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10 April 2008

Garnaut Review Secretariat
Level 2, 1 Treasury Place
EAST MELBOURNE VIC 3002

Dear Sir / Madam

GARNAUT CLIMATE CHANGE REVIEW
SUBMISSION OF COMMENTS FROM ALSTOM LTD

Alstom is a leading provider of power generation and transport infrastructure. We have supplied over 20% of the world's installed power generation capacity as well as one in four of the world's metros. Dealing with environmental and climate change issues is a key imperative for the company.

It is therefore with pleasure that we submit herewith comments and supporting information relating to your Issues Papers released at public forums between Nov 07 and Feb 08. These comments are founded on the wealth of Alstom's global experience in the fields of power generation and rail transportation.

We trust that our input is beneficial to the Garnaut Review's deliberations.

Please feel free to contact the undersigned if you have any further questions or requirements for additional information.

Yours faithfully
ALSTOM Ltd



Chris Raine
Country President
Australia & New Zealand

1. PREAMBLE - ABOUT ALSTOM

Alstom is a world leader in the fields of power generation and rail transportation, both of which heavily interact with greenhouse gas emissions policy developments. The company is headquartered in Paris, France, where it is publicly listed with a current market capitalisation of around EUR 16,730M (approx AUD 27,000M). It has operations in over 70 countries around the world and employs approx. 66,000 people globally. Alstom's turnover for fiscal year 2006/07 was EUR 14,208M (approx A\$23,000M), with an order backlog of EUR 32,350 M (approx A\$53,000M).

In power generation, ALSTOM has provided over 20% of installed global power generation capacity; and has extensive involvement across a wide range of technologies and fuel types, from traditional fossil fuels such as coal, oil and gas; through nuclear (conventional islands excluding reactors) and co-generation; to renewables such as hydro, wind and biomass. Additionally, Alstom undertakes significant annual expenditure on R&D to improve the performance of existing technologies; and develop the next generation of generating equipment.

Alstom is also one of the major global players in rail transportation, with, for example, one in three modern trams rolling off our production line; one in four metro systems world-wide coming from Alstom; and our leadership in Very Fast Train technology. As such, we are well placed to offer advice from a global perspective on both cost and emissions competitive transport solutions. As with power, we undertake significant R&D work to advance passenger rail technology, with recent Alstom advances testament to our efforts: our "wire-less" tram systems; "driverless" metro systems; and last year's breaking of Alstom's previous world rail speed record to a new level of 574.8 kph by the latest generation of our very high speed train, the AGV.

In Australia, ALSTOM employs around 700 people nationally, with both our power and transport activities headquartered in North Ryde, NSW. Alstom has enjoyed significant project success in Australia over the last decade, encompassing provision of around 3500 MW of new generating capacity including such recent highlights as the Tallawarra Combined Cycle Power Plant in NSW; and the Kwinana Combined Cycle plant in WA. In Transport, we have provided both our Citadis Trams and Xtropolis trains for use on the Melbourne metropolitan public transport network; and supplied significant advanced componentry for Sydney's latest generation Millennium trains.

Additionally, Alstom has one of the largest service organisations supporting the power industry in Australia. This unit provides specialist goods and services to support the operation, maintenance and upgrade of power plants and other similarly strategic process industries; and includes workshops that provide Australian industry with specialist capabilities unique in this country.

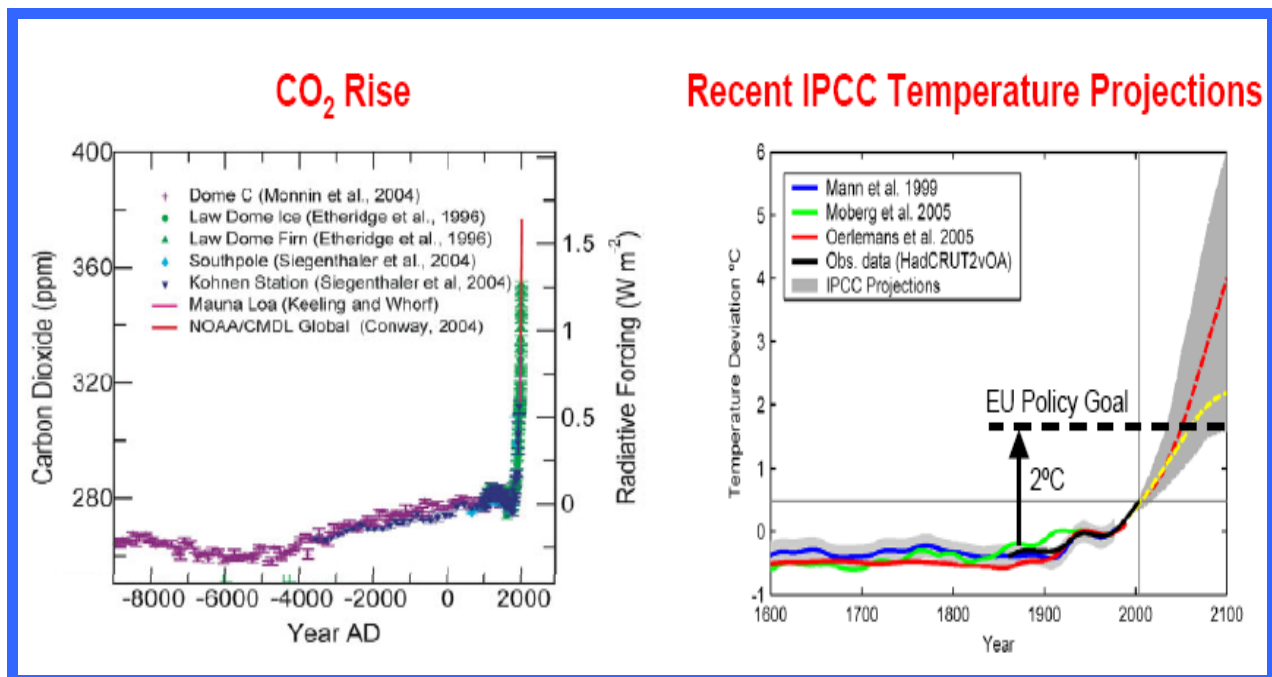
As one of the major global players in both the power generation and rail transportation industries, ALSTOM is well placed to comment on issues raised by the Garnaut Review as they so relate. In particular, we have large technology development programs related to carbon emissions abatement and much recent experience working with both the public and private sectors in Australia in areas such as implementation of large scale emissions reduction demonstration plants; and new passenger transport systems.

2. COMMENTS ON GARNAUT CLIMAT EXCHANGE REVIEW ISSUE PAPERS

Alstom Submission on Issues Paper 3 - Climate Change and Emissions Stabilisation

Alstom's Position on GHG / Climate Change:

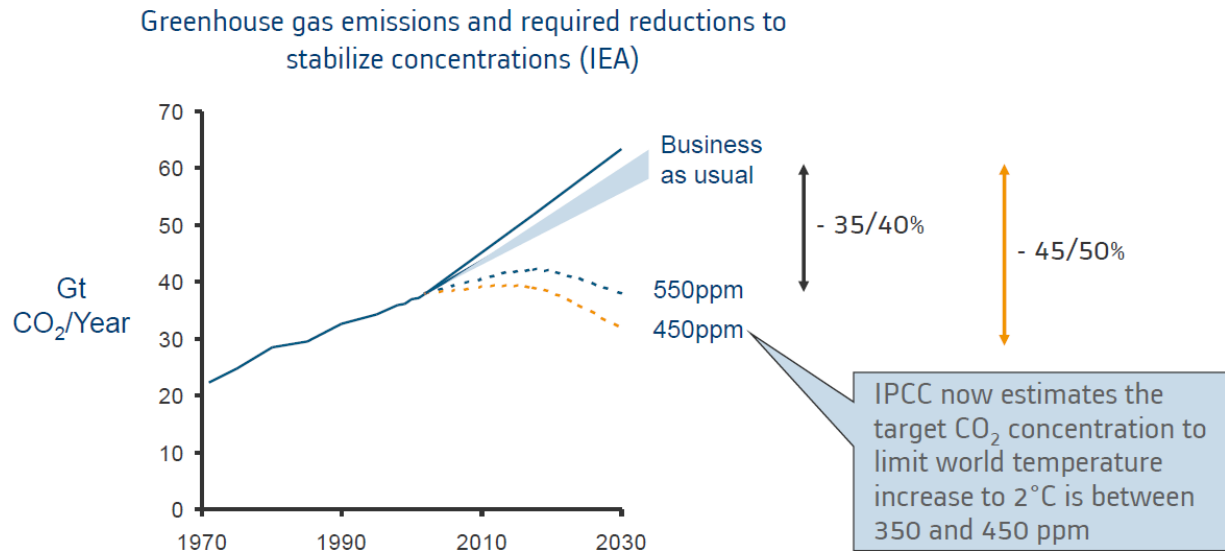
Alstom is primarily a technology company operating in the fields of power generation and rail transportation. We develop, manufacture and deliver technological solutions in these areas. We are not an organisation engaged in any independent research on atmospheric science or the mechanics of climate change. As such, whilst we as a company have formed an educated view on the climate change information being presented to date by the scientific community, we are not in a position to add to that body of knowledge on the basic science behind climate change per se.



Current atmospheric CO₂ concentration 380 ppm, the highest ever.....

Alstom's view is that it accepts as scientifically measured facts that atmospheric CO₂ concentrations have risen significantly over recent decades; and that average global atmospheric temperatures have also risen in this timeframe. We also acknowledge that the IPCC has recognised the link between anthropogenic CO₂ emissions and earth surface temperature as unequivocal; and that Governments are establishing policy settings to counteract manmade CO₂ atmospheric concentration rise in response. As a

consequence, Alstom is developing technological solutions to reduce CO₂ in the markets we serve to meet our customers' needs to meet with the policies established by their Governments.



Greenhouse Gas Emissions – Global Perspective:

Overall, massive efforts are required from all sectors to achieve a stabilisation in CO₂ emissions. Globally, power generation is one of the largest sources of man-made CO₂ with many single source emitters. Transport is also a significant emitter, though not on the same scale as power generation. Passenger transportation, the primary area of transportation that Alstom participates in, is a smaller subset of transport emissions again. As such, Alstom would view power generation as offering the most potential for large CO₂ emission reductions globally.

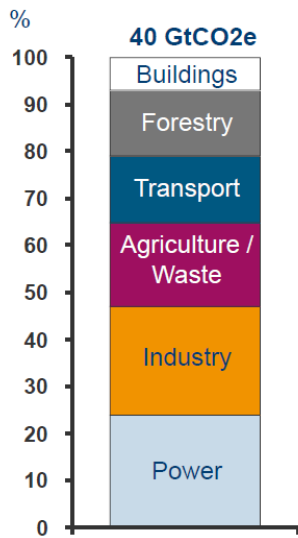
A portfolio of solutions will need to be deployed to meet emission reduction targets in the power generation sector including:

- 1) Demand reduction through the setting of end-user efficiency standards and energy management solutions including deployment of smart grid solutions,
- 2) Improved technology mix with more nuclear and the massive roll out of renewable energies like hydro and wind, including biomass co-firing;
- 3) Improved production efficiency through aggressive retrofit of the installed base and adoption of the best available technologies for new plants.
- 4) Mandation of carbon capture and storage (CCS) on all fossil-fuel power generation plants.

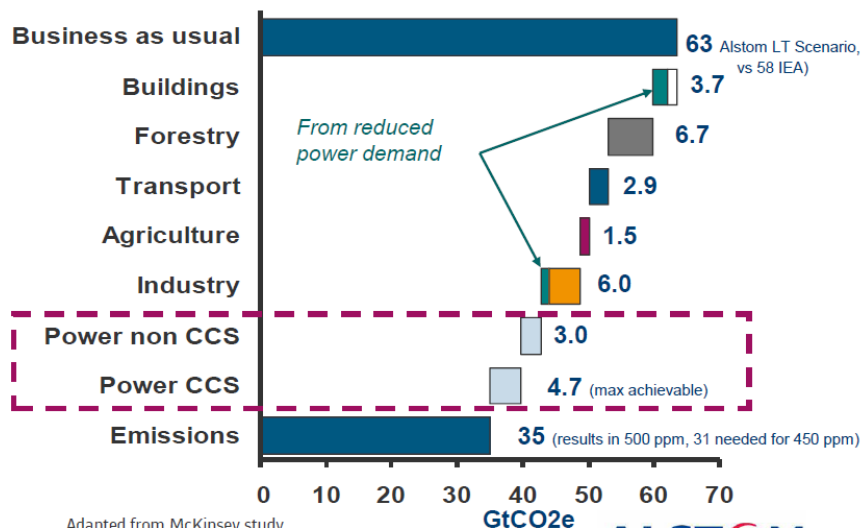
CCS technologies are the main ones capable of ensuring the early & fast ramp-up needed to achieve the necessary reduction targets. Retrofitting on a large part of the recently installed base for carbon capture (and storage) as well as on new plants will be also necessary to achieve such targets.

Alstom strongly contends that global CO2 targets simply cannot be achieved without CHINA introducing carbon capture and storage (CCS), as early as 2020. This is a major and critical conclusion from Alstom’s analysis of CO2 issues, implying that a robust world-wide emission trading scheme and emissions reducing technologies including CCS have to be proven well before 2020. By contrast, Australia’s levels of emissions, of themselves, are too small in absolute terms to make a significant difference to global atmospheric CO2 concentrations. Australia’s efforts will need to part of a co-ordinated global action to make a meaningful contribution and show technology leadership.

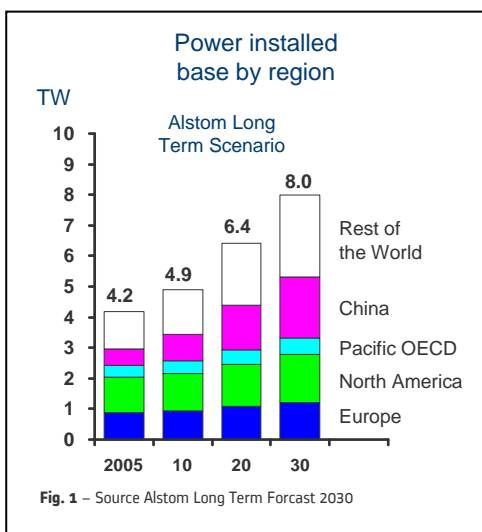
GHG emissions by sector



Abatement potential by sector from 2030 business as usual (GT CO2e/yr)



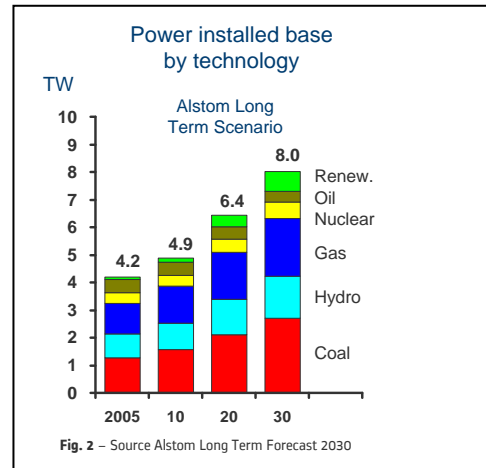
Global Power Market Projections



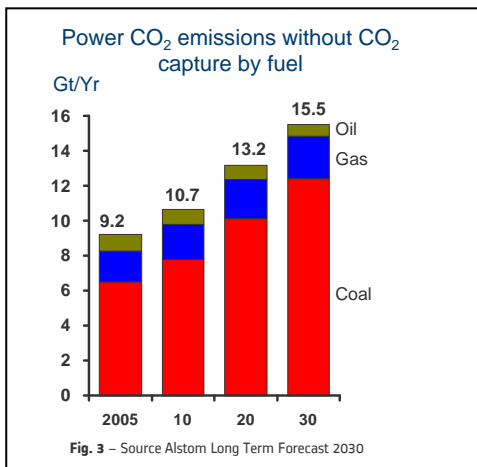
Alstom’s long-term global power market projections indicate a doubling of world-wide installed power generation capacity by 2030. This is in line with the IEA baseline proposed in its Reference Scenario from the World Energy Outlook 2007, at 8.2 TW in 2030 . Alstom expect that Asia will continue its economic expansion, lead by China. Other major developing countries such as India will also see rapidly increasing power demand. In Europe, we expect Western Europe to stabilise demand by 2030 through more efficient use of power, but Eastern Europe will likely continue strong growth in power demand. North America should also be able to control its demand growth, assuming sufficient end-user efficiency policies are implemented.

Increased demand translates as a continued strong growth in coal-based power generation, mainly driven by the new installations in China and the replacement of the ageing fleet in Europe and North America. For energy security reasons, Alstom foresees that coal and gas will still retain their current respective market shares.

Renewable energy technologies (excluding hydro), driven mainly by wind, will see their share increase from 2.3% in 2005 to 8.9% in 2030, which is a seven fold increase in installed capacity. This in itself presents a strong industrial challenge for the power sector. Hydro power will see a strong 80% increase, with a third of this growth in China, and a fifth in South America. Applications such as hydro pumped storage will also increase strongly, driven both by the increase in wind and nuclear power. There is also renewed interest in nuclear power in many countries world-wide. However, leaving aside any political obstacles, an acceleration in new nuclear plant capacity faces several challenges, including a lack of experienced nuclear engineers, licensing and permitting problems, financing difficulties for the large capital investments required; and long-lead times to organise the necessary regulatory processes for new entrant countries. For these reasons, Alstom forecasts a strong increase in nuclear capacity (50%+), but that appears to be the limit of possibility into the mid-term.



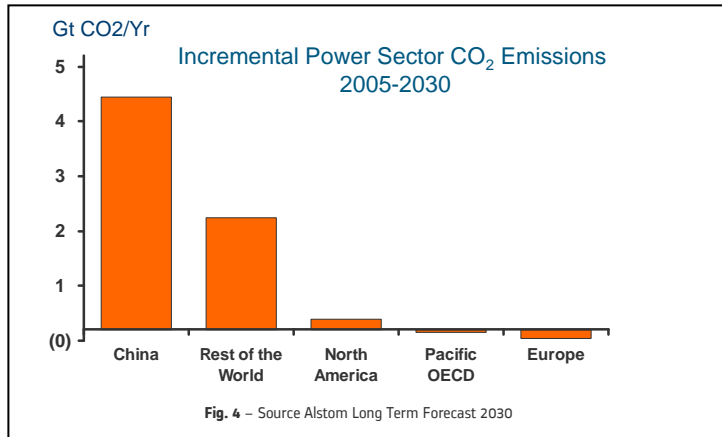
The carbon emissions perspective:



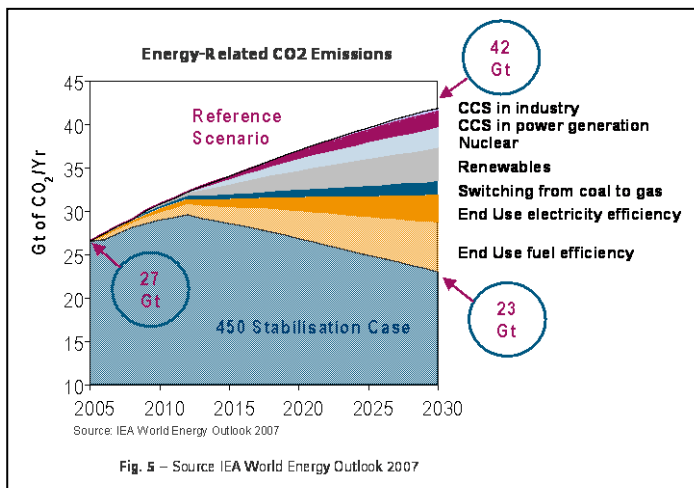
Under the above Alstom scenario for global power generation, our best case emissions projections from the power sector show that CO₂ emissions will increase by 6.3 GT/yr and should peak at 15.5 GT/yr in 2030, if no CO₂ capture and storage solution is put in place (compared with approx 19 GT of emissions under the IEA reference scenario). On the power primary fuel side, coal is by far the largest emitter of CO₂, increasing its share of emissions from 70% in 2005 to 80% in 2030. It must be noted that those projections already include 3.0 GT of CO₂ "avoidance" through world-wide deployment of best available technologies for new plant, the aggressive retrofit for efficiency improvement on existing coal power plants and the positive effect of the penetration of renewable energies and nuclear described above.

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On a regional basis, China will be by far the largest contributor to incremental CO₂ emissions. Alstom estimate that between now and 2030, about 1300 GW of new power generation capacity will be installed in China, 70% coal fired. This will generate over 4 GT of incremental CO₂ emissions, as much as the current emissions of the entire power sector in Europe and North America. This clearly implies that the sustainability of coal as a primary energy resource for power must include carbon capture and storage (CCS) capabilities. This technology must be rapidly demonstrated (by 2015) and then deployed on a large scale, starting in 2020, and including in CHINA.



Climate and CO₂ abatement targets:



The May 2007 IPCC Summary for Policymakers gives a maximum target of 450 ppm CO₂ in the atmosphere in order to limit the long-term earth surface temperature increase to 2°C. This represents a world-wide 50% abatement of emissions from fossil-fuel compared with the expected emissions of “business as usual” scenarios, for a total reduction of around 19 GT of CO₂ equivalent per year, to be achieved by 2030. The power sector will be at the forefront of this effort

and the IEA predicts that its emissions must be reduced from close to 19 GT under their reference scenario down to 6 GT to achieve the 450 ppm goal.

Such a dramatic reduction will require stringent actions on many fronts including in power generation: drastic demand reduction, early retirement of older plants, increased generation through renewable energy sources, very strong nuclear power generation programs and carbon capture and storage. Alstom believe such actions are feasible and will need to be implemented rapidly in all developed countries if emission reductions are to be met. In developing countries, however, Alstom believe that such a portfolio approach, with the exception of carbon capture and storage, will be very difficult to deliver practically at large scale because:

- strong growth in demand;
- relatively little old existing fleet to retire;
- technological, cost and logistical constraints on renewables such as wind; and
- lack of indigenous capability and resources to develop nuclear in time frame required.

This leaves carbon capture and storage as the main solution by 2030 for large scale deployment on the back of the rapidly expanding coal fleet in Asia, especially in China. In accordance with the IEA, Alstom believe that a realistic goal of 2 GT/yr of CCS installation by 2030 is achievable.

GHG Emissions in Australia:

Appendices 2 & 3 show the latest (2005) Australian Government breakdowns of Greenhouse Gas Emissions nationally, by both *Source of Emissions*; and by *Source of Economic Activity*.

Power Generation: Electricity is shown to be the Source of 34% of Greenhouse Gas (GHG) Emissions in Australia – the largest single category. Coupled with the fact that power stations are large single-source emitters, it is clear that, just as globally, a significant part of Australia's efforts to reduce GHG emissions will need to be bourn by the power industry.

Rail Transportation: "Residential Transport" is shown to be the source of 8.3% of GHG emissions by Economic Sector. This includes all forms of residential passenger transport such as automobiles, buses, trains, ships and planes etc. As such, passenger rail would be a subset of this and its potential to reduce national GHG emissions would be much smaller than power generation. Nevertheless, it can contribute to GHG reduction efforts in two ways:

- Directly - Passenger rail transport tends to have a lower kg CO₂ / passenger / km than other forms of transport, especially when patronage is high in higher density urban applications. This advantage would be enhanced as the CO₂-e of power generation is lowered, as most power for urban passenger rail transportation is from electricity.
- Indirectly, - through reduction in congestion. Passenger rail transportation has the ability to relieve congestion on alternative forms of transport like roads and airports, especially during peaks. As such, the indirect GHG reductions from passenger transportation may be a very significant part of its advantage; and should be accounted for in any project benefit assessment.

Alstom Submission on Issues Paper 4 - Research and Development: Low Emissions and Energy Technology

What is the role of an emissions trading scheme in driving innovation?

An ETS delivers the economic price signal that creates demand for innovation; and creates the freedom to meet mandated outcomes without mandated technical solutions being imposed. It leads to innovation in the search for lower cost ways of achieving such mandated outcomes; and also provides certainty around timescales for both innovation and investment.

How large are market failures in innovation?

The major issue in innovation is at the stage where a new technology moves from Technology R&D to demonstration. The costs go up by orders of magnitude (often \$100Ms in case of major new power generation technologies) whilst industry players have to place existing asset performance at risk to allow them to be used in demonstration. Significant Government funding will be required to allow new technologies to be demonstrated at industrial scale as they move towards commercialisation.

How can Australian governments improve policy clarity, continuity and coherence for businesses looking to invest in new energy technologies, or in other sectors with the potential to contribute to mitigation or adaptation?

Given that most energy and transport industry investments have high capital expenditure, long lead times and long investment lives of 25 + years; long term policy certainty is required. Any ETS, for example, must clearly define targets and timescales going forward; full details of the operating regime and if / when any reviews will occur. Once implemented, the policy needs to be maintained over the long term.

How can the Australian Governments avoid “picking winners” while encouraging increased innovation? What is the current best practice for technology neutral innovation policy?

Set up funding programs for both R&D and demonstration that encourage multiple technologies which will deliver several technical options commercially proven under Australian conditions, and thus made available to the market; so allowing an ETS to deliver the lowest cost outcomes by affording the market the opportunity of taking up the most economic option from the proven ones available.

What types of reform are needed to ensure that public funding is allocated to the most appropriate and highest value uses?

Broad industry representation on funding selection panels to ensure relevance in meeting overall Govt policy outcomes.

What are the spillovers faced by firms at the marketisation phase and how large are these spillovers?

Significant Govt funding support is required as technologies are carried through the demonstration phase to full commercialisation as spillovers are large at this stage, Intellectual Property ownership and protection at the demonstration phase is also required in any Govt funding arrangements to provide participants with incentive to develop technologies.

Are there significant spillovers at the other stages?

At the Technology R&D stage, Intellectual Property protection is required by private sector participants if they are to be attracted to carry out such R&D in Australia.

What policy alternatives are available to increase the incentives for firms to undertake more demonstration or commercialisation activities?

From the perspective of an international company, significant additional demonstration plant funding as a follow on to previous LETDF program, coupled with acceptance by Govt that private sector intellectual property needs to be protected under such programs.

How can Governments encourage the diffusion of technology internationally without diluting the incentives for innovation?

By encouraging globally significant companies to develop technology in Australia by: partnering in Australian based R&D / demonstration projects; being involved in Australian programs; and setting up R&D infrastructure / programs in Australia. Central to this effort to attract the participation of such international companies is the need to ensure that they will get adequate Intellectual Property protection.

3. ADDITIONAL COMMENTS ON ISSUES RELATED TO GHG EMISSIONS IN POWER AND TRANSPORT

POWER



A new set of technologies is under development by Alstom and others to meet power generation in a more economic and environmentally benign way as well as improving the environmental performance of the currently installed base. Alstom believes that ultimately the market will choose the most appropriate in terms of being able to deliver the lowest cost of electricity consistent with meeting mandated environmental performances.

Alstom has a “four pillars” approach to reducing CO₂ emissions from power generation activities sufficiently to meet suggested atmospheric CO₂ stabilisation targets, namely

1. Improve the efficiency of Installed Base
2. Increase efficiency of new plant via advanced cycles
3. Introduce concept of “Carbon Capture Ready” plants
4. CO₂ Capture solutions for both new plant AND Retrofit on Installed Base

As will be shown below, commercialisation of new carbon capture and storage technologies will likely start around 2015. As a consequence, improvement in the efficiency of the existing base is essential to start to make a more immediate impact as well as reduce the economic cost of greenhouse gas emissions reduction by allowing existing assets to achieve their economic lives. Alstom has had extensive experience in retrofitting improvements to existing plant, both here in Australia and overseas. Where applicable, retrofitting can produce an increase in unit output, improvement in efficiency (ie lower CO₂ intensity per MWh sent out), lower emissions of specific pollutants such

as NOX, SOX and/or particulates; and an extension to the economic life of a plant. These incremental improvements can often be achieved with relatively modest capital investment relative to construction of new plant. Additionally, several technologies will become available to be retrofitted to existing plant to further boost their CO₂ emission intensity, namely:

- Biomass Co-firing
- Solar Thermal Boosting of Fossil Fuel Fired Power Plant Steam Cycles
- Turbine Shaftline Retrofit
- Post combustion CO₂ capture
- Oxyfiring

Improving the efficiency of new plants via adoption of “advanced steam cycles” is also considered an essential “next step”, on the basis that each kg of CO₂ avoided is one that does NOT need to be captured and stored. The consequence of improved efficiency is that any CO₂ capture and storage technology will be proportionately smaller and thus the cost of adaption to a carbon constrained power generation world thus lowered.

Alstom has adopted a multi-pronged approach to low emission technology development and deployment because:

- 1) the various technologies under development have different timescales to full commercialisation, meaning some may need to be deployed before others become available if mandated emissions targets are to be met, even if the latter technologies ultimately prove to be the most cost effective; and
- 2) it is not yet possible to determine which particular technology will ultimately be the most cost effective (in fact, different technologies may well predominate under different circumstances).

The deployment time-line:

Alstom have studied the necessary industrial ramp-up requirements needed to achieve the target of 2.0 GT CO₂/yr capture and storage capacity by 2030. First, the overall deployment time-line of the various technologies was studied, in order to understand the overall feasibility constraints.

CCS Roadmap

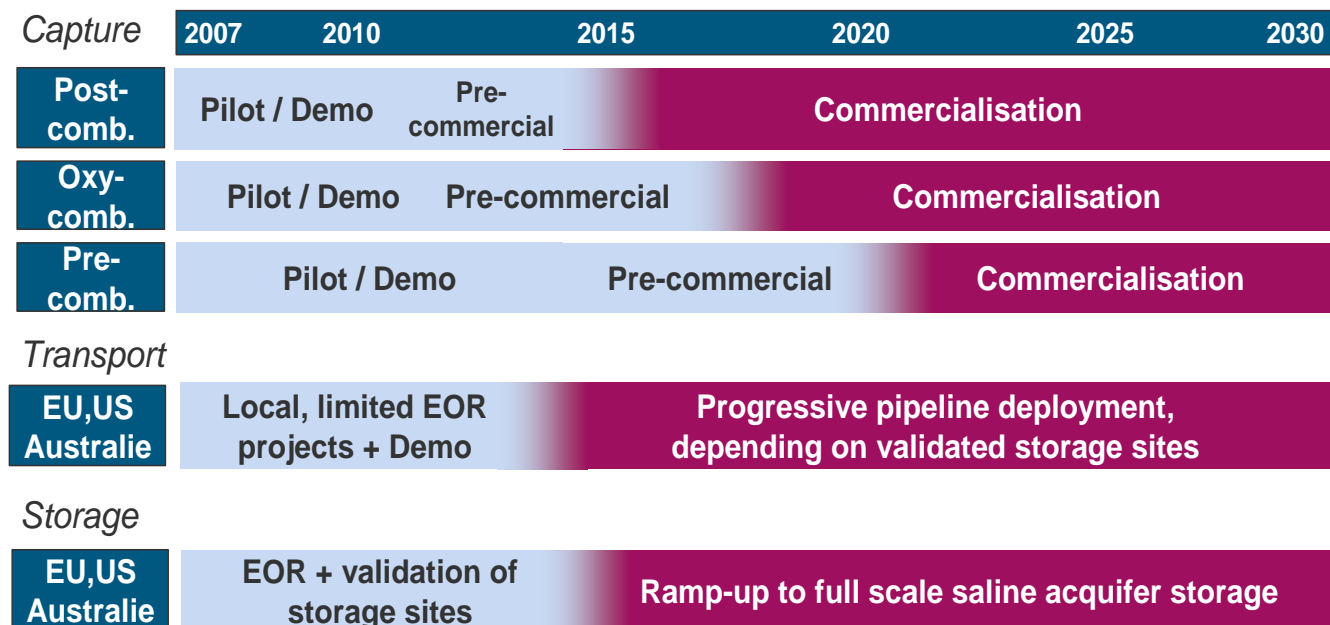


Fig. 6 – Source Alstom Analysis

There are various capture technologies under development: Post-combustion, which involves removing the CO₂ from the exhaust gases by means of a solvent such as amine or ammonia; Oxy-combustion, which, as its name implies, is a method of burning the fuel in oxygen to obtain a stream of CO₂; and Pre-combustion, which involves removing the CO₂ before the fuel is burnt, the most well known method of which is commonly referred to as IGCC. Alstom is working on all three types of CO₂ capture, with a strategic focus on post-combustion and oxy-combustion.

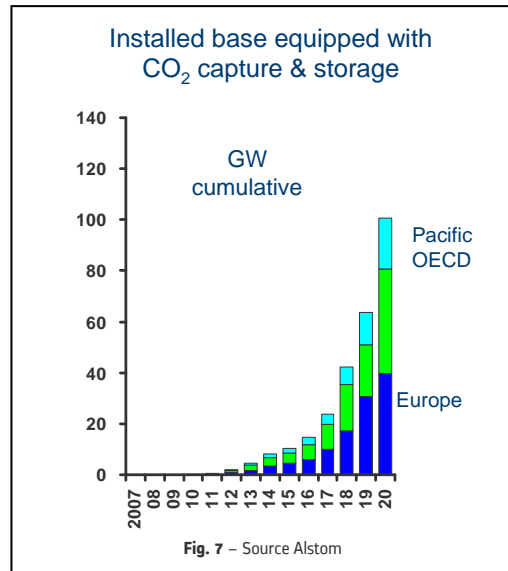
A set of different capture technologies will be fully commercial by 2020. Post-combustion technologies, such as amine or ammonia scrubbing, will be available as early as 2014 for full commercial deployment, owing to the fact that they can be fully tested at a smaller scale and flexibly deployed in several trains on any power generation unit, whereas other technologies require full size scale-up.

On the CO₂ transportation and storage side, we see early local testing of several storage solutions in the demonstration phase, including in Australia. Commercial applications for enhanced oil recovery (EOR) and storage in depleted oil and gas fields are being looked at in both Europe and in the US. World-wide attention is also being given to storage in saline aquifers, the main known storage solution able to credibly cope with the huge storage volumes of CO₂ being considered in the long term. In this regard, programs to evaluate actual saline aquifer CO₂ storage potential must be strongly encouraged in China and India. As there is no EOR potential and limited geological exploration capabilities in these rapidly developing countries, early support in those areas is of critical importance.

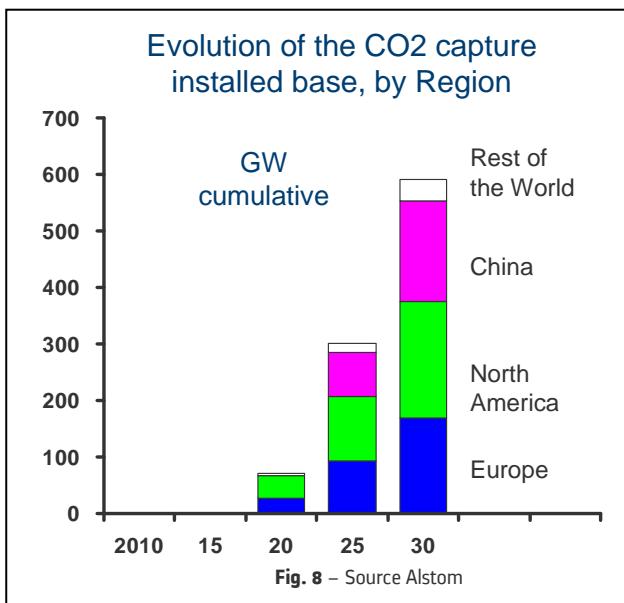
Lack of legislative framework around CCS is another factor which could hold up deployment of CO₂ storage. Australia is well advanced in this regard relative to other countries and may be able to provide a template for others to follow.

The path to CO₂ free energy:

In order to study industrial ramp-up requirements, Alstom have adapted an internal computing model capable of simulating technology deployment according to a set of assumptions. In this case we have made the model work with assumptions derived from our analysis of the likely regulations and CO₂ capture and storage needs derived from the market analysis cited above. Those assumptions include, in date order: - until 2012, identified demonstration units, - from 2010 to 2014 limited release of post-combustion solutions, - from 2014-2016, commercial ramp-up of post-combustion solutions and limited release of all other technologies - from 2016 full commercial availability of all technologies and 100% (in 2016) of new plants ordered to be equipped with carbon capture and storage in Europe, North America and Pacific OECD. The resulting simulation gives an idea of the ramp-up that is technically possible and needed to prepare the major industrial effort required after 2020.



For the next period 2020 to 2030, there will be additional constraints including priorities in the fleet equipment pattern of purchasing for capturing and storing CO₂ according to the cost of each solution. It will be cheaper to implement CCS on a new plant than retrofitting an old plant to capture CO₂. For deployment until 2030, our model takes into



account the targets set by region according to assumptions on regulations, and deducts all possibilities in a given region to achieve the target. If the target exceeds the CO₂ capture possibilities in a given region, the model then “suggests” abatement in another region were those reductions are still possible, until the region target is fulfilled. As shown in figure 8, this allocation method results in a major conclusion: the goal of capturing and storing 2.0 GT of CO₂ by 2030 **cannot** be achieved without a significant portion of installations in **China**, starting as early as 2020.

According to our modelling, this scenario is especially true for the US, where ambitious reductions targets in the power sector cannot be met locally. There are simply not enough new plants expected to be built in the US (to be equipped with CCS) or enough plants suitable for retrofitting to CCS between 2020 and 2030 to cope with the expected CO₂ abatement policies in the power sector. Therefore, equipping new plants in China with CCS appears as a cheaper and desirable solution, starting by 2020, with even faster ramp-ups than will be seen in Europe and North America. Assuming that no emission regulations would be in place in China by 2020, a strong and reliable world-wide emission trading scheme market, including credits for carbon storage, becomes an absolute must.

In terms of industrial ramp-up, the above analysis puts us at the limits of feasibility. However, enormous ramp-up factors have, at a smaller scale, already been seen in the power industry with the fast wave of equipment tested and introduced for flue-gas desulphurisation, rapidly reducing emissions of acid-rain-producing SO₂ from power stations. Such extremely fast ramp-up will only be possible with a strong post-combustion solution rapidly being made commercially available.

As the various CCS technologies will reach commercialisation at different times, it is expected that they will be introduced sequentially. Ultimately, the most cost effective will predominate, though this may vary from application to application.

Below is a brief synopsis of ALSTOM's developments in various areas of low emissions power technologies:

Ultra-Supercritical (*USC') Coal Fired Plant

"Ultra-Supercritical" (USC) Coal Fired Plant is a continuing evolution of existing coal fired steam plant technology. It is based around the long proven "Rankine" Steam cycle, with steam pressures and temperatures progressively increased to boost cycle efficiency.

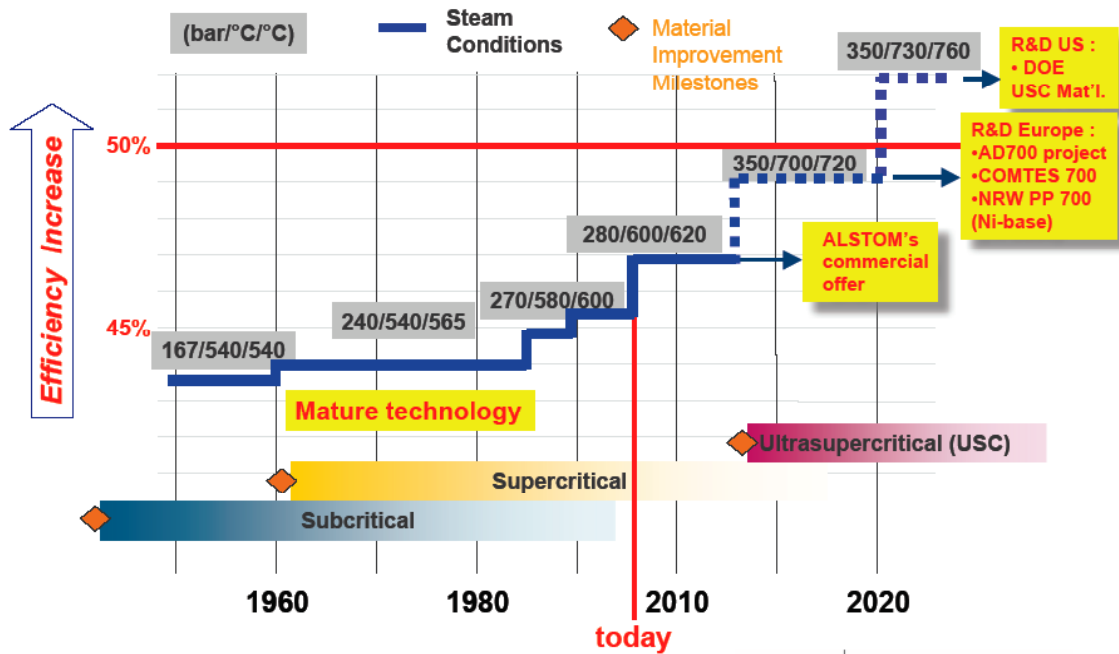
Advanced Steam Cycles: Subcritical base load black coal plant from the 1970-80s era currently installed around Australia typically have steam temperatures in order 540°C and an efficiency in the order of 35% (LHV). Supercritical plants installed over the last 10 years, in Queensland for example, usually had steam temperatures in order of 560-570°C and efficiencies around 38-39% (LHV). The latest offerings from Alstom typically have steam temperatures in order of 600-620°C and corresponding net efficiencies which can exceed 45% (LHV).

Research efforts by Alstom and others are aimed at producing materials such as Ni-based alloys that can economically and reliably operate with steam temperatures in order of 700-720°C, permitting adoption of Advanced Steam Cycles with net efficiencies of greater than 50% (LHV). These targets will not easily be achieved however, the increase in steam cycle temperatures and efficiencies will continue to advance in an evolutionary fashion over the next 10 years, whilst ensuring that plant reliability is maintained and confirmed as cycle efficiency improves.

Aside from the direct cost benefit of lowering fuel consumption and its corresponding cost, boosting cycle efficiency has the additional benefit of also proportionately lowering the amount of CO₂ emitted from the plant per MWh produced. As such, it lowers the CO₂ intensity of the plant. Consequently, the higher the efficiency of a plant, the lower the size, cost and energy consumption of any flue gas emissions control equipment needed to clean the flue gas, including CO₂ capture equipment. A tonne of CO₂ emissions avoided is a tonne of CO₂ that does not have to be captured and sequestered. Therefore, boosting cycle efficiency is important to both directly reduce emissions; and to minimise the economic cost of emissions control equipment.

An additional benefit of increased cycle efficiency is a lowering of the heat rejection load to the environment. This will mean a significant reduction in the not-insubstantial capital cost of air cooled condensers if dry cooling is adopted; or a reduction in water requirements if a wet cooled system is used.

Overview of technological developments



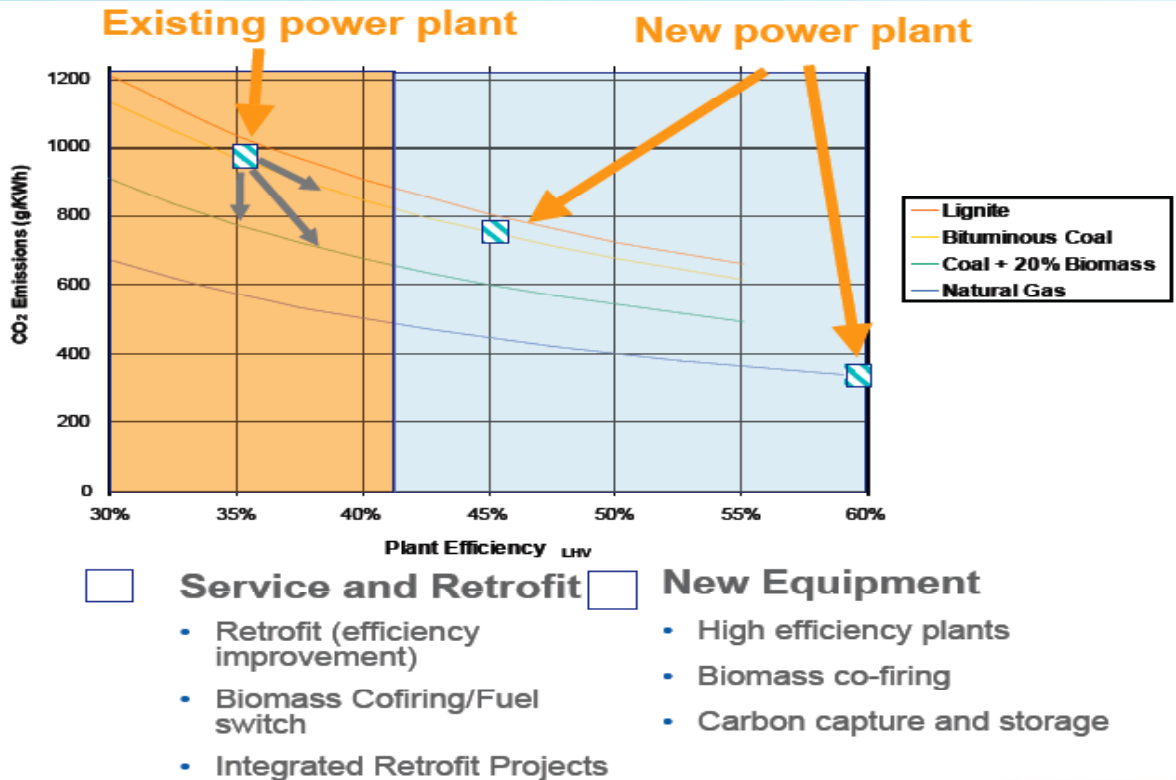
Brown Coal Drying: Brown Coal plants in Victoria typically have a net efficiency approx four percentage points (4% pts) lower than an equivalent black coal fired plant with similar steam conditions. This reduced efficiency results from the very high moisture content in Victorian Brown Coal (>60%). Using current brown coal boiler technology, additional coal is burnt to provide the energy to drive off this high moisture, resulting in a CO₂-e intensity per MWh typically 25%+ higher than an equivalent black coal fired unit. Alstom is currently working with RWE of Germany to introduce WTA Coal Drier technology on a Demonstration Plant in Hazelwood in the La Trobe Valley. This technology uses mostly waste latent heat of exhaust steam rather than chemical energy from additional coal combustion to dry out the fuel prior to combustion. This technology thus lowers CO₂-e / MWh intensity for a brown coal fired unit down to that of an equivalent black coal unit. The technology will be available for new plant and retrofit applications. Again, as well as the direct reduction in CO₂ emitted, a kg of CO₂ avoided is one that does not have to be captured and stored.



Hazelwood Power Station with Artists Impression of Demonstration Coal Drying Plant

Unit Size: Unit size has also been increasing over the last several years. The current standard 1970-80s era unit size was in the range of 500-660MW. From Alstom's current experience of the global market for base load coal plant, unit size is moving towards a norm in the range between 800-1100 MW unit size. It also needs to be recognised that larger plants, whether they be coal or gas fired, as well as offering economies of scale that lower the cost of electricity, tend to be both more efficient and offer better environmental outcomes. This fact is due to several reasons:

- (a) larger plants afford economies of scale that permit economic inclusion of efficiency enhancing and emissions controlling equipment and designs;
- (b) equipment tends to become larger with each design evolution and so, larger equipment tends to incorporate the latest technology; and
- (c) Larger turbo machinery eg gas and steam turbines, are intrinsically more efficient because leakage losses are proportionately lower relative to their overall size.



Biomass Co-firing

Biomass Co-firing is the practice of co-firing a renewable biomass with coal to lower the plants overall greenhouse gas intensity. Alstom has already done considerable work on retrofitting biomass co-firing to existing plants including commissioning the first dedicated biomass co-fired plant in the UK (500MW sized units with up to 20% biomass firing). We will be looking to further develop the market for this technology over the next few years.

Typical biomasses that can be used include wood waste, various agricultural wastes; bagasse etc. A mixture of such biomasses may be used where available. The option of incorporating biomass co-firing technology offers great potential for Australia, given Australia’s large agricultural and forest product industries.

Biomass co-firing can lower the CO₂-e of a plant proportionately to the percentage of co-firing incorporated. Additionally, where Carbon Capture and Storage is installed on the back end of a power plant, it would be possible to have a power plant with a “negative” CO₂-e intensity ie the power station would be taking CO₂ out of the atmosphere and sequestering it underground.

It should be noted that Biomass Co-firing can either be designed into a new plant or retrofitted onto an existing one.

Carbon Capture and Storage using Chemical Processes:

Alstom is currently undertaking development of a number of options for post-combustion capture of CO₂ using chemical processes from coal fired power plant flue gas streams:

- Amine-based Absorption Processes (MEA, MDEA): up-scaling of amine based absorption processes currently used in the oil and gas industry to a size suitable to handle the larger scale of power plant flue gas flows. These processes are retrofittable and flexible. However, they suffer the drawback of having very high energy demands for the regeneration of solvents.
- Chilled Ammonia Process: This is a promising post-combustion carbon capture technology that Alstom is developing that uses ammonia rather than amines to absorb CO₂. It offers lower costs of reagents; lower energy consumption and better tolerance to flue gas contaminants. It thus promises to be more suited to CO₂ capture in power industry applications.

One point to note about amine based CO₂ capture technologies is that they all require a flue gas with low levels of other contaminants. Therefore, the flue gas will need to be filtered for contaminants such as NO_x, SO_x, Hg and particulates to a higher degree than is currently the case in Australia. Alstom currently has technology commercially available to remove these contaminants that is incorporated in plants overseas, especially in the USA. Our current development focus in this area is to reduce the cost of such equipment by integrating the various emission control systems into a single multi-pollutant system. All these post-combustion processes that Alstom is developing are aimed at being retrofittable to existing plants when they are commercialised.

CO₂ Capture Ready: On new plants, if at the time such plant is constructed, either the CO₂ capture technology is not yet fully commercially developed; or the “price of carbon” under a carbon trading scheme has not yet reached a level where such plant is economically justified; or suitable carbon geo-sequestration sinks have not yet been developed, Alstom would design the power plant to be “CO₂ CAPTURE READY” - meaning the plant will be designed to permit carbon capture equipment being added in the future without restriction and with minimal impact on the plant operations.

Specifically, “CO₂ CAPTURE READY” would mean:

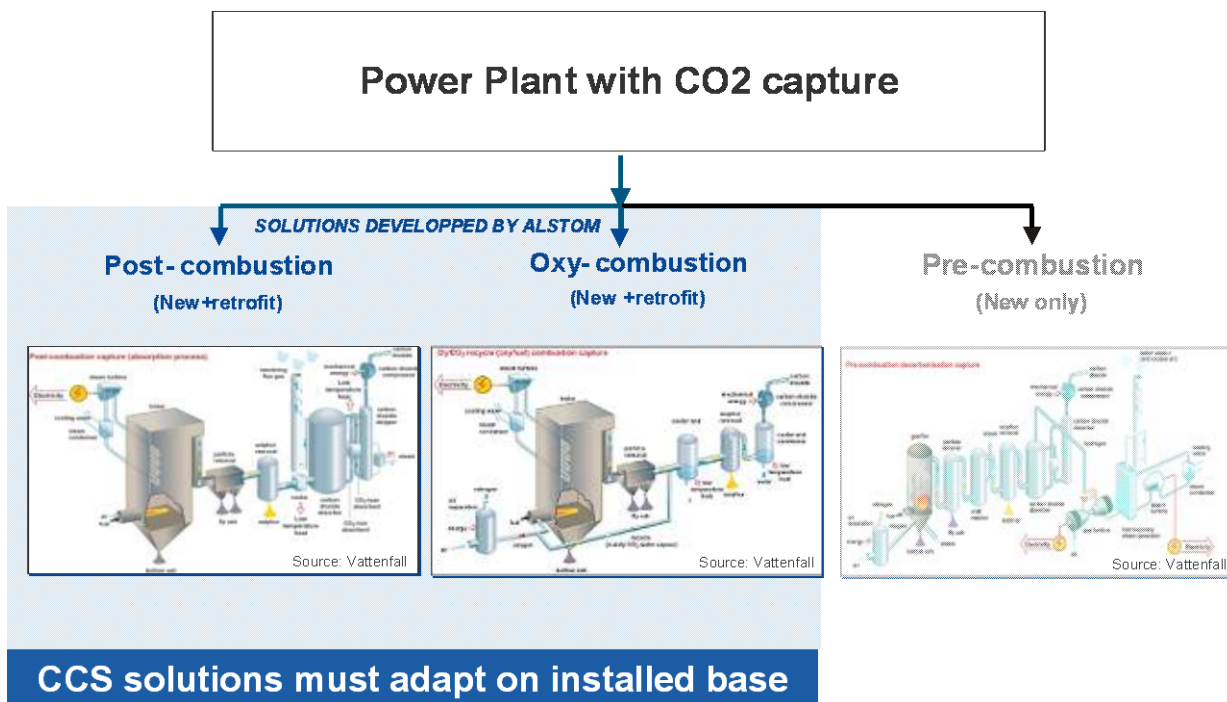
- extra room is left in the plant layout for future installation of capture plant
- suitable back-end equipment is installed
- future shut-down time to “cut-in the capture plant” is minimised
- reasonable CO₂ transport & storage are validated
- no restrictions on later implementation of Carbon Capture being designed into the plant

Carbon Capture and Storage using Oxyfiring: Oxyfiring is a system that can be used on both PF and CFB boilers whereby the fuel is burned in a pure oxygen environment, producing a flue gas stream very rich in CO₂. The advantage of this arrangement is that because the flue gas produced has such a high concentration of CO₂, it can be post-combustion captured and sent for geo-sequestration without the need for CO₂ separation using a chemical process. It has the side benefits of requiring a

smaller (and hence less expensive) boiler; and of producing lower flue gas volumes, with consequently lower NOX emissions. The main disadvantage is that it requires a large O₂ source such as an Air Separation Unit that is energy intensive imposing consequent large parasitic loads on the power plant.

Alstom is also working on developing Oxyfiring systems concurrent with work on the various PCC systems. Ultimately, the choice between traditional air combustion with chemical post-combustion capture; and oxyfiring will be made around economics as the various technologies mature into commercial scale. It should be noted that Oxyfiring's competitiveness would be substantially boosted if a new lower energy-intensive means of air separation could be developed in lieu of the current high energy consuming cryogenic processes.

Oxyfiring systems are also retrofitable on existing boilers, as will be demonstrated with the experiment conducted by Total in Lacq (France), where Alstom will retrofit an existing 30MW boiler to oxy-combustion. This will be the first integrated capture and storage unit in Europe, due to start-up in 2009. The CO₂ will be transported in an existing pipeline and stored in a depleted oil&gas reservoir.



Combined Cycle (fuelled by either NG or Coal Seam Methane)

As mentioned above, gas fired Combined Cycle (CC) plants are already a commercially available and well proven technology. They can currently deliver efficiencies of greater than 58% and Alstom would see this increasing further in an evolutionary manner over the next ten years. CC plants offer lower specific capital costs, relatively short construction times, lower site area requirements; lower maintenance costs and faster startup -response times than coal plants. Environmentally, they offer a CO₂-e intensity

of around half that of existing coal plant designs, and have relatively low NO_x and SO_x outputs. If required, as with coal plants, technologies are already commercially available and well proven to reduce NO_x and SO_x emissions to near negligible levels

For all these reasons, CC technology has been widely adopted around the world for both intermediate power requirements, including here in Australia (eg Tallawarra in NSW; Swanbank E in Qld); and for base load power where there is a lack of an alternative lower cost fuel source such as coal. Alstom see increased demand for CC plant in Australia over the next ten years to meet such intermediate load growth; and we would expect that a significant proportion of this CC plant will be fuelled by relatively low cost Coal Seam Methane.

With Carbon Capture and Storage

As with coal plants, it is feasible to install (or retrofit) a post-combustion CO₂ capture plant to extract CO₂ from the exhaust of the Combined Cycle plant. It would work on the same principles as is described above. Alstom has a strong roadmap to apply post-combustion ammonia technology to GTCC's, including agreements with Statoil.

Integrated Gasification Combined Cycle (IGCC)

Integrated Gasification Combined Cycle (IGCC) is an arrangement whereby coal is gasified and the resultant gas is combusted in a gas turbine that forms part of a Combined Cycle power plant. Initial gasification processes form a low calorific hydrocarbon gas known as "Syngas". Currently, gasification processes are being worked on that will reduce the coal to H₂ and CO₂ directly, with the H₂ combusted in the Gas Turbine after CO₂ recovery for storage.

Gas Turbine technology is already available to burn low calorific value hydrocarbon gases such as Syngas, a result of developments in steelworks cogen plants where the burning of low calorific value "Blast Furnace Gasses" is required. Current development efforts revolve around scaling up these technologies and tailoring them to the larger sized high efficiency gas turbines that predominate in base load power plants; and then proving their long term reliability in service. R&D work to adapt gas turbines to burn H₂ is still in its infancy and will require significantly more time and resources to become commercially reliable and proven.

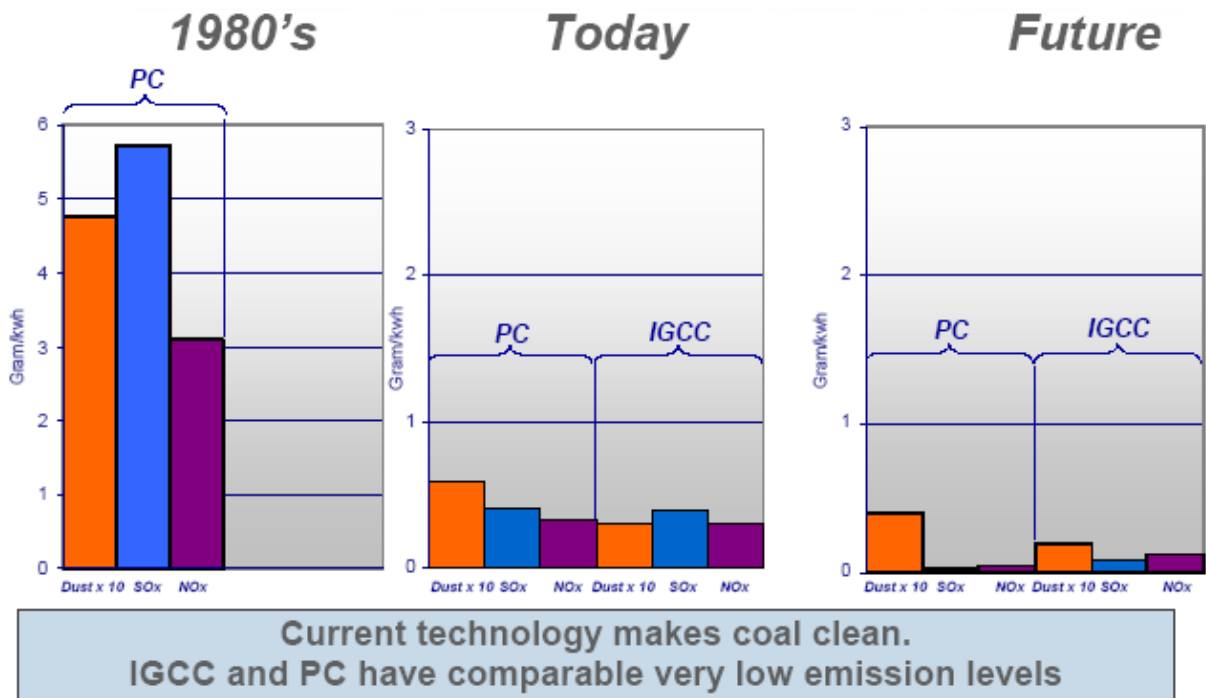
A small number of IGCC demonstration plants burning Syngas have been constructed around the world to date, though several more are planned in the next 10 years. However, to date, they have proved to bear a high capital cost relative to Ultra-Supercritical steam solutions, with little difference in environmental performance; and they are known to have experienced reliability issues in the gasifier portion of the plant. As such, all IGCC plants to date have required a large amount of subsidy to be built. If gasifier reliability cannot be improved, a solution may be to introduce dual redundant gasifier trains to the plant. However, this will add further capital cost disadvantage of IGCC. IGCC technology using H₂ as the fuel is less advanced in its development and proving.

With natural gas as the base fuel, the process is actually a reforming technology and is hence known by the terminology Integrated Reforming Combined Cycle (IRCC). The

efficiencies of IRCC are lower than comparable GTCC plants due to the significant parasitic loads from upstream natural gas reforming. Making hydrogen from natural gas is expensive due to feedstock cost. Therefore IRCC only makes sense when higher value products like chemicals (fertilisers) are produced or when fuels are upgraded in a refining context.

With coal, the efficiencies of IGCC are still lower than state of the art USC plants. Moreover, this difference drastically increases if the plant is to be located at elevated locations, where turbine performance decreases rapidly. With lower rank coals, IGCC is even less able to compete with USC plants. Likewise, IGCC only seems to make commercial sense if it is combined with other chemical production in so called poly-generation. Commercialisation of IGCC is also dependent on the full commercialisation of H₂ burning GTs.

Additionally, IGCC requires up to 50% more site area than an equivalent USC coal plant.



IGCC With Carbon Capture and Storage

The comments for CCS on USC plant do not apply for IGCC. The decision to build an IGCC must include an upfront decision to capture and store the CO₂, and include a detailed assessment and validation of a CO₂ transport and storage solution..

In order to remove CO₂, IGCC plants are equipped with several systems to convert syngas to hydrogen and achieve the separation of CO₂. These systems need to be installed upstream of the gas turbine, and this is why this technology is called pre-combustion capture. The required systems include: two CO shift reactors plus CO₂/H₂ scrubbing systems and regenerator. Those systems work at high pressure. The separated CO₂ can then be compressed and sent for storage, while the hydrogen is delivered to the turbine for combustion.

This hydrogen turbine is however still in the developmental stage. The current state of the art in hydrogen turbine design is such that pure hydrogen combustion is not yet possible and significant amounts of nitrogen are needed as additional load on the turbine. This requires a high pressure Air Separation Unit. Alternatively, partial CO₂ capture could be considered, with a single stage shift conversion and up to 50-60% capture achievable. This solution is however likely to generate prohibitive CO₂ cost avoidance, when taken in conjunction with the very high overall capital investment required by an IGCC unit. Those considerations highlight the fact that IGCC technology is not yet sufficiently mature; and requires high upfront risk and cost technological choices to be made.

Given its current state of development, Alstom believes IGCC is unlikely to be able to provide a fully commercially proven technology before 2020. Both the capital cost of the plant and the cost of electricity from IGCC are higher than for USC technology, and the CO₂ emission profile is worse under those conditions. Consequently, early investment in an IGCC plant does not make economic or environmental sense.

As only a relatively small proportion of an IGCC plant is dedicated to power generation, with the bulk being part of the gasification process, it is essentially a chemical plant. Alstom anticipates that when IGCC is eventually commercialised, it will find application as embedded generation within chemical and/or petrochemical plants. Such an arrangement will allow for sharing of infrastructure to help defray the capital cost disadvantage of IGCC; and would also permit the use of the skills and infrastructure in the chemical industry that is relevant to it. It is therefore more likely IGCC will eventually find a niche in the generation mix rather than predominate over USC generation for a stand alone power station.



API Falconara IGCC, 290 MW Cogeneneration with ALSTOM 190 MW GT13E2

Nuclear

Whilst Alstom does not manufacture nuclear reactors per se, we have had a long history of involvement with nuclear power plants, particularly in France. Alstom manufactures what is known as the “conventional island” of a nuclear plant, namely, the steam turbine and auxiliaries associated with the steam cycle. As part of our efforts in this regard, we have manufactured the world’s largest steam turbine to date at 1650MW.

Nuclear power offers a technology for base load power that is well proven and is being advanced. However, its very high capital cost makes the overall cost of electricity delivered uncompetitive in most of the Australian context when compared with clean coal. Additionally, despite nuclear having a very good track record on safety with even further safety enhancements in the latest generation of reactors, any nuclear development in Australia would invariably face long development delays due to public and political scrutiny. Nuclear plants also take longer to construct.

Cooling requirements are also a significant factor when considering a nuclear plant. The steam cycle in a nuclear power plant is 20% efficient to keep steam temperatures and pressures down for safety reasons. As fuel cost is minimal compared with a fossil fired plant, this lack of relative efficiency is not particularly relevant in respect of overall cost of electricity but the 80% of energy that is rejected as waste heat results in the need for a much larger cooling system than required on an equivalently sized coal plant. Therefore, the best site for a nuclear plant would be on the coast utilising sea water for cooling. However, if obtaining such a site should prove problematic, then the

alternatives would be to use wet cooling towers that would consume a large amount of scarce water resource; or to attempt dry cooling. Given the relative size of the heat load, dry cooling on a nuclear plant could prove prohibitively expensive.

Nuclear technology is currently available and well proven as a method of near zero-CO₂ emissions for base load power generation. Further, the next generation of nuclear reactors promise even higher standards of safety with “intrinsically fail safe” designs. Nevertheless, disadvantages such as long lead times; un-competitiveness on cost of electricity relative to clean coal options in the Australian context; lack of current nuclear infrastructure and skills in Australia; and the need for large cooling systems and/or high cooling water quantities mean that nuclear is not likely to become a realistic option for Australia in the foreseeable future. Given current Government policy does not support the establishment of a nuclear power plant, it even less likely that a nuclear plant will be constructed in Australia in the short to medium term.

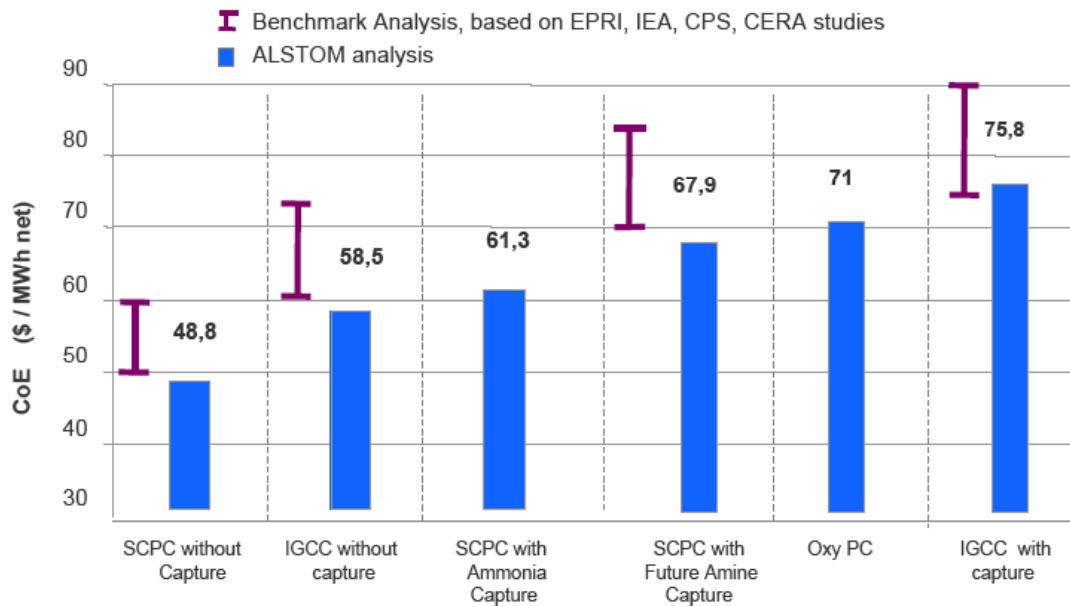
Renewables

Wind - Alstom has recently entered the fast growing global wind market. Australia has particularly good onshore wind resources in the south of the country. Because wind generation is reliant on instantaneous wind conditions, it cannot be relied upon to continuously meet demand profiles. As such, wind generation will require back up generation in the form of peaker Gas Turbines or hydro pump-storage (see discussion below) to meet system requirements. Wind suffers a significant capital cost disadvantage relative to fossil fuel fired plant. Alstom is working on increasing individual turbines size upto 3 MW to boost economies of scale and thus help bridge that gap.

Hydro – hydro is the most well established of renewable energy sources and Australia has some long standing and well developed hydro assets eg Snowy Mountains Scheme, Tasmania. It should be noted that Hydro has the capacity to provide a lot of instantaneous peak power but is limited by water storage capacity in the amount of base load energy it can supply. Significant work is on-going on retrofitting hydro plants to improve efficiency and output. There are still potential large scale hydro scheme sites available in Australia eg Clarence River and Far North Queensland. However, such schemes would face significant opposition and therefore are unlikely to be readily developed in the foreseeable future. Nevertheless, if climate change does result in a drying out of the SE of Australia and an increased rainfall to the north, some of these systems in the North may need to be reconsidered if the existing schemes in the SE face output restrictions due to lower water inflows.

Pump-Storage – hydro plant globally is increasingly being used as pump storage, whereby water is pumped up the hill in off peak and used for generation in peaks. This balancing is particularly useful in a system where a lot of wind generation has been constructed as a way of storing the wind generated energy for when it is required. It is likely that conversion of some existing hydro assets to pump storage will be considered as wind generation increases.

Cost of electricity comparison



Water Requirements for Base Load Generation

Most thermal Power Plants currently require huge quantities of water for cooling purposes. Australia will need to minimise its use of scarce water resources relative to existing power plant usage through use of technologies such as dry cooling if climate change leads to a reduction in such water resources. Whilst dry cooling technology is certainly available and well proven, people should be aware that it is not as efficient as wet cooling, lowering thermal efficiency levels and hence raising CO₂-e/MWh on fossil fired plants relative to an equivalent wet cooled plant. Dry cooling is also significantly more expensive in capital cost, probably prohibitively so for a nuclear plant. Therefore, in making assessments of various sites for the next base load station, authorities will need to be aware of cooling alternatives such as use of sea water; treated waste water; or a wet-dry hybrid cooling system to mitigate against the negative CO₂ emissions effects of dry cooling. Alstom is also aware of the potential for use of water contained in coal seams to be used for part or all of a power plant's cooling requirements.

Retrofit of Existing Plant

Alstom has had extensive experience in retrofitting improvements to existing plant, both here in Australia and overseas. Where applicable, retrofitting can produce an increase in unit output, improvement in efficiency (ie lower CO₂ intensity per MWh sent out), lower emissions of specific pollutants such as NOX, SOX and/or particulates; and an extension to the economic life of a plant. These incremental improvements can often be achieved with relatively modest capital investment relative to construction of new plant. Such projects can also be achieved in a much shorter time frame. Therefore, it is likely in the short term that retrofit projects will be carried out on existing plants as the ETS

price signal ramps up. Additionally, several technologies will be capable of being retrofitted to existing power plants to boost the CO₂ emission intensity, namely:

- Biomass Co-firing
- Solar Thermal Feedheating of Coal fired Steam Cycles
- Turbine Shaftline Retrofit
- Oxyfiring
- Post combustion CO₂ capture

TRANSPORT



Personal transportation does not contribute to the same extent as power generation to Australia's current CO₂ emissions (see full details of Australian Greenhouse Office figures for comparison in *Appendices 2&3 attached*). Nevertheless, passenger rail transportation still has some capacity to reduce CO₂ emissions by directly lowering the intensity of CO₂-e per passenger per km relative to alternative personal transport modes – see Appendix 1 for a typical (European) comparison. Whilst the exact quantum of this advantage varies with fuel used in electricity generation to drive the transport; the average distance and average passenger loading factor assumed and needs to be specifically calculated for each particular application, the general principle holds true for most cases, especially during periods of high patronage.

However, as important a factor to consider is the “indirect” CO₂-e benefit that passenger rail transportation can deliver by reducing urban congestion at peak periods in lieu of alternative modes of transport eg metro systems relieving high urban road congestion; fast regional trains relieving airport congestion. Aside from any direct CO₂-e benefits per passenger km, fast and efficient rail systems can also boost the competitiveness of cities, which are the largest regions of GDP generation in Australia. As such, they can help boost the nation's overall economic capacity to manage carbon emissions reduction in other more heavily impacted areas of the economy.

Alstom's Rail Transport Technology

Alstom provides rail transportation products and services in four major areas:

- Rolling Stock – everything from urban trams like our Citadis trams in Melbourne to Very High Speed Trains, such as our latest AGV that set a world land speed record for a “wheeled” train of 578 km / hr in 2007.
- Rail Infrastructure - such as the latest signalling, information, electrical, communications and safety systems that delivers safer , more reliable and more efficient railways
- Services – provision of operating and maintenance services and products to support rails system operators throughout the life of their rail systems
- Turnkey Rail Systems – provision of whole tram or train systems including rolling stock, electrical power systems, signalling and other information / communications infrastructure; trackwork

Alstom has the broadest range of Rolling Stock technologies including:

- Trams / Light Rail: Alstom's CITADIS tram systems, as operating in Melbourne, offer efficient, low emission transport options for urban areas. Alstom has recently introduced a number of innovations to enhance the flexibility and applicability of tram technology such as a “wire-less” power delivery system that removes they need to install an overhead power supply system; and “Tram-trains” that are designed to travel on tram tracks in inner city areas but can then move onto conventional train tracks to travel to suburban areas at speeds of up to 100 km/hr



- Metros – Alstom has installed one in four metro systems operating around the world. Our METPOLOLIS metro systems can come with either steel or rubber wheels, and can carry up to 50,000 people per hr, thus delivering transport systems that can provide a competitive alternative to traffic congestion in high density urban areas. Recent Alstom innovations in this area include a “driverless” train, as installed in Singapore, that adds to the economics of a metro as a competitive transport solution.



- Commuter / Suburban - Our XTRAPOLIS range of commuter trains come in both single and double deck arrangements for commuter / suburban applications, the traditional rail market in Australian cities.



- Regional Trains – Our CORADIA range of intercity trains provide reliable, efficient and comfortable transport solutions for intercity and regional applications. Both single and double deck designs can be offered.



- High Speed Trains – Alstom's PENDOLINO range of high speed trains incorporate "tilting technology". This permits high speeds of upto 250 km/hr on existing track, negating the need for expensive new stand alone Very High Speed track and infrastructure systems.



- Very High Speed Trains – Alstom leads the world in wheeled Very High Speed Trains including the famous TGV in France and our latest offering, the fourth generation AGV. The AGV, which broke the rail land speed record in 2007 at 574.8 kph on special track, has a commercial operating speed of 350 km/hr. Very High Speed trains require new track with low radii bends to attain these high speeds but also can operate on standard track at lower speeds, meaning they can operate into existing urban rail infrastructure environments. At 350 km/hr, the AGV could travel between central Sydney and central Melbourne in less than 3 hrs; and between central Canberra and Central Sydney in less than 1 hr, making them more than competitive with jet travel on such routes.



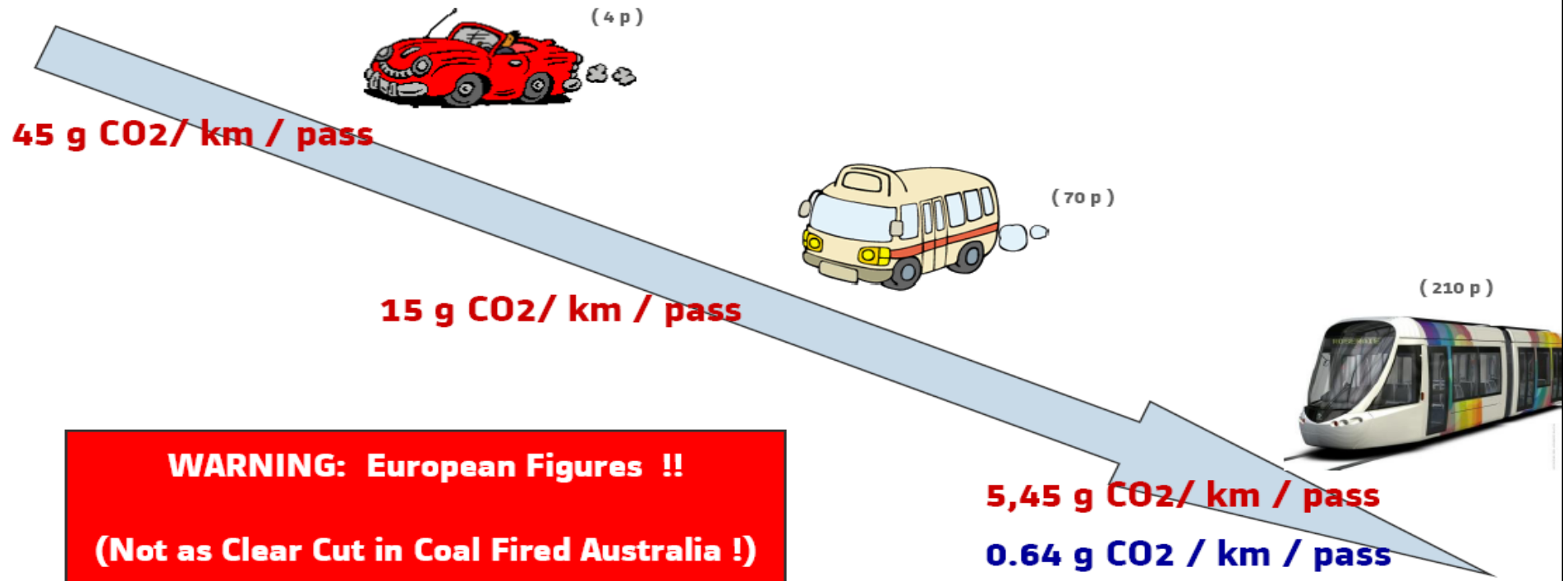
Installing higher speed passenger rail transportation systems on medium to long distance journeys eg Newcastle to Sydney, Canberra to Sydney, Albury to Melbourne; Bundaburg to Brisbane would provide for a lessening of congestion at airports as well as advancing urban decentralisation initiatives.

In Australia, Alstom has recently provided both our CITADIS trams and XTRAPOLIS trains sets into Melbourne's public transport system; and also supplied the traction and control operating systems incorporated in the Millennium trains now in operation in Sydney.



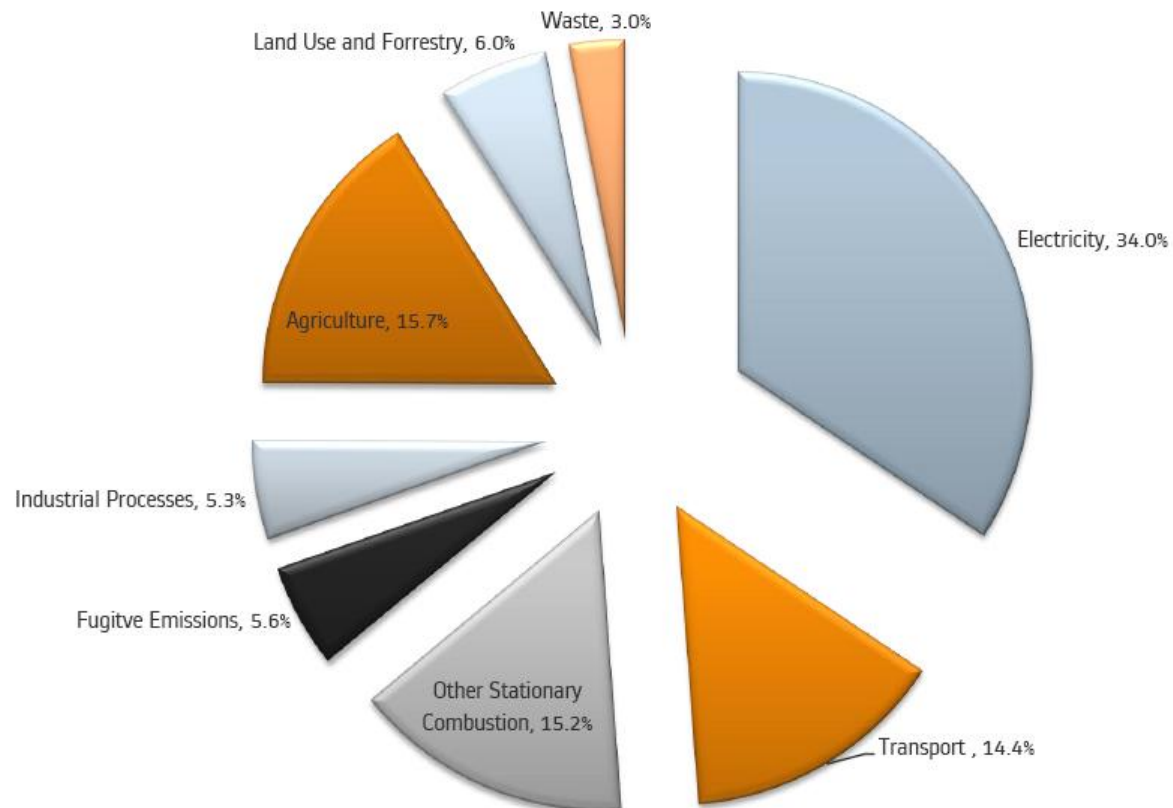
Transport – Trains/Trams in Carbon Constrained World

According to EU25 Electricity calculation mode
FR Electricity calculation mode



Appendix 2 – Australia's Greenhouse Gas Emissions – By Source of Emissions

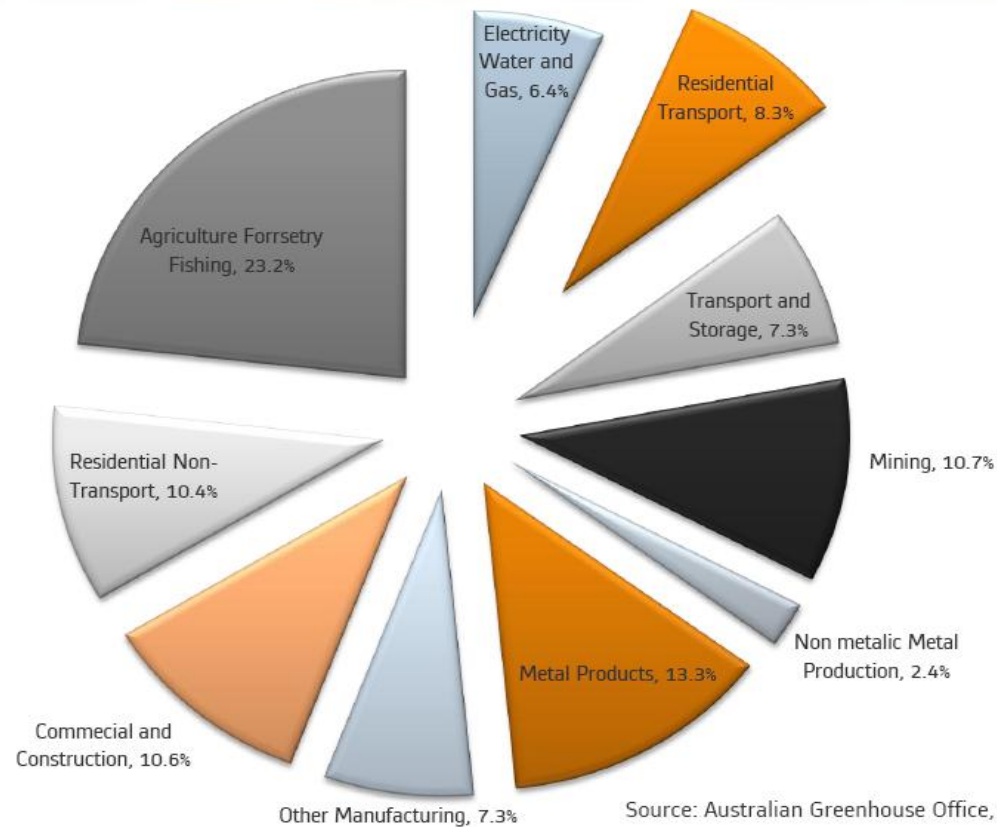
Australian GHG Emissions 2005 by Source of Emissions



Source: Australian Greenhouse Office, Feb 2007

Appendix 3– Australia’s Greenhouse Gas Emissions – By Source of Economic Activity (where emissions Power Generation is apportioned into electricity consumer industry; and only net emissions from gen and transmission of electricity are shown under electricity)

Australian GHG Emissions 2005 by Source of Economic Activity



Notes:

1. Electricity, Gas and Water covers solely the emissions from losses in gen and tx of power. Consumed Electricity is contained in each respective Economic Activity.
2. Transport is divided into Residential Transport (including Urban Public Transport); and Transport and Distribution covering mainly Commercial Transport of Goods