

Spain: “What seems to be arms are just their sails, which go around in the wind and turn the millstone” – Sancho Panza



1. The Windmills of La Mancha

([Consuegra](#), near Toledo). As the first inanimate “prime movers,” watermills started to impact Europe and Asia by 200 CE and windmills by 900 CE. Believed to have originated in Persia, wind power was adapted from early sailing boats, before being brought by the Moors through Spain to northern Europe in the 1200s.

2. Galician Wind Farms ([Galicia](#)). In 2013, Spain achieved a global first as wind-generated power became its main source of energy (21% of total demand, enough to run 7 million homes. Today more than 3 GW of installed capacity is available from more than 500 wind turbines in the provinces of A Coruña, Lugo, Ourense, and Pontevedra.

3. El Hierro wind farm ([El Hierro](#), Canary Islands) The 5-turbine, 11.5-MW El Hierro wind farm in the Canary Islands generates almost all of the electrical power for an island community of 10,000 people, and provides a good rule of thumb: 1 MW costs \$1 million for 1,000 people (~ 250–330 homes).

4. Pumped Storage Hydro ([La Muela II](#), near Valencia). Europe’s largest hydroelectric facility at 2 GW is a reversible power plant, where water in an upper reservoir falls to a lower reservoir during peak demand and is pumped back up during low demand, available for future on-demand use and to manage the inherent intermittency of renewables (solar and wind).

5. Chrome Dome accident ([Palomares](#)). When a nuclear-armed American B-52 collided in mid-air with a refueling plane during a regular Chrome Dome test run in 1966, 7 of 11 crew members on the two planes were killed and 4 nuclear bombs inadvertently dropped, landing near the fishing village of Palomares in southern Andalusia.

6. Gas tremors ([Castellón](#)). A rise in seismic activity was observed in 2013, in an abandoned petroleum field under the Mediterranean Sea after compressed gas was injected into porous rock off the coast of Castellón, Spain, for a proposed gas storage plant. The regional government halted further injections after hundreds of tremors were recorded, including a 4.2 quake that destabilized the underground strata.

7. PS10 and PS20 ([Sanlúcar la Mayor](#), near Seville). The world’s first commercial power-tower concentrated solar power (CSP) system, Planta Solar 10 (PS10), was built in 2007 just west of the Andalusian capital of Seville, which receives over 3,000 hours of sun a year, and produces 11 MW. The adjacent 20-MW Gemasolar plant (PS 20) was the first to run 24/7 with molten-salt heat storage, able to operate for 15 hours in winter and 24 hours in summer, perfect for baseline power. The nearby Solnova parabolic-trough solar-thermal plant produces a further 150 MW.

8. Olmedilla Photovoltaic Park ([Castile-La Mancha](#)) In 2008, the world’s largest PV solar park at 60 MW (Nobesol) after the 11.4-MW Erlasee Solar Park in 2005 in Bavaria (S.A.G. Solarstrom), eclipsed in 2010 by the 97-MW Sarnia Photovoltaic Power Plant in Ontario (First Solar). As of 2020, the world’s largest PV solar park is the 2.2-GW Bhadla Solar Park in Rajasthan, India (RSPDCL).

9. District heating in mines ([Mieres](#)). For a first-of-its-kind district-heating system in the former mining region of Asturias, a disused mine in the town of Mieres provides input heating water at 23 °C increased to 85 °C. Developed and operated by energy provider and mining company Grupo Hunosa, the 6-MW plant heats the town hospital, a university building, and various apartment buildings in the largest district-heating system in Spain.

10. Wave Energy Plant ([Mutriku](#), the Basque Country). Europe’s first commercial wave-power plant installed in 2011, the Mutriku Wave Energy Plant has a capacity of 300 kW, using incoming waves of 1 to 6 meters in a 440-meter long breakwater to compress air that turns a turbine. Originally built to protect the town from incoming storms, the converted breakwater is also used now as a test site for marine-energy prototypes.

Other interesting science education sites: A [Columbus House Museum](#) (Gran Canaria), [The Factory of Light](#) (Ponferrada), C [Science and Technology Museum](#) (A Coruña), D [Museum of the Sciences](#) (A Coruña), E [City of Arts and Sciences](#) (Valencia)



The Truth About Energy: Our fossil-fuel addiction and the transition to renewables

[Cambridge University Press John K. White](#)

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The Truth About Energy: Our fossil-fuel addiction and the transition to renewables

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Many trade books on energy are light on technical details, while textbooks are full of equations, theory, and problem sets. *The Truth About Energy* aims to bridge the gap, giving the reader a comprehensive scientific grounding in energy technology without the complex mathematical or theoretical detail. Everyday power generation is explained with historical examples, taking the reader through each of the watershed energy technologies since the start of the Industrial Revolution — wood, coal, oil, natural gas, hydro, and nuclear — as well as modern renewables such as biomass, photovoltaics, concentrated solar power, wind, wave, and geothermal.

Chapter 1: Called “the rock that burns” by Aristotle, coal was the first major industrial fuel, created about 300 million years ago as heat and pressure compressed pools of decaying plant matter. Burned to generate heat to boil water and make steam to move a piston in a Watt “fire engine” or a giant turbine in a modern power station, the industrialization of manufacturing, transportation, and electric power is examined from beginnings in the United Kingdom to today’s increased use of coal combustion in developing countries despite the limited thermal efficiency and harmful combustion by-products. A transition simplifies or improves the efficiency of old ways, turning intellect into industry with increased capital — when both transpire, change becomes unstoppable.

Chapter 2: The great discoveries of the past two and a half centuries — the steam engine, electromagnetic induction, the electric power grid, the internal combustion engine, the transistor, personal computers, the internet — change not just the way we live, but an entire global economy. Nothing, however, created more change or made more millionaires than one discovery. By the early 1900s, the iron carriage had made its appearance on the streets of our booming cities, but a new kind of engine and a new kind of fuel would be needed to make a “gasmobile” run. Oil.

Chapter 3: The history of nuclear power is examined through the work of a number of pioneering physicists, chemists, and engineers, including Marie Curie in Paris (radiation), Ernest Rutherford, James Chadwick, and John Cockcroft in Cambridge (model of the nucleus), and Enrico Fermi in Rome, New York, and Chicago (the first nuclear reactor CP-1). Albert Einstein and Leo Szilard’s cautionary letter to Franklin Roosevelt, the Manhattan Project at Los Alamos that oversaw the making of the first nuclear bomb, US Admiral Hyman Rickover’s nuclear fleet, and the transition to electricity-generating fission power by the US, UK, and Soviet Union is explored. The ‘70s growth of “too cheap to meter” nuclear power is shown to be expensive, dangerous, and incapable of treating its own waste.

Chapter 4: Photovoltaic solar power is examined from the atomic level up, starting with solid-state electronics, elemental crystals, and semiconductors. The preferential doping of silicon and germanium to make p-n junctions, transistors, and solar batteries is explained along with the growth of the PV industry that has seen solar panel prices drop and uptake increase exponentially over the past 4 decades according to Swanson’s Law (a solar equivalent of Moore’s Law). The manufacturing of the modern solar cell, behind-the-meter installations (residential and commercial solar), and utility-scale solar are all discussed.

Chapter 5: The history of wind power is discussed, from pumping water that reclaimed land in the Netherlands in the 1600s to today’s megawatt-scale, grid-tied, electricity-generating behemoths. Installations in Denmark (Vindeby, Copenhagen), the US (West Texas, Wyoming, offshore Atlantic), Spain (100% wind in El Hierro), the UK (London Array, North Sea), and China (China’s Wind Base program is expected to reach 1 terrawatt of grid power by 2050) are examined as are novel horizontal-axis, vertical-axis, and vibrating turbine technologies. The number of onshore and offshore sites continues to increase the amount of grid-tied renewable energy year on year (now 10%). The problems of long-distance transmission, stranded power, and recycling are discussed.

Chapter 6: The role of the car is examined from the advent of the internal combustion engine (ICE) in the early 1900s (Benz and Daimler in Stuttgart, Olds and Ford in Detroit) to electric vehicles (EVs) in the past 2 decades (GM’s EV1, Toyota’s hybrid Prius, and Tesla’s Roadster). With over 1 billion cars on the road and annual sales of almost 100 million, 90% run on hydrocarbon combustion, EV propulsion is changing the rules of the road. By 2035, the sale of gasoline and diesel cars will end across Europe and other regions. Examples of electric propulsion are given, including cars, trucks, buses (especially China), marine transport, and airplanes, as are the challenges to electrify each sector (cost, range, weight, charging infrastructure). Vehicle-to-grid (V2G) technology, energy storage, and microgrids are all examined.

Chapter 7: Conservation, the circular economy, and the concept of “negawatts” are explained using everyday examples in the house, on the road, and in modern industry. Ways to save energy and money through increased efficiency and changed consumer habits are discussed as is the sharing economy that sees fewer cars for personal use. If we want more control of our daily lives, smaller-sized, scalable renewable energy allows us to become self-sufficient, letting us make our own decisions about our own needs. With an off-grid power setup, no one can tell me what to do.