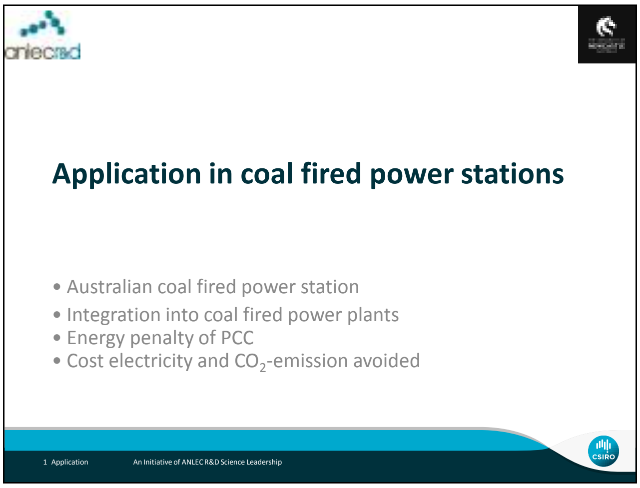
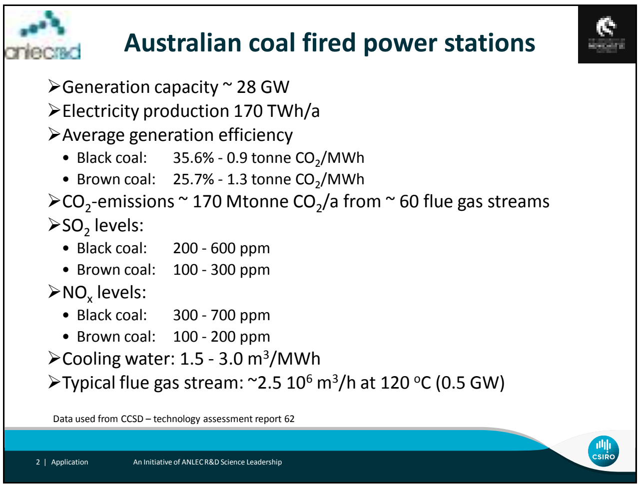
Application in coal fired power stations



This section represents a brief foray into some of the practical considerations and the consequences of doing CO_2 capture in a coal fired power station. The focus will be on Australian coal fired power stations.

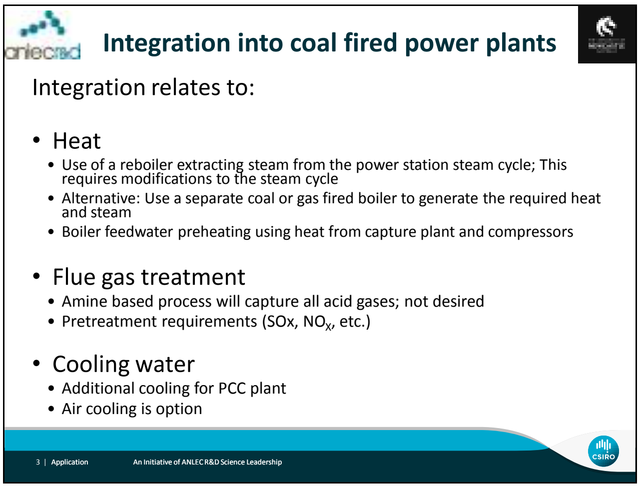
There are different ways you can integrate a capture plant into a power station. Do you use steam produced from electrical heating or extract it from the power station steam cycle? Does the station have flue gas desulfurization? If no what sort of pre-treatment of the flue gas is required? What is the energy penalty in terms of electricity output of operating the capture plant? What effect will capture have on the price of electricity and how much CO_2 will you avoid releasing into the atmosphere?

Australian coal fired power stations



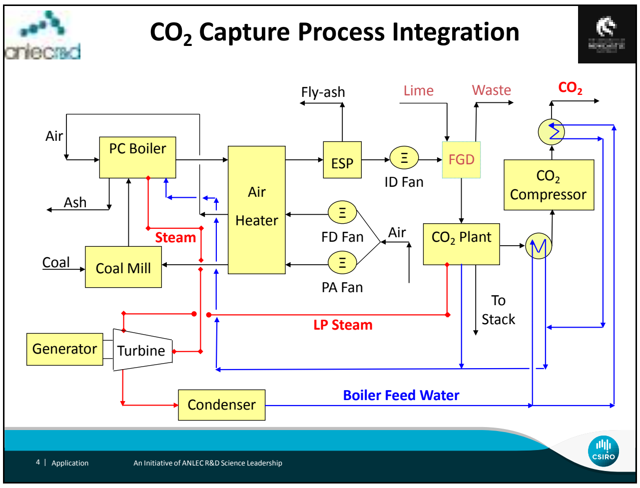
75% of the Australian electricity demand is generated on black and brown coal fired power stations. The CO_2 emissions from brown coal fired power stations are significantly higher because of the lower efficiency, resulting from the high moisture content of brown coal. The levels of sulphur- and nitrogen-oxides are important because they will react with the alkaline solutions used for PCC. Cooling water requirement is also important as there are limitations in its availability in Australia. Cooling water is not necessary in an air-cooled power plant.

Integration into coal fired power plants



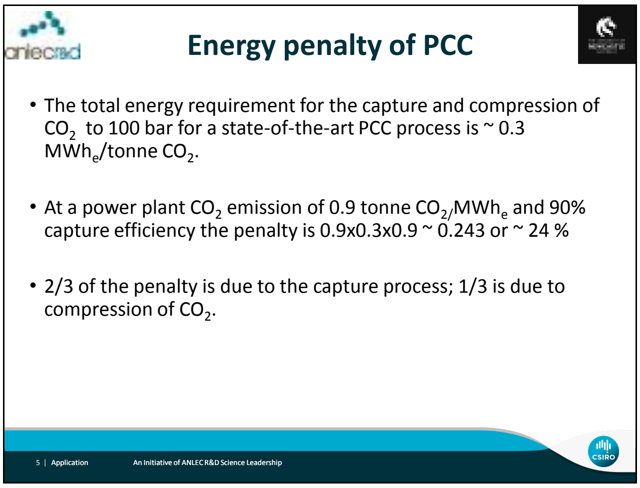
This slide mentions the interfaces between a capture plant and power station. The capture process requires energy in particular heat to increase the temperature of the solvent which then releases the captured CO_2. Part of this heat can be reused in the power plant at lower temperature levels. Compression of CO_2 will also generate heat (*feel the valve of your bike pump when you inflate the tyre*) and this heat can be used the power plant. The other important consideration for integration into a power station is flue gas pre-treatment. If the power station has flue gas desulfurization and NO_x removal minimal pre-treatment will be required. However, if these processes are not present a pre-treatment column (typically a packed column containing a weakly caustic solvent) will be required to reduce the concentration of these contaminants passing into the capture process as well as to cool the flue gas to the absorption temperature. The capture plant will also require some cooling and this will need to be minimised. Air cooling in the capture plant might be preferred as this does not require more cooling water.

CO_2 capture process integration



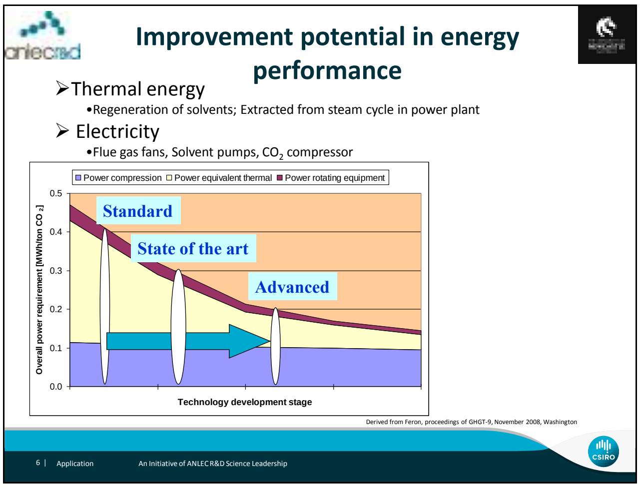
The figure shows how a capture plant could be integrated into a power station. In this case the flue gas pre-treatment would consist of an electro-static precipitator (ESP) and flue gas desulphurisation (FGD) in addition to flue gas cooling. Low pressure (LP) steam is used to regenerate the solvent and the condensate is returned to the pulverised coal (PC) fired boiler. This steam is then not available to generate electricity.

Improvement potential in energy performance



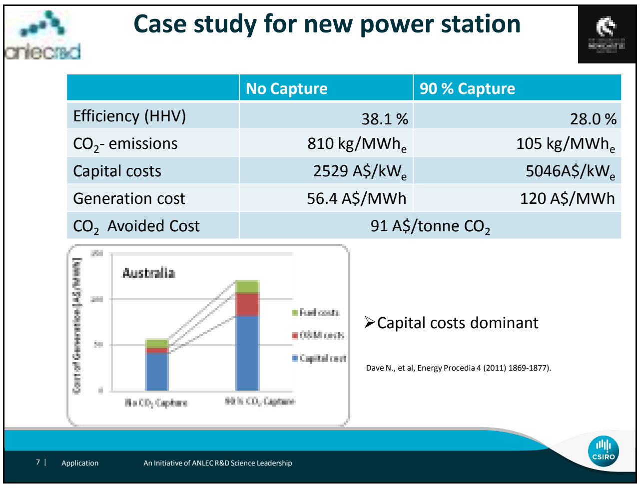
As you would expect CO_2 capture does not come free. The energy demand in a CO_2 capture plant comes to a large extent from the heat required to produce the steam for CO_2 stripping. Taking steam from the steam cycle and/or electricity reduces the power station's electricity output. Also pumps, fans and the compressors will use electricity from the power station. Typically the aim is to capture a significant amount of the emissions of a power station, i.e. 90 %. For a state-of-the-art CO_2 capture process a typical energy requirement is ~0.3 MWh/CO_2 captured. This represents about 24% of the output of a coal fired power station.

Improvement potential in energy performance



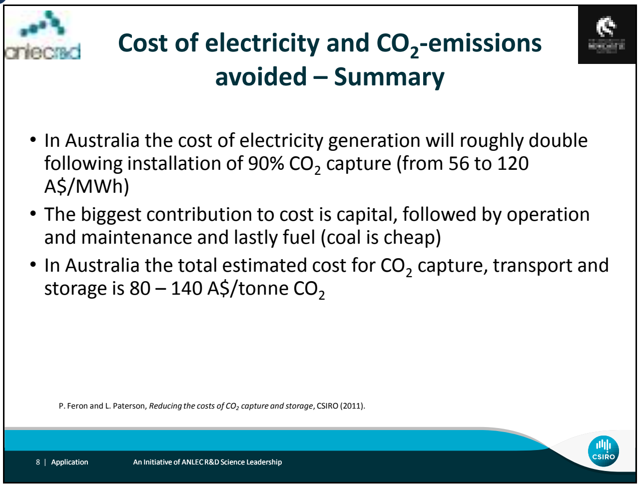
This slide indicates that there is considerable improvement potential in the energy performance of the PCC process. Over the past two decades the energy requirement has come down from ~0.4 MWh/tonne CO_2 to ~0.3 MWh/tonne CO_2. In particular the thermal energy requirement has been reduced. Further reduction to ~0.2 MWh/tonne CO_2 appear possible. One has to bear in mind that the theoretical minimum is ~0.1 MWh/tonne CO_2.

Case study for new power station



This slide gives relevant data for the power plant efficiency, CO_2 emissions, capital costs, generation cost and CO_2-avoided cost for a new power station, in the situation without capture and with 90% CO_2 capture. Although the emissions are significantly reduce the increase in the capital cost and electricity generation cost is significant.

Cost of electricity and CO_2-emissions avoided – Summary



It has been estimated that in Australia 90% CO_2 capture will double the cost of electricity generation. This is not as bad as it sounds as the cost of generation is only part of the cost of the final price paid by electricity consumers. The biggest contribution to cost is the capital cost to build the capture plant. Second is the energy required for capture plant operation and the loss of electricity output, followed by maintenance and lastly fuel. In Australia the predicted cost for capture, transport and storage is in the range 80 – 140 \$/tonne CO_2.