Powerforge — Activity Book

A Spark & Anvil activity book — puzzles, questions, and fun from Powerforge.

Write in the book, circle your answers, and check the Answer Key at the back.

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1. Energy Basics and Forms of Energy

Circle the correct answer

1. What is energy?
(A) Something that can only be created by burning fossil fuels (B) A force that only exists inside batteries and power plants (C) A type of invisible matter that floats in the air around us (D) The ability to do work or cause change — energy makes things move, heat up, light up, or change in some way

2. Which of the following is an example of kinetic energy?
(A) A soccer ball flying through the air after being kicked (B) A stretched rubber band held in place (C) A battery sitting in a drawer unused (D) A book sitting on a high shelf

3. A roller coaster car sits at the top of the first hill, about to go down. What type of energy does it have the most of at this moment?
(A) Kinetic energy because it is about to start moving very fast (B) Thermal energy because the metal track is warm from the sun (C) Gravitational potential energy — stored energy due to its height above the ground (D) Chemical energy because the motor pushed it up the hill

4. When you rub your hands together quickly, they get warm. What energy transformation is happening?
(A) Chemical energy from your skin is being released into the air (B) Kinetic energy (motion of your hands) is converting to thermal energy (heat) through friction (C) Electrical energy from your nerves is heating up your palms (D) Light energy from the room is being absorbed by your hands

5. A flashlight converts chemical energy from its batteries into light and heat. If you measured all the energy going in (from the battery) and all the energy coming out (light + heat), what would you find?
(A) More energy comes out than goes in because the flashlight amplifies the battery's power (B) The total energy coming out equals the total energy going in — energy is conserved, it just changes form (C) Less energy comes out because some

energy is destroyed inside the flashlight (D) You can't measure energy so there's no way to compare input and output

6. Your body converts energy from food to do many things. Trace the energy transformations from eating an apple to running across a playground.
(A) Thermal energy from the apple → potential energy in your stomach → kinetic energy of running (B) Chemical energy in the apple → chemical energy stored in your body's cells → kinetic energy (muscle movement) + thermal energy (body heat) (C) Light energy from the sun → kinetic energy in your legs → sound energy from your footsteps (D) Electrical energy in your brain → nuclear energy in your muscles → kinetic energy of running

Write the answer

7. A wind-up toy car works by turning a key that tightens a spring inside. When released, the car moves across the floor. Apply the concept of energy transformation to explain each step of how this toy works.
Answer: _____

8. Solar panels convert sunlight into electricity. But on a cloudy day, a solar panel produces much less electricity than on a sunny day. Analyze why the same solar panel performs differently under different conditions.
Answer: _____

9. An incandescent lightbulb converts electrical energy into light, but it also produces a lot of heat. An LED bulb produces the same amount of light but much less heat. Both use electrical energy as input. Analyze which bulb is more energy-efficient and explain why.
Answer: _____

10. A perpetual motion machine is a hypothetical device that, once started, would run forever without any energy input. Evaluate whether such a machine could actually exist, and explain your reasoning using the law of conservation of energy.
Answer: _____

Match each question to its answer

1. What unit is used to measure energy in the metric system? →
2. What is the difference between energy and power? →
3. Name the six main forms of energy. →
4. When a drummer hits a drum, multiple energy transformations happen at once. Trace all the energy changes from the drummer's arm movement to the sound reaching your ears. →
5. A student says: 'When I turn off a light, the energy disappears.' Is this correct?

Explain what actually happens to the energy. →

(A) The joule (J) — named after physicist James Prescott Joule
(B) Chemical energy in muscles → kinetic energy of arm and drumstick → kinetic energy of drum membrane vibrating → sound energy (pressure waves in air) → kinetic energy of your eardrum vibrating → electrical signals in your nerves
(C) Energy is the total amount of work that can be done, while power is how fast that energy is used — power equals energy divided by time
(D) The energy doesn't disappear — when you flip the switch, you stop the flow of electrical energy to the bulb. The light and heat the bulb was producing have already been absorbed by the room (warming surfaces and being absorbed by walls). Energy is never destroyed, only transformed
(E) Kinetic (motion), potential (stored — gravitational, elastic, chemical), thermal (heat), electrical, light (radiant/electromagnetic), and sound

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2. Electricity and Circuits

Circle the correct answer

11. What is electric current?
(A) The weight of a battery (B) The flow of electric charge through a conductor (C) The brightness of a light bulb (D) Static electricity sitting on a surface

12. Which material would make the best conductor of electricity?
(A) Rubber band (B) Wooden stick (C) Copper wire (D) Glass rod

13. A simple circuit has a battery, a wire, and a light bulb. Why does the bulb light up?
(A) Electric charge flows in a complete loop from the battery through the bulb and back (B) The battery sends light through the wire to the bulb (C) The bulb generates its own energy when connected to wire (D) The wire creates its own electricity to power the bulb

14. What happens to the brightness of bulbs when you add more bulbs in a series circuit?
(A) The brightness stays exactly the same for all bulbs (B) Only the first bulb lights up and the rest stay dark (C) Each bulb gets dimmer because they share the available energy (D) Each bulb gets brighter because more bulbs create more energy

15. In a parallel circuit with three light bulbs, one bulb burns out. What happens to the other two?
(A) The other two bulbs become much brighter (B) The other two bulbs start flickering (C) The other two bulbs continue to shine normally (D) All three bulbs go out immediately

16. A battery is labeled 9 volts. What does 'voltage' measure?
(A) How many electrons the battery contains (B) How fast the battery will run out of power (C) The physical size and weight of the battery (D) The amount of energy the battery gives to each unit of electric charge

Write the answer

17. You are building a flashlight circuit. You have a battery, wires, a switch, and a bulb. In what order should you connect them to make the switch turn the light on and off?
Answer: _____

18. Why do electricians wear rubber gloves when working with electrical wiring?
Answer: _____

19. A student builds two circuits: Circuit A has two bulbs in series, and Circuit B has two bulbs in parallel. Both use identical batteries and bulbs. Which statement is true?
Answer: _____

20. What is electrical resistance?
Answer: _____

Match each question to its answer

1. A circuit has a 6-volt battery and a bulb that uses 2 amps of current. Using Ohm's Law (Resistance = Voltage ÷ Current), what is the resistance of the bulb? →
2. Why is a short circuit dangerous? →
3. Static electricity builds up when you rub a balloon on your hair. What is actually happening at the atomic level? →
4. A student measures that a toaster uses 10 amps of current from a 120-volt outlet. How much power does the toaster use? (Power = Voltage × Current) →
5. Your electricity bill shows that your family used 900 kilowatt-hours (kWh) last month. What does a kilowatt-hour actually measure? →

(A) Current flows through a path with almost no resistance, causing excessive heat that can start fires
(B) 1,200 watts
(C) Electrons transfer from your hair to the balloon, giving the balloon a negative charge
(D) The total amount of electrical energy consumed over time
(E) 3 ohms

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3. Renewable Energy Sources

Circle the correct answer

21. What makes an energy source 'renewable'?
(A) It is the cheapest type of energy to produce (B) It can only be found in tropical climates (C) It produces zero pollution of any kind (D) It is naturally replenished on a human timescale and will not run out with responsible use

22. Name four major types of renewable energy sources.
(A) Wind, gasoline, coal, and tidal (B) Solar, diesel, propane, and biomass (C) Solar, wind, hydroelectric, and geothermal (D) Coal, oil, natural gas, and nuclear

23. How does a solar photovoltaic (PV) panel generate electricity?
(A) Semiconductor materials in the panel absorb photons from sunlight and release electrons, creating an electric current (B) The panel stores sunlight during the day and releases it at night (C) Mirrors focus sunlight to create a laser beam that generates power (D) The panel heats water to create steam that spins a turbine

24. Why do wind turbines have long, thin blades instead of short, wide ones?
(A) Long blades sweep a larger area to capture more wind energy, while thin profiles reduce drag and allow them to spin efficiently (B) Short blades would be too heavy for the tower to support (C) Thin blades are cheaper to manufacture than wide ones (D) Wide blades would block too much sunlight from reaching the ground

25. A hydroelectric dam converts what form of energy into electrical energy?
(A) Chemical energy stored in the water molecules (B) Nuclear energy from hydrogen atoms in the water (C) Gravitational potential energy of water stored at a height (D) Thermal energy from the sun heating the water

26. Where does geothermal energy come from?
(A) Heat from the Earth's interior, produced by radioactive decay and residual heat from the planet's formation (B) Chemical reactions between underground minerals and water (C) Friction caused by the moon's gravitational pull on the Earth (D) Heat absorbed from the sun's rays by dark-colored rocks

Write the answer

27. A city is planning a solar farm. Which of these factors would MOST reduce the farm's electricity output?
Answer: _____

28. What is the main environmental concern about large hydroelectric dams?
Answer: _____

29. Iceland generates nearly 100% of its electricity from renewable sources (geothermal and hydroelectric). Why can't every country do the same?
Answer: _____

30. A wind farm produces 50 megawatts of power when the wind blows at optimal speed. But on a calm day, it produces almost nothing. What term describes this challenge?
Answer: _____

Match each question to its answer

1. How can energy storage solve the intermittency problem of renewable energy? →
2. Solar panels on a house in the Northern Hemisphere should ideally face which direction? →
3. Offshore wind farms are often more productive than onshore wind farms. Why? →
4. A pumped-storage hydroelectric facility uses two reservoirs at different elevations. During low-demand hours, it pumps water uphill. During peak demand, it releases the water downhill through turbines. What energy conversion happens when water is pumped uphill? →
5. A community wants to install renewable energy but is located in a flat, cloudy region with no nearby rivers or volcanic activity. Which renewable source is their best option? →

(A) Electrical energy is converted to gravitational potential energy for storage
(B) Wind energy, since flat terrain with few obstacles often has consistent wind
(C) Batteries store excess energy generated during sunny or windy periods and release it when generation drops
(D) Ocean winds are stronger and more consistent because there are no buildings, trees, or hills to slow them down
(E) South, because the sun travels across the southern sky

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4. Fossil Fuels and Environmental Impact

Circle the correct answer

31. What are the three main types of fossil fuels?
(A) Coal, oil (petroleum), and natural gas (B) Wood, charcoal, and biomass (C) Uranium, plutonium, and thorium (D) Solar, wind, and geothermal

32. How did fossil fuels form?
(A) Volcanic eruptions melted rocks and created fuel deposits, which is why this approach is recommended by experts (B) Dinosaur bones decomposed and turned into oil and coal, as this directly follows from the underlying principles (C) Ancient organisms died and were buried under layers of sediment, then heat and pressure over millions of years converted their remains into fossil fuels (D) Underground rivers carried minerals that formed into fuel, as this is what research and standard practice suggests

33. What is the greenhouse effect?
(A) The ozone layer blocks all heat from escaping into space (B) Plants in greenhouses produce gases that warm the entire planet (C) Certain gases in the atmosphere trap heat from the sun, warming Earth's surface like the glass of a greenhouse (D) Factories release green-colored gases that create smog

34. Which greenhouse gas is released in the largest quantity by burning fossil fuels?
(A) Oxygen (O_2) (B) Carbon dioxide (CO_2) (C) Nitrogen (N_2) (D) Helium (He)

35. How does a coal-fired power plant generate electricity?
(A) Coal is ground into powder and directly converted to electricity in fuel cells (B) Coal is heated until it glows, and the light is captured by solar cells (C) Coal is burned to heat water into steam, which spins a turbine connected to a generator that produces electricity (D) Coal is dissolved in water and the chemical reaction generates current

36. Natural gas is sometimes called a 'bridge fuel.' What does this mean?
(A) Natural gas was discovered under a famous bridge, which is the most common explanation for this phenomenon (B) Natural gas is used to power bridges and tunnels, as this directly follows from the underlying principles (C) Natural gas creates a chemical bridge between hydrogen and oxygen, as this is what research and standard practice suggests (D) Natural gas produces fewer emissions than coal or oil, so it can serve as a transitional fuel while renewable energy infrastructure is built

Write the answer

37. What is the carbon cycle, and how have humans disrupted it?
Answer: _____

38. A typical car burning gasoline produces about 4.6 metric tons of CO_2 per year. If an electric car is charged entirely from solar panels, how much tailpipe CO_2 does it produce?
Answer: _____

39. What is 'acid rain' and how is it connected to fossil fuel use?
Answer: _____

40. Why can't we simply stop using all fossil fuels tomorrow?
Answer: _____

Match each question to its answer

1. Methane (CH_4) is a greenhouse gas that traps about 80 times more heat per molecule than CO_2 over a 20-year period. Where does methane come from in the energy sector? →
2. What is a 'carbon footprint'? →
3. An oil spill from a tanker contaminates a coastal area. List three ways this harms the ecosystem. →
4. What is 'carbon capture and storage' (CCS) technology? →
5. Coal mining can happen at the surface (strip mining) or underground. Compare the environmental impacts of these two methods. →

(A) Oil coats seabirds preventing flight and insulation, suffocates fish by clogging gills, and kills marine plants by blocking sunlight
(B) A process that captures CO_2 from power plant exhaust before it enters the atmosphere and stores it underground in geological formations
(C) Strip mining destroys surface habitats and landscapes but is safer for miners, while underground mining preserves surface land but risks mine collapses, toxic water drainage, and miner health hazards
(D) Methane leaks from natural gas drilling sites, pipelines, and storage facilities, since natural gas is primarily methane
(E) The total amount of greenhouse gases produced by a person, organization, event, or product, usually measured in tons of CO_2 equivalent

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5. Power Grid and Energy Distribution

Circle the correct answer

41. What is an electrical grid?
(A) A type of battery that stores electricity underground (B) A network of power plants, transmission lines, substations, and distribution lines that delivers electricity from generators to consumers (C) A metal screen placed on windows to protect against lightning (D) A single power line connecting one house to one power plant

42. Why is electricity transmitted at very high voltages (hundreds of thousands of volts) over long distances?
(A) High voltage is cheaper because it uses less wire material (B) Low voltage would cause the wires to become magnetic and attract metal objects (C) High voltage makes electricity travel faster through the wires (D) Higher voltage reduces current, which

reduces energy lost as heat in the transmission wires

43. What does a transformer do in the electrical grid?
(A) It stores electricity for use during power outages (B) It measures how much electricity each home uses (C) It changes voltage levels — stepping up for long-distance transmission and stepping down for safe delivery to homes (D) It converts DC power from solar panels into AC power

44. What is 'load balancing' on the electrical grid?
(A) Connecting the same number of power plants to each city (B) Continuously matching electricity generation to electricity demand so the grid stays stable (C) Making sure every home pays the same electricity bill (D) Distributing the physical weight of power lines equally between towers

45. The AC electricity in the US grid operates at exactly 60 hertz. What does this mean, and why does it matter?
(A) The voltage level is maintained at 60 volts across the grid, which is why this approach is recommended by experts (B) The current reverses direction 60 times per second; all generators and devices on the grid must maintain this exact frequency or equipment can be damaged (C) Each power plant produces exactly 60 watts of electricity, which is why this approach is recommended by experts (D) Electricity travels at 60 miles per hour through the wires, making this the most widely accepted explanation

46. Why does electricity demand typically peak in the late afternoon during summer?
(A) The sun is strongest at noon, so solar panels create a surplus (B) Power plants produce more electricity in the afternoon naturally (C) Factories run more machines in the afternoon than the morning (D) Air conditioning use surges as buildings absorb heat throughout the day, while people return home and turn on appliances

Write the answer

47. A power plant generates 1,000 MW of electricity. After traveling 300 miles through transmission lines, only 940 MW reaches the destination. What happened to the other 60 MW?
Answer: _____

48. What is a 'microgrid' and how does it differ from the main grid?
Answer: _____

49. What is the 'duck curve' in electricity grid management?
Answer: _____

50. How can smart grid technology help integrate more renewable energy?
Answer: _____

Match each question to its answer

1. What is 'demand response' and how does it help the grid? →
2. In August 2003, a massive blackout left 55 million people without power across the northeastern US and Canada. The outage cascaded across states in just 8 seconds. How can one failure cause such widespread collapse? →
3. What role do 'baseload' power plants play in the grid? →
4. Why do power companies charge more for electricity during peak hours? →
5. An inverter is a critical component in solar energy systems. What does it do? →

(A) A system where consumers voluntarily reduce electricity use during peak periods in exchange for lower rates, helping balance supply and demand without building more power plants
(B) When one section fails, its electrical load transfers to neighboring sections, which can become overloaded and fail too, creating a chain reaction across the interconnected grid
(C) They run continuously at a steady output to meet the minimum constant demand, providing the foundation that variable sources are built on top of
(D) Generating peak-hour electricity requires expensive, less-efficient backup plants that only run during high demand, and the infrastructure must be built to handle these maximum loads
(E) It converts the DC (direct current) electricity from solar panels into AC (alternating current) electricity that the grid and home appliances use

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6. Thermodynamics and Energy Efficiency

Circle the correct answer

51. What does the First Law of Thermodynamics state?
(A) Heat always flows from cold objects to hot objects, which is the most common explanation for this phenomenon (B) Energy cannot be created or destroyed, only converted from one form to another — the total energy in a closed system is always conserved (C) Machines can create energy if they are efficient enough, which is why this approach is recommended by experts (D) All energy eventually becomes light energy, making this the most widely accepted explanation

52. What does the Second Law of Thermodynamics tell us about energy conversions?
(A) Cold objects can spontaneously transfer heat to hot objects, as this directly follows from the underlying principles (B) You can only convert energy twice before it disappears, and this is the standard approach used in most cases (C) Energy conversions always produce light as a byproduct, which is why this approach is

recommended by experts (D) Every energy conversion increases the total entropy of a system — some useful energy is always lost as waste heat, making 100% efficiency impossible

53. What is 'energy efficiency' in the context of a machine or device?
(A) The ratio of useful energy output to total energy input, expressed as a percentage (B) How quietly a machine operates while running (C) The total amount of energy a machine uses in one hour (D) How fast a machine can produce energy

54. A gasoline car engine is about 25% efficient. What happens to the other 75% of the fuel's energy?
(A) It is converted into sound energy that propels the car forward (B) It evaporates into the atmosphere as pure energy (C) It is stored in the car's battery for later use (D) It is lost as waste heat — through the exhaust, radiator, and friction — and cannot be recovered for propulsion

55. What is the Carnot limit and why does it matter for power generation?
(A) The largest power plant that can be built in one location, making this the most widely accepted explanation (B) The total amount of energy available in the universe, which is why this approach is recommended by experts (C) The Carnot limit is the maximum theoretical efficiency any heat engine can achieve, determined by the temperature difference between its hot source and cold sink — no real engine can exceed this limit (D) The maximum speed at which a turbine can safely spin, as this directly follows from the underlying principles

56. What is a Sankey diagram and how is it used in energy analysis?
(A) A flow diagram where the width of arrows represents energy quantity, showing how input energy splits into useful output and various waste streams (B) A blueprint for building a new type of generator, and this is the standard approach used in most cases (C) A chart showing the price of different energy sources over time, which is the most common explanation for this phenomenon (D) A map showing where power plants are located in a country, and this principle applies across similar situations

Write the answer

57. Heat naturally flows from hot objects to cold objects. Why can a refrigerator move heat from cold (inside) to hot (kitchen)?
Answer: _____

58. An LED light bulb uses 10 watts to produce the same brightness as a 60-watt incandescent bulb. Calculate the energy saved per year if the bulb is used 5 hours per day.
Answer: _____

59. What is 'cogeneration' (also called combined heat and power)?
Answer: _____

60. Why is a heat pump more efficient than an electric heater for warming a building?
Answer: _____

Match each question to its answer

1. What is 'thermal equilibrium'? →
2. Three methods of heat transfer are conduction, convection, and radiation. Which method allows the Sun's energy to reach Earth through the vacuum of space? →
3. A combined-cycle gas turbine (CCGT) power plant has two stages: a gas turbine followed by a steam turbine that uses the gas turbine's waste heat. If the gas turbine is 35% efficient and the steam turbine captures 50% of the waste heat, what is the overall plant efficiency? →
4. Building insulation reduces heat transfer between inside and outside. A well-insulated house loses 5 kW of heat on a cold day, while a poorly insulated house loses 15 kW. If heating costs $0.10 per kWh, how much does the well-insulated house save in a 24-hour cold period? →
5. What is 'entropy' in simple terms, and why does it always increase? →

(A) Entropy is a measure of energy dispersal or disorder in a system — it always increases because energy naturally spreads out from concentrated to dispersed forms
(B) Radiation — electromagnetic waves that can travel through empty space without needing any material medium
(C) The state when two objects in contact reach the same temperature and heat stops flowing between them
(D) 67.5% (Gas turbine: 35% useful + 65% waste; Steam turbine: 50% of 65% = 32.5% additional useful; Total: 35% + 32.5% = 67.5%)
(E) $24.00 saved (Difference: 10 kW × 24 hours = 240 kWh; 240 × $0.10 = $24.00)

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7. Sustainable Engineering Design

Circle the correct answer

61. What is the engineering design process?
(A) A single step where engineers build whatever they imagine, and this principle applies across similar situations (B) A systematic cycle of defining problems, researching constraints, brainstorming solutions, building prototypes, testing, and refining designs based on results (C) A method for manufacturing products as cheaply as possible, making this the most widely accepted explanation (D) A process where scientists discover new laws of physics, as this directly follows from the

underlying principles

62. What does it mean for an engineering design to have 'constraints'?
(A) Constraints are optional suggestions that engineers can ignore, and this principle applies across similar situations (B) Constraints are limitations that the design must work within, such as budget, available materials, physical laws, safety requirements, and environmental regulations (C) Constraints are the goals that the design is trying to achieve, and this principle applies across similar situations (D) Constraints are the tools used to build the prototype, and this principle applies across similar situations

63. What is a 'life cycle assessment' (LCA) for an energy technology?
(A) A measurement of how many years a power plant operates, which is why this approach is recommended by experts (B) An analysis of total environmental impact from raw material extraction through manufacturing, operation, and eventual disposal or recycling — the full cradle-to-grave footprint (C) A study of how organisms are affected by living near a power plant, making this the most widely accepted explanation (D) A test of how long a battery lasts before it needs replacement, which is the most common explanation for this phenomenon

64. Why do engineers use 'levelized cost of energy' (LCOE) rather than just the price per watt of a power plant?
(A) LCOE is a marketing term that makes renewable energy look cheaper, which is the most common explanation for this phenomenon (B) LCOE is the same as price per watt — just a different name, which is why this approach is recommended by experts (C) LCOE only measures construction costs, which are the most important, making this the most widely accepted explanation (D) LCOE includes all costs over the entire lifetime (construction, fuel, maintenance, decommissioning) divided by total energy produced, enabling fair comparison across different energy sources

65. An engineer is designing a wind turbine for a remote village. The village needs 50 kW of average power, but wind data shows the location averages 6 m/s wind speed with a capacity factor of 30%. What rated capacity turbine should they specify?
(A) 15 kW — because 30% of 50 is 15 (B) 500 kW — to ensure there is always enough power (C) About 167 kW rated capacity (50 kW ÷ 0.30 = 166.7 kW, round up to nearest available size) (D) 50 kW — the turbine should match the demand exactly

66. What are 'rare earth elements' and why are they a concern for renewable energy technology?
(A) Rare earth elements like neodymium and dysprosium are used in wind turbine magnets and EV motors; they are concentrated in a few countries, creating supply chain vulnerability and environmental concerns from mining (B) They are fossil fuels found only in rare geological formations, and this has been consistently demonstrated in practice (C) They are a type of renewable energy source found in soil, which is the most common explanation for this phenomenon (D) Rare earth elements are

radioactive materials used in nuclear fuel rods, and this is the standard approach used in most cases

Write the answer

67. What is 'energy density' and why does it matter for battery design?
Answer: _____

68. A school project requires building a model solar water heater. Which design choice would maximize heat absorption?
Answer: _____

69. What is the 'energy payback time' for a solar panel, and why is it an important metric?
Answer: _____

70. An island nation wants to achieve 100% renewable electricity. They have strong trade winds, moderate sunshine, and limited land area. Design an energy system addressing generation, storage, and grid stability.
Answer: _____

Match each question to its answer

1. What is 'green hydrogen' and why is it considered important for decarbonizing heavy industry? →
2. Lithium-ion batteries degrade over time. A battery that starts with 100 kWh capacity might have only 80 kWh after 10 years. What can be done with these degraded EV batteries? →
3. What is 'embodied energy' and why must engineers consider it when choosing sustainable materials? →
4. Compare three battery chemistries for grid storage: lithium-ion, iron-air, and flow batteries. Which is best suited for storing 100 hours of renewable energy? →
5. An engineer must decide between building a new natural gas plant or a solar-plus-battery system to meet a city's electricity needs. Both have the same LCOE. What other factors should influence the decision? →

(A) Green hydrogen is produced by splitting water using renewable electricity (electrolysis) — it can replace fossil fuels in steel production, chemical manufacturing, and long-haul transport where batteries aren't practical

(B) Carbon emissions and climate commitments, fuel price volatility risk, air quality impacts on public health, local job creation, grid flexibility, water usage, construction timeline, and long-term technology cost trends

(C) Embodied energy is the total energy consumed during a material's extraction, processing, manufacturing, and transportation — a material that saves energy in use

but requires enormous energy to produce may not be truly sustainable
(D) Iron-air batteries — they use cheap, abundant iron and are designed for very long duration storage (100+ hours) at low cost per kWh, though they charge and discharge slowly
(E) Repurpose them as stationary grid storage — 80% capacity is too low for vehicles but perfectly adequate for storing solar energy at homes or businesses, extending the battery's useful life by 10+ more years

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8. Master Grid Engineer Capstone

Circle the correct answer

71. A power plant burns coal to heat water into steam, which spins a turbine connected to a generator. How many energy transformations occur in this process?
(A) Two: chemical → electrical (B) One: coal → electricity (C) Three: chemical → thermal → electrical (D) Four: chemical → thermal → mechanical → electrical

72. What is the fundamental reason that high-voltage transmission lines are used to carry electricity over long distances?
(A) High voltage is needed because electricity loses voltage naturally over distance (B) Higher voltage means lower current for the same power, reducing I^2R heat losses in the wires (C) Higher voltage makes electricity travel faster through the wires (D) Thick wires can only handle high-voltage electricity safely

73. A city currently generates 500 MW from natural gas plants operating at 40% efficiency. If they switch to combined-cycle gas turbines at 60% efficiency, how much less fuel (in percentage) would they need to produce the same 500 MW?
(A) 20% less fuel (B) 40% less fuel (C) 50% less fuel (D) 33% less fuel

74. Why does the 'duck curve' problem get worse as a region installs more solar panels?
(A) Duck curve only affects regions near the equator where solar is strongest (B) Solar panels become less efficient when too many are installed close together (C) The electrical grid cannot handle more than a certain percentage of solar power (D) More solar creates a deeper midday surplus and steeper evening ramp when solar drops off, requiring faster-responding backup generators

75. A community is debating whether to build a new natural gas plant or invest in wind turbines plus battery storage. The gas plant costs $400 million with an LCOE of $55/MWh. The wind-plus-storage system costs $600 million with an LCOE of $48/MWh. Which factors should weigh most heavily in this decision?
(A) The wind system is clearly better because its LCOE is lower (B) Long-term LCOE

favors wind-plus-storage despite higher upfront cost, but grid reliability, financing availability, and CO_2 reduction goals all matter (C) The decision should be based solely on which option creates more local jobs (D) The gas plant is clearly better because it costs $200 million less to build

76. What is the Second Law of Thermodynamics, and why does it matter for energy engineering?
(A) Heat always flows from cold objects to hot objects without external work (B) All machines eventually stop working because energy is used up (C) Energy cannot be created or destroyed, only transformed between forms (D) Energy conversions always increase entropy — some energy becomes unavailable waste heat, making 100% efficiency impossible for heat engines

Write the answer

77. Explain why a heat pump can deliver 3-4 units of heating energy for every 1 unit of electrical energy it consumes, without violating the laws of thermodynamics.
Answer: _____

78. A school has 200 solar panels, each rated at 350 watts. The panels have a capacity factor of 18% in their location. How much energy (in kWh) do they produce in a 30-day month?
Answer: _____

79. A region has three power sources: a coal plant (800 MW, $45/MWh LCOE, 900 g CO_2/kWh), a wind farm (400 MW capacity, 35% capacity factor, $42/MWh, 11 g CO_2/kWh), and a natural gas plant (600 MW, $50/MWh, 450 g CO_2/kWh). During peak demand of 1000 MW, which combination minimizes cost while meeting demand?
Answer: _____

80. Some people argue that nuclear power should be expanded to fight climate change because it produces nearly zero carbon emissions during operation. Others argue it should be phased out due to waste and safety concerns. What is the strongest argument for including nuclear in a climate strategy?
Answer: _____

Match each question to its answer

1. What does the energy payback time of a solar panel measure? →
2. A parallel circuit has three branches with resistances of 10Ω, 20Ω, and 20Ω connected to a 40V battery. Explain why the 10Ω branch carries more current than the others, and calculate the total current drawn from the battery. →
3. A wind farm has 50 turbines, each rated at 3 MW. The farm's annual capacity factor is 32%. If the average household uses 10,000 kWh per year, how many households can

this wind farm power? →
4. Compare the energy storage challenge for a grid that is 30% renewable versus one that is 80% renewable. Why does the difficulty increase non-linearly? →
5. A company claims their new battery technology can store energy at $20/kWh and last 20 years with 10,000 charge cycles. Compared to current lithium-ion batteries ($150/kWh, 10-year lifespan, 5,000 cycles), evaluate whether this claim seems credible. →

(A) At 30%, fossil fuels easily fill gaps. At 80%, storage must cover multi-day weather events, seasonal variation, and rapid ramps — requiring fundamentally different storage technologies and much larger capacity
(B) The time it takes for the panel to generate as much energy as was used to manufacture, transport, and install it
(C) The claim represents a 7.5× cost reduction and 2× lifespan improvement simultaneously — such dramatic leaps across multiple metrics are extremely rare and warrant skepticism until independently verified
(D) About 42,048 households
(E) Lower resistance allows more current (V=IR, so I=V/R). The 10Ω branch carries 4A, each 20Ω branch carries 2A, totaling 8A from the battery

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9. Energy & Power

Circle the correct answer

81. What is nuclear fission?
(A) The combining of two light nuclei into a heavier one (B) The absorption of neutrons by a stable atom (C) The decay of a radioactive isotope over time (D) The splitting of a heavy atomic nucleus into smaller nuclei

82. What fuel is most commonly used in nuclear power plants?
(A) Uranium-235 (B) Hydrogen-2 (C) Thorium-230 (D) Plutonium-244

83. What device is used to control the rate of fission in a nuclear reactor?
(A) Control rods (B) Steam turbines (C) Cooling towers (D) Fuel rods

84. What is nuclear fusion?
(A) The conversion of nuclear waste into stable elements (B) The emission of gamma rays from an unstable atom (C) The splitting of a heavy nucleus into lighter nuclei (D) The combining of two light nuclei to form a heavier nucleus

85. What type of radiation consists of two protons and two neutrons?
(A) Alpha radiation (B) Beta radiation (C) Neutron radiation (D) Gamma radiation

86. What is the term for the time it takes for half of a radioactive sample to decay?
(A) Fission time (B) Half-life (C) Decay constant (D) Radiation period

Write the answer

87. Why does nuclear fission release energy?
Answer: _____

88. How does a nuclear power plant generate electricity?
Answer: _____

89. Why is nuclear fusion difficult to achieve on Earth?
Answer: _____

90. What is a chain reaction in the context of nuclear fission?
Answer: _____

Match each question to its answer

1. How does alpha radiation differ from gamma radiation in terms of penetrating power? →
2. A nuclear reactor uses 200 kg of uranium-235 per year. If the plant operates for 30 years, how much total uranium fuel is consumed? →
3. If a radioactive isotope has a half-life of 10 years and you start with 80 grams, how much remains after 30 years? →
4. A nuclear power plant produces 1,000 MW of electricity. If it operates at 90% capacity factor for a year, how many megawatt-hours does it generate? →
5. A sample of radioactive material has a half-life of 5 years. What fraction of the original sample remains after 20 years? →

(A) 10 grams
(B) 7,884,000 MWh
(C) Alpha particles are stopped by paper, while gamma rays can pass through most materials
(D) 1/16
(E) 6,000 kg

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10. Energy & Power

Circle the correct answer

91. What type of energy is stored in a battery?
(A) Kinetic energy (B) Nuclear energy (C) Thermal energy (D) Chemical energy

92. What are the two electrodes in a battery called?
(A) Conductor and insulator (B) Positive and neutral (C) Proton and electron (D) Anode and cathode

93. What type of battery is most commonly used in smartphones and laptops?
(A) Alkaline battery (B) Lithium-ion battery (C) Nickel-cadmium battery (D) Lead-acid battery

94. What is a fuel cell?
(A) A container for storing gasoline, and this is the standard approach used in most cases (B) A device that converts chemical energy from a fuel (like hydrogen) directly into electricity (C) A type of solar panel that stores fuel, and this principle applies across similar situations (D) A battery that cannot be recharged, as this is what research and standard practice suggests

95. What is a capacitor?
(A) A device that stores energy in an electric field between two conductive plates (B) A type of battery that uses acid (C) A wire that resists the flow of current (D) A generator that converts motion to electricity

96. What does the unit 'watt-hour' (Wh) measure?
(A) The voltage of a battery (B) The amount of energy a battery can store or deliver (C) The speed at which a battery charges (D) The weight of a battery

Write the answer

97. Why do lithium-ion batteries eventually lose their ability to hold a full charge over time?
Answer: _____

98. How does a hydrogen fuel cell produce electricity without combustion?
Answer: _____

99. Why can a capacitor deliver energy much faster than a battery?
Answer: _____

100. What is the difference between energy density and power density in batteries?
Answer: _____

Match each question to its answer

1. Why is pumped hydro storage considered a form of energy storage even though it doesn't use batteries? →
2. A smartphone battery is rated at 4,000 mAh at 3.7 V. What is its energy capacity in watt-hours? →

3. A battery bank stores 500 kWh of energy. If a home uses 30 kWh per day, how many days can the battery bank power the home? →
4. A capacitor can deliver 1,000 watts for 2 seconds. How much energy does it release in joules? →
5. If a lithium-ion battery retains 80% of its original capacity after 500 charge cycles, and it started at 5,000 mAh, what is its capacity after 500 cycles? →

(A) 4,000 mAh
(B) 2,000 joules
(C) 14.8 Wh
(D) About 16.7 days
(E) It stores energy by pumping water uphill and releases it by letting the water flow back down through turbines

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11. Energy & Power

Circle the correct answer

101. What does energy efficiency mean?
(A) Using as much energy as possible (B) Generating energy from renewable sources (C) Storing energy in batteries for later use (D) The ratio of useful energy output to total energy input

102. What is the main form of wasted energy in most machines?
(A) Heat (B) Sound (C) Magnetic energy (D) Light

103. What does the Energy Star label on an appliance indicate?
(A) The appliance runs on solar power (B) The appliance meets government standards for energy efficiency (C) The appliance was made in the United States (D) The appliance is the cheapest option available

104. What unit is commonly used on electricity bills to measure energy consumption?
(A) Ampere (A) (B) Volt (V) (C) Watt (W) (D) Kilowatt-hour (kWh)

105. What type of light bulb is the most energy-efficient?
(A) Halogen (B) Incandescent (C) LED (Light-Emitting Diode) (D) Fluorescent

106. What is an energy audit?
(A) A test of how much energy a power plant produces (B) An inspection of electrical wiring for safety (C) A systematic assessment of how energy is used in a building to identify ways to reduce consumption (D) A financial review of energy company profits

Write the answer

107. Why is insulation important for energy efficiency in buildings?
Answer: _____

108. How does a programmable thermostat save energy compared to a manual thermostat?
Answer: _____

109. Why do incandescent light bulbs waste so much energy?
Answer: _____

110. Explain why 'phantom loads' or 'standby power' from electronics waste energy.
Answer: _____

Match each question to its answer

1. How does combined heat and power (CHP) improve the overall efficiency of a power plant? →
2. An incandescent bulb uses 60 W and an LED bulb produces the same brightness using 9 W. If both run for 5 hours per day for 30 days, how much energy does each use? →
3. If electricity costs $0.12 per kWh, how much money per year does a household save by replacing ten 60 W incandescent bulbs with ten 9 W LEDs, assuming 5 hours of use per day? →
4. A furnace has an efficiency rating of 80%. If it consumes 100,000 BTUs of natural gas, how many BTUs of useful heat does it deliver? →
5. A washing machine uses 500 Wh per cycle on the warm setting and 200 Wh per cycle on the cold setting. If a family does 6 loads per week, how much energy per year do they save by switching to cold water? →

(A) Incandescent: 9 kWh; LED: 1.35 kWh
(B) 93.6 kWh per year
(C) CHP captures the waste heat from electricity generation and uses it for heating buildings or industrial processes, raising overall efficiency from about 33% to 80%+
(D) About $112 per year
(E) 80,000 BTUs

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12. Energy & Power

Circle the correct answer

111. What is a smart grid?
(A) A grid that only uses artificial intelligence, which is why this approach is recommended by experts (B) An electricity network that uses digital technology to monitor and manage the flow of electricity from all sources to meet demand efficiently (C) A grid made of smart materials that generate electricity, and this is the standard approach used in most cases (D) A small solar panel used on smartphones, and this principle applies across similar situations

112. What is hydrogen fuel and how is it most commonly produced today?
(A) Hydrogen is extracted from water using solar-powered robots (B) Hydrogen is mined from underground deposits like natural gas (C) Hydrogen is a radioactive fuel made in nuclear reactors (D) Hydrogen is a clean-burning fuel that is currently most commonly produced by steam methane reforming of natural gas

113. What is the purpose of energy research into nuclear fusion?
(A) To create artificial stars for space travel (B) To find new ways to split uranium atoms more efficiently (C) To develop a nearly limitless, clean energy source by replicating the process that powers the Sun (D) To replace all batteries with fusion reactors

114. What does the term 'green hydrogen' mean?
(A) Hydrogen produced from plants and algae (B) Hydrogen produced using renewable energy to split water through electrolysis, with no carbon emissions (C) Any hydrogen used in environmentally friendly vehicles (D) Hydrogen that is dyed green for identification

115. What is a microgrid?
(A) A grid that only powers microscopes and small lab equipment (B) A local energy system that can operate independently from the main power grid, using local generation and storage (C) A very small battery used in watches (D) A power grid that covers an entire country

116. What is perovskite and why is it important for solar energy?
(A) Perovskite is a wind turbine blade material, and this is the standard approach used in most cases (B) Perovskite is a crystal structure used in a new type of solar cell that can be cheaper and easier to manufacture than traditional silicon cells (C) Perovskite is a rare gas used in fusion reactors, as this is what research and standard practice suggests (D) Perovskite is a type of nuclear fuel, as this directly follows from the underlying principles

Write the answer

117. Why is energy storage considered the key challenge for transitioning to 100% renewable energy?
Answer: _____

118. How does a smart grid differ from a traditional power grid?
Answer: _____

119. Why is nuclear fusion considered safer than nuclear fission?
Answer: _____

120. Explain how vehicle-to-grid (V2G) technology could help stabilize the electricity grid.
Answer: _____

Match each question to its answer

1. Why is long-duration energy storage (days to weeks) harder to achieve than short-duration storage (hours)? →
2. A city has 50,000 EVs with an average battery capacity of 60 kWh each. If 20% of EVs participate in V2G and each contributes half their battery, how much energy is available to the grid? →
3. If green hydrogen electrolysis has an efficiency of 70%, how much renewable electricity (in kWh) is needed to produce hydrogen containing 100 kWh of energy? →
4. A perovskite-silicon tandem solar cell has an efficiency of 30%, while a standard silicon cell has 20% efficiency. For a rooftop that receives 5 kWh/m^2/day of sunlight, how much more energy does 10 m^2 of tandem cells produce per day compared to standard silicon? →
5. A smart grid reduces transmission losses from 7% to 4%. If a power plant generates 1,000,000 MWh per year, how many additional MWh reach consumers with the smart grid? →

(A) 30,000 MWh
(B) Current battery technologies lose energy over time and are cost-prohibitive at the scale needed for multi-day storage, requiring entirely different approaches like hydrogen or compressed air
(C) About 143 kWh
(D) 5 kWh more per day
(E) 300,000 kWh (300 MWh)

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13. Solar Energy

Circle the correct answer

121. Thermal energy is different from temperature. A swimming pool at 25°C has much more thermal energy than a cup of hot coffee at 80°C. Explain why.
(A) This statement is wrong — the hotter coffee must have more thermal energy, which is the most common explanation for this phenomenon (B) The pool has more thermal energy because water is a better conductor of heat than coffee (C) Thermal energy depends on BOTH temperature AND the amount of matter — the pool has vastly more water molecules, so even at a lower temperature, the total kinetic energy of all its molecules is much greater than the few molecules in the cup (D) The pool absorbs thermal energy from the sun, which the coffee cup doesn't, as this directly follows from the underlying principles

122. A roller coaster car sits at the top of the first hill, about to go down. What type of energy does it have the most of at this moment?
(A) Kinetic energy because it is about to start moving very fast (B) Chemical energy because the motor pushed it up the hill (C) Gravitational potential energy — stored energy due to its height above the ground (D) Thermal energy because the metal track is warm from the sun

123. Your body converts energy from food to do many things. Trace the energy transformations from eating an apple to running across a playground.
(A) Chemical energy in the apple → chemical energy stored in your body's cells → kinetic energy (muscle movement) + thermal energy (body heat) (B) Light energy from the sun → kinetic energy in your legs → sound energy from your footsteps (C) Electrical energy in your brain → nuclear energy in your muscles → kinetic energy of running (D) Thermal energy from the apple → potential energy in your stomach → kinetic energy of running

124. A flashlight converts chemical energy from its batteries into light and heat. If you measured all the energy going in (from the battery) and all the energy coming out (light + heat), what would you find?
(A) More energy comes out than goes in because the flashlight amplifies the battery's power (B) You can't measure energy so there's no way to compare input and output (C) Less energy comes out because some energy is destroyed inside the flashlight (D) The total energy coming out equals the total energy going in — energy is conserved, it just changes form

125. A hydroelectric dam uses falling water to generate electricity. Apply the concept of energy transformation to explain each step of how a hydroelectric dam works.
(A) Gravitational potential energy of water behind the dam → kinetic energy of water falling through pipes → kinetic energy of spinning turbine blades → electrical energy generated by the turbine's generator → transmitted through power lines to homes (B) Chemical energy of water → nuclear energy of the dam → electrical energy of the wires, and this principle applies across similar situations (C) Sound energy of the waterfall → kinetic energy of the dam → electrical energy for the grid, as this is what

research and standard practice suggests (D) Thermal energy of the river → magnetic energy of the dam → light energy in homes, and this principle applies across similar situations

126. A combined-cycle gas turbine (CCGT) power plant has two stages: a gas turbine followed by a steam turbine that uses the gas turbine's waste heat. If the gas turbine is 35% efficient and the steam turbine captures 50% of the waste heat, what is the overall plant efficiency?
(A) 67.5% (Gas turbine: 35% useful + 65% waste; Steam turbine: 50% of 65% = 32.5% additional useful; Total: 35% + 32.5% = 67.5%) (B) 17.5% (35% × 50%), and this has been consistently demonstrated in practice (C) 50% (average of 35% and 65%), which is why this approach is recommended by experts (D) 85% (35% + 50%), and this principle applies across similar situations

Write the answer

127. What is the difference between energy and power?
Answer: _____

128. What is electrical resistance?
Answer: _____

129. A homeowner plugs too many appliances into one outlet using power strips. The circuit breaker keeps tripping. Why?
Answer: _____

130. How can energy storage solve the intermittency problem of renewable energy?
Answer: _____

Match each question to its answer

1. What is 'agrivoltaics' and why is it gaining popularity? →
2. Offshore wind farms are often more productive than onshore wind farms. Why? →
3. What is the main environmental concern about large hydroelectric dams? →
4. Where does geothermal energy come from? →
5. What are the three main types of fossil fuels? →

(A) Coal, oil (petroleum), and natural gas
(B) Heat from the Earth's interior, produced by radioactive decay and residual heat from the planet's formation
(C) Growing crops underneath elevated solar panels, allowing the same land to produce both food and electricity
(D) They block fish migration routes and flood large areas of natural habitat
(E) Ocean winds are stronger and more consistent because there are no buildings,

trees, or hills to slow them down

14. Solar Energy

Circle the correct answer

131. What is energy?
(A) The ability to do work or cause change — energy makes things move, heat up, light up, or change in some way (B) Something that can only be created by burning fossil fuels (C) A type of invisible matter that floats in the air around us (D) A force that only exists inside batteries and power plants

132. A student claims that a parked car on top of a hill 'has no energy because it's not doing anything.' Evaluate this claim.
(A) The claim is incorrect — the parked car has gravitational potential energy due to its height, chemical energy stored in its fuel tank, thermal energy (it's above absolute zero), and even nuclear energy in its atoms. 'Not doing anything' doesn't mean 'has no energy' (B) The car only has kinetic energy from the Earth's rotation, and this principle applies across similar situations (C) The car has energy, but only if someone is inside it, which is the most common explanation for this phenomenon (D) The student is correct because energy requires motion

133. A perpetual motion machine is a hypothetical device that, once started, would run forever without any energy input. Evaluate whether such a machine could actually exist, and explain your reasoning using the law of conservation of energy.
(A) It already exists but governments are keeping it secret to protect energy companies, and this has been consistently demonstrated in practice (B) A perpetual motion machine is impossible because every real machine loses energy to friction, air resistance, and heat — without new energy input, the machine must eventually stop as its energy is converted to unusable thermal energy (C) It could exist if we found a material with zero friction, making this the most widely accepted explanation (D) It's possible in space where there's no gravity to slow things down, making this the most widely accepted explanation

134. Solar panels convert sunlight into electricity. But on a cloudy day, a solar panel produces much less electricity than on a sunny day. Analyze why the same solar panel performs differently under different conditions.
(A) Solar panels only work with direct sunlight and completely shut off when clouds appear, making this the most widely accepted explanation (B) Clouds make the air cold, which damages the solar panel's circuits, which is why this approach is recommended by experts (C) Clouds block and scatter much of the sun's light energy before it reaches the panel, so less light energy is available to convert to electrical

energy — the panel's conversion ability hasn't changed, but the energy input has decreased (D) The solar panel gets tired from working on sunny days and needs cloudy days to rest, making this the most widely accepted explanation

135. Design a waste-heat recovery system for a steel manufacturing plant where furnaces reach 1,500°C but the waste exhaust leaves at 600°C. What could you do with this high-temperature waste heat?
(A) Use the 600°C exhaust to generate electricity via a steam turbine (high Carnot efficiency at this temperature), preheat incoming materials to reduce furnace fuel needs, and supply remaining lower-temperature heat to nearby buildings or industrial processes (B) Vent the exhaust directly into the atmosphere — heat cannot be reused, and this has been consistently demonstrated in practice (C) Use the heat to melt more steel in a second furnace, and this is the standard approach used in most cases (D) Convert the heat directly into light using thermoelectric bulbs, which is the most common explanation for this phenomenon

136. Two cars are driving at the same speed, but Car A has twice the mass of Car B. Which car has more kinetic energy, and by how much?
(A) Car A has four times the kinetic energy because mass is squared in the formula (B) Car A has exactly twice the kinetic energy of Car B — kinetic energy is directly proportional to mass, so doubling the mass doubles the kinetic energy at the same speed (C) Both have the same kinetic energy because they're going the same speed (D) Car B has more kinetic energy because lighter objects move more easily

Write the answer

137. What is electric current?
Answer: _____

138. What makes an energy source 'renewable'?
Answer: _____

139. A city is planning a solar farm. Which of these factors would MOST reduce the farm's electricity output?
Answer: _____

140. Why do wind turbines have long, thin blades instead of short, wide ones?
Answer: _____

Match each question to its answer

1. A pumped-storage hydroelectric facility uses two reservoirs at different elevations. During low-demand hours, it pumps water uphill. During peak demand, it releases the water downhill through turbines. What energy conversion happens when water is pumped uphill? →
2. Coal mining can happen at the surface (strip mining) or underground. Compare the environmental impacts of these two methods. →
3. What is the difference between 'global warming' and 'climate change'? →
4. An inverter is a critical component in solar energy systems. What does it do? →
5. What is 'grid inertia' and why is it important for stability? →

(A) The physical spinning momentum of large generators that resists sudden frequency changes, acting as a buffer against rapid supply-demand imbalances
(B) Strip mining destroys surface habitats and landscapes but is safer for miners, while underground mining preserves surface land but risks mine collapses, toxic water drainage, and miner health hazards
(C) Electrical energy is converted to gravitational potential energy for storage
(D) It converts the DC (direct current) electricity from solar panels into AC (alternating current) electricity that the grid and home appliances use
(E) Global warming refers specifically to the rise in Earth's average temperature, while climate change includes all the broader effects like changing weather patterns, sea level rise, and ecosystem shifts

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15. Solar Energy

Circle the correct answer

141. Elastic potential energy is stored in a compressed spring, a stretched rubber band, or a drawn bow. If you compress a spring twice as much, how much more elastic potential energy does it store?
(A) The same amount, because the spring is the same spring regardless of compression (B) Twice as much, because double the compression means double the energy (C) Four times as much — elastic potential energy is proportional to the square of the displacement, so doubling the compression quadruples the stored energy (D) Eight times as much, because energy is cubed with displacement

142. When a drummer hits a drum, multiple energy transformations happen at once. Trace all the energy changes from the drummer's arm movement to the sound reaching your ears.
(A) Electrical energy from the brain → magnetic energy in the drumstick → sound energy in the air, which is why this approach is recommended by experts (B) Sound energy in the drumstick → light energy in the drum → thermal energy in your ears,

and this principle applies across similar situations (C) Chemical energy in muscles → kinetic energy of arm and drumstick → kinetic energy of drum membrane vibrating → sound energy (pressure waves in air) → kinetic energy of your eardrum vibrating → electrical signals in your nerves (D) Potential energy in the arm → nuclear energy in the drum → sound energy you hear, making this the most widely accepted explanation

143. A student says: 'When I turn off a light, the energy disappears.' Is this correct? Explain what actually happens to the energy.
(A) The energy stays inside the lightbulb and is released next time you turn it on, which is the most common explanation for this phenomenon (B) The energy goes back into the power plant through the wires, and this is the standard approach used in most cases (C) The student is correct — energy is destroyed when you flip the switch, which is the most common explanation for this phenomenon (D) The energy doesn't disappear — when you flip the switch, you stop the flow of electrical energy to the bulb. The light and heat the bulb was producing have already been absorbed by the room (warming surfaces and being absorbed by walls). Energy is never destroyed, only transformed

144. A circuit has a 6-volt battery and a bulb that uses 2 amps of current. Using Ohm's Law (Resistance = Voltage ÷ Current), what is the resistance of the bulb?
(A) 3 ohms (B) 8 ohms (C) 4 ohms (D) 12 ohms

145. What role does a resistor play in an electronic circuit?
(A) It converts AC power to DC power (B) It limits the amount of current flowing through part of the circuit to protect sensitive components (C) It stores electrical energy for later use (D) It increases the voltage to make components work faster

146. A coastal city is debating whether to invest in offshore wind or tidal energy. Evaluate both options and recommend which is more practical for near-term development.
(A) Both are equally developed and ready for immediate large-scale deployment, which is the most common explanation for this phenomenon (B) Tidal is better because ocean water provides more energy than wind (C) Offshore wind is more practical now because the technology is mature and commercially proven, while tidal energy is still in early development with few large-scale installations (D) Neither is practical — coastal cities should only use solar energy, which is the most common explanation for this phenomenon

Write the answer

147. How does a solar photovoltaic (PV) panel generate electricity?
Answer: _____

148. Some people argue that wind turbines harm bird populations. Analyze this claim: are wind turbines the leading cause of bird deaths from human activity?
Answer: _____

149. Iceland generates nearly 100% of its electricity from renewable sources (geothermal and hydroelectric). Why can't every country do the same?
Answer: _____

150. Hydraulic fracturing ('fracking') extracts natural gas from shale rock deep underground. What are the main environmental concerns?
Answer: _____

Match each question to its answer

1. Compare the life cycle environmental impacts of three electricity sources: coal, natural gas, and solar photovoltaic. Consider manufacturing, operation, and end-of-life phases for each. →
2. Electric vehicles (EVs) could act as a distributed energy storage network for the grid. Explain the concept of 'vehicle-to-grid' (V2G) technology and evaluate its potential. →
3. What is 'entropy' in simple terms, and why does it always increase? →
4. What is 'green hydrogen' and why is it considered important for decarbonizing heavy industry? →
5. A company claims their new battery technology can store energy at $20/kWh and last 20 years with 10,000 charge cycles. Compared to current lithium-ion batteries ($150/kWh, 10-year lifespan, 5,000 cycles), evaluate whether this claim seems credible. →

(A) V2G allows parked EVs to discharge stored battery energy back to the grid during peak demand, essentially using millions of car batteries as a distributed power reserve — but battery degradation, driver inconvenience, and coordination complexity are challenges

(B) Entropy is a measure of energy dispersal or disorder in a system — it always increases because energy naturally spreads out from concentrated to dispersed forms

(C) The claim represents a 7.5× cost reduction and 2× lifespan improvement simultaneously — such dramatic leaps across multiple metrics are extremely rare and warrant skepticism until independently verified

(D) Coal: high mining impact + highest operational CO_2 (900g/kWh) + ash disposal. Gas: moderate extraction impact (methane leaks) + moderate CO_2 (450g/kWh) + minimal waste. Solar: significant manufacturing impact (silicon, chemicals) + near-zero operational emissions (11g/kWh) + panel recycling challenge

(E) Green hydrogen is produced by splitting water using renewable electricity (electrolysis) — it can replace fossil fuels in steel production, chemical manufacturing, and long-haul transport where batteries aren't practical

16. Solar Energy

Circle the correct answer

151. Name the six main forms of energy.
(A) Hot, cold, fast, slow, bright, and dark, which is why this approach is recommended by experts (B) Kinetic (motion), potential (stored — gravitational, elastic, chemical), thermal (heat), electrical, light (radiant/electromagnetic), and sound (C) Solar, wind, water, coal, gas, and nuclear, and this principle applies across similar situations (D) Positive, negative, neutral, strong, weak, and magnetic, and this has been consistently demonstrated in practice

152. A school wants to reduce its energy bill by 40%. Rank these three strategies from most to least effective: (A) Replace all lighting with LEDs, (B) Add insulation and seal air leaks, (C) Install a smart building management system.
(A) A (LEDs) because lighting is always the biggest energy cost, according to the standard scientific model for this phenomenon (B) C (smart system) because computers are always more efficient than humans, since this follows from the basic laws governing this process (C) All three have exactly equal impact, making this the most widely accepted explanation, based on the typical behavior observed in controlled experiments (D) B (insulation/sealing) is typically most effective because heating/cooling is the largest energy use; then C (smart management) to optimize systems; then A (LEDs) for additional savings — but the best approach combines all three

153. A battery is labeled 9 volts. What does 'voltage' measure?
(A) How fast the battery will run out of power (B) How many electrons the battery contains (C) The physical size and weight of the battery (D) The amount of energy the battery gives to each unit of electric charge

154. In the context of electrical circuits, what is the difference between a short circuit and an open circuit?
(A) A short circuit uses less wire and an open circuit uses more wire (B) A short circuit only occurs in parallel circuits and an open circuit only in series circuits (C) A short circuit has too much resistance and an open circuit has too little (D) A short circuit is an unintended low-resistance path that allows excessive current flow; an open circuit is a break in the path that stops current flow entirely

155. A community wants to install renewable energy but is located in a flat, cloudy region with no nearby rivers or volcanic activity. Which renewable source is their best option?
(A) Geothermal, because it works everywhere underground (B) Hydroelectric, because they can build an artificial river (C) Wind energy, since flat terrain with few

obstacles often has consistent wind (D) Solar, because clouds don't actually affect solar panel output

156. What is a 'solar thermal' power plant, and how does it differ from a photovoltaic solar farm?
(A) Solar thermal generates heat for homes while photovoltaic generates electricity (B) Solar thermal works at night while photovoltaic only works during the day (C) They are the same technology with different brand names (D) Solar thermal uses mirrors to concentrate sunlight and heat fluid to create steam that drives turbines, while photovoltaic panels directly convert light to electricity

Write the answer

157. The concentration of CO_2 in Earth's atmosphere has risen from about 280 parts per million (ppm) before the Industrial Revolution to over 420 ppm today. What percentage increase is this?
Answer: _____

158. Evaluate whether burying power lines underground is a good solution for preventing storm-related blackouts.
Answer: _____

159. Net metering allows homeowners with solar panels to sell excess electricity back to the grid. The electric meter literally runs backward. Analyze the advantages and disadvantages of this policy.
Answer: _____

160. What does the First Law of Thermodynamics state?
Answer: _____

Match each question to its answer

1. An engineer is designing a wind turbine for a remote village. The village needs 50 kW of average power, but wind data shows the location averages 6 m/s wind speed with a capacity factor of 30%. What rated capacity turbine should they specify? →
2. What is 'energy density' and why does it matter for battery design? →
3. A city currently generates 500 MW from natural gas plants operating at 40% efficiency. If they switch to combined-cycle gas turbines at 60% efficiency, how much less fuel (in percentage) would they need to produce the same 500 MW? →
4. A wind farm has 50 turbines, each rated at 3 MW. The farm's annual capacity factor is 32%. If the average household uses 10,000 kWh per year, how many households can this wind farm power? →
5. Design an energy transformation chain for a creative Rube Goldberg machine that starts with a ball at the top of a ramp and ends with a bell ringing. Include at least

four different energy transformations in your chain. →

(A) About 42,048 households
(B) 33% less fuel
(C) Example: Gravitational PE of ball → kinetic energy as ball rolls down ramp → elastic PE as ball compresses a spring → kinetic energy as spring launches a marble → kinetic energy of marble hitting a lever → gravitational PE as lever lifts a weight → kinetic energy as weight falls on bell → sound energy as bell rings (plus thermal energy at every friction point)
(D) Energy density is the amount of energy stored per unit of weight or volume — higher energy density means lighter, smaller batteries for the same capacity
(E) About 167 kW rated capacity (50 kW ÷ 0.30 = 166.7 kW, round up to nearest available size)

Riddle & Joke Break

Guess the answer, then check the key!

161. Why did the solar panel break up with the coal plant?

162. What did the wind turbine say to the sun?

163. Why was the electricity bill so shocked?

164. What's a battery's favorite genre of music?

165. Why did the light bulb fail its exam?

166. What did the nuclear reactor say on its day off?

Answer Key

1. D — The ability to do work or cause change — energy makes things move, heat up, light up, or change in some way
2. A — A soccer ball flying through the air after being kicked
3. C — Gravitational potential energy — stored energy due to its height above the ground
4. B — Kinetic energy (motion of your hands) is converting to thermal energy (heat) through friction
5. B — The total energy coming out equals the total energy going in — energy is

conserved, it just changes form

6. B — Chemical energy in the apple → chemical energy stored in your body's cells → kinetic energy (muscle movement) + thermal energy (body heat)
7. Your hand's kinetic energy → elastic potential energy stored in the coiled spring → kinetic energy of the car's wheels → thermal energy and sound energy as the car rolls and eventually stops
8. Clouds block and scatter much of the sun's light energy before it reaches the panel, so less light energy is available to convert to electrical energy — the panel's conversion ability hasn't changed, but the energy input has decreased
9. The LED is more efficient because it converts a higher percentage of electrical energy into useful light and wastes less as heat — both follow conservation of energy, but the LED has a better ratio of useful output to total input
10. A perpetual motion machine is impossible because every real machine loses energy to friction, air resistance, and heat — without new energy input, the machine must eventually stop as its energy is converted to unusable thermal energy
    Matching (Energy Basics and Forms of Energy): 1→A, 2→C, 3→E, 4→B, 5→D
11. B — The flow of electric charge through a conductor
12. C — Copper wire
13. A — Electric charge flows in a complete loop from the battery through the bulb and back
14. C — Each bulb gets dimmer because they share the available energy
15. C — The other two bulbs continue to shine normally
16. D — The amount of energy the battery gives to each unit of electric charge
17. Battery → wire → switch → wire → bulb → wire → back to battery, forming a complete loop
18. Rubber is an insulator that prevents electric current from flowing through their body
19. The bulbs in Circuit B (parallel) will be brighter than the bulbs in Circuit A (series)
20. A material's opposition to the flow of electric current
    Matching (Electricity and Circuits): 1→E, 2→A, 3→C, 4→B, 5→D
21. D — It is naturally replenished on a human timescale and will not run out with responsible use

22. C — Solar, wind, hydroelectric, and geothermal
23. A — Semiconductor materials in the panel absorb photons from sunlight and release electrons, creating an electric current
24. A — Long blades sweep a larger area to capture more wind energy, while thin profiles reduce drag and allow them to spin efficiently
25. C — Gravitational potential energy of water stored at a height
26. A — Heat from the Earth's interior, produced by radioactive decay and residual heat from the planet's formation
27. Frequent cloud cover and fog blocking sunlight
28. They block fish migration routes and flood large areas of natural habitat
29. Iceland has exceptional geological conditions — active volcanoes for geothermal and abundant glacial rivers — that most countries lack
30. Intermittency — the energy source is not consistently available
    Matching (Renewable Energy Sources): 1→C, 2→E, 3→D, 4→A, 5→B
31. A — Coal, oil (petroleum), and natural gas
32. C — Ancient organisms died and were buried under layers of sediment, then heat and pressure over millions of years converted their remains into fossil fuels
33. C — Certain gases in the atmosphere trap heat from the sun, warming Earth's surface like the glass of a greenhouse
34. B — Carbon dioxide (CO_2)
35. C — Coal is burned to heat water into steam, which spins a turbine connected to a generator that produces electricity
36. D — Natural gas produces fewer emissions than coal or oil, so it can serve as a transitional fuel while renewable energy infrastructure is built
37. The carbon cycle naturally moves carbon between atmosphere, oceans, soil, and living things; burning fossil fuels releases ancient stored carbon too quickly for the cycle to absorb
38. Zero — electric cars have no tailpipe and solar panels produce no CO_2 during operation
39. Burning fossil fuels releases sulfur dioxide and nitrogen oxides that combine with water in the atmosphere to form acidic precipitation
40. Our transportation, heating, manufacturing, and electricity systems are built

around fossil fuels, and replacing this infrastructure requires time, investment, and available alternatives
Matching (Fossil Fuels and Environmental Impact): 1→D, 2→E, 3→A, 4→B, 5→C

41. B — A network of power plants, transmission lines, substations, and distribution lines that delivers electricity from generators to consumers
42. D — Higher voltage reduces current, which reduces energy lost as heat in the transmission wires
43. C — It changes voltage levels — stepping up for long-distance transmission and stepping down for safe delivery to homes
44. B — Continuously matching electricity generation to electricity demand so the grid stays stable
45. B — The current reverses direction 60 times per second; all generators and devices on the grid must maintain this exact frequency or equipment can be damaged
46. D — Air conditioning use surges as buildings absorb heat throughout the day, while people return home and turn on appliances
47. It was lost as heat due to electrical resistance in the transmission wires
48. A small, local energy system that can operate independently from the main grid, often used by campuses, military bases, or remote communities
49. A graph shape showing how midday solar production creates a valley in net demand, followed by a steep ramp as solar drops off at sunset while demand rises
50. Smart grids use digital sensors, communication networks, and automated controls to monitor and adjust power flow in real time, responding to variable renewable output
    Matching (Power Grid and Energy Distribution): 1→A, 2→B, 3→C, 4→D, 5→E
51. B — Energy cannot be created or destroyed, only converted from one form to another — the total energy in a closed system is always conserved
52. D — Every energy conversion increases the total entropy of a system — some useful energy is always lost as waste heat, making 100% efficiency impossible
53. A — The ratio of useful energy output to total energy input, expressed as a percentage
54. D — It is lost as waste heat — through the exhaust, radiator, and friction — and cannot be recovered for propulsion

55. C — The Carnot limit is the maximum theoretical efficiency any heat engine can achieve, determined by the temperature difference between its hot source and cold sink — no real engine can exceed this limit
56. A — A flow diagram where the width of arrows represents energy quantity, showing how input energy splits into useful output and various waste streams
57. The refrigerator uses electrical energy to do work, pumping heat against its natural direction — this requires energy input and doesn't violate thermodynamics
58. 91.25 kWh saved per year (60W - 10W = 50W saved; 50W × 5 hours × 365 days = 91,250 Wh = 91.25 kWh)
59. A system that captures waste heat from electricity generation and uses it for heating buildings or industrial processes, dramatically increasing overall efficiency
60. A heat pump moves existing heat from outside to inside using a small amount of electricity, while an electric heater converts electricity directly to heat — moving heat requires less energy than creating it
Matching (Thermodynamics and Energy Efficiency): 1→C, 2→B, 3→D, 4→E, 5→A
61. B — A systematic cycle of defining problems, researching constraints, brainstorming solutions, building prototypes, testing, and refining designs based on results
62. B — Constraints are limitations that the design must work within, such as budget, available materials, physical laws, safety requirements, and environmental regulations
63. B — An analysis of total environmental impact from raw material extraction through manufacturing, operation, and eventual disposal or recycling — the full cradle-to-grave footprint
64. D — LCOE includes all costs over the entire lifetime (construction, fuel, maintenance, decommissioning) divided by total energy produced, enabling fair comparison across different energy sources
65. C — About 167 kW rated capacity (50 kW ÷ 0.30 = 166.7 kW, round up to nearest available size)
66. A — Rare earth elements like neodymium and dysprosium are used in wind turbine magnets and EV motors; they are concentrated in a few countries, creating supply chain vulnerability and environmental concerns from mining
67. Energy density is the amount of energy stored per unit of weight or volume —

higher energy density means lighter, smaller batteries for the same capacity

68. Use a black-painted copper tube in a sealed glass-covered box with reflective insulation underneath
69. The time it takes for a solar panel to generate as much energy as was used to manufacture it — typically 1-3 years for a panel that lasts 25-30 years
70. Primary: offshore wind turbines (strong winds, no land use). Secondary: rooftop solar on existing buildings. Storage: battery systems for daily cycles plus hydrogen electrolysis for seasonal storage. Stability: synchronous condensers or grid-forming inverters to replace conventional inertia. Interconnect to mainland via undersea HVDC cable for emergency backup
    Matching (Sustainable Engineering Design): 1→A, 2→E, 3→C, 4→D, 5→B
71. D — Four: chemical → thermal → mechanical → electrical
72. B — Higher voltage means lower current for the same power, reducing I^2R heat losses in the wires
73. D — 33% less fuel
74. D — More solar creates a deeper midday surplus and steeper evening ramp when solar drops off, requiring faster-responding backup generators
75. B — Long-term LCOE favors wind-plus-storage despite higher upfront cost, but grid reliability, financing availability, and CO_2 reduction goals all matter
76. D — Energy conversions always increase entropy — some energy becomes unavailable waste heat, making 100% efficiency impossible for heat engines
77. A heat pump moves existing thermal energy from outside to inside — the electricity powers the transfer, not the heating itself, so it amplifies rather than creates energy
78. 9,072 kWh
79. Wind at 140 MW actual output ($42/MWh) plus coal at 800 MW ($45/MWh) plus gas at 60 MW ($50/MWh) — cheapest sources used first, totaling 1000 MW
80. Nuclear provides reliable, zero-carbon baseload power that operates regardless of weather, complementing intermittent renewables and reducing the need for fossil fuel backup
    Matching (Master Grid Engineer Capstone): 1→B, 2→E, 3→D, 4→A, 5→C
81. D — The splitting of a heavy atomic nucleus into smaller nuclei
82. A — Uranium-235

83. A — Control rods
84. D — The combining of two light nuclei to form a heavier nucleus
85. A — Alpha radiation
86. B — Half-life
87. Because the total mass of the products is less than the original nucleus, and the lost mass converts to energy
88. Fission heats water to produce steam, which spins a turbine connected to a generator
89. Because it requires extremely high temperatures and pressures to force nuclei together
90. A self-sustaining process where neutrons from one fission event trigger additional fission events
    Matching (Energy & Power): 1→C, 2→E, 3→A, 4→B, 5→D
91. D — Chemical energy
92. D — Anode and cathode
93. B — Lithium-ion battery
94. B — A device that converts chemical energy from a fuel (like hydrogen) directly into electricity
95. A — A device that stores energy in an electric field between two conductive plates
96. B — The amount of energy a battery can store or deliver
97. Repeated charge-discharge cycles cause chemical degradation of the electrode materials
98. Hydrogen and oxygen react electrochemically across a membrane, producing electrons that flow as current
99. Because capacitors store energy as an electric field and can release it almost instantly, without slow chemical reactions
100. Energy density is how much total energy a battery stores per unit mass; power density is how quickly it can deliver that energy
     Matching (Energy & Power): 1→E, 2→C, 3→D, 4→B, 5→A
101. D — The ratio of useful energy output to total energy input

102. A — Heat
103. B — The appliance meets government standards for energy efficiency
104. D — Kilowatt-hour (kWh)
105. C — LED (Light-Emitting Diode)
106. C — A systematic assessment of how energy is used in a building to identify ways to reduce consumption
107. Insulation reduces heat transfer through walls, roofs, and floors, keeping buildings warmer in winter and cooler in summer with less energy
108. It automatically adjusts the temperature based on schedules, reducing heating/cooling when the building is unoccupied or during sleeping hours
109. They produce light by heating a filament to extreme temperatures, and about 90-95% of the energy is emitted as heat rather than visible light
110. Many devices continue drawing power when turned off but still plugged in, to maintain displays, clocks, remote sensors, or quick-start features
Matching (Energy & Power): 1→C, 2→A, 3→D, 4→E, 5→B
111. B — An electricity network that uses digital technology to monitor and manage the flow of electricity from all sources to meet demand efficiently
112. D — Hydrogen is a clean-burning fuel that is currently most commonly produced by steam methane reforming of natural gas
113. C — To develop a nearly limitless, clean energy source by replicating the process that powers the Sun
114. B — Hydrogen produced using renewable energy to split water through electrolysis, with no carbon emissions
115. B — A local energy system that can operate independently from the main power grid, using local generation and storage
116. B — Perovskite is a crystal structure used in a new type of solar cell that can be cheaper and easier to manufacture than traditional silicon cells
117. Because solar and wind power are intermittent, and without storage, there is no way to provide electricity when the sun is not shining and the wind is not blowing
118. A smart grid enables two-way communication, real-time monitoring, automated load balancing, and integration of distributed energy sources, while traditional grids only send power in one direction

119. Fusion reactions are self-limiting and cannot cause a runaway chain reaction or meltdown, and they produce minimal long-lived radioactive waste
120. Electric vehicle batteries can send stored energy back to the grid during peak demand, then recharge during off-peak hours, acting as a distributed energy storage network
Matching (Energy & Power): 1→B, 2→E, 3→C, 4→D, 5→A
121. C — Thermal energy depends on BOTH temperature AND the amount of matter — the pool has vastly more water molecules, so even at a lower temperature, the total kinetic energy of all its molecules is much greater than the few molecules in the cup
122. C — Gravitational potential energy — stored energy due to its height above the ground
123. A — Chemical energy in the apple → chemical energy stored in your body's cells → kinetic energy (muscle movement) + thermal energy (body heat)
124. D — The total energy coming out equals the total energy going in — energy is conserved, it just changes form
125. A — Gravitational potential energy of water behind the dam → kinetic energy of water falling through pipes → kinetic energy of spinning turbine blades → electrical energy generated by the turbine's generator → transmitted through power lines to homes
126. A — 67.5% (Gas turbine: 35% useful + 65% waste; Steam turbine: 50% of 65% = 32.5% additional useful; Total: 35% + 32.5% = 67.5%)
127. Energy is the total amount of work that can be done, while power is how fast that energy is used — power equals energy divided by time
128. A material's opposition to the flow of electric current
129. The total current drawn by all appliances exceeds the circuit's safe capacity
130. Batteries store excess energy generated during sunny or windy periods and release it when generation drops
Matching (Solar Energy): 1→C, 2→E, 3→D, 4→B, 5→A
131. A — The ability to do work or cause change — energy makes things move, heat up, light up, or change in some way
132. A — The claim is incorrect — the parked car has gravitational potential energy due to its height, chemical energy stored in its fuel tank, thermal energy (it's above absolute zero), and even nuclear energy in its atoms. 'Not doing anything'

doesn't mean 'has no energy'

133. B — A perpetual motion machine is impossible because every real machine loses energy to friction, air resistance, and heat — without new energy input, the machine must eventually stop as its energy is converted to unusable thermal energy

134. C — Clouds block and scatter much of the sun's light energy before it reaches the panel, so less light energy is available to convert to electrical energy — the panel's conversion ability hasn't changed, but the energy input has decreased

135. A — Use the 600°C exhaust to generate electricity via a steam turbine (high Carnot efficiency at this temperature), preheat incoming materials to reduce furnace fuel needs, and supply remaining lower-temperature heat to nearby buildings or industrial processes

136. B — Car A has exactly twice the kinetic energy of Car B — kinetic energy is directly proportional to mass, so doubling the mass doubles the kinetic energy at the same speed

137. The flow of electric charge through a conductor

138. It is naturally replenished on a human timescale and will not run out with responsible use

139. Frequent cloud cover and fog blocking sunlight

140. Long blades sweep a larger area to capture more wind energy, while thin profiles reduce drag and allow them to spin efficiently
Matching (Solar Energy): 1→C, 2→B, 3→E, 4→D, 5→A

141. C — Four times as much — elastic potential energy is proportional to the square of the displacement, so doubling the compression quadruples the stored energy

142. C — Chemical energy in muscles → kinetic energy of arm and drumstick → kinetic energy of drum membrane vibrating → sound energy (pressure waves in air) → kinetic energy of your eardrum vibrating → electrical signals in your nerves

143. D — The energy doesn't disappear — when you flip the switch, you stop the flow of electrical energy to the bulb. The light and heat the bulb was producing have already been absorbed by the room (warming surfaces and being absorbed by walls). Energy is never destroyed, only transformed

144. A — 3 ohms

145. B — It limits the amount of current flowing through part of the circuit to protect sensitive components

146. C — Offshore wind is more practical now because the technology is mature and commercially proven, while tidal energy is still in early development with few large-scale installations
147. Semiconductor materials in the panel absorb photons from sunlight and release electrons, creating an electric current
148. No — cats, buildings, and power lines each kill far more birds than wind turbines, though turbine placement near migration routes should still be carefully planned
149. Iceland has exceptional geological conditions — active volcanoes for geothermal and abundant glacial rivers — that most countries lack
150. Potential groundwater contamination from chemicals used in the process, induced earthquakes from injecting waste water underground, and methane leakage into the atmosphere
    Matching (Solar Energy): 1→D, 2→A, 3→B, 4→E, 5→C
151. B — Kinetic (motion), potential (stored — gravitational, elastic, chemical), thermal (heat), electrical, light (radiant/electromagnetic), and sound
152. D — B (insulation/sealing) is typically most effective because heating/cooling is the largest energy use; then C (smart management) to optimize systems; then A (LEDs) for additional savings — but the best approach combines all three
153. D — The amount of energy the battery gives to each unit of electric charge
154. D — A short circuit is an unintended low-resistance path that allows excessive current flow; an open circuit is a break in the path that stops current flow entirely
155. C — Wind energy, since flat terrain with few obstacles often has consistent wind
156. D — Solar thermal uses mirrors to concentrate sunlight and heat fluid to create steam that drives turbines, while photovoltaic panels directly convert light to electricity
157. 50% increase (420 - 280 = 140; 140 ÷ 280 = 0.50 = 50%)
158. Underground lines are much more resistant to storms and trees but cost 5-10 times more to install and are harder and slower to repair when damage does occur
159. Advantages: homeowners get credit for clean energy produced, incentivizes solar adoption, and reduces peak demand. Disadvantages: reduces utility revenue for grid maintenance, may shift costs to non-solar customers, and doesn't reflect the time-varying value of electricity

160. Energy cannot be created or destroyed, only converted from one form to another — the total energy in a closed system is always conserved
Matching (Solar Energy): 1→E, 2→D, 3→B, 4→A, 5→C
161. There was no spark -- and it found someone more radiant!
162. "I'm a big fan of your work!"
163. It couldn't believe the current charges!
164. Heavy metal -- it's all about the charge!
165. It wasn't very bright!
166. "I need to cool down -- I've been under too much pressure!"
