

## Chapter 1

1-1

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

Average  
Wasted  
Power

$$P_{\text{avg}} = \frac{122 \times 10^9 \text{ kWh/yr}}{8760 \text{ hr/yr}} = 13.92 \times 10^3 \text{ MW}$$

(a)

$\therefore \sim 13$  1,100-MW generating plants running continuously provide this power.

$$\begin{aligned} \text{(b) Annual Savings} &= 0.12 \frac{\$}{\text{kWh}} \times 122 \times 10^9 \frac{\text{kWh}}{\text{yr}} \\ &= 14.64 \text{ Billion } \$/\text{yr} \end{aligned}$$

1-2

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:

<u>hrs of Operation</u>	<u>Drive</u>	<u>Outlet</u>	<u>Inlet</u>
20 hrs @ 100%	1 x 20 kWh	1 x 20 kWh	1 x 20 kWh
20 hrs @ 80%	0.5 x 20	0.92 x 20	0.81 x 20
30 hrs @ 60%	0.3 x 30	0.87 x 30	0.7 x 30
10 hrs @ 30%	0.1 x 10	0.72 x 10	0.65 x 10
Total Energy Consumption	$E = 40 \text{ kWh}$ Drive	$E = 71.7 \text{ kWh}$ Outlet	$E = 63.7 \text{ kWh}$ Inlet

Using an adjustable speed drive,

$$(a) \% \text{ reduction over outlet damper} = \frac{E_{\text{outlet}} - E_{\text{Drive}}}{E_{\text{outlet}}} \\ = \frac{71.7 - 40}{71.7} \times 100 \approx 44\%$$

$$(b) \% \text{ reduction over inlet vanes} = \frac{E_{\text{inlet}} - E_{\text{Drive}}}{E_{\text{inlet}}} \\ = \frac{63.7 - 40}{63.7} \times 100 \approx 37\%$$

### Problem 1-3

$$P_o = \frac{\eta}{1-\eta} P_{loss} \quad (1-2)$$

②  $\eta = 87\% = 0.87$

$$P_{o1} = \frac{0.87}{1-0.87} P_{loss} = 6.69 P_{loss}$$

③  $\eta = 95\% = 0.95$

$$P_{o2} = \frac{0.95}{1-0.95} P_{loss} = 19.0 P_{loss}$$

$\therefore$  The power densities<sup>(PD)</sup> are related to the output power

$$\frac{PD_2}{PD_1} = \frac{19.0}{6.69} = 2.84$$

$\therefore$  The improvement in power density is

$$\frac{PD_2 - PD_1}{PD_1} = \frac{PD_2}{PD_1} - 1 = 1.84$$

or the power density is 184%

### Problem 1-4

$$\begin{aligned}\text{Energy saved per year} &= 3.8 \times 10^9 \times 0.16 \times 0.3 \\ &= 182.4 \times 10^6 \text{ MW-hrs}\end{aligned}$$

$$1 \text{ year} = 365 \times 24 = 8760 \text{ hrs}$$

$\therefore$  Power need to supply wasted energy

$$P = \frac{182.4 \times 10^6}{8760} \text{ MW}$$

$$= 20822 \text{ MW}$$

$\therefore$  Approximately 19 generating plants

each with an output of 1,100 MW are

needed to supply this wasted energy.

### Problem 1-5

$$E_{\text{wind}} = 10.8 \times 10^9 \frac{\text{MW-hrs}}{\text{year}}$$

$$\begin{aligned} \text{Number of Wind mills} &= \frac{0.1 \times E_{\text{WIND}} / (\text{no. of hrs per year})}{P_{\text{Wind mill}} \times \text{Capacity factor}} \\ &= \frac{0.1 \times 10.8 \times 10^9 / 8760}{1.5 \times 0.3} \end{aligned}$$

$$\approx 2.74 \times 10^5$$

$$= 274 \text{ thousand}$$

### Problem 1-6

$$\text{Power rating of power electronics} = 1,500 \text{ kW / windmill}$$

$$\text{from problem 1-5, no. of wind mills} = 2.74 \times 10^5$$

$$\therefore \text{Total rating of power electronics}$$

$$\text{interface} = 1,500 \times 2.74 \times 10^5 \text{ kW}$$

$$= 411 \text{ GW}$$

### Problem 1-7

$$E_{\text{Conventional}} = 3.8 \times 10^9 \times 0.19 \text{ MW-hrs/year}$$

$$E_{\text{CFL}} = 0.25 E_{\text{Conventional}}$$

$$\text{Savings in annual energy} = E_{\text{Conventional}} - E_{\text{CFL}}$$

$$= 0.75 E_{\text{Conventional}}$$

$$= 0.75 \times 3.8 \times 10^9 \times 0.19$$

$$= 0.54 \times 10^9 \frac{\text{MW-hrs}}{\text{year}}$$

### Problem 1-8

$$\text{Gallons per car per year} = \frac{11,766}{22.1} = 532.4$$

$$\text{Gallons per hybrid per year} = \frac{11,766}{52} = 226.27$$

$$\therefore \text{Savings per vehicle per year} = 532.4 - 226.27 \\ \approx 306 \text{ gallons of gasoline}$$

$$1 \text{ barrel of oil} = 20 \text{ gallons of gasoline}$$

$$\therefore \text{Savings per vehicle per year} = \frac{306}{20} \\ \approx 15.3 \text{ barrels of oil}$$

Problem 1-9

$$\begin{aligned}\text{Savings per year} &= 150 \times 10^6 \times 306 \\ &= 45.9 \times 10^9 \text{ gallons}\end{aligned}$$

(using Prob 1-8)

$$\begin{aligned}&= 5 \times 45.9 \times 10^9 \text{ lbs of carbon} \\ &= 229 \times 10^9 \text{ lbs of carbon}\end{aligned}$$

Problem 1-10

$$\begin{aligned}\text{Savings of barrels of oil} &= 15.3 \times 150 \times 10^6 \\ &= 2295 \times 10^6 / \text{year}\end{aligned}$$

Problem 1-11

$$\begin{aligned}E_{\text{Fuel Cells}} &= 5 \text{ kW} \times 25 \times 10^6 \times \frac{8760}{\text{hrs/year}} \frac{\text{kw-hrs}}{\text{year}} \\ &\approx 10^9 \frac{\text{MW-hrs}}{\text{year}}\end{aligned}$$

### Problem 1-12

$$\text{Energy needed to cook} = 0.55 \times 2 \text{ kW-hrs}$$

$\therefore$  Energy needed by Induction cookers

$$= \frac{0.55 \times 2}{0.8} \text{ kW-hrs}$$

$$= 1.375 \text{ kW-hrs}$$

$$\therefore \text{Energy saved} = (2 - 1.375) \times 20 \times 10^6 \text{ kW-hrs}$$

$$= 12.5 \times 10^6 \text{ kW-hrs}$$

$$= 12.5 \times 10^3 \text{ MW-hrs}$$

### Problem 1-13

$$P_{pv} = 800 \times 0.1 = 80 \text{ W/m}^2$$

$$\therefore \text{Area} = \frac{1000 \times 10^6}{80} \text{ m}^2$$

$$= 12.5 \times 10^6 \text{ m}^2$$

$$= 3535 \times 3535 \text{ m}^2$$



### Problem 1-14

From Problem 1-13,  $\text{Area} = 12.5 \times 10^6 \text{ m}^2$

$$\begin{aligned}\therefore \text{no. of homes} &= \frac{12.5 \times 10^6}{40} \\ &= 312.5 \text{ thousand}\end{aligned}$$

### Problem 1-23

$$V_{in} = 12 \text{ V}, \quad V_o = 9 \text{ V}, \quad f_s = 400 \text{ kHz}$$

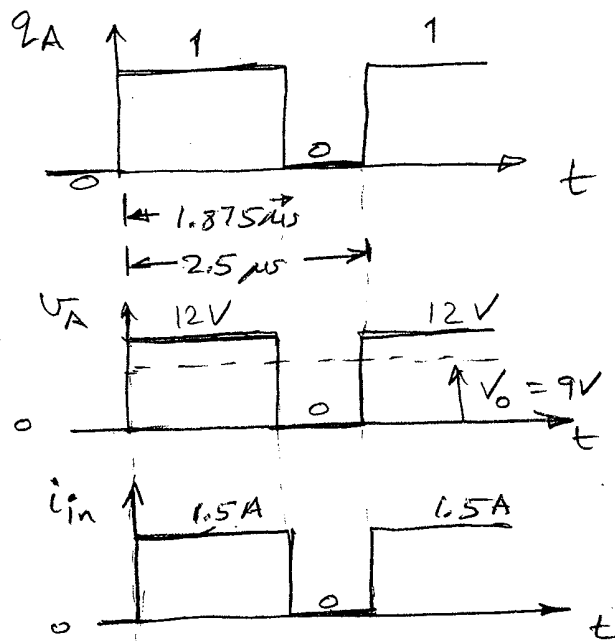
Using Eqs. 1-3 & 1-4

$$d_A = \frac{V_o}{V_{in}} = \frac{9}{12} = 0.75$$

$$\begin{aligned}\text{and, } T_{up} &= d_A T_s = d_A \left( \frac{1}{f_s} \right) \\ &= 1.875 \mu\text{s}\end{aligned}$$

# Problem 1-24

from problem 1-15,  $T_S = 2.5 \mu s$ ,  $T_{up} = 6.875 \mu s$



# Problem 1-25

$$V_{in} = 12V, \quad V_O = 9V, \quad I_O = \text{not given}$$

$\therefore$  Voltage dropped across the linear regulator  $V_{reg} = 12 - 9 = 3V$

$$\therefore \eta_{max} = \frac{9V \times I_O}{12V \times I_O} = \frac{9}{12} = 75\%$$

1-26 Modify Lab Experiment-4 of PSpice  
at [www.cusp.umn.edu](http://www.cusp.umn.edu) under  
Power Electronics Course

1-27 Same as Prob 1-26 except  
modify Lab Experiment-1.