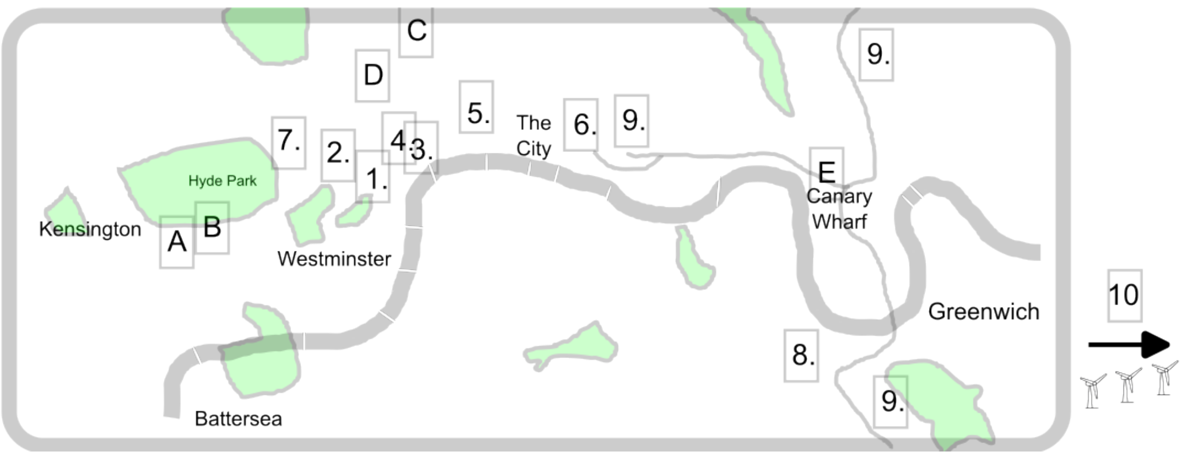
London: “When a man is tired of London, he is tired of life” – Samuel Johnson



1. **Royal Society of London** (6-9 Carlton House Terrace). Founded in 1662, the Royal Society was the world’s first scientific society, which evolved from an amateur congregation of neo-alchemist apothecaries and natural philosophers to an order of professional scientists studying and codifying natural laws through the able stewardship from 1703 to 1727 of its twelfth president, Sir Isaac Newton. Outdoor street lighting began along the nearby Pall Mall, the world’s first gas-lit street in 1807. Sir Humphry Davy was president from 1820 to 1827.

2. **The Royal Institution of Great Britain** (21 Albermarle Street). Founded in 1799, the RI is a scientific organization famous for research, public demonstrations, and science education. As laboratory director (1881), chemist and quintessential scientific showman Humphry Davy helped to popularize the wonders of emerging new science, in particular, his brilliant display of artificial “arc” lighting, powered by his own battery, as did his successor Michael Faraday (1825). After setting up his own “artificial sky in a tube” in the basement, John Tyndall (1867) noted that varying amounts of water vapor, carbon dioxide, and methane could be responsible for past ice ages.

3. **Michael Faraday Statue** (2 Savoy Place). Inspired by Hans Christian Ørsted’s discovery that an electric current in a wire could move a magnetized needle, Michael Faraday wondered if a magnet could create an electric current in a wire, so-called “induction.” Faraday demonstrated the principle in his lab on October 17, 1831, sharing the results a month later at the Royal Society of London.

4. **The Savoy Theatre** (Savoy Court). Powered by an in-house generator for a December 28, 1881, performance of Gilbert and Sullivan’s comic opera *Patience*, the Savoy Theatre was the first commercial building lit entirely by electric light. The first series of buildings lit by an external central power station began the following year along the nearby Holborn Viaduct by the Edison Electric Company.

5. **Holborn Street dynamo** (Holborn Viaduct) In 1884, Charles Parson designed a rotating steam-powered turbine first used with the Holborn Street dynamo, which generated more energy from the same amount of steam by passing it through a modified set of fans instead of jerkily moving a piston up and down. Parson’s insight was to make the fan blades as small as possible in a compound turbine assembly.

6. **The London Metal Exchange** (10 Finsbury Square). The demand for metal components in electric-vehicle and charge-storage batteries will continue to rise with increased electrification, such that more minerals will be mined in the next three decades than throughout the whole of human history, requiring hundreds of mines and doubling supplies by 2050. In 2019, the London Metal Exchange banned the trading of irresponsibly mined cobalt from 2022.

7. **Millennium Hotel** (44 Grosvenor Square). Alpha particles don’t easily penetrate the skin, but are especially dangerous when inhaled or ingested, for example, the poisoning of the Russian émigré Alexander Litvinenko in the Millennium Hotel, who was given tea laced with polonium-210, a high-intensity alpha emitter.

8. **Deptford Power Station** (Basevi Way, near Greenwich). Following developments in high-voltage transformers and polyphase induction motors, alternating current (AC) became the leading electrical power system for generators, transmission, and industrial applications, including Sebastian de Ferranti’s 1889 Deptford Power Station on the Thames River near Greenwich that lit the City of London less than 2 miles away. The station was demolished in 1993.

9. **Docklands Light Railway line** (DLR map). Artificial intelligence (AI) and automated vehicles (AV) are no longer science fiction. The Docklands Light Railway line in London has operated without drivers since it opened in 1987. The system now comprises 45 stations over almost 40 km of track. A driverless, narrow-gauge, electric Mail Rail system also scurried under the streets of London between Paddington and White Chapel for three-quarters of a century before being discontinued, conveniently bypassing above-ground congestion.

10. **The London Array** (outer Thames Estuary). In 2015, global offshore wind capacity was only 12 GW, including the London Array in the outer Thames Estuary, which accounted for 630 MW from 175, 3.6-MW turbines. The then world’s largest offshore wind farm could power one-quarter of all London homes at peak output.

Other interesting science education sites: A Natural History Museum (South Kensington), B Science Museum (South Kensington), C Institute of Physics (37 Caledonian Rd), D The Wellcome Collection (215 Euston Road), Museum of London Docklands (West India Quay)

THE TRUTH ABOUT ENERGY

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

Cambridge University Press John K. White

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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.