Impact of Kyoto on the Cost Structure of the World's Resource Industry

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The subject of my talk today is on the impact of implementing the Kyoto Protocol on the future cost structure of the world's resource industry.

It should be acknowledged that Kyoto is a very complex subject. In order to address the various issues raised by it a large consulting industry has been built up to service it. I am approaching it as a relative outsider – namely from the perspective of a minerals economist.

Notwithstanding the fact that my analysis might be over-simplistic it clearly shows that there will be winners and losers from Kyoto. From this I believe that one can develop viable strategies which improve the sustainability of the resources industry.

Overview

- Kyoto Protocol
- Energy-Intensity of various commodities
- Carbon-Intensity of various commodities
- Impact of a Carbon-charge on costs
- Issue of "free-riders" on commodity prices
- Which commodities will be most affected
  - Inter-Material competition
  - Supply-Chain issues
  - Industry sustainability issues

The talk will be in six parts.

•Firstly, I will give a brief overview of the Kyoto Protocol – what are its objective and its current status

•Secondly, I will present data on the energy-intensity of 27 different commodities. The analysis will cover all of the important metals as well as their intermediate products

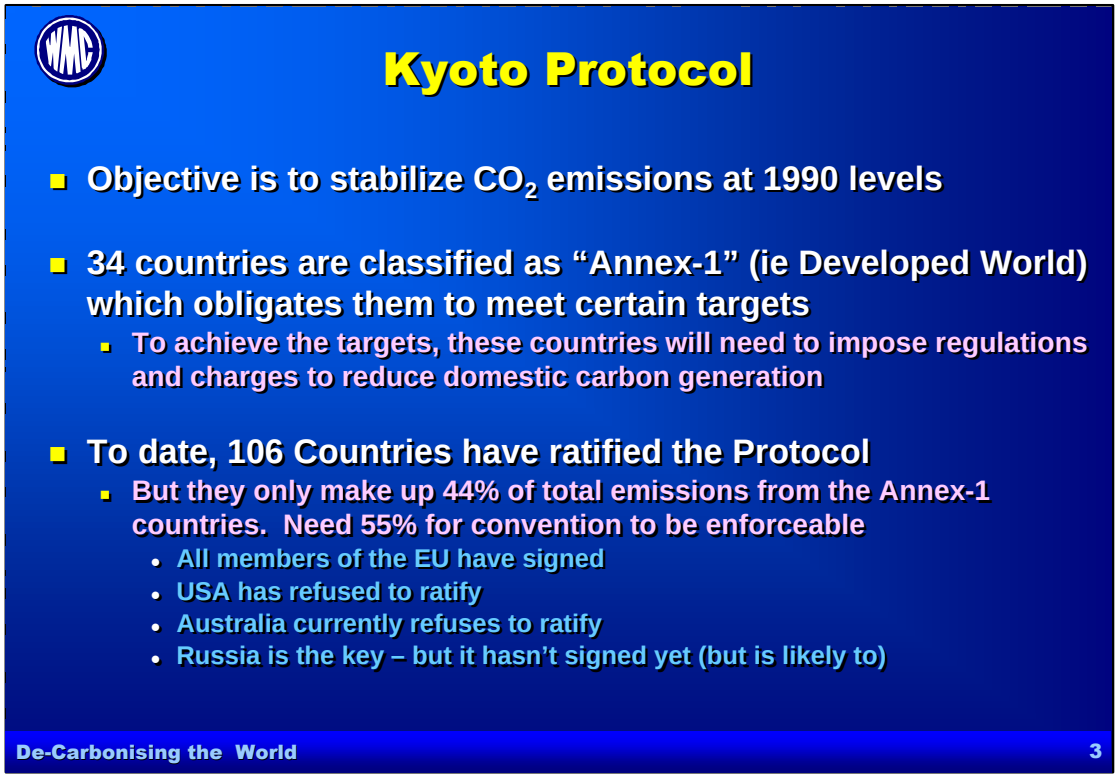
•Thirdly, I will show the carbon-intensity of these commodities, ranked from lowest to highest

•From this one can calculate the impact of a carbon charge on the cost of producing these commodities

•Fifthly, as not all countries have signed up for Kyoto and or are exempt from its obligations, industries in these countries will be directly affected by carbon charges. On this basis, one needs to consider the effect of "free-riders" on the likely commodity prices

•And lastly, from this it is possible to identify which commodities will be most affected by Kyoto. This will be framed in terms of inter-material competition and possible impacts on the supply-chain

From this analysis it is possible to draw some conclusions about the likely responses from resource companies will be and the long run sustainability of the overall industry. In short, Kyoto will have a major impact on the industry – and there will be winners and losers. This creates business opportunities for those companies with a forward-looking outlook.



What is the Kyoto Protocol ?

The Kyoto Protocol was set up in 1997 and is an international treaty whereby countries agree to reduce the amount of greenhouse gases they emit if their neighbours do likewise. The overall objective is to stabilize carbon emissions at 1990 levels. The treaty is yet to be implemented.

The Protocol is very complex, and the rules get even more complicated the closer we get to implementation.

One important feature is that a short-list of 34 countries have been identified which should have specific targets for carbon minimisation. To achieve these targets it is envisaged that these countries will need to impose regulations on their local industries. These countries are all in the Developed World and in the parlance of the Protocol are called "Annex-1 Countries".

To date (ie March 2003), a total of 106 countries have ratified the protocol. Many of these countries are in the developing world.

However, the big players - such as USA and Russia have not yet signed.

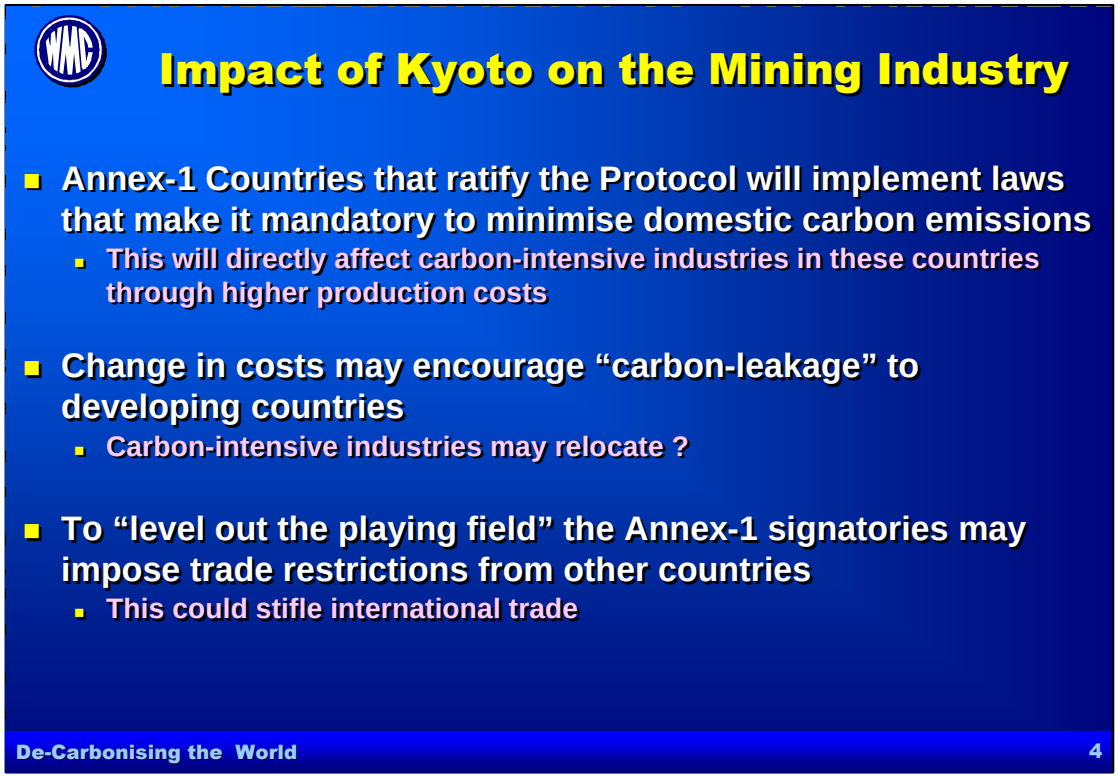
For the Protocol to be enacted, it needs ratification from 55% of the Annex-1 countries. So far it only has 44%.

•As mentioned before, all of the countries in the EU have signed up

•However, under George Bush, the US has categorically refused to ratify Kyoto

•Australia will not ratify Kyoto because, "it is not currently in the national interest to do so"

•The key to whether Kyoto comes into action is Russia – as it makes up 17% of the Annex-1 emissions. With them, the coverage will rise from 44% to 61%. The general view is that Russia will sign up – however it is currently tied up in detailed negotiations with the other key players about how it will trade its carbon credits. It is speculated that they will sign later this year



What does Kyotol mean for the Mining and Resources Industry?

In the first instance, Annex-1 Countries that ratify the Protocol will implement laws that make it mandatory to minimise domestic carbon emissions. This will directly affect carbon-intensive industries in these countries through higher production costs.

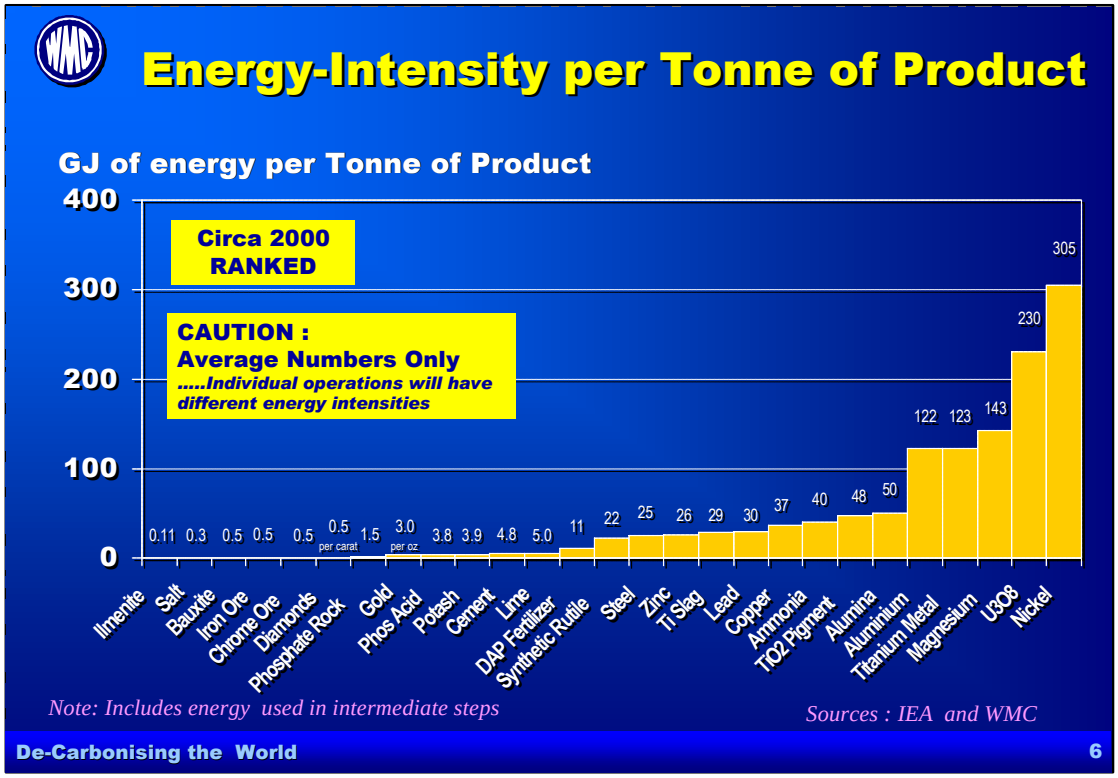
As a response, the increase in costs may encourage industries to relocate to other countries. In other words there may be "carbon-leakage".

Governments are concerned about this leakage. No doubt countries are exploring domestic policy options to "level out the playing field". This could result in Annex-1 signatories imposing trade restrictions from other countries. If so, then this would stifle international trade and cut across the initiatives of the WTO.

Energy-Intensity of Various Commodities

I would now like to cover the second part of my presentation – namely what is the energy-intensity of various commodities ?

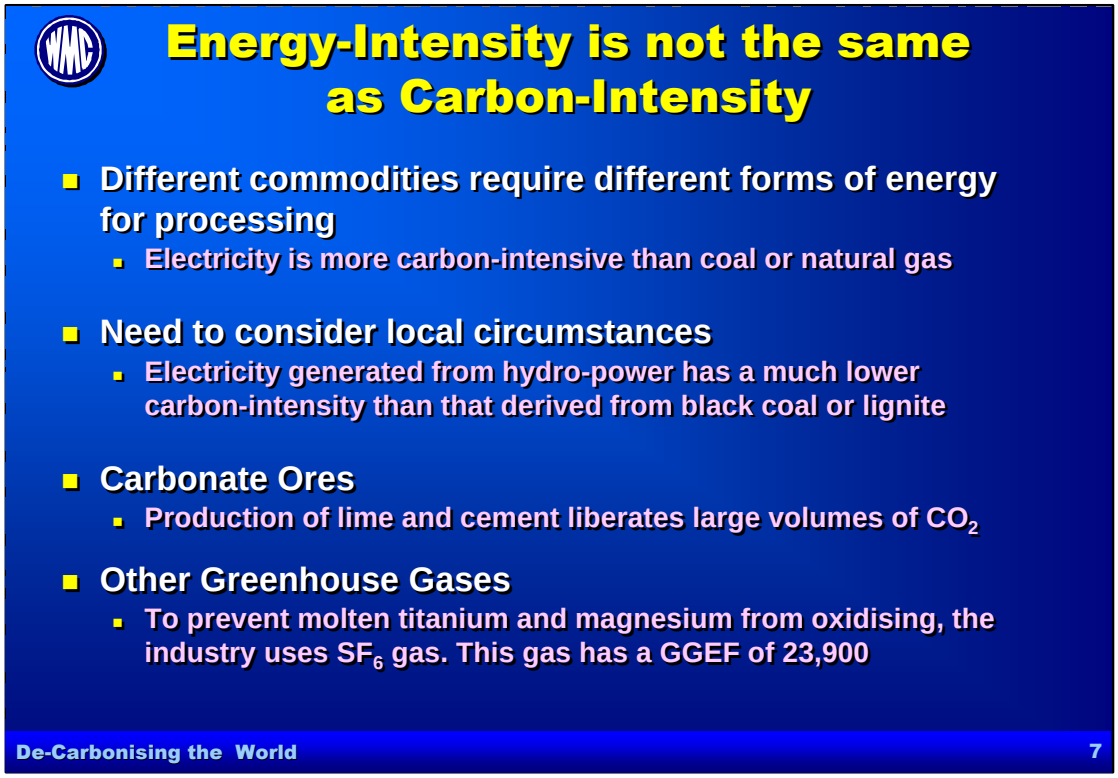
A lot of work has been published in this area and following analysis draws much on work published by the International Energy Agency.



This chart shows the average amount of energy (in Giga Joules per tonne) to produce various commodities. The list covers 27 commodities, including all of the major metals and some of their intermediate products.

From this you can see that the most energy-intensive commodity in my survey was Nickel at 305 GJ/t.

It should be cautioned that these numbers are averages only. When you you look at individual operations within an industry you can get wide variations in energy-intensity. For example, in the case of Nickel, operations based on high grade nickel sulphides are an order of magnitude less energy-intensive than those based on processing nickel laterites.



However it should be noted that materials that consume large amounts of energy may not necessarily be very carbon-intense. And visa versa.

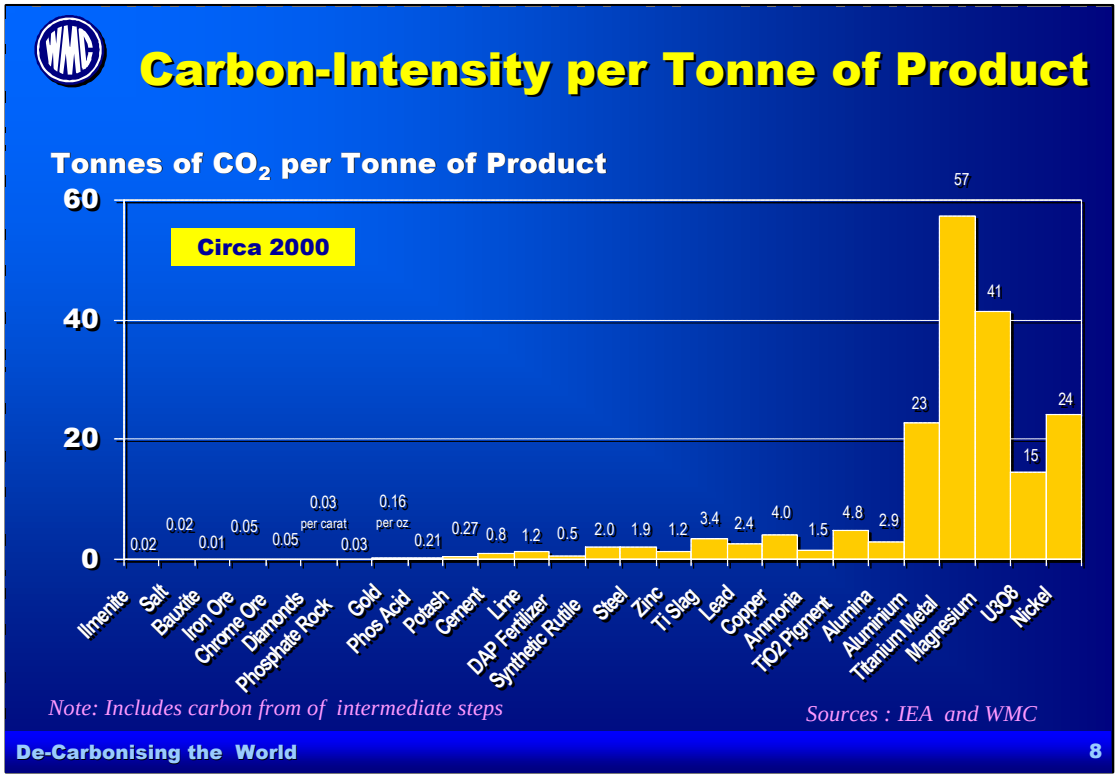
This is because :

•Different commodities require different forms of energy for processing. For example, as a generalisation, commodities that require electricity for processing will be more more carbon-intensive than those that use coal or natural gas

•Need to consider local circumstances. For example, the electricity generated from hydro-power has a much lower
carbon-intensity than that derived from black coal or lignite

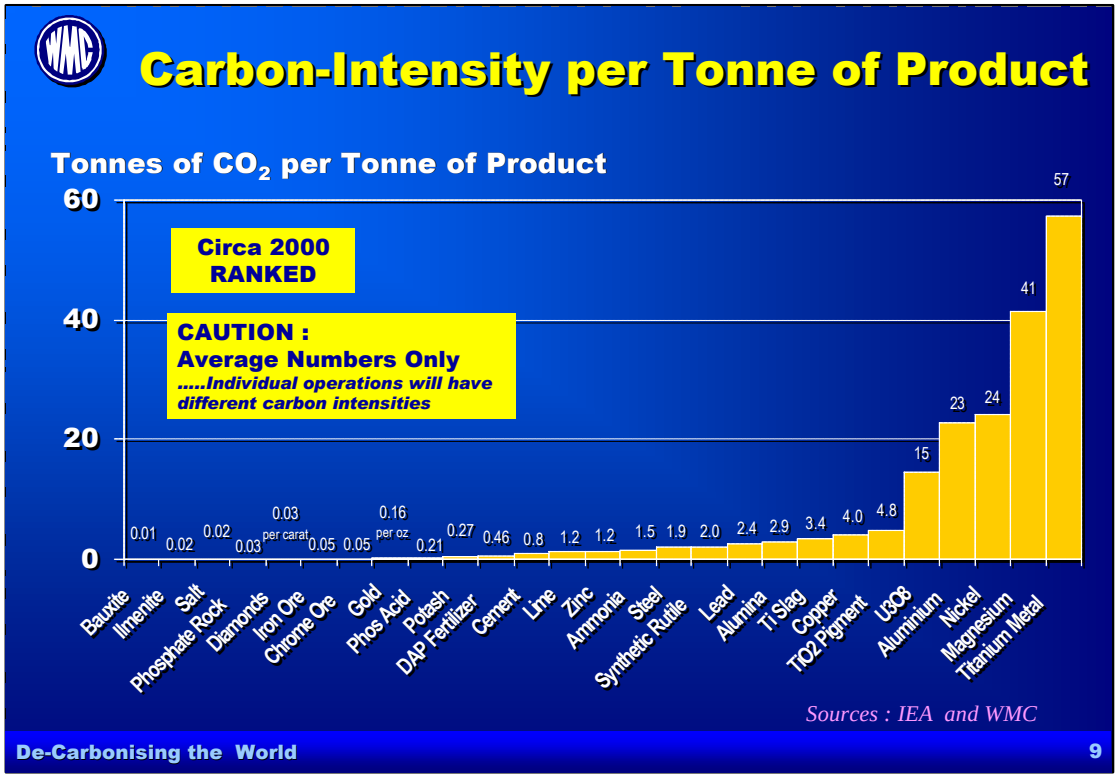
•Thirdly, it depends on the mineralogy of the ores. Some ores contain carbonates, which when roasted, produce large volumes of CO_2. This is a particular problem when producing lime and cement

•And finally, during processing, other greenhouse gases may be emitted. For example, in the production of titanium and magnesium, the operator has to use an inert atmosphere to prevent the molten metal from catching on fire. This involves using sulphur-hexaflouride (SF_6) gas. This gas has a *Greenhouse Gas Emission Factor* of 23,900. In other words, the release of 1 tonne of this gas is equivalent to releasing 23,900 tonnes of CO_2 !



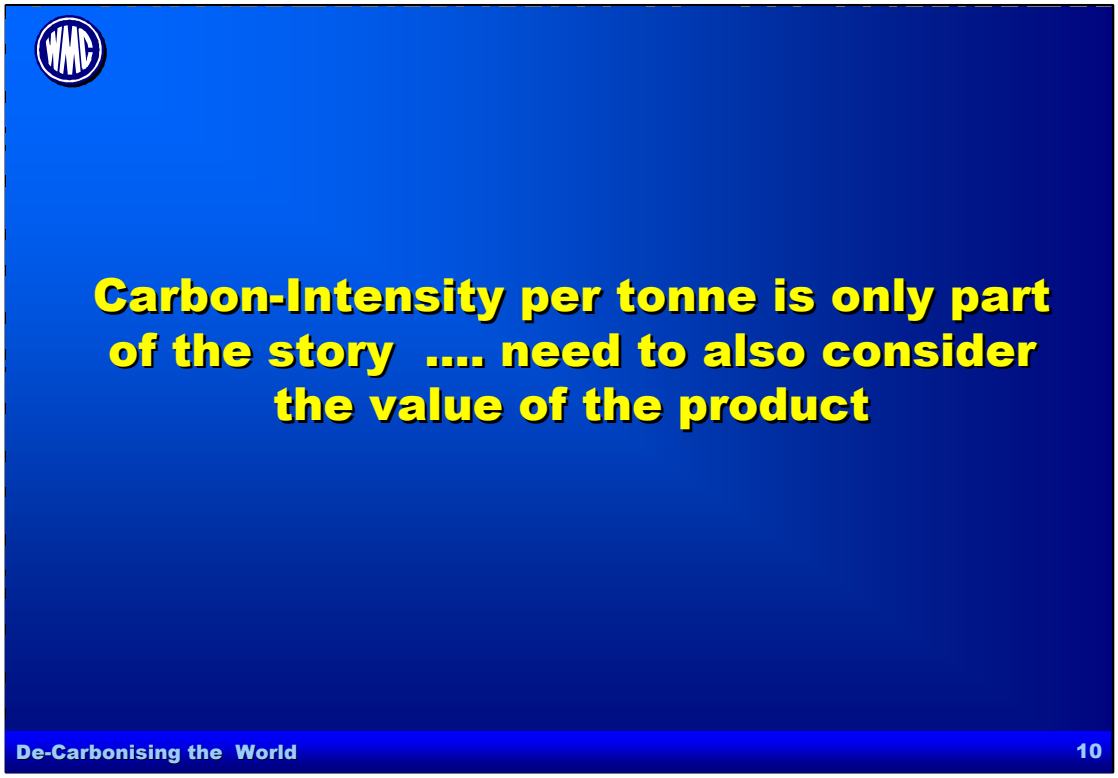
This chart shows the carbon-intensity in tonnes of CO_2-equivalent per tonne of product.

It uses the same ranking as the earlier slide on energy-intensity. As you can see, Nickel has a much lower carbon-intensity than Titanium Metal (24 versus 57 tonnes of CO_2 per tonne of metal).

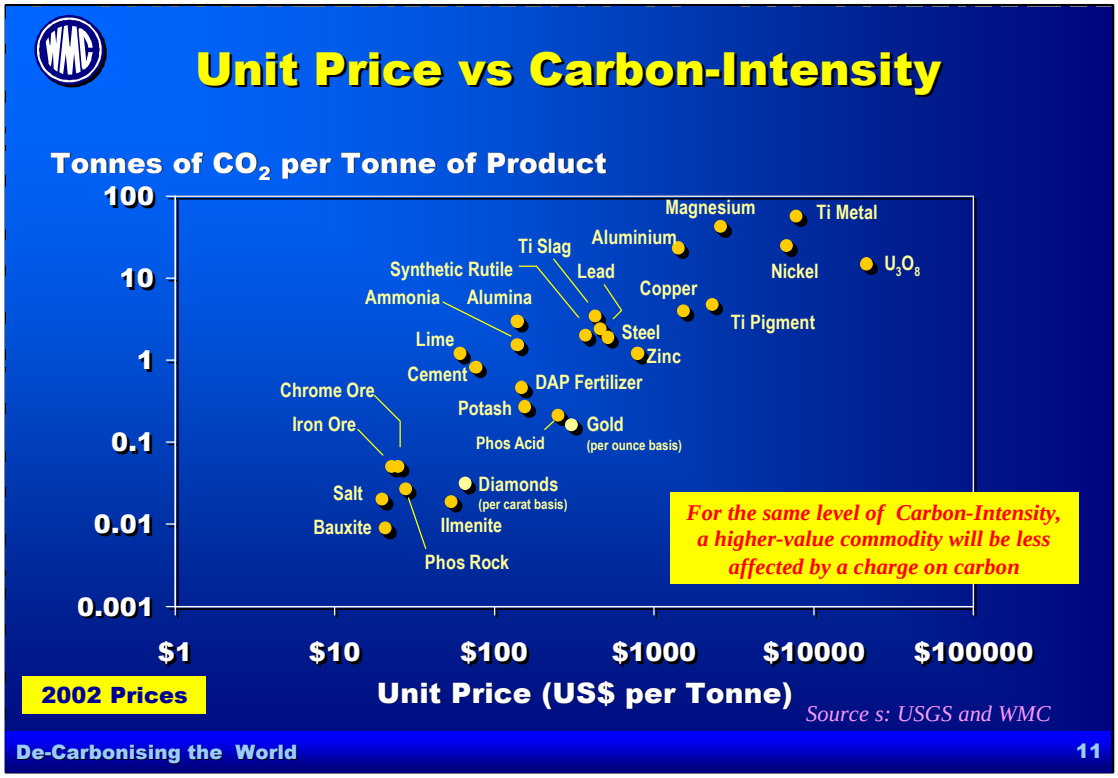


This is the same data as the precious slide – but has been re-ranked from lowest to highest.

A word of caution in using these numbers. It must be recognised that the figures are based on average carbon-intensities. For each commodity, individual operations will have higher/ lower values.



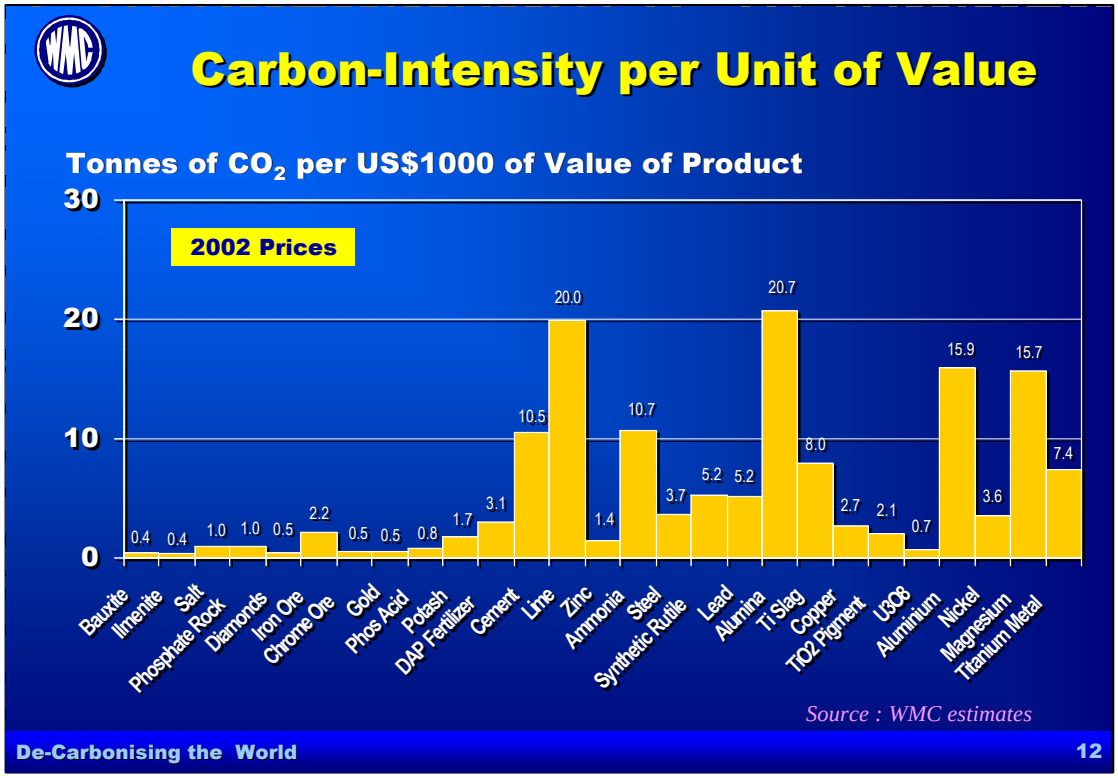
However carbon-intensity per tonne of product is only part of the story. To get a better understanding of the impact of a charge on carbon, one needs to consider the sales price of the product itself.



This chart compares the unit sales price of various commodities against their carbon-intensity.

Please note that the chart uses log-log axes.

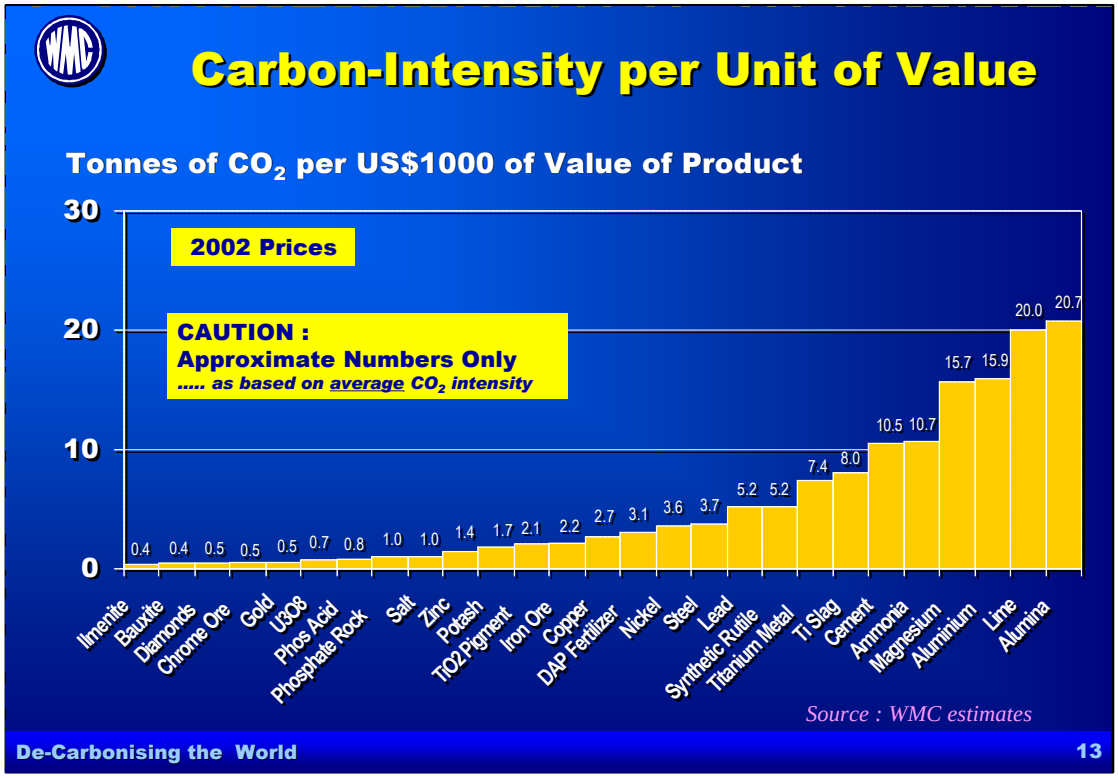
As can be seen, Nickel has a similar carbon-intensity per tonne of metal as Aluminium, but the former sells for nearly five times the price. Therefore, on a percentage basis, the cost of carbon will be much less for Nickel than Copper.



This chart shows the amount of carbon per unit of sales revenue for each of the commodities.

For example, Lime generates 20 tonnes of CO_2 per thousand dollars of revenue.

It should be noted that the revenues are based on the average sales price achieved in 2002.



This is the same data, but re-ranked from smallest to largest.

Again, a word of caution in using these numbers. It must be recognised that the figures are based on average carbon-intensities. For each commodity, individual operations will have higher/lower values.

Effect of a Charge on Carbon

If a material generates (say) 20 tonnes of CO_2 per $1000 worth of value, then the introduction of a carbon charge of $10/t CO_2 will increase the cost by (20x10 =) $200

To maintain his profit levels, the producer will need to pass this $200 charge to the customer. In other words the price will need to rise by ($200/$1000=) 20%

Lets go through a worked example of the possible effect of paying for carbon ….

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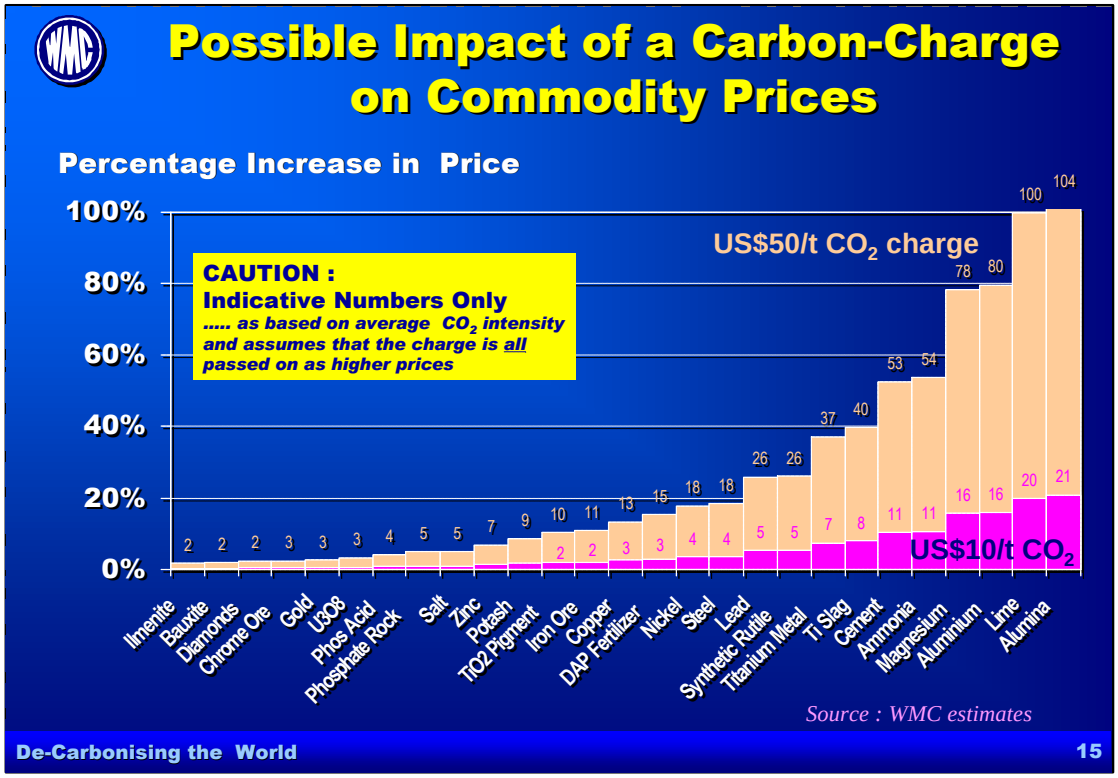

This chart summarises the overall impact of a possible charge on carbon production on commodity prices.

At this point in time it is unclear what the cost of carbon will be – and we won't know until the Protocol is fully implemented. Key variables is the speed, size and cost of implementing various carbon-saving measures. A related factor is the extent that there will be a true international trading regime exists.

Nevertheless, a quick reading of the literature suggests that most experts expect the cost to be somewhere in the range of US$10 to $50 per tonne of CO_2. Recent modeling suggests that the likely answer could be closer to the lower end of the range.

What this chart show is that, at (say) a US$10/t charge, the cost of producing lime will rise by 20% of its sales price. If all of this cost is passed onto the consumer, the price will correspondingly rise by 20%.

If the carbon charge is $50/t CO_2 then the impact will be five times larger – resulting in a doubling in the price of lime !

It should be cautioned that the above analysis simplistically assumes that the producer can actually pass on all the costs. Also, that the demand is price-inelastic. In practice, not all the costs will be passed on, and higher prices will affect overall demand for the product. Consequently, this analysis should be viewed as setting an upper-limit for the impact of a carbon charge on commodity prices.

Effect of "Free-Riders" on Commodity Prices

- Not all of the producers will incur a carbon-charge
  - Under the Kyoto Protocol, producers in non Annex-1 countries (ie the developing world) are not required to meet specific emission targets
- Producers in these countries could get a "free-ride".
  - If most of the world's production is in these countries then it is unlikely that those producers who do pay for the cost of carbon produced will be able to recoup all of this cost through higher commodity prices

Note : To "level the playing field", it is conceivable that some of the signatory countries could impose trade barriers

In practice not all of the costs will be incurred – and nor will it all be passed onto the consumer. This is because of the presence of "Free Riders" in the system.

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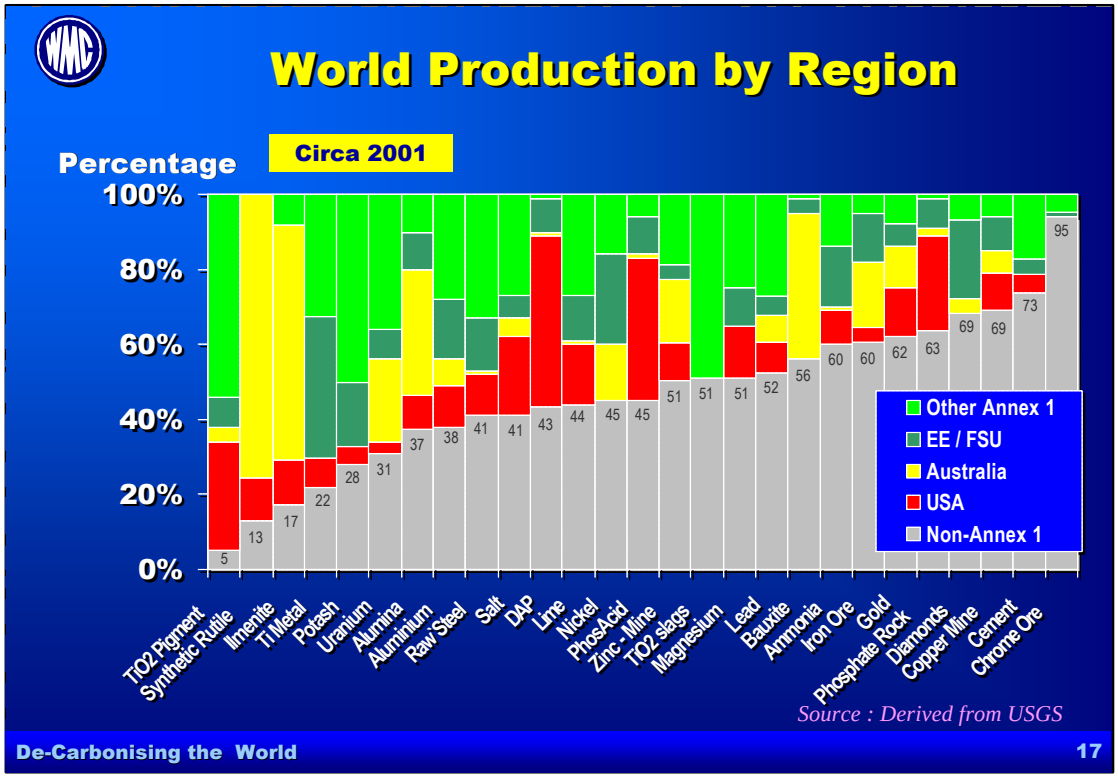
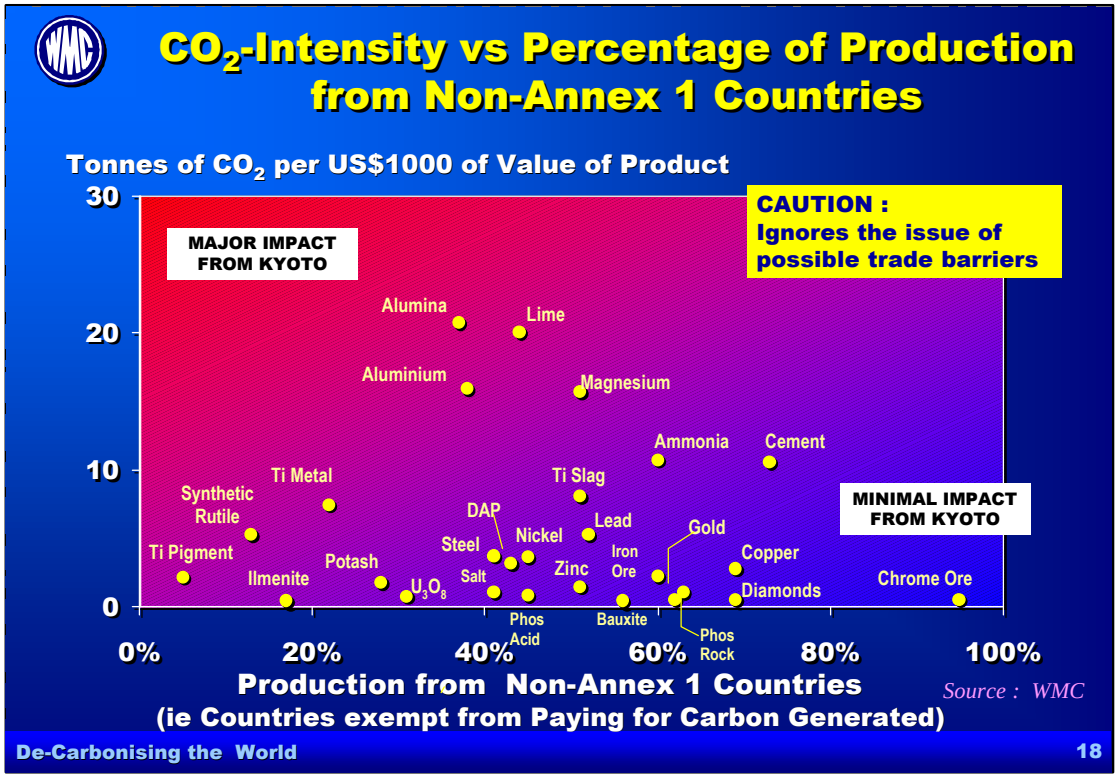


This chart shows the level of production by region for each commodity.

The grey bars refer to those countries not in the Annex-1 category – and hence not required to meet carbon production targets.

As can be seen, a large proportion of the world's resources are produced in countries that are outside the restrictions of Kyoto.

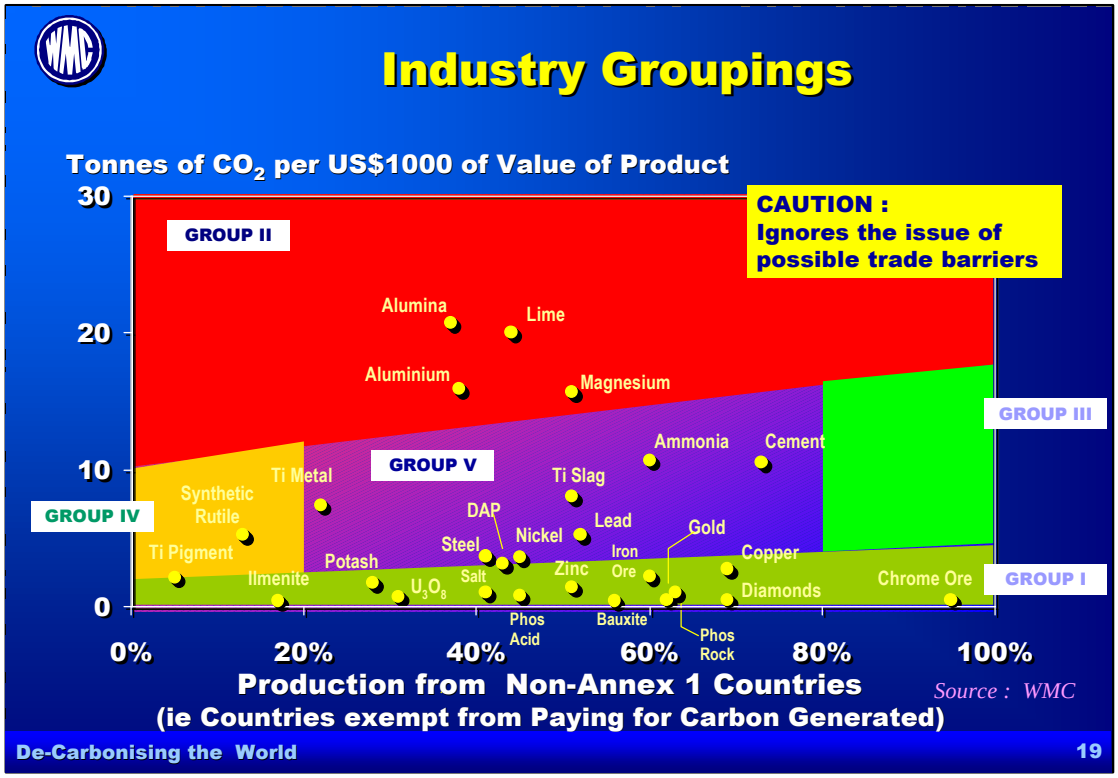
The red bars refer to the US, which has stated that it won't ratify the Kyoto Protocol.



This is an important chart.

It compares the carbon-intensity per unit of value for each commodity against the amount of production in countries not on the Annex-1 list.

As can be seen, the biggest impact of Kyoto will be felt by those commodities in the upper left quadrant of the chart – with high carbon intensities and high level of production in Annex-1 countries. Conversely, commodities at the bottom of the chart will be less affected – especially those in the bottom right hand corner.



For convenience, I have arbitrarily broken the chart up into five separate groupings.

Commodities in Group 1, which is at the bottom of the chart will, in my personal view, will not be materially affected by carbon charges. This is because their carbon-intensity is low. Depending on what the cost of carbon is the impact on prices will only be of the order of a few percent. This grouping includes Copper, Gold and Zinc.

On the other hand, commodities in Group II will be significantly affected by Kyoto. These commodities include Alumina, Aluminium , Lime and Magnesium. Not surprisingly, these industries have been very pro-active in managing the greenhouse gas issues.

Between these two extremes are three other groups. Group III are moderately carbon intensive, but won't be significantly affected by Kyoto as most of the production is in developing countries. In this Group, it is unlikely that the price commodity will rise.

At the other end is Group IV, where most of the production is Annex-1 Countries. As most of the producers are in Annex-1 countries, they are all equally affected – and hence are in a stronger position to pass on the cost to consumers in the form of higher commodity prices.

The last group is Group V - which occupies the middle ground. In here the situation is much more complex, and outcome more uncertain. It is recommended that you assess each industry on a case-by-case basis.

Caution : This analysis assumes that the Annex-1 countries don't implement trade barriers against production from other countries.

Impact of USA not signing Kyoto

- USA produces 36% of the Annex-1 greenhouse gas emissions
- Although the US won't set absolute targets, the Bush Energy Plan does commit it to reducing the country's carbon-intensity
  - This will require a major investment in R&D
- By not signing the Kyoto Protocol it :
  - Seeks to protects its local industry, but it …
  - Risks political fallout from the other countries (and possible trade sanctions ?)
  - Locks-out a large market for carbon-trading opportunities

End result is an increase in the level of "free-riders"

The previous chart also needs to take into account what may happen to the United States if it doesn't sign Kyoto.

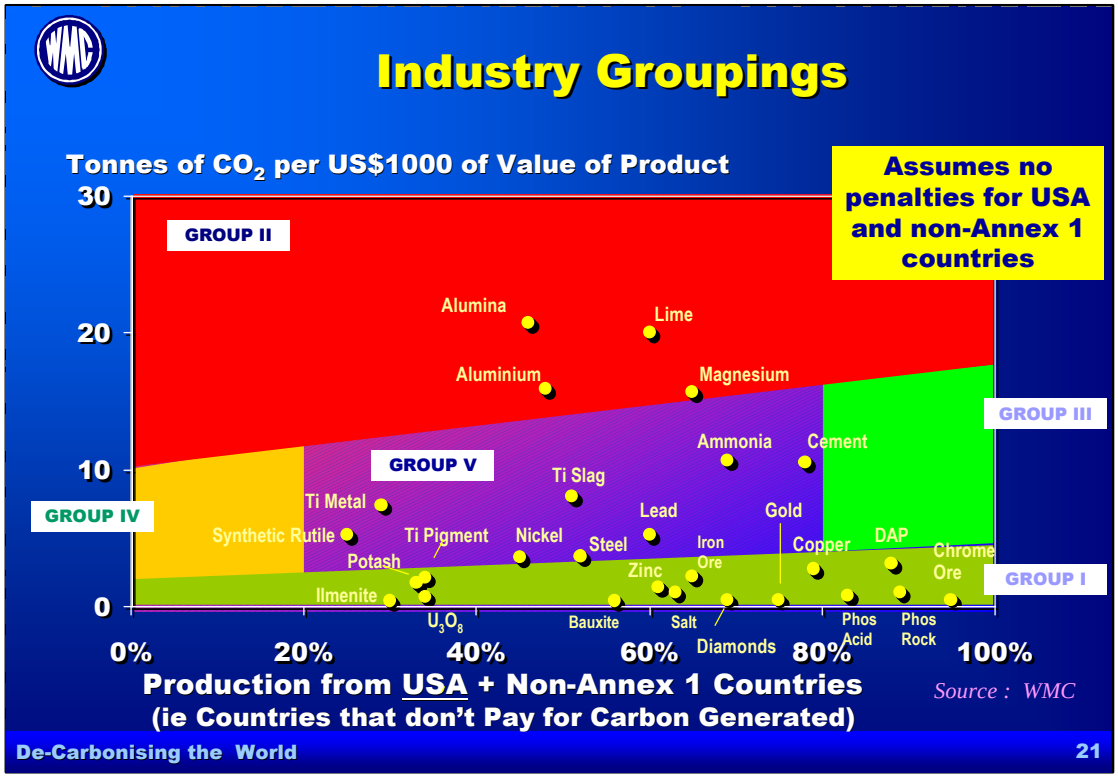
By way of background, USA produces 24% of the world's greenhouse gas emissions or 36% of those produced by the Annex-1 countries.

Even though it won't sign the Protocol, it should be recognised that the recently announced Bush Energy Plan shows that the US is firmly committed reducing the country's carbon-intensity. This will require a major investment in R&D and a significant injection of capital.

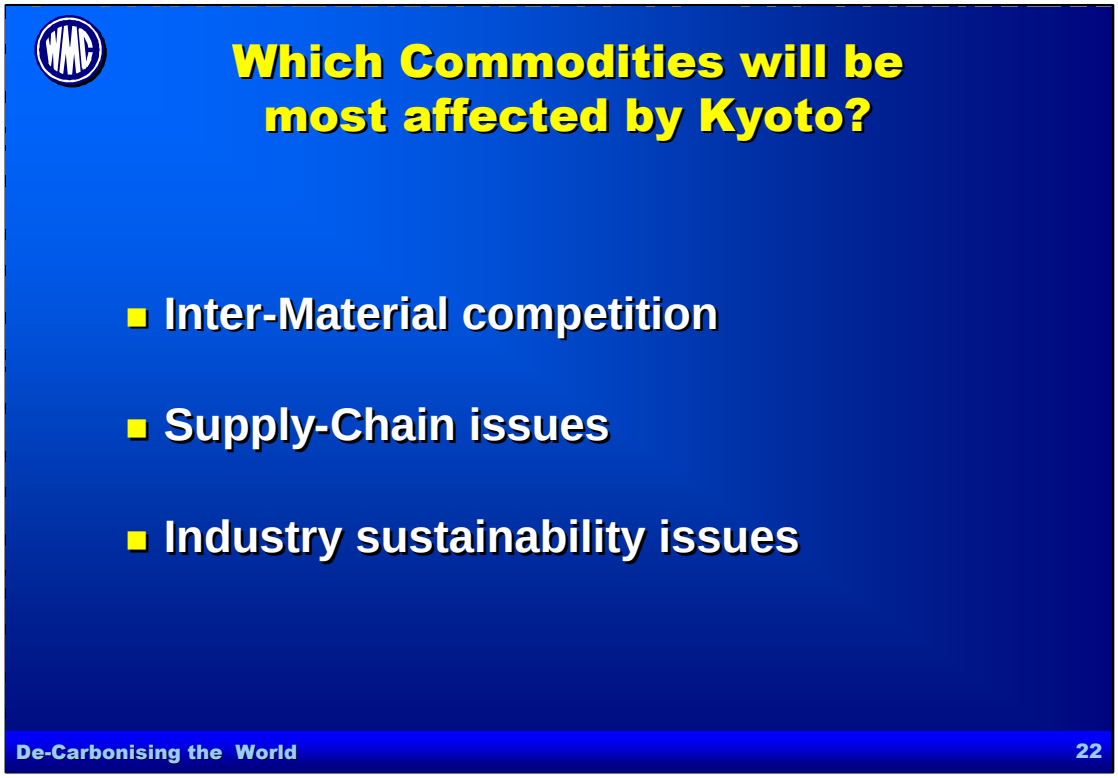
However, by not signing the Kyoto Protocol, the US seeks to protects its local industry. But in the process it risks political fallout from the other countries (and possible trade sanctions ?).

It also locks-out a large market for carbon-trading opportunities.

The end result is an increase in the level of "free-riders".



This chart is similar to the previous one – but with the inclusion of the US with the other non-Annex 1 countries. The effect is to move most of the commodities to the right.



I would now like to move onto the last part of my presentation – namely identifying which commodities will be most affected by Kyoto.

I have broken this down into three parts.

•Firstly, possible changes arising form increased competition between materials

•Secondly possible changes in the supply chain for various commodities, and

•Thirdly, I would like to make some general comments on long term sustainability of the resource industry

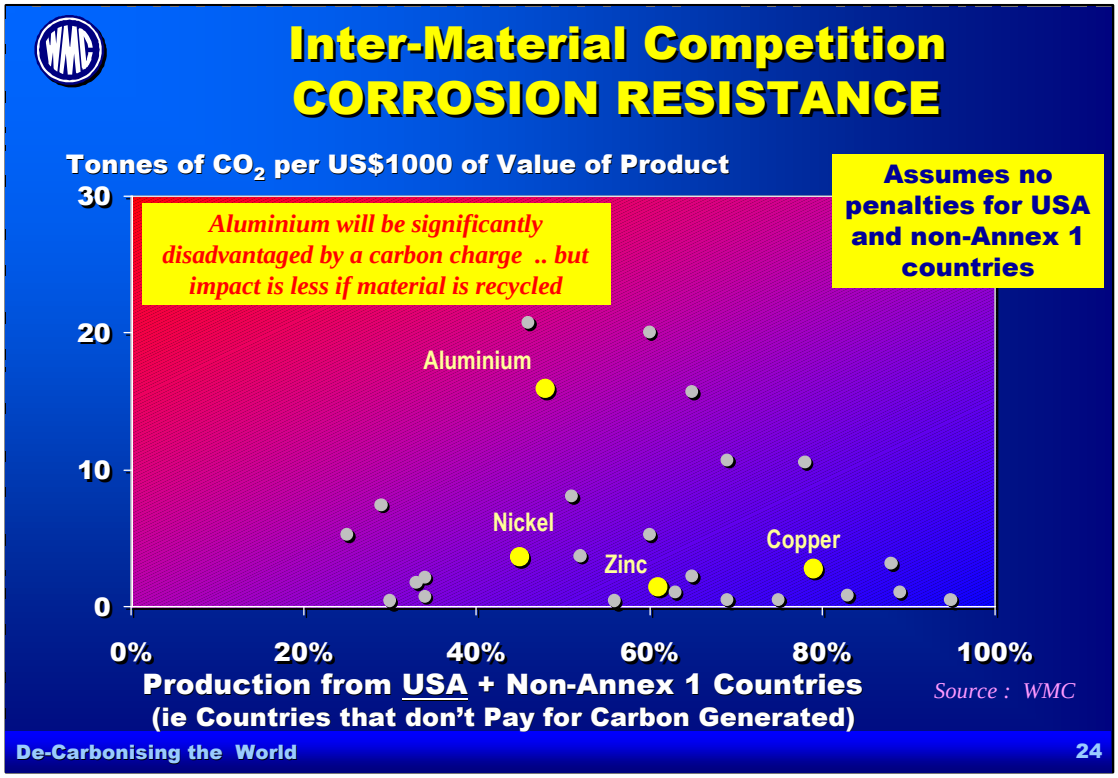
Inter-Material Competition

- The level of competition between various materials will be driven by the :
  - End-Use Markets
  - Relative Carbon-Intensity per unit value
  - Relative amount produced by the Signatory Annex-1 Countries

Case Studies : Corrosion Resistance
Power
Transport
Construction
Fertilizers

With regard to inter-material competition, the level of competition will be driven by the markets they operate in, their relative carbon-intensity and the level of production by the signatory Annex 1 countries.

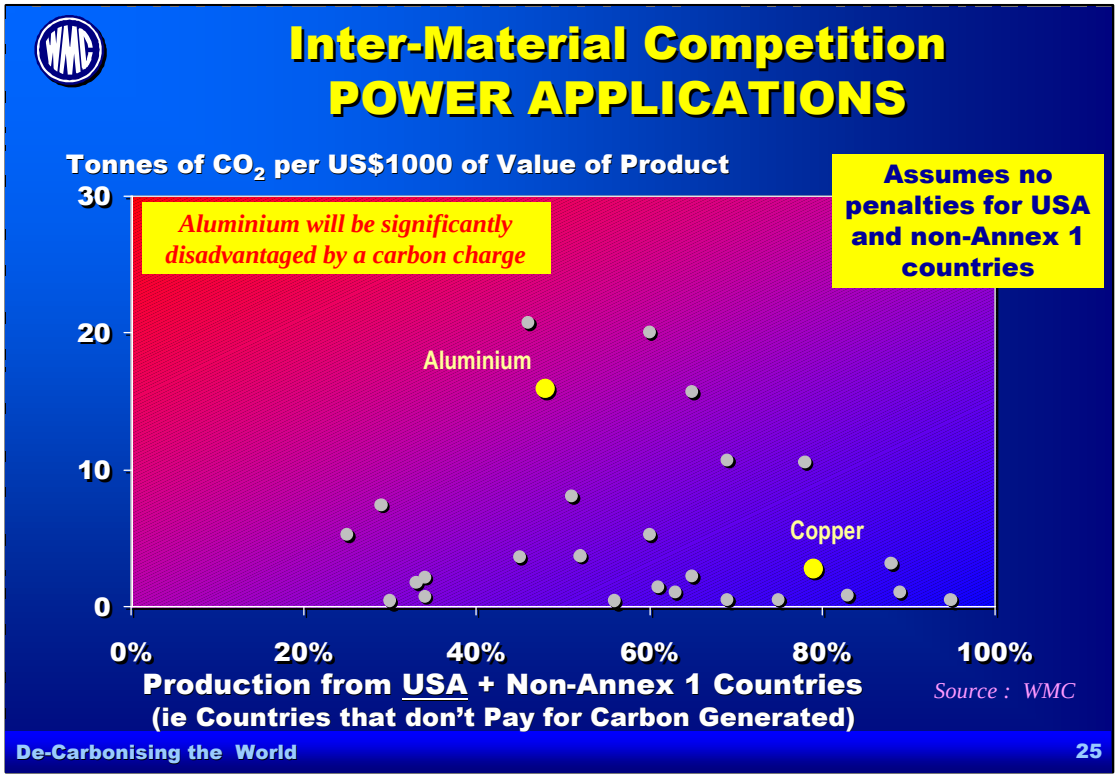
I would like to do some quick case studies in the following five end-use markets …



With regard to corrosion-resistance applications, the main materials used are Aluminium, Nickel (for Stainless Steel), Zinc and Copper.

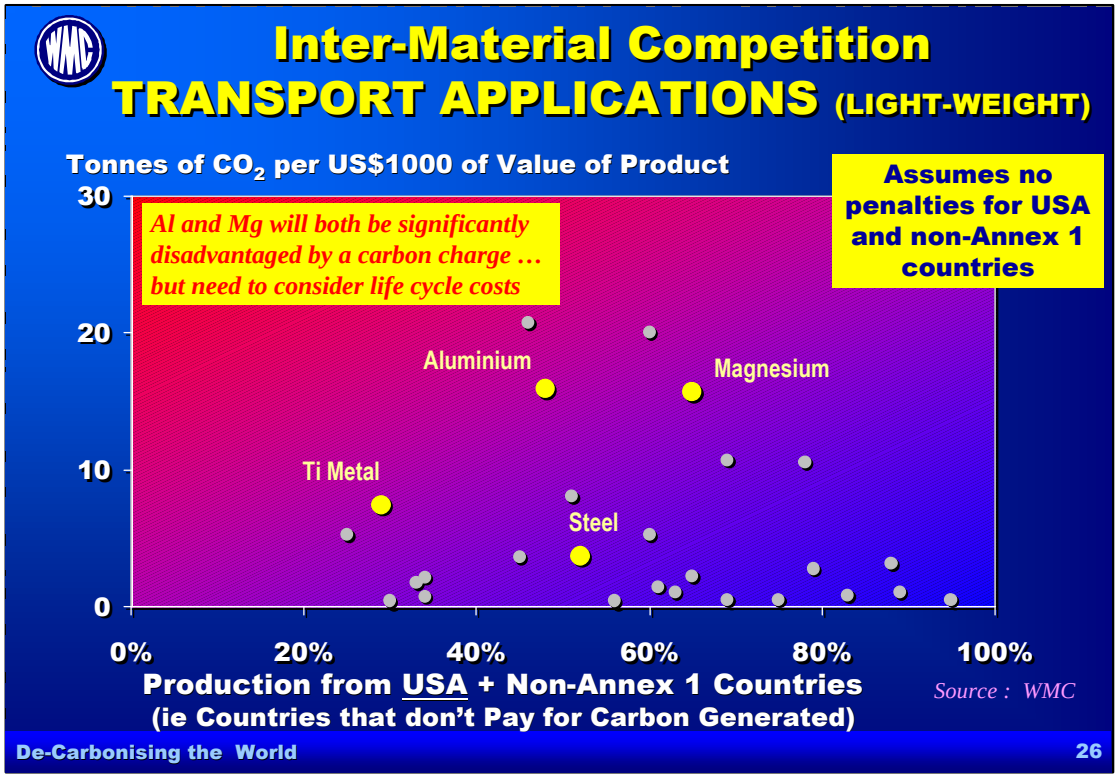
As can be seen, Aluminium is significantly more carbon-intensive than the other commodities. In relative terms the cost / price of Aluminium will rise against the others – resulting in a loss in markets for this application.

On the other hand, the Aluminium producers will argue that recycling will reduce their carbon usage. However, this suggests a change in the structure of the industry away from primary production.



With regard to Power applications where electrical conductivity is important, the two main competing materials are Aluminium and Copper.

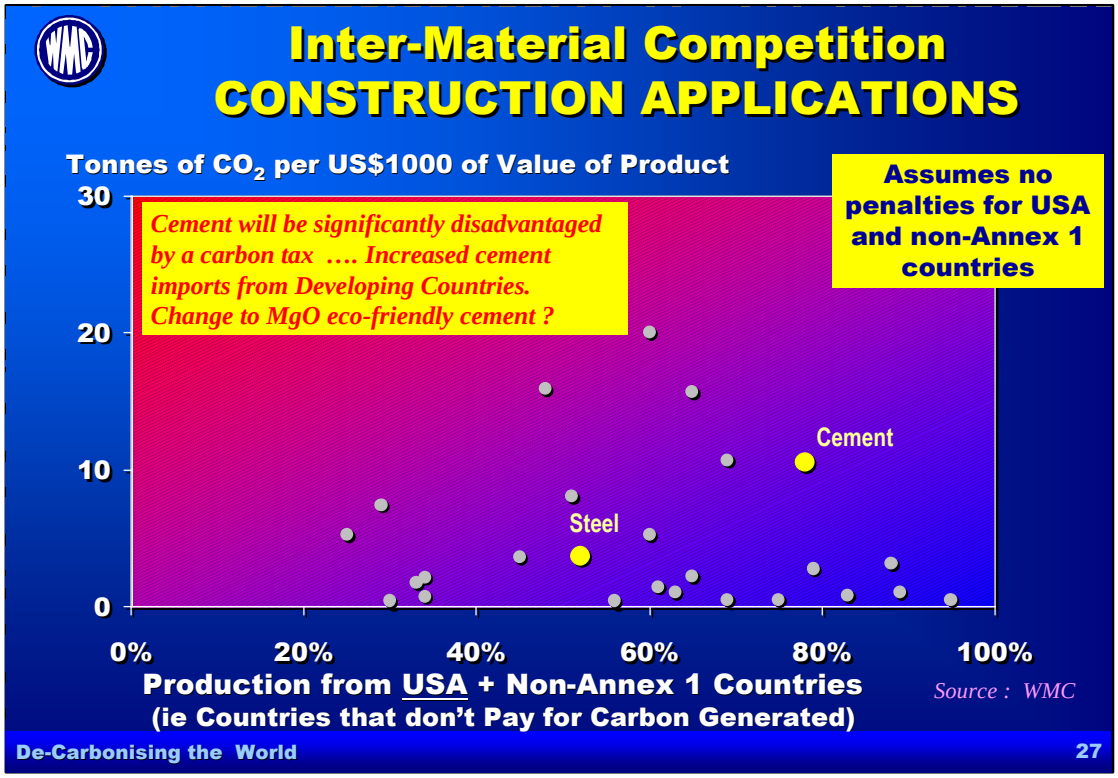
The same story applies as before – namely that Aluminium may lose market share to Copper.



The story for Transport applications is more complicated.

The competing materials are Aluminium, Magnesium and Titanium. These are much lighter than Steel (the main material currently used in transport applications).

While the former materials are all much more carbon-intensive, it must be recognised that they may still grow their share of this market. This because these materials offer energy savings over the life of the vehicle. So you need to consider life-cycle issues.



For Construction Applications, the two main materials are cement and structural steel. The former has a much higher carbon-intensity and so will be adversely affected – certainly so in the Annex-1 countries.

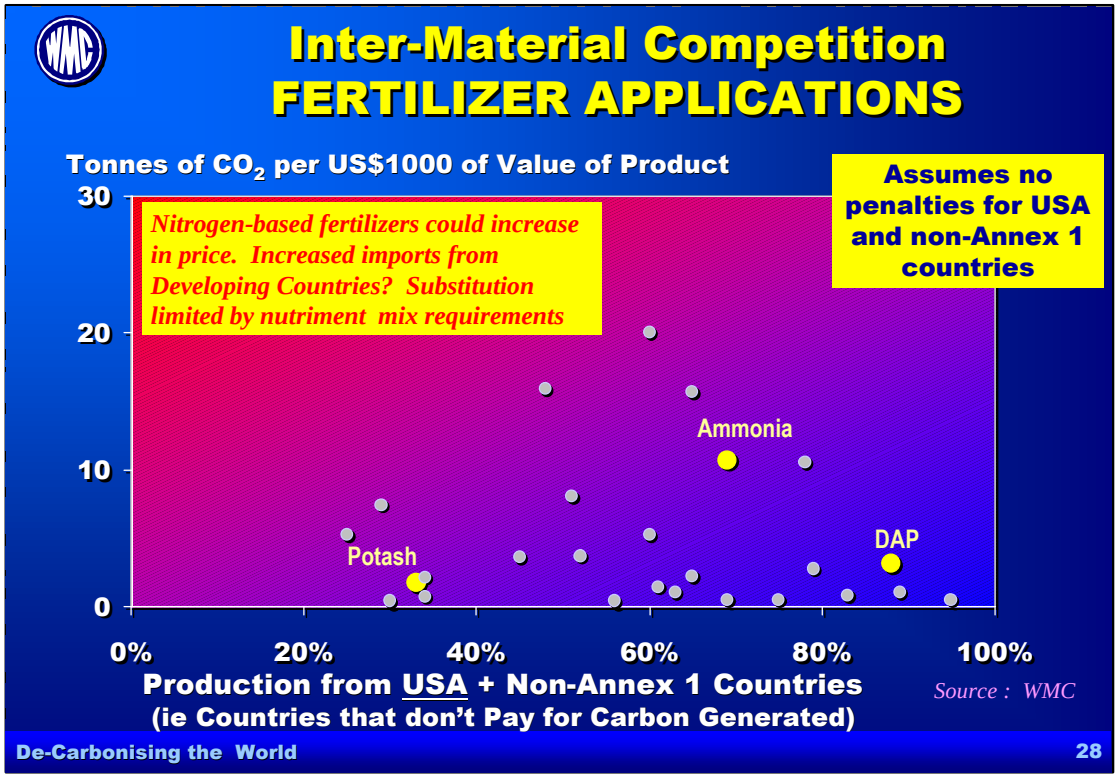
The industry response in these countries might be to import cement powder from non-Annex 1 countries. Alternatively, there are opportunities to switch the raw material over from Calcium Carbonate to Magnesium Oxide – with the latter being much less carbon-intensive. This is the so-called "eco-friendly" cement.

Speakers Note :

The main raw material for cement manufacture is $CaCO_3$. During the roasting process (which requires heating finely-ground material to 1450°C) this material separates into CaO and CO_2. On average, the production of 1 tonne of Portland Cement generates ~810 kg of CO_2.

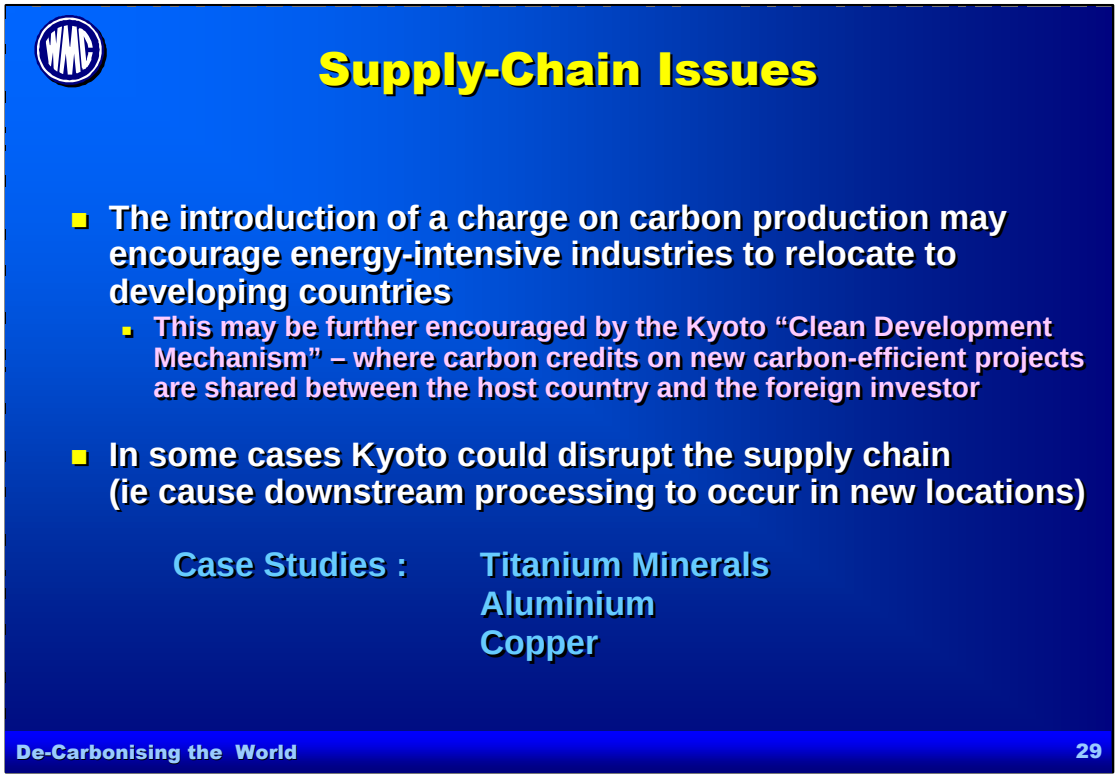
Portland Cement consists mainly of Ca_3SiO_5 and Ca_2SiO_4. Adding water to this causes a chemical reaction to produce crystals of $CaO.2SiO_2.4H_2O$. Over time, some of the cement may revert back to $CaCO_3$ by absorbing CO_2 from the air. However this takes several decades and reduces the cement's strength.

So-called "Eco-Friendly" cements made from magnesium carbonate ($MgCO_3$) also generate CO_2 on roasting. However, because of the lower temperature required (650°C), the roasting process is much less energy-intensive. More importantly, the material "hardens" into cement by by absorbing CO_2 from the air and reverting back to magnesium carbonate. The end-result is a much lower carbon-intensity of ~400 kg per tonne of Cement.



Finally, there is the Fertilizer Market. The three main competing materials are Potash, Nitrogen-based fertilizers and Phosphate-based fertilizers.

Nitrogen-based fertilizers require Ammonia, which is carbon-intensive. However, the extent to which there will be substitution away from it will be limited by nutritional requirements for a required mix of elements. In any case, Ammonia producers may shift more of their production offshore to developing countries.



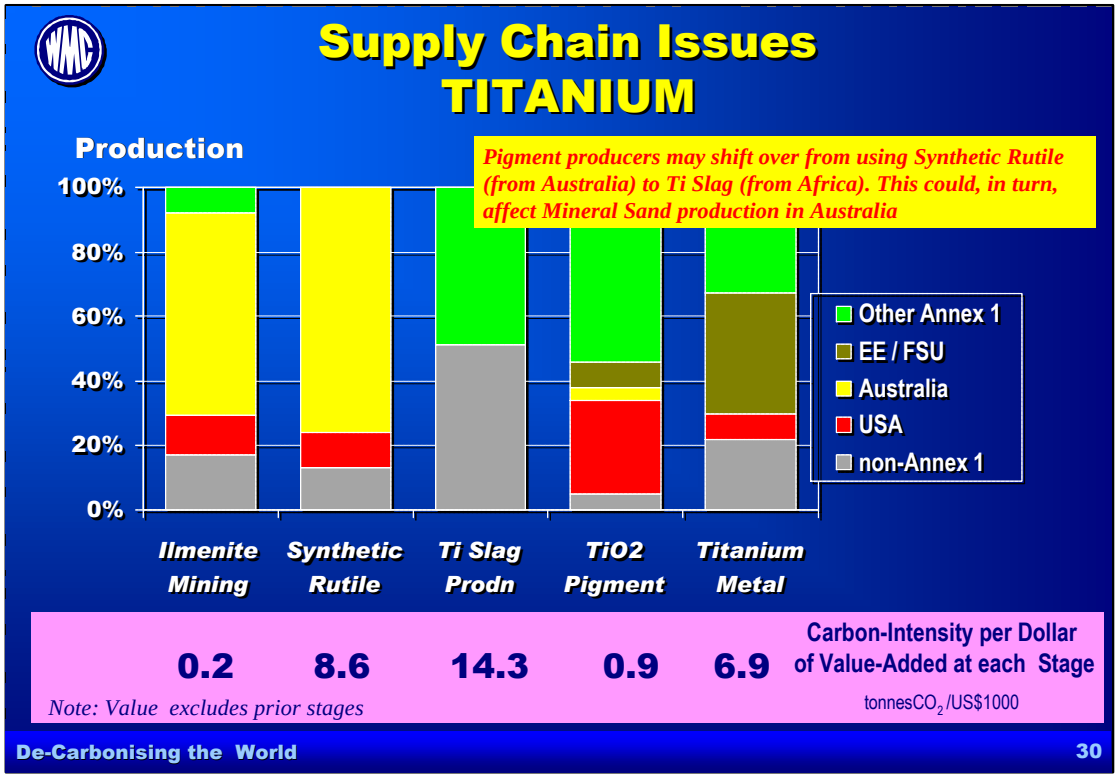
Moving on to the subject of Supply-Chain issues …..

The introduction of a charge on carbon production may encourage energy-intensive industries to relocate to developing countries.

This may be further encouraged by the Kyoto "Clean Development Mechanism" – where carbon credits forn new carbon-efficient projects are shared between the host country and the foreign investor.

In some cases implementing Kyoto could disrupt the supply chain by causing down-stream processing to occur in new locations.

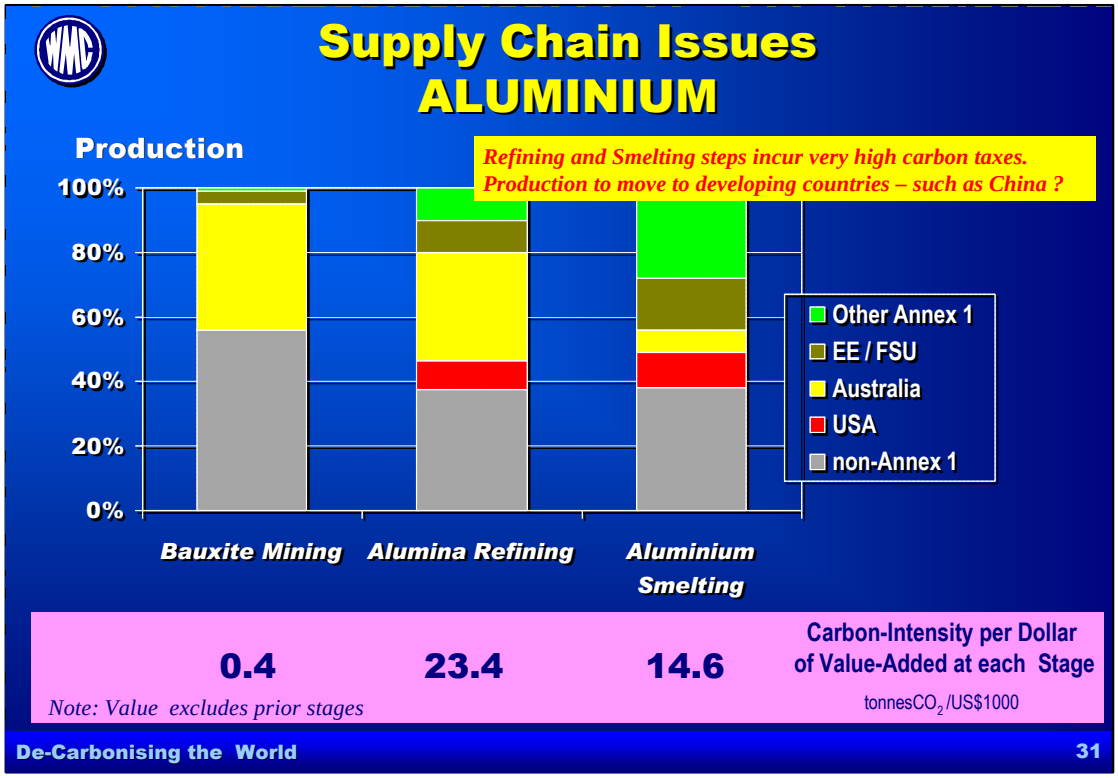
I would like to do some quick case studies in the following three commodities …



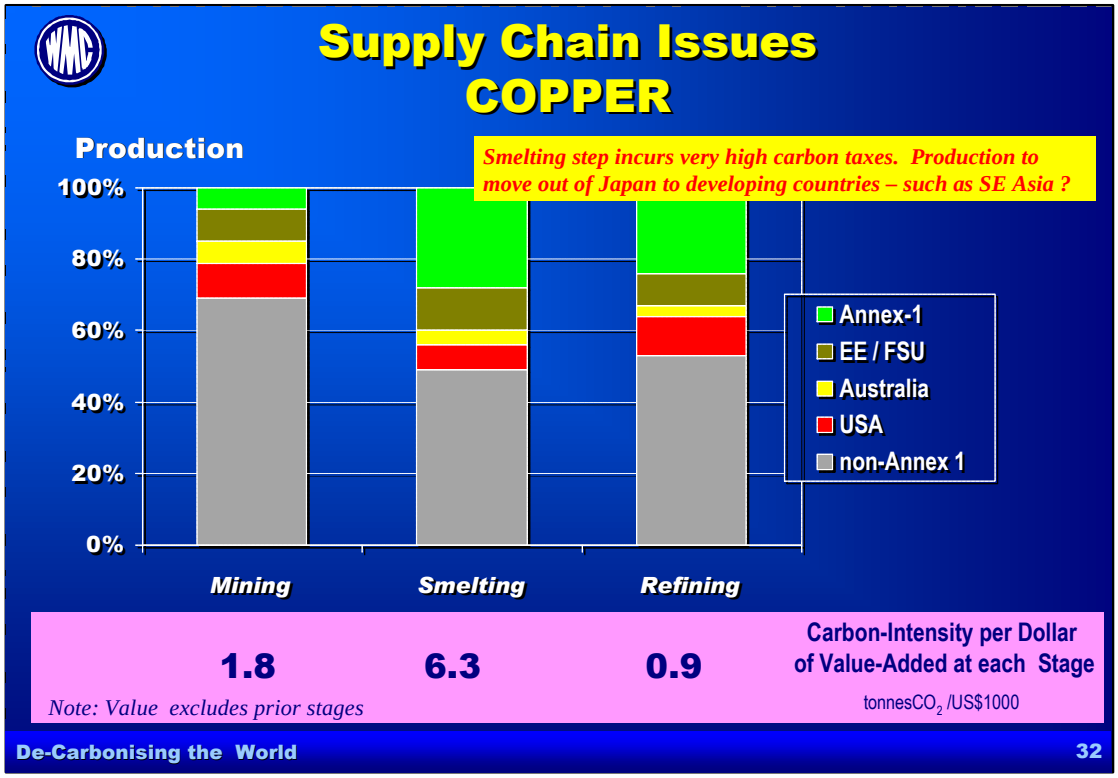
Firstly, Titanium.

As can be seen the majority of Titanium Dioxide Pigment production occurs in Annex-1 countries. The process can use synthetic rutile or titanium slag. While the latter is more carbon-intensive, most of the production comes from developing countries (mainly South Africa, and soon to be Mozambique). By comparison, most synthetic rutile comes from Australia. Assuming no trade barriers, and assuming Australia does ratify Kyoto, it is possible that the pigment producers could switch over to slag. If so, this would have significant implications for upstream ilmenite producers in Australia.

Furthermore, if Australia cuts back production, the world supply of by-product materials such as Zircon and Rutile may also be affected.



With regard to the Aluminium supply chain, a large proportion of the world's Alumina is produced in Australia. Per unit of value, this is the most carbon-intensive step. Kyoto may encourage Alumina production to move to other countries. Also new smelters may also be built in developing countries – such as China.

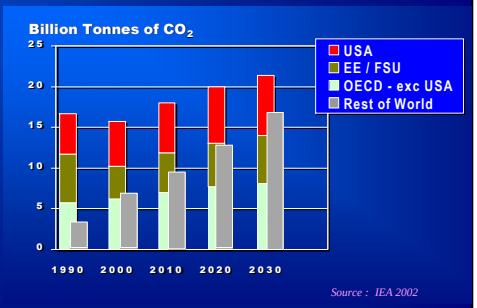


Finally, with regard to Copper, it is significant to note that the majority of production at all stages occurs in developing countries.

Even so, Japan still has a large smelting industry. Given that smelting is a carbon-intensive step (per unit of value added), this may relocate to other countries.

Unresolved Issues

- No certainty that Kyoto will be implemented
  - Depends on Russia
- Unclear how Carbon Charges will be implemented
  - Clean Development Mechanism
  - Joint Implementation Rules
  - Emission Trading
  - Broad-based Carbon Taxes ?
- Need to broaden the net
  - Can't get a "free-ride" forever
  - Possible convergence of initiatives ?
- How will the revenues be spent ?
  - Governments don't like hypothecated taxes



Before I finish, I would like to talk about some unresolved issues associated with Kyoto.

Firstly, there is no certainty that Kyoto will actually be implemented. It all depends on Russia.

Also, it is still unclear how Carbon Charges will actually be implemented. There are a number of mechanisms that still need to be worked out – including the rules for carbon trading. Also, individual governments may implement broad-based carbon taxes to reach their emission targets.

As mentioned before, the issue of "free-riders" will need to be addressed. This problem will only get worse over time. Data from the International Energy Agency indicates that carbon emissions from non-Annex 1 countries will exceed those from the ratified countries by 2020. These other countries need to come into the net. Some people envisage a convergence of initiatives between the countries.

And finally, it is unclear how the revenues raised by the Governments will be recycled. Ideally, these should be spent on new initiatives / technology to reduce carbon. In practice, Governments don't like to be constrained by hypothecated taxes.

Conclusions

- Not certain that it will be ratified – depends on Russia
- If Kyoto is ratified, a large proportion of the world's mining industry will be affected by a charge on carbon production
- Based on (say) a charge of US$10/t CO_2, the cost of several commodities will substantially increase
  - Largest impacts will be on Alumina (up to 21% increase in the price), Lime (20%), Aluminium (16%) Magnesium (16%), Ammonia (11%) and Cement (11%)
- Most other commodities will not be significantly affected
  - These include Nickel (4%), Copper (3%), Zinc (1%), and Gold (1%)
- How much of this cost increase is transferred to the customer depends on what proportion of the industry is located within Annex-1 countries

In conclusion ….

It is no certainty that Kyoto will be ratified. It all depends on Russia.

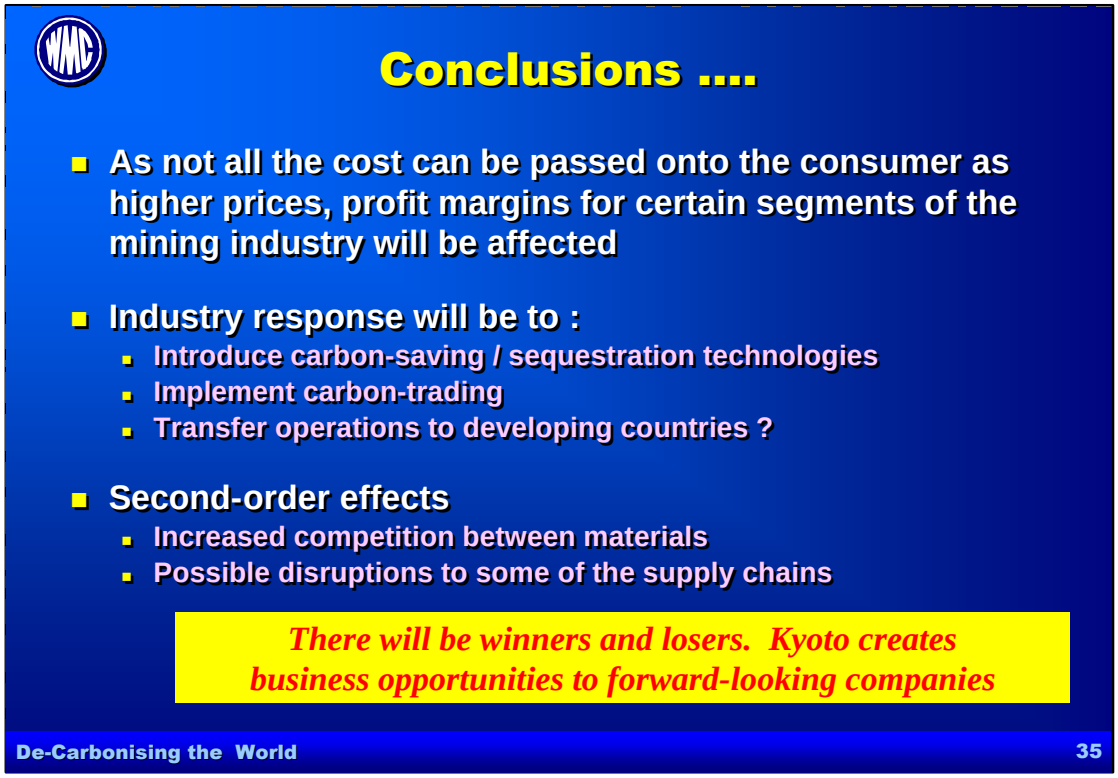
However, if Kyoto is ratified, a significant proportion of the world's mining industry will be affected by a charge on carbon production

Based on (say) a charge of US$10/t CO_2,which is the lower end of expectations, the cost of several commodities will substantially increase.

The largest impacts will be felt Alumina (by up to 21% increase in the price), Lime (up to 20%), Aluminium (16%) Magnesium (16%), Ammonia (11%) and Cement (11%). In practice, due to competitive pressures, and price elasticity, not all these cost imposts will be passed on to the consumer.

Many commodities will not be significantly affected. These include Nickel (by up to 4%), Copper (3%), Zinc (1%), and Gold (1%).

In the first instance, how much of this cost increase is transferred to the customer depends on what proportion of the industry is located within Annex-1 countries.



As not all the cost can be passed onto the consumer as higher prices, profit margins for certain segments of the mining industry will be adversely affected.

I believe that industry will respond by introducing carbon-saving / sequestration technologies and implementing carbon-trading. It may also possibly relocate some operations to developing countries.

On the other hand, the desire to relocate to developing countries may be tempered by the possible introduction of trade restrictions from Annex-1 countries. There is also the possibility that, over time, the carbon practices for various parts of the world may converge – eliminating the "free-rider" problem.

Kyoto will also result in some second-order effects . Namely, increased competition between materials and possible disruptions to some of the supply chains.

In summary, I believe that there will be winners and losers from Kyoto. From a positive perspective this means that the need to "de-carbonise" the world will create great business opportunities for those companies and countries that are forward-looking.

Thank you …