

# More Windpower and Areas

## Physics and Mathematics of Sustainable Energy

College of the Atlantic. September 27, 2019

1. In 2018 the Scherer coal plant in Georgia, USA, generated 15,420,000 MWh of electricity.
  - (a) How much CO<sub>2</sub>e does the plant emit in one year?
  - (b) What is the power of the plant expressed in Watts?
  - (c) What is the power density of the plant expressed in W/m<sup>2</sup>.
  - (d) If we wanted to shut down this coal plant and replace it with electricity generated by wind, how large would such a wind farm need to be.
2. Residential electricity use in Maine is 21 billion kWh/year. What area of land would be needed to generate this electricity from terrestrial windpower?
  - (a) Answer in square meters, square kilometers, square miles, and acres.
  - (b) A square of what side (in km or miles) has this same area?
  - (c) If this amount of electricity was generated using existing methods, how much CO<sub>2</sub> would be released into the atmosphere? Express your answer in tonnes per person.
3. The area of Mount Desert Island is 108 square miles. Convert this to:
  - (a) Square kilometers
  - (b) Square meters
  - (c) Acres
  - (d) Hectares
4. COA uses around 800,000 kWh of electricity in one year.
  - (a) Express this power in Watts.
  - (b) What size terrestrial wind installation would we need shore to generate this much power? Express this area in a meaningful way.
  - (c) What size offshore wind installation would we need shore to generate this much power? Express this area in a meaningful way.
5. A 3 MW turbine produces 10 GWh in one year. What is the turbine's capacity factor?
6. A 1 GW coal power station operates for one year at a capacity of 90%. How much energy does it produce in one year?
7. The transportation sector in Maine in 2014 used  $38 \times 10^9$  kWh.
  - (a) Convert this to kWh per person per day.
  - (b) Convert this to W.
  - (c) Suppose we wanted to replace half of this  $38 \times 10^9$  with electricity from wind? (This would roughly result in a complete electrification of the transport sector, since electric vehicles are much more efficient than gas vehicles.) How much land mass would we need to devote to wind turbines in order to do so? Express your answer in a meaningful way.