.

INTRODUCTION

This book and its counterpart on environment, health and society are distillations of the *First Annual International Technical Workshop on Climate Risk* held in the autumn of 2016 in Wells, Maine in the United States (U.S.), an area of the country known for its environmental beauty. The workshop was serendipitously held only weeks before the U.S. presidential election.

The premise of the book is that long before the Paris Agreement[2], scientists, engineers, business men and women, public officials, academicians and non-governmental organizations (NGOs) throughout the U.S. and the world were hard at work in trying to solve the myriad of problems associated with anthropogenic (i.e., human-caused) climate change. The legislative force of the Montreal Protocol is now in support of the Agreement's key emission reduction goals by its inclusion of hydrofluorocarbons (HFCs), 'super' greenhouse gases used for refrigeration and air conditioning[3]. It was time for the seasoned leaders who implemented the Protocol, the world's most successful international treaty for the protection of the atmosphere[4], to share their knowledge and wisdom with the next generation of policy makers, technical professionals and educators before that expertise was lost.

Based on other contributors' expertise and the multidisciplinary nature of climate change, topics ranged from design modifications of drainage systems in response to increases in extreme weather events in this book to an update on the outbreak of the Zika virus[5]. Material is organized into major themes, while maintaining each author's individual writing style.

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[2] The 2015 United Nations Climate Change Conference held November 30-December 12 that negotiated a consensus document on the reduction of climate change from the 196 countries in attendance.

[3] Originally introduced by the chemical industry to replace ozone-destroying chlorofluorocarbons (CFCs), HFCs are 3,830 times more potent than carbon dioxide (CO2) with an atmospheric lifetime of 14 years.

[4] United Nations Development Program, 25 years of the Montreal Protocol: Partnerships for Change, November 20, 2012.

[5] Available in the second volume, "Demystifying Climate Risk Volume I: Environmental, health and societal implications".

This volume covers industry and infrastructure implications (in order of their appearance in the text):

1. A stand-alone chapter on the Montreal Protocol;
2. A section specific to industry and infrastructure concerns;
3. A section devoted to sustainability and strategic planning; and
4. A stand-alone chapter on climate science and informing business risk.

The third category (second section), while seemingly esoteric in nature, provides the reader with the opportunity to apply critical thinking methodologies to his or her own situational awareness of climate change. A separate volume covers environmental, health and societal implications.

The purpose of bringing these various communities of practice together was to:

- Leverage the many climate-related successes to date to inspire future innovations through 'lessons learned';
- Ensure that new atmospheric environmental regulations are timely communicated and economically executed; and
- Identify business opportunities for related sustainable development efforts.

As editor, I was struck by contributors' diverse fields and backgrounds, all working towards the common goal of climate protection. Consequently, several mini-interviews of authors are included and provide personal insight, so that the student reader might consider lending his/her own various talents to this endeavor as well.

Finally, the closing chapter serves as an abbreviated climate science tutorial for those readers less familiar with the topic and related climate change effects, especially professional outcomes. Coming full-circle with the book's first chapter, it speaks to the 'lessons learned' of the Montreal Protocol and concludes with general and specific business recommendations.

It is my fervent hope that the contents of both volumes of *Demystifying Climate Risk* do just that: by translating the science of climate change, for advocates and naysayers alike, through real-life stories as told by practitioners themselves, the book's contributors, to whom I owe such gratitude and respect. Should we be successful, then U.S. Senator King's words will ring true:

> "Now is the time to address current and near-future climate related challenges. From clean and renewable energy sources, to efficiency technology and standards, to emission-reducing policies and incentives,

there are many options at our disposal, many of which can foster economic growth and job creation. Like other complex challenges we have overcome in our past, no one single step will stop or reverse climate change alone; but, in combination, they represent a comprehensive framework that will help us pass on a stable and hospitable climate to future generations."

Chapter Summaries

Chapter One: *The Montreal Protocol: Stratospheric Ozone Protection Treaty Has Reinvented Itself as a Climate Protection Treaty*, by Drs. Steve Andersen and Nancy Sherman, champions the protocol as the premier instrument for climate protection, based on its years of successfully protecting stratospheric ozone, the chemical responsible for shielding the Earth from damaging solar radiation. The authors present a carefully constructed case for their position, including: every United Nations State is a party to the protocol; every State is in compliance; 99% of global ozone-depleting substances (ODSs) have been phased out in production and consumption; and, most importantly, the Earth's ozone layer is expected to recover by mid-century. ODSs are also powerful greenhouse gases (GHGs) that intensify global warming and, hence, climate change. The continued success of the protocol is attributed to previous amendments and adjustments that added newly-controlled substances which, in turn, accelerated the phaseout of ODSs. The Kigali amendment to phase down production and consumption of HFCs, unanimously passed in 2016, marks the first time that a non-ODS will be regulated under the Montreal Protocol. HFCs are GHGs used in thermal insulating foam, refrigeration and air conditioning. Based on the successful removal of ODSs from the upper atmosphere with the use of other viable, safer alternatives by industry, the authors contend that HFCs as ODS replacements are no longer needed. Finally, they demonstrate through scientific data and publications that the real danger in the continued and expanding use of HFCs is their high global warming potential (GWP).

Chapter Two: *Resilience: Business Leadership on Climate Risk*, by Dr. Ann Goodman, captures the essence of her own research for her book, ***Adapting to Change: The Business of Climate Resilience*** in terms of emerging resilience approaches to climate risk. Climate change is characterized as posing serious and novel risks to businesses of all types and sizes. Solutions range from taking basic, innovative steps to the sublime, that is, creating new products or identifying new markets. These solutions, which need not be expensive, may also address growing social or human needs as well as enhance a company's reputation and customer

loyalty. Poor communication or collaboration among multiple experts and teams—both within and outside the company—are identified as key obstacles to resilience. Examples of creative responses to climate challenges are cited and drawn from large, publicly traded and mostly international companies. These may serve as prototypes for small- to medium-size enterprises with less resources. The author categorizes resilience activities into seven major themes such as, "resilience can't be achieved in a silo" and "resilience is never 'finished', it's a mindset".

Chapter Three: *Solvent Substitution Is a Myth*, by Barbara Kanegsberg and Dr. Ed Kanegsberg, documents the elusive search for the ideal solvent, that is, one that performs well while, at the same time, is environmentally-friendly and safe. The authors illustrate the difficulty of this task by explaining the various conditions that need to be understood: what needs to be cleaned, how clean does it need to be, and how cleaning actually works. It is also difficult to duplicate actual cleaning conditions in testing to assess cleaning performance—substrate configurations and soils may be hard to emulate. Cleaning agents are adjudged by factors such as Hansen parameters and KB (Kauri-Butanol) numbers, which the Kanegsberg do an admirable job explaining. Aqueous (i.e., water-based) cleaners and blends are differentiated. The authors describe the impact of regulation on cleaning formulations and, given the growing list of attributes of the ideal solvent, recommend more involvement of the manufacturing community. It may be that the 'new paradigm' is to view cleaning as a process, not as a chemical, which must be conducted safely.

Chapter Four: *Climate Change Adjustment of Intensity-Duration-Frequency (IDF) Curves*, by Mark Klingenstein, advocates for the development and widespread acceptance of effective and standardized tools that translate General Circulation Models (GCMs) projections into point-specific IDF projections for short rainfall durations. This will be necessary if climate resilience is to be incorporated in both the upgrade and design of stormwater infrastructure since current climate change science suggests that one of the likely effects of increasing average global temperatures is the increase in more frequent intense precipitation. Historical data has already revealed an increase in the amount of rainfall occurring during intense precipitation events in the continental U.S. from 1958 to 2012, in particular, in the Northeast and Midwest. Furthermore, the increase in intense precipitation positively tracks the degree to which GHG emissions are assumed to increase. The author articulates what stormwater collection and management facilities are designed to do. He defines IDF curves as

presenting rainfall intensity/frequency relationships at a point within a given specified city, region or area (an individual IDF curve presents rainfall intensity/duration combinations having a single, specified return frequency). The author also describes the three ways in which distribution curves are generated and the importance of determining in which part (quartile) of the storm the peak rainfall occurs. Mr. Klingenstein differentiates separate sanitary sewer systems from older, combined sewer systems whose communities may evaluate performance in controlling wet weather overflows using a 'typical year'. He outlines the two 'downscaling' approaches, dynamical and statistical, used to translate GCMs' large-scale projections into much finer temporal and spatial scales. The author mentions four efforts to develop location-specific IDF curves, including the U.S. EPA's Climate Resilience Evaluation and Awareness Tool (CREAT) and one effort in London to produce a climate-adjusted typical year. In closing, a number of future studies are recommended for stormwater infrastructure.

Chapter Five: *Cleaning Solvents: How to Choose a Safer One*, by Dr. Jason Marshall details the work of the Toxics Use Reduction Institute (TURI) Cleaning Laboratory at the University of Massachusetts Lowell. Following a primer on the 'why' and 'how to' clean, Dr. Marshall describes halogenated solvents, offers a brief history of related chemicals, and mentions trichloroethylene (TCE) as a current cleaning 'work horse' because it is easy to use and relatively inexpensive. A number of newer solvents are mentioned whose physical and safety profiles are compared. TCE usage is then thoroughly examined with regard to: company types using the chemical; surface contaminants removed; types of cleaning equipment used; and dramatic reductions in TCE usage and emissions in the state of Massachusetts from 1990-2010. This success is promulgated on a systematic, scientific approach that has been generally lacking. Initially, this involves a five-point screening system of indicators to assess a chemical's overall risk as well as to avoid shifting risk. Standardized tests to evaluate cleaning performance may follow, but those tests may not always reflect real-world circumstances. TURI's lab consequently conducts customized cleaning trials, after the completion of a brief questionnaire by the client, based on a five-step process: product selection, chemistry evaluation, mechanical agitation, lab piloting and field testing. Cleaning trials conducted thus far by TURI's lab are summarized, followed by an easy-to-understand tutorial on how to use the lab's online searchable database to find safer cleaning solvents. Finally, the Pollution Prevention Options Assessment System (*P2OASys*) developed by TURI is

described and the collaborative effort required to perform successful solvent substitution is re-enforced.

Chapter Six: *Building Resilience and Saving Energy in High-tech Manufacturing*, by Steve Norris and Jim Unmack, chronicles Plasma Technology Inc. (PTI) efforts to reduce it energy budget, eliminate waste and enhance safety while, at the same time, increasing production. Founded in 1969, the company manufactures surface coatings at its facilities on the east and west coasts of the U.S. PTI found opportunities to reduce its carbon footprint and reduce energy requirements in: lighting; process cooling water; compressed air; and water consumption. PTI also found savings in recycling overspray. The segregation of previously landfilled metal waste allowed for the recycling of valuable metals including nickel, tungsten and stainless—this metal reclamation turned a cost into a revenue stream that has paid for improvements in energy efficiency. Other energy reductions include the application of variable frequency drives (VFD) and the recovery of process heat to dry feed stock and to use as an aid in comfort ventilation. As a consequence of these improvements, PTI has standardized processes and equipment across 22 work stations throughout its two facilities. This standardization provides resilience in meeting production schedules, helps the company to achieve its quality objectives and gives leverage to negotiate recycling contracts—giving PTI a competitive edge while demonstrating social responsibility.

Chapter Seven: *Quantifying Climate Risk through Time*, by Dr. Terry Thompson, describes how detailed climate projections can be used to quantify specific climate impacts on human and economic resources, and how the magnitude of these impacts evolves through time. This temporal aspect is essential to perform cost-benefit analysis for the many elements of adaptation plans for climate change but was unavailable until now. *ClimateIQ* was developed to perform the data assembly and analysis needed for quantifying climate risk through time. This toolset contains a screening level for rapid inter-comparisons and a detailed level for quantification. The author goes on to explain the four principle steps in calculating climate risk through time and applies a test case of the process in Western Equatoria, South Sedan for crop yields. Comparisons to a study in South Sudan by the International Food Policy Research Institute (IFPRI) using four models reveal that *ClimateIQ*: utilizes more models; gives better spatial and temporal resolution; and provides regional aggregation, statistical analysis and analysis of yield changes through time that the IFPRI study did not. In conclusion, localized climate risk driven

by ensemble statistics from all available climate models is now feasible and an important addition to efficient planning for climate change adaptation.

Chapter Eight: *The Plan-Do-Check-Act Cycle (PDCA) to Mitigate Climate Change*, by Dr. Phil Barnes, supports more and better use of the PDCA to reduce contributions to climate change, including the materials used in production, how/what services are rendered and energy. The PDCA is a process tool used to guide managers in the implementation and maintenance of a management system for change and continual improvement. Its history dates back to the 1940s and the development of the International Organization for Standardization (ISO) series of quality standards, ISO 9000. In 1993, the U.S. Environmental Protection Agency (EPA) initiated the Code of Environmental Management Principles, which used the PDCA for continual environmental management improvement. In 1996, the first ISO Environmental Management System (EMS) standard was published as ISO 14001 EMS and included the PDCA; an EMS calls for an organization to identify environmental aspects (causes) and impacts (effects) and plans made to manage them (e.g., address risks) accordingly. Since that time, a number of ISO climate change standards have been promulgated, dealing primarily with GHG inventories and emissions. To date, there are over 1.3 million organizations that have certified to the ISO quality and EMS standards with many integrating the two management systems. The key to successfully using the PDCA as a climate change tool is to ensure that managers incorporate the PDCA continual improvement cycle into the performance culture of the organization.

Chapter Nine: *Climate Change Progress through Sustainable Economics*, by Christopher Juniper, proposes that the challenges of climate change can only be met successfully if the principles of risk-averse sustainability are embraced. That is, building per capita *natural* (which is in decline) as well as *human* capital; both being necessary to create wealth. In particular, governments must take steps (e.g., policies) to ensure that more sustainable choices are also the most economically advantageous ones. The author describes progress in sustainability as reducing unnecessary suffering of people today and in the future such that, in theory, per capita global human and natural capital levels are increasing at least as fast as the population. Mr. Juniper states that there are really only two possible responses to declining natural capital: reduce the human activities responsible for it or implement 'fixes' to stop it. The longer societies wait to reduce the causes of the decline, the more likely a dramatic solution will

be enacted with little predictability, especially upon large-scale implementation. Climate change is one of the most studies threats to natural capital because of its (1) long-lasting impacts, (2) interactions with other natural capital resources and services, and (3) the likely long-time period of social and economic adjustments required to abandon GHG-intensive (i.e., carbon-based fossil fuels) economic systems. Consequently, climate change (and the resultant climate chaos) has correctly been dubbed a market failure; breakdowns of this kind occurring when markets fail to deliver desired outcomes due to flawed calculations. The author also comments on the role of management systems to address climate change, principally lifecycle-based systems, since inclusion of externalities into prices appears politically remote. Finally, to continually improve sustainability performance, a sustainable economic management system, or SEMS, for governments is proposed: a whole-system self-audit to occur at least every other year. SEMS is based on four components leading to specific goals that are attained through detailed actions.

Chapter Ten: *Designing into the Anthropocene*, by JohnPaul Kusz, uses the analogy of sailing into the perfect storm as we approach designing into the Anthropocene. The Anthropocene is the geological epoch in which human activities have had an environmental impact on the Earth, generally thought to have started in mid-20th century with the birth of the nuclear age. The author goes into some detail describing a 'Copernican moment', an emerging consciousness shifting from a man-centric to an earth-centric reality, named after the Polish Renaissance mathematician, astronomer and physician. Just as a weather storm has certain components (wind, precipitation, etc.), the forces coming together into the Anthropocene are: (1) population growth; (2) energy depletion; (3) toxic overload; (4) economic insecurity; and (5) climate change. Mr. Kusz examines each of these topics thoroughly. Particularly noteworthy is his treatment of the Precautionary Principle in the section on toxic overload. The principle could have been an appropriate strategy to evaluate and temper substances *before* they were prolifically incorporated into our products, thus avoiding many of the unintended consequences facing us today. The author's proposed solution is to rethink product, business and system models. This will require a necessary paradigm shift from consumer capitalism to conscious capitalism that promotes trust, accountability, transparency and integrity, among other attributes, and the development of "healthy" capital. All capital may be viewed as assets (for example, the total asset management concept of leasing) which then promotes the basic attributes of sustainability. Finally, traditional return-on-investments (ROIs)

focusing only on financial returns in product development are juxtaposed against ROIs born of comprehensive design thinking: the resultant model of wealth creation is circular rather than linear.

Chapter Eleven: *Climate Science and Informing Business Risk*, by Dr. Carole LeBlanc, purports that big or small, local or international, companies are and will continue to be impacted by attempts to mitigate climate risks. These impacts may not always be substantial, but they need to be addressed to control costs, regardless of the enterprise's sector. Climate-related developments in both public and private sectors are examined, including: energy, labor, agriculture, insurance and finance. This paper provides (1) the scientific and cost-based evidence to promote corporate leadership in relevant environmental matters and (2) a strong case for action to present to corporate executives where that leadership may be lacking. The objective is to foster better understanding of the underlying principles of climate science among business professionals to help them communicate the potential impacts of climate-related developments to their colleagues. In doing so, enterprises will be (1) better prepared with the best options for making decisions and managing risks for the short- and long-term future and (2) better informed to help ensure that the costs of mitigating climate change are equitably shared. The author demonstrates that the benefits of climate change action outweigh the costs and delineates the lessons learned from the Montreal Protocol. The chapter concludes with both general and specific recommendations for businesses.

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