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Environmental Investing: It Starts with the Academics

Angelo A. Calvello, PhD

Editor in Chief

It is not by coincidence that this issue of the *Journal of Environmental Investing* is published shortly after the release of the Intergovernmental Panel on Climate Change's (IPCC) report, *Climate Change 2014: Impacts, Adaptation, and Vulnerability.* The report says that the effects of climate change are already occurring on all continents and across the oceans, and that the world, in many cases, is ill-prepared for risks from a changing climate. A lesser but significant aspect of the report is that it represents the collective and collaborative scholarship of hundreds of scientists and researchers from around the world: A total of 309 coordinating and lead authors and review editors, drawn from 70 countries, were selected to produce the report. They enlisted the help of 436 contributing authors, and a total of 1,729 expert and government reviewers.

This seventh issue of the *JEI* spotlights the work of those in the academy who not only illuminate the challenges of our changing climate, but also apply their accumulated knowledge to the discovery and development of processes and technologies that may mitigate the worst of the environmental threats cited in *Climate Change 2014* and other reputable studies.

It is sobering to remind ourselves that environmental investing, in any shape or form, begins with the scientific investigations of such academics. This worldwide community of scholars, now, more than ever, needs the support of its two partners: the policy makers and the investment community. The science of climate change is the bedrock upon which policy initiatives and prudent economic decisions rest. And, it is a robust climate policy that will provide the incentives for investors of all sorts to deploy capital and continue to give rise to transformative environmental investment opportunities.

The headlines tend to go to the investors—the asset managers, hedge funds, and venture capital and private equity firms—but the recognition certainly belongs to the scholars who quite often, literally, get their hands dirty and do the heavy lifting. Without them and their work, the possibility of properly affecting or responding to changes in the environment would not be possible.

Best wishes,

Dr. Angelo Calvello

Environmental Investing: The Most Influential Academicians

Daron Acemoglu, the Elizabeth and James Killian Professor of Economics, Massachusetts Institute of Technology, USA

Dr. Acemoglu teaches and writes about climate change and technology. His groundbreaking research in environmental economics includes developing climate models and examining technological innovation. He also studies economic development and growth, human capital and training, political economy, and network economics. In his work, he has shown how directing technological changes generated by the market toward cleaner technologies and away from fossil-fuel-dependent ones can lead to effective climate-change intervention. Dr. Acemoglu is the co-author with James Robinson of the award-winning book *Why Nations Fail: Origins of Power, Poverty and Prosperity,* in which the authors examine the history of political and economic institutions that underlie economic success or failure.

Michael Adams, Distinguished Research Professor, Department of Biochemistry and Molecular Biology, Franklin College, University of Georgia, USA

Dr. Adams, along with Robert Kelly, a chemical engineer at North Carolina State University, and other researchers have engineered a strain of Pyrococcus (a microorganism that normally lives in near-boiling-point hot springs) to make a compound called 3-hydroxyproprionic acid from carbon dioxide and hydrogen (the latter of which can be produced via electricity or other environmentally friendly methods). This work "can be expanded to produce important organic chemicals, all through biological activation of carbon dioxide." Dr. Adams's research encompasses the physiology, metabolism, enzymology, bioinorganic chemistry, and functional and structural genomics of anaerobic microorganisms, particularly archaea and the so-called hyperthermophiles (those growing in an environment with temperatures that are near or higher than 100°C).

Peter Adriaens, Professor of Civil and Environmental Engineering and Professor of Entrepreneurship and Strategy in the Ross School of Business, University of Michigan; CleanTech Entrepreneurship Strategy, USA

Dr. Adriaens teaches courses on sustainable finance and cleantech venture assessment. As a speaker and writer on the potential of clean technologies, he demonstrates his interest in the environment at the confluence of science and

business. He is also the founder of Global CleanTech LLC, a consulting business and executive education firm concerned with global cleantech (particularly pertaining to water and energy) in relation to economic growth and development, and is director of Asian Operations at LimnoTech, an environmental services firm focused on the nexus of energy and water issues in the United States and China.

***Rachel Armstrong, Co-Director of Advanced Virtual and Technological Architectural Research (AVATAR), specializing in Architecture & Synthetic Biology at the School of Architecture and Construction, University of Greenwich, London, UK**

Dr. Armstrong is a sustainability innovator who investigates a new approach to building materials called "living architecture," a concept that suggests it is possible for our buildings to share some of the properties of living systems. She works collaboratively across disciplines to build and develop prototypes that embody her approach. She is also a 2010 TED Senior Fellow; visiting research assistant at the Center for Fundamental Living Technology, Department of Physics and Chemistry, University of Southern Denmark; and director of the Institute for Interstellar Studies for Development and Sustainability. ***Learn more about Dr. Armstrong's work on page 50.***

Vicki Arroyo, Executive Director of the Georgetown Climate Center; Assistant Dean of Centers and Institutes; and Director of the Environmental Law Program at Georgetown Law; Georgetown University, USA

Lawyer Vicki Arroyo oversees the Georgetown Climate Center's work at the nexus of climate and energy policy by supervising staff and student work on climate mitigation and adaptation at the state and federal level. She teaches "experiential" environmental law courses to both law and public policy students. She previously served at the Pew Center on Global Climate Change, most recently as the Pew Center's vice president for Domestic Policy and General Counsel. For over a decade, she directed the Pew Center's policy analysis, science, adaptation, economics, and domestic policy programs. Ms. Arroyo uses environmental law and her background in biology and ecology to help prepare for global climate change. She works on climate mitigation and adaptation policies as viable solutions to climate change's inevitable disruptions to current practices. Using the best available science, Arroyo collaborates with U.S. policymakers at both the state and federal level to develop "planetary management" strategies. She has recently served on California's Economics and Allocation Advisory Committee and worked with the National Center for Atmospheric Research (NCAR).

Jill Atkins, Professor of Accounting and Financial Management; Head of Accounting and Financial Management Group; Director of the Governance, Accountability and Responsible Investment Research Centre (GARI); Director of Research—BISA, Henley Business School, University of Reading, UK

Dr. Atkins's primary research focus is on the overarching area of corporate governance and includes institutional investor engagement and dialogue, responsible investment, stakeholder accountability, integrated reporting, pension fund governance, and sustainability issues in accounting and finance. She is the co-author of *Private Climate Change Reporting: A Discourse of Risk and Opportunity?* and author of a best-selling textbook, *Corporate Governance and Accountability*. She lectures mainly on corporate governance, accountability, and ethics.

Edward B. Barbier, John S Bugas Professor of Economics, Department of Economics and Finance, University of Wyoming, USA

As an environmental and resource economist with more than 20 years of experience, Dr. Barbier works on the economics of natural resource and development issues. He also studies the interface between economics and ecology. He has served as a consultant and policy analyst for a variety of national, international, and nongovernmental agencies, including many UN organizations, the Office of Economic Development, and the World Bank. His applied work has focused particularly on issues of land degradation, wildlife management, trade and natural resources, coastal and wetland use, tropical deforestation, biological invasions, and biodiversity loss.

James Barnard, Research Scientist; Global Practice and Technology Leader for Black and Veatch Corporation, USA; former Senior Chief Research Officer at the National Institute of Water Research, South Africa

Dr. James L. Barnard is recognized internationally as the "Father of Biological Nutrient Removal" for developing the first successful biological treatment process for the removal of phosphorus and nitrogen from wastewater. The biological nutrient removal (BNR) processes he developed are the basis for all biological and nutrient removal configurations in use today. He first conceived of the idea while working with water quality challenges in South Africa and arid Namibia in the 1970s. From then on, he has been engaged in water resource engineering and has designed over 100 innovative installations throughout the world by successfully adapting the BNR principles to suit different climates, environmental limitations,

locations, and water infrastructures in both developing and industrialized countries. In 2007, Dr. Barnard was awarded the Clarke Prize in recognition for his development of the BNR process and his many contributions to the advancement of water-quality science. In 2011, he received the Lee Kuan Yew Water Prize in Singapore for his work in recycling used water.

Alexander Bassen, Professor of Capital Markets and Management at the University of Hamburg, Faculty of Business, Economics and Social Science, Germany

In addition to his teaching and research, Dr. Bassen is a member of Germany's Council for Sustainable Development before the Federal Cabinet. The group advises Germany's federal government on the implementation and continuing development of the national sustainability strategy and is intended to effectively spread the topic of "sustainability" to the general public. Dr. Bassen is also a principal investigator at the Cluster of Excellence for Climate Research (CliSAP); a participant in the Network for Sustainable Financial Markets; and a member of Hamburg's "Center for a Sustainable University," which, as an interdisciplinary academic platform, develops and tests new concepts and new approaches to questions of sustainability. Its primary goal is to firmly anchor the concept of sustainability at the University of Hamburg, in both research and education.

Rob Bauer, Professor of Institutional Investors, Maastricht University, School of Business and Economics, The Netherlands

Dr. Bauer's academic research is focused on pension funds, strategic investment policy, mutual fund performance, responsible investing, shareholder activism, and corporate governance. His research into the field of sustainability and corporate governance resulted in the establishment of a new research institute, the European Centre for Corporate Engagement (ECCE). The purpose of the ECCE is to focus research on sustainable finance and responsible investing through the relationship between extra-financial information and the financial performance of companies and investors in those companies. In addition, he is founder and managing director of Rob Bauer Consultants BV, an investment consultancy firm for which he advises and supports institutional investors on topics related to strategic investments. He is also an associate director at the International Centre for Pension Management (ICPM) at the Rotman School of Management, University of Toronto, Canada.

Angela Belcher, W.M. Keck Professor of Energy, Massachusetts Institute of Technology, USA

At her Biomolecular Materials Group at MIT, Dr. Belcher's research focus is on biomaterials, biomolecular materials, and organic-inorganic interfaces. The group is "evolving simple organisms using directed evolution to work with the elements in the rest of the periodic table. We encourage these organisms to grow and assemble technologically important materials and devices for energy, the environment, and medicine. These hybrid organic-inorganic electronic and magnetic materials have been used in applications as varied as solar cells, batteries, medical diagnostics and basic single molecule interactions related to disease." The research is highly interdisciplinary and brings together the fields of inorganic chemistry, materials chemistry, biochemistry, molecular biology, and electrical engineering. The focus of her research is on understanding and using the process by which nature makes materials in order to design new hybrid organic-inorganic materials. Professor Belcher founded Cambrios Technologies, a Cambridge-based startup focused on applying her work with natural biological systems to the manufacture and assembly of electronic, magnetic, and other commercially important materials. She is a TED Fellow, a recipient of a US$500,000 Lemelson-MIT Prize honoring mid-career scientists who have an impact on society, and a MacArthur Fellow.

Andrew Benedek, Executive Chairman and Chief Technology Officer for Anaergia Inc.; former Professor of Chemical and Civil Engineering at McMaster University, Ontario, Canada

A highly respected international authority in the field of water and wastewater treatment technology, Dr. Benedek pioneered the development of low-pressure membranes in water treatment. He has over 30 years of experience in developing technology for wastewater treatment and is actively involved in the development and management of technology that is related to biogas and the recovery of other values from waste organics. A professor of Chemical and Civil Engineering, specializing in water treatment at McMaster University in Hamilton, Ontario, for 10 years, he then founded and led ZENON Environmental Inc. in 1980. Important membrane technologies used for water and wastewater treatment were developed at ZENON. Dr. Benedek was awarded the prestigious Stockholm Water Industry award in 2003 and the Lee Kuan Yew Water Prize in 2008. He is recognized by his colleagues as a visionary engineer, global leader, and philanthropist.

Eric Berlow, Co-Founder of Vibrant Data Labs; Research Scientist, USA

An ecologist and network scientist, Dr. Berlow "specializes in not specializing." He characterizes his work as focusing on three broad themes: ecology and network theory, data storytelling, and making the complex simple. A TED Senior Fellow, Berlow is recognized for his creative approaches to complex problems, particularly in his research on food webs and ecological networks. He was the founding director of the University of California's first environmental science center inside Yosemite National Park, where he continues to develop data-driven approaches to managing natural ecosystems with the USGS Yosemite Field Station. He also pursues research with the Pacific Ecoinformatics and Computational Ecology Laboratory. In 2012, Berlow co-founded Vibrant Data Labs to build tools that help people ask better questions with data. He often works collaboratively with network theorists, computer scientists, and other researchers and field ecologists. He advocates for and practices using a combination of approaches to better understand the broader ecological impacts of biodiversity loss and species invasions.

Richard A. Betts, Head of Climate Impacts at Met Office; Chair in Climate Impacts at the University of Exeter, UK

As a lead author of the IPCC 5th Assessment Report in Working Group 2 (*Impacts, Adaptation and Vulnerability*), Dr. Betts was responsible for assessing the impacts of climate change on terrestrial ecosystems. At the Met Office, the national weather service of the United Kingdom, Dr. Betts leads the Climate Impacts area, specializing in the interactions among ecosystems, hydrology, and climate, and overseeing work on climate's influences on urban, health, industry, and finance issues. He has worked in climate modeling since 1992, with a particular interest in the effects of climate change on ecosystems and water resources. He also studies the wide-ranging effects of land-use and land-cover changes on climate. He has pioneered a number of key developments in the extension of climate models to include biological processes. He leads the EU Framework 7 Project HELIX (High-End Climate Impacts and Extremes), which assesses the impacts of climate change at 2°, 4°, and 6°C global warming above the pre-industrial state.

Willem Brandenburg, Research Scientist, Plant Science Group, Wageningen University, The Netherlands

As a research scientist, Dr. Brandenburg works in biosaline agriculture. His latest work focuses on how to reclaim nutrients from the sea. "I want to test in practice how weeds are cultivated," says Brandenburg. "We want to grow sea lettuce at a

test location in the Oosterschelde. Short term, this will produce sustainable food for the fish and mussel cultivation. In ten years, it will lead to sea farms where sustainable sources of protein are produced for human consumption." His goals for this project are to contribute to global food production and to help prevent the depletion of direly needed phosphates, all while advancing the Netherlands' technological edge. "Currently more phosphates flow into the sea than can be extracted from the mines. And that while the global phosphate supply is so limited. If we continue to travel along this road, then all of our phosphate supplies will have washed into the sea within a century's time. Gone forever." Through their seaweed cultivation plan, Dr. Brandenburg and his group plan to reclaim invaluable micronutrients in addition to phosphate.

Klaas van Breugel, Professor; Program Leader for the Materials Science and Sustainable Construction Programme, Delft University of Technology, The Netherlands

Dr. van Breugel is the program leader for the Materials Science and Sustainable Construction Programme, which works to develop materials and structures that have the potential to improve the quality of the environment. The research focuses mainly on concrete, a porous material that is perfectly suited to interact with the environment, to clean it, and to serve as a barrier to noise and as a substrate for air-cleaning vegetation. In addition, the group conducts research in the socio-cultural, economic, and policy aspects of sustainable building and living.

Richard Brutchey, Associate Professor of Chemistry, University of Southern California, USA

Dr. Brutchey and his research group work in nanotechnology, including the development of semiconductor nanocrystals for solar cells. They've created a stable, electricity-conducting liquid filled with solar-collecting nanocrystals, which can be painted or printed like an ink onto surfaces such as window glass or plastic roof panels. The group has devised a way to kinetically access semiconductor nanocrystals with unusual crystal structures, non-stoichiometric compositions, and unique morphologies. They use these semiconductor nanocrystals to fabricate hybrid inorganic/organic solar cells. These systems offer promising alternatives to cadmium-containing II-VI solar cells, which are environmentally toxic. The Brutchey Group is also working with nanocrystals that can be incorporated into polymer nanocomposites to make high-energy density capacitors for energy storage applications.

Cees Buisman, Professor in Biologically Sustainable Technology at Wageningen University; the Scientific Director of Wetsus, The Netherlands

Since 2003, Dr, Buisman has been a professor in the sub-department of Environmental Technology at Wageningen University in the field of biological reuse and recovery technology. His work focuses on devising technology that can improve the existing water purification systems in order to remove phosphate (a nutrient), nitrogen (a nutrient), copper (a poisonous compound), and zinc (a poisonous compound) from wastewater. One focus of his research has been to develop a method for recycling phosphate that does not require an auxiliary substance. His research team has discovered a way to recover phosphate from wastewater without using chemicals, thus making it possible to reuse this increasingly scarce substance as a plant fertilizer. Dr, Buisman is also an executive board member at Wetsus, an organization that focuses on creating sustainable water technologies.

Richard T. Carson, Professor in, and former Chair of, the Department of Economics at University of California, San Diego, USA

Dr. Carson's fields of research are environmental and resource economics, including environmental valuation, climate change, environment and developments, and fisheries. He has worked at assessing the benefits and costs of environmental policies, with a specialty is valuing non-marketed goods and new commercial products. Dr. Carlson has also estimated the benefits of the U.S. Clean Water Act, the removal of low-level carcinogens from drinking water, the protection of groundwater aquifers, the economic impacts associated with fisheries' management practices, and the health and visibility improvements due to air quality changes. He writes extensively on environmental and economic issues and has been named the most cited environmental economist in the world.

Marco J. Castaldi, Associate Professor, Chemical Engineering, City College of New York/CUNY, USA

Professor Marco J. Castaldi's main research interests are in combustion, gasification, and catalytic reaction engineering, and in waste to energy processes. He directs the Combustion and Catalysis Lab. The lab's main focus is the thermal and catalytic conversion of carbon-based material to desired products. For example, municipal solid waste and biomass can be converted to synthetic fuels, liquid fuels to hydrogen, and greenhouse gases (carbon-based) to fuels. He has 11 patents in the fields of catalysis, combustion, and gasification and has won numerous awards, given many keynote lectures, and published dozens of articles.

Guang-hao Chen, Professor of Civil and Environmental Engineering, Hong Kong University of Science and Technology (HKUST); Associate Director of HKUST Institute for the Environment (IENV), Hong Kong

Dr. Chen's research interests include sustainable sewage treatment systems; sludge minimization in bio-treatment; sewer process modeling; MBR process optimization; and low-cost and compact wastewater treatment technology. Dr. Chen led a team in making use of saline water as an alternative water resource in project partnerships with various NGOs, universities, and other organizations. The research team leveraged Hong Kong's unique seawater flushing system to develop a novel, energy-efficient, and low-carbon sewage treatment technology. The HKUST team was also invited by the UNESCO-IHE Institute of Water Education to join a four-year research project to develop this environmentally friendly and economically viable practice. Its findings, co-published at an IWA-hosted magazine, *Water21,* are especially valuable for countries hard-hit by clean water scarcity, such as Cuba. He and his research team are responsible for inventing and developing about 12 patented unique wastewater-sanitary treatment processes.

Hongzheng Chen, Professor of Chemistry, Department of Polymer Science and Engineering, Zhejiang University, China

Dr. Hongzheng Chen's research interests focus on organic (organic/inorganic) optoelectronic materials for photovoltaic, photodetector, and biosensor applications. The objective of her work is to develop advanced organic (organic/inorganic) optoelectronic materials by tailoring molecular structures and aggregations, to construct new optoelectronic devices, and to achieve a fundamental understanding of optical and electronic processes in organic semiconductors. Professor Hongzheng Chen is also a Global School for Advanced Studies (GSAS) Fellow, where she participated in the 2012 session on organic solar cells.

Stephen Chou, Joseph C. Elgin Professor of Engineering and the head of the NanoStructure Laboratory at Princeton University, USA

Dr. Chou and his team have significantly improved the efficiency of solar cells by creating a nanostructured metal and plastic sandwich-like plasmodic cavity with sub-wavelength hole array. The cells are also cost-effective because they can be manufactured in sheets through a nanolithography process developed by Dr. Chou. This process embosses the nanostructures over a large area, similar to the way newspapers are printed. Chou's group, the NanoStructure Laboratory (NSL) has

two primary missions: to develop new nanotechnologies for fabricating structures substantially smaller, better, and cheaper than current technology permits; and to explore innovative nanodevices and advanced materials in electronics, optics, optoelectronics, magnetics, and biology, by combining cutting-edge nanotechnology with frontier knowledge from different disciplines.

Gordon Clark, Director of the Smith School of Enterprise and the Environment with cross-appointments in the Saïd Business School and the School of Geography and the Environment at Oxford University; Fellow of St Edmund Hall, Oxford, UK; Sir Louis Matheson Distinguished Visiting Professor, Faculty of Business and Economics, Monash University, Melbourne, Australia

An economic geographer, Professor Clark is interested in the responsibilities and behavior of investors engaged in long-term sustainable investment. This work has involved research on the proxy-voting behavior at institutions; corporate engagement strategies, given concerns about environmental liabilities and the sensitivity of firms to brand image and reputation; the regulation of corporate disclosure on issues related to environment and social responsibility; and the governance of investment institutions that have an explicit long-term mandate. His current research focuses on the governance of investment decision-making in the context of market volatility and long-term obligations. In part, this project has developed in collaboration with Oxford colleagues and graduate students as well as the UNPRI, Mercer, the Telos Project, Towers Watson, and the project led by Professor Tessa Hebb at Carleton University (Ottawa) that is funded by the Social Science and Humanities Research Council of Canada.

Corrado Clini, Chair of the Global Bioenergy Partnership; former Director General of the Italian Ministry of Environment, Land and Sea, Italy

Dr. Clini is the former director general of the Italian Ministry for the Environment, Land, and Sea. He actively engaged in the ministry's mission to respond to climate change, ozone-layer protection, sustainable development, and international cooperation for protection of the global environment. He has also been a visiting professor at the Department for Environmental Sciences and Engineering of Tshingua University (Beijing) and at Harvard's Kennedy School of Government. He is currently the chair of the Global Bioenergy Partnership and project leader of national and international cooperation programs on environment, energy, and sustainable development. He is also chair of the National Sustainable Development Strategy and of the Task Force for the implementation of the Kyoto Protocol in Italy. He trained as a medical doctor and holds degrees in hygiene and health.

Suani Teixeira Coelho, Energy Researcher; Coordinator of the Brazilian Reference Center on Biomass, Electrotechnics, and Energy Institute at the University of São Paulo, Brazil

As a chemical engineer, Dr. Coelho researches energy production from biomass. Her work includes the coordination of technical, economic, environmental and institutional studies on using biomass for energy with Brazilian and foreign institutions, including federal and state government. She served as a member of the UN Secretary General's Advisory Group on Energy and Climate Change and the International Renewable Energy Agency (IRENA), whose task focused on the integration of bioenergy as an efficient energy resource. Dr. Coelho works at the Brazilian Reference Center on Biomass (CENBIO/IEE/USP), founded in 1996, with a group of research scientists in bioenergy located at the University of São Paulo, in the Institute of Electrotechnics and Energy. CENBIO/IEE/USP was established with the main goal of promoting the development of research activities and the disclosure of scientific, technologic, and economic information to make feasible the use of biomass as an efficient energy source in Brazil.

Robert Costanza, Chair in Public Policy at Crawford School of Public Policy at Australian National University, Australia

Dr. Costanza's transdisciplinary research integrates the study of humans and the rest of nature to address research, policy, and management issues. This work focuses on the intersection of economic and ecological systems at multiple time and space scales, from small watersheds to the global system. His work includes landscape-level spatial simulation modeling;, systems ecology, ecological economics, landscape ecology, ecological modeling, ecological design, energy analysis, environmental policy, social traps, incentive structures, and institutions. Dr. Costanza is co-founder and past-president of the International Society for Ecological Economics, and is recognized as a global expert on economic and ecological issues, about which he has published a wealth of articles and books.

Debabrata Das, Professor, Biotechnology; Professor-in-Charge, PK Sinha Centre for Bio-Energy, Indian Institute of Technology Kharagpur (IITK), India

Dr. Das works in biohydrogen production processes, CO_2 sequestration for algae cultivation, and microbial fuel cell research. As the principal investigator at IITK's Bioprocess Engineering Laboratory, he and the research team recently completed an integrated multidisciplinary project that used solar energy for the production of renewable hydrogen combined with CO_2 capture to address global warming and

energy production. Professor Das has more than 25 years of experience working on biological gaseous energy-recovery systems. He has pioneered the promising research and development of a biohydrogen production process by applying fermentation technology, which is a major area of green technology. Dr. Das and his team hope to develop a commercially competitive and environmentally benign bioprocess hydrogen fuel. This work began with the isolation and characterization of high-yielding hydrogen producing bacterial strain Enterobacter cloacae IIT-BT 08, which, as of today, is known to be the highest producer of hydrogen by fermentation. His other major contribution in the field of biohydrogen research was the molecular characterization of the Hydrogenase-coded gene.

Jonathan Davis, Lead Researcher for Taylor Resources, Inc.; Affiliate Associate Professor at the University of Washington, School of Fishery and Aquatic Sciences, USA

Jonathan Davis has engaged in shellfish research and aquaculture for over 30 years on both U.S. coasts and for international sites. He was a finalist in the 2013 Paul G. Allen Ocean Challenge for the proposal, "Cultivating Seaweed to Mitigate Ocean Acidification, and Generate Habitat, Fertilizer, Food, and Fuel." As the lead researcher at Taylor Resources, he focuses mainly on broodstock genetics, nutrition, and sustainable culture methods. As an affiliate assistant professor at the School of Fishery and Aquatic Sciences (University of Washington), Dr. Davis works closely with the university's researchers on similar issues. He assists in restoration ecology projects for native oysters and pinto abalone with the Puget Sound Restoration Fund and on a number of research projects about the environmental effects of shellfish culture with the Pacific Shellfish Institute. He also owns and operates his family's small clam and oyster farm.

Faye Duchin, Professor of Economics, Rensselaer Polytechnic Institute, USA

Dr. Duchin researches ways of achieving economic development while avoiding environmental disasters. She analyzes alternative scenarios about the future by using mathematical models of individual economies and the world economy. In her most recent work, she has focused on future demands for land and fresh water, particularly for the production of food. Dr. Duchin believes that a sustainable development research agenda requires cross-disciplinary collaborations that engage not only the policy community and corporate decision-makers, but also, and mainly, civil society. She is also active in the integration of input-output economics with industrial ecology, rooted in engineering, and with social science approaches to sustainable consumption.

Mike Dunne, Director for Laser Fusion Energy, Lawrence Livermore National Laboratory, USA

Dr. Dunne's role includes leadership of LIFE, which is designed to build on the National Ignition Facility (NIF) demonstration of ignition in order to deliver electrical power for the United States at the gigawatt scale. NIF has 92 laser beams that are capable of delivering nearly two million joules of ultraviolet laser energy in billionth-of-a-second pulses. It serves as a preeminent facility for conducting fusion energy research and for studying matter at extreme densities and temperatures. The goal for LIFE is to deliver a safe, secure, carbon-free, affordable, sustainable, and enduring supply of base-load electricity to people throughout the world. Professor Dunne previously led the European laser fusion program, HiPER—a consortium of 26 institutions across 10 countries. He was also Director of the UK's Central Laser Facility and a visiting professor at Imperial College London, where he obtained his Ph.D. in Plasma Physics.

Peter Eisenberger, Professor of Earth and Environmental Sciences at Columbia University, USA

For over 30 years, Dr. Eisenberger has worked in the applied sciences, focusing his research on the microscopic understanding of materials. Eisenberger, a physicist, is also a co-founder and managing director of Global Thermostat, a group of experts united to support the development and commercialization of a technology for the direct capture of carbon dioxide from the atmosphere and other sources. Its unique process co-generates carbon capture and power. He is a fellow of both the American Physical Society and the American Association for the Advancement of Science. Dr. Eisenberger was one of the authors of the National Action Plan for Materials Science and Engineering, and a member of the Commission on the Future of the National Science Foundation (NSF).

Paul Ekins, Director of UCL Institute for Sustainable Resources; Professor of Resources and Environment Policy, University College, London, UK

Dr. Ekins's academic work focuses on the conditions and policies that lead to achieving an environmentally sustainable economy. He is an authority on a number of areas of energy-environment-economy (E3) interaction and environmental policy, including: sustainable development assessment methodologies; resource productivity; sustainable energy use; E3 modeling and scenarios; the adjustment of national accounts to in consideration of environmental impacts; environmental economic instruments and ecological tax reform;

sustainable consumption; and environment and trade. He is a member of United Nations Environment Programme's International Resource Panel; a fellow of the Energy Institute; a senior consultant to Cambridge Econometrics; and a co-director of the UK Energy Research Centre, in charge of its energy systems and modeling theme. He also leads UCL's participation in the EPSRC SUPERGEN, a consortium on hydrogen fuel cells and bioenergy research.

Kerry Emanuel, Cecil & Ida Green Professor of Atmospheric Science, Massachusetts Institute of Technology, USA

Dr. Emanuel investigates various aspects of moist convection in the atmosphere and tropical cyclones. He researches the scaling of convective velocities and the nature of the diurnal cycle of convection over land. His research group has developed a promising technique for inferring tropical cyclone activity from coarse-grain output of climate models or re-analyses. In his work on hurricanes, he has analyzed the power of thousands of hurricanes that occurred over decades. He found that that power of the storms doubled in the period in which climatologists have been measuring greenhouse gases and that these storms have been raising atmospheric and ocean temperatures. Along with Professor David Rothman, he leads the MIT Lorenz Center, which was founded to engage in fundamental inquiry about global climate change. By emphasizing curiosity-driven research, the center fosters creative approaches to learning how climate works. Among the books written by Dr. Emanuel is *What We Know About Climate Change.*

Charles Forsberg, Research Scientist, MIT; Executive Director, MIT Nuclear Fuel Cycle Study; Director and Principle Investigator Fluoride Salt-Cooled, High-Temperature Reactor Project; and University Lead, Idaho National Laboratory Hybrid Energy Systems, USA

The holder of 11 patents, Dr. Forsberg is a fellow of the American Nuclear Society and the American Association for the Advancement of Science. He received the 2002 American Nuclear Society Special Award for Innovative Nuclear Reactors (Fluoride salt-cooled, high-temperature reactors), and in 2005, the American Institute of Chemical Engineers Robert E. Wilson Award in recognition of his chemical engineering contributions to nuclear energy, including his work on reprocessing, waste management, repositories, and production of liquid fuels using nuclear energy. Forsberg proposes combining nuclear with artificial geothermal, shale oil, or hydrogen production, which could help slow climate change, in a paper published in the November 2013 issue of the journal *Energy Policy*.

Édouard François, Architect, Urban Planner, Teacher; Maison Édouard François, France

Édouard François has been an architect and urban planner since 1986. He launched his career with various projects, including "The Building that Grows" in Montpellier (2000) and the "Flower Tower" in Paris (2004). Sustainable development, the utilization of local materials and services, and the preservation and enhancement of existing buildings are all recurrent themes in his work. The M6B2 Tower in Paris (to be completed in 2014) and the Planted Tower in Nantes explore more closely the idea of biodiversity. The former includes the use of wind to spread first-generation seeds and promote the regeneration of plants throughout the Paris metropolitan area. François has taught in schools around the world, including at the Architectural Association in London, the Ecole Spéciale d'Architecture in Paris, and the Design Academy in Eindhoven.

Ruth Gates, Researcher at Hawai'i Institute of Marine Biology; Graduate Faculty, Department of Molecular Biosciences and Bioengineering, University of Hawai'I at Manoa, USA

Dr. Gates focuses her research on the biological mechanisms and traits that dictate the environmental threshold of marine organisms. With her research group, she examines the tropical marine ecosystems of coral reefs that protect coastlines, engage tourism, and provide nutrition to many island nations. The group's work includes studying and evaluating the "complex interactions between climate change stressors (disturbances in temperature, ocean chemistry, storm frequency and severity) and chronic or acute local impacts (coastal development, pollution and over-fishing) [that] have driven the global deterioration in the quality of these ecosystems." Dr. Gates is a co-winner of the 2013 Paul G. Allen Ocean Challenge along with Dr. Madeleine van Oppen from the Australian Institute of Marine Science for the pair's idea to increase the resilience of critical and highly vulnerable coral reef ecosystems.

Jessica Green, Associate Professor, Institute for Ecology and Evolutionary Biology, University of Oregon, Eugene; External Professor, Santa Fe Institute; Environmental Task Force, American Academy of Microbiology, USA

Dr. Green is an engineer and ecologist who specializes in biodiversity theory and microbial systems. A major goal of hers is to develop buildings and urban areas that promote sustainability, human health, and well-being. As the founding director of the Biology and Built Environment (BioBE) Center, she is spearheading efforts to model and design urban environments as complex microbial ecosystems that

intimately interact with the trillions of microbes living in and on humans—the human microbiome.

Ing-Marie Gren, Professor in Environmental and Resource Economics, Swedish University of Agricultural Economics, Sweden

Dr. Gren's research focuses on environmental policy instruments made under conditions of uncertainty and risk, specifically regarding the behavior of humans and nature, and in relation to biodiversity. Much of this research has been applied to large-scale water quality management, specifically of the Baltic Sea. Professor Gren is responsible for the first major report on the total costs and benefits from mitigating eutrophication in the Baltic Sea. She also looks at the valuation of ecosystem services, in particular, regulatory functions that affect wetlands' ability to act as nutrient sinks to the benefit of downstream ecosystems. Her research and teaching encompass cost-benefit analysis, environmental policy, and social science perspectives on sustainable development.

R.S. (Dolf) de Groot, Associate Professor, Environmental Systems Analysis, Wageningen University, The Netherlands

Dr. de Groot works in the environmental systems analysis department where he conducts quantitative and multidisciplinary research aimed at analyzing, interpreting, simulating, and communicating complex environmental problems. His areas of expertise include environmental economics, environmental management, nature management, and ecology. He was recently acclaimed for his work in devising a database for ecosystem services. An international team led by Dr. de Groot put ecosystem services, such as food and oxygen, into a database that expresses the value of the services in hard currency. The group's goal is to establish ecosystem service values that can then be used effectively in decision-making processes undertaken by scientists, policy makers, governments, NGOs, and others. Dr. de Groot also recently co-founded the new journal *Ecosystem Services*.

Michael Grubb, Senior Research Fellow at 4CMR, Cambridge University Centre for Climate Change Mitigation Research; Senior Advisor on Sustainable Energy Policy to the UK Energy Regulator Ofgem, UK

Dr. Grubb is the lead author of several reports put out by the Intergovernmental Panel on Climate Change (IPCC) to address the economic, technological, and

social aspects of limiting greenhouse gas emissions. He initiated and chaired the global Innovation Modelling Comparison project, widely cited in both the Stern Review and the IPCC Fourth Assessment. He is editor-in-chief of the journal *Climate Policy*, is on the editorial board of *Energy Policy*, and was recently the Specialist Adviser to a House of Lords European Committee enquiry, *No Country is an Energy Island: Securing Investment for the EU's Future* (2013). In March 2014, he published the book *Planetary Economics,* in which he relates the lessons he has acquired from 25 years of research and the implementation of energy and climate policies.

Luke Hanley, Professor of Chemistry and Department Head, Chemistry, the University of Illinois at Chicago (UIC); Adjunct Professor, UIC Bioengineering Department, USA

The research of Dr. Hanley and his group is at the interface of analytical chemistry, mass spectrometry, bioengineering, and surface science. They apply advanced instrumental methods to modify and characterize both biological and materials surfaces in several distinct projects. In some cases, this involves the construction of novel instrumentation. The group is growing nanocomposite materials from the gas phase. This work includes preparing lead sulfide nanocrystal-organic oligomer films by this method for use in nonlinear optical devices and third generation photovoltaics. Henley received a 2012 National Science Foundation grant to develop a solar-related nanotechnology project.

Lars Hassel, Professor of Accounting; Rector/Dean at Umeå School of Business; Program Director, Sustainable Investment Research Platform (SIRP), Sweden

Dr. Hassel's research interests include the value relevance of environmental, social, and governance (ESG) information in the value chain of financial markets. He has written extensively on international, financial, management, and environmental accounting topics. Together with Dr. Gary M. Cunningham, visiting professor at Åbo Akademi University in Finland, he was presented with the 2013 Lee H. Radebaugh Notable Contribution to International Research Award for their article "Psychic Distance and Budget Control of Foreign Subsidiaries" in the *Journal of International Accounting Research.* The paper was based on their research, which was the first such study to introduce cultural and geographic distance factors into management accounting research.

James Hawley, Management Professor, School of Economics and Business Administration; Founder of the Elfenworks Center for Responsible Business; Senior Research Fellow, St. Mary's College of California, USA

Corporate governance and responsible investment are two of Dr. Hawley's main research topics. He studies comparative corporate governance and institutional investors of the United States, the European Union, and Japan; conducts a continuing study of the impact of globalization of financial markets on international financial stability and national economic policy formation and effectiveness; and examines the fiduciary duty of major institutional organizations. His approach to responsible investment, or ESG, of corporate valuation is from the varied viewpoints of a teaching academic and a researcher. From this work, he develops policy implications for use by institutional investors, governments, and inter-governmental organizations. The Elfenworks Center, which he founded, has just expanded its prior focus on fiduciary capitalism to one that encompasses responsible business. "Responsible business must mean more than simply claiming to be responsible," says Hawley. "What are emerging worldwide are standards for responsible business through the concepts of ESG, for environmental, social, and governance standards." Professor Hawley is the author of *The Rise of Fiduciary Capitalism: How Institutional Investors Can Make Corporations More Democratic.*

Michael Hoel, Professor of Economics, Department of Economics, University of Oslo; Scientific Advisor, Frisch Centre of Economic Research; Associate Researcher at Vista Analyse; Fellow at The Beijer Institute of Ecological Economics; Fellow at CESifo, Norway

As a researcher, professor, and author, Dr. Hoel specializes in environmental, resource, and energy economics. His ongoing work includes the investigation and study of the costs of renewable fuel standards, forestry and carbon emissions, and climate economics. A widely cited authority, Professor Hoel has also written on game theory; analysis of international environmental negotiations and treaties; domestic and international policy instrument design under uncertainty; and optimal resource use. In 2011, he received the European Lifetime Achievement Award in Environmental Economics, given by the European Association of Environmental and Resource Economists, in recognition that "his contribution has been particularly noteworthy in bringing environmental concerns to the research agenda of mainstream economics, and in demonstrating the suitability of the economic analysis tools in the areas of environmental policy."

***Pieter Hoff, Inventor; Founder of AquaPro Holland, The Netherlands**

Inventor Pieter Hoff introduced the Groasis Technology through his privately owned company AquaPro Holland. The Groasis Technology (GT) is a planting technology (not an irrigation system) that is used in over 30 countries with good results. Hoff's research resulted in the seemingly simple Groasis Waterboxx, which has received a wide range of notice and awards: the Dutch Bèta Dragons Science Award 2008; the *Popular Science* magazine award as one of the top 10 inventions of 2010; and the Limburg Design Association Award in 2011. Groasis is a biomimicry technology that works as a water incubator by capturing water from the air condensation and rain and wicks it into the soil. There is no energy expenditure and the water savings in the first year of use are reported to be over 90 percent better than those reported for other planting methods. Mr. Hoff promotes using the box in dry and eroded regions as a practical and successful way to plant trees and produce food at little cost but with life-changing benefits. ***Learn more about Pieter Hoff's work on page 60.***

John Holdren, Assistant to the President for Science and Technology; Director of the White House Office of Science and Technology Policy; Co-Chair of the President's Council of Advisors on Science and Technology (PCAST), USA

Dr. Holdren is recognized as an authority on energy technology and policy, global environmental change, and nuclear nonproliferation. As a researcher and academician, he was an early advocate of an interdisciplinary approach to energy and environmental issues within the academic, research, and policy communities. Before joining the Obama administration, Dr. Holdren was the Teresa and John Heinz Professor of Environmental Policy and the director of the program on Science, Technology, and Public Policy at Harvard University's Kennedy School of Government, as well as a professor in Harvard's Department of Earth and Planetary Sciences and director of the independent, nonprofit Woods Hole Research Center. He has led or served on national and international panels that have helped shape new understanding and new policies relating to energy strategy for sustainable development, the causes and consequences of global climate change, and the protection of weapon-usable nuclear materials. ***To learn more about Dr. Holdren's views on energy and market-based solutions to environmental challenges, read Lia Abady's interview in the Journal of Environmental Investing Vol. 1, No. 2 (2010), available in the JEI archives.***

Kees Hummelen, Professor of Chemistry of Molecular Organic and Bio-organic Materials, University of Groningen, The Netherlands

Together with his staff, Dr. Hummelen is working to create plastic solar panels that will be an inexpensive alternative to the resources normally used to produce solar cells. The group works with conjugated polymers, which can absorb more light and are better conductors than many other materials, and with electron acceptors, called buckyballs, which are football-shaped molecules. Recognized as one of the top researchers in the field of materials science, Dr. Hummelen works in multidisciplinary chemistry and organic energy and fuels. In 2011, he received a EUR five million Foundation for Fundamental Research on Matter (FOM) grant to further improve solar cells. He is also the scientific director of the Stratingh Institute for Chemistry; chairman of the group Chemistry of (bio)Molecular Materials and Devices; and co-founder and CEO of Solenne BV, Groningen, which was established to provide academic and industrial researchers with high-quality PCBM and many other fullerene derivatives.

Julian Hunt, Emeritus Professor of Climate Modelling, University College London; Visiting Fellow of the Malaysian Commonwealth Studies Centre in Cambridge University; Chairman of Cambridge Environmental Research Consultants (CERC), UK

Dr. Hunt's research studies in the field of fluid dynamics have encompassed such topics as turbulent and stratified flows, complex atmospheric flows, and dispersion. His work has been applied to practical solutions in building design, wind energy generation, and air pollution modeling. His experimental and theoretical research in magneto-hydrodynamics was related to problems in the technology of thermo-nuclear fusion and to engineering problems of electromagnetic stirring and heating of liquid metals. He has been involved in model assessment and the development of computer codes in these subjects. As the chief executive of the UK Meteorological Office, he was elected to the executive committee of the World Meteorological Organisation. Among his accomplishments is the active part he took in negotiating new international arrangements for the exchange of data to ensure that national meteorological services worldwide can continue to collaborate with each other. He and his colleagues at Cambridge formed a company, Cambridge Environmental Research Consultants Ltd (CERC), which developed environmental software and, in collaboration with other organizations, a new air pollution dispersion model that is now the standard model for the UK Environment Agency.

Kamarulazizi Ibrahim, Professor of Physics, Universiti Sains Malaysia, Malaysia

Dr. Kamarulazizi Ibrahim's areas of interest are energy, semiconductor materials and devices, nanotechnology, and sustainability. He is actively engaged in research on materials for multi-junction solar cells. A certified energy manager, he is a recipient of an IRPA research award valued at RM24 million on "blue light emitting devices" and has represented Malaysia in G–15 Solar Energy Experts meetings and the World Solar Summit. He has chaired and works with the Nano Optoelectronic Research And Technology Laboratory and the Energy Research Program, both at the university.

Wiebren de Jong, Associate Professor of Energy Technology, Process and Energy Department, Delft University of Technology, The Netherlands

Dr. de Jong works in the field of thermo-chemical conversion of biomass and hybrid bio-refinery concepts. He is a member of the STW platform for clean and efficient combustion and the university's representative member in the Dutch Flame Research Foundation. His research fields are biomass characterization (pyrolysis, gasification), biomass co-firing, supercritical water gasification of wet biomass, and bio-refinery process development.

Matthew Kanan, Assistant Professor of Chemistry, Stanford University, USA

Dr. Kanan's areas of research are organic and inorganic chemistry. His research group focuses on challenges in catalysis for renewable energy applications and fine chemical synthesis. They have pioneered a new class of heterogeneous catalysts for electrochemical carbon-fuel synthesis and experimental studies of electrostatic effects on the selectivity of catalytic reactions. "The ability to convert H_2O, CO_2 and N_2 into fuels by using renewable energy inputs could, in principle, provide a viable alternative to the current dominance of fossil fuels. This prospect faces great technical challenges, the foremost of which is the lack of efficient and robust electrocatalysts for the various multi-electron processes that fuel synthesis demands. The ultimate goals of this research area are to develop catalyst design principles that are applicable to multiple materials and to provide viable candidate electrode materials for electrolytic devices."

David Keith, Gordon McKay Professor of Applied Physics and Professor of Public Policy, Harvard University, USA

Dr. David Keith has worked near the interface of climate science, energy technology, and public policy for twenty years. His interest in geoengineering, the

concept of intentionally making changes to Earth's climate system in order to combat global warming, has engendered curiosity and support as well as controversy. He is the president of Carbon Engineering, a start-up company developing industrial scale technologies for the capture of CO_2 from ambient air. His other areas of study include the economics and climatic impacts of large-scale wind power and the use of hydrogen as a transportation fuel.

Robert Kelly, Alcoa Professor; Director of the Biotechnology Program, North Carolina State University, USA

The work undertaken by Dr. Kelly and his research group is aimed at the boundary between biology and engineering. They address issues of fundamental importance in understanding the bioenergetics, biochemistry, physiology, and genomics of extreme thermophiles, which are organisms that thrive at relatively high temperatures and are found at various geothermal heated regions of the Earth, such as in hot springs, the deep sea, and the decaying plant matter of compost and peat bogs. Extreme thermophiles, in particular, require a very high temperature (80 °C to 105 °C) for growth; their membranes and proteins are unusually stable at these extremely high temperatures. The Kelly group's studies have given rise to a number of technologically important developments related to bioenergy and biofuels; the recovery of base, precious, and strategic metals from ores; and industrial biocatalysis. Dr. Kelly's specific areas of focus are biomolecular engineering, biocatalysis at extremely high temperatures, microbial physiology, functional genomics, bioenergy, and biofuels.

Sebastián Kind, Founder and Managing Director of the Renewable Energy Master of Science Programme at the Technical University of Argentina; President and CEO of Aires, Renewable Energy Sources, Argentina

Sebastián Kind is a founder and managing director of the Renewable Energy Master of Science Programme at the Technical University of Argentina. He has taught courses and advised on energy issues at multiple public and private institutions in Argentina and abroad. He is also a founding partner and president of Aires Renewables, a renewable energy company that is dedicated to the development of wind energy in Latin America and that provides consultancy services to governments, companies, and ventures interested in investing in the South American renewable-energy market. He has evaluated wind energy projects for the government of Uruguay (Ministry of Energy and Mines) and consulted for Chile Energy and the German Cooperation Agency (GTZ) on issues of wind energy and bidding processes in Latin America.

Nils Kok, Associate Professor in Finance and Real Estate at Maastricht University, The Netherlands; Affiliated Faculty and Visiting Scholar at the UC Berkeley Program on Housing and Urban Policy, USA

Dr. Kok is the recipient of a prestigious three-year grant from the Dutch National Science Foundation for his work on the intersection of sustainability and finance in the real estate sector. He is a co-founder of the Global Real Estate Sustainability Benchmark (GRESB), which is recognized as a premier investor-led initiative to assess the environmental and social performance of the global real estate investment industry. Professor Kok spent the last two years as a visiting scholar at the Haas School of Business, UC Berkeley. He frequently communicates his ideas and findings as a speaker at international academic and industry conferences and actively shares his expertise through workshops with investment practitioners and policy makers.

Charles Kolstad, Professor Emeritus in Environmental Economics, University of California, Santa Barbara; Senior Fellow, Stanford Institute for Economic Policy; Senior Fellow, Precourt Institute for Energy, USA

Dr. Kolstad is interested in the role information plays in environmental decision-making and regulation, and does much of his applied work in the area of climate change and energy markets. He is also an adviser to the California Air Resources Board. Professor Kolstad was a lead author for the Intergovernmental Panel on Climate Change (which was the co-recipient of the 2007 Nobel Peace Prize) and a member of the National Academy of Sciences committee charged with evaluating the U.S. Climate Change Research Program. He is a former president of the Association of Environmental and Resource Economists, and editor of the journal *Review of Environmental Economics & Policy.* His more than 100 publications include the undergraduate text *Environmental Economics*. He is a former chair of the UCSB Economics Department and co-director of the UC Center for Energy & Environmental Economics, a joint undertaking of UC Berkeley and UCSB. He is a university fellow at Resources for the Future and a research associate at the National Bureau of Economic Research.

Frederik Krebs, Professor and Section Head, Department of Energy Conversion and Storage, Technical University of Denmark, Denmark

While working in the field of organic photovoltaics (OPV), Dr. Krebs has been particularly interested in moving his research from the lab into the real world to ensure that the results benefit people in realistic ways. His aim has also been to do real-life demonstrations of OPV in order to learn how to improve the technology.

One outcome of this idea was his research group's frequently cited paper, "Manufacture, Integration and Demonstration of Polymer Solar Cells in a Lamp for the 'Lighting Africa' Initiative." The group's goals were to test the new technology against real-life settings, discover how well the technology would perform, and identify how it could be improved. Dr. Krebs's additional research interests includes new materials with low-band gap and novel processing capability; large-area processing and manufacture of polymer solar cells; all aspects of roll-to-roll printing-coating-processing and testing; life cycle analysis; stability and lifetime testing; degradation mechanism studies; outside testing, demonstration, and electricity grid-connected polymer solar cells.

***Merle de Kreuk, Assistant Professor, Wastewater Treatment and Anaerobic Digestion Processes at the Sanitary Engineering Section, Department of Water Management, Delft University of Technology, The Netherlands**

Dr. de Kreuk's work focuses on wastewater treatment systems and anaerobic processes. She is one of three scientists who were co-finalists for the 2012 European Inventor Award (EIA) in the research category for their invention and development of the Nereda water technology, which enables efficient and inexpensive purification of industrial and household wastewater. In this technology, the treatment of domestic wastewater uses 25 percent less energy and takes up 75 percent less space than older technology processes do. In 2007, she was awarded the Simon Stevin Fellowship Prize by STW and in 2010, she won the Jaap van der Graaf award. ***Learn more about Dr. de Kreuk's work on page 63.***

Johannes Lehmann, Professor, Department of Crop and Soil Sciences, Cornell University, USA

Dr. Lehmann conducts research and teaches in soil biogeochemistry and soil fertility management. His specializations are in soil organic matter and nutrient studies of managed and natural ecosystems, and he focuses on soil degradation and sustainable agriculture in the tropics (especially Africa); bio-energy; greenhouse gas emissions from soil and headwaters; and synchrotron-based methods for soil research. Dr. Lehmann is also a co-founder and chair of the board of the International Biochar Initiative (IBI), which promotes biochar, a 2,000 year-old practice that converts agricultural waste into a soil enhancer that can hold carbon, boost food security, and discourage deforestation. It is a relatively inexpensive, widely applicable, and quickly scalable sustainable technology.

Gatze Lettinga, Emeritus Professor Anaerobic Treatment and Reuse Technologies, Wageningen University, The Netherlands; Advisor at LeAF, The Netherlands

Professor Gatze Lettinga was awarded the Lee Kuan Yew Water Prize 2009 for his sustainable solution for the treatment of used water, the Upflow Anaerobic Sludge Blanket reactor. Dr. Lettinga pioneered the widespread use of anaerobic technology, which uses microorganisms in an oxygen-free environment to purify used water. Not only does the treatment enable the cost-effective purification of industrial used water, but it also produces renewable energy, fertilizers, and soil conditioners. The water prize noted another significant aspect of Dr. Lettinga's work: by choosing not to patent his invention, he made his technology universally available. As a result, it has been widely adopted by industrial as well as municipal users. The system has even anticipated the increasing concerns about energy efficiency. Over the course of his four-decade career, Dr. Lettinga has been involved with over 15 engineering projects on anaerobic wastewater treatment plants in developing countries, including projects in Cuba, Brazil, Indonesia, India, Vietnam, and Morocco. He continues his work as an advisor to the Lettinga Associates Foundation (LeAF), a not-for-profit knowledge and consulting center that develops and implements sustainable, environmental-protection technologies and supports young scientists.

Bruce Logan, Kappe Professor of Environmental Engineering; Evan Pugh Professor, Department of Civil and Environmental Engineering, the Pennsylvania State University, USA

Dr. Logan's main area of research is in the sustainability of the water infrastructure. The Logan laboratory is actively engaged in researching ways to ensure water sustainability through bio-energy, or methods of producing electricity or energy carriers such as hydrogen from biomass. Specific research topics include bioelectricity using microbial fuel cells and biohydrogen production using microbial electrolysis cells (MECs or BEAMR) or by fermentation. Other areas being studied are water treatments that use biological processes to target specific chemicals such as perchlorate, and bacterial adhesion for the purposes of bioaugmentation for remediation of contaminated aquifers. Ongoing projects that Dr. Logan and his colleagues have written about include "Energy sustainable wastewater treatment systems for forward operating bases based on microbial fuel cells," and "Energy sustainability for water infrastructure and agriculture."

Mark van Loosdrecht, Professor and Group Leader in Environmental Technology, Department of Biotechnology, Delft University of Technology, The Netherlands

Dr. van Loosdrecht's research interests are in biofilm and granular sludge systems, microbial storage polymers, nutrient removal processes, and the microbial ecology of engineered systems. A world-renowned, award-winning scientist and engineer, Professor van Loosdrecht's work focuses on the interface between microbiology and biotechnology, specifically pertaining to wastewater treatment. To shorten the often lengthy transmission process involved in introducing research solutions to the marketplace, Dr. van Loosdrecht works actively with the wastewater industry to implement the solutions derived from his research. As a result of his direct involvement, many breakthroughs in wastewater treatment have been successfully commercialized in a relatively short time. He was awarded the Lee Kuan Yew Water Prize 2012 for his contributions in used water treatment, in particular, the completely autotrophic nitrogen removal process, Anammox. This process reduces the overall energy consumption, chemical usage, and carbon emissions of a conventional wastewater treatment plant. The process was made possible by the discovery of a unique group of bacteria that removes pollutants in used water by using less oxygen than conventional processes and no added organic carbon.

Derek Lovley, Distinguished University Professor, University of Massachusetts, Amherst, USA

Dr. Lovley's research is focused on the physiology and ecology of novel anaerobic microorganisms. Current topics of investigation include: in situ groundwater bioremediation; microbial fuel cells; directed and natural evolution of anaerobic respiration; anaerobic biofilms; and extracellular electron transfer mechanisms. In Dr. Lovley's lab, the Geobacter Project, these studies are being approached at the genome scale and involve genetic, biochemical, ecological, and in silico modeling approaches. The research ranges from basic physiological studies to collaborations with industry undertaken to optimize the function of microbial fuel cells. His lab was one of 14 chosen to work under a U.S. government-supported project to make biofuel substitutes for gasoline from microbes in the laboratory. A result of this work is butanol, a substitute that doesn't rely on plants or arable land, and thus leads to much less environmental degradation than would occur with the use of plant-based biofuels.

Greg Lowry, Professor of Civil and Environmental Engineering at Carnegie Mellon University; Deputy Director of the Center for Environmental Implications of Nanotechnology (CEINT), USA

Environmental nanotechnology, energy and environment, and environmental remediation are the broad categories of Dr. Lowry's research interests. His specific research areas include nanoparticle characterization, reactivity, and transformations; and macromolecule-nanoparticle interactions and contaminant fate in the subsurface. He focuses on the fundamental physical and geochemical processes affecting the fate of engineered nanomaterials and organic contaminants in the environment. His current research includes investigating the processes affecting the permanence of CO_2 when injected underground for carbon sequestration. His experimental work also includes a variety of fundamental and application-oriented research projects from which he and his colleagues plan to develop novel environmental technologies for restoring contaminated sediments and groundwater. Dr. Lowry's paper, "Transformations of Nanomaterials in the Environment," was named the top paper by the journal *Environmental Science and Technology* in 2012.

Bruce Menge, Wayne and Gladys Valley Professor of Marine Biology, Oregon State University, USA

The wide-ranging research interests of Dr. Menge and his colleagues at the Lubchenco/Menge Lab encompass marine life and coastal oceans with concentrations on the structure and dynamics of marine meta-ecosystems; the responses of coastal ecosystems to climate change; linking benthic and inner shelf pelagic communities; the relationship between scale and ecosystem dynamics; bottom-up and top-down control of community structure; recruitment dynamics; eco-physiology and sub-organismal mechanisms in environmental stress models; larval transport and connectivity; impact of ocean acidification on marine ecosystems; controls of productivity; population, community, and geographical ecology; and models of community regulation. The group is the lead institution in the Partnership for Interdiscipinary Studies of Coastal Oceans (PISCO), a long-term, large-scale ecological consortium. Other consortium members include the Universities of California at Santa Barbara and Santa Cruz, and Stanford University's Hopkins Marine Station. Over the next five years, the research goals of PISCO are to understand the impacts of climate change on large marine ecosystems, to further the theory and application of marine reserves, and to help

inform the sustainable management of marine resources. Dr. Menge was a 2013 Paul G. Allen Ocean Challenge Finalist as the team leader for their work on the "Mitigation of Ocean Acidification by Adaptation: Identification of Neighborhoods of Resilience."

Subodh Gautam Mhaisalkar, Associate Professor, School of Materials Science & Engineering; College of Engineering Executive Director, Energy Research Institute, Nanyang Technological University, Singapore

Dr. Subodh Mhaisalkar has over 10 years of research and engineering experience in the microelectronics industry where he has held various engineering, research, and development positions. His areas of expertise and research interests include printed electronics, bioelectronics, printed power, and organic photovoltaics. Common to all these projects are methods of solution processing of semiconductors (organic, carbon nanotubes, or inorganic nanowires); fundamental device physics studies; and device integration. Dr. Mhaisalkar and his colleagues have raised more than $100 million in research funding for a variety of sustainable energy projects. With organizations like Vestas, Bosch, Rolls-Royce, and IBM, he has initiated partnerships that contribute significantly to research in energy systems that range from solar cells and smart grids to wind and marine turbines. In addition, he works closely with several national agencies and has been instrumental in securing partnerships with other educational research institutes, including UC Berkeley, TU Munich, Cambridge, and Imperial College.

Sushanta Mitra, Professor in the Department of Mechanical Engineering and the Assistant Vice-President (Research) at the University of Alberta, Canada; Director of the Micro and Nano-scale Transport Laboratory located at the National Institute for Nanotechnology (NINT), Canada

Dr. Mitra's areas of research are microfluidics and nanofluidics; bioMEMS; flow-through porous media; fuel cells; and atomization and sprays. The objective of one of the current research projects at the NINT Lab is the bioconversion of coal into any possible gaseous fuels, such as methane or hydrogen, through laboratory core-flooding experiments that mimic field conditions. The purpose of this experiment is to (1) monitor methane generation; (2) investigate metabolic bi-products, microbial interactions with coal, the growth of microbes, and the effects of microbes and nutrients loading on methanogenesis, and factors that facilitate and inhibit methanogenesis, and finally (3) develop optimal engineering routes to accelerate the bioconversion process.

Madjid Mohseni, Professor, Chemical and Biological Engineering, University of British Columbia; Scientific Director, RES'EAU-WaterNET Strategic Network, Canada

Dr. Mohseni's research interests are in environmental bioprocess engineering, biofiltration, biological wastewater treatment, advanced oxidation, and photocatalysis. In his view, "Advanced oxidation technologies and bioprocess engineering have great potentials to contribute and lead to a cleaner environment and new sources of energy." His laboratory's research focuses on the application of advanced oxidation technologies and their applications to the removal of organic contaminants from air and water, in particular, and on developing and evaluating technologies for drinking-water treatments. As an expert in advanced oxidation and water treatment processes, Dr. Mohseni brings a wealth of industry experience to the RES'EAU-WaterNET Strategic Network. A recipient of the Ontario Ministry of Environment's Award of Excellence in Research and Technology Development in 1998, Dr. Mohseni has led a number of industrially funded collaborative projects related to air and water treatments using photocatalysis, UV photolysis, and UV-based advanced oxidation processes.

Ernest Moniz, United States Secretary of Energy; Professor of Physics, Emeritus, Massachusetts Institute of Technology, USA

Dr. Moniz's research interests center on energy, science and technology, and national security policy. At MIT, Professor Moniz served as head of the department of physics and as director of the Bates Linear Accelerator Center. His principal research contributions have been in theoretical nuclear physics and in energy technology and policy studies. In his current position as the U.S. Secretary of Energy, Dr. Moniz responsibilities are to implement goals for growing the economy, enhancing security, and protecting the environment. This includes maintaining the nuclear deterrent and reducing nuclear danger; promoting American leadership in science and clean energy technology innovation; cleaning up the legacy of the cold war; and strengthening management and performance.

Ulf Moslener, Professor of Sustainable Energy Finance, Frankfurt School of Finance & Management; Head of Research of the UNEP Collaborating Centre for Climate and Sustainable Energy Finance, Germany

Dr. Moslener's main areas of research are international climate policy; the analysis of carbon regulation; carbon emissions trading; and policy instruments to promote renewable energy. He has led a number of research projects, including those on

behalf of the German Federal Ministries or the European Commission. Among his recent publications, written in collaboration with his research colleagues, are "Taxing Externalities under Financing Constraints" and "Barriers to Increasing Energy Efficiency: Evidence from Small-and Medium-Sized Enterprises in China." As the head of research of the UNEP Collaborating Centre for Climate and Sustainable Energy Finance, Dr. Moslener's current fields of research center on the economics of climate change, the finance of sustainable energy systems, and climate finance. He also represents Germany on the UN Standing Committee on Climate Finance, and has worked with KfW Development Bank, on the practice of financing renewable energy and energy efficiency in developing and newly industrialized countries within the German development cooperation.

Benard Muok, Director of Programmes at the African Centre for Technology Studies (ACTS); Project Manager, Policy Innovation Systems for Clean Energy Security (PISCES) of ACTS, Kenya

Dr. Muok's experience is in research on and management of natural resources, and encompasses science technology innovation; environmental conservation; sustainable development; forestry; climate change adaptation and mitigation; energy access; food security; and policy analysis and development. He is a commonwealth fellow in bioenergy and climate change at the University of Edinburgh and holds an International Diploma in Conservation at the Royal Botanical Garden, Kew/National Museums of Kenya. In his work with PISCES, a five-year initiative funded by the UK's Department for International Development, he works with a team to develop new knowledge and policies that promote energy access and implement energy technologies through bioenergy. This work is carried out in partnership with India, Tanzania, Kenya, and Sri Lanka in order to improve livelihoods in those countries. Dr. Muok is also the national chairperson of the Kenya National Biofuel Policy Committee, which leads the development of biofuel policies by engaging stakeholders and policy makers.

Ron Nahser, Fellow and a Founding Director of the Oxford Leadership Academy in the United States; Senior Wicklander Fellow at DePaul University's Institute for Business and Professional Ethics, Chicago; Provost Emeritus of Presidio School of Management, San Francisco, USA

Dr. Nahser lectures and consults with business and academic audiences in the United States and internationally on business values, vision, marketing strategy, branding, social responsibility, and integrative sustainable management. He works

with the Oxford Leadership Academy, whose mission is to "develop leaders who transform business for good." The author of *Learning to Read the Signs: Reclaiming Pragmatism in Business* and *Journeys to Oxford: Nine Pragmatic Inquiries into the Practice of Values in Business and Educatio*n, he has developed a strategic business problem-solving model known as PathFinder Pragmatic Inquiry® which has been used by more than 100 organizations and thousands of participants. As Senior Wicklander Fellow at DePaul's Institute for Business and Professional Ethics, Dr. Nahser is now leading the launch of an executive education program on integrative sustainable management.

Jatin Nathwani, Professor, Civil and Environmental Engineering, the University of Waterloo; Executive Director of the Waterloo Institute for Sustainable Energy (WISE), Canada

Dr. Nathwani's research interests focus on energy policy and life-cycle energy risk management; policy tools and the development of decision-frameworks for managing life-safety risk under the constraints of scarce resources; the evaluation of regulatory and market-based instruments for achieving environmental objectives; and planning for long-term sustainability of energy systems, including the potential for technology convergence of the power and transportation infrastructures. He has worked in a leadership capacity in the energy sector, focusing on strategy, policy developments, and management of risk. At WISE, he works with 70 University of Waterloo faculty members in a collaborative process with a focus on managing complex environmental policy issues while helping to shape directions for the future development of Ontario's energy resources. One of his main goals is to evaluate the world's diverse energy challenges in order to provide solutions, such as micro-grid developments, that will make sustainable lifestyles available to all communities.

Mohammad Khaja Nazeeruddin, Professor of Chemistry and Chemical Engineering and Senior Scientist at École polytechnique fédérale de Lausanne, Switzerland; World Class University Professor at the Korea University; Distinguished Professor at KAU, Jeddah, Saudi Arabia

Dr. Nazeeruddin is an expert in the design, synthesis, and characterization of platinum-group metal complexes associated with dye-sensitized solar cells and organic light-emitting diodes. He directs and manages several industrial, national, and European Union projects on hydrogen energy, photovoltaics (DSC), and

organic light emitting diodes. He is the inventor of 40 patents, and has published extensively in his field. The significance of his work has been recognized with invitations to speak at over 75 international conferences.

Alireza Nojeh, Associate Professor, Electrical and Computer Engineering, the University of British Columbia, Canada

Dr. Nojeh's research interests are in the area of nanotechnology, including nanostructures (especially based on carbon nanotubes), controlled nanofabrication, electron emission phenomena, electron microscopy, modeling, and simulation of nanoscale systems. The Nojeh Nanostructure Group emphasizes modeling and simulation of nanodevices, using methods such as molecular dynamics and the density functional theory.

Jong Moon Park, Professor of Environmental Biotechnology at the Pohang University of Science and Technology (POSTECH), Pohang, Korea

Dr. Jong Moon Park works in the field of energy and environmental engineering and uses biotechnology as a tool in his research. His innovative work includes achieving biosorption of heavy metals by using biomass, which integrates elements of environmental engineering and biotechnology. His recent biomass research focuses specifically on biorefinery and bioenergy production from biomasses such as micro- and macro-algae and organic wastes. Professor Park is also in charge of the core project "Development of Biorefinery Platform Technology for the Production of Carboxylic Acid Compounds from Biomass," which is a project being conducted within the Global Frontier Program.

Richard Perez, Research Professor; Senior Research Associate, Atmospheric Sciences Research Center (ASRC), University at Albany (State University of New York), USA

At the ASRC, Dr. Perez directs applied research in the fields of solar radiation and solar energy applications and daylighting. The focus of his current research is solar energy resource assessment and the evaluation of the impact of solar energy systems on utility power grids. His expertise encompasses solar and renewable energy, the environment, and economics. Regarding solar energy assessment, Dr. Perez has described his group's work: "Because the weather is the main driver of solar energy technologies, it is important to characterize and to quantify the influences of climate and weather on the solar resource. We have developed approaches to utilize the imagery from weather satellites to infer the amount of

solar energy available at any point in time and space. We have used this capability to produce solar resource maps for the U.S. and several other countries, and to provide operational data for solar system output quality control." In addition to building and living in a passive, solar, photovoltaic home, Dr. Perez has a dozen or more awards and solar energy-related patents and has written extensively in the fields of solar radiation, renewable energy applications, and daylighting.

Raymond Pierrehumbert, Louis Block Professor in Geophysical Sciences, University of Chicago, USA

Dr. Pierrehumbert's central interest is in how climate works as a system. He wants to develop idealized mathematical models for addressing the big questions about Earth's past, present, and future climates, as well as those of other planets. These questions include role of water vapor in global warming on Earth, the problem of a warm, wet early Mars, and the global glaciations of Earth's distant past. This research involves work at the interface of fluid dynamics and radiative transfer. He is also interested in storm track structure and planetary wave propagation as well as fluid mechanical research of a more abstract nature, particularly as related to two-dimensional turbulence and mixing in two-dimensional area-preserving flows. Professor Pierrehumbert's philosophy is to use simplified models that can be understood completely as a complement to insights that can be derived from comprehensive general circulation models. His textbook, *Principles of Planetary Climate,* is founded on the tenet that "big ideas come from small models." Besides teaching and research, he writes for *Real Climate*.

Steve Polasky, Fesler-Lampert Professor of Ecological/Environmental Economics; University of Minnesota Regent's Professor; Department of Applied Economics and the Department of Ecology, Evolution and Behavior; Faculty Fellow at the Institute on the Environment, University of Minnesota, USA

Dr. Polasky's research interests focus on issues at the intersection of ecology and economics. This work includes studying the impacts of land use and land management on the provision and value of ecosystem services; natural capital, biodiversity conservation; sustainability; environmental regulation; renewable energy; and common property resources. He served as the senior staff economist for environment and resources for the President's Council of Economic Advisers, 1998-1999. Dr. Polasky is on a member of the Nature Conservancy's Science Council and is one of the leaders of the Natural Capital Project's environmental service mapping and valuation effort.

Pavle Radovanovic, Associate Professor, Chemistry, Waterloo University; Principle Investigator, Radovanovic Research Group, Canada

Dr. Radovanovic studies the optical, magnetic, and electronic interactions in nanosystems and their uses in creating next generation forms of information processing and computer memory. His research looks at how light, the magnetic field, and electrical current interact in nanometer-scale materials in advanced and next-generation microcomputing. The knowledge gained from this research is a key to designing new forms of information processors and non-volatile Random Access Memory (RAM)—memory that doesn't disappear with electricity. This work could lead to a promising new form of RAM that stores information with a combination of magnetic field and electricity (magneto-resistance), using much less electrical power in the process. The research in nanotechnology pursued by Radovanovic and his group show promise in addressing issues such as renewable energy, improved medical diagnosis and treatment, more efficient information technology, and environmental protections.

Richard Reed, Professor; Chair in Property and Real Estate in the School of Management and Marketing, Deakin University, Australia

Dr. Reed's interest in real estate and property sustainability led him to develop a new property and real estate course that offers a major in sustainability at Deakin University. His research focuses on three main areas: (1) the links between sustainability and the built environment, specifically regarding valuation and the business case for sustainability and lifecycle costing; (2) valuation or appraisal research on both real property (all land uses) and personal property; and (3) housing-related research, including social geography, reverse mortgages, housing affordability, and low-income housing. He has conducted research on the business case for sustainability and adaptive re-use of existing buildings. Projects that he has collaborated on with colleagues include research on sustainability through off-site production and a study into how the interactive learning process can affect the implementation of sustainability in commercial buildings.

Angele Reinders, Professor of Energy-Efficient Design, Delft University of Technology; Associate Professor in Industrial Design Engineering, the University of Twente, The Netherlands

In her position as a part-time professor of energy-efficient design in the design for sustainability section of the Industrial Design Engineering Department at Delft University, Dr. Reinders focuses on innovative product design for integrated

sustainable energy technologies. She also teaches and conducts research in the Department of Design, Production, and Management at the University of Twente, with a focus on innovative product design for integrated, sustainable energy technologies. This work includes the development of applications for photovoltaic (PV) solar energy technologies, such as PV systems and modules; solar-powered boats; and PV products for indoor use. A main goal of this design-driven energy research is to match PV solar-cell technologies with conditions of use, optimized energy performance, and manufacturability. Dr. Reinders's innovative approach to design in photovoltaic and other renewable energy technologies is discussed and illustrated in her 2012 book, *The Power of Design: Product Innovation in Sustainable Energy Technologies.*

Johan Rockstrom, Professor of Environmental Science; Executive Director of Stockholm Resilience Centre, Stockholm University, Sweden

Dr. Rockstrom's focus within environmental science is on water resources and global sustainability. He is a leading scientist on global water resources and the strategies needed to build resilience in water-scarce regions of the world, including tropical regions. He has published extensively about his work in areas ranging from applied land and water management to global sustainability. At the Stockholm Resilience Centre, his group's focus is on developing a new approach to sustainability: the capacity to use change and crisis to spur renewal and innovative thinking. In 2009, Rockstrom, along with an international team of scientists, "identified and quantified a set of nine planetary boundaries within which humanity can continue to develop and thrive for generations to come—while crossing them could generate abrupt or irreversible environmental changes." Since then, international organizations, governments, NGOs, and companies have adopted this "boundaries" research as both a tool and a new framework to guide the discussion about sustainable growth.

Sanjit "Bunker" Roy, Founder and Director of the Barefoot University, India

In 1972, Sanjit Roy founded the Social Work and Research Centre, now the Barefoot University, as a nonprofit organization in Tilonia, Rajasthan, India. Since that time, Roy has been a leading figure in sustainable development within the Indian NGO community and has helped expand the work of the college through a geographic focus on the least-developed countries (LDCs), particularly those of Asia and Africa. The college launches training centers, disseminates sustainable and eco-friendly technologies for water treatment and energy production, and

supports innovative approaches to resource management and public health. Its current projects include establishing solar communities and electronic workshops; building dams, underground storage for harvested rainwater, and solar-operated, reverse-osmosis desalinization plants; manufacturing household items and toys from recycled materials; and instituting other educational, developmental, and activist programs. The college has been recognized internationally with funding and awards for its pioneering efforts in developing solutions that improve the rural poor's environment and quality of life.

Jeffrey Sachs, Director, Earth Institute; Quetelet Professor of Sustainable Development; Professor of Health Policy and Management, Columbia University, USA

As the Director of the Earth Institute of Columbia University, Dr. Sachs leads a university-wide organization of more than 850 professionals from natural-science and social-science disciplines who conduct research on all aspects of earth systems and sustainable development. Professor Sachs advocates for the expansion of university education on sustainable development, and helped to introduce the PhD in sustainable development at Columbia University and championed the new Masters of Development Practice (MDP), which has led to a consortium of major universities around the world offering the new degree. His policy and academic works span the challenges of globalization, and include: the relationship of trade and economic growth; the resource curse and extractive industries; public health and economic development; economic geography; strategies of economic reform; international financial markets; macroeconomic policy; global competitiveness; climate change; and the end of poverty. He has written several books, including *Common Wealth: Economics for a Crowded Planet* and *The Price of Civilization*.

Toru Sato, Professor, Division of Environmental Studies, Department of Ocean Technology, Policy, and Environment; Marine Environmental Engineering; School of Frontier Sciences, the University of Tokyo, Japan

Dr. Sato's main research topic is to develop methods of assessing the environmental effects of CO_2 sequestration technologies in the sea. His research group's aim is to develop systems that can coexist with natural environments in support of global sustainability. In order to accomplish this, they devise computational models of environments that incorporate principles of physics, chemistry, biology, and social sciences. "These models are subsequently synthesized into simulation systems in order to predict environmental impacts and

build public acceptance." The ongoing work includes studying the ocean sequestration of CO_2; biological fixation of CO_2 through ocean nourishment; prediction of methane hydrate decomposition; and the development of highly effective photo behavior of oceanic turbulence and stratified rotating fluid. They also develop computer models based on a physiologic mechanism for investigating the flushing-light effect of photosynthesis and the effect of CO_2 on the fish. Part of the research is conducted by a team that collaborates with the government, other universities, and companies. Dr. Sato is also affiliated with the Graduate Program in Sustainability Science, Global Leadership Initiative at the University of Tokyo, which was launched in 2012.

Graham Sinclair, Principal and Sustainable Investment Strategist, SinCo; Adjunct Professor and Lecturer, USA and South Africa

For the past decade, Graham Sinclair, who has graduate degrees in business and law, has explored sustainable investment themes, including long-term investment; influential investor networks; fiduciary duty; carbon intensity; water scarcity; biodiversity; nutrition security; and sustainable mining. He has lectured on sustainable investment at leading business schools throughout the world. At SinCo, he leads the design and development of the sustainable investment case for clients managing billion dollar investments or global investor initiatives. As an ESG architect, he integrates ESG factors into investment strategies, processes, and indexes in frontier and emerging markets. His recent projects include private equity in emerging markets, infrastructure investment, green bonds, pension fund investment value chains, a national sustainability index, and impact investing. He worked on the UN Environment Programme Financial Initiative and the UN Principles for Responsible Investment and co-founded the not-for-profit Africa Sustainable Investment Forum project, AfricaSIF.org, in 2009. He also contributed three chapters, "Private Equity," "Frontiers in Africa," and "Sustainability Indexes" to the 2012 book *Evolutions in Sustainable Investing*.

Alison Smith, Professor of Plant Biochemistry, Department of Plant Sciences; Researcher at the Bioenergy Initiative, University of Cambridge, UK

Dr. Smith's work concentrates on how plants, algae, and microbes make chemicals, particularly vitamins. Her discovery that half of known algal species have a much closer relationship with bacteria than previously thought has implications for the study of aquatic ecosystems. Professor Smith is also examining the potential of algae as a source of bioenergy. Algae have two

potential advantages over crop plants for biofuel production: they do not use up agriculturally productive land and they can be used to sequester carbon dioxide. Research projects in Dr. Smith's group focus on studying the metabolism of plants, algae, and bacteria; the organization and expression of genes for the enzymes; and the regulation of the pathways by using microarray and metabolomics approaches. Using the knowledge gained from these studies, the group is exploring the potential for metabolic engineering of high-value products in plants and algae, and for the exploitation of algae for bioenergy production. The Department of Plant Sciences is also actively involved in translational research that addresses food security, sources of sustainable energy, and the protection of biodiversity.

Marjolein Spaans, Senior Researcher, Urban and Regional Development, Delft University of Technology, The Netherlands

Dr. Spaans works as a senior researcher in the field of urban governance and area development. Much of her research focuses on urban planning and the instruments needed for spatial planning at various levels of scale. One aspect of her research involves finding practical ways to climate-proof cities. Her work often has an international comparative dimension and she carries out both academic and contract research. She has conducted research on behalf of the government and the market, including several ministries, provinces, municipalities, and project developers. She is a board member of the Delft Environment Initiative, whose purpose is to bring together the knowledge, academics, and facilities of Delft University of Technology as a combined expert partner for companies and government agencies.

Robert Stavins, Albert Pratt Professor of Business and Government; Environment and Natural Resources Program; Belfer Center for Science and International Affairs, Harvard Kennedy School of Government, USA

Dr. Stavins has examined diverse areas of environmental economics and policy, including market-based policy instruments; regulatory impact analysis; innovation and diffusion of pollution-control technologies; environmental benefit valuation; policy instrument choice under uncertainty; competitiveness effects of regulation; depletion of forested wetlands; political economy of policy instrument choice; and costs of carbon sequestration. Professor Stavins directed Project 88, a bi-partisan effort co-chaired by former Senator Timothy Wirth and the late Senator John Heinz, to develop innovative approaches to environmental and resource problems. He continues to work closely with public officials on matters of national and international environmental policy.

Marcel Stive, Professor, Hydraulic Engineering; Chair, Coastal Engineering; Department Head, Hydraulic Engineering, Faculty of Civil Engineering and Geosciences, Delft University of Technology, The Netherlands

Dr. Stive is a specialist in coastal engineering. His work includes managing the risks of climate change and rising sea levels. His notable activities includes two major research projects that address coastal erosion: the Nearshore Monitoring and Modelling: Interscale coastal behaviour (NEMO); and NatureCoast. The latter involves the Sand Engine (Zandmotor), and is an interdisciplinary project of six universities. Professor Stive came up with the idea of the Sand Engine, a massive mound of sprayed sand (21 million cubic meters), in order to create a peninsula off the coast at Kijkduin-Ter Heijde. It has been working as expected and has provided the coast with a protective sand barrier, although this experimental project continues to be refined. In 2011, he received a European ERC Advanced Grant that has enabled him to continue his research into the operation of the Sand Engine. Dr. Stive has also been recognized for his pioneering work in the field of mathematical calculations on how currents and waves work.

Stephen Sweeney, Professor of Physics; Engineering and Physical Sciences Research Council (EPSRC) Leadership Fellow; Head of Photonics Group, University of Surrey, UK

Among the topics researched by Dr. Sweeney are semiconductor lasers for temperature insensitive operation (quantum dots, dilute-nitrides etc); widely tunable lasers; vertical cavity surface emitting lasers and LEDs for plastic fiber systems; semiconductor lasers for optical pumping (EDFA, Raman) and printing and data storage applications; and photonic devices used to sense chemical and biological samples (liquids and gases). One possible benefit to come from Professor Sweeney's laser research is space-based solar energy that can be beamed directly to earth.

Nickolas Themelis, Director, Earth Engineering Center; Stanley-Thompson Professor Emeritus, Earth and Environmental Engineering, Columbia University, USA

Dr. Themelis is founder and Chairman of the Waste-to-Energy Research and Technology Council (WTERT), an international consortium of universities, companies, and governmental organizations concerned with the recovery of materials and energy from industrial and municipal wastes by means of recycling, anaerobic digestion, composting, WTE, and landfill gas capture and utilization.

WTERT has sister organizations in China, Greece, Canada, and Germany. The mission of WTERT and its parent organization, the Earth Engineering Center of Columbia University, is to promote the design and advancement of sustainable methods for material and energy recovery from used products.

Eric Toone, Vice Provost and Director, Duke Innovation and Entrepreneurship Initiative; Anne T. and Robert M. Bass Professor of Chemistry and Professor of Biochemistry; Director of the Small Molecule Synthesis Facility (SMSF), Duke University, USA

Dr. Toone has contributed significantly to the diverse fields of energy, medicine, and pharmaceuticals. From 2009 to 2012, he worked at the U.S. Department of Energy, where he was a founding member of the Advanced Research Projects Agency—Energy (ARPA-E). During that time, he served both as program director and as deputy director for technology. He devised and implemented ARPA-E's Electrofuels program, which explores the use of non-photosynthetic autotrophic organisms for the production of energy-dense, infrastructure-compatible liquid fuels. Dr. Toone is currently the leader of the Duke Innovation and Entrepreneurship Initiative.

Jonathan Trent, Bioengineering Scientist, Ames Research Center, NASA; Adjunct Professor in the Dept. of Biomolecular Engineering at the University of California at Santa Cruz, USA

Dr. Trent's recent research and inventions are focused on methods for obtaining alternative fuels, processing municipal wastewater, and economically producing fresh water by desalination. One of his current projects is to develop a solar-powered system to grow algae for biofuel by cleansing wastewater and trapping carbon dioxide in the process. He works at NASA's nanotechnology department where he builds microscopic devices out of proteins from extremophiles, a type of bacteria that live in the world's harshest environments. The technology of "Offshore Membrane Enclosure for Growing Algae" (OMEGA) aims at re-using wastewater that coastal cities currently pipe out and dispose of into the seas. Fueled by the sun and carbon dioxide from the atmosphere, the algae eat the waste and produce oils that can be converted to fuel. Unlike some alternative fuel processes, such as growing corn for ethanol, OMEGA doesn't threaten the world's food supply. Trent and the team at the Global Research into Energy and the Environment at NASA (GREEN) are developing systems for producing a sustainable, carbon-neutral feedstock for the biofuels of the future.

Kazuhiro Ueta, Professor of Public Finance, School of Economics, Kyoto University, Japan

Dr. Ueta's fields of specialization are public finance and environmental economics. For over 30 years, he has advocated for a sustainable society, a goal that has only recently become a global aspiration. One of his main pursuits is to identify how to break away from the idea that there is a trade-off between economic growth and sustainable development. One solution is in pursuing economic growth through technological innovations that use fewer resources to develop cleaner production, zero emissions, and inverse manufacturing. Professor Ueta believes that the newer field of environmental economics can help construct public policy that overcomes the trade-off between the environmental conservation and economic growth. He also emphasizes the need for dialogue that addresses the present global situation while it embraces "third parties," such as future generations and other forms of life. He has published many articles and books including *CDM and Sustainable Development in China: Japanese Perspectives,* and co-edited with Yukio Adachi the 2014 book, *Transition Management for Sustainable Development (Multilevel Environmental Governance for Sustainable Development).*

Madeleine van Oppen, Australian Research Council Future Fellow; Senior Principal Research Scientist in the "A Healthy and Resilient Great Barrier Reef (GBR)" Program, Australian Institute of Marine Science, Australia

Dr. van Oppen's work focuses mainly on microbial symbioses in corals, coral bleaching, adaptation, the acclimatization of corals to climate change, and the connectivity of coral reefs. She conducts her research in laboratory and field studies and combines ecological, population, and functional genetics and genomics with the study of organismal physiology, ecology, and morphology. Another major area of research of Dr. van Oppen's involves assessing the feasibility of manipulating genes to enhance the stress tolerance and fitness of corals in a changing environment. She is a co-winner of the 2013 Paul G. Allen Ocean Challenge, along with Dr. Ruth Gates of the Hawai'i Institute of Marine Biology, for the pair's idea to increase the resilience of critical and highly vulnerable coral reef ecosystems.

Judi Wakhungu, Cabinet Secretary, Environment, Water and Natural Resources in the Government of Kenya; former Executive Director, African Centre for Technology Studies, Kenya

In her current position as a cabinet secretary, Dr. Wakhungu is spearheading programs in sustainable development and improved water quality and wastewater treatment. Her duties also include working with groups on the current forest and national wetlands conservation and management policies. Her research interests include science, technology, and innovation; agriculture and food security; biodiversity and natural resource management; energy and water security; and gender issues in science and technology. She also advises world leaders on how to tackle global climate change and food scarcity. Dr. Wakhungu previously served as the executive director of the African Centre for Technology Studies (ACTS) in Nairobi, Kenya, a Nairobi-based international intergovernmental science, technology, and environmental policy think-tank that generates and disseminates new knowledge through policy analysis, capacity building, and outreach. She was the first woman geologist in the Ministry of Energy and Regional Development, where her duties entailed exploring for geothermal energy in Kenya's Rift Valley. She was also the first female faculty member in the Department of Geology at the University of Nairobi.

Michael Webber, Deputy Director of the Energy Institute; Josey Centennial Fellow in Energy Resources; Co-Director of the Clean Energy Incubator at the Austin Technology Incubator; and Associate Professor of Mechanical Engineering at the University of Texas at Austin, USA

Dr. Webber leads the Webber Energy Group, which analyzes energy and environmental problems at the intersection of engineering, science, and public policy. The group's four broad categories of research are the energy-water nexus; energy systems modeling; alternative transportation fuels; and the nexus of food, waste, and energy. Dr. Webber also has a syndicated television special, *Energy at the Movies*, which is telecast on PBS. The special bridges the gap between academic discourse and popular culture by synthesizing expert analysis of Hollywood films into digestible lessons on the science and history of energy. Government agencies such as the Department of Energy and nongovernmental organizations such as UNESCO have featured Dr. Webber's research in their policy-making decisions. His capstone class "Energy Technology and Policy" is scheduled for distribution as a Massive Open Online Course (MOOC), titled "Energy 101," and which has a global scope that fits with his motto of "changing the way America thinks about energy."

Olaf Weber, Associate Professor; Export Development Canada Chair in Environmental Finance; Program Director, Master's Program in Sustainability Management, University of Waterloo, Canada

Dr. Weber's research and teaching interest is in the area of environmental and sustainable finance, with a focus on sustainable credit risk management; socially responsible investment; social banking; and the link between sustainability and financial performance of enterprises. His current projects include studies on integrating reputation-risk indicators into credit-risk assessment procedures; the relation between banks' sustainability performance and their financial performance; sustainability reporting of Chinese companies; and measuring the impact of microfinance, social banking, and impact investing. The Sustainability Management Program, which he directs, takes an interdisciplinary, research-based approach in which economic, social, environmental, and development issues are taken into account equally. The program's goal is to contribute to the creation of academic knowledge for methods, systems, concepts, and tools for careers in sustainability management such as academia, public policy, and business analytics. In addition to directing the program, Dr. Weber will continue teaching about and researching sustainable finance while holding in mind the question, "What is the sustainability case for banks, insurances, and institutional investors?"

***Patricia Widener, Associate Professor, Florida Atlantic University, USA**

Patricia Widener studies the political economy of the environment and the community responses to the social, economic, and environmental impacts of oil disasters and natural resource extractions. Her recent work, *Oil Injustice*, examines how oil-impacted communities and their transnational allies mobilized in response to the construction of an oil project in Ecuador. Currently, she is developing research projects on climate change and food-system justice in South Florida. She has conducted research in Alaska, Ecuador, Florida, and the Philippines. ***Learn more about Dr. Widener's work on page 66.***

Brian Willis, Associate Professor, Chemical and Biomolecular Engineering, School of Engineering, University of Connecticut, USA

Dr. Willis's current research includes the study of epitaxial oxides on semiconductors; scanning tunneling microscopy investigations of organic/semiconductor interfaces; tunneling spectroscopy for molecular electronics and nano-sensors; and nanoscale investigations of electrocatalysis. Willis has developed a fabrication technique called *selective area atomic-layer deposition,*

which makes it possible to coat the electrodes with layers of individual copper atoms until they are separated by just 1.5 nanometers. This could provide the breakthrough technology scientists have been looking for in order to make vast improvements to today's solar energy systems. One goal of the research on tunneling spectroscopy for molecular electronics and nano-sensors is to gain knowledge that will enable scientists to engineer selective interactions between molecules for mimicking the biological sense of smell. In addition, using different electrode materials will allow the researchers to investigate surface reactions of interest to a broad spectrum of surface-science applications in areas such as catalysis and solar energy research.

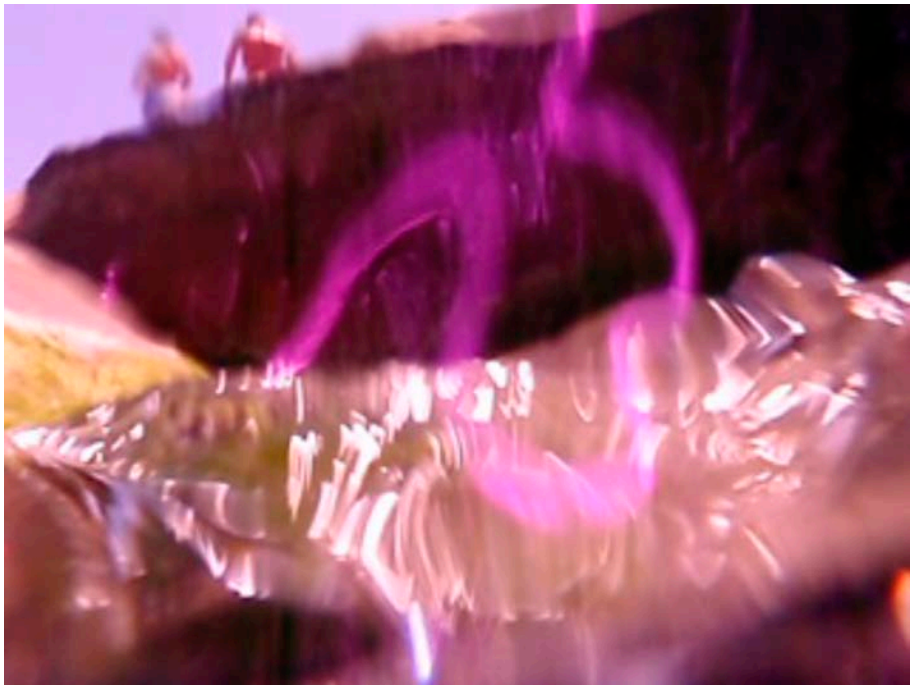
Rachel Armstrong, Co-Director of Advanced Virtual and Technological Architecture Research (AVATAR) Laboratory, specializing in Architecture and Synthetic Biology at the School of Architecture and Construction, University of Greenwich, London

United Kingdom

How can academics have a more powerful influence on the development of practical environmental solutions and improve the likelihood of their being adopted by society at large?

Dr. ARMSTRONG: Academics can have a more potent influence in ecological innovation through working with companies whose activities have significant environmental impacts. My own work has engaged with professional architects, construction engineers, and property developers to begin new conversations about what "sustainability" actually means and how they may respond to this in practice. For example, collaboration with Arup *Thoughts* on a blog post entitled "From sustainable to evolvable" challenged expectations in ecological practices within this international construction engineering company by proposing that building solutions needed to account for continual change and not simply to consider the efficiency of a particular product, or building, at the time of its construction (Armstrong, 2012a). Also, with Astudio architects, I have been working as a consultant and facilitator in their new research and development department, where I shared my research and brought new academics into their networks. Now, the architectural practice is able to design and develop new projects such as algae installations and facades that were not previously within their skill set to achieve (Astudio, No date).

Yet the challenge for academics in commercial environments is to make the dissemination of knowledge a profitable endeavor for universities. While it is one thing to offer consultancy and knowledge transfer, getting paid sufficiently as an academic to make it worthwhile for the educational institution is another matter altogether. University funding structures are complex, and without formal financial systems that can facilitate commercial exchanges between academia and business, goodwill and the desire for outreach are not in themselves sustainable. Yet, such partnerships are powerful ways of bringing academic visions, which stimulate new ways of thinking, into an active public forum where complex conversations about professional practices and traditions, costs, social impacts, and cultural values can transform the potential of a forward-looking organization into a far-sighted one that is also able to initiate innovation. Indeed, industry has the potential to support new ideas through their endorsements.



This view of the Romanian Black Sea shoreline encapsulates the turbulent, lively character of the natural world in the 21st century that Koert van Mensvoort describes as Next Nature. *Photograph from movie still by Rachel Armstrong, 2009.*

In a perceptive comment following a panel discussion on a talk I gave on "Tomorrow's Technologies" at Wragge & Co., a legal firm specializing in patents for emerging technologies, Head of Sustainability Pascal Mittermaier proposed that large corporations such as Lend Lease have a duty to support cutting-edge and challenging research, since it

is the way they can predict the future and anticipate public and commercial needs—by having a role in shaping it (Tomorrow's Company, 2013). His comments on spreading risk in innovation were inspiring, as it appears that when it comes to the social value of new developments and visionary thinking—risk operates as a form of currency. This starkly contrasts with wealth generation, which is about reducing risk to maximize profits.

Potentially then, academic, commercial, and community contracts could be developed along these principles whereby radical developments are underpinned by sharing investments in change, which may take various forms, such as in kind, skill sets, knowledge, funding etc. Maybe by examining alternative forms of value and how they may be used as a contract between universities, businesses, and communities, foundations for sustainable and even profitable relationships with academia may become possible—so that academics may indeed play more effective roles and influence the development of practical environmental solutions and their uptake by society.

Given that the public and governmental debates on environmental issues often include discussions about science, technology, and business practices, what do you think is the most constructive path to achieving active working relationships with all members of society?

Dr. ARMSTRONG: To achieve active working relationships with all members of society, a much broader understanding of the complexity of the cultural issues that are entangled with prevailing discussions of science and technology need to be more fully grasped by the organizations responsible for the public understanding of science. In the language of institutions, science has a special place as the language of secular truth, and from an institutional perspective, it may be difficult to comprehend why even an informed public may appear to be so resistant to persuasion by "evidence." However, from a public perspective, scientific narratives are newcomers to a much deeper and complex understanding of reality. Yet, 21st century culture is deeply steeped in scientific advances and technological developments that have become naturalized as part of everyday reality. Indeed the "magic" of gadgets and their ability to transform our world has bound them so closely to us that we think of them as extensions of ourselves, whereby we actually miss our mobile phones when we forget to bring them with us. In this sense, science does not have a special place in the construction of narratives but is simply just one more form of storytelling in a palette of competing narratives that shape our understanding of the world.

Interestingly, we are also very comfortable with paradoxical perspectives on the nature of our reality since, while our understanding of technology has become naturalized, our relationship with the natural world appears increasingly contrived. Koert van Mensvoort observes that technology, ecology, and culture are deeply entangled in a phenomenon that

he calls Next Nature – or, the Nature produced by people (Mensvoort, No date). Dealing with this complex entanglement of belief systems and desires in an age of advanced technology is no simple matter but is critical to developing inclusive and active working social relationships.

The Charles Ray 'Boy with Frog' statue in Venice, discusses how science and culture play an entangled role in shaping our communities. Photograph by Rachel Armstrong, 2011.

Arguably, the greatest challenge that academia and institutions face in the current environmental crisis, is in galvanizing the efforts of the public and organizational bodies to respond synergistically to the unpredictable liveliness of our material world—a challenge that is shaped by discourses about "climate change." Yet this term refers to more than a set of empirical changes in environmental conditions that can be attributed to specific causes—such as climbing partial-pressures of carbon dioxide; greater-than-average rainfall; reductions in biodiversity; the march northwards of tropical diseases; or apparent shifts in the earth's magnetic poles. It also represents our cultural experience of materiality, which is not only extremely lively (Bennett, 2010), but also highly technologized. So while Old Nature may spontaneously produce tornadoes—which are the kind of nonhuman phenomenon that architects are typically called upon to design against and factor out of our lives—(for example, Q4 Architects' Tornado-Proof CORE House, for the American Institute of Architects Designing Recovery competition, is equipped with a virtually "indestructible" inner concrete core (Grozdanic, 2013))—Next Nature offers a different kind of materiality that gives rise to energy-producing human-

made tornadoes such as those produced by Louis Michaud (Michaud and Michaud, 2010). Or, it creates dramas for storm chasers where tornadoes do battle with wind turbines. Moreover, although the Fukushima nuclear disaster was precipitated by a tsunami of shivers down the geothermal spine of the Pacific tectonic plate, its radioactive leakage into the Pacific Ocean is a co-designed act of environmental radiation, in which we've played a significant part.

Timothy Morton insists that to observe Nature more clearly, we should divest it of entrenched aestheticisms since they obscure and constrain its true materiality (Morton, 2007). Yet, how do we begin to embrace this material strangeness through an understanding of say, the continent-sized toxic entanglements of plastics, wildlife, and currents that constitute our Great Ocean Garbage Patches? Yet, not all of these bizarre encounters with Next Nature are shocking. When torrential rainfall burst the banks of the River Severn and water surged through the streets of Worcester this Christmas, graceful white birds paddled through the flooded town in a magnificent spectacle known as—*Swangeddon* (Edmonds, 2013).

Next Nature has a radically different materiality from Old Nature and may be distinguished by its profound technological and social transformations that promise new design opportunities. While Old Nature has always been restlessly unpredictable, our design attitudes have generally sought protection—by assuaging her fits of ill temper in appeasing the deities of a pre-industrial age. Or, since the Industrial Revolution, we have sought to create the illusion of environmental stability—through the construction of barriers, powerful machines, and knowledge from scientific insights—that have enabled us to believe that we can understand, control, and therefore conquer matter. Yet, in the late 20th century researchers such as Rachel Carson and Edward O. Wilson also showed these very processes—that spawned the conglomerations of Le Corbusier's "machines for living in" of our modern cities—are irreversibly destroying our environment. Global governments have responded with notions of "sustainable development," where generations can meet their own needs without compromising the prosperity of subsequent generations. This commitment has intensified with the recent advent of megacities and with a global population set to hit 9 billion by the middle of this century, according to the UN Population Division; the survival of our species is deeply entangled with the future of the built environment.

Potentially, more inclusive relationships with all members of society may be developed through creating new narratives about Next Nature that break from our industrial past and paint new possibilities of survival in a time "beyond" our umbilical dependency on machines. For example, following 30 years of biotechnological advances, we are now at a

point where we can use the technologies of life to create new developmental platforms that shape our world. Governing bodies, policy makers, and academics therefore need to think differently about the power of story telling, and how this may be applied in their own work to more persuasively expose people to the complexity of the issues that we all face and remind them just how important their individual choices really are. Creating enabling frameworks where new stories, which speak of empowerment, enable people to engage, make choices, and feel as if they are able to constructively contribute to society by living well, rather than being constrained by notions of austerity, which foster "learned helplessness." Indeed, new, optimistic, but not naive, visions of future possibilities may bring about positive responses to the challenges posed by climate change. This is not to say that careful conservation of our limited resources should not be practiced in an industrial era, but rather, that institutors and academics may forge better working relationships with general audiences by using their "facts" and "data" to free the public imagination—rather than constrain it—and encourage them to speculate on what happens "next" so we may collectively and positively shape human development in the next technological era.

What global activity/process/innovation would you put in place immediately to address environmental challenges?

Dr. ARMSTRONG: It is urgent and essential to invest in developing qualitatively different production platforms to our current industrial technologies, so that we may produce new toolsets that shape human development without fundamentally harming ecological systems—but rather restore and strengthen them.

My research seeks such a technological system by working across the Two Cultures to develop ecological design principles and practices that shape our encounters with the unique materiality of Next Nature. I have been working on a unique production platform since 2009 based on the notion of "assemblage" technology. The term originates from Giles Deleuze and Felix Guattari's notion of *agencement,* which refers to specific groupings of interacting, intrinsically empowered objects called *actants* (Deleuze and Guattari, 1979). In my research activities, I have operationalized the concept of assemblages using *dissipative structures* (Prigogine, 1997, p27) to produce a meta-technology that can couple together heterogeneous agents to form new tools and technical objects. Assemblage technology can be manipulated by applying the principles of *natural computing*—a term inspired by Alan Turing's interest in the computational powers of Nature (Denning, 2007). Natural computing techniques influence assemblages by constructing spatial programs that alter their chemistry, context, and infrastructure, which lead to different outcomes that deal with the transformation of matter, rather than resource consumption.

Through a set of design-led experiments—which included the cybernetic installation Hylozoic Ground, a collaboration with architect Philip Beesley that was exhibited at the 2010 Venice Architecture Biennale (Armstrong and Beesley, 2011), and Future Venice, a site specific proposal to grow a carbon-fixing limestone reef under the city to attenuate its sinking (Armstrong, 2012b) —I developed a set of design principles that can be used to apply assemblage technology in a range of contexts, such as in the under-imagined sites in our buildings, like cavity wall spaces that are currently filled with inert, or toxic materials.

The golden orbs within this Hylozoic Ground installation by architect Philip Beesley, shown at the Venice Architecture Biennale 2011, contain "living" chemistries that can sense the carbon dioxide breathed out by gallery visitors by changing color. Photograph by Rachel Armstrong, 2010.

Pressing support for further developing this platform is essential, since, despite being at the earliest stages of its scientific and technological development, it promises to be a powerful integrating platform and may offer a radical new platform for human development that builds, rather than harms, ecological relationships. Importantly, assemblage technology creates new architectural design opportunities where the lively and technological properties of the material realm may be applied in the construction of spatial

programs as physical expressions of *vibrant architecture,* which take the form of post-natural fabrics and synthetic ecologies (Armstrong, 2011). By supporting the development of vibrant architectures, we may transform the materiality of our megacities so that they are not static edifices but maintain their liveliness through metabolic processes. Metabolic networks enable vibrant architectures to continue to couple with others actants, bodies, and networks of material-flows that strengthen relationships within ecosystems. They are therefore consistent with Morton's notion of an *ecological* practice (Morton, 2007), where metabolic processes shape design and engineering practices in ways that do not replicate the tactics of mechanical systems. From a pragmatic perspective, vibrant architecture is not an architectural "fix," for it does not propose to save us from the contrary predicament of Next Nature, which is continually constructing surprising new material encounters. Rather, in its current form, vibrant architecture may simply increase the portfolio of strategies through which we may (re)negotiate our own ecological survival.

Yet, from an idealistic viewpoint, vibrant architecture proposes to completely change the developmental platform that underpins this millennial wave of human expansion. It utterly rejects the austere view of sustainability as a continuation of the "war on matter" that was begun during the Industrial Revolution and looks to the technologies of life as its allies. Indeed, lifelike materials offer something potentially revolutionary to architectural design by liberating the radical creativity of the material realm and catalyzing many different kinds of couplings with Next Nature. These potent hybrid bodies may continue to combine with others in ways that transform, rather than consume our surroundings. Of course, humans may play a part in these manifold metamorphoses by unleashing the shocking fertility of the material realm through the production of vibrant architectures. In this way, we may resist the relentless march of industrial machines that are unrepentantly reverse-terraforming the Earth.

At this critical juncture in our existence, we cannot accept the glut of economic taboos, political inertia, conceptual blind spots, and social platitudes that prevent us from rewriting our shared future as one of mutual survival. Instead we must urgently seize this moment and invest in the science, technology, and design practices that midwife the existence of vibrant architectures to prompt an immediate (re)imagining of our world, notions of life, community, and what it means to be human at a time of ecological crisis—so that we can set free the creative powers of our nonhuman partners in (co)existence and facilitate their inexorable evolution.

References:

Armstrong, R. 2011a. Architectural synthetic ecologies. In: C. Daly, S. Hicks, A. Keene and R.R. Ricardo, eds. "Paradigms of Nature: Post Natural Futures." *Kerb 19. Journal of Landscape Architecture.* Melbourne: Melbourne Books. pp. 92–98.

Armstrong, R. and P. Beesley. 2011. Soil and protoplasm: The Hylozoic Ground project, *Architectural Design,* 81(2): 78–89.

Armstrong, R. 25 April 2012a. "Cities: An introduction," *Thoughts*, Arup. [online] Available from: http://thoughts.arup.com/post/details/187/an-introduction. [Accessed 16 January 2014].

Armstrong, R. 2012b. "Future Venice." In Myers, W. and P. Antonelli, eds. *Bio Design: Nature, Science, Creativity.* London: Thames & Hudson /New York: MOMA. pp. 72–73.

Astudio. No date. Research and development, Astudio. [online] Available from: http://www.astudioarchitecture.com. [Accessed 16 January 2014].

Deleuze, G. and Guattari, F. 1979. *Thousand Plateaus: Capitalism and schizophrenia* (Athlone Contemporary European Thinkers). London: The Athlone Press.

Denning, P. J. 2007. "Computing is a natural science." *Communications of the ACM,* 50(7): 13–18.

Edmonds, L. 24 December 2013. "Severn swans a-swimming! Inquisitive birds make the most of river's burst banks to go exploring." *Mail* online. [online] Available from: http://www.dailymail.co.uk/news/article-2528924/Severn-swans-swimming-Inquisitive-birds-make-rivers-burst-banks-exploring.html. [Accessed 17 January 2014].

Grozdanic, K. 10 July 2013. "Q4 Architects' Tornado-Proof CORE House is an Indestructible Home Within a Home." *Inhabitat.* [online] Available from: http://inhabitat.com/q4-architects-tornado-proof-core-house-is-an-indestructible-home-within-a-home/. [Accessed 17 January 2014].

Mensvoort, K. No date. "What is Next Nature?" Nextnature.net [online] Available from: http://www.nextnature.net/about/. [Accessed 17 January 2014].

Michaud, L. and E. Michaud. 3 January 2010. “Harnessing energy from upward heat convection.” *Power Magazine.* [online] Available from: http://www.powermag.com/harnessing-energy-from-upward-heat-convection/. [Accessed 17 January 2014].

Morton, T. 2007. *Ecology Without Nature: Rethinking Environmental Aesthetics.* Cambridge: Harvard University Press.

Prigogine, I. 1997. *The End of Certainty: Time, Chaos and the New Laws of Nature.* First edition. New York: The Free Press.

Tomorrow’s Company. 1 October 2013. Tomorrow's Thought Leadership Lecture: Tomorrow’s technologies, Events. [online] Available from: http://tomorrowscompany.com/tomorrows-thought-leadership-lecture-tomorrows-technologies. [Accessed 16 January 2014].

BIOGRAPHY

Rachel Armstrong is a Co-Director of AVATAR (Advanced Virtual and Technological Architecture Research) specializing in Architecture and Synthetic Biology at the School of Architecture and Construction, University of Greenwich, London. She is also a 2010 Senior TED Fellow, Visiting Research Assistant at the Center for Fundamental Living Technology, Department of Physics and Chemistry, University of Southern Denmark, and Director of the Institute for Interstellar Studies for Development & Sustainability. Rachel is a sustainability innovator who investigates a new approach to building materials called *living architecture,* which suggests it is possible for our buildings to share some of the properties of living systems. She works collaboratively across disciplines to build and develop prototypes that embody her approach.

Pieter Hoff, Inventor; Founder of AquaPro Holland

The Netherlands

Pieter Hoff with a one-year-old tree in the biodegradable Groasis Waterboxx, San Mateo, Spain.

How can academics have a more powerful influence on the development of practical environmental solutions and improve the likelihood of their being adopted by society at large?

Mr. HOFF: In general academics can have more influence if they accept the realities of: (1) life—a person needs a house/roof, water, food and (some) income; (2) businesses—they have to make profit to survive; and (3) cultural differences—influence the way we look at problems, and the way we accept solutions to them.

It happens too many times that academics find solutions, or propose solutions, that are too much based on their own point of view, forgetting that the implementation of their proposed solutions has to be done by others, that might have a different point of view from them.

Given that the public and governmental debates on environmental issues often include discussions about science, technology, and business practices, what do you think is the most constructive path to achieving active working relationships with all members of society?

Mr. HOFF: To propose solutions that solve every person's or company's issues in a practical, logical way, offering advantages for them. Many times, solutions from academics offer restrictions instead of advantages; that constrains the implementation of them and maybe even prevents the implementation of them.

What global activity/process/innovation would you put in place immediately to address environmental challenges?

Mr. HOFF: Please read the autobiography below for my thoughts about this issue.

AUTOBIOGRAPHY

I am from an agricultural family that has been practicing producing food since the Middle Ages. This education has colored my life, formed my character, and helps in developing practical solutions. As a 10-year-old child, I had to cooperate with my grandfather and father, harvesting vegetables, seed potatoes, and flower bulbs. I had the luck that after World War II, the Dutch government started to understand that it is very important to offer education to growers. That offered me the possibility to study and finally become a breeder. I was able to develop one of the leading tulip and lily growing companies of Holland, with export to over 50 countries. While travelling to my clients, I found that big parts of the world that were once forested and fertile are now eroded and degraded. And everywhere, governments allow the use of drip irrigation without any control or payment, to solve the infertility of the soil. Because of this erratic policy, already four countries have no groundwater anymore, and I expect that within 100 years, over 50 percent of the populated areas will have no fresh groundwater anymore, if nothing changes. But in order to change, we must have the possibility to change. So, in 2003 I decided to develop a planting technology that allows us to plant and grow without drip irrigation. After 10 years of investigations, errors, and experiments, I have succeeded in doing this. I call it the Groasis Technology: grow + oasis = Groasis!

There is an instrument in nature that can help solve what I call the "seven world problems": the Tree. FAO [the Food and Agricultural Organization of the UN] and IUCN

[the International Union for Conservation of Nature] have published that we have over two billion hectares of human-made deserts. So, if this area was once green, and we were able to cut it, then this area can be green again, as we are also able to plant it. This is what happens with the "seven world problems" if we implement the Groasis Technology:

- Erosion—trees will cover the soil and make it fertile again.
- Poverty—each hectare of trees creates approximately 10K US$ of revenues. That is 20 trillion US$ of extra economic development.
- Food crisis—each hectare of fruit trees can produce five tons of sound food. Two billion hectares is one trillion tons of extra food.
- Climate change—each year, two billion extra hectares of fruit trees "disconnect" 10 billion tons of CO_2. That is more than we annually produce with fossil fuels. So, we can neutralize all the present CO_2 pollution to zero by planting trees that produce food.
- Unemployment—each hectare of trees creates one direct/indirect job. Two billion hectares of fruit trees create two billion jobs.
- Rural-urban migration—when there are two billion extra jobs in rural areas, people will migrate back to the rural areas.
- Sinking ground water levels—trees change the eroded soil into a sponge again and water tables will rise instead of drop.

Our solutions must be based on a sound business model. The challenge is too big to solve if the solution is based on receiving subsidies. So I have worked on making the use of the Groasis Technology so cheap, that the one who uses it is able to make money with it. If making money is possible, finding capital will be easier. I worked on the dream of finding a cheap solution to replant our human-made deserts with economical and ecologically interesting trees. I hope that before 2050 the Groasis Technology will have helped to change the world into a green and fertile area where people love to live, are able to feed and educate their children, and have decent lives. There are 300 million small farmers in the world—just as small as my grandfather and father's company was when I was a child. If each of these small farmers plants seven hectares of fruit trees, the job is done. The Groasis Technology is now available; it is up to our governments if they want to have it happen. Governments have spent eight trillion US$ since 2008 in order to save banks. We need only two trillion US$ for using the Groasis Technology in order to plant two billion hectares with fruit trees. So, money cannot be the problem. If we vote for governments who are willing to do this, then we will be successful. So to conclude, it's up to you if you want to have it happen!

Merle de Kreuk, Assistant Professor of Wastewater Treatment and Anaerobic Digestion Processes at the Sanitary Engineering Section, Department of Water Management, Delft University of Technology

The Netherlands

How can academics have a more powerful influence on the development of practical environmental solutions and improve the likelihood of their being adopted by society at large?

Given that the public and governmental debates on environmental issues often include discussions about science, technology, and business practices, what do you think is the most constructive path to achieving active working relationships with all members of society?

Dr. de Kreuk [in answer to the first two questions above]:

I believe that academics should listen to the needs of the end users who seek for and would like to apply solutions to environmental challenges. This doesn't mean that academics need to respond to all issues brought up in any media, but that they should sometimes escape from their universities and mingle with companies or government. Of course, many academics cooperate in one way or the other with the outside world, but often this involves acquiring PhD research funding, followed by meeting twice per year. That is not what I mean; I believe in more intensive cooperation and feel it is important to know how "the other part of society" reasons, where legislation comes from, which bottlenecks end-users come across, and what the driver is for people who market

innovations. For example, during academic careers, being able to work for a certain period at another university in order to broaden academic perspective and be inspired by fellow researchers is highly valued experience. I think, from my own experience, that working at governmental organizations or industry should be valued as much. Allowing academics this "real contact" with society and, in the meantime, accepting that publication numbers will decline for a short while, will finally improve communication between researchers and government/industry. This will enhance the adoption of academic-driven research and on the other hand will teach the scientist what society is really asking for. It also teaches the people in the field what scientists are capable of.

What global activity/process/innovation would you put in place immediately to address environmental challenges?

Dr. de Kreuk: The last question is not easy to answer; there are many environmental challenges, all asking for different innovations or approaches. In my field of work, sanitary engineering, I would appreciate it if wastewater is not wasted anymore, but that all its contents are reused as much as possible. This is not a world- or humanity-saving topic, but it helps to close our disturbed natural cycles.

BIOGRAPHY

Merle de Kreuk started her career in 1997 at IHC Holland, a shipyard for dredging vessels, where, with her colleagues, she worked on an innovative technology for the separation of contaminated soil and the clean sand fraction. This so-called *jig-technology* was later applied in many soil remediation projects.

After returning to academics, Dr. de Kreuk obtained her PhD in environmental biotechnology at Delft University of Technology, the Netherlands, in 2006. During her PhD work, she joined with two other scientists to research and develop the aerobic granular sludge technology Nereda, currently brought to the market by Royal HaskoningDHV. The Nereda technology is characterized by the granular growth of the biomass used in wastewater treatment. The use of this single-tank Nereda system makes wastewater treatment plants compact, energy efficient, and cheap. She won several prestigious awards for this technology and was a finalist with her fellow researchers for the European Inventor Award 2012 for the Nereda.

After earning her PhD, Dr. de Kreuk spent a few years bridging academic research with full-scale development of Nereda at Royal HaskoningDHV. Beginning in 2009, she

worked for almost three years at a Dutch Water Authority, where she started a project on the application of Anammox in the mainstream of a wastewater treatment plant. While there, she was part of the "wastewater treatment-plant of the future" studies, that led to the *resource factory* concept, in which technologies are developed and applied to produce energy-producing sewage treatment, as well as to secure the recovery of resources as nutrients and water. In 2011, she returned to TU Delft, where she focuses on granule formation processes (aerobic and anaerobic) and hydrolysis processes in anaerobic digestion. Furthermore, she is still interested in the product formation from waste streams by means of mixed microbial processes.

Patricia Widener, Associate Professor of Sociology at Florida Atlantic University

United States

Dr. WIDENER: It is imperative that we, all members of a global society, work toward addressing global inequality and meeting global energy and food needs in a manner that is just, that relies on non-toxic, renewable and sustainable production methods, that reduces the world's greenhouse gas emissions, and that involves the increased participation and determination of affected people and local communities.

How can academics have a more powerful influence on the development of practical environmental solutions and improve the likelihood of their being adopted by society at large?

Dr. WIDENER: Social scientists keep calls for equality, justice, and community participation at the center of the issue. It is not that society should adopt new solutions, but that those solutions have included the input of society, and in particular of the intended community. If proposed developments or projects exclude communities, or aggravate existing inequality or promote new inequality between people based on socio-economic status, gender, race or ethnicity, or place of birth or residence, then they may become a problem, rather than the solution.

Given that the public and governmental debates on environmental issues often include discussions about science, technology, and business practices, what do you think is the most constructive path to achieving active working relationships with all members of society?

Dr. WIDENER: One path is to increase the inclusion of affected or intended community members, who contribute their concerns, questions, and solutions to discussions on science, technology, and business. This effort would include answering community questions and concerns before proceeding with a project or practice. An additional, and complementary path, is education. Nations can produce a citizenry who learn and practice, from an early age, the meaning of participatory democracy, ecological well-being, and community resiliency so that they mature into responsible, locally acting, and globally thinking members of a community—in order for them to contribute to and inform discussions on just science, just technology, and just business practices for their time and for the future. Or, nations may not. If we believe that more people are being excluded from contributing to, participating in, or benefitting from such debates, open up the avenues and forums of discussion so that over time more people are accustomed, enabled, and excited to learn the issues and to participate.

What global activity/process/innovation would you put in place immediately to address environmental challenges?

Dr. WIDENER:

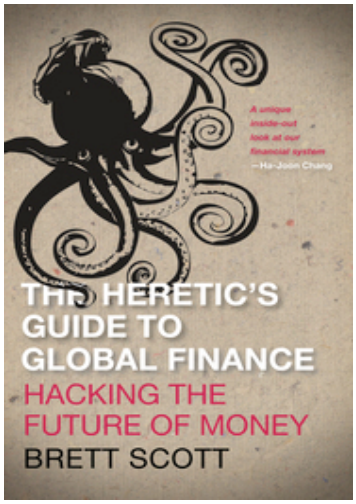
1. Stop any new fossil-fuel extraction and production proposals. We are not transitioning while simultaneously granting new fossil-fuel project proposals.
2. Separate the fossil-fuel industry and fossil-fuel money from elected leaders and government agencies around the world.
3. Foster alternative energy science and technology, and producers and suppliers—into the hands of more people and communities, who are working for people and communities, and not solely with profit in mind.
4. Launch public educational campaigns on climate change.
5. Reduce the level of inequality that is experienced within and between nations. By keeping inequality at the front of discussions, we may encourage leaders in science and technology to incorporate solutions that are inclusive and fair.
6. End the production and use of toxins, especially in the production and supply of energy and food.
7. Divest from fossil fuels; invest in non-toxic oil and energy alternatives.

8. Analyze the negative environmental and societal impacts caused by the world's wealthiest people or companies, and hold them to account for those impacts.

BIOGRAPHY

Patricia Widener is an associate professor of sociology at Florida Atlantic University. Her research examines how community and environmental groups respond to oil projects or oil disasters. Using a political economy approach, with regard to oil and the environment, she has studied experiences of conflict, contamination, negotiation, and/or tourism in Ecuador, the United States, and the Philippines. Her current research is in New Zealand, studying arguments for and against new oil projects, including both deep sea and hydraulic fracturing, in a time of climate-change concerns and known oil-related disasters. She is the author of *Oil Injustice: Resisting and Conceding a Pipeline in Ecuador.*

Book Review



The Heretic's Guide to Global Finance: Hacking the Future of Money, by Brett Scott; London: Pluto Press, 2013, 272 pp. £11.50 or $80 (hardcover); $21.00 (paperback); $11.99 (eBook)

Reviewed by Dylan Brix, CFA

Introduction

Author Brett Scott has created exactly what the title implies: a guide. As such, this book features maps, histories, and step-by-step instructions. It is written in a practical, plain-language style. Scott wants to equip the reader with an understanding of the processes of the global financial system. In so doing, he aims to break down the insider-outsider dichotomy he feels is gagging a productive public discourse on the financial system. Scott acknowledges that many people view the financial system negatively. He engages common fears of finance: that it dissociates institutions from communities, that it creates incomprehensible complexity, that it proliferates risk, and that it contaminates cultures. In the course of his book, he speaks to those fears, debunks them, and supplies his readers with an alternative perspective. At its core, this book is a self-help manual for activists who want to engage the financial system more effectively. As Scott sees it, the biggest obstacle for social activists is that most of them cannot articulate what goes on at a bank, that is, the roles, cultures, incentives, and flow of funds. He identifies this barrier as the key to preventing radicals from accessing financial intermediaries. Social justice movements often misunderstand financial concepts, thus allowing an entrenched financial press to swiftly dismiss them based on their technical weakness. Scott seeks to guide these activists to be better prepared for progressive action.

As Scott himself puts it, this book speaks from the heart, not from the intellect. As such, the book is based on his personal experience, both as a scholar-activist, and as a salesperson of exotic financial derivatives. His résumé demonstrates his experience in

blending social, environmental, and financial value, and so too does his professional network. His work has been endorsed across disciplines by leaders such as Bill McKibben of 350.org, Ha-Joon Chang of Cambridge University, and Tony Greenham of the New Economics Foundation. He is a fellow at the Finance Innovation Lab hosted jointly by the World Wildlife Fund for Nature Institute of Chartered Accountants of England and Wales. If you run a Google search for his name, you will uncover contributions he has made to the BBC, the Guardian, and the Ecologist, among others.

The Hacking Approach

As indicated by the title of the book, Scott uses the idea of "hacking" as a driving theme. He appropriates the term from computer culture, and uses it to describe the process of learning the financial system, exploiting its vulnerabilities, and rewiring it to create something new. For Scott, hacking the future of money entails gaining an empathetic understanding of financial structures, subverting them, and building hybrid solutions. Scott imbues his guide with a radical spirit in order to steer money in positive ways, and he builds it on a foundation of micro-level financial acumen. Hacking, according to Scott, involves three main steps: exploring, jamming, and building. "Exploring" is the process of learning the system on its own terms. "Jamming" is the process of exploiting vulnerabilities to challenge perceptions and purposes. "Building" is the process of creating hybrid vehicles that leverage components of the system for new experiments.

The book is arranged in three main sections based on Scott's three main steps for hacking. Its numerous corresponding subsections make it easy to navigate, if a bit disjointed. For those readers with less experience in finance, the section "Part 1: Exploring" may be particularly useful, because he relates high finance to its roots in everyday life. He explains how high finance developed by delineating it in terms of how institutional structures grew from modest individual transactions performed by regular people. Subsections include "A Fifteen-Minute Map of Finance," "The Primary Markets," and "Opacity, Complexity, and Systemic Risk." He breaks down the system into geographical centers, institutional specialties, systemic interconnectedness, and common problems. Considering the ubiquity of finance and the clarity with which Scott writes this section, I would recommend it anyone, regardless of his or her familiarity with the subject. Even those readers working in the financial sector may find that it reinforces an understanding of how each piece fits into the bigger puzzle.

In "Part 2: Jamming," Scott illustrates the system's vulnerabilities by separating realities from perceptions. He debunks beliefs commonly held by those inside and outside the system. He accomplishes this by highlighting divisions within components of the global financial system. In so doing, he discredits the common activist perception of global

finance as a unified force driven by toxic motives. Instead, he presents the global financial system as an amalgamation of individuals, each driven by pragmatic motives. He explains how the functions, styles, personalities, and goals differ depending on the institution, role, and vehicle. He exposes tensions within the system and he demonstrates opportunities to pit forces against each other within the system. "Part 3: Building" picks up where the jamming section leaves off. Whereas the jamming section details the opportunities for challenging the financial system, the building section details how organizations are constructing solutions to social justice problems. This section outlines examples of innovations in the realms of governmental policy, environmental finance, and the spectrum of social investing.

Surprising Balance

Scott loves radical debate. *The Heretic's Guide* delves into debate from a dynamic array of angles. Accordingly, Scott writes the book from two traditionally opposing vantage points: the social justice activist and the conventional financial professional. A unique characteristic of Scott's work is his anthropological approach. He engages the perspectives of both the social activist and the financial professional with empathy. In fact, he repeatedly emphasizes empathy as the key to making progress. Multiple times while reading this book, I find myself expecting him to launch into a judgmental, condescending, self-righteous rant against the global financial regime. But, each time, he pivots. Rather than rage against the machine, Scott regularly defends conventional financial actors against negative perceptions. Scott impressively maintains balance as he presents creative progressive ideas. For example, in the building section, Scott describes the design of a carbon-neutralizing hedge fund. After presenting the concept in technical detail, he explains criticisms of this structure from the point of view of *both* the environmentalist and the capitalist. As he notes, the environmentalist is concerned about the environmental sustainability of commoditizing environmental welfare, while the capitalist is concerned about the financial sustainability of internalizing an external cost. Scott outlines benefits and drawbacks of progressive projects. He imparts an approach to radical debate that stresses openness and experimentation.

Equipping a New Generation

As Scott explains, in order for social activists to gain access to the global financial system, they need to understand it on its own terms. He believes that in the discourse on the global financial system, there is a barrier separating insiders and outsiders. In his view, this barrier has been built by the perceptions created by, and perpetuated by, people on both sides of the divide. Scott positions his book as a guide for social activists to hack the financial system. However, I would posit that his book is also a guide for hacking the

future of social activism. In the same way as he engages the financial system, he also explores, jams, and builds on the activist system. He does so by empathetically explaining the culture and methods of activism, identifying its weaknesses, and then offering this guide to financial markets as a hybrid solution. His book is inspired by his passion for channeling the moral energy of social justice in a more effective way. In this way, Scott has produced a piece that helps him move closer to achieving his stated goal: equipping a new generation of heretics with the technical skills, professional networks, and humanist spirit to respond to the future financial crises.

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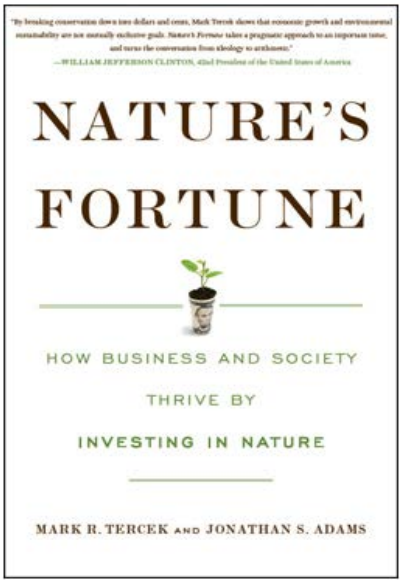
Dylan Brix, CFA. Dylan is an active contributor to the impact investing and ESG investing communities. Please contact him at dylancbrix@gmail.com in order to connect.

This review is being provided for informational purposes only. It is not an endorsement of the concepts in the book. This review does not provide investment advice, nor is it an offer or solicitation of any kind to buy or sell any investment products. The opinions expressed here represent those of the reviewer and not any firm or organization with which he is associated.

Book Review



Nature's Fortune: How Business and Society Thrive by Investing in Nature, by Mark R. Tercek and Jonathan S. Adams; New York: The Nature Conservancy and Basic Books, 243 pp. $26.99 (hardcover); $14.99 (eBook); $14.99 (audiobook)

Reviewed by Sonal Mahida, MBA

From the Oyster Reef to the Flood Plains, How Nature Creates Value for Business

Mark Tercek wants to change how we think about and value nature. The former managing director of Goldman Sachs and current CEO of the Nature Conservancy (TNC) believes that considering nature as a capital asset and applying business concepts to nature can align conservation goals and business interests. "Viewing nature through these basic business principles, focuses more attention on the benefits of conservation. You may not become a conservationist, but you will realize that conservation—protection of nature—is a central and important driver of economic activity," Tercek asserts in *Nature's Fortune: How Business and Society Thrive by Investing in Nature,* written in collaboration with science writer and conservation biologist Jonathan Adams. Using an economic lens, the book calls for increased efforts to preserve our natural resources.

Tercek draws on global examples, from the oyster reef to the floodplain, to demonstrate the business and public value of natural assets. By identifying the value that ecosystem services provide to business and local economies, the book presents investments in nature as opportunities to address climate change, water scarcity, flooding, overfishing, and food shortages.

Resource Rights and Scarcity

Resource scarcity highlights interdependencies between nature and business, and shortages of essential resources lead to risk. In order to manage this risk, Tercek observes, water-dependent companies are beginning to evaluate the resource through their business planning.

For example, water is an essential input for all beverage bottlers. The need for a reliable water supply has driven Coca-Cola FEMSA, which bottles and distributes Coca-Cola products in Latin America, to explore how protecting upstream forests can be key to securing this access. To the CEO, Carlos Salazar, the issue is a business matter leading him to ask questions that the conservation movement has not necessarily explored, such as, "How much water will I get for each dollar I spend on conservation?" To Tercek, this approach exemplifies how both the business and environmental communities need to evaluate the role of natural capital and the opportunities for conservation that arise as a result.

Issues of resource rights (including human rights), use, and availability have potential impacts for current global corporations, argues Tercek, including input scarcity, interrupted operations driven by local community outrage, damage to brand or reputation, and changes in client standards. Coca-Cola's experience in Kerala, India, and Greenpeace's engagement of McDonald's, as shared in the book, illustrate how, in an increasingly connected world, changes in availability of natural resources on local and regional levels have the potential to impact major corporations, brands, and reputations from a global perspective.

Public Investments in Natural Capital

As Tercek points out, not all opportunities in natural capital are suited for private investments. Echoing arguments made for sustainable development, Tercek urges for increased integration of natural systems into public infrastructure, using the New York City water system's leverage of the Catskills watershed as one example of how green infrastructure can boost local economies as well as conserve nature.

Green infrastructure needs to play a greater role in public strategies for climate change adaptation in order to fill the gaps left by gray infrastructure, according to the book. For example, Tercek creates a case that natural system solutions, such as oyster reefs and marshes, can be more resilient and therefore a better investment than gray infrastructure such as levees and seawalls. Our current reliance on gray infrastructure hinders climate adaptation, continues the argument, because it is often built on outdated assumptions of

regional climate variance and because gray infrastructure can exacerbate instead of mitigate the climate change impacts. Levees along the Mississippi river now redirect sediment that once replenished the marshes along the coastal road of LA1 in Grand Isle, Louisiana. These marshes now overflow with water and the road could be completely underwater by 2030. Closing the road could lead to billions of dollars of economic loss because it connects to a major oil and gas shipping terminal; the cost of rebuilding an elevated road would be much less: in the millions.

Low Hanging Fruit: The Value of Collaboration

Tercek wants to scale up conservation through collaboration. He calls for traditional businesses and NGOs to understand the benefits of collaboration and to leverage business value that aligns with conservationist goals. "The point is not just to help businesses and governments do less harm, but to make them become part of something far bigger," he writes. Citing strategies that have worked for TNC and other NGOs in engaging business, Tercek sees business as one of the most powerful tools and a major ally available to conservationists. In Morro Bay, where overfishing led to the collapse of groundfish species, thus decimating the local fishing industry, TNC worked with the local fishing community to develop a solution that protected a 3.8-million-acre fishing habitat. The collaboration called for some inventive solutions, including the creation of a fishing version of a land conservation easement. Engaging business is an opportunity to address the challenges of limited capital and limited base facing the conservation movement, says Tercek.

Tercek recognizes the complexity behind his call to action, admitting early on that, "Putting a value on nature is a tricky and even controversial task." The nuanced discussions in the book highlight where there is still work to be done and more importantly, acknowledge that not all scenarios are win-win and current successes are not necessarily permanent. Potential downfalls of blanket approaches or black and white anti-corporate approaches are also addressed in the book. Regarding the value chain of Amazonian beef, the book points out that "Engaging the big multi-national companies brings leverage, but driving them out of Brazil leads either to someone else filling the void, or to simply relocating the problem." To Tercek, the solution lies in transforming the market by encouraging methods to raise cattle that do not lead to deforestation. This is not an easy task; it is one that requires capacity building for small and medium enterprises (SMEs) to adapt current technologies in order to track and monitor where cattle is being raised. Nevertheless, he argues, this approach will allow for the Amazon rainforests and the Brazilian beef industry to coexist.

Solutions are possible once we begin to understand and address the nuances of interactions between business and nature. Viewing nature as a typical business inventory without understanding its underlying systems can make some of the examples presented in the book seem counterintuitive. However, Tercek successfully demonstrates how conservation can lead to increased value. On the Micronesian island of Pohnpei, Dakio Paul's enforcement of a no-fishing area increased fish for the adjacent areas via the spillover effect. Protecting the reef of Black Coral Island, a location for grouper spawning, created benefits that rippled out to others. The practice was then adopted by other communities across the island. This scaled response led to the full recovery of the grouper-spawning habitat, thus improving the local fishing industry. Eventually, five countries in the region signed on to the Micronesia Challenge, and committed to "effectively conserve at least 30 percent of the near-shore marine resources and 20 percent of the terrestrial resources across Micronesia by 2020."

Conclusion

The book's overall argument will be familiar to those working in the fields of responsible and environmental investing. The text weaves together business fundamentals such as market dynamics with the author's appreciation of nature. Sections such as the discussion of TNC's work with the Dow Chemical Company can be informative for readers working in equity investing. A number of the case studies can be valuable for those engaged in impact investing and business-NGO collaborations. While the majority of examples are focused on NGO initiatives, they provide analogous insights for shareholder engagement strategies.

The book falls short of sharing insights into the process for arriving at the solutions. The concept of leveraging business to address social and environmental concerns is not new; the value in Tercek's offering is the specific perspective used by TNC and others. More of the content could have been spent expanding on the 'aha' moment or presenting suggestions for how readers can change perspectives and culture in order to further integrate the advocated approach. The book also skirts the divergence between timeframes for business planning and ecosystem solutions, which is a potentially major hurdle for implementation.

The most successful arguments in the book are lost at times in the descriptive, albeit beautifully written text. This may be a downfall of the book's approach to integrating two disciplines.

Overall, Nature's Fortune is a perfect introductory text for clients, the mainstream financial industry, environmentalists, and anyone who is skeptical of integrating business solutions with conservation goals. The words are often steeped in the language of an environmental NGO, but the underlying concepts are based on good management theories. For those in environmental investing, Tercek's arguments could convince the stalwart clients of the potential to enact change by engaging with companies. It can also help clients leaning towards divestment understand why engagement in certain situations can be more likely to lead to change. As Tercek writes, "The bigger the company's footprint, the bigger the opportunity for the company to reduce its impact by changing its behavior."

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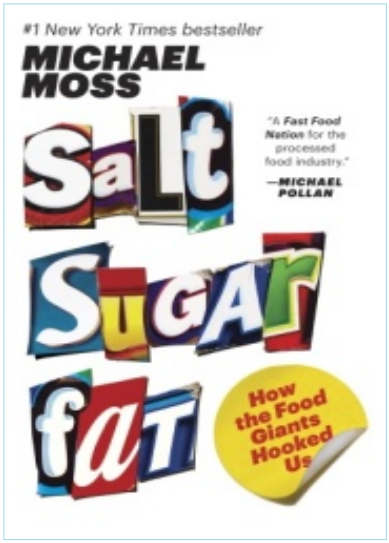
Book Review



Salt Sugar Fat: How the Food Giants Hooked Us, by Michael Moss; New York: Random House, 2013, 480 pp. $28.00 (hardcover); $16.00 (paperback); $11.99 (eBook); 22.50 (audiobook); $45.00 (CD)

Reviewed by Robert Schwarz

As a "foodie," I am as knowledgeable as I am disdainful of the processed food industry's products. Aside from the exceedingly rare indulgence[1] or the complete lack of another option in a dire hunger situation, I avoid processed foods as being totally devoid of value. Beyond my diet, however, is a more serious concern: processed foods can have direct, negative health impacts on those who choose to consume them. Moreover, from the broader standpoint of sustainable and responsible investing (SRI), these health impacts have negative socio-economic effects on all of society. These types of effects are of particular concern to SRI investors as they consider environmental, social, and corporate governance criteria in the process of making investment decisions that could generate long-term competitive financial returns and positive societal impacts.[2] With the interrelated perspectives of SRI and an appreciation of food in mind, I read *Salt Sugar Fat: How the Food Giants Hooked Us* by Michael Moss.

Mr. Moss, one may recall, is the *New York Times* investigative journalist who won a Pulitzer Prize for his 2009 laudatory work uncovering the "pink slime"[3] fiasco, wherein he

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[1] I find it ironic that many of the food items in which American society indulges are, very often, unhealthy.

[2] SRI is an alternative to the vast majority of other investment strategies, which primarily focus on short-term profits with very limited, if any, consideration for the negative environmental and social impacts produced by the companies in which one is invested.

[3] Mr. Moss did not coin the term pink slime. He discovered its use during the course of his investigative work on beef safety.

exposed the beef industry's unsavory practice of incorporating highly processed beef trimmings into hamburger patties and ground beef in a shameless effort to increase profits. His exposé resulted in the removal of this distasteful additive from these beef products peddled by grocery stores, fast-food chains, and school lunch programs across the United States.

Salt Sugar Fat (*SSF*) is in the same vein as the aforementioned series, yet on a grander scale. Moss spent three and a half years writing this 476-page work of diligent and exhaustive research. Divided into three sections, salt, sugar, and fat, Moss's book reveals the business and marketing strategies behind leading processed-food companies through the compelling use of interviews with the executives who crafted them and the managers who implemented them. The author also recounts a host of site visits to processing plants and labs wherein he elucidates the extensive research and development that goes into both devising the stated strategies and manufacturing the food products.

Moss begins by informing readers of an imminent predicament the industry was facing in 1999. He accomplishes this in a striking comparison to big tobacco, a comparison drawn not by him originally but by prescient industry insiders who were looking to bring the burgeoning obesity issue to the attention of the industry's corporate leaders. The ultimate risk to the food-processing industry in ignoring this issue, would, of course, be that it could potentially suffer the same fate as big tobacco did after the public became aware of its deceitful and manipulative practices regarding the use of nicotine and other chemicals in cigarettes. That fate for big tobacco entailed having to pay a US $535 billion settlement and weather other significant associated losses. Given the analogous situation in which the food-processing industry found itself, there was sufficient cause for concern.

Said comparison is delivered via an account of a privately held, unprecedented conference attended by the heads of the major processed-food companies. The primary objectives of the gathering were to (1) explain the industry's connection to the ongoing American obesity epidemic; (2) lay out the immediate and long-term risks associated with continuing business as usual; and (3) outline the opportunities associated with changing tack so as to mitigate the risks without sacrificing long-term profitability.

At the end of the daylong conference, the CEO of General Mills, who at the time was the industry leader in market share and sales, responded. The response, as later paraphrased by the organizer of the event, was "we are not going to screw around with the company jewels here and change the formulations because a bunch of guys in white coats are worried about obesity." This attitude served to justify the industry's unbridled use of salt, sugar, and fat going forward. Always keen to further my understanding of the tactics employed by this powerful and influential industry, I was hooked from this point on.

The formulations referred to in the quotation above are the respective amounts and proportions of salt, sugar, and fat the industry uses to make consumers "crave"[4] their products. Moss thoroughly describes the great lengths an array of talented, expert food scientists, chemists, biologists, bio-psychologists, and others go to in their collaborative and well-funded efforts. These efforts include using advanced statistical analysis, brain imaging, and other sophisticated means to determine scientifically, for example, a product's "bliss-point," optimum "mouth-feel," and other characteristics in order to ensure that its taste is as irresistibly appealing as possible. *Bliss-point*, as the term connotes, is the narrow range of salt, sugar, and fat that is the most pleasurable in a food product. Regarding mouth-feel, specialists at Frito Lay have figured out the most desirable crunchiness of a chip by determining the exact amount of force, in pounds per square inch, consumers prefer to exert when they bite into chips. Determining these product characteristics, of course, virtually eliminates the overuse of raw materials, thus optimizing margins, and serves to keep consumers coming back for more and more.

In addition to describing the technical aspects of processed food production, Moss does an equally fine job of demonstrating marketing strategies used by the industry. These strategies involve another cadre of highly qualified experts who conduct consumer studies and testing, using advanced mathematics to accurately determine whom to target and how best to do so. By employing taste preference and demographic data, the researchers further categorize consumers in terms of detailed consumption frequency and time statistics. These methods enable highly influential product messaging and other marketing tactics to be deployed to great effect. One effect is the gain of mindshare. Mindshare, as the reader learns, is the amount of time a consumer spends thinking about a product or brand. Coca-Cola has mastered this technique by managing to associate Coke, through decades of commercials and other forms of advertising, with the most meaningful and/or enjoyable moments in one's life. Examples of these moments include a father and son enjoying a baseball outing, an athlete winning an Olympic gold medal, or someone proposing marriage.

SSF also provides insight into the unethical mindset behind the creation of these types of advertisements. This mindset is put into action in a variety of marketing devices that often exploit consumers' biological and psychological vulnerabilities in order to trigger the desire to buy a product. For instance, a 2008 Kellogg's commercial aimed at mothers claimed that kids who ate Frosted Mini-Wheats improved their classroom attentiveness by nearly 20 percent. Aside from the fact that the study was commissioned and paid for by Kellogg's, 50 percent of the children in the study showed no improvement whatsoever, and only 1 in 7 showed an increase of 18 percent or more. Similarly, a former Coca-Cola

[4] Which is not to say become addicted. This term, in all forms, is avoided in the industry as it draws comparisons to drug abuse.

executive who ended up retiring early, partly due to his moral qualms regarding entering emerging markets, bluntly stated Coke's overall strategy as one "… [to] drive more ounces into more bodies more often." And, on keeping an industry-wide promise not to market to children under the age of 12, "teenagers became the battleground for early brand adoption." Then, "magically, when they would turn twelve, we'd suddenly attack them like a bunch of wolves."

SSF proceeds in a similar manner through each section by detailing the means by which the industry has engineered and marketed its products, using the vast intellectual, capital, and political resources at its disposal. Analogous to the means by which the industry entices consumers with its products, Moss's easy yet informative style facilitates the consumption of considerable amounts of business and science subject matter for the lay reader. He writes interesting vignettes and case-study-like scenarios, thus rendering his work very enjoyable and thought provoking. Moreover, although *SSF* is very much an indictment of the industry, Moss maintains a fair degree of objectivity regarding his research findings by letting the quotations obtained from corporate executives and management and the descriptions of events speak for themselves, thereby empowering readers to reach their own conclusions.

This information would have been as pleasurable as it was fascinating, to a sustainability-minded foodie at least, if it were not for the fact that all the testing, experimentation, and analyses are done in an effort to knowingly manipulate consumers into buying and consuming unhealthy foods and to increase corporate profits. Granted, the industry cannot be held totally responsible for the related socio-economic costs of their efforts, such as the 33 percent of adults and 20 percent of youths who are clinically obese in America. Nor is it totally accountable for the estimated annual cost of $300 billion in added medical expenses and lost productivity that result from this condition and the diseases it causes. What the industry can be held accountable for, however, is its concerted efforts to manipulate levels of salt, sugar, and fat in a single serving too close to the respective recommended daily allowance and, in some cases, beyond these levels in order to drive sales and maximize profits.

The industry's twofold response to this charge has typically been along the lines of *we are simply supplying market demand* and *ingredients are stated on labels,* that is, respectively, *we are giving consumers what they want and we are not hiding anything.* Although essentially true, this response does not acknowledge these key points:

1. The industry has engineered the demand it references.
2. In so doing, its members have largely eliminated consumers' abilities to choose nutritious foods.
3. Labels can be very deceiving and confusing.

4. Despite being well aware of the negative health effects of the extensive consumption of salt, sugar, and fat, they have done little, if anything, to curb the use of these ingredients in their products.
5. They could easily develop healthier alternatives.

Broadly speaking, the element of choice and the information at one's disposal to make choices, for consumers, producers, and regulators alike, complicates these issues, and thus limits the industry's potential ultimate liability. An example of one such factor[5] is Moss's estimation of the role of the USDA and the FDA in regulating what Americans eat as "less a matter of regulation than it is promotion of some of the industry practices deemed most threatening to the health of consumers"; that is, consumers are getting mixed signals from competing parties, both of whom claim to have consumers' best interest in mind.

The point of knowing deceit, however, which recalls the earlier analogy to the tobacco industry, is key as it demonstrates a clear governance issue. Although not written with the intention of evaluating the industry from a sustainable and responsible investing (SRI) perspective, *SSF* does provide evidence of endemic ethical lapses and lack of accountability. In addition to those previously cited in the description of the industry's manufacture and marketing practices, Moss further demonstrates this disconnect within the industry by way of interviewees' position on processed foods as having a negative value. Examples include the scientist who formulated Dr. Pepper and does not drink soda because "it's not good for your teeth"; the Frito-Lay executive whom Moss visited and who had virtually no processed foods in his home; and finally, the scientist who regretfully remarked, "I feel sorry for the public."

The revelations *SSF* brings to the fore regarding the link between the food-processing industry's manipulation of salt, sugar, and fat and the increase in obesity rates also highlight clear and present long-term investment risks that do not offer a commensurate reward. These risks extend from investment portfolios to society at large, since they carry significant short- and long-term negative health and economic consequences as previously evidenced. Therefore, SRI investors may do well to review their holdings for the presence of processed food companies.

The justification for said review, simply put, is the prospect of declining sales and profits that could result from consumer backlash against an industry too focused on profits to make the changes necessary to eliminate the health risks their products pose. On top of that risk is the threat of processed foods being regulated or phased out of diets in one way or another. Even if not carried out on the scale suffered by big tobacco, there are

[5] Two other important factors, a full discussion of which is beyond the scope of this review, are individual biology and psychology.

considerable forces at work toward similar ends. For instance, at the federal level, First Lady Michelle Obama has made childhood obesity her cause. She has successfully lobbied food companies to remove hundreds of billions of sugar and fat calories from their products as well as to restrict their use of salt. At a municipal level, a decision from the New York Court of Appeals is due in 2014 regarding former New York City Mayor Michael Bloomberg's proposed ban on sugary drinks. At an organizational level, Kaiser Permanente eliminated the sale of soft drinks and fried french-fries organization-wide.

Reputational risk is another consideration. Institutional investors, in particular, can add this risk to those aforementioned, since activist and concerned share- and stakeholders will not abide by investments in companies whose products inherently contribute to the detriment of society. Furthermore, if institutional investors were to sell off processed-food-industry stocks, stock devaluations could result, which could negatively affect other investors.

With these risks in mind, but without either taking on the merits and demerits of divestiture or advocating for such a measure, a case can easily be made for screening[6] food-processing-industry equities from one's portfolio. For, just as one may view profiting from the manufacture or sale of products such as alcohol, firearms, pornography, or tobacco as inherently detrimental to society, and therefore an unacceptable investment, one may also conclude that there is little, if any, well-founded evidence of processed foods doing anything but financial, social, and environmental harm.[7]

Some may fault Moss for not offering any solutions to the issues he has identified so clearly, despite his being privy to inside information and having spent three and a half years thinking about the subject. One could surely assert that he must be in a position to offer some ideas on how best to address the issues. Nevertheless, I will refrain from criticizing Moss for the absence of any substantive recommendations or solutions to the issues. The reasons are that the issues are complex and complicated and Moss is an investigative journalist, not a management consultant, biologist, psychologist, lawyer, lawmaker, or any of the other professionals who would be needed to help formulate a solution. His self-assumed charge is to uncover the issues, not solve them.

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[6] Screening is the active exclusion of an investment from one's portfolio based on one's morals, ethics, and/or values.

[7] There is no discussion of environmental harm in SSF. The industry does, however, rely on monoculture farming, particularly for the cultivation of GMO corn, from which high-fructose corn syrup, i.e. sugar, is derived. This farming method uses vast quantities of fossil-fuel-based fertilizers, the production of which contribute to climate change. Monoculture farming also destroys soil, reduces bio-diversity, and is water-intensive. In addition, food processing itself can be very energy and water intensive.

Moss hopes *SSF* will serve as "a wake-up call for the processed food industry, and at the same time… "[provide] a powerful tool in learning to shop and eat more healthily." At this he certainly succeeds; and read from the perspective of an investor seeking to integrate ESG criteria into food-processing equities, *SSF* takes on an additional degree of utility and importance. Sadly, it is doubtful *SSF* will have as immediate and wide-ranging an effect as the pink slime investigation did, which is unfortunate given the ubiquity, accessibility, and mass consumption of processed foods in the United States.

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