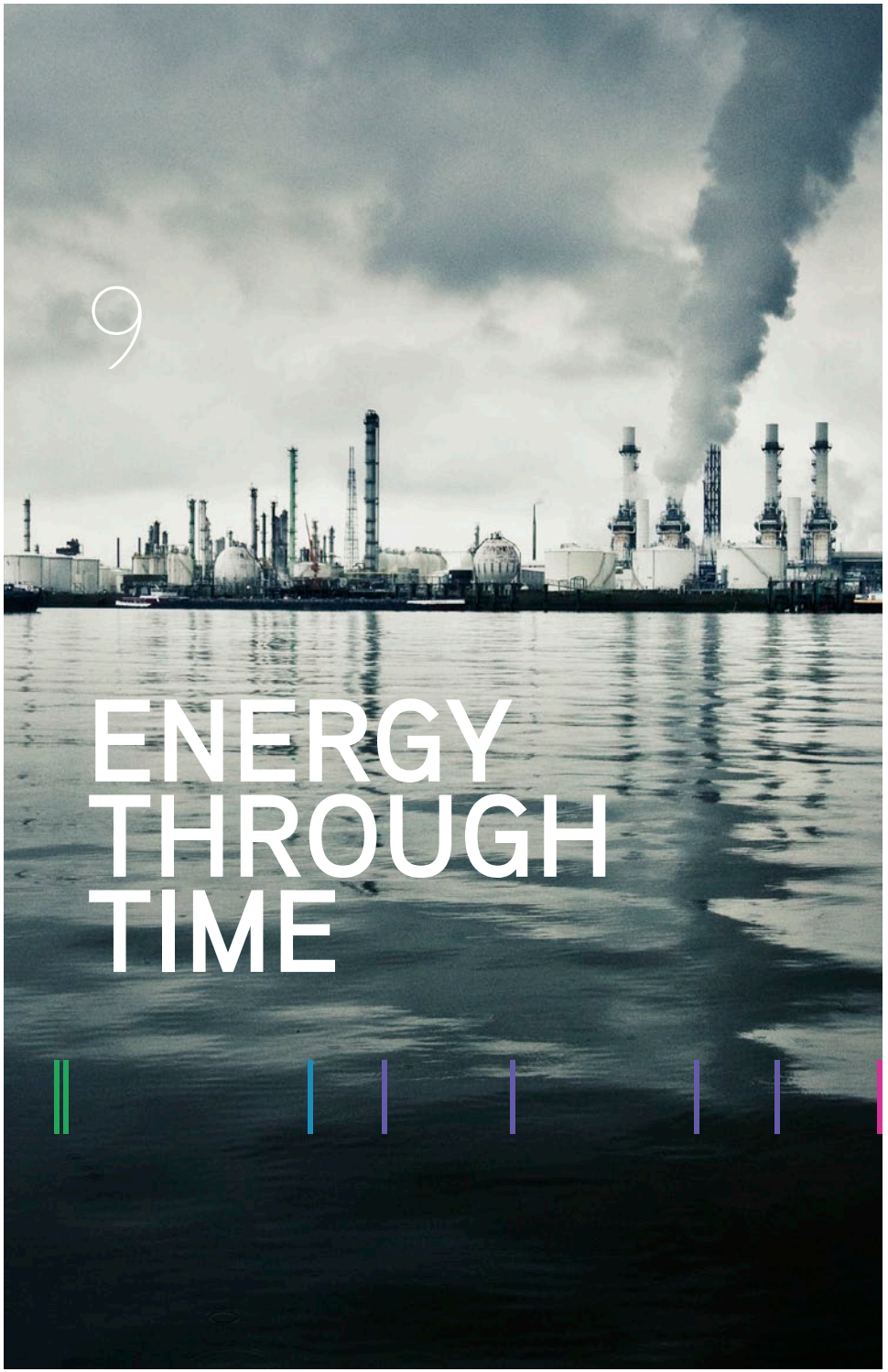
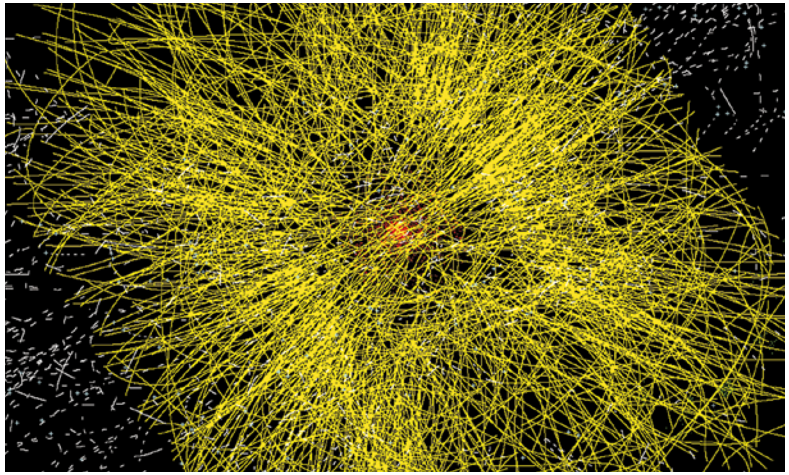


BIG HISTORY PROJECT

ENERGY THROUGH TIME

A NATURAL FLOW FROM
THE BIG BANG TO
MODERN HUMAN SOCIETY

The quest for energy has always been a balancing act. As humans have gained greater control over their environment, they've found abundant resources — and faced numerous challenges.



Early energy sources

Humans are driven to find ways to amplify their own force — to get stronger and move things faster. This has meant an increase in consumption consumption and a never-ending search for new energy sources. The results: greatly expanded capabilities and lasting implications for the world around us. Balancing the benefits and the costs of each successive innovation is a crucial part of the quest — a quest begun 13.7 billion years ago.

It's hard to fathom that all of the energy in the Universe was created with the Big Bang. Since then, the Universe has developed according to that finite amount of energy, transforming nothingness to atomic matter and ultimately into everything around us: the planet we live on, the food we eat, the cars we drive, and so on.

While life on Earth may have begun at the deep-sea vents in the ocean floor, thriving on chemical energy from beneath the crust, prokaryotes first floated to the ocean's surface about 3.5 billion years ago. Using photosynthesis, these organisms consumed energy from the Sun and converted it to fuel for growth and ultimately reproduction — and the adaptations that came with subsequent generations. Thus the Sun played an important role in the evolution of life from single-celled organisms to highly complex beings, like people.

The arrival of humans

Humans produce power (as do all life forms). We lift, lower, pull, push, turn, and twist things — in essence, we can exert force on the world around us. To do so, we must consume food, which gets converted to energy, or calories. This fuels our bodies and makes it possible for us to expend energy.

Human power enabled early *Homo sapiens* to walk, find and prepare food, and shape and build habitats. It also quickly became a limiting factor for growth, as early humans could only move physical obstacles or kill predators with their hands and bodies. But through collective learning, innovation, and human power itself, new energy sources were developed, initially with the making of tools.

Tools first came to prominence in the Lower Paleolithic era. They allowed the transfer of human power to formed objects that could more efficiently carve, cut, smooth, pierce, or gore stone, wood, animals, and other materials. These axes, awls, and various technologies aided progress in hunting and other methods of gathering food, speeding the rate of change and impacting the environment in the process.

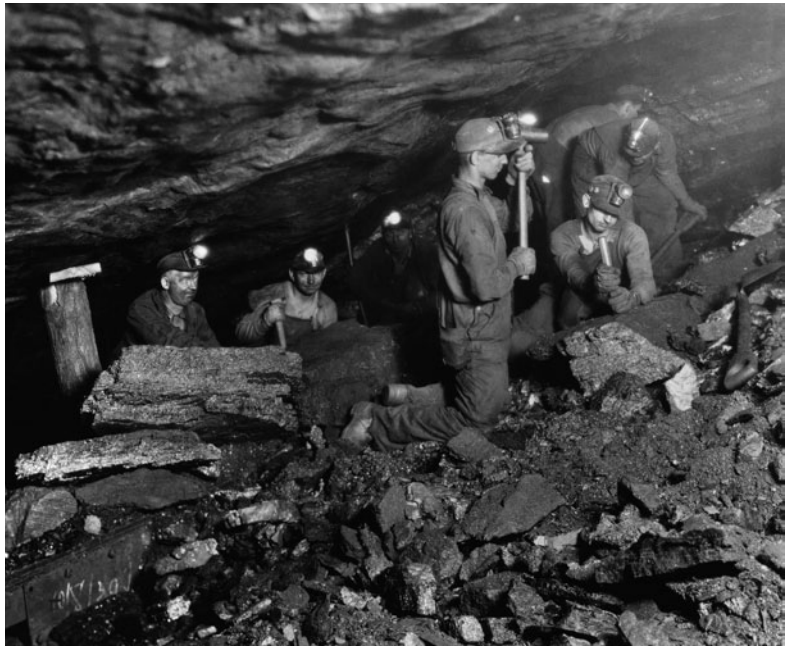
The same era saw the harnessing of fire. Fire proved that humans could radically transform things without exerting much of their own energy. Fire could rip through forests, clearing land in minutes. It could cook meat and vegetables, changing their taste, composition, and "shelf life." It could burn skin, light the darkness, and exude heat for warmth. Fire was a life-altering form of energy and it was relatively "cheap" — you just had to rub two sticks together (very fast and hard). But it had its limitations.

All energy forms have benefits and costs, and the latter tend to fall into four categories: (1) creation or extraction, (2) storage, (3) transportation, and (4) waste created through the process. Fire was easy to create, impossible to store and transport, and created minimal amounts of waste. For many things it worked well, but it was also quite dangerous and not always highly controllable. The search for additional sources of energy continued.

Domestication of animals, utilization of coal

As humanity developed, people realized that they needed to apply energy in more focused ways and they needed energy available at specific times. Large, strong animals presented one such source of energy. Humans started using animals to carry large cargo loads, work agricultural fields, and transport people. Of course, animals required care and had to be housed safely, but in general they provided an excellent energy source for a limited set of applications. Still, the power they provided wasn't scalable enough for the growing needs of our civilization.

One candidate to provide this — coal — was in use as early as a few thousand years ago. It didn't truly come into its own, however, until the Industrial Revolution approached. By the 18th century, populations had grown, cities had formed, and more people were in need of more things — and thus more



powerful energy sources. Coal's extraction had always proved challenging: as miners dug, the mines flooded, constantly slowing the mining process.

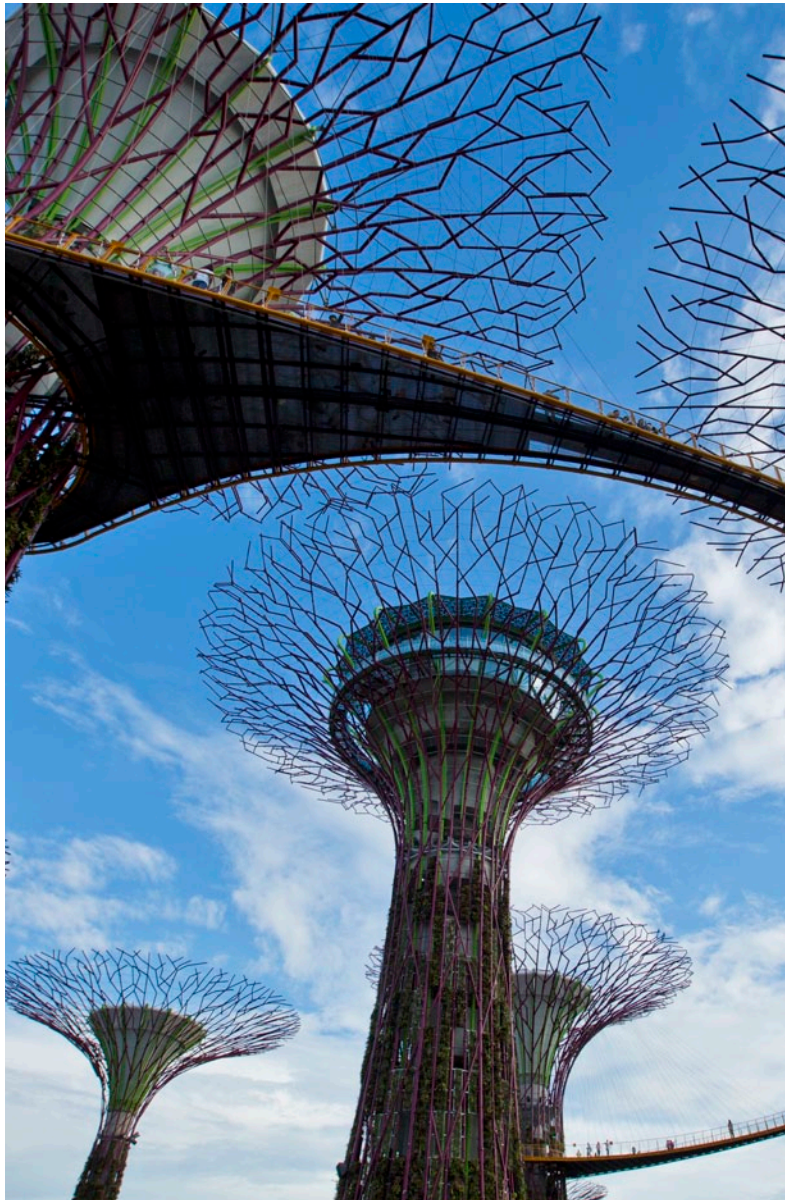
Around this time several steam-powered devices were in use, some even as pumps. None were particularly reliable, but Englishman Thomas Newcomen (1664–1729) elaborated on these devices to create the Newcomen steam engine. His machine helped coal mining by quickly pumping water out of the mines, reducing flooding. Subsequent steam engine designs by other inventors, like James Watt, made mining even more efficient.

Coal mining improved, but increasingly the coal that was mined came to be used in the steam engines that supported mining and, eventually, other industries. Demand for coal grew and extraction of this fossil fuel remained energy intensive — and does so to this day. Coal is also heavy to transport, and the burning of it creates noxious pollution. Nevertheless, it largely powered the Industrial Revolution in Britain and the United States, and, while in decline today, is still a relied-upon source of power.

Modern energy sources

Thousands of years of collective learning have enabled us to tap new forms of energy and have encouraged an ever-increasing appetite for resources that can fuel further innovations, a powerful feedback loop. Through the last few hundred years, we've moved from coal to natural gas, oil, nuclear power, and sustainable energy sources like wind and the Sun. In modern times, demand for energy has surged and we expect it to be reliable and consistently available so we can turn on lights, heat homes, drive cars, email friends, and fly around the world.

Meanwhile, we're trying to minimize pollution and conserve resources for future generations. Where does this put us? It turns out that oil and natural gas are fairly easy to transport, making them good candidates for fuel on-the-go. We can keep a known amount with us in tanks while we travel. Oil, however, is a finite and expensive resource. Burning oil creates carbon monoxide, a greenhouse gas that negatively affects global warming. We



These treelike towers are part of a solar-powered complex in Singapore that includes conservatories, gardens, and an information center on global warming

have some known oil sources, but the greatest reserves exist in a handful of specific countries, adding political and economic considerations to our environmental concerns. Digging for oil is expensive, resource intensive, and impactful to the environment.

Nuclear energy provides a relatively cheap, controllable energy source that can be produced within a limited physical space, with manageable environmental impact under normal operating conditions. Unfortunately, nuclear power production creates highly hazardous waste that must be handled under very strict precautions. The other potential concern is the threat of a breakdown or leak at a nuclear power plant, which threatens surrounding lands, wildlife, and human populations. Nuclear energy is another high-value but high-risk option.

What about natural energy sources like wind and solar power? In the last few years we've seen significant exploration and growth in both areas. While wind and solar energy present strong alternatives with far less environmental impact, major obstacles remain. Specifically, these two energy sources are highly dependent on their availability — presenting a challenge when winds are quiet or when sunlight is scarce. As we search for ways to better store, save, and transport energy produced from the Sun and wind, these may become more viable alternatives for broad use.

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