

# THE MOST EFFICIENT FORM OF RENEWABLE ENERGY

For this infographic, we'll explore renewable energy efficiency, and we'll examine which renewable energy type is the most efficient.



## STATISTICS



In 2015, renewable energy accounted for 10% of total U.S. energy consumption. It also represented 13% of total electricity generation. EIA

Half of the U.S.'s available renewable energy goes towards the production of electricity.

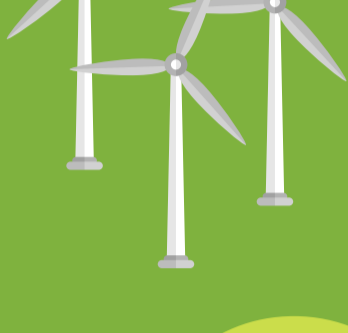


### GEOTHERMAL ENERGY



- Our planet contains 1031 joules of heat energy
- This energy flows at a conduction rate of 44.2 terawatts (TW)
- According to the 2016 Annual U.S. & Global Geothermal Power Production Report, "the global geothermal industry is expected to reach about 18.4 GW by 2021." Geo

### WIND ENERGY



- The Department of Energy has estimated that by 2050, the wind energy industry could comprise 35% of U.S. electrical production.
- Estimates by the Global Wind Energy Council and Greenpeace International have claimed "wind power could provide as much as 25 to 30% of global electricity by 2050." PHYS



### SOLAR ENERGY

By 2050, solar thermal energy (STE) and photovoltaic (PV) systems will be 25% of the energy market, according to International Energy Agency estimates.



### BIOMASS ENERGY

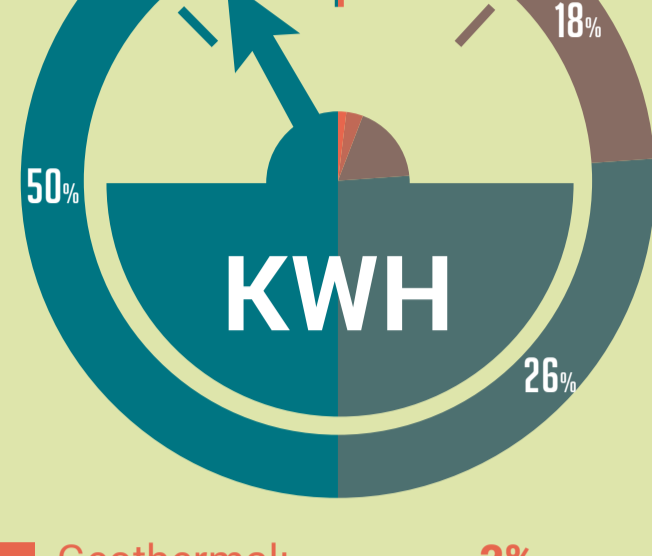
The U.S. Energy Information Administration has projected biomass generation to rise from 4.2 quadrillion British thermal unit (Btu) in 2013 to 5 quadrillion Btu in 2040 biomass



### HYDROELECTRICITY

- Accounts for 7% of total U.S. energy production
- Low operations and maintenance costs, but have high investment costs USGS

### U.S. energy consumption in 2014, according to the United States Geological Survey (USGS)



- Geothermal: 2%
- Solar: 4%
- Wind: 18%
- Hydroelectricity: 26% USGS
- Biomass: 50% (wood, biomass waste, biofuels)

## MEASURING THE EFFICIENCY OF RENEWABLE ENERGY SOURCES

Efficiency is calculated by the cost of the fuel associated, cost of production, and the cost of dealing with environmental damages.

### WIND

1,164%\*\* most efficient form of renewable energy

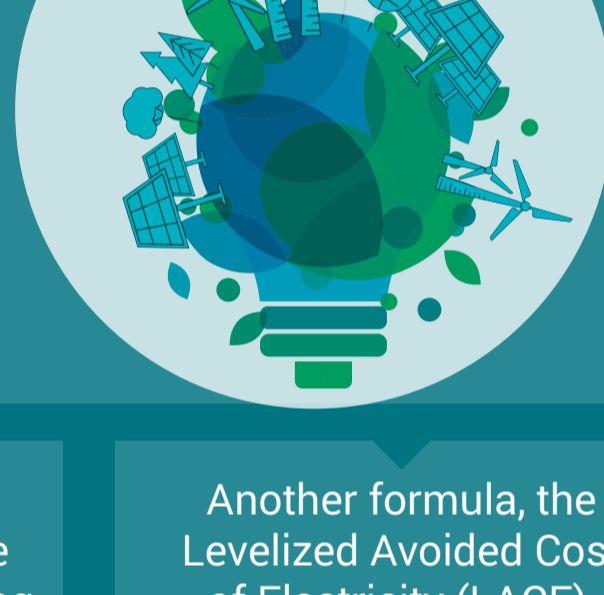
### THE TOP FIVE, IN TERMS OF MOST EFFICIENT, ARE

GEOTHERMAL	HYDRO	NUCLEAR	SOLAR
514%	317%	290%	207%

### HOW TO MEASURE THE EFFICIENCY OF AN ENERGY GENERATION METHOD

The formula to calculate Levelized Cost of Electricity (LCOE) depends on the following factors:

- Fixed and variable operations and maintenance costs
- Projected utilization rate for each plant type
- Fuel costs
- Capital costs



Plant owners and investors should also take into consideration other factors that can affect the efficiency of a renewable generation method:

- Policy-related factors (investment or production tax credits and environmental regulations)
- Uncertainty (regarding future public policies or fuel prices) EIA

Other factors that would affect a wind farm's efficiency include the existing energy generation method is less effective than a wind farm, then the operation of a newly installed wind farm and the displacement of existing resources would increase a region's economic viability

Another formula, the Levelized Avoided Cost of Electricity (LACE), measures "what it would cost the grid to generate the electricity that is otherwise displaced by a new generation project, as well as its levelized cost."

The LACE formula addresses the potential the LCOE formula provides, since it compares technology efficiencies without accounting for regional differences.

### TYPES OF WIND POWER

- According to the Energy Information Administration, "Offshore wind is more than 2.5 times more expensive than onshore wind." Institute
- "Offshore wind farms are 90 per cent more expensive than fossil fuel generators and 50 per cent more expensive than nuclear." Boythorpwind
- Offshore wind- the wind turbines are placed in bodies of water
- Utility-scale wind- the generated electricity is delivered to the power grid and is then disbursed by electric utilities to the end user; wind turbines are larger than 100 kilowatts
- Small-wind - also known as distributed wind power, the generated electricity is delivered directly to the end user; the turbines are 100 kilowatts or smaller AWEA

### HOW WIND IS CONVERTED INTO ENERGY

- Two types of wind turbines
- Horizontal-axis wind turbine (make up the majority of modern wind turbines)
- Mechanical parts include: blade, drive train, tower, and other equipment (group support & interconnection equipment, controls, and electrical cables)
- Vertical-axis wind turbine windeis

### WIND TURBINE SIZE AND POWER

Utility-scale turbines: 50-750 kilowatts

"A small home-sized wind machine has rotors between 8 and 25 feet in diameter and stands upwards of 30 feet and can supply the power needs of an all-electric home or small business." windeis

The power of wind is measured by wind-power density classes.

A large machine can produce sufficient electricity to power 1,400 homes. It is 20 stories tall, and blades are the length of a football field (120 yards).



## ADVANTAGES & DISADVANTAGES OF WIND ENERGY



### ADVANTAGES/BENEFITS OF WIND ENERGY

- As of January 2016, wind energy provides 88,000 jobs in the U.S.
- 21,000 of those jobs are in manufacturing
- Economic benefits include:
  - The taxes wind farm owners pay benefit rural communities
  - A drought-resistant cash crop for farmers and ranchers
  - Generated over \$128 billion in private investment from 2008 - 2015
  - Wind farms benefit rural communities as 70 percent are located in low-income counties
  - As of 2015, wind power produced \$7.3 billion in public health benefits "by cutting pollutants that create smog and trigger asthma attacks and other lung diseases." AWEA
- A free, renewable resource
- Clean and non-polluting
- Wind farms can be located on land that can also be used for grazing or growing crops
- A high initial investment is offset by low operating expenses and no requirement for fuel windeis

### DISADVANTAGES

- Wind, while efficient, has downsides that engineers need to address.
- Wind is intermittent
- Satisfactory wind sites are usually located in remote geographic regions which are far from areas that demand electric power (for example cities and metropolitan areas) windeis
- They can be noisy, unsightly and difficult to build: the blades are often 60 meters long, and the turbines themselves are usually 20 stories high. They are very difficult to transport to construction sites!
- They are also devastating to wildlife. In 2012, wind farms killed 573,000 birds. By 2030, it's projected that they will kill 1.4 million.
- However, offshore wind farms (placed in oceans) are removed from people, are not as unsightly and—if migratory bird patterns are addressed beforehand—might be safer for marine birds. ABC

## CONCLUSION



Advancements in wind turbine technology saw exports reach \$488 million in 2014- a significant increase from \$16 million in 2007

according to the Office of Energy Efficiency & Renewable Energy.

The development of a specially curved blade tip by Knight and Carver's Wind Blade Division and the Department of Energy's Sandia National Laboratories has lead to a 12% increase in energy capture. This is one of many developments in the wind energy sector that is making this source of renewable energy more attractive and efficient Energy.

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