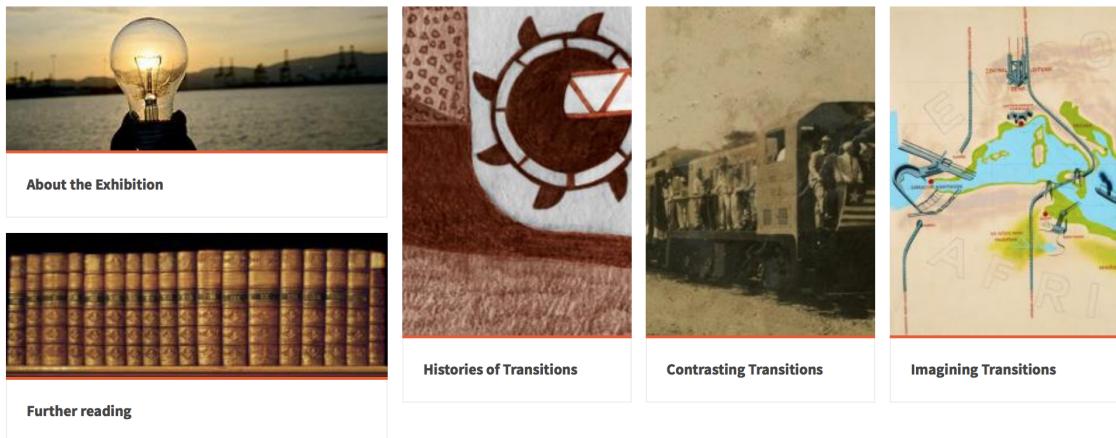




## Energy Transitions

by Nuno Luís Madureira

Human practices of energy consumption both transform—and are transformed by—social structures. This exhibition—written by historian Nuno Luís Madureira—introduces the concept of “energy transitions,” structural shifts in energy use and their pathways, obstacles, and consequences, challenging the view of “transitions” as the simple replacement of one energy resource by another.



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### How to cite:

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ISSN 2198-7696 Environment & Society Portal, *Virtual Exhibitions*

## About the Exhibition

Human practices of energy consumption both transform—and are transformed by—social structures. This essay introduces the concept of “energy transitions,” structural shifts in energy use and their pathways, obstacles, and consequences, challenging the view of “transitions” as the simple replacement of one energy resource by another. Moreover, it also showcases, in three galleries, open-access multimedia resources on “histories of transitions,” “contrasting transitions,” and “imagining transitions.”

## About the Author



Nuno Luís Madureira

**Nuno Luís Madureira** is professor at the History Department of the Lisbon University Institute, former visiting scholar at UC Berkeley and Harvard University, and referee of the European Science Foundation. With several publications in the fields of contemporary global history, history of technology and energy and environmental policy, his last book is entitled *Key Concepts in Energy* (Heidelberg and New York: Springer, 2014). His most recent research embraces the analysis of historical methods and nuclear technologies, particularly the plutonium fuel cycle.

## How to cite

Madureira, Nuno Luís. “Energy Transitions.” Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. <https://doi.org/10.5282/rcc/7780>.

**ISSN 2198-7696**

**Environment & Society Portal, Virtual Exhibitions**



2016 Nuno Luís Madureira

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**Chapter:** About the Exhibition

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Photo by Kee Seng Heng

<https://www.flickr.com/photos/intelfreepress/12838515965>

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"The shovel is digging into the bedrock." Coal mining affects the ground water, vegetation, and the environment as a whole. Drawn by *Ruhan Wang*, 2014.



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Anthropocene Milestones



Inaugural train ride at the dedication of the Antoinette Tubman railroad bridge

Photograph: Leon M. Jordan (1952)

Courtesy of [Indiana University Liberian Collections](#)

Click [here](#) to view Indiana University source.

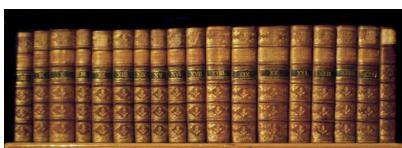
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Exhibition poster, 1932

© Deutsches Museum

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Literature



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- <http://www.onliberia.org/>
- <http://purl.dlib.indiana.edu/indl/lcp/tubman/VAA7927-5004>

Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

**Chapter:** About the Exhibition

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## **Histories of Transitions**

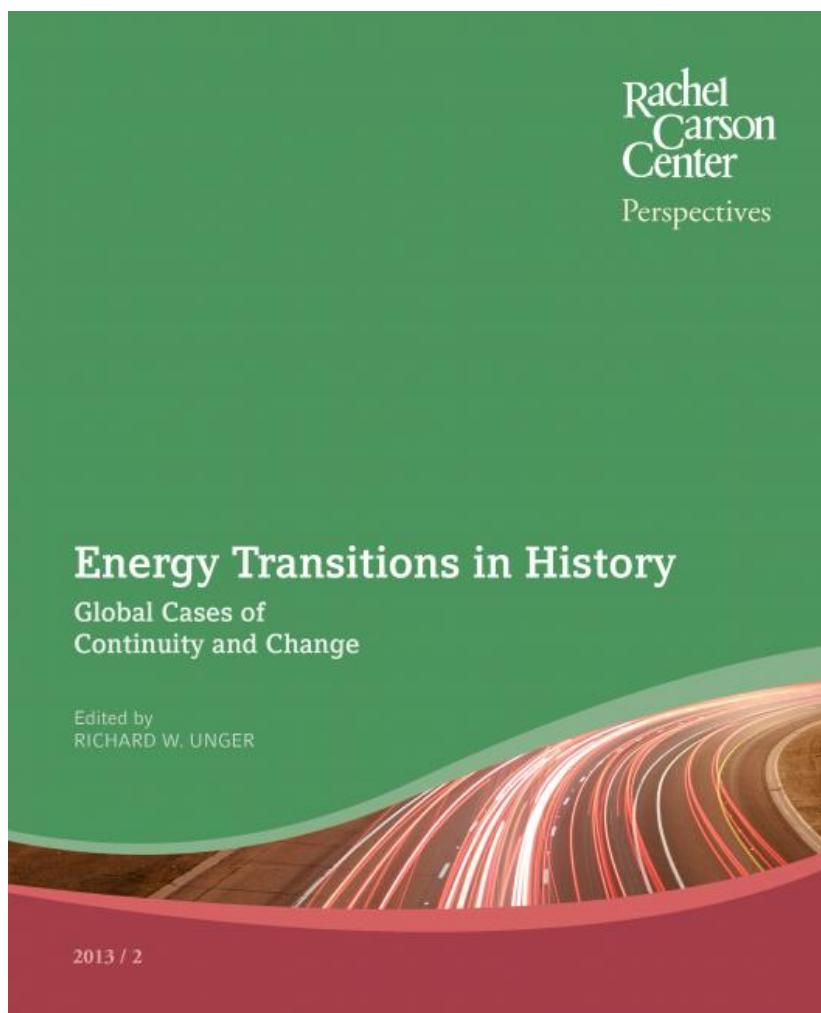
Until recently, the study of “energy transitions” had been modelled on the shift from traditional energy sources such as wood, biomass, muscular force, wind, and water power to fossil fuels, nuclear, and renewable energy sources that started in eighteenth century Britain and is still underway in some African and Central American countries. The realization, however, that fossil fuel combustion and the massive release of CO<sub>2</sub> into the atmosphere has increased greenhouse gas concentration to the point where climate and natural systems might be irreversibly affected has opened a new and urgent agenda: The downscaling of fossil fuel consumption to attain the most efficient exit pathway from this pattern of energy production. How to get from here to there? To achieve a “low carbon economy,” CO<sub>2</sub> emissions must be either radically reduced, captured, and stored safely underground, or mitigated by other technologies.

Often considered a single event drawn out over 50 to 150 years, the classical model of energy transition proves to be a constellation of multiple independent but mutually reinforcing events. What was previously regarded as a single substitution process of older and less efficient power sources by modern equipment with higher efficiency ratios (input–output conversions) and energy densities (amount of energy per unit mass), is actually a process driven by the search for additional, better, and cheaper services associated with the deployment of new energy sources and new technologies.

Take, for example, the classic commodity of coal. Every time a technological advance promised an energy service innovation, coal diffusion took off. First, domestic consumption in hearths and “fire-cages” spread the use of good-quality bituminous coal in spite of the disadvantages (filling the house with smoke and soot). Simple reverberatory furnaces also consumed coal for smelting non-ferrous metals. During the eighteenth century, the discovery of a method for using coke in furnaces to make small cast iron objects provided a stepping stone for wide industrial use. Later, coke was adopted as the feedstock for finery forges in the final stages of iron production and more broadly in larger blast furnaces. From here, coal’s expansion was swift. The steam engine extended coal’s applications as a general source of industrial power as railways and steamboats took fossil fuel demand to new heights, particularly after 1840. Meanwhile scientists discovered that coal could be distilled in a “retort” so as to give off carbureted hydrogen (methane) and hydrogen, together with other gases. After being washed, the gases could be stored, purified, and distributed through pipes to feed local networks of lighting-gas customers. Known as “urban gas,” this distilled coal further amplified demand for fossil fuels.

The original exhibition features an interactive gallery of items from the Environment & Society Portal’s multimedia library with a focus on the history of transitions. View the items on the following pages.

## Gallery 1: Histories of transitions



Allen, Robert C., "Energy Transitions in History: The Shift to Coal," in "Energy Transitions in History: Global Cases of Continuity and Change," ed. Richard W. Unger, *RCC Perspectives* 2013, no 2: 11-15.

### Cover, *RCC Perspectives* 2013, no 2.

Much of the shift to coal happened in England prior to the Industrial Revolution. In his paper "**Energy Transitions in History**," **Robert C. Allen** presents the long history of coal's diffusion within the private domain. This new fuel was not only very different from firewood and charcoal but also required the adoption of a new style of housing construction along with the transformation of family habits. Throughout the modern period, unheralded innovators strove to improve chimney design, narrowing their flues, installing hoods above the fire to capture the smoke, improving fireplace enclosures and confining combustion within metal chambers. This energy transition thus took shape in a decentralized manner through collective adaptations that were then copied whenever they accrued advantages such as upgrading heat conservation or reducing smoke and fuel consumption.

Allen, Robert C., "Energy Transitions in History: The Shift to Coal," in "Energy Transitions in History: Global Cases of Continuity and Change," ed. Richard W. Unger, *RCC Perspectives* 2013, no 2: 11-15. <http://www.environmentandsociety.org/node/6216> and <https://www.jstor.org/stable/10.2307/e26240486>

Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

**Chapter:** Histories of Transitions

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## Gallery 1: Histories of transitions

→ Introduction by Richard W. Unger

### The Long View

- Energy Transitions in History: The Shift to Coal by Robert C. Allen
- Arrested Development? Energy Crises, Fuel Supplies, and the Slow March to Modernity in Scotland, 1450–1850 by Richard Oram
- "The People's Fuel": Turf in Ireland in the Nineteenth and Twentieth Centuries by Liam Kennedy
- The Social Metabolism of European Industrialization: Changes in the Relation of Energy and Land Use from the Eighteenth to the Twentieth Century by Fridolin Krausmann
- Fossil Fuels Consumption and Economic Growth in Italy in the Last Two Centuries by Silvana Bartoletto
- The View from Below: On Energy in Soils (and Food) by Verena Winiwarter

### The Twentieth Century and Beyond

- Telling by Showing: Early Twentieth Century Exhibitions as Advocates in Energy Transition Processes by Nina Möllers
- Energy Regimes, Foodways, and the Efficiency of the Human Engine by Karin Zachmann
- Hybridization of Electric Utility Regimes: The Case of Wind Power in Denmark, 1973–1990 by Matthias Heymann, Kristian H. Nielsen
- The AC Electrical Grid: Transitions into the Twenty-First Century by José R. Martí
- A Dutch Revolution: Natural Gas in the Netherlands by Ben Gales
- World War as a Factor in Energy Transitions: The Case of Canadian Hydroelectricity by Matthew Evenden

Unger, Richard W., ed. "Energy Transitions in History: Global Cases of Continuity and Change." *RCC Perspectives* 2013, no 2.

### Table of Contents, *RCC Perspectives* 2013, no 2.

Humans have come to rely on ever-increasing quantities of energy. In this volume of RCC Perspectives on "Energy Transitions in History: Global Cases of Continuity and Change," scholars from around the world consider the nature, causes, and future of our changing relationships to energy.

Unger, Richard W., ed. "Energy Transitions in History: Global Cases of Continuity and Change." *RCC Perspectives* 2013, no 2.

<http://www.environmentandsociety.org/node/5602> and <https://www.jstor.org/stable/10.2307/e26240486>

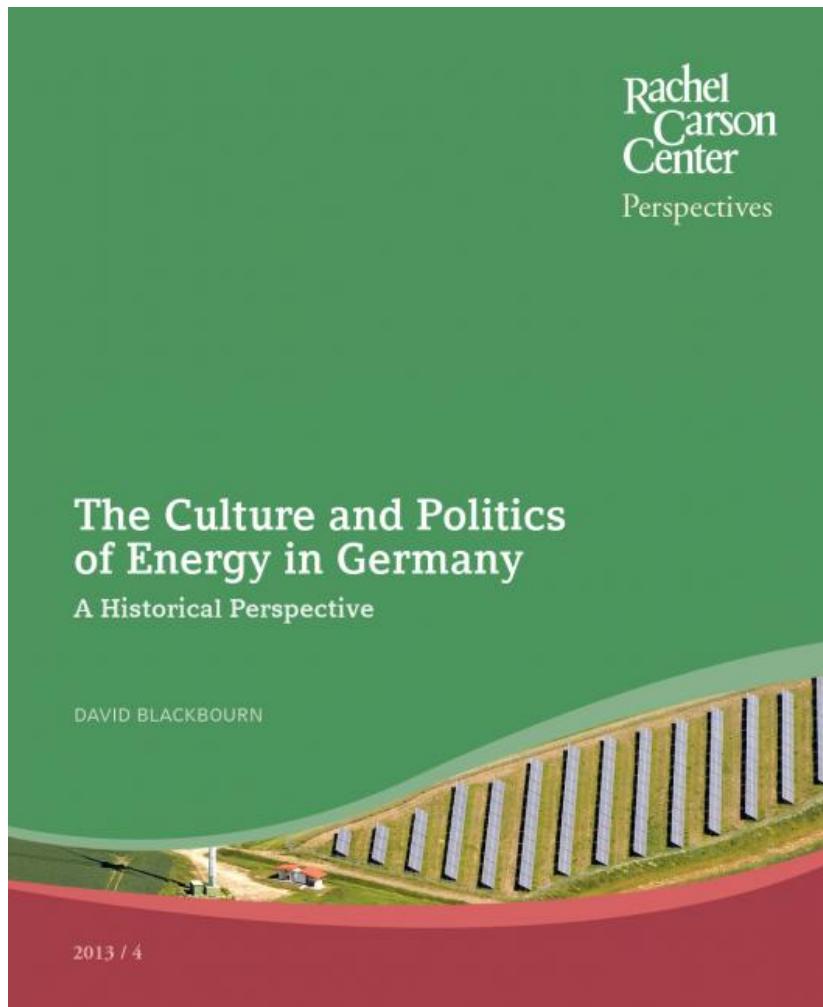
Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. <doi.org/10.5282/rcc/7780>.

**Chapter:** Histories of Transitions

**Source URL:** <http://www.environmentandsociety.org/node/7783>

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## Gallery 1: Histories of transitions



Blackbourn, David. "The Culture and Politics of Energy in Germany: A Historical Perspective." *RCC Perspectives* 2013, no. 4.

### Cover, *RCC Perspectives* 2013, no 4.

In a special issue of *RCC Perspectives* on "*The Culture and Politics of Energy in Germany: A Historical Perspective*" David Blackbourn traces the political, cultural, and economic contexts of German energy regimes over the past two hundred years—from wood and coal, to hydroelectricity and nuclear power, to renewable technologies.

Blackbourn, David. "The Culture and Politics of Energy in Germany: A Historical Perspective." *RCC Perspectives* 2013, no 4.

<http://www.environmentandsociety.org/node/5624> and <https://www.jstor.org/stable/10.2307/e26240513>

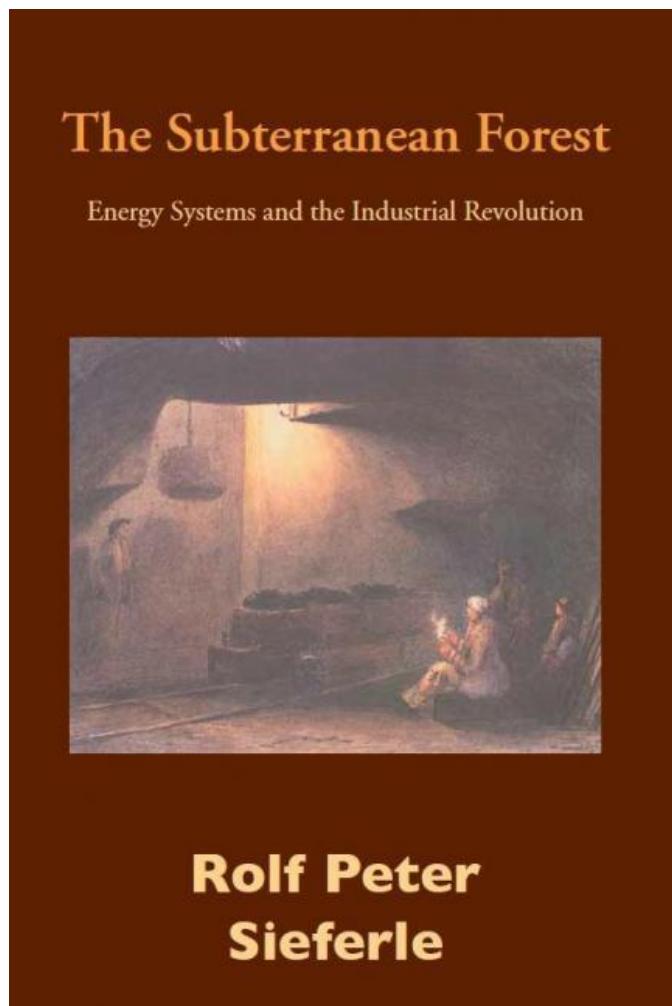
Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](http://doi.org/10.5282/rcc/7780).

**Chapter:** Histories of Transitions

**Source URL:** <http://www.environmentandsociety.org/node/7783>

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## Gallery 1: Histories of transitions



Sieferle, Rolf Peter. *The Subterranean Forest: Energy Systems and the Industrial Revolution*. Translated from the German original by Michael P. Osman. Cambridge: The White Horse Press, 2001.

**Cover, *The Subterranean Forest: Energy Systems and the Industrial Revolution*.**

In *The Subterranean Forest*, Peter Sieferle explains industry's switch to coal. The trades faced a scarcity of wood combined with burgeoning pressure for large amounts of industrial heat for salt making, limestone burning, and metal processing, brewing, pottery, brick-, and glassmaking. At the close of the eighteenth century, the agrarian solar energy system, based on the concentration of diluted solar energy through photosynthesis and the mass consumption of wood, verged on exhaustion. Sieferle highlights this turning point in humanity's history as the drive towards a new type of "forest": the subterranean forest. Instead of biomass fed by solar energy, industrializing nations began drawing on resources from the bank of stored energy formed by deeply buried vegetation slowly transforming into carbon.

Sieferle, Rolf Peter. *The Subterranean Forest: Energy Systems and the Industrial Revolution*. Translated from the German original by Michael P. Osman. Cambridge: The White Horse Press, 2001. <http://www.environmentandsociety.org/node/3487>

Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

**Chapter:** Histories of Transitions

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## Gallery 1: Histories of transitions



Nieptyalska, Marta, "Interview with John McNeill I: An Environmental History of the Industrial Revolution." *Carson Fellow Portraits*. Directed by Alec Hahn. Filmed August 2011. MPEG video, 3:13.

### Screenshot, “Interview with John McNeill I: An Environmental History of the Industrial Revolution.”

In **this short interview, John McNeill** argues that the classical energy transition mostly proved an environmental and ecological transformation.

Nieptyalska, Marta, "Interview with John McNeill I: An Environmental History of the Industrial Revolution." *Carson Fellow Portraits*. Directed by Alec Hahn. Filmed August 2011. MPEG video, 3:13. <http://www.environmentandsociety.org/node/3565/>.

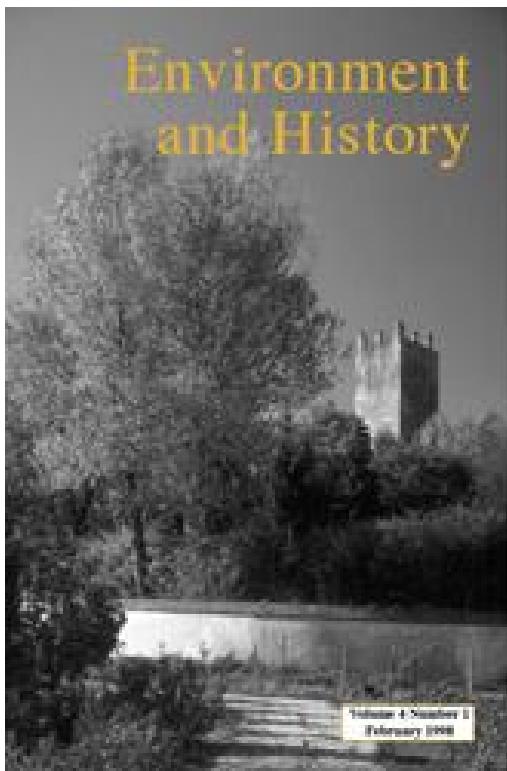
Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

**Chapter:** Histories of Transitions

**Source URL:** <http://www.environmentandsociety.org/node/7783>

**PDF created on:** 10 June 2021 10:57:00

## Gallery 1: Histories of transitions



Cioc, Mark. "The Impact of the Coal Age on the German Environment: A Review of the Historical Literature." *Environment and History* 4, no. 1 (1998): 105–124. doi: 10.3197/096734098779555754.

### Cover, *Environment and History* 4, no. 1 (1998).

A detailed account of its impact on water pollution, air pollution, noise, human health and landscape degradation forms the basis of the panoramic perspective of **Mark Cioc's article "The Impact of the Coal Age on the German Environment."**

Cioc, Mark. "The Impact of the Coal Age on the German Environment: A Review of the Historical Literature." *Environment and History* 4, no. 1 (1998): 105–124. doi: 10.3197/096734098779555754. <http://www.environmentandsociety.org/node/2961>

Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

**Chapter:** Histories of Transitions

**Source URL:** <http://www.environmentandsociety.org/node/7783>

**PDF created on:** 10 June 2021 10:57:00

## Gallery 1: Histories of transitions



Schanze, Jens. *Otzenrath 3° kälter [Strange Homeland]*. Munich: Mascha Film, 2007. Super 16 mm, 81 min.

### Screenshot, *Otzenrath 3° kälter [Strange Homeland]*.

In the film **Strange Homeland** by **Jens Schanze** documents the launch of open-pit brown coal mining operations near 700-year-old village in North Rhine-Westphalia and its impact of the relocated residents.

Film profile of *Otzenrath 3° kälter [Strange Homeland]*. Directed by Jens Schanze. Munich: Mascha Film, 2007. Super 16 mm, 81 min.  
<http://www.environmentandsociety.org/node/3435>

## Gallery 1: Histories of transitions



Wang, Ruohan. "Mining." Environment & Society Portal, Multimedia Library, 2014. Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

### Comic, "Mining."

The final frames of the graphic sequence "**Mining**" by **Ruohan Wang** warns about the consequences of coal mining in a color palette of gray, cinnamon, and chestnut brown.

Wang, Ruohan. "Mining." Environment & Society Portal, Multimedia Library, 2014.

<http://www.environmentandsociety.org/node/6649/>

Published in Hamann, Alexandra, Reinhold Leinfelder, Helmuth Tischler, and Henning Wagenbrett, eds. *Anthropozän – 30 Meilensteine auf dem Weg in ein neues Erdzeitalter*. München: Dt. Museum, 2014.

#### Websites linked in the image captions:

- <http://www.environmentandsociety.org/perspectives/2013/2/article/energy-transitions-history-shift-coal>
- <http://www.environmentandsociety.org/perspectives/2013/2/energy-transitions-history-global-cases-continuity-and-change>
- <http://www.environmentandsociety.org/perspectives/2013/4/culture-and-politics-energy-germany-historical-perspective>
- <http://www.environmentandsociety.org/mml/subterranean-forest-energy-systems-and-industrial-revolution>
- <http://www.environmentandsociety.org/mml/john-mcneill-environmental-history-industrial-revolution>
- <http://www.environmentandsociety.org/mml/impact-coal-age-german-environment-review-historical-literature>
- <http://www.environmentandsociety.org/mml/otzenrath-3deg-kaelter-strange-homeland>
- <http://www.environmentandsociety.org/node/6649/>

Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. <doi.org/10.5282/rcc/7780>.

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## Contrasting Transitions

As markets for coal spread and matured, mutually reinforcing mechanisms boosted the various energy services deployed around a common infrastructure. Coal's long-term costs began to decline steeply due to technical improvements in mining and transportation. Commercial distribution networks expanded throughout the globe, creating a web of retail outlets around grocery stores, warehouses, and bunker stations for fuelling ships. It replaced wood for heating, and muscular force and water engines for power. Distilled coal, in turn, substituted whale and colza (rapeseed) oils for lighting. In the final decades of the nineteenth century, fossil fuels began to transform the electricity generation market: coal-fired power stations became platforms for the provision of a remarkable range of services such as outdoor lighting, indoor lighting with incandescent bulbs, industrial power, and urban transportation such as trams. In the years ahead, electricity generation would become the main driver of coal consumption worldwide. Depicted as a single course of action from the primary energy sources point of view, the classical energy transition encapsulates several differentiated processes in terms of end-user energy technologies. Compared to this pattern of classical energy transition, future changes will likely occur within shorter time spans and entail decentralized productive structures and intelligent devices, eventually blurring the distinction between energy producers and consumers. They will most certainly be driven by changes in transportation services, in building infrastructures and optimal/smart control. The share of electricity in the overall energy balance is furthermore likely to increase. Much harder to ascertain are the unexpected spillover effects along with the social, economic, and environmental impacts of structural shifts in energy production and consumption. "Low carbon economies" are unimaginable without significant changes in geographical mobility, employment, trade, agriculture and globalization. They also imply major shifts in the equilibrium between winners and losers with the resulting overhaul of policy arenas and social movements. Ultimately, energy transitions will continue to lead to the transformation of habits, individual preferences, societal values, time schedules, and leisure.

Different types of energy transitions occur at the same time. Whilst some countries embark down the path of offering incentives for the installation of efficient and competitive renewable energy system others are still circumventing the constraints of the solar agrarian energy system and its associated energy poverty.

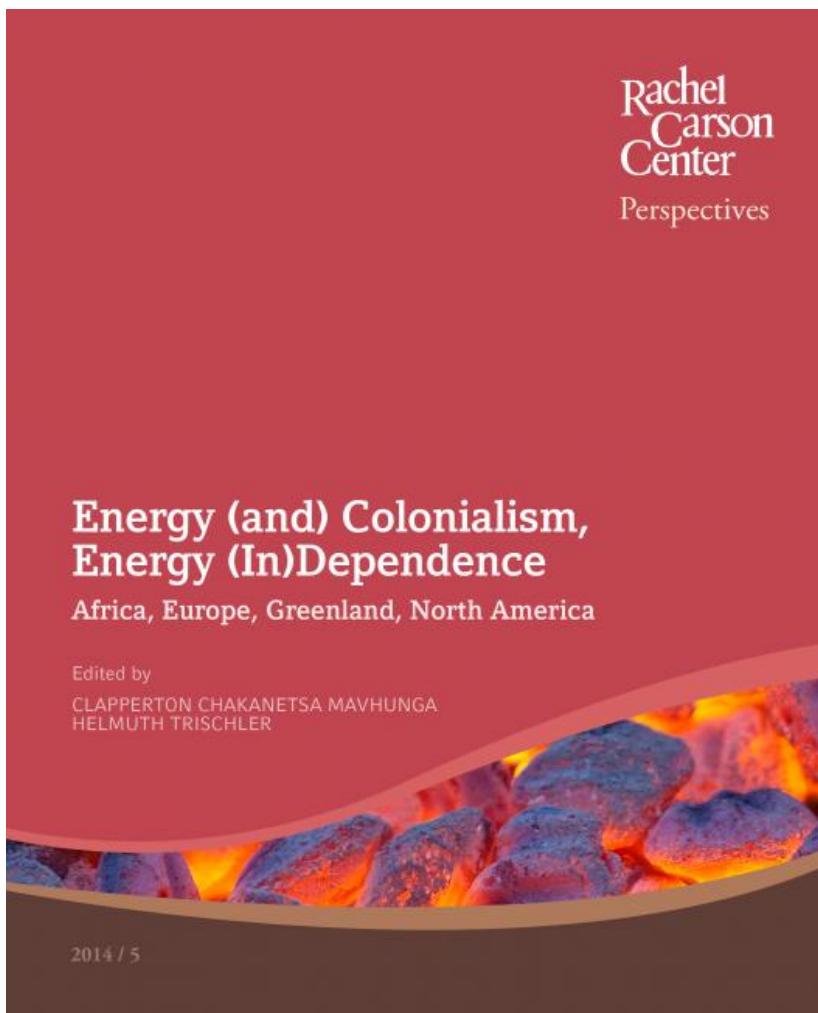
Certain factors can accelerate transitions. Technological niches offer "protected spaces" for the early experimentation of radical innovations that may sow the seeds for systemic change. Such niches may be research and development laboratories, subsidized demonstration projects, or small markets where users are willing to back emerging innovations and provide feedback. As long as these spaces and facilities continue to support technologies at the prototype or small-unit-scale stages and allow for design diversity for replication and learning, they enhance the innovations' chances of survival. Particularly in periods of destabilization in the existing technoeconomic regime, niche innovations may overcome competitive barriers and move into the competitive fringes of markets. Hence, niches buy time for novel technologies. Time allows for the acquisition of experience

through learning-by-doing, learning-by-using, and learning-by-interacting. Drawing on the idea that costs decrease following a learning curve, these niches enable the pursuit of cost reductions so that when circumstances allow, the competitive gap is shortened and the diffusion process accelerated.

Accordingly, energy transitions tend to be faster for latecomers and slower for pioneers. Adapting to new energy systems proves much easier when there are none of the sunk costs in capital intensive equipment, network economies of interconnected infrastructures and the human resources and institutions devoted to the old system. In this respect, analysis of less-developed countries demonstrates how some regions have leapfrogged entire stages in the Western historical energy transition path as happened with the abrupt changeover from coal to oil by Costa Rica, Cuba, Mexico, and Peru in the early twentieth century, or in the swift domestic substitution of charcoal and firewood by butane gas in Senegal and Botswana at the close of the twentieth century. Overall, the more the transition focuses on the substitution of end-user technologies rather than the displacement of large and complex energy systems, the easier and the faster the process of change. This point tips the balance towards the design of flexible, semi-autonomous, and decentralized energy usage systems.

The original exhibition features an interactive gallery of items from the Environment & Society Portal's multimedia library with a focus on contrasting transitions. View the items on the following pages.

## Gallery 2: Contrasting transitions



Mavhunga, Clapperton Chakanetsa, and Helmuth Trischler, eds. "Energy (and) Colonialism, Energy (In)Dependence: Africa, Europe, Greenland, North America." *RCC Perspectives* 2014, no. 5.

### Cover, *RCC Perspectives* 2014, no. 5.

Different types of energy transitions occur at the same time. Whilst some countries embark down the path of offering incentives for the installation of efficient and competitive renewable energy system others are still circumventing the constraints of the solar agrarian energy system and its associated energy poverty. A clear picture of the inherent global diversity emerges clearly from the five histories of colonial energy projects presented by **Clapperton Chakanetsa Mavhunga and Helmuth Trischler** in their edited special issue of *RCC Perspectives on Energy (and) Colonialism*.

Mavhunga, Clapperton Chakanetsa, and Helmuth Trischler, eds. "Energy (and) Colonialism, Energy (In)Dependence: Africa, Europe, Greenland, North America." *RCC Perspectives* 2014, no. 5. <http://www.environmentandsociety.org/node/6554> and <https://www.jstor.org/stable/10.2307/e26241270>

Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

**Chapter:** Contrasting Transitions

**Source URL:** <http://www.environmentandsociety.org/node/7785>

**PDF created on:** 10 June 2021 10:57:01

## Gallery 2: Contrasting transitions



Urey, Emmanuel K. "Corridors, Concessions, and the Extraction of Natural Resources in Liberia." Environment & Society Portal, *Arcadia* 2015, no. 8. Rachel Carson Center for Environment and Society.

### ***Arcadia 2015, no. 8.***

In "Corridors, Concessions, and the Extraction of Natural Resources in Liberia" Emmanuel Urey critiques the "open door" development policy promoted by the Liberian government after World War II.

Urey, Emmanuel K. "Corridors, Concessions, and the Extraction of Natural Resources in Liberia." Environment & Society Portal, *Arcadia* 2015, no. 8. Rachel Carson Center for Environment and Society.

<http://www.environmentandsociety.org/node/6945> .

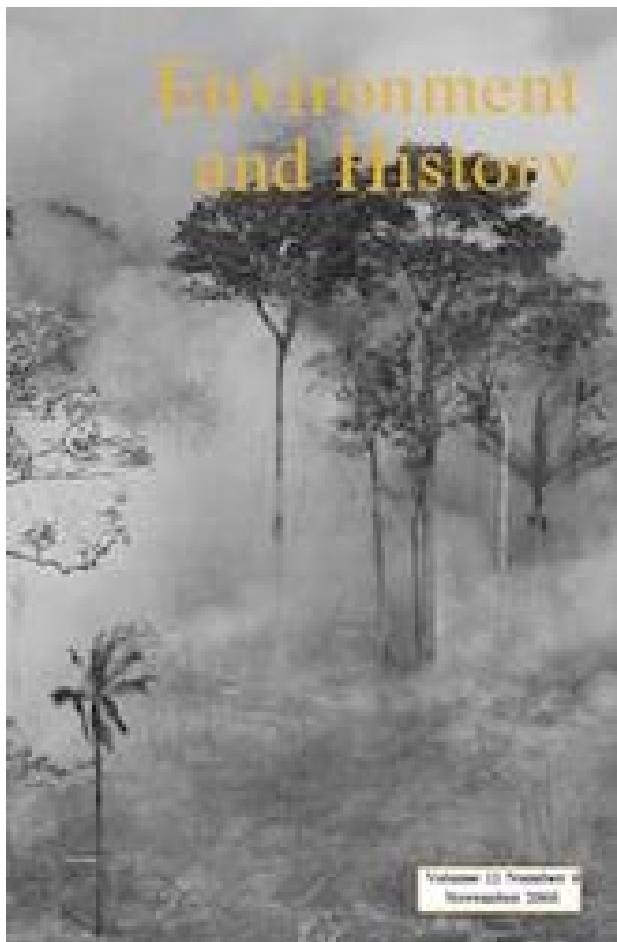
Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

**Chapter:** Contrasting Transitions

**Source URL:** <http://www.environmentandsociety.org/node/7785>

**PDF created on:** 10 June 2021 10:57:01

## Gallery 2: Contrasting transitions



Brannstrom, Christian. "Was Brazilian Industrialisation Fuelled by Wood? Evaluating the Wood Hypothesis, 1900–1960." *Environment and History* 11, no. 4 (Nov. 2005): 395–430.

**Cover, *Environment and History* 11, no. 4 (Nov. 2005).**

In "Was Brazilian Industrialization Fuelled by Wood?" Christian Brannstrom offers a revised "wood hypothesis": That São Paulo's industrialisation depended on the interplay of three energy sources, led by biomass fuels, then fossil fuels and hydroelectricity, each of which was supplied by a distinct energy hinterland.

Brannstrom, Christian. "Was Brazilian Industrialisation Fuelled by Wood? Evaluating the Wood Hypothesis, 1900–1960." *Environment and History* 11, no. 4 (Nov. 2005): 395–430. <http://www.environmentandsociety.org/node/3247>.

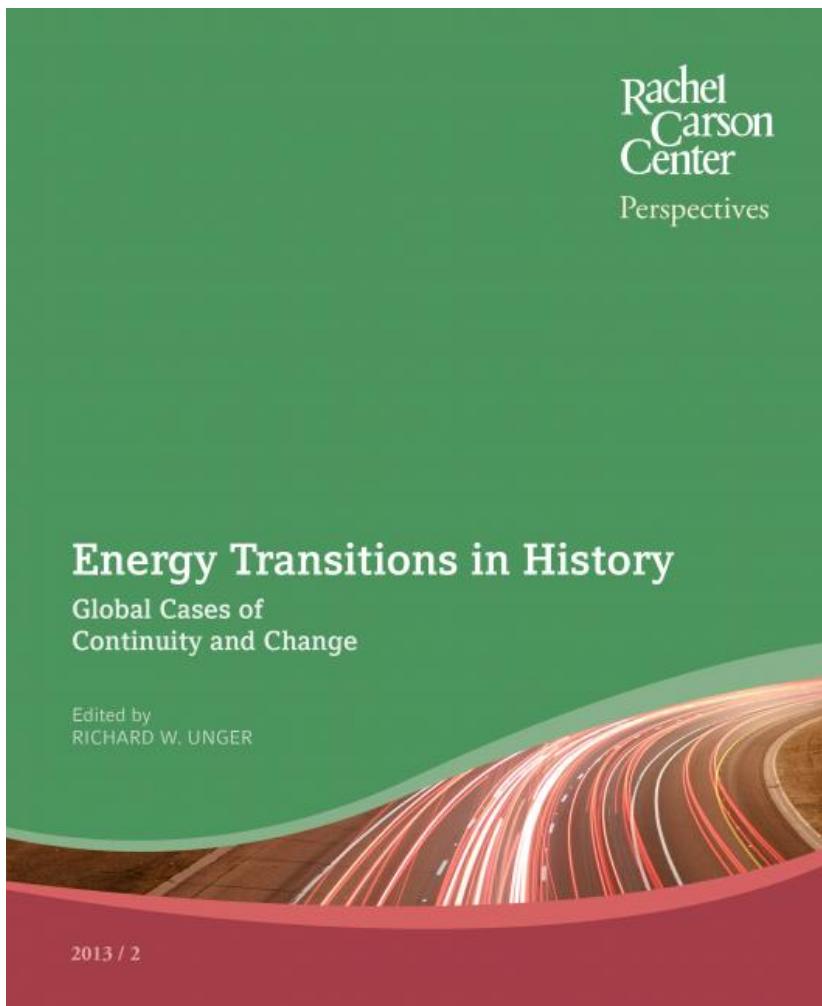
Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

**Chapter:** Contrasting Transitions

**Source URL:** <http://www.environmentandsociety.org/node/7785>

**PDF created on:** 10 June 2021 10:57:01

## Gallery 2: Contrasting transitions



Gales, Ben, "A Dutch revolution: Natural Gas in the Netherlands," in "Energy Transitions in History: Global Cases of Continuity and Change," ed. Richard W. Unger, *RCC Perspectives* 2013, no 2: 83-90.

### Cover, *RCC Perspectives* 2013, no 2.

Massive modernization projects aside, swift changes in environmental landscape are also likely to occur whenever a nation with plentiful natural resource endowments decides to ground its development strategy upon a singular resource. Such proves the case of both the **natural gas revolution** that swamped the Netherlands from 1959 onwards, a story spotlighted by **Ben Gales**.

Gales, Ben, "A Dutch revolution: Natural Gas in the Netherlands," in "Energy Transitions in History: Global Cases of Continuity and Change," ed. Richard W. Unger, *RCC Perspectives* 2013, no 2: 83-90. <http://www.environmentandsociety.org/node/6226> and <https://www.jstor.org/stable/10.2307/e26240486>

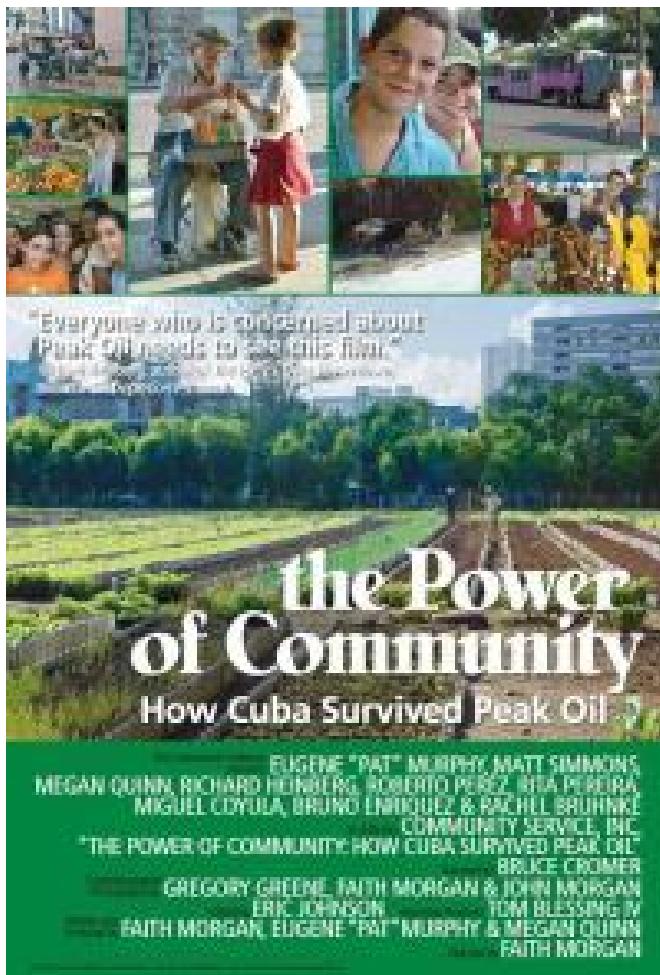
Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](http://doi.org/10.5282/rcc/7780).

**Chapter:** Contrasting Transitions

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## Gallery 2: Contrasting transitions



Morgan, Faith. *The Power of Community: How Cuba Survived Peak Oil*. Yellow Springs, OH: Arthur Morgan Institute for Community Solutions, 2006. 53 min.

### Film Profile of *The Power of Community: How Cuba Survived Peak Oil*.

Another source of contrasting changes stem from sudden geo-political events whose impact shatters the established ways of life of long standing communities. In this respect, the film *The Power of Community: How Cuba Survived Peak Oil* conveys what happened when Cuba was forced to cut back on its oil imports in the wake of the collapse of the Soviet Union in 1991. One gains a glimpse into the intensity of a scarcity shock, even though the specifics of the Cuban economy made the transition relatively manageable. After the collapse of the Soviet Union in 1991, oil imports in Cuba were halved and food imports reduced by up to 80 percent. This film suggests that, given the perceived imminence of peak oil, there is much to be learned from the Cuban experience.

Film profile of *The Power of Community: How Cuba Survived Peak Oil*. Directed by Faith Morgan. Yellow Springs, OH: Arthur Morgan Institute for Community Solutions, 2006. 53 min. <http://www.environmentandsociety.org/node/3799>

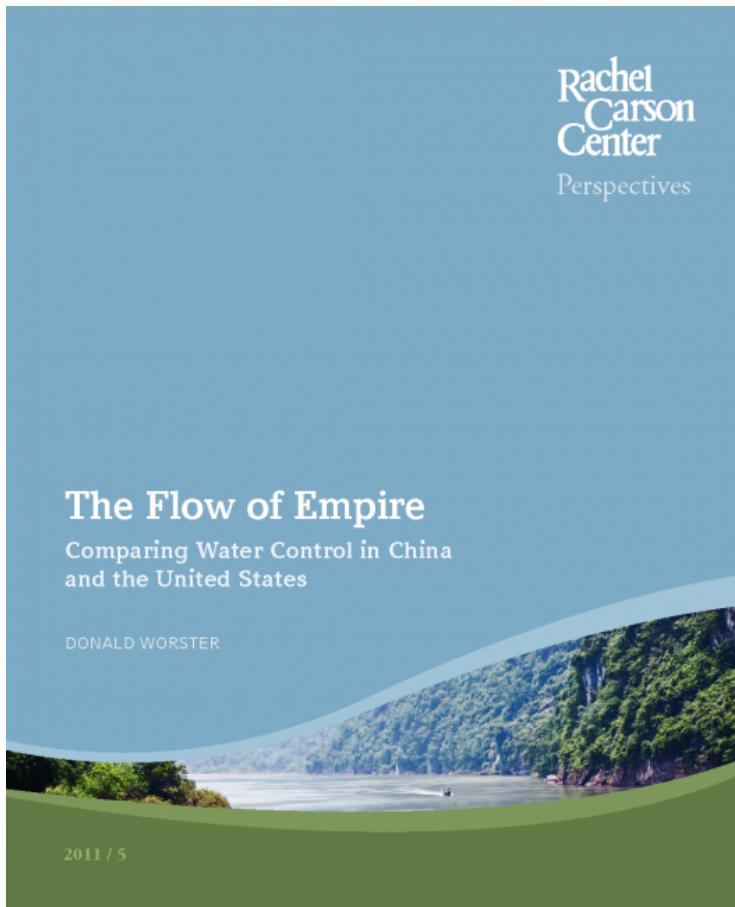
Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](http://doi.org/10.5282/rcc/7780).

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## Gallery 2: Contrasting transitions



Worster, Donald. "The Flow of Empire: Comparing Water Control in the United States and China." *RCC Perspectives* 2011, no 5.

### Cover, *RCC Perspectives* 2011, no 5.

A good read to close this gallery is **Donald Worster's "The Flow of Empire: Comparing Water Control in the United States and China."** Worster reveals sharp contrasts in resource usage intermingled with amazing similarities. He argues that the environmental foundation of China's empire was water control, and that the water policies of the United States can be understood in a similar way. Worster, Donald. "The Flow of Empire: Comparing Water Control in the United States and China." *RCC Perspectives* 2011, no 5. <http://www.environmentandsociety.org/node/5586> and <https://www.jstor.org/stable/10.2307/e26240324>

#### Websites lined in the image captions:

- <http://www.environmentandsociety.org/perspectives/2014/5/energy-and-colonialism-energy-independence-africa-europe-greenland-north-america>
- <http://www.environmentandsociety.org/arcadia/corridors-concessions-and-extraction-natural-resources-liberia>
- <http://www.environmentandsociety.org/mml/was-brazilian-industrialisation-fuelled-wood-evaluating-wood-hypothesis-1900-1960>
- <http://www.environmentandsociety.org/perspectives/2013/2/article/dutch-revolution-natural-gas-netherlands>
- <http://www.environmentandsociety.org/mml/power-community-how-cuba-survived-peak-oil>
- <http://www.environmentandsociety.org/perspectives/2011/5/flow-empire-comparing-water-control-united-states-and-china>

Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. <doi.org/10.5282/rcc/7780>.

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## Imagining Transitions

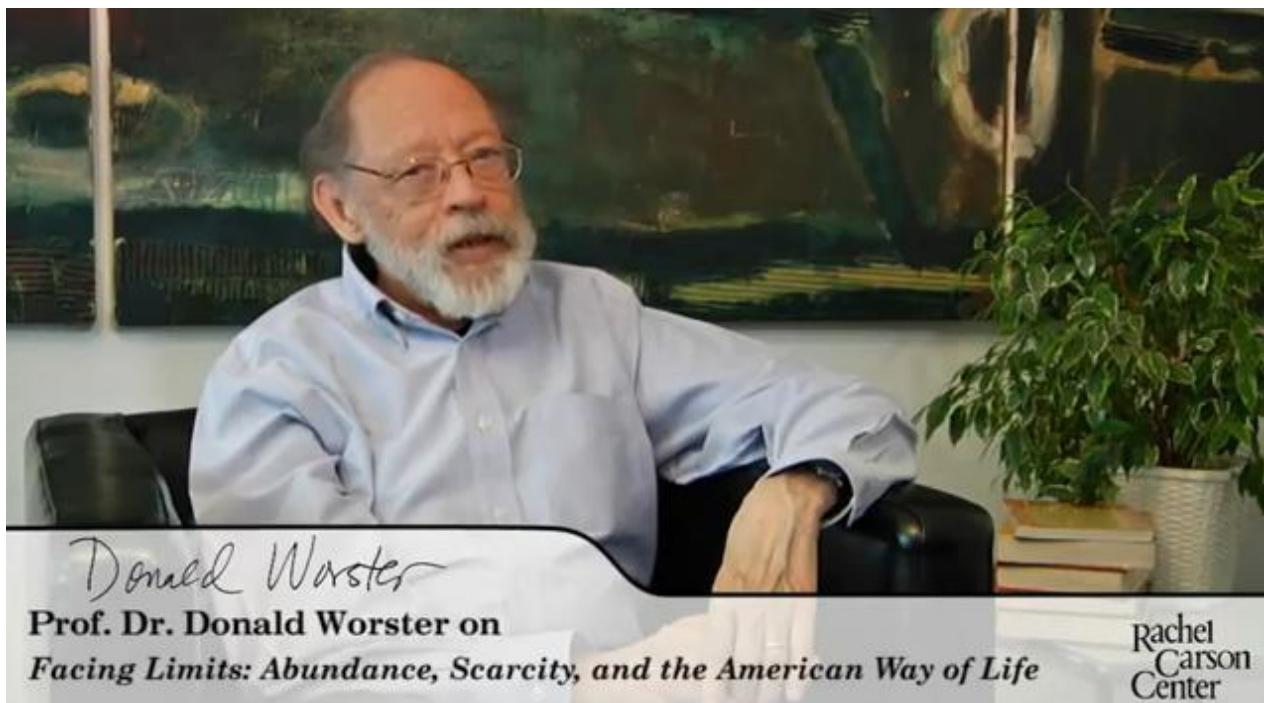
Another important lesson from past energy transitions is that incumbent energy sources and energy services do not fade away just because their competitive edge is lost. Under certain conditions, they react to and counter the competitive threat. To defend their profit margins, businesses fight back and set in motion a new cycle of investments aimed at furthering efficiency, seizing new markets, and reacquiring leverage. Dubbed the “last gasp” in the techno-economic literature, older technologies try to capitalize on competitors’ innovations either by copying and adapting them, making hybrid products that ensure a foothold in new markets, or further specializing them in applications best suited to the older technology. The recent evolution of car makers into hybrid vehicle producers, for instance, is driven by the intent to safeguard sunk investments in the long-established internal combustion engine manufacturing technology by adding the electric drive to oil-fueled powertrains. Thus, the incumbent oil-based technology seizes a strategic position in future markets and can adapt flexibly to the changing oil prices: users may opt either for a standard “hybrid-electric vehicle” in which the internal combustion engine works as the primary system with an electric motor supporting the main motor or covering short distances, or a “plug-in hybrid-electric vehicle” in which the primary power system comes from a rechargeable battery while a small on-board internal combustion engine works primarily to boost this recharging process.

From a long-term perspective, energy transitions are sustained by economic structures, specifically by the dynamics of relative prices. It was no accident that both the upswing in energy prices that marked the oil crisis of the 1970s and the escalation of oil and natural gas prices in 2004 provided a decisive push to conservation policies, renewable energy applications, and new technologies for fossil fuel exploration and extraction. A demand-side response to climate change has been to foster the low-carbon transition with carbon pricing programs such as emissions trading (a cap on aggregate emission levels) or carbon taxation (a tax levied on the price of carbon). This path has been hampered, however, by several problems, some stemming from the limited geographic scope of the initiatives, the diversity of targets, and the complicated revision of guidelines. In all probability, the transition towards a low-carbon economy will require a mix of policies on the demand side (prices and user habits) and on the supply side (fostering innovation).

Environmental thinking brings the debate about alternative futures to the fore. Individuals have long shown great ingenuity in envisioning positive global outcomes. Humans’ ability to meet this challenge depends on the capacity to look ahead and imagine feasible outcomes.

The original exhibition features an interactive gallery of items from the Environment & Society Portal’s multimedia library with a focus on imagining transitions. View the items on the following pages.

### Gallery 3: Imagining transitions



Nieptyalska, Marta, "Interview with Donald Worster I. Facing Limits: Abundance, Scarcity, and the American Way of Life." *Carson Fellow Portraits*. Directed by Alec Hahn. Filmed May 2011. MPEG video, 3:52.

#### Scrennshot, “Interview with Donald Worster I. Facing Limits: Abundance, Scarcity, and the American Way of Life.”

Environmental thinking brings the debate about alternative futures to the fore. The tendency to look ahead and envision feasible global outcomes places individuals within the perspective of imagining transitions. In this interview, **Donald Worster** reflects on the circumstances surrounding the making of the book *Limits to Growth* (1972) and the worldwide controversy then triggered. The study argued that continued global economic growth would lead to planetary limits being exceeded sometime in the twenty-first century, most likely resulting in the collapse of the economic system. Not by accident, the integrated global computer model developed by the “Limits to Growth” team was labelled “World3.”

Nieptyalska, Marta, "Interview with Donald Worster I. Facing Limits: Abundance, Scarcity, and the American Way of Life." *Carson Fellow Portraits*. Directed by Alec Hahn. Filmed May 2011. MPEG video, 3:52. <http://www.environmentandsociety.org/node/3427>

Madureira, Nuno Luis. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

**Chapter:** Imagining Transitions

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### Gallery 3: Imagining transitions



Mauch, Felix. "Atlantropa – Endless Energy from the Mediterranean Sea." Environment & Society Portal, *Arcadia* 2012, no. 9. Rachel Carson Center for Environment and Society.

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*Arcadia* 2012, no. 9.

An insight into this brave new world arises out of the proposal from the architect **Hermann Sörgel** to build a giant dam across the Strait of Gibraltar, **Atlantropa**. Designed to be the world's largest hydroelectric facility, it aimed to provide half of Europe's electricity needs.

Mauch, Felix. "Atlantropa – Endless Energy from the Mediterranean Sea." Environment & Society Portal, *Arcadia* 2012, no. 9. Rachel Carson Center for Environment and Society.

<http://www.environmentandsociety.org/node/3864>

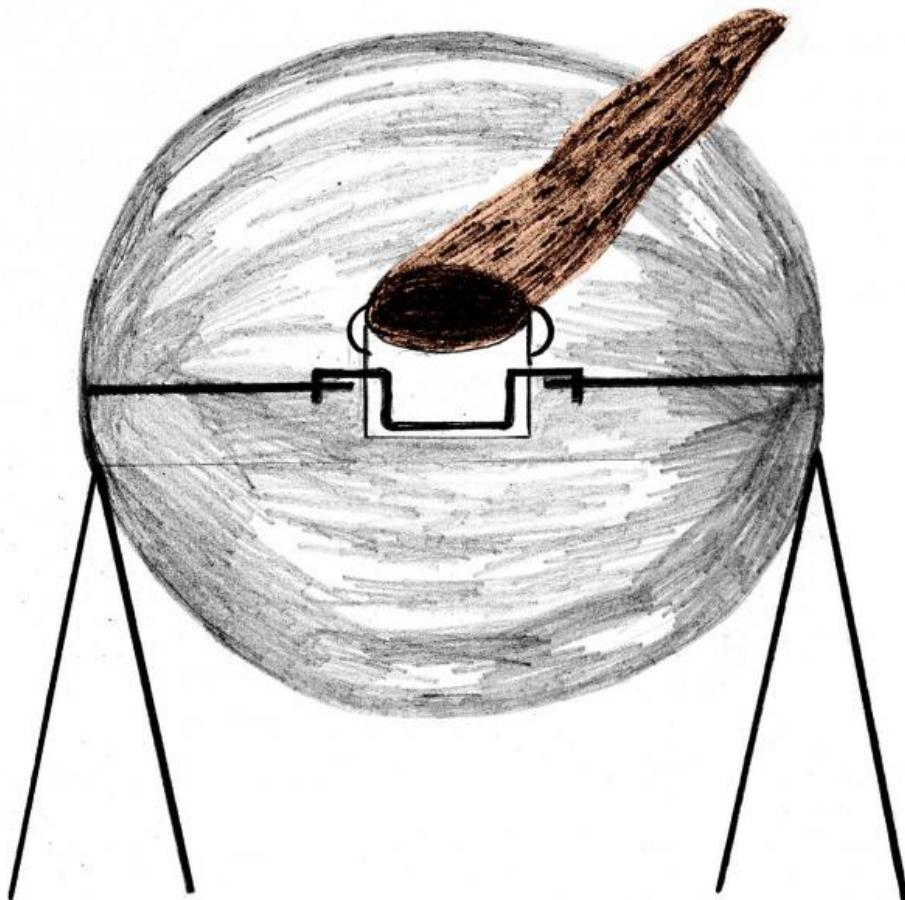
Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

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### Gallery 3: Imagining transitions



Artz, Sophie. "Solar Energy." Environment & Society Portal, Multimedia Library, 2014. Creative Commons License This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

#### Comic, "Solar Energy."

Pioneering attempts to take advantage of solar energy so as to fuel a whole new type of transportation vehicles can also be found in the utopic comic series on **"Solar Energy" by Sophie Artz.**

Artz, Sophie. "Solar Energy." Environment & Society Portal, Multimedia Library, 2014.

<http://www.environmentandsociety.org/node/6635>

Published in Hamann, Alexandra, Reinhold Leinfelder, Helmuth Tischler, and Henning Wagenbrett, eds. *Anthropozän – 30 Meilensteine auf dem Weg in ein neues Erdzeitalter*. München: Dt. Museum, 2014.

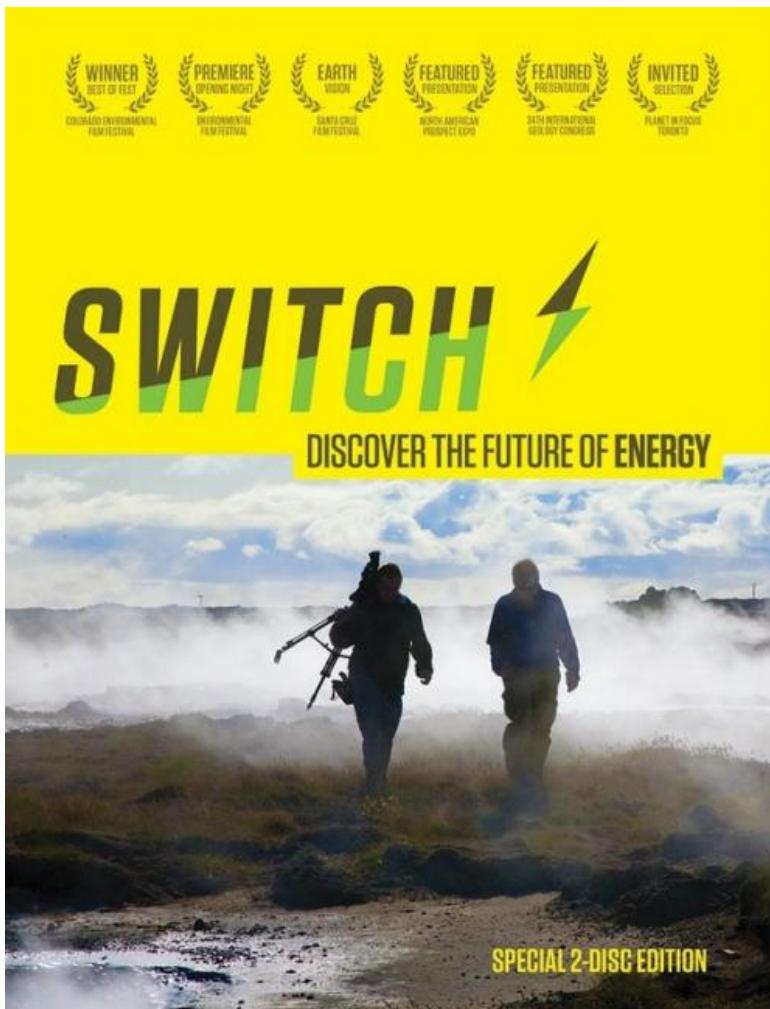
Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

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### Gallery 3: Imagining transitions



Lynch, Harry. < i>Switch. Austin: Arcos Films, 2012. HD, 98 min.

#### Trailer for the film *Switch*.

Modelling virtual worlds and anticipating probable transition challenges furthermore is the theme of the film *Switch*, directed by Harry Lynch, which provides a balanced documentary account of the current energy crisis and possible transition paths. Aside from these attempts to imagine the future, many inventors have struggled to shorten the transition to such sunny societies through the discovery of “inexhaustible” sources of energy. Variants of technological utopias have again and again surfaced within research paradigms such as the study of perpetual motion engines, nuclear fission or fusion power.

Trailer for the film *Switch*. Directed by Harry Lynch. Austin: Arcos Films, 2012. HD, 98 min.

<http://www.environmentandsociety.org/node/7164>

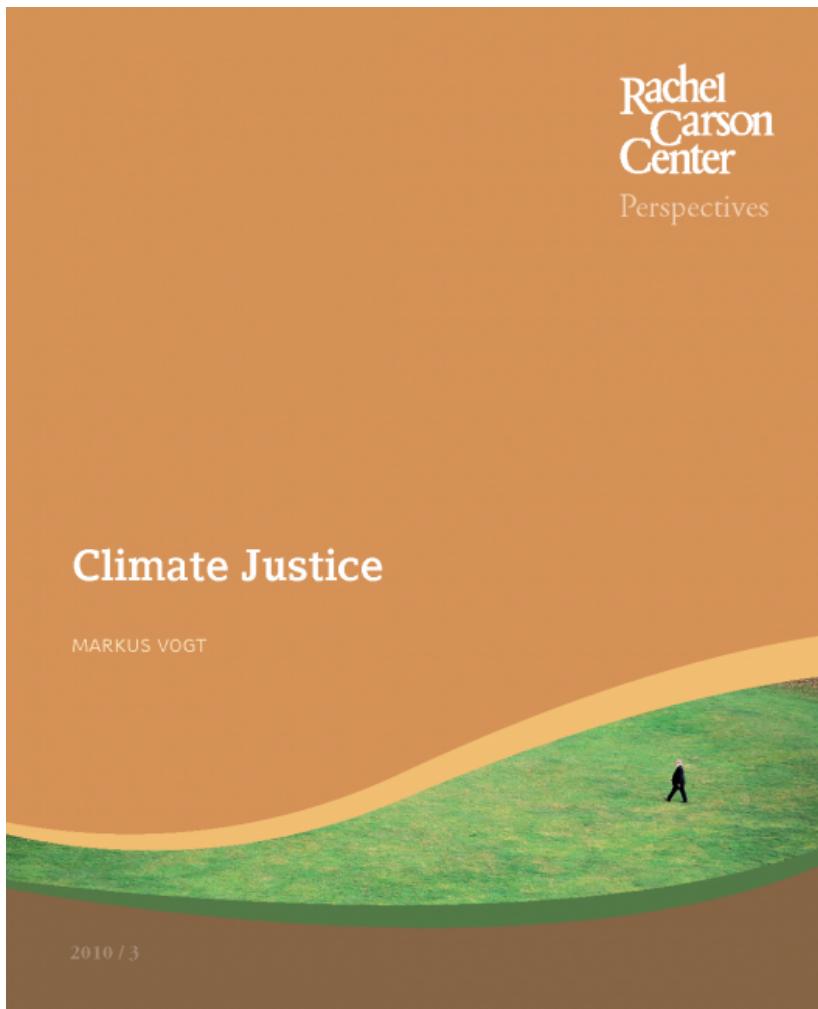
Madureira, Nuno Luís. “Energy Transitions.” Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. [doi.org/10.5282/rcc/7780](https://doi.org/10.5282/rcc/7780).

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### Gallery 3: Imagining transitions



Vogt, Markus. "Climate Justice." *RCC Perspectives* 2010, no 3.

#### Cover, *RCC Perspectives* 2010, no 3.

In contrast with these visions of instantaneous technical transformations, the **Markus Vogt** reminds us how imagining the future might involve much broader ethical issues and social choices.

Vogt, Markus. "Climate Justice." *RCC Perspectives* 2010, no 3. <http://www.environmentandsociety.org/node/5566> and <https://www.jstor.org/stable/10.2307/e26240257>

#### Websites linked in image captions:

- <http://www.environmentandsociety.org/mml/donald-worster-facing-limits-abundance-scarcity-and-american-way-life>
- <http://www.environmentandsociety.org/arcadia/atlantropa-endless-energy-mediterranean-sea>
- <http://www.environmentandsociety.org/mml/solar-energy>
- <http://www.environmentandsociety.org/mml/switch>
- <http://www.environmentandsociety.org/perspectives/2010/3/climate-justice>

Madureira, Nuno Luís. "Energy Transitions." Environment & Society Portal, *Virtual Exhibition* 2016, no. 2. Rachel Carson Center for Environment and Society. <doi.org/10.5282/rcc/7780>.

**Chapter:** Imagining Transitions

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<http://www.environmentandsociety.org/node/6216>.

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Blackbourn, David. “The Culture and Politics of Energy in Germany: A Historical Perspective.” *RCC Perspectives* 2013, no 4. <http://www.environmentandsociety.org/node/5624>.

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<http://www.environmentandsociety.org/node/2961>.

Fouquet, Roger, and Peter Pearson, eds. “Past and Prospective Energy Transitions.” Special issue, *Energy Policy* 50 (2012). doi:10.1016/j.enpol.2012.08.014. <http://www.sciencedirect.com/science/journal/03014215/50>.

Gales, Ben, “A Dutch revolution: Natural Gas in the Netherlands,” in “Energy Transitions in History: Global Cases of Continuity and Change,” ed. Richard W. Unger, *RCC Perspectives* 2013, no 2: 83-90.

<http://www.environmentandsociety.org/node/6226>.

Lynch, Harry. *Switch*. Austin: Arcos Films, 2012. HD, 98 min.

<http://www.environmentandsociety.org/node/7164>.

Madureira, Nuno Luís. “The Iron Industry Energy Transition.” *Energy Policy* 50 (November 2012): 24–34. <http://www.environmentandsociety.org/node/7478>.

———. *Key Concepts in Energy*. Heidelberg and New York: Springer International Publishing, 2014. Preview chapter: <http://www.springer.com/gb/book/9783319049779>.

Mauch, Felix. “Atlantropa – Endless Energy from the Mediterranean Sea.” Environment & Society Portal, *Arcadia* 2012, no. 9. Rachel Carson Center for Environment and Society.

<http://www.environmentandsociety.org/node/3864>.

Mavhunga, Clapperton Chakanetsa, and Helmut Trischler, eds. “Energy (and) Colonialism, Energy (In)Dependence: Africa, Europe, Greenland, North America.” *RCC Perspectives* 2014, no. 5.

<http://www.environmentandsociety.org/node/6554>.

Morgan, Faith. *The Power of Community: How Cuba Survived Peak Oil*. Yellow Springs, OH: Arthur Morgan Institute for Community Solutions, 2006. 53 min. <http://www.environmentandsociety.org/node/3799>.

Nieptyalska, Marta. "Interview with Donald Worster I. Facing Limits: Abundance, Scarcity, and the American Way of Life." *Carson Fellow Portraits*. Directed by Alec Hahn. Filmed May 2011. MPEG video, 3:52. <http://www.environmentandsociety.org/node/3427>.

———. "Interview with John McNeill I: An Environmental History of the Industrial Revolution." *Carson Fellow Portraits*. Directed by Alec Hahn. Filmed August 2011. MPEG video, 3:13. <http://www.environmentandsociety.org/node/3565/>.

Schanze, Jens. *Otzenrath 3° kälter [Strange Homeland]*. Munich: Mascha Film, 2007. Super 16 mm, 81 min. <http://www.environmentandsociety.org/node/3435>.

Sieferle, Rolf Peter. *The Subterranean Forest: Energy Systems and the Industrial Revolution*. Translated from the German original by Michael P. Osman. Cambridge: The White Horse Press, 2001. <http://www.environmentandsociety.org/node/3487>.

Unger, Richard W., ed. "Energy Transitions in History: Global Cases of Continuity and Change." *RCC Perspectives* 2013, no 2. <http://www.environmentandsociety.org/node/5602>.

Urey, Emmanuel K. "Corridors, Concessions, and the Extraction of Natural Resources in Liberia." Environment & Society Portal, *Arcadia* 2015, no. 8. Rachel Carson Center for Environment and Society. <http://www.environmentandsociety.org/node/6945>.

Vogt, Markus. "Climate Justice." *RCC Perspectives* 2010, no 3. <http://www.environmentandsociety.org/node/5566>.

Wang, Ruohan. "Mining." Environment & Society Portal, Multimedia Library, 2014. <http://www.environmentandsociety.org/node/6649/>.

Worster, Donald. "The Flow of Empire: Comparing Water Control in the United States and China." *RCC Perspectives* 2011, no 5. <http://www.environmentandsociety.org/node/5586>.

#### Websites linked in this text:

- <http://www.environmentandsociety.org/perspectives/2013/2/article/energy-transitions-history-shift-coal>
- <http://www.environmentandsociety.org/mml/solar-energy>
- <http://www.environmentandsociety.org/perspectives/2013/4/culture-and-politics-energy-germany-historical-perspective>
- <http://www.environmentandsociety.org/mml/was-brazilian-industrialisation-fuelled-wood-evaluating-wood-hypothesis-1900-1960>
- <http://www.environmentandsociety.org/mml/impact-coal-age-german-environment-review-historical-literature>

- <http://www.sciencedirect.com/science/journal/03014215/50>
- <http://www.environmentandsociety.org/perspectives/2013/2/article/dutch-revolution-natural-gas-netherlands>
- <http://www.environmentandsociety.org/mml/switch>
- <http://www.environmentandsociety.org/mml/iron-industry-energy-transition>
- <http://www.springer.com/gb/book/9783319049779>
- <http://www.environmentandsociety.org/arcadia/atlantropa-endless-energy-mediterranean-sea>
- <http://www.environmentandsociety.org/perspectives/2014/5/energy-and-colonialism-energy-independence-africa-europe-greenland-north-america>
- <http://www.environmentandsociety.org/mml/power-community-how-cuba-survived-peak-oil>
- <http://www.environmentandsociety.org/mml/donald-worster-facing-limits-abundance-scarcity-and-american-way-life>
- <http://www.environmentandsociety.org/mml/john-mcneill-environmental-history-industrial-revolution>
- <http://www.environmentandsociety.org/mml/otzenrath-3deg-kaelter-strange-homeland>
- <http://www.environmentandsociety.org/mml/subterranean-forest-energy-systems-and-industrial-revolution>
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- <http://www.environmentandsociety.org/arcadia/corridors-concessions-and-extraction-natural-resources-liberia>
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- <http://www.environmentandsociety.org/perspectives/2011/5/flow-empire-comparing-water-control-united-states-and-china>

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**Chapter:** Recommended Reading

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