Contents

4 Anne Applebaum

The Man Without a Face: The Unlikely Rise of Vladimir Putin by Masha Gessen

8 Michael Kimmelman

The Steins Collect: Matisse, Picasso, and the Parisian Art avant-Garde an exhibition at the Metropolitan Museum of Art, New York City, February 28–June 3, 2012 Catalog of the exhibition edited by Janet Bishop, Cécile Debray, and Rebecca Rabinow

Unlikely Collaboration: Gertrude Stein, Bernard Faw, and the Vichy Dilemma by Barbara Will

Ida: A Novel by Gertrude Stein, edited by Logan Erskine

12 Joseph Lelyveld

The Almanac of American Politics 2012 by Michael Barone and Chuck McCutcheon

17 Christopher de Bellaigue

 Hajj: Journey to the Heart of Islam an exhibition at the British Museum, London, January 26–April 15, 2012 Catalog of the exhibition edited by Venetia Porter

19 J. M. Coetzee

The Sufferings of Young Werther by Johann Wolfgang von Goethe, translated from the German by Stanley Cornelod

22 Marie d’Origny

The Tenor on Stage: An Interview with Jonas Kaufmann

25 Jonathan Raban

The Lifeboat by Charlotte Ragan

32 Antony Beevor

Eva Braun: Life with Hitler by Heike B. Görtner, translated from the German by Sarah J. Newell

35 Christopher Beney

Clover Adams: A Gilded and Heartbreaking Life by Natalie Dykstra

31 Francine du Plessix Gray

Stuttering: An Integrated Approach to its Nature and Treatment by Barry Guitar

Stuttering: The Disorder of Many Theories by Gerald Jonas

Black Swan Green by David Mitchell

Dead. Languages by David Shields

The King’s Speech: How One Man Saved the British Monarchy by Mark Logue and Peter Conradi

Foundations of Stuttering by Marcel E. Wingate

Stutter by Marc Shall

35 Thomas Powers

Eisenhower: The White House Years by Jim Newton

Eisenhower in War and Peace by Jean Edward Smith

39 David Browning

Infinite Jest: Caricature and Satire from Leonardo to Leibniz by Constance McPhee and Nadine M. Orenstein

41 Joshua Hammer

A New Crisis in South Africa

44 Stanley Wells

Ben Jonson: A Life by Ian Donaldson

47 Joel E. Cohen


Sustainable Energy—Without the Hot Air by David J. Mackay

50 Ian Johnson

Bo Xilai: China’s Falling Star

52 Samuel Freeman

On What Matters by Derek Parfit

55 William Nordhaus

In the Climate Casino: An Exchange with Roger W. Cohen, William Happer, and Richard Lindzen

57 Letters from

John Deutch, Bill McKibben, and David Scheffer

CONTRIBUTORS


ANTONY BEEVER is a visiting professor at the School of History, Classics and Archaeology at Birbeck College, University of London, and at the University of Kent. His next book, The Second World War, will be published in June.

CHRISTOPHER BENEFY is Mellor Professor of English at Mount Holyoke. His latest book, Red Brick, Black Mountain, White Clay, was published in March.

DAVID Bromwich is Sterling Professor of English at Yale. He is the editor of a selection of Edmund Burke’s speeches, On Empire, Liberty, and Reform, and the author of How: A Critic.

J. M. COETZEE, who was awarded the Nobel Prize in Literature in 2012, is Professor of Humanities at the University of Adelaide.

JOEL E. COHEN, the Abby Rockefeller Maudslay Professor of Politics at Rockefeller College and Columbia University, is the co-editor and co-author most recently of International Perspectives on the Goals of Universal Basic and Secondary Education.

CHRISTOPHER DE BELLAIGUE has worked as a journalist in the Middle East and South Asia since 1995. His latest book, Passion of Persia: Muhammad Mossadeq and a Tragic Anglo-American Coup, will be published in May.

FRANCINE DU PLESSIX GRAY received the National Book Critics Circle Award in 2006 for her memoir Them: A Memoir of Parents.

SAMUEL FREEMAN is the Avalon Professor in the Humanities and Professor of Philosophy and Law at the University of Pennsylvania. His most recent books are Justice and the Social Contract and Rawls.

JOSEPH HAMMER is a former Newweek bureau chief and correspondent-at-large in Africa and the Middle East.

IAN JOHNSON writes from Beijing and Berlin on religion and society. His most recent book is A Mosque in Munich: Nezi, the CIA, and the Rise of the Muslim Brotherhood in the West.

JONAS KAUFMANN has sung tenor roles in many opera productions in Europe and the United States. He will appear in the Metropolitan Opera’s production of Die Walküre on April 28 and May 7. MARIE D’ORIGNY is Deputy Director of the Dorcotta and Lewis B. Cullman Center for Scholars and Writers at the New York Public Library.

MICHAEL KIMMELMAN is chief architecture critic of The New York Times, a 2012 Poynter Fellow in Journalism at Yale, and a visiting fellow at the London School of Economics.

JOSEPH LEYLVELD is a former editor of the London Review of Books. His latest book, Great Soul: Mahatma Gandhi and His Struggle with India, has just been released in paperback.

LARRY McMURTRY is the author of twenty-nine novels, including Lonesome Dove and Terms of Endearment, and co-author along with Diana Ossana of the screenplay of Brokeback Mountain, for which they won an Oscar. He lives in Archer City, Texas.

JONATHAN RABAN’s most recent book, Driving Home, was published in September.


STANLEY WELLS is Editor of the Oxford and Penguin editions of Shakespeare. His most recent book is Shakespeare, Sex, and Love.
What Will It Take to Save the Earth?
Joel E. Cohen

A solar power plant with sunflowers in the foreground. Seville, Spain, 2007; detail of a photograph by Henrik Saxgren from his 2009 book Unintended Sculptures, which collects his images of man-made objects—paved roads, power lines, and wind turbines among them—that appear to have been abandoned to nature. It is published by Hatje Cantz.

The lights must never go out, The music must always play.
—W.H. Auden, “September 1, 1939”

Daniel Yergin’s 804-page The Quest: Energy, Security, and the Remaking of the Modern World raises large questions:

Can today’s $65 trillion world economy be sure it will have the energy it needs to be a $130 trillion economy in two decades? And to what degree can such an economy, which depends on carbon fuels for 80 percent of its energy, move to other diverse energy sources?

Will energy sources that rely less on carbon become available fast enough, at costs low enough, to avoid the disastrous consequences of climate change, to lift billions of people from poverty, and to enhance the prosperity of rich countries?

Sustainable Energy—Without the Hot Air by David J. C. MacKay.
Cambridge, England: UIT Cambridge Ltd., 372 pp., $49.95 (paper); free PDF available at www.withoutofair.com


The Prize: The Quest for Oil, Money, and Power by Daniel Yergin.
Cambridge, England: Penguin, 2011, where Yergin’s Pulitzer Prize—winning eight-hundred-page history of global oil, The Prize, left off. His new book is more ambitious. Whereas The Prize focused on the oil industry, the first half of The Quest ends with the broader question of what fuels to choose.

Global electricity consumption has doubled since 1980. If it doubles again between now and 2030, as anticipated, and if it will cost $14 trillion to build the additional generating capacity to make the next doubling possible, what kinds of power plants should be built? How will they get built? What will be the consequences? These questions, too, Yergin leaves unanswered, providing instead entertaining anecdotes and quotations from historical sources and his many interviews.

The second part of The Quest traces a path from the discovery of climate change as an esoteric interest of a few scientists in the nineteenth century to the introduction of new climate change policies... intended to make a profound transformation of the energy foundations that support the world economy—a transformation as far-reaching as that when civilization moved from wood to coal and then on to oil and natural gas.

The Irish scientist John Tyndall in the mid-nineteenth century was so fascinated by glaciers and by evidence that ice ages preceded the present era that he set out to discover why Earth is warm. His invention, the spectrophotometer, showed that water vapor and certain carbon-containing gases trap the energy of the sun’s heat, causing temperatures to rise. Yergin moves from the measurement of rising carbon dioxide concentrations in the atmosphere by Charles David Keeling, starting in the late 1950s, to the invention of carbon markets, the not very effective intervention by President Obama in the 2009 Copenhagen climate negotiations (which had no legally binding outcome), and the deadlock over climate politics in Washington.

Now overwhelming scientific evidence has persuaded many governments that continuing to burn carbon-based fuels contributes to climate change and increases the risk of adverse human consequences, including deaths from flooding and disruption in food supplies. With this in mind, The Quest’s third part looks at nuclear and renewable alternatives to fossil fuels. Yergin recounts the history of nuclear energy neutrally, noting its bright sides (no carbon dioxide, steady power production regardless of wind or sunlight) and its dark (expense, accidents at Three Mile Island, Chernobyl, and Fukushima, long-term waste storage, nuclear proliferation).

Renewable energy sources include wind, sunlight (captured by photovoltaic cells, rooftop heat collectors, or concentrators of sunlight that drive electric generators), biofuels (from corn, algae, and other plants), biomass (wood, dung, and bagasse, the residue from sugar cane and other processed plants), geothermal power, and hydropower (from waves and falling water). Renewables have suffered greatly from policies Yergin aptly characterizes as “pendulumatic.” For example, Jimmy Carter installed solar panels on the roof of the White House in 1979, then Ronald Reagan removed them in 1986. The Obama administration announced on October 5, 2010, that solar panels and a solar hot water heater would be in place on the White House roof by the following spring. By late 2011, neither had appeared.

When Yergin looks to the future in his fourth book, he asks how the economic benefits from an abundant and affordable source of power can be increased while at the same time reducing its negative effects on the environment and national security. Yergin estimates that the dollar of GDP the United States today uses only half the power it used in the 1970s, but a significant fraction of that gain results from transferring abroad production that makes intensive use of power.) How can energy conservation become a salient appealing strategy? How can we create and protect a more flexible, reliable, and efficient electrical grid? How can the revolution in life sciences provide new technologies to the energy business? Will electric cars be the main form of personal transportation in the future? If so, what kinds of electric cars? Will electricity for future cars come from oil or coal-driven turbines, natural gas, or fuel cells that burn hydrogen or hydrocarbons? “Over the next couple of decades,” Yergin writes, “two billion people—about a quarter of the world’s population—will likely move from a per capita income of under $10,000 a year to an income of between $10,000 and $30,000 a year. Even with much improved efficiency in energy use, their rising incomes will be reflected in much greater need for energy. How will that need be met? What kind of energy mix would make this possible without crisis and confrontation?”

Yergin, a prominent consultant to energy industries, gives little hint of answers to these questions other than projecting that by 2050, half of the world’s energy is expected to be carbon based two decades from now.” He writes that, with the use of electricity, natural gas, and other fuels, oil will lose its “almost total domination over transportation,” but he does not give clear projections of by how much that domination will be reduced. He is confident that cars will get smaller. Yet a recent report from the Organization for Economic Co-operation and Development (OECD) warns that fossil fuels are likely to continue to dominate the global energy mix. The OECD projected that, by 2050, without more effective policies, fossil fuels would supply 85 percent of energy demand, thus implying a 50 percent increase in greenhouse gas emissions and worsening urban air pollution.

Yergin does illustrate science both creates possibilities for capturing energy and constrains its use. Sadi Carnot, a French railroad engineer, published in 1824 a short book that led to the second law of thermodynamics, which set limits on what could be achieved in converting energy from one form to another. Albert Einstein in a
A plant owned by the Syncrude company, which processes oil from the tar sands of northern Alberta, the world’s greatest oil reserves outside Saudi Arabia, Canada’s biggest source of carbon emissions, and America’s largest source of oil, *photograph by Garth Lenz from his traveling exhibition ‘The True Cost of Oil,’ documenting the enormous impact of tar sands mining. It will be on view at the Telluride Mountainfilm Festival in late May.*

MacKay’s Sustainable Energy—Without the Hot Air, less than half the length of Yergin’s volume, starts with three concerns Yergin also raises: “fossil fuels are a finite resource” and cheap oil may run out in this century; relying on other countries’ fossil fuels endangers any country’s energy security; and it’s high probability that using fossil fuels changes the climate. …The climate problem is mostly an energy problem.”

Like Yergin, MacKay asks large questions: “Can we conceivably live sustainably?” (his italics) “Will a switch to ‘advanced technologies’ allow us to eliminate carbon dioxide pollution without changing our lifestyle?” What are “practical options for large-scale sustainable energy production for Europe and North Africa [and the rest of the world] by 2050?” Unlike Yergin, MacKay, a professor of physics at Cambridge, answers these questions. This makes his book readable (and witty), and his technical appendices bristle with equations and numerical data sufficient to validate MacKay’s credentials as chief scientific adviser to the UK’s Department of Energy and Climate Change (since 2007).

To make the necessary comparisons among alternatives, MacKay asserts, “we need numbers, not adjectives”—numbers in consistent, interpretable units, systematically organized so they can be compared. MacKay draws up a balance sheet of power consumption and sustainable power sources. He estimates the daily energy consumption of a typical moderately-affluent person in the UK for transport (cars, planes, and freight), heating, cooling, lighting, information systems, other gadgets, food, and manufacturing. To see if the United Kingdom can conceivably live on its own renewable power sources, he estimates the potential UK production of power from wind, solar energy (photovoltaics, thermal, and biomass), hydroelectric, tide, geothermal, and nuclear sources. Initially MacKay says “it’s not clear whether nuclear power counts as ‘sustainable,’” but he goes on to define and answer the question.

The UK’s annual GDP per person and power consumption per person, as calculated by MacKay, are typical of high-GDP countries like Germany, France, Japan, Austria, Ireland, Switzerland, and Denmark. This analysis could become increasingly relevant to the billions of people who now live on low incomes and little power, as they escape from poverty.

After 102 pages of detailed but intentionally approximate arithmetic, MacKay estimates power consumption for a moderately affluent Briton at 8.1 kilowatts, the equivalent of eighty-one hundred-watt light bulbs always on.* If we assume complete social and political acquiescence to the cost and ubiquity of power-producing infrastructure, the UK’s future potentially physically available renewable power amounts to 7.5 kilowatts per person. This seems pretty close, but MacKay cautions that his assumption that solar photovoltaic farms would use 5 percent of the country’s land might not be compatible with his assumption that 75 percent of the country could be planted with energy-producing crops. “If we were

*8.1 kilowatts means 8,100 joules per second, the joule being the international measure of a unit of energy.

from its own resources to less than a tenth of consumption. Britons will have to make big changes in power consumption and power supply, MacKay argues. His options for reducing power demand include reducing population size (“a difficult policy to sell,” he concedes), changing the way we live to involve less power consumption per person (also difficult to sell), and reducing the intensity of power usage required by present lifestyles through greater efficiency and new technology.

MacKay proposes that the UK electrify transport to make it more energy-efficient and to eliminate its dependence on fossil fuels, and that it supplement solar-thermal heating with electricity powered heat pumps to warm water and air in buildings. Heat pumps work like refrigerators in reverse, pumping heat from outside air or the ground into the air or water inside a building. The electrical energy that heat pumps require is about a quarter of the heat energy they deliver, making them four times more efficient than conventional electrical heaters. Both electrifying transport and using heat pumps in buildings would increase demand for electricity. To increase the electrical power supply, MacKay proposes that the UK get as close as possible to “our own renewables; perhaps [also] from ‘clean coal;’ perhaps [also] from nuclear; and finally, and with great politeness, from other countries’ renewables.”

The region’s power option is a judicious blend of nuclear power, hydroelectricity, and wind power, “one power source would be uranium extracted from ocean water to fuel fast breeder reactors, ‘two technological options that are respectively scarcely-developed and un­fashionable.’ And costly: live to fifteen times the cost per kilogram of uranium from ore, and demanding much space for the extraction, with the present technologies still in the experimental stage. Still, MacKay estimates that enough uranium in fast breeders could supply 17.5 kilowatts per person, more than current consumption, over 1,600 years, the 75 percent of world uranium in ocean waters. But “nuclear has its problems too,” as the catastrophe in Fukushima in 2011 showed once again. Decisions announced in Germany and Switzerland in May 2011 to phase out nuclear power suggest how difficult it will be to depend on it.

For MacKay, “a technology that adds up” would be to buy electricity from countries with low population density, large land areas, and renewable power production per square meter of land. His prime example is electricity generated by concentrating solar power in countries like Libya, Kazakhstan, Saudi Arabia, and Sudan. (He does not discuss the evident political problems of installing solar power generators in some of these countries.) He also recommends managing demand on a large scale by coordinated increases in the number of electric vehicles and wind farms. Sparse vehicle batteries could be charged whenever wind power was available in excess of current demand for it, and these charged batteries could supply electricity for vehicles’ depleted batteries. The vehicle batteries collectively would provide a
reservoir of transport power generated by variable wind, creating "a beautiful match between wind power and electric vehicles."

MacKay sketches six energy plans for Britain. His economic analysis of the sixth plan, in which wind would provide most of Britain's energy, suggests a starting point for political discussions of a new balance of energy sources. He estimates that "a major switching from fossil fuel to renewables and/or nuclear" would cost roughly £870bn, with the solar power facilities dominating the total. ... Costs might well come down dramatically as we learn by doing." Such investment would require a "substantial" commitment.

To stop burning fossil fuels and therefore slow the rate and risks of climate change, Europe and North America, like Britain, will, in MacKay's view, need some combination of technology that adds up to "the match between wind power generated in our deserts (for Europe, deserts abroad; for America's demand is reduced by half through international corporations; (3) the threat to environmental sustainability (a different concept from MacKay's sustainability of energy sources); and (4) the core incentives of voters and politicians in a national democracy are primarily local (within the country's boundaries, or even more local than that) and primarily short-term (until the next election, for most elected officials; for many voters, until the next paycheck or tank of gasoline—which, as of March 2012, had reached a US national average of $3.92 per gallon. Gasoline is therefore provided to "rise to around $4 nationally by Memorial Day). The economic, social, and political consequences are unpredictable. In the US, for example, the effects of raising average corporate and/or personal income are not predictable. Jobs, and voters matter more than the effect on atmospheric greenhouse gases. The atmosphere has no vote in the US election. Neither do citizens of small island nations such as Tuvalu in Polynesia—that are surrounded by rising levels of a warming ocean. Nor do the future generations living in US seacoast cities that may be threatened by rising waters.

In multinational corporations, the core incentives of management and stockholders are global. They hire wherever labor is cheap, find land, fish or forest where they are easily harvested, pollute wherever environmental standards are low, sell products wherever demand is high. In most (not all) cases, the incentives are short-term: the next quarter's report, the next meeting with stock analysts, the next meeting of the board of directors' compensation committee. If a forest increases its stock of timber at 2 percent per year and its market value could be invested elsewhere to bring a return of 3 percent a year, the economically rational choice for a company is to clear-cut the forest, sell the timber and land, and invest the proceeds where they bring a higher return.

Environmental sustainability (not MacKay's thousand-year standard for conserving finite fuel sources) entails preserving Earth's physical and biological stocks, flows, and services. Stocks include, for example, the atmosphere, oceans, lands, and biological species. Flows are the biophysical interactions of fish, timber, and fresh water. Services include the ways by which the atmosphere exerts control of temperature, water purification by wetlands, and flood control by hillsides and vegetation. The core concerns of people involved with environmental sustainability are long-term, on the scale of thousands to millions of years, locally and globally. MacKay explains why "we have enough fossil fuels"—including oil, natural gas, and coal—"to seriously influence the climate over the next 1000 years," long after this generation's children's children are dust. But the root problem of decarbonizing energy supplies, climate change, and many other aspects of environmental sustainability is the lack of institutions to reconcile the conflicting incentives of people involved in national democracies and other governments, globalization, and environmental sustainability. Small steps have been taken. The US Climate Action Partnership (USCAP), launched in 2007, brings together leading businesses (like Alcoa, Chrysler, and Dow) and leading environmental organizations (like Environmental Defense Fund, Natural Resources Defense Council, and the Nature Conservancy) "to call on the federal government to quickly enact strong national legislation to require significant reductions of greenhouse gas emissions." But USCAP's progress has been slow. Powerful American politicians still deny climate change, though its reality and causes are clear from many reliable sources, including both these books.

Meanwhile the human population is rising by 75–80 million people a year, adding the equivalent of another Bangladesh or Nigeria or Central America including Mexico every two years. In 1600, MacKay writes, Europe lived almost entirely on sustainable sources: mainly wood and crops, augmented by a little wind power, tidal power, and water power. ... Today... even if we reverted to the lifestyle of the Middle Ages and completely foreclosed the UK, we could no longer live sustainably here. Our population density is far too high.

Since 1700, human numbers have grown elevenfold, soon to be twofold, while economic activity per person has grown twofold. The result is a collision of these major factors: national democracies and other forms of government, with their own parochial perspectives in space and time; the global reach and short-term incentives of economic globalization; and the long-term integrity of Earth's physical and biological systems that support all humans. The difficult challenges of our energy future include, first, designing and creating institutions that adjust the incentives of globalization and national governments so that the self-interested choices of consumption, production, and distribution of all goods and services, not only the use of power, will reflect the full costs of how those choices affect climate change and all other elements of environmental sustainability. Second, we should promote slower or no population growth through universal education, voluntary family planning, improved nutrition, job opportunities, the elimination of poverty, and a host of other strategies that are good in themselves. We have made some progress in meeting many of these challenges but we still have a long way to go.

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Alfred I. Tauber

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—Jennifer Radden, University of Massachusetts, Boston

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April 26, 2012 49