Chapter 1

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$$1\ yr = 365\ \frac{days}{yr} \times 24\ \frac{hrs}{day} = 8760\ hrs$$

Average Wasted Power

$$P_{avg} = \frac{100 \times 10^9\ kWh/yr}{8760\ hr/yr} = 11.41 \times 10^3\ MW$$

(a)

$\therefore \sim 11\frac{1}{2}$ 1000-MW generating plants running continuously provide this power.

(b) Annual Savings $= 0.10\ \frac{\$}{kWh} \times 100 \times 10^9\ \frac{kWh}{yr}$

$= 10$ Billion $/yr

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For the ease of solving this problem, let us assume that the system operates for 100 hrs and draws 1 kW while delivering 100% flow rate.

The percentage reduction in the power consumption is the same as the percentage reduction in the energy consumption.

The following Table shows the energy consumption using each of the three methods:

hrs of Operation	Drive	Outlet	Inlet
20 hrs @ 100%	1 × 20 kWh	1 × 20 kWh	1 × 20 kWh
20 hrs @ 80%	0.5 × 20	0.92 × 20	0.81 × 20
30 hrs @ 60%	0.3 × 30	0.87 × 30	0.7 × 30
10 hrs @ 30%	0.1 × 10	0.72 × 10	0.65 × 10
Total Energy Consumption	$E_{Drive} = 40$ kWh	$E_{outlet} = 71.7$ kWh	$E_{inlet} = 63.7$ kWh

Using an adjustable speed drive,

(a) % reduction over outlet damper $= \dfrac{E_{outlet} - E_{Drive}}{E_{outlet}}$

$$= \frac{71.7 - 40}{71.7} \times 100 \simeq 44\%$$

(b) % reduction over inlet vanes $= \dfrac{E_{inlet} - E_{Drive}}{E_{inlet}}$

$$= \frac{63.7 - 40}{63.7} \times 100 \simeq 37\%$$

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$$\lambda = k \frac{\omega_m r}{V_{wind}}$$

$V_{wind, rated} = 12$ m/s

$V_{wind, cut\ in} = 4$ m/s

For maximum value of C_p, $\omega_m = 20$ rpm at the rated wind.

$\therefore$ ω_m at the cutin wind speed is

$$20 \times \frac{4}{12} = 6.66 \text{ rpm}$$

$\therefore$ the blade rotational speed should vary between 6.66 rpm to 20 rpm between the cut-in and the rated wind speeds, in order to keep C_p at its maximum value.