b) In Sydney a 15 kW solar array can average about 5 to 6 kWh per day o electricity. This can be fed in via a Gross metering scheme (all electricit going into grid, or a net Time of Use (TOU) metering scheme where electricit at any one time is either being used by the house or the excess is bein exported to the grid.

Let us consider system connected using a Net TOU metering scheme.

Before Net TOU metering the house would pay electricity at two rates Normal (20.6 c/kWh) and Controlled-Load Off-Peak (for water heating at 10. c/kWh) and unaffected by the solar panels. The Service Charge is 48 c per day

Under new solar connection a three tier system is used so that Peak (2 pm to pm weekdays) is 40.6 c/kWh, Shoulder is 16.4 c/kWh (7am - 2pm weekdays, am to 8 am weekends and holidays) and off peak (9.6 c/kWh). The off Peal Water Heating is not affected by the solar panels. Excess energy is exported a 6 c/kWh. The following data is logged for a particular **Quarter (92 days)**:

| Energy Used | Used [kWh] | Cost rate [c/kWh] |
|---|---|---|
| Peak | 118.8 | 40.6 |
| Shoulder | 330.7 | 16.4 |
| Off Peak | 400.0 | 9.6 |
| Off Peak Water Heating | 340.0 | 10.8 |

| Energy Fed to Grid | Supplied [kWh] | Cost rate [c/kWh] |
|---|---|---|
| Peak | 44 | 6 |
| Shoulder | 261 | 6 |

| Energy used in house | [kWh] |
|---|---|
| Peak | 35 |
| Shoulder | 165 |

Service Charge: 59 c per day.

Calculate the savings per year assuming that the Normal and Controlled-Loa Off-Peak rates would be used without the solar panels, and payback time if th system costs $5000. [13]

b) Quite an involved question.
Calculate under old billing scheme of 20.6 c/kWh and 10.8 c/kWh for off-peak water heating.
Energy used = 118.8 + 330.7 + 400 + 35 + 165 = 1049.5 kWh
Cost:- Normal = 0.206 × 1049.5 = 216.20
o/p water = 0.108 × 340 = 36.72
Service charge = 0.48 × 92 = 44.16
$ 297.08

New Rates
Peak = 118.8 × 0.406 = 48.15
Shoulder = 330.7 × 0.164 = 54.23
O/P = 400 × 0.096 = 38.40
O/P water = 340 × 0.108 = 36.72
Service Ch = 92 × 0.59 = 54.28
Generation = 305 × 0.06 = −18.3
$ 213.48

Quaterly saving = 297.08 − 213.48 = $ 83.6
Per year = 83.6 × 4 = $ 334.40
Payback = $\frac{5000}{334.4}$ = 15 years
But is this the true pay-back since rates changed!

Under smart meter
saving = 35 × 0.406 = 14.21
165 × 0.164 = 27.06 (into grid)
$ 59.57 + 18.3 = 59.57 per quater
Per year = 4 × 59.57 = 238.28
Payback = $\frac{5000}{238.28}$ = 21 years!

Therefore either 15 or 20 years depending on view point. The TOU metering is really power metering with 15 minute logging periods.
If the grid power could be used then saving would be higher:-
44 × 0.406 = 17.87
261 × 0.164 = 42.80
60.67

60.67 + 41.27 = 101.94 per quater
= 407.78 per year
So payback if no power returned to grid
= $\frac{5000}{407.78}$ = 12 years

As time goes on then prices will rise so pay-back will shorten. (however, what about interest on panels if you kept the money and did not buy them?) [13]

a) A hybrid electric car has a tare weight of 1500 kg and can carry one driver an four passengers. The average weight of the driver and passengers is 75 kg eac person. The car was running at 70 km/hour when the driver saw a red traffic ligh about 150 m away and applied the brake immediately. The regenerative brakin system of the car is designed to capture the kinetic energy of the car until th speed is reduced to 15 km/hour, and then switch to the mechanical brak automatically to bring the car to complete standstill. It was noticed by the drive that the reading of the car speedometer was 15 km/hour when the car was 15 m away from the traffic lights and the car stopped right in front of the traffic lights a few seconds later. Assume the car speed was reduced linearly during the period of both the regenerative braking and mechanical braking, and ignore all the powe losses due to mechanical friction and wind drags, etc.

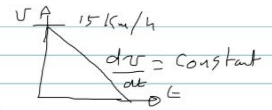
Determine:

i) The total amount of time it takes to brake the car from 80 km/hour to complet standstill;
ii) The ratio between the energy captured by the regenerative braking and the tota kinetic energy before braking;
iii) The minimum rated power of the generator, assuming 100% generato efficiency;
iv) The minimum capacity of the super-capacitor bank required to store th captured kinetic energy in the form of electrical charges if the rated termina voltage of the super-capacitor bank is 200 V DC and ignore the electrica power loss during the charging process. [10]

b) Review the different bio-energy solutions that are available. List their advantage and disadvantages. In this review make reference to key indicators such a conversion rates, ease of processing, greenhouse gas emissions, practicality an final usage. [10]

(5) M = 1500 + 4 × 75 = 1800 kg
$v_1$ = 70 km/h = 19.4 m/s
$v_2$ = 15 km/h = 4.17 m/s
$v_1 - v_2$ = 55 km/h = 15.28 m/s
L = 150 m
$L_{regen}$ = 150 − 15 = 135 m
$\frac{dv}{dt}$ is constant over each range
i) To get total from 70 km/h to zero requires the problem to be split up into sections.

From 15 km/h → 0




$v = u_1(T-t)/T$

$\frac{dx}{dt} = v \quad \int_0^x x = \int_0^T v\,dt$

$x = \int_0^T \frac{4.17(T-t)}{T}\,dt \rightarrow 15 = \left[\frac{4.17t - 4.17t^2}{2T}\right]_0^T$

$T = 15 / \frac{4.17}{2} = 7.19s$

From 70 to 15 km/h $135 = \int_0^T \left(19.4 - \frac{15.28t}{T}\right) dt$

$135 = 19.4T - \frac{15.28}{2}T \quad T = 11.48s$

Total T = 11.48 + 7.19 = 18.67s

ii) Total kinetic energy = $\frac{1}{2}Mv^2 \rightarrow E = \frac{1800 \times 19.4^2}{2} = 338.7$ kJ

at 15 km/h $E = \frac{1800 \times 4.17}{2} = 15.65$ kJ

Regen = $\frac{338.72 - 15.65}{338.72}$ = 0.954 = 95.4%

In reality it would be much lower than this due to mechanical and electrical losses

iii) $a = \frac{dv}{dt} = \frac{-15.28}{11.48} = -1.322$ m/s

F = ma = 1800 × 1.322 = 2380 N
P = Fv = 2380 × 19.4 = 46.2 kW

OR $E = \frac{1}{2}Mv^2 = \frac{1}{2}M\left[19.4 - \frac{15.28t}{T}\right]^2$

$= \frac{1}{2}M\left[19.4^2 - \frac{2 \times 19.4 \times 15.28}{11.48} + \frac{15.28^2 t^2}{11.48^2}\right]$

$\frac{dE}{dt} = \frac{1}{2}M\left[\frac{-2 \times 19.4 \times 15.28}{11.48} + \frac{2 \times 15.28^2}{11.48^2}t\right]$

when t = 0 max $\frac{dE}{dt}$

$\therefore P = \frac{1800}{2} \times \frac{2 \times 19.4 \times 15.28}{11.48} = 46.17$ kW

Phew!!

iv) $E = \frac{1}{2}CV^2 = E_{regen}$

$C = \frac{323.07 \times 2 \times 1000}{200^2} = 16.15$ F

[10] long!

b) Same as 2012 Q6a) but with added pointers to what is required. Typically low conversion rates, need of much processing because of mixed solids and volatile gases, energy crops use a lot of space. Burning biofuels is not green but crops do put $CO_2$ back into the atmosphere and methane is a relatively "clean" carbon fuel [10]