Possible scenarios for transport fuels to 2050

by Jim Le Cornu

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In mid 2008 the Future Fuels Forum[1] issued two reports[2] prepared by CSIRO, on the likely development of vehicles and transport fuels through to year 2050. One report summarised the main findings and the other provided details of the modelling assumptions and a more in-depth discussion. The purpose of this paper is not to replicate those reports but bring them to the notice of fellow engineers and to encourage interest in them by highlighting some of their findings.

The forum members commenced the study by identifying domestic and international factors most likely to drive future changes in Australia's transport fleets and fuels, e.g. oil availability, oil price, the level of greenhouse gas emission reduction required by a future emission trading scheme, the rate of uptake of new technologies, community attitudes to public transport use, etc. Various scenarios were then developed, based on a selection of possible combinations of these key driving factors, so as to get a reasonable coverage of plausible future situations.

CSIRO has computer models of the Australian energy sector which contain a detailed database on each of the main energy sector activities, e.g. transport fuel and electricity production and use targeted by the study. When provided with a set of input assumptions, the models can be used to determine the least costly way of achieving a specified set of input objectives. Each of the scenarios mentioned above was used as the input to these models to obtain an analysis of the likely way in which the energy sector would change through to year 2050 if these scenarios eventuated.

One interesting outcome of this is displayed in the following Fig 9 of the Modelling Report [Fig 6 of the Summary Report].

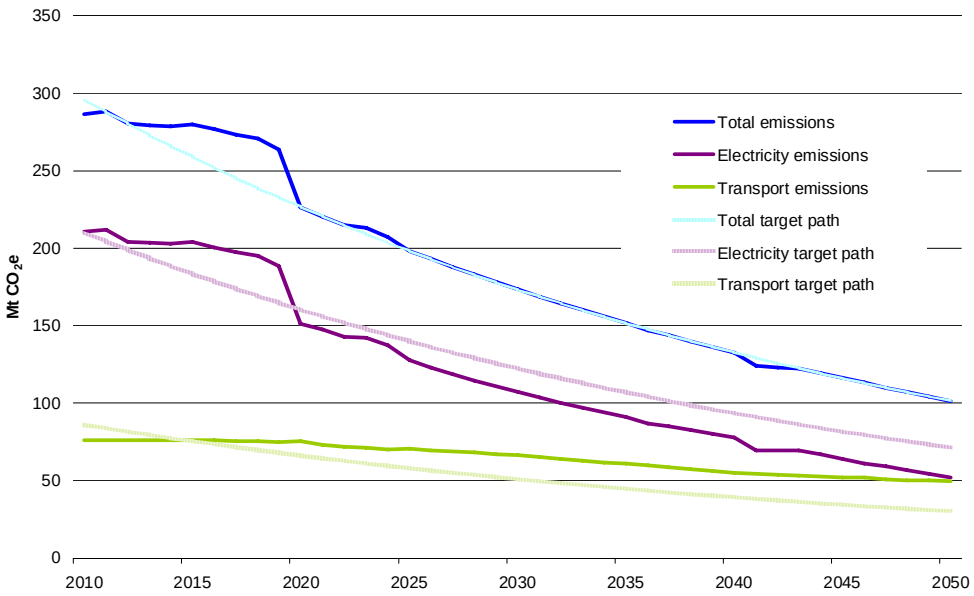

Figure 9: Electricity and transport sector greenhouse gas emissions: EIA[3] high reference oil price and 2000-60 emission target

[1] EA was represented on the Forum by members of the National Fuels & Energy Committee and the National Transport Engineering Committee

[2] Both are available at http://www.csiro.au/resources/FuelForThoughtReport.html

[3] EIA: US Energy Information Agency.

This plot relates to a scenario where crude oil is assumed to continue to be available in sufficient quantities, albeit at the EIA 'high' price, and where overall greenhouse gas emissions from the combined sectors in year 2050 are capped at 60% below the level which occurred in year 2000. The paler colour lines show trajectories where 'target' declines in greenhouse gas emissions might fall if the transport and electricity sectors were required to each smoothly reduce their sector emissions by 60% over that period. The darker lines show where the modelling reveals these trajectories would fall when the same overall 60% greenhouse gas emission reduction by the combined sectors was achieved, but where this reduction was imposed via a greenhouse gas emission trading scheme rather than as arbitrary, equal smooth declines in each sector.

The modelling found it to be cheaper to achieve greenhouse gas emission reductions in the electricity production sector than in the transport sector. Hence the cheapest way of achieving an overall emission reduction of 60% from the two sectors was by the electricity sector reducing its emissions by more then its equal share and avoiding the need to purchase emission permits, with the transport sector acquiring emission permits to offset its higher share of emissions.

Figure 19 of the Modelling Report provides an indication of what some of the implications of such an outcome might be.

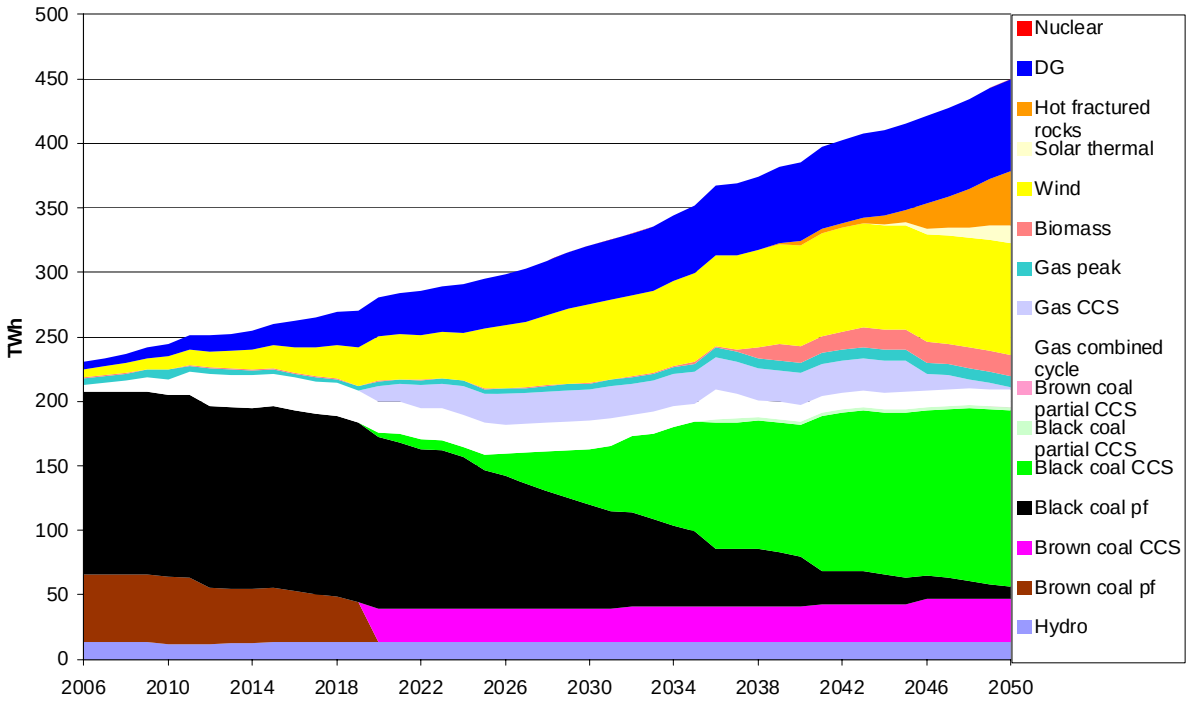

Figure 19: Electricity generation by technology: EIA high oil price and 2000-60 emission target

The reader is encouraged to ponder on the many interesting facets of this plot. Electricity production from pulverised fuel black and brown coal phases out, with a dependence on carbon capture and storage [CCS] technology. Other electricity generation options gain growing shares.

These trends become even more pronounced if a more demanding target is imposed, such as in Figure 63 of the Modelling Report where a 95% emission reduction is required. Here coal based electricity completely disappears, with carbon sequestration and storage unable to reduce emissions far enough at acceptable cost. Even gas fired electricity generation with CCS is eventually phased out. Geothermal [hot rocks], wind, solar thermal, hydro, biomass, nuclear, distributed generation [DG] and gas peaking electricity form the mainstays of production.

As always, the output is only as good as the inputs. Questions remain as to the ability of some of the options to deliver. For instance, solar thermal and geothermal electricity production at the modelled cost has yet to be proven up in Australia. Should some of these new options not be able to deliver as much electricity as assumed, the next higher cost options would tend to replace any deficit, e.g. leading to a greater role for nuclear.

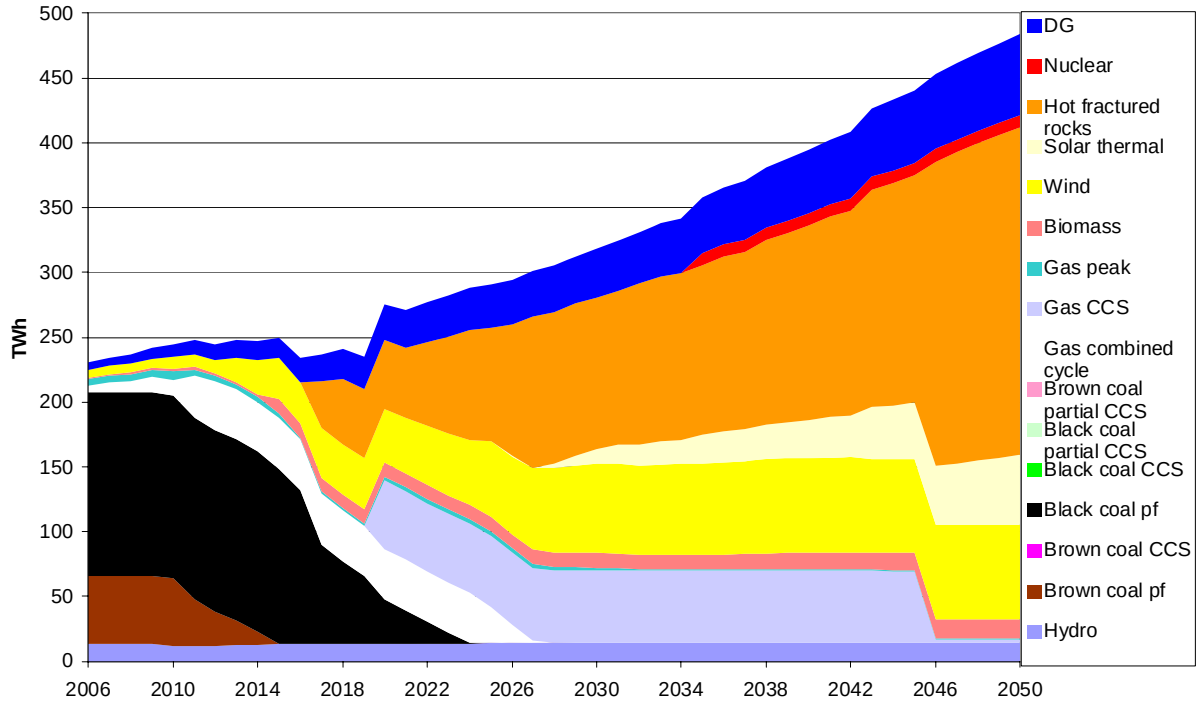

Figure 63: Electricity generation by technology: nuclear power is an option sensitivity case, EIA high oil price, 2000-95 emission target

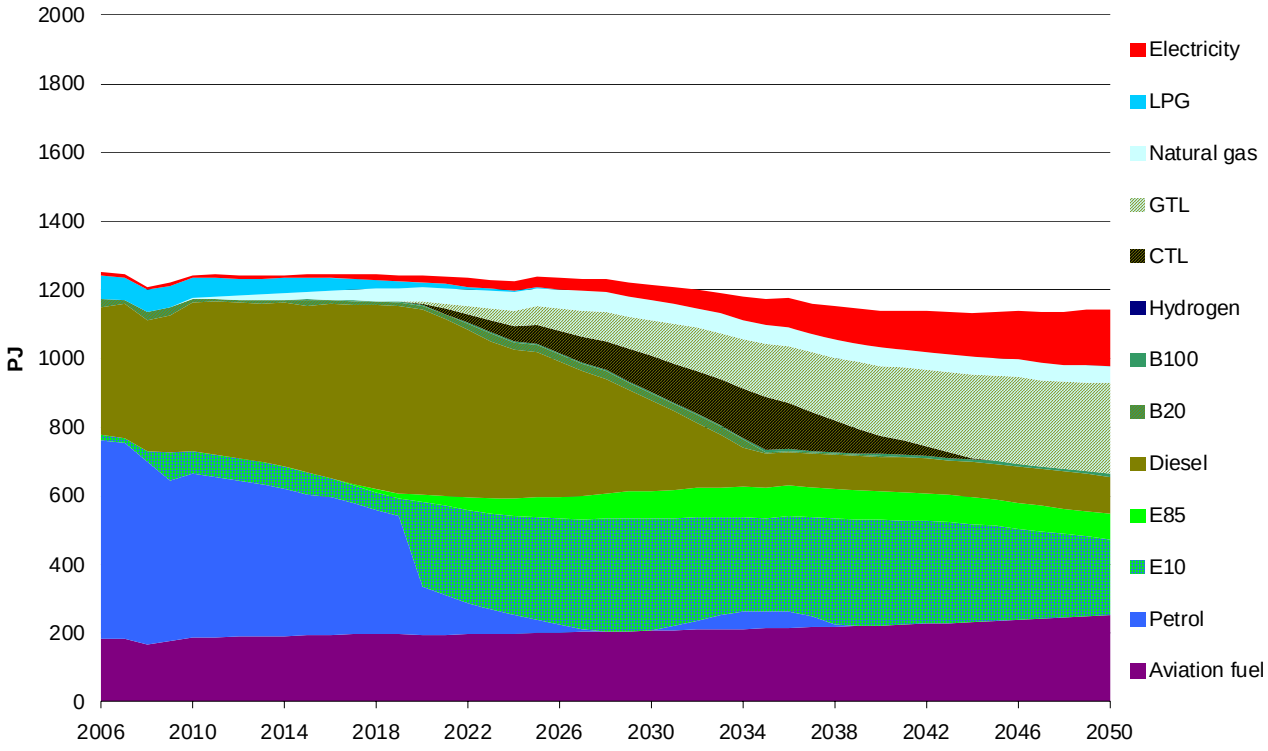

Figure 17: Transport sector fuel consumption: EIA high oil price and 2000-60 emission target

Even though the greenhouse gas emissions from the transport sector will not be reduced as much as in the electricity sector, this does not mean that there will not be major changes occurring. This can be seen from an inspection of Figure 17 of the Modelling Report.

In this 60% greenhouse gas emission reduction scenario, the modelling envisages all petrol containing 10% or 85% ethanol blends by 2050. Some use of conventional diesel fuel remains but there is an additional supply of synthetic diesel from coal and natural gas. The use of natural gas, LPG & electricity to power vehicles also expands, together with a small amount of biodiesel.

A sensitivity case [not shown here], which assumes that low cost production of biodiesel from algae becomes available, indicates a substantial reduction in gas to liquid [GTL] fuels production and the complete displacement of coal to liquid [CTL] production shown in Figure 17.

The vehicle fleet will undergo similarly great changes, as indicated in Figure 18 of the Modelling Report [Figure 13 of the Summary Report]. Plug-in and 100% electric vehicles will be nearly greenhouse emission free as a result of the changes in the electricity sector.

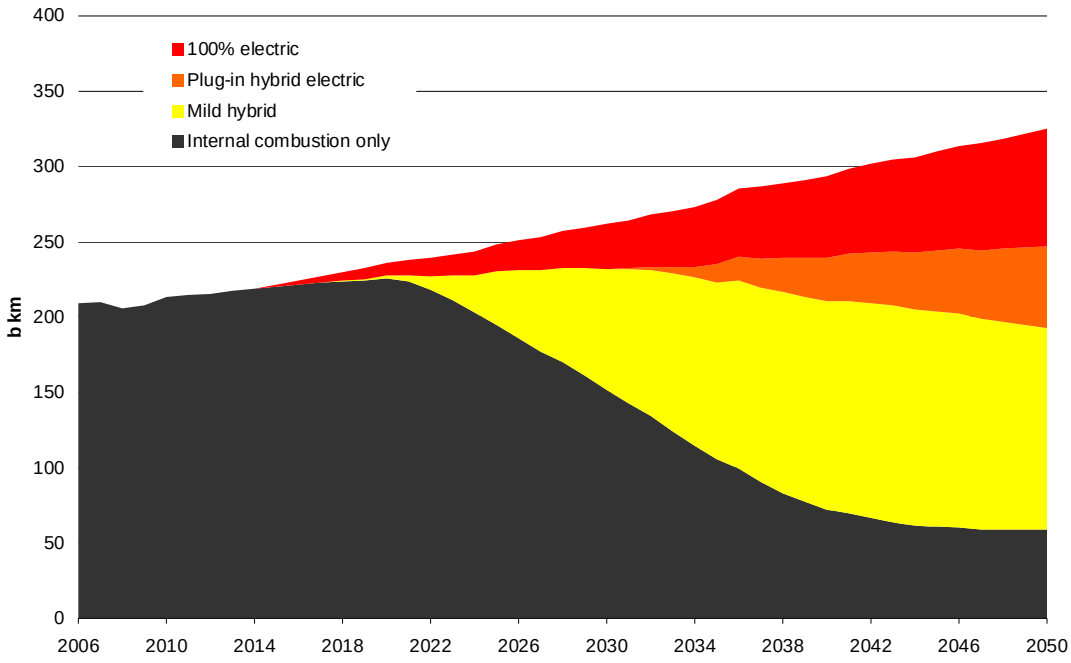

Figure 18: Share of different engine types in road kilometres travelled: EIA high oil price and 2000-60 emission target

The report also covers aspects such as:

- Australia's choice of travel preferences and greater use of public transport.
- The implications for the electricity and transport sectors of crude oil supply having now reached its peak production rate and entering a period of constant decline.
- The implications of the fast or slow pursuit of new greenhouse friendly technologies.
- The impact of policy measures such as:
  - The accelerated scrapping of old vehicles
  - Higher fuel excise
  - Subsidies for low emission vehicles
  - More stringent mandatory emission standards
- Land use and crop production impacts.
- Biofuels from algae.
- Hydrogen as a fuel

- Projected CO_2 emission permit prices, electricity prices and road transport costs
- The weighted cost of passenger transport and freight transport $/km in future years.
- Cost assumptions for the various technologies involved

If this paper has whetted your interest in the study, check out the full reports on CSIRO's site at http://www.csiro.au/resources/FuelForThoughtReport.html .

Jim Le Cornu is a member of Engineers Australia's National Fuels & Energy Committee and participated in the Future Fuels Forum as an Engineers Australia representative.