Question1:

a)

According to the data from: http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy.html

Natural gas consumption in UAE 2012 = *65.6 (Billion Cubic Metres per Year).*

According to this website: http://www.unitjuggler.com/convert-energy-from-GcmNG-to-Mtoe.html?val=65.6

65.6 (Billion Cubic Metres per Year)=59.04 (MTOE per year)

Similarly,

65.6 Gm3 NG = 686635200 MWh=686635.2 GWh

(According to the website http://www.unitjuggler.com/convert-energy-from-GcmNG-to-MWh.h)

In summary:

	Billion Cubic Metres per year	MTOE per year	GWh per year
Natural gas consumption in UAE 2012	65.6	59.04	686635.2

b)

From: http://www.eia.gov/environment/emissions/co2_vol_mass.cfm

We know natural gas will produce $54.4 kg\ CO2\ per\ thousand\ cubic\ feet$

65.6 (Billion Cubic Metres per Year) = 2295453336.2483thousand cubic feet

So, 65.6 (Billion Cubic Metres per Year) will produce:

$$2295453336.2483 \times 54.4 kg\ CO2 = 1.249 \times 10^{11} kg\ CO2$$

c)

CO2 saving:

$$5\% * total\ natural\ gas * CO2\ equivalent = 5\% \times 1.249 \times 10^{11} kg\ CO2 = 6.245 \times 10\text{^}9\ kg$$

As the question said, the output energy of the solar plant in its lifetime is equal to 5% of the secondary consumed energy in the natural gas.

$$Nautral\ gas\ energy \times 5\% = Solar\ plant\ capacity \times full\ load\ hours \times Grid\ transmission\ efficiency$$

$$Solar\ plant\ capacity\ (MW) = \frac{secondary\ consumed\ energy\ in\ the\ natural\ gas * 5\%}{life\ time * grid\ transmission\ efficiency}$$

$$= \frac{energy\ in\ the\ comsumed\ natural\ gas *\ fuel\ conversion\ efficiency * 5\%}{full\ load\ hours * years * grid\ transmission\ efficiency}$$

$$= \frac{686635200\ \text{MWh} * 40\% * 5\%}{1700 hours * 25 years * 92\%} = 351.22MW$$

Question2:

a)

Capital: $I_t = 2700\$/kW$,$M_1 = 0, M_t = 5\% * \frac{2700\$}{kW} = 135\$(for\ other\ years), F_t = 0, E_1 = 0, E_t = 351.22MW$, r=70%*3%+30%*15%=0.066, t=0,1,2…25.

Land cost=$\frac{1800\$}{ha*year} \times 351.22MWh * 1000 \times 0.404686 \times \frac{7.9acres}{MW}$ =2,021,142.88$/year

End of Year	Capital Costs	Annual O&M Costs	Land Costs	Total Cost
1	948294000	0	2021142.88	950315142.88
2	0	47414700	2021142.88	49435842.88
3	0	47414700	2021142.88	49435842.88
4	0	47414700	2021142.88	49435842.88
5	0	47414700	2021142.88	49435842.88
6	0	47414700	2021142.88	49435842.88
7	0	47414700	2021142.88	49435842.88
8	0	47414700	2021142.88	49435842.88
9	0	47414700	2021142.88	49435842.88
10	0	47414700	2021142.88	49435842.88
11	0	47414700	2021142.88	49435842.88
12	0	47414700	2021142.88	49435842.88
13	0	47414700	2021142.88	49435842.88
14	0	47414700	2021142.88	49435842.88
15	0	47414700	2021142.88	49435842.88
16	0	47414700	2021142.88	49435842.88
17	0	47414700	2021142.88	49435842.88
18	0	47414700	2021142.88	49435842.88
19	0	47414700	2021142.88	49435842.88
20	0	47414700	2021142.88	49435842.88

21	0	47414700	2021142.88	49435842.88
22	0	47414700	2021142.88	49435842.88
23	0	47414700	2021142.88	49435842.88
24	0	47414700	2021142.88	49435842.88
25	0	47414700	2021142.88	49435842.88
26	0	47414700	2021142.88	49435842.88

LCOE [$/kWh]=$\frac{\sum_{t=1}^{n}\frac{(I_t+M_t+F_t)}{(1+r)^t}}{\sum_{t=1}^{n}\frac{(E_t)}{(1+r)^t}}$ =0.21$/kWh (Details, please see the attached Excel)

b)

If we sell the electricity at the price of 0.3$/kWh,

IRR[%]=13%

See the attached Excel for the detail.

Question3:

a)

As the question given:

$$P_v = \frac{m_v * u^3}{2d} + \frac{1}{2}\rho_{air} * A * c_d * u^3 + m_v * g * c_{rr} * u$$

$$P_v = \frac{1550kg*\left(\frac{72km}{h}\right)^3}{2*180km} + \frac{1}{2} * \frac{1.2kg}{m3} * 2.45m2 * 0.28 * \left(\frac{72km}{h}\right)^3 + 1550kg * \frac{9.79m}{s2} * 0.01 * \frac{72km}{h}$$

$$= 6362\ W$$

b)

$P_v = 6362W$, and the average car speed 72km/h

Also, according to http://en.wikipedia.org/wiki/Fuel_economy_in_automobiles

Modern gasoline engines have a maximum thermal efficiency of about 25% to 30% when used to power a car. In here I assume the efficiency of the engine sedan is 30%.

I also assume:

Drivetrain loss (such as loss in transmission, braking) 20%, electrical system consumption 2.2kW

Therefore,

For 40,000km a year:

$$energy\ required(MWh) = \frac{(P_v + electrical\ system\ consumption)}{engine\ efficiency * (1 - drivetrain\ loss)} \times \frac{distance}{average\ velocity}$$

$$= \frac{(6.362kW + 2.2kW)}{30\%(1-20\%)} \times \frac{40000km}{72km/h}$$

$$= 19.82\ MWh$$

c)

From b), we know for one vehicle, we need 19.82 $MWh\ per\ year$.

Assume all the vehicles need 19.82 $MWh\ per\ year$,

So, for 600,000 vehicles:

$$energy\ required\ for\ 600{,}000\ vehicles$$

$$= \text{Number of vehicles} \times \text{energy required for a single vehicles}$$

$$= 600000 * \text{need } 19.82\ MWh$$

$$= 11892000 MWh$$

Using the gross heat of combustion of one cubic meter of gasoline to be 12.26kWh/kg (According to http://wogone.com/science/the_energy_and_fuel_data_sheet.pdf)

So, $11892000MWh$ is equal to 969983686.8kg gasoline.

The density of gasoline is 0.755 kg/L, according to http://en.wikipedia.org/wiki/Gasoline

969983686.8kg gasoline=1284746605liter gasoline=301,7210 metric tons of CO2=3.017×10^9 kg CO2

(According to http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results)

d)

From 1.c we assume now the solar system of UAE has a capacity of $351.22MW$.

50% of today's CO2 =1.508×10^9 kg CO2=484991843.4kg gasoline=5946000 MWh

The annual installation per year=$\frac{\frac{5946000\ MWh}{1700\times 92\%}}{5}$=760.36MWh