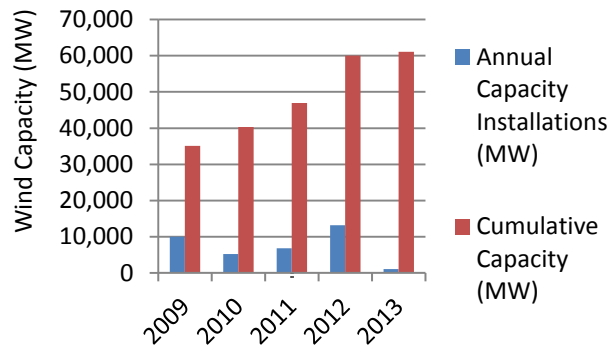
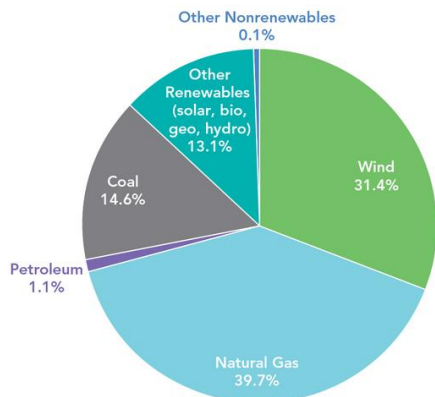


Overview

- Wind turbines have originated from windmills which were traditionally used to pump water.
- As fossil fuel prices rose and tax incentives were awarded for sustainable energy in the late 20th century, research was done on the turbines to make them economically feasible.
- It is expected that future turbines will be able to achieve a 20 MW rating compared to their current 2.5 MW average rating.
- Although there are not currently any plans in the U.S., offshore wind energy is an emerging sector in Europe.
- Initial capital costs are high for the turbines and require minimal maintenance.
- Most importantly, wind energy results in no pollution or greenhouse gas emissions.

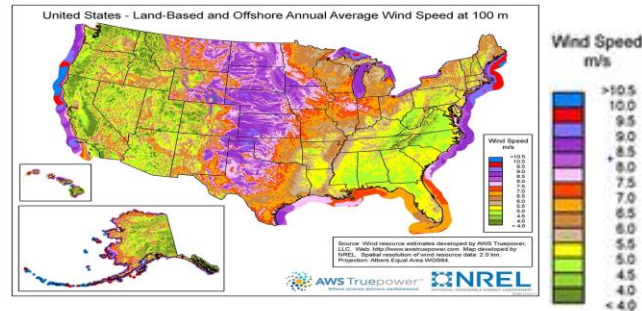


U.S. Average Annual Power Capacity Additions (2009-2013)



• Based on the figure, wind energy projects to become one of the highest output renewable energy sources. It may even rival fossil fuels by the end of the century depending on future costs and policies.

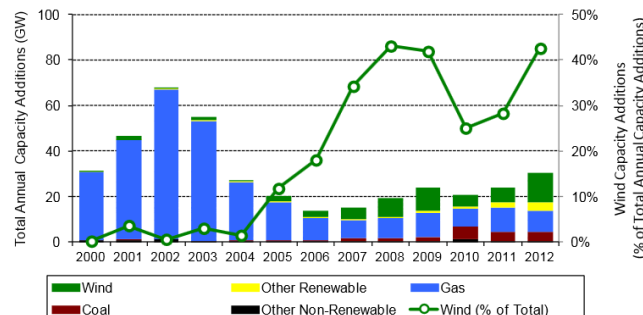
Production and Distribution



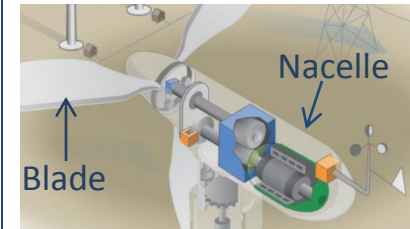
State	Output (MW)	% State's Total Energy Output
Texas	35,937	8.3%
Iowa	15,571	27.4%
California	13,230	6.6%
Oklahoma	10,881	14.8%
Illinois	9,607	4.7%

• Based on EIA projections, renewables are expected to supply 16% of our energy consumption by 2040. Of that, I predict wind will account for 35% (28% currently). These tables reflect the number of new turbines need to meet this demand which changes to average power rating and capacity factor.

CF	# turbines	Power Rating (MW)	# turbines
0.3	14,870	2.5	14,870
0.4	3,717	10	11,152
0.5	2,478	15	8,922
0.6	1,859	20	7,435



Technology



• Rotation of the blades occur when wind creates a low-pressure air pocket on the other side.

This results in a lifting force on the blades which in turn, causes the rotor to turn.

• The low-speed shaft rotates at rate of around 30-60 rpm. This angular speed is amplified by the gearbox which causes the high-speed shaft to power the generator at a higher rate.

• This output is regulated by the transformer which ensures the correct voltage is produced.

• Since wind velocity generally increase at higher altitudes, it is advantageous to raise the turbines to produce the highest possible output. Tower heights are typically at least 100 ft high.

• Wind turbines have a relatively low capacity factor (20-40%) compared to other energy sources.

Policy

State

- Renewable Portfolio Standard (RPS) – a statewide initiative to attain a certain percentage of energy production by renewables. To date, 29 states have established a RPS.
- States have also established renewal energy funds that provide funding for continued development.

Federal

- Renewable Energy Production Tax Credit – provided 2 cents/kWh for wind energy (and other renewables) production. Unfortunately, the credit expired after 2013 and was not renewed by Congress.

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