2nd EXPERT MEETING ON FINANCING CCS PROJECTS

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INTERNATIONAL ENERGY AGENCY

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The IEA Greenhouse Gas R&D Programme supports and operates a number of international research networks. This report presents the results of a workshop held by one of these international research networks. The report was prepared by the IEA Greenhouse Gas R&D Programme as a record of the events of that workshop.

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Further information on the network activities or copies of the report can be obtained by contacting the IEA Greenhouse Gas R&D Programme at:

IEA Greenhouse Gas R&D Programme, Orchard Business Centre, Stoke Orchard, Cheltenham Glos. GL52 7RZ. UK
Tel: +44 1242 680753 Fax: +44 1242 680758
E-mail: mail@ieaghg.org
www.ieagreen.org.uk

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Author: John Kessels

Title: **IEA Greenhouse Gas R&D Programme, World Coal Institute and IEA Clean Coal Centre Summary Report on Expert Workshop on Financing Carbon Capture and Storage (CCS): Barriers and Solutions**
Date: May 28-29 2008

Venue: New Yorker Hotel, New York, USA

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Executive Summary

The expert meeting provided an opportunity for discussion on the issues that are restricting the development of carbon capture and storage (CCS) in North America from a financial perspective. The meeting enabled a discussion of the possible options to overcome hurdles as well as ways to facilitate and encourage more CCS projects. Numerous unresolved issues and potential difficulties in the use of CCS still exist, including insurance, viable financial incentives and the need for the establishment of a robust policy and regulatory framework.

An important outcome is that many of the speakers thought the difficulties and issues surrounding CCS can be resolved. However, from a private investment viewpoint CCS in North America was an unattractive financial option without Government incentives and a legal framework in place. There was also a general consensus that if the USA implemented an emission trading systems that the revenue would need to be targeted at CCS and relying on a market derived carbon price would still not be enough to make CCS a financially viable option in the near to medium term. The conference discussion provided the following points of note:

- The view from the investment banks was that there would be no major private investment in CCS in the USA until they can be offered a secure return on their investment, such as loan guarantees or tax credits.
- Development of CCS regulatory frameworks is well underway internationally in a number of regions. The speed of development may be enhanced with the launch of the IEA CCS International Regulatory Network.
- The Interstate Oil and Gas Compact Commission (IOGCC) recommends that in the USA that CO_2 storage should be regulated as a commodity to allow the application of oil and gas conservation laws to facilitate development of storage projects. The IOGCC has a Task Force that also produced a set of guidelines on permitting CCS projects.
- There are a number of CCS projects underway in North America and future possibilities through the restructuring of FutureGen. In Canada, the Government intends to have new coal fired plants capture ready by 2018.
- There is a perception that an emissions trading scheme will not be enough to accelerate deployment of commercial CCS projects in the future and that other incentives will be required.
- There are several proposals in the USA investigating how to facilitate the deployment of CCS. For instance the proposed bill by Lieberman-Warner has use of some of the revenues from sale of allowances to fund low carbon technology projects including CCS. Further proposals discussed at the meeting were the use of the Bond market and setting up a Trust Fund for CCS.
- There is a clear gap in the USA about information on CCS with the general public and within the financial sector and hence an urgent need to provide further information and educate people about the risk and benefits of CCS in an informed manner.

- Legal and environmental liability is seen as an issue. Insurance companies do currently have the business models to insure CCS projects during the operational phase but there is a lack of data to provide coverage for the long term liability that would exist post-injection. Development work in this area is critical.
- Quantifying the potential long term liability of CCS projects in dollar terms would allow insurance companies to assess the underwriting that is needed. Otherwise until more information is available for long term liability in CO_2 storage there is likely to be only limited insurance on a 1-2 year revolving contract.
- If financing of CCS is to occur from the private sector then the 30 trillion dollar bond market must be utilized. This is unlikely to occur until there is greater regulatory certainty from the US government and the States, and greater certainty of cost recovery approval and permitting allowed by the local public utilities commissions. Ultimately, the willingness of ratepayers to pay higher electricity bills to pay for CCS, as reflected in decisions by local public utilities, will be critical to the financing of such projects.

Introduction

The CCS Expert Meeting on Finance took place over two days in New York. This meeting was a follow up to one that was held in London during 2007. The Meeting was by invitation and limited to 80 people that included representatives from Governments, industry, insurance, financial institutions, academia and research organizations.

The main purpose of the conference was to provide a clearer picture of the options available to finance CCS projects in North America and to increase the involvement of experts from the financial sector in discussion about possible financial instrument options for CCS. The ultimate outcome of this work will be to identify, encourage and develop world-wide collaboration and practical development of financial mechanisms to accelerate the progression of CCS projects from R&D to commercial reality.

The objectives of the meeting were to explore the options of:

- Identifying key drivers on financing CCS projects in North America by the financial sector.
- Contributing to building financial mechanisms for deployment of CCS projects
- Gaining access to financial information relevant for all major stakeholders such as industry, insurance companies, Government and investors in CCS projects
- Use of futures, derivatives and insurance markets to reduce financial risks of CCS deployment
- Improving the awareness of the status of CCS technology for the financial community.
- Use of insurance to address the financial risks of CCS demonstration plants

The IEA Clean Coal Centre (IEA CCC), IEA Greenhouse Gas R&D Programme (IEA GHG) and the World Coal Institute (WCI) have extensive global links and are in an excellent position to facilitate co-operation between leading research groups and industry on greenhouse gas (GHG) mitigation. IEA GHG already has experience in coordinating a number of international research networks. One option under consideration is the establishment of a new network to bring together existing expertise and experience of organizations at the forefront of research, development and demonstration into GHG mitigation technologies as well as financial institutions. To date, financial institutions have limited experience with CCS which was highlighted at the meeting with one speaker from the financial sector stating that his institution was not being asked to include CCS in the assessment of new coal fired plant in the USA. The objectives of this report are:

1. To pass on information about the CCS Expert Meeting on Finance;
2. Give an overview of each of the presentations, and
3. To outline the main outcomes of the meeting.

Day One Sessions

The meeting opened with a welcome by Barbara McKee of the US Department of Energy. Ms McKee highlighted the importance of CCS as a major contributor to mitigation of CO_2 emissions and pointed out that in many countries there were other issues to consider. These issues included electricity deprivation, scarcity of clean water and food and legitimate aspirations for economic improvement in the lives of those with low per capita incomes.

The meeting was divided into six parts. **Session One** was on the worldwide status of CCS given the importance of fossil fuels which currently supply 80% of the global energy demand with a further 60% growth in energy demand expected by 2030. CCS after energy efficiency is the second biggest potential mitigation option and will be a key transformational technology. There are many barriers to CCS deployment including technology development, cost, legal and regulatory, public acceptance, international mechanisms and making it commercial. If the barriers are removed CCS could change the way the energy industry operates with opportunities for innovators. However, if this is to be achieved it is important to recognize that it is vital to develop and deploy CCS to use fossil fuel resources sustainably.

Kelly Thambimuthu the Chairman of the IEA GHG said that CO_2 emissions are expected to grow an additional 14.3 Gt by 2030 with more than half of the growth coming from power stations in India and China. This presents a dilemma with energy demand growing and being met more and more by fossil fuels. The Intergovernmental Panel on Climate Change Fourth Assessment (IPCC AR4) also discusses how mitigation efforts over the next 2-3 decades will have a large impact on the potential to achieve lower stabilization levels. There is also the risk of "carbon lock" in with new and replacement fossil fuelled power plants 2003-2030 expected to be 1,391 GW for coal, 1,883 GW for gas and 237GW for oil. This means the next 10 years will be very critical as this technology will be locked in and producing CO_2 emissions for 30-40 years at least.

The status of CCS in terms of maturity differs with injection, storage and transport. Some parts of the cycle are well established in the oil and gas industry, for example CO_2 transport as part of enhanced oil recovery (EOR) operations. International policy developments have seen CCS being increasingly accepted with it now being considered for inclusion within the EU ETS from 2013. However, there are still barriers preventing the inclusion of CCS within the Clean Development Mechanism (CDM).

There is currently no large scale coal fired demonstration projects to accelerate deployment of CCS technologies. However, there are several proposed integrated CCS projects in Europe, USA, Canada, Australia and plans for a project in China. Lastly, the amount of money to be invested in the power sector including transmission and distribution networks up to 2030 is estimated to be over US$11 trillion according to the IEA WEO 2007.

Jonathan Pershing from the WRI outlined four key points. Climate science is robust and the urgency to undertake large scale change is strong. There is no silver bullet, so we need to undertake all options. CCS is challenging in cost and public acceptability. Scaling up globally will be critical. Finally the policy needed to make all this work needs to be in place. In the USA, coal makes up over 30 % of the energy mix and it would be impossible to shut the existing coal fired stations down as they are critical to meet energy demand.

Session two examined national and regional initiatives with many countries building and moving forward on existing legal/regulatory frameworks taking into account onshore and offshore CO_2 injection including:

- Australia: based on Offshore Petroleum Act of 2006: ETS in 2010
- Canada: action at both Federal and Provincial level (Alberta and BC)
- United Kingdom: storage offshore; government taking long term liability
- Japan: storage offshore with Environmental Ministry responsibility
- Norway: building on existing offshore oil and gas regulations

Tom Wilson, a Senior Technical Leader at the Electrical Power Research Institute (EPRI) discussed CCS activities in the USA asking the key question of who is going to pay for early deployment of new CCS technology? Is it going to be Government, industry, or a combination? CCS is a critically important technology to the USA with both its large coal reserves and large potential for geological storage. However, in the USA the cost of coal along with other generation technologies has doubled since 2000. CCS retrofit is being considered and the Lieberman-Warner bill, if enacted, could produce CO_2 price and incentives sufficient to spur CCS deployment. To make CCS commercial by 2020 will require investment in the technology to start immediately.

Eric Beynon from the ICO2N Group discussed several CCS initiatives in Canada. ICO2N is made up of 18 companies representing many of the major potential CCS players. The companies in his group produce over 100Mt of CO_2 emissions annually or 15% of Canada’s emissions. This includes 95% of oil tar sands emissions and greater than 60% of Alberta’s energy emissions. In Canada, there is potential for 3,762 $MtCO_2$ to be stored in oil and gas reservoirs alone.

Initially, it is expected that CCS will begin in Western Canada. ICO2N has completed several economic analyses identifying CCS as a critical component of Canada’s GHG reduction strategy in coal and the oil tar sands in the long term. There is currently 150 billion Canadian dollars earmarked for investment to utilize tar sands up to 2015. From a regional perspective, Alberta views CCS as a means to reduce its emissions by 60%.

Lawrence Bengal is from the Interstate Oil and Gas Compact Commission (IOGCC) presented his work with the IOGCC Task Force. The IOGCC is made up of 30 members, associate states and several international affiliates and a Task Force has produced a set of guidelines on permitting CCS projects. The IOGCC Resource Management philosophy on CCS is:

- Given the regulatory complexities of CO_2 storage. The Task Force strongly believes that geologically stored CO_2 should be treated under resource management frameworks as opposed to waste disposal frameworks. These regulatory complexities include environmental protection, ownership and management of the pore space, maximization of storage capacity and long term liability.
- Regulating the storage of CO_2 under a waste management framework sidesteps the public role in both the creation of CO_2 and the mitigation of its release into the atmosphere and places the burden solely on industry to rid the "waste" from which an "innocent" public must be "protected".
- Such an approach lacking citizen buy-in with respect to responsibility for the problem as well as the solution could well doom geological storage to failure and diminish significantly the potential of geologic carbon storage to meaningfully mitigate the impact of CO_2 emissions on the global climate.

Kai Tullius from the European Commission (EC) gave an overview of CCS policy developments in Europe. The aim in Europe is to build 10-12 coal and gas CCS plants by 2015 which is estimated to cost between 10-20 billion euros. The long term policy goal is to make CCS commercially feasible by 2020. The current CCS directive is proposing an enabling framework with Member States determining whether and where CCS will happen and companies deciding whether to use CCS on the basis of conditions in the carbon market. At the moment CCS is not mandatory. The overall strategy from the European Union (EU) includes in the third phase from 2013 to have full auctioning of CO_2 certificates for the power sector and to include CCS.

Marc Levinson from JP Morgan Chase spoke on CCS and investment. His first comment was that this meeting and the discussions on financing CCS are premature from a private sector perspective. He pointed out that none of their clients had approached JP Morgan Chase about CCS and that in his view that this is unlikely to change in the next five years. If there are going to be any projects in the USA it is likely that the coal and gas companies will go first to the Government for funding, such as FutureGen. He went on to point out that any government subsidies would not be necessarily be positive for facilitating CCS. This could artificially allow CCS to sell low cost electricity and discourage renewables and other low carbon technologies. He then went on to outline what an investor would need to know before lending:

- How will lenders and investors get their money back? The state has to decide that the utility can recover the costs from the rate payer. It needs to be determined that the additional expenditure is “prudent”.
- No lending or investing in CCS until the legal and regulatory uncertainty is sorted out such as pore ownership and liability of leakage.

- They will want to see financial engagement from suppliers to overcome technology risk. There needs to be more suppliers involved in CCS as this will increase investor confidence that these technologies will work.

The discussion and questions on this session focused on the JP Morgan Chase presentation. Several questions were asked on how JP Morgan Chase viewed the future for CCS. Mr Levinson made it clear that if the Government was going to rely on private funding without loan guarantees then CCS projects were unlikely to proceed. A question was asked about what a deal on CCS would have to look like for investors to come to the table. A suggestion was made – "would it assist if the commodity risk was taken out with a 20 year rate price on fuel in a rate regulated environment". Mr Levinson responded that a rate regulated market is one way to approach it and the other is to put a meaningful cost on carbon as in Europe. Basically CCS has no positive purpose, it only has a negative purpose to avoid another cost (putting CO_2 into the air) and currently this does not have a cost in the USA.

Session three discussed the financial industry and CCS. The session began with Mark Trexler from Ecosecurities Global Consulting Services presenting on the relationship between CCS and carbon markets and how they could assist in getting CCS off the ground. Several possible scenarios exist but the carbon market is complicated and not a typical commodity market with many variables including science, media and public opinion all influencing carbon credit price forecasting. Demand is based largely on policy decisions, on how strict the market is, and on how credits are defined. All of which are different from other commodity markets.

In order for CCS projects to proceed, it will need several elements in place including public acceptance, financial incentives, clarification of the permitting issues and demonstration projects to get underway as soon as possible. In order for CCS finance to be secured it will require subsidies and risk offloading. In the end, CCS is reliant on policy, expectations about policy and market demand. It is clear that the carbon market will not be a launch pad for CCS, more likely the carbon market will supply a cash flow.

Professor Edward Rubin argued that in an increasingly carbon constrained world, large reductions of CO_2 emissions from coal plants will be urgently needed and only CCS offers that reduction option. Deployment is needed to establish reliability and true cost of CCS in utility applications at commercial scale across different technologies, different types of coal (bituminous, sub-bit, lignite) and in different geological settings. To reduce costs, learning by doing and R&D is needed.

Professor Rubin then outlined a CCS Trust Fund option he is proposing funded by fees from the use of coal for power generation to pay the full additional cost of CCS for new coal fired plants. This option can raise large amounts of money via small fees. It also decouples the regulatory requirement to reduce CO_2 and can rapidly start deployment with well defined revenues. There are two reports on the Pew Centre website at www.pewclimate.org that give more details about the Trust Fund and further options to accelerate deployment of CCS.

Robert Sussman presented on proposals that could assist CCS. Until legislation in the USA is put in place clarifying the status of CCS there will remain uncertainty about the drivers and incentives amongst plant developers with it currently not in their economic interest to deploy CCS plants. One recently proposed climate change bill in the USA was the Lieberman-Warner Climate Security Act (S.2191) which could achieve emission reductions below 2005 levels of 17-19% by 2020, and 57-63% by 2050. It is a cap and trade program where sources that fall within the terms of the Act must hold allowances equal to their emissions. A key point is that US $16 billion from auction revenues in the current Lieberman-Warner Bill would be made available for CCS projects. However, in the long term, cap and trade this is not enough to finance the wide scale deployment of CCS; additional incentives would be needed. One alternative approach that examined emissions trading could be linked to a performance standard requiring CCS for new plants plus a subsidy to close the cost gap from the revenues of auctioning allowances. The Bill was rejected but likely to be resubmitted at a later date.

Paul Zakkour presented on Financing CO_2 Infrastructure examining financial aspects of building CO_2 pipeline networks including backbone systems. His key messages were that:

- Integrated backbone pipeline networks may be most efficient long-term option but will need "guaranteed" capacity utilisation in order to be economically viable. Point-to-point pipelines on the other hand will be funded on a project-by-project basis by individual developers because of certainty over capacity utilisation.
- Public policy such as Government incentives, and loan guarantees will be needed to encourage development of optimised networks. In particular, Government support in first years when capacity is ramping up will be important for commercial viability

CO_2 pipeline projects, if they can be reduced in terms of carbon price risks, will become the same in terms of risks as any other oil & gas pipeline project. However, currently banks and financial institutions view such projects as having greater regulatory and market (carbon price) risks than oil and gas pipeline projects.

The audience asked several questions concerning the Trust Fund option, the Lieberman-Warner Bill that was being put forward and the political feasibility of the proposals. The panel responded that leadership has to come from countries that can implement CCS. The sooner CCS can be deployed and come down the learning curve it is likely the costs will come down as did with other technologies such as SO_2 control and NO_x control.

Tom Kerr from the International Energy Agency (IEA) discussed the recently launched CCS International Regulatory Network on 13-14 May, 2008 and outlined what the IEA was doing in other areas of CCS including high-level recommendations for consideration at the G8 summit in Tokyo in June 2008.

Day Two Sessions and Discussion

Session four began with Preston Chiaro from Rio Tinto Energy present on the Hydrogen Energy Abu Dhabi project and Carson project. He explained that the Hydrogen Energy Company is jointly owned by BP and Rio Tinto and was established to supply low carbon hydrogen fuel to the power sector by using fossil fuels and carbon capture and storage. The Abu Dhabi project could be operational by 2012 and will sequester 1.7Mt CO_2 with EOR as the main economic driver. The Carson project has actually been relocated to Bakersfield in California. Both projects aim to generate hydrogen for power and other uses and to use the CO_2 for EOR.

Anthony Tarr, the CEO from the Zerogen project in Australia, stated that with their ratification of the Kyoto Protocol, the Australian government also created a large clean coal technology fund. He went on to describe the Zerogen project in Queensland that will use IGCC and CCS with aims to complete the feasibility study in 2009 and have an 82MW plant operational by 2012 and a 400MW plant operational by 2017. The storage component will be in a saline aquifer with a goal of 75% - 90% CO_2 capture.

Bruce Braine from American Electric Power (AEP) discussed their activities on CCS including a project in New Haven, West Virginia which will be the first CCS demonstration plant for AEP using chilled ammonia for CO_2 capture. AEP sees technology development and deployment as a critical issue. AEP is focusing on IGCC and ultra supercritical (USC) technologies with AEP first to announce two 600MW IGCC commercial scale plants. A new generation plant using ultra supercritical steam conditions is being built in Arkansas for the first time in the USA with a temperature above 1100F. AEP is looking at all capture techniques.

Gary Loop from Dakota Gas discussed the Dakota Gasification plant that his company operates and which supplies CO_2 to the Weyburn CO_2EOR project. These projects combine to form the largest capture and storage project in the world. 14 gasifiers operate to produce synthetic natural gas (SNG) or methane capturing 4.5 million tonnes of CO_2 and deliver 3 million tonnes of CO_2 per year for EOR operations in the Northern USA and Canada. To date, in Weyburn, Saskatchewan 13 million tonnes have been injected. The capture process costs in US$8 per tonne of CO_2 (capital US$4, O&M US$4). To provide incentives for CCS a tax credit of $15/ton CO_2 can stimulate sites to prove evolving technologies. A 30% investment tax credit for demonstration plant can stimulate sites as well.

Several questions were asked about the use of EOR. EOR can improve the amount of oil that can be recovered and with oil at $130 barrel it makes EOR even more economically viable. EOR has positive revenue but other options need US$20-30. Preston Chiaro pointed out these projects are long term investments and no one knows whether the price of oil will remain high. In addition, if CCS takes off then there will be a lot of CO_2 and thus high demand and a high CO_2 price may not be sustained for a long period.

Session five was a panel discussion on insurance and liability concerning CCS projects. The panel was moderated by Arthur Lee, Principal Advisor, Environment and Climate Change, Chevron Corporation. A presentation on risk and liability was given by Chiara Trabucchi a Principal at Industrial Economics. The Panel also included: Lindene Patton, Chief Climate Product Officer, Zurich Financial Services, Rick Hawkinberry, Senior Vice President, Willis Environmental Practice and Adrienne Atwell, Senior Vice President, Swiss Reinsurance America Corporation. Several questions were addressed in the session and they were:

What are the risks? What risks are insurable?

Adrienne Atwell discussed this from a life cycle viewpoint starting at the site selection then went on to the different phases such as operation, contamination by leakage, local environment damage and raised the link between surface leakage and removal of carbon credits and who is liable to make up any shortfall from a loss of containment. At the other end of the life-cycle is the post-closure phase and the risk of quantification or how much has been stored and who is liable in the long term. All the risks are insurable up to the post closure stage. Rick Hawkinberry added that there are several types of existing insurance to cover many aspects of the life cycle. However, the post-closure phase is the complicated issue as there is little actuarial data available currently to assess this risk. Adrienne Atwell said that the insurance industry needs to understand what you are insuring and what the risks are to be able to determine what is then insurable?

What does the insurance industry need in order to formulate insurance products for CCS projects?

Lindene Patton said that companies need to determine what business model is in play and whether it will be the utilities responsible for most of the project or whether parts will be sub contracted. The business model determines who bears the risk and what sort of risk is being structured. So every time a new party is inserted there is further contractual risk. It is insurable, but there are public policy decisions that will decide on how this will be managed. In terms of the Lieberman-Warner bill the insurance sector will send a price signals when the final structure is in place. The question to address is how to get projects off the ground and once completed what happens with the future liability?

What kind of policy environment is needed to develop these insurance products?

There is currently a lack of regulatory framework in the USA and this will influence the development and design of insurance products. Because of a lack of actuarial data, this type of insurance for CCS technology is specialty coverage. This could in the USA create anti-trust issues as there may only be a limited number of insurance companies willing to cover the risk. There is also the issue that company will not provide insurance, is it worth proceeding? A further issue is that if the Government meets any long term liability issues price it would send the wrong investment signals to companies investing in CCS as there would be no risk to them. The Panel pointed out this is the wrong message to send to companies as it creates a false sense of security and courts may overturn this at a future date.

The final session of the day covered investment in CCS. Ross Willims, Chairman of the Australian Coal Association Low Emissions Technology Ltd (ACALET) spoke about the CCS activities that the Australian Coal Association undertakes in Australia. This work programme is called the Coal21 action plan with support from a voluntary fund provide from a levy on Australian coal production. It is estimated that the levy will over 10 years raise around A$1 billion.

There are several projects being supported by the fund involving oxy-fuel research, IGCC Zerogen, PCC-CSIRO post combustion capture project and the Otway project by CO2CRC as well as regional storage assessments in Queensland and New South Wales. There are several key elements for success that include a robust political framework with support, effective collaboration, clear goal to aim for a commercial plant, financial incentives including emissions trading and supporting regulation. In Australia CCS is moving forward on clean coal technologies but it is just the beginning and decades of work will be needed.

Mark Taylor from New Energy Finance started by highlighting that there are 65 CCS projects announced worldwide with total costs exceeding $42 billion and they could, by 2016, cumulatively inject around 67 MtCO_2/yr. This figure represents a 0.25% reduction in annual CO_2 emissions from global fossil fuel usage.

Due to the need to build investor confidence, the first commercial scale plant is likely to be the catalyst to get several built. One commercial scale project would determine the actual cost for a project, contribute to public acceptance, help refine regulatory definitions, help prove technical feasibility and lastly contribute to investor confidence.

Andrew Paterson from Econergy said to finance large scale projects will need more than the carbon market and that the bond market is needed to make progress. In the USA, 15GW of coal plant is under construction, none of which include CCS. There are several challenges still to overcome for CCS in the USA and they are:

1. Retail electricity competition and merchant power mostly failed in the USA, with major bankruptcies and many states remain committed to rate regulation.
2. Consumers do not buy electricity based on price, anyway; it is an essential good – and many utilities mask the signals.
3. New electricity supply is heavily constrained due to natural resource limits (wind, sunlight) and regulations no matter the option.
4. Energy efficiency and demand side management can help, but are not sufficient with growth and cannot replace a lot of "old coal" units.
5. USA regional differences in electricity fuel mix, prices, and access to renewable resources are severe.
6. "Urgent" cap and trade (2012, 2020) in the EU is a mixed bag: emissions are not lower, and other measures (feed-in tariffs, regulations, direct subsidies, local tax policy) are in the mix.

7. Because of a huge USA budget deficit and national debt, federal fiscal options are limited and need risk-based incentives.

The key financial market for CCS is the bond market in the USA which is around US$30 trillion and which annually issues US$6-7 trillion in new bonds of which US$80-100 billion is for power providers. With dependence in the USA on coal-based electricity (50% of supply), CCS is vital to reducing carbon emissions. It is also clear that CCS is not economic and subsidies will be needed for the first plants. Finally, financing is the key and ultimately without financing there will be no CCS deployment.

A question was asked on what length of time would there needed for bond markets to fund CCS projects? Andrew Paterson responded that it will depend on how much it will cost the consumers. A longer term cap up to 2040 would engage the bond market but also have a very long term pathway.

Conclusions

Preston Chiaro the Chairman thanked the speakers and the World Coal Institute, IEA CCC and IEA GHG for organizing the meeting and Chevron for sponsoring. He said it was interesting to see how the discussion had matured since the meeting in London last year. It is important to recognize that there has been progress, but a lot is still needed to establish CCS projects built in terms of regulations, insurance and practical experience in stakeholders operating CCS plants.

It is also important to note that while there has been considerable work and interest in CCS. There are also a lot of players ready to move forward but there is a need for urgency and direction from Governments. Policy and regulatory regimes are still uncertain and CCS is largely unknown to policy analysts, planners, politicians, the general public and this is something that will need to be addressed. In particular, Governments will need to provide financial support for the first CCS projects.

In order to move forward Governments will also need to have robust CCS policies that provide certainty to investors and allow for the deployment of CCS projects. We need to keep our options open and not to select a winner as we do not know what will be the final answer.

New York Skyline

2nd Expert Meeting on Financing CO_2 Capture and Storage Projects

28th-29th May 2008

New York, USA

Organised by

IEA Greenhouse Gas R&D Programme
IEA Clean Coal Centre
World Coal Institute

Sponsored by
Chevron

28th May 2008 Day 1

08.30 Registration opens

Session 1: The Worldwide Status of CCS: Chair Preston Chiaro, Chief Executive Energy and Minerals, Rio Tinto Energy and Chairman, World Coal Institute

09.00 to 09.15 Welcome by Barbara McKee, Director, Office of Clean Energy Collaboration, US DOE

09.15 to 09.35 Opening Address: The Status of CCS Internationally and Issues surrounding CCS Projects: Kelly Thambimuthu, Chairman of IEA GHG R&D Programme

09.35 to 09.55 WRI Perspectives on CCS: Jonathan Pershing, World Resource Institute

09.55 to 10.10 Question and Answer: Chaired by Preston Chiaro

10.10 to 10.30 Break

Session 2: National and Regional Initiatives: Chair Barbara McKee, Director of Clean Energy, US DOE

Questions to address: What is driving National Governments with CCS? Are there lessons to apply from Europe to North America and vice versa

10.30 to 10.50 The Role, Status and Financing of CCS as a Mitigation Option in the United States: Tom Wilson, Senior Technical Leader, Electric Power Research Institute

10.50 to 11.10 Canadian Perspective on Financing CCS: Eric Beynon, ICO2N Group

11.10 to 11.30 The IOGCC Guidelines on Permitting CCS: Lawrence Bengal, IOGCC

11.30 to 11.50 CCS Projects in Europe and the Issue of Finance: Kai Tullius, Project Officer, European Commission

11.50 to 12.30 Panel Discussion by Speakers: Chaired by Barbara McKee

12.30 to 14.00 Lunch Sponsored by Chevron

Session 3: Financial Industry and CCS: Chair Milton Catelin, Chief Executive, World Coal Institute

Questions to Address: What financial options are available for CCS projects? Have any banks provided finance for CCS projects?

14.00 to 14.20 How Investors Look at CCS: Marc Levinson, JP Morgan Chase

14.20 to 14.40 Will Future Carbon Prices Make CCS a Viable Mitigation Option, and what are the Key Factors Going into Answering this Question?: Mark Trexler, Director, Ecosecurities Global Consulting Services.

14.40 to 15.00 A Trust Fund Approach for Accelerating the Demonstration and Adoption of CCS: Edward Rubin, Director, Center for Energy and Environmental Studies, Carnegie Mellon

15.00 to 15.20 Break

15.20 to 15.40 Treatment of CCS in emissions trading schemes - methodological issues Robert Sussman, Senior Fellow, Centre for American Progress

15.40 to 16.00 Financing CO_2 Infrastructure: Paul Zakkour, Principal Consultant, ERM

16.00 to 17.20 Panel Discussion: Chair Milton Catelin

17.20 to 17.30 CCS Regulatory Issues: Tom Kerr, IEA

Close Day 1

18.30 Reception and Dinner in the Gramercy Park room of the New Yorker Sponsored by WCI

29th May 2007 Day 2

Session 4: Project Developers and CCS: Chair John Topper, Managing Director, EPL
Questions to address: What Financial Incentives do Project Developers Need to Accelerate CCS projects? How is the US Developing CCS Projects? What Lessons have been Learnt from CCS project Developing thus far?

08.30 to 08.50 Abu Dhabi and Carson and the Commercial Aspects of Making it Work and What is Needed from Governments: Preston Chiaro, Chief Executive Energy and Minerals, Rio Tinto Energy and Chairman, WCI

08.50 to 09.10 Challenges for Early Movers - The ZeroGen Experience: Anthony Tarr, CEO, ZeroGen

09.10 to 09.30 AEP and CCS: Bruce Braine, AEP

09.30 to 09.50 Ongoing CO_2 Capital and Transport Costs: Gary Loop, Senior VP and Chief Operating Officer, Dakota Gas

09.50 to 10.20 Panel discussion by Speakers: Chair John Topper

10.20 to 10.40 Break

Session 5: Insurance and Liability Related to CCS Projects: Chair Arthur Lee, Principal Advisor, Chevron
Questions to address: Can the insurance industry provide risk options for CCS? What frameworks are currently being used to address liability risks?

10.40 to 10.55 Risk and Liability Overview: Terminology, CCS Uncertainty in Different Parts of the CCS Lifecycle, and Past Industry Experience. Chiara Trabucchi, Principal, Industrial Economics

10.55 to 11.10 Introduction of Panel:
Lindene Patton, Chief Climate Product Officer, Zurich Financial Services
Rick Hawkinberry, Senior Vice President, Willis Environmental Practice
Adrienne Atwell, Senior Vice President, Swiss Reinsurance America Corporation
Chiara Trabucchi, Principal, Industrial Economics

11.10 to 12.30 Panel Discussion of Speakers: Chair Arthur Lee

12.30 to 14.00 Lunch Sponsored by Chevron

Session 6: Investment in CCS: Chair John Gale, General Manager, IEA GHG
Questions to address: What are green investors looking for and how does that fit with CCS?

14.00 to 14.20 Coal Technology Investment Developments and Issues Concerning CCS in Australia Ross Willims, Chairman, Australian Coal Association Low Emissions Technologies Ltd (ACALET)

14.20 to 14.40 The Carbon Principles Initiative, and Raising Capital for Large Energy Projects and How this Relates to CCS: Eric Fornell, JP Morgan Chase

14.40 to 15.00 Investment in CCS: Mark Taylor, Associate, New Energy Finance

15.00 to 15.20 Break

15.20 to 16.15 Panel Discussion: Chair John Gale

16.15 to 16.30 Wrap up: Preston Chiaro

Close

2nd Expert Meeting on Financing CO2 Capture and Storage Projects

28th-29th May 2008, New York, USA

Mr William Ellison	Arch Coal	Mr Andrew Paterson	ECONERGY International
Mr Malcolm Anderson	Southern California Edison	Mrs Lindene Patton	Zurich Financial Services
Ms Adrienne Atwell	Swiss Re Financial Services	Dr Jonathan Pershing	World Resources Institute
Mr Julian Beere	BHP Billiton	Mr Stan Pillay	Anglo Coal
Mr Brendan Beck	IEA Greenhouse Gas R&D Programme	Mrs Alexandrina Platonova-Oquab	The World Bank, Carbon Finance
Mr Lawrence Bengal	Arkansas Oil and Gas Commission	Mr Jeffrey Price	Bluewave Resources, LLC
Mr Eric Beynon	Integrated CO2 Network (ICO2N)	Mr Wishart Robson	Nexen Inc.
Mr Bruce Braine	American Electric Power (AEP)	Dr Edward Rubin	Carnegie Mellon University
Mr Mark Brownstein	Environmental Defense Fund	Mr Mark Saunders	Shell International Ltd
Mr James Bryant	Energy Futures Network Ltd.	Miss Stephanie Saunier	Schlumberger Carbon Services
Mr Benjamin Court	Princeton University CEE dept	Mr Emily Schlect	National Mining Association
Ms Lisa Campbell	Environmental Resources Management	Mr Bruce Schlein	Citigroup
Mr Milton Catelin	World Coal Institiute	Dr Norman Shilling	GE Energy
Mr Preston Chiaro	Rio Tinto plc	Mr Stephens Skip	Joy Global
Mr Kipp Coddington	Alston & Bird LLP	Mr Max Slee	Clinton Foundation
Mr John Eaves	Arch Coal	Mr Andrew Stevenson	National Resource Defense Council
Mr Don Elder	Solid Energy	Mr Bob Stobbs	Canadian Clean Power Coalition
Ms Sarah Eastabrook	Alstom Power Systems	Mr Scott Stone	Hunton & Williams LLP
Mr Darrick Eugene	Texas Carbon Capture and Storage Association	Mr Anthony Tarr	ZeroGen Pty Ltd
Mr Eric Fornell	J.P. Morgan Securities Inc.	Mr Mark Taylor	New Energy Finance
Mr John Gale	IEA Greenhouse Gas R&D Programme	Dr Kelly Thambimuthu	Centre for Low Emission Technology
Mr Michael Hamilton	MIT Energy Initiative	Mr Frank Tierney	AEGIS Insurance Services Inc

Mr Rick Hawkinberry	Willis North America, Environmental Practice	Mr John Topper	IEA Greenhouse Gas R&D Programme
Mr Michael Parker	ExxonMobil Production Company	Ms Chiara Trabucchi	Industrial Economics
Mr David Hunter	IETA	Dr Mark Trexler	EcoSecurities
Mr Tommy Johnson	CONSOL ENERGY INC	Mr Kai Tullius	European Commission
Mr Glenn Kellow	BHP Billiton	Mr John Wallington	Anglo Coal
Mr Thomas Kerr	International Energy Agency	Mr Roger Wicks	Anglo Coal
Mr John Kessels	IEA Clean Coal Centre	Mr Ross Willims	BHP Billiton Mitsubishi Alliance
Mr Peter Lilly	CONSOL ENERGY INC	Ms Sarah Wade	AJW, Inc
Mr Arthur Lee	Chevron Corporation	Mr Luke Warren	World Coal Institute
Mr Marc Levinson	JPMorgan Chase & Co.	Mr Colin Whyte	Xstrata Coal
Mr Gary Loop	Dakota Gasification Comapny	Dr Thomas Wilson	Electric Power Research Institute
Mrs Trina Mallik	The Climate Group	Mr Steve Winberg	CONSOL ENERGY INC
Mrs Ffiona McDonough	Dewey & LeBoeuf LLP	Mr Allen Wright	Coal Association of Canada
Ms Barbara McKee	U.S. Department of Energy	Mr Fernando Zancan	Brazilian Coal Association
Miss Katie Mills	World Coal Institute	Mr Alexandrina Zapantis	Rio Tinto plc
Mr Kraig Naasz	National Mining Association	Mr Muttasif Zaidi	Deutsche Asset Management
Mr Niall O'Dea	Environment Canada	Dr Paul Zakkour	ERM
Mr William Ellison	POWER Magazine	Dr Kourosh Zanganeh	Natural Resources Canada
Mr Thomas Alttmeyer	Arch Coal	Mr Muttasif Zaidi	Deutsche Asset Management
Mr Jim Butcher	Morgan Stanley	Mr Scott Stone	Hunton & Williams LLP

Financing Carbon Capture and Storage: Transforming the World of Energy

Presentation to:
Expert Meeting on
Financing Carbon Capture and Storage

Barbara N. McKee,
Director, Office of Clean Energy Collaboration
US Department of Energy

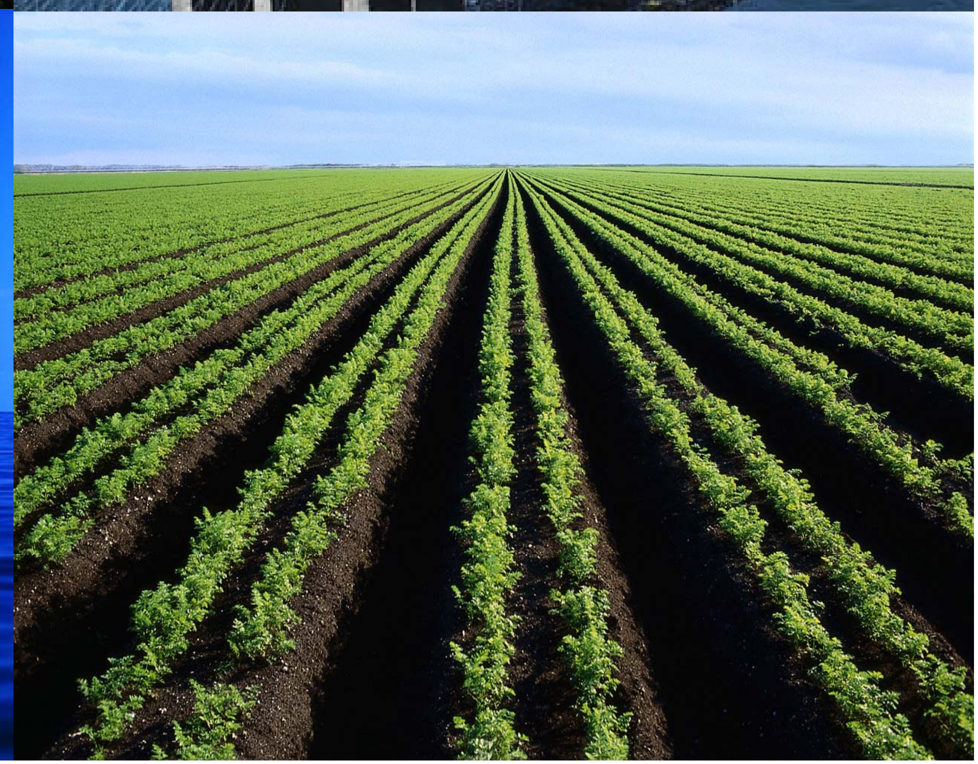
New York, New York
May 28, 2008

The International Energy Agency (IEA)

- The IEA is an autonomous agency linked with the Organization for Economic Cooperation and Development (OECD).
- IEA Objectives:
  - Maintain and improve systems for coping with oil supply disruptions;
  - Promote rational energy policies in a global context;
  - Operate a permanent information system on the international oil market;
  - Improve the world's energy supply and demand structure;
  - Assist in the integration of environmental and energy policies.
- The IEA has 26 Member Countries.
- The work of the IEA is implemented through Standing Groups, Committees and Working Parties composed of member delegates.
- Working Party on Fossil Fuels advises IEA on fossil energy related trends and carries out collaborative activities.

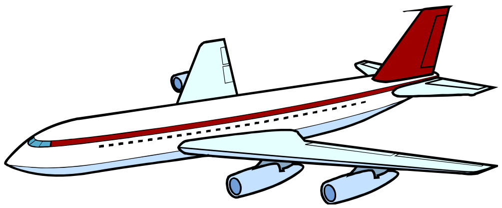
Workshop Sponsors

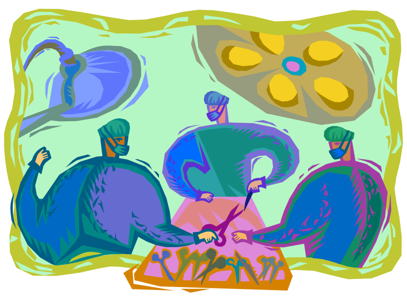


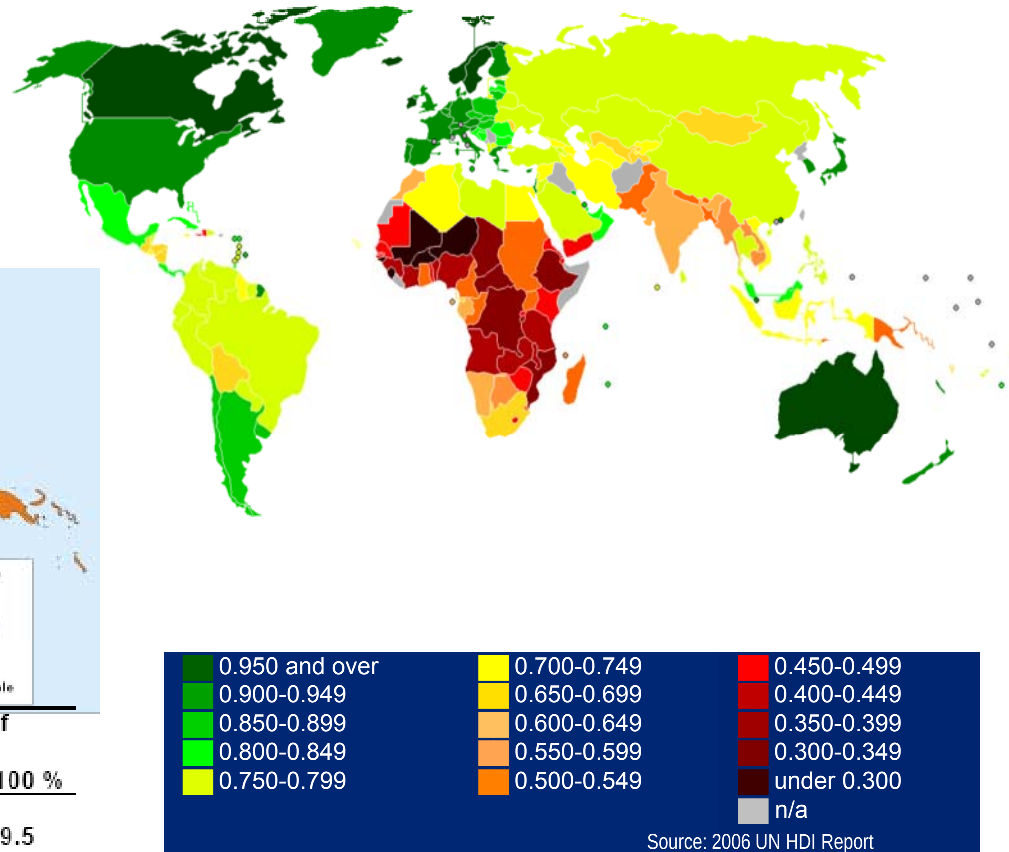
“Failure is not an option.”

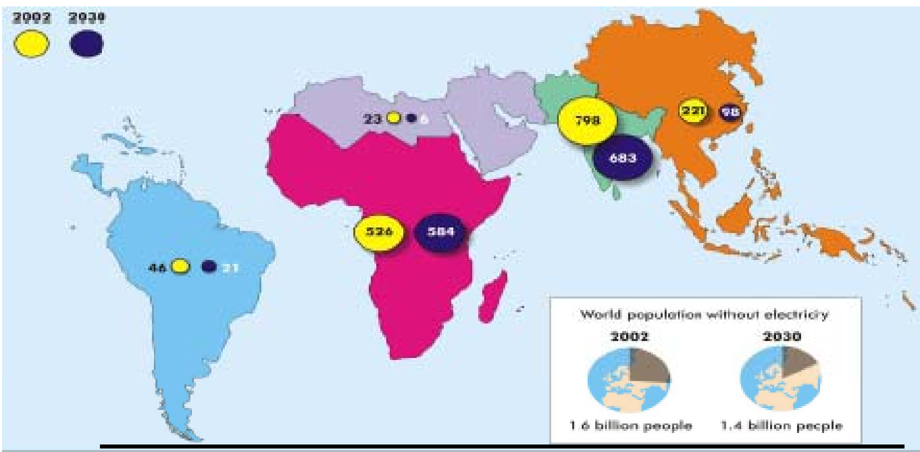
Energy enables modern life.





Without affordable energy, life is difficult.



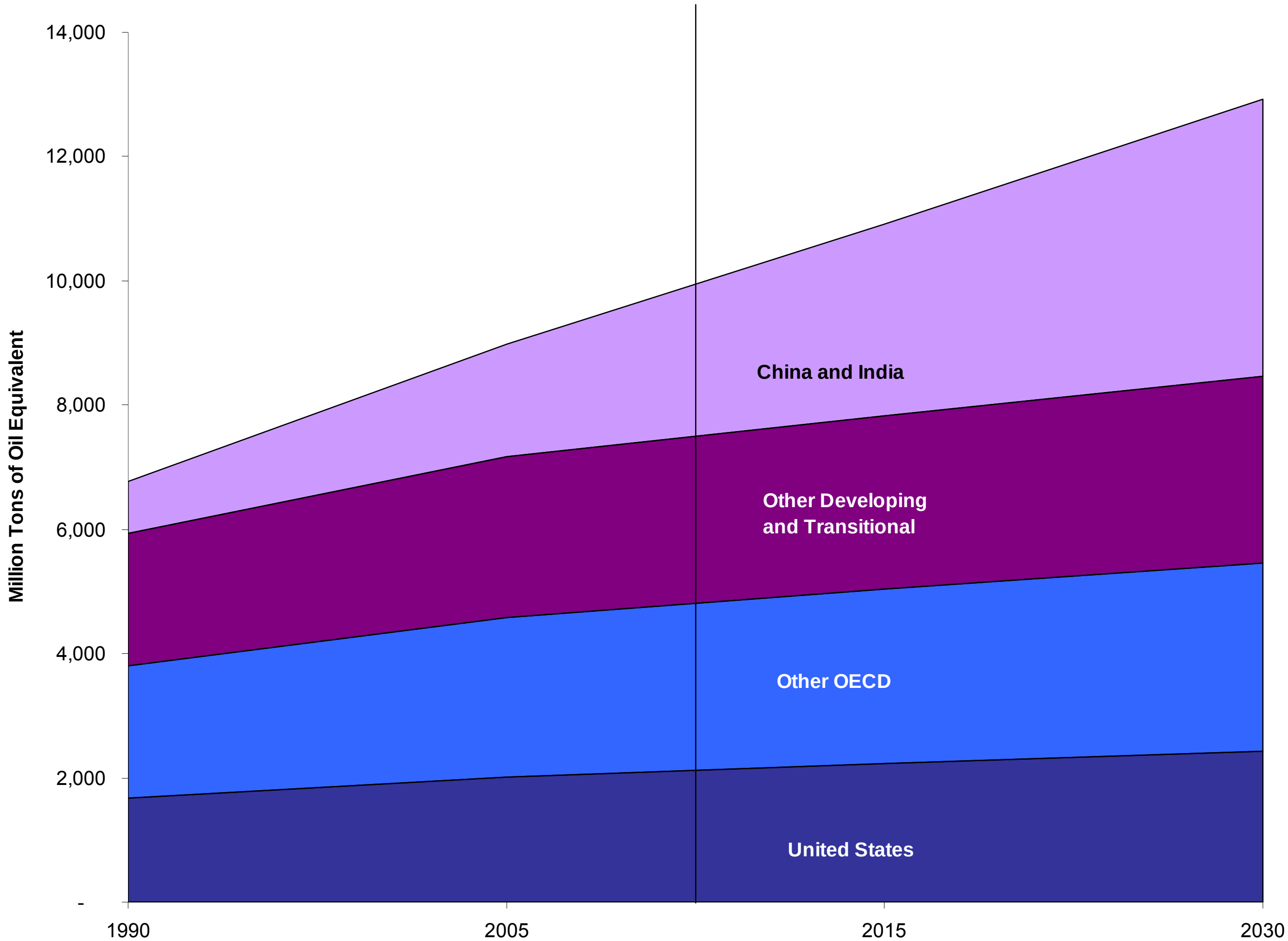


Indicator of Human Welfare	Commercial Share of Total Energy 0-20 %	21-40 %	41-100 %
Life Expectancy (Years)	59.8	69.0	69.5
Probability of not surviving to 40	21.7	9.4	9.1
School Enrollment (%)	52.4	65.4	76.9
Children Underweight (%)	40.9	15.1	11.9
No Access to Clean Water (%)	20.9	22.8	12.8

Source: IEA World Energy Outlook

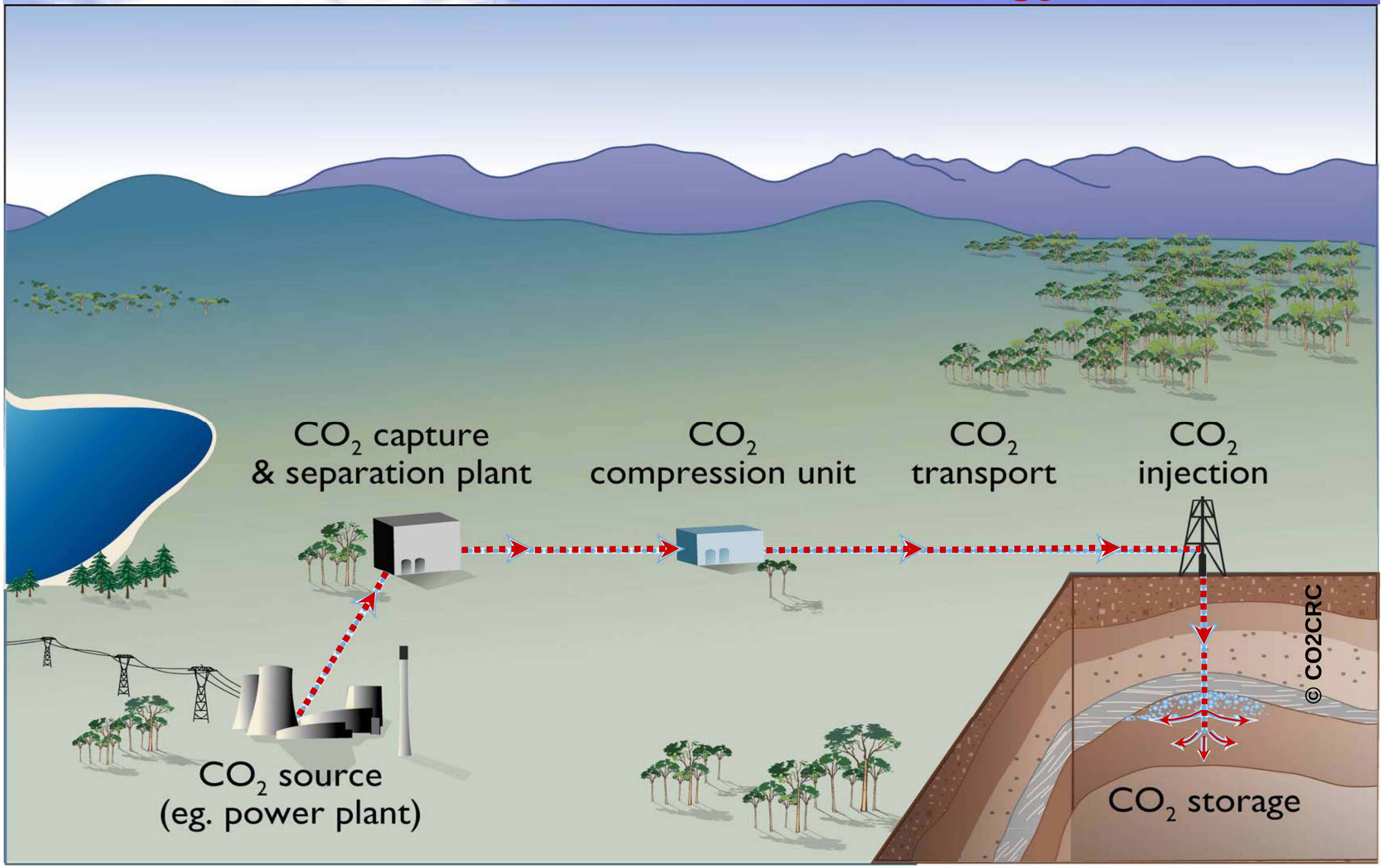
Fossil energy use is expected to grow.

Projected Fossil Energy Consumption (1990-2030)

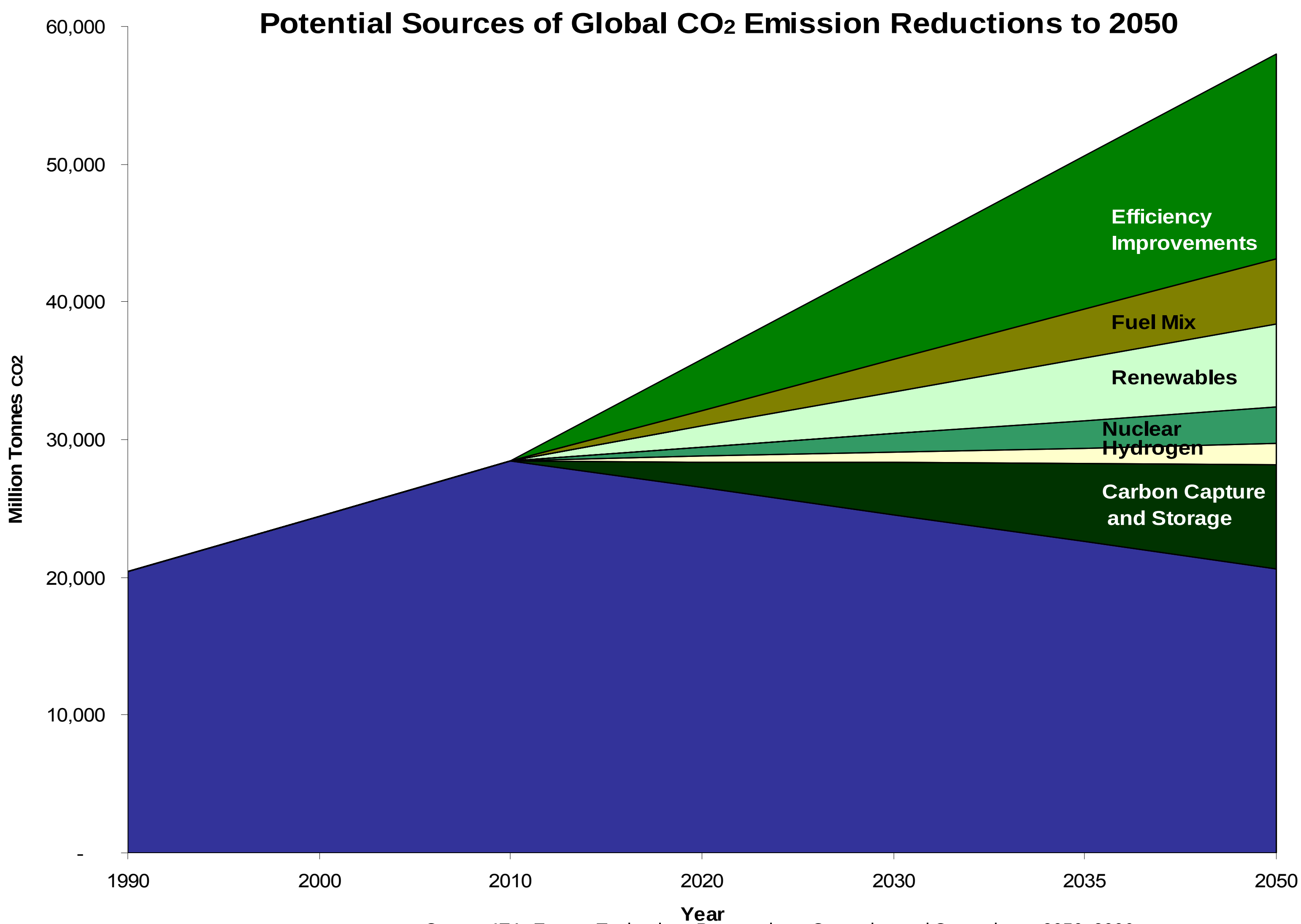


Source: International Energy Agency, World Energy Outlook 2007

Carbon Capture and Storage (CCS): A transformational technology.



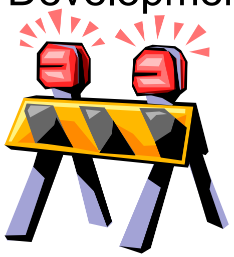
CCS: Critical “wedge” in climate stabilization, affordable energy and energy security.



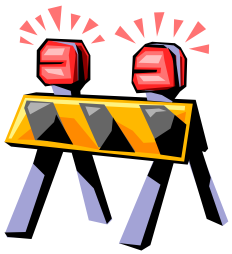
Source: IEA, Energy Technology Perspectives: Scenarios and Strategies to 2050, 2006

Barriers to CCS Deployment

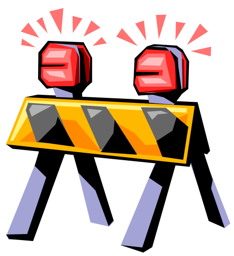
Technology Development



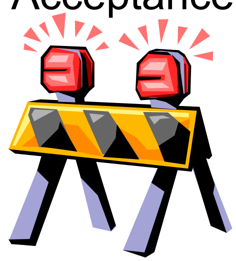
Cost



Legal & Regulatory

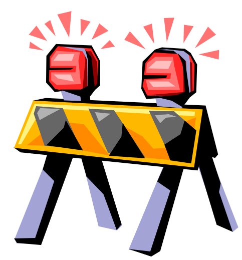


Public Acceptance



International Mechanisms

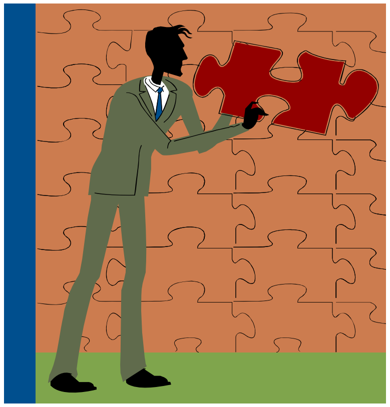
Commercial Financeability



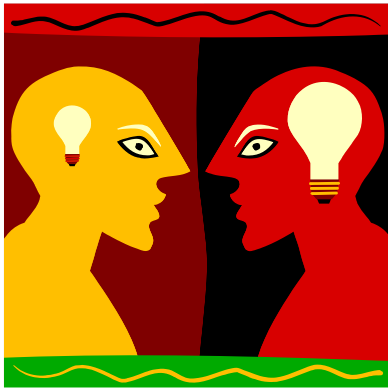
CCS: transformation creates opportunities.

Creating the new technology standard.

Fitting together the the business puzzle.



Executing innovative financing strategies.



The status of CCS and issues surrounding CCS projects

Kelly Thambimuthu
Chairman
IEA Greenhouse Gas R&D Programme

Financing CCS - May 28th 2008

Overview

- IEA Greenhouse Gas R&D Program
- Energy Demand and Global Warming
- Fossil Fuel Consumption and Carbon Lock-in
- CCS, its Role and Technology Status
- CCS Policy and Regulation
- Current and Future CCS Projects
- Next Steps in Financing CCS

IEA Greenhouse Gas R&D Programme

- A collaborative research programme involving governments, industry and other bodies founded in 1991
- Aim is to:

  Provide members with information on the role that technology can play in reducing greenhouse gas emissions.

- Funding approximately $2.5 million/year.
- Activities:- technical studies (>100), international research networks , facilitating and focussing R&D and demonstration activities
- Producing information that is:
  - Objective, trustworthy, independent
  - Policy relevant but NOT policy prescriptive
  - Reviewed by external Expert Reviewers
  - Subject to review of policy implications by members

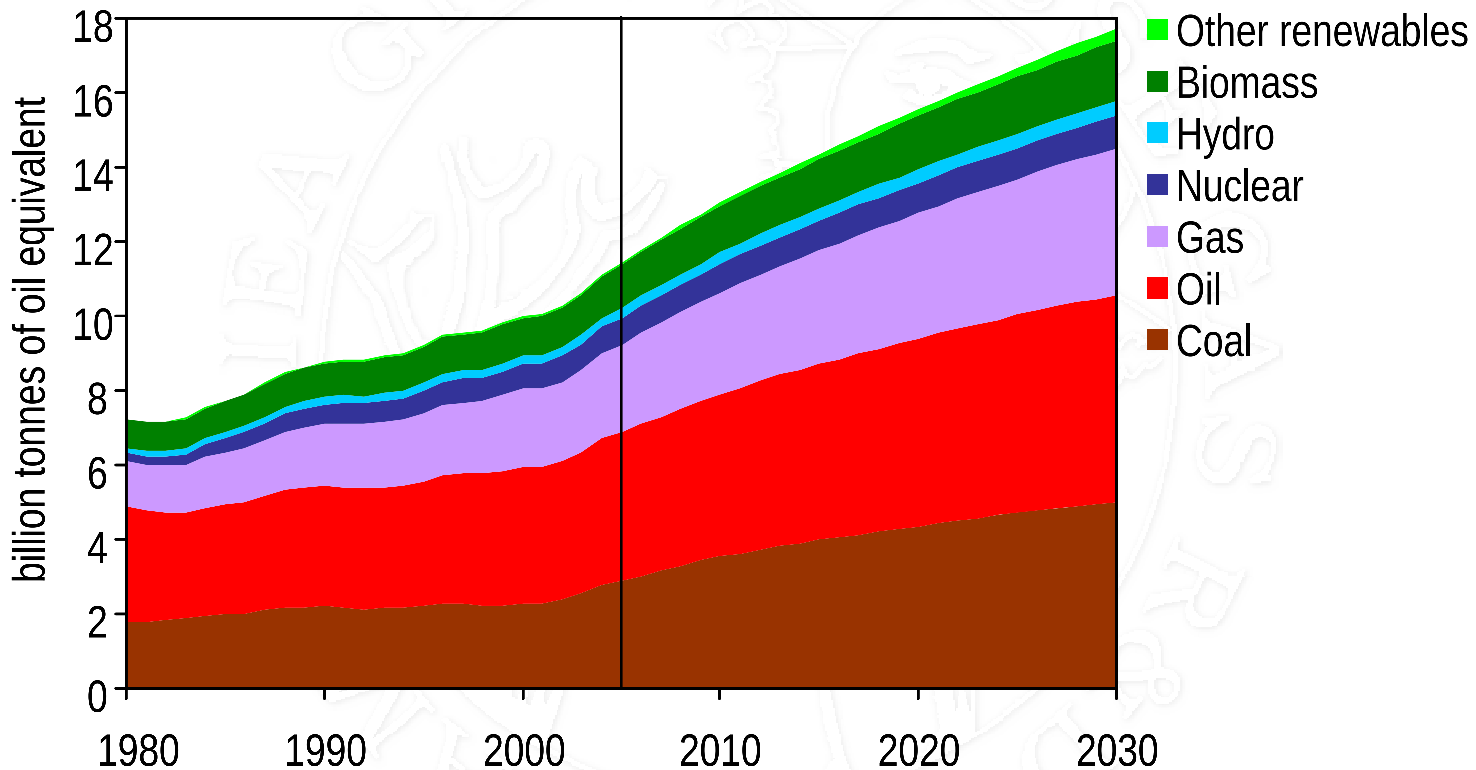
IEA Greenhouse Gas R&D Programme

OPEC Organization of the Petroleum Exporting Countries

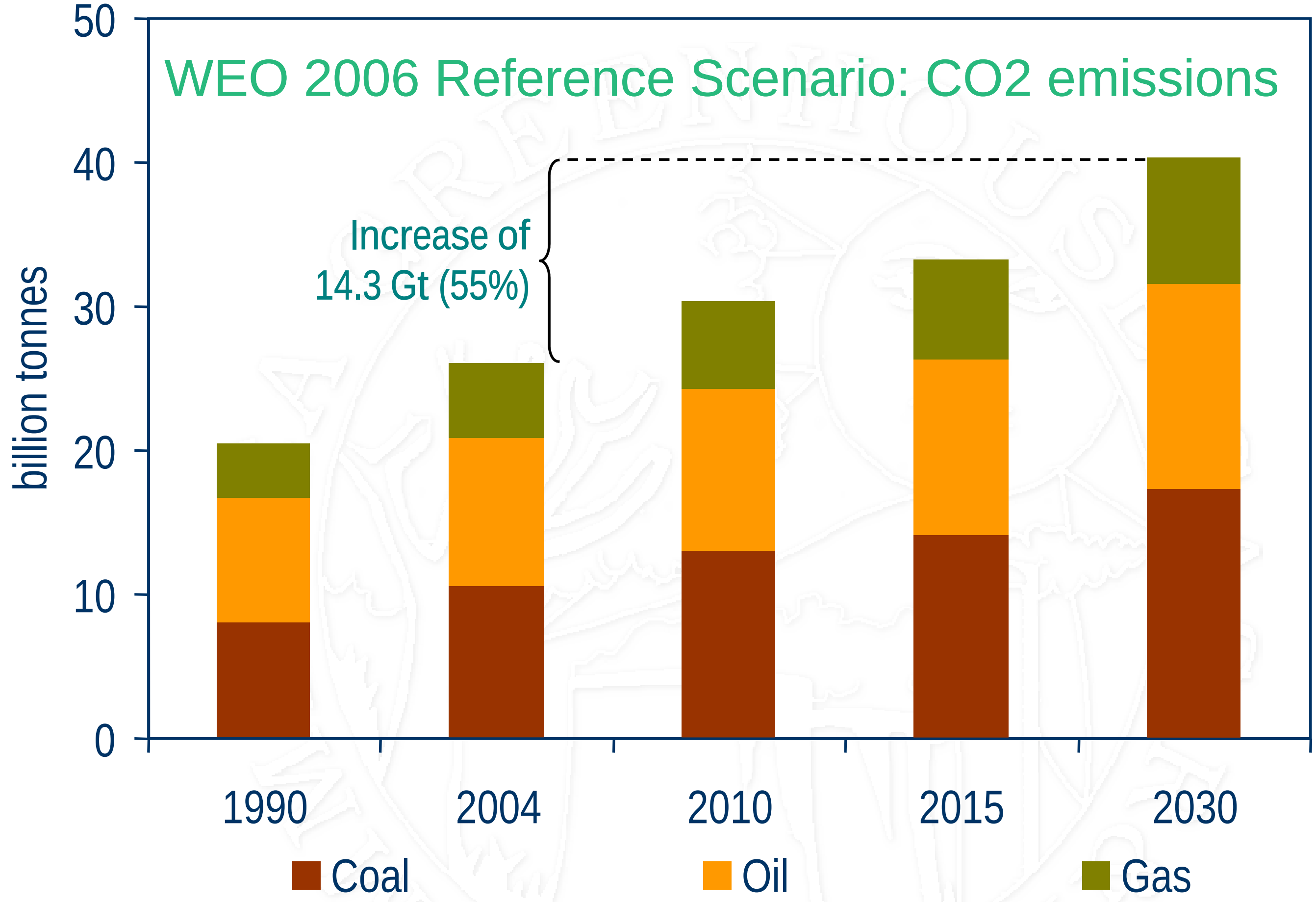
ALSTOM
B&W
BG GROUP
bp
CEZ GROUP
Chevron
ConocoPhillips
EniTecnologie
e·on
EPRI
ExxonMobil
REPSOL YPF
RWE
Schlumberger
Statkraft
STATOIL
TOTAL
VATTENFALL

www.ieagreen.org.uk

WEO 2007 Reference Scenario: World Primary Energy Demand

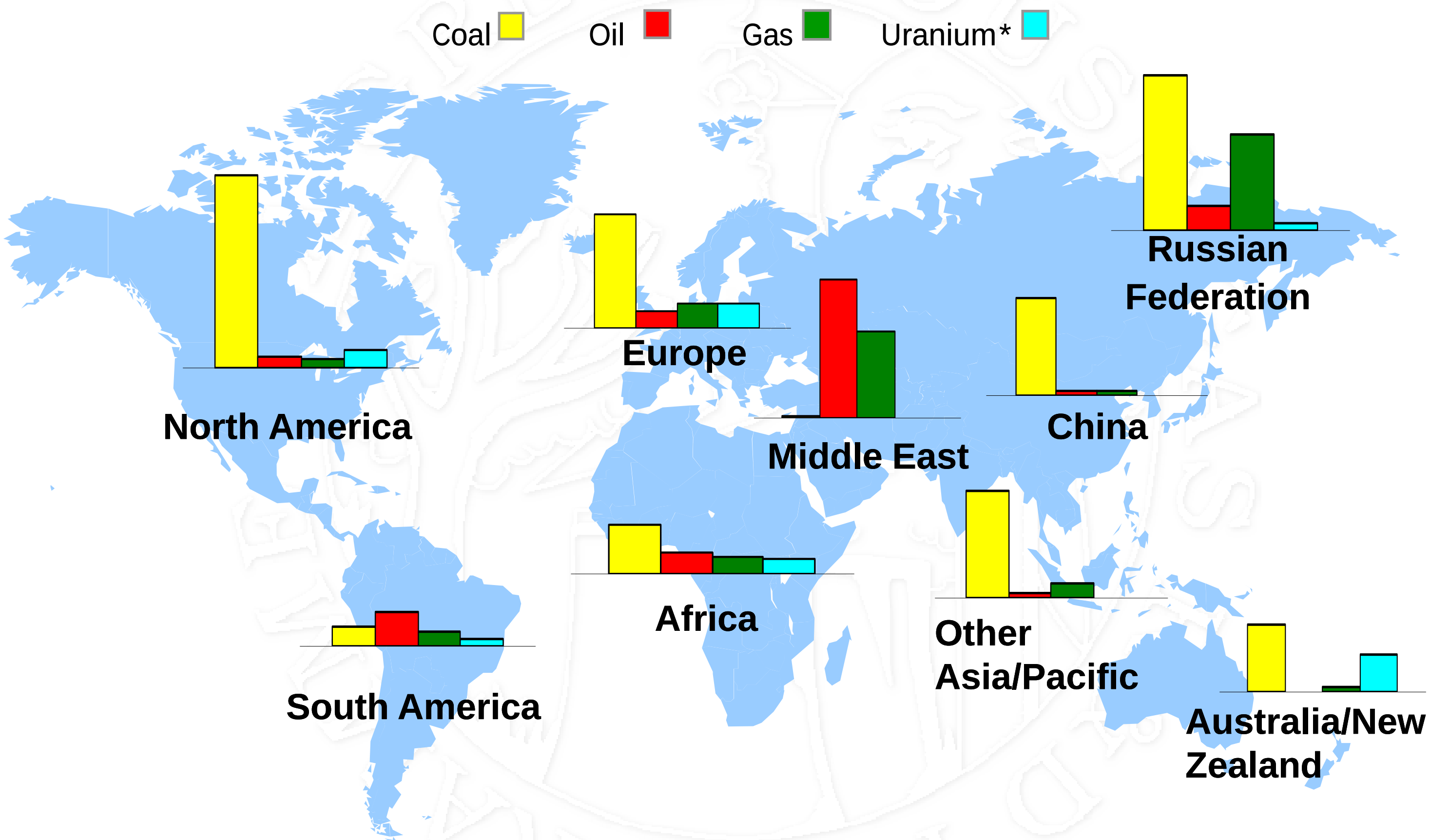


Global demand grows by more than half over the next quarter of a century, with coal use rising most in absolute terms



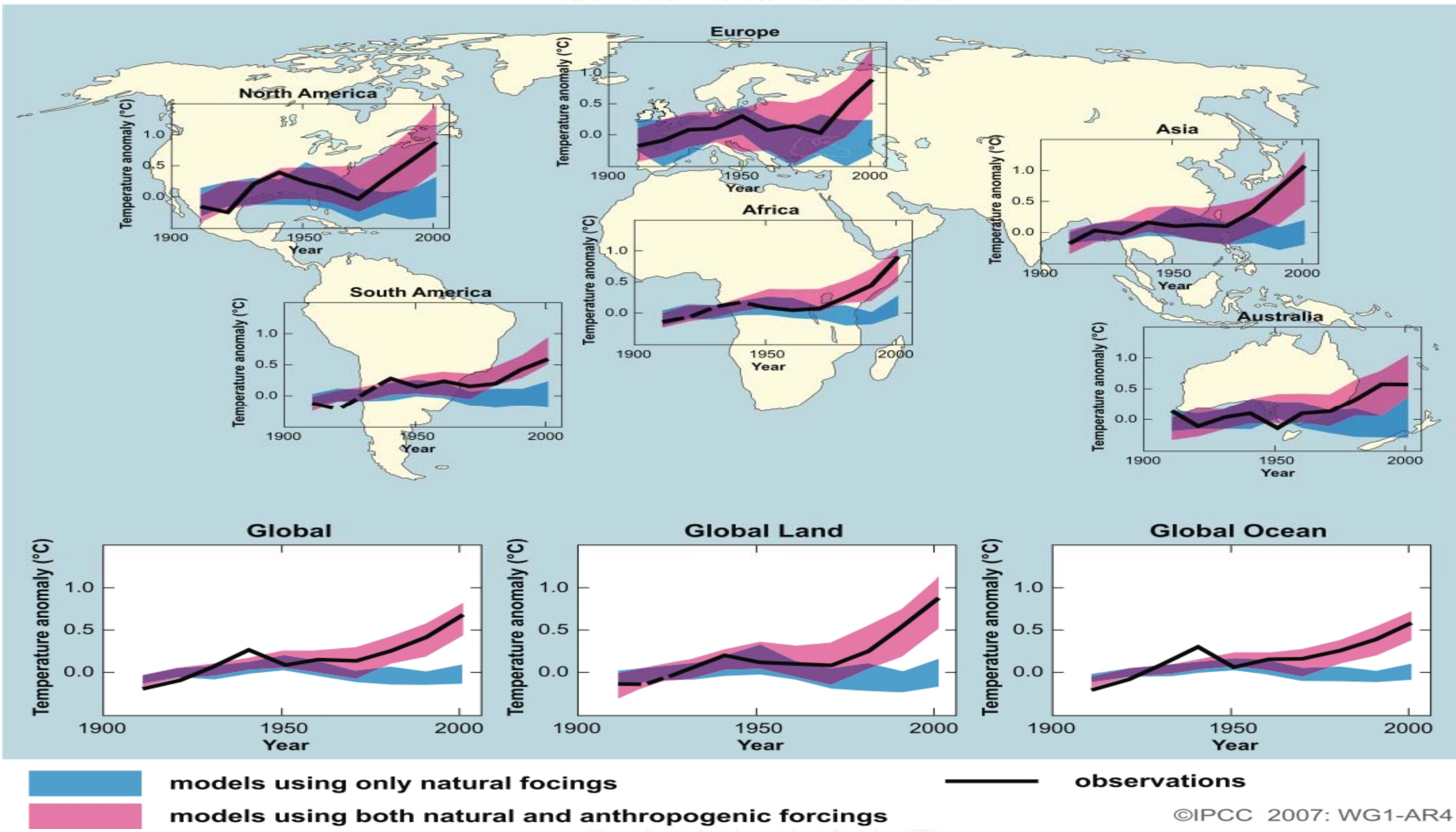
Half of the projected increase in emissions comes from new power stations, mainly using coal & mainly located in China & India

How much energy is left in the world?



Sources: BP Statistical Review 2005; WEC Survey of Energy Resources 2001; Reasonably Assured Sources plus inferred resources to US$80/kg U 1/1/03 from OECD NEA & IAEA Uranium 2003; Resources, Production & Demand updated 2005; *energy equivalence of uranium assumed to be ~20,000 times that of coal

Global warming



Predicted Future Global Warming

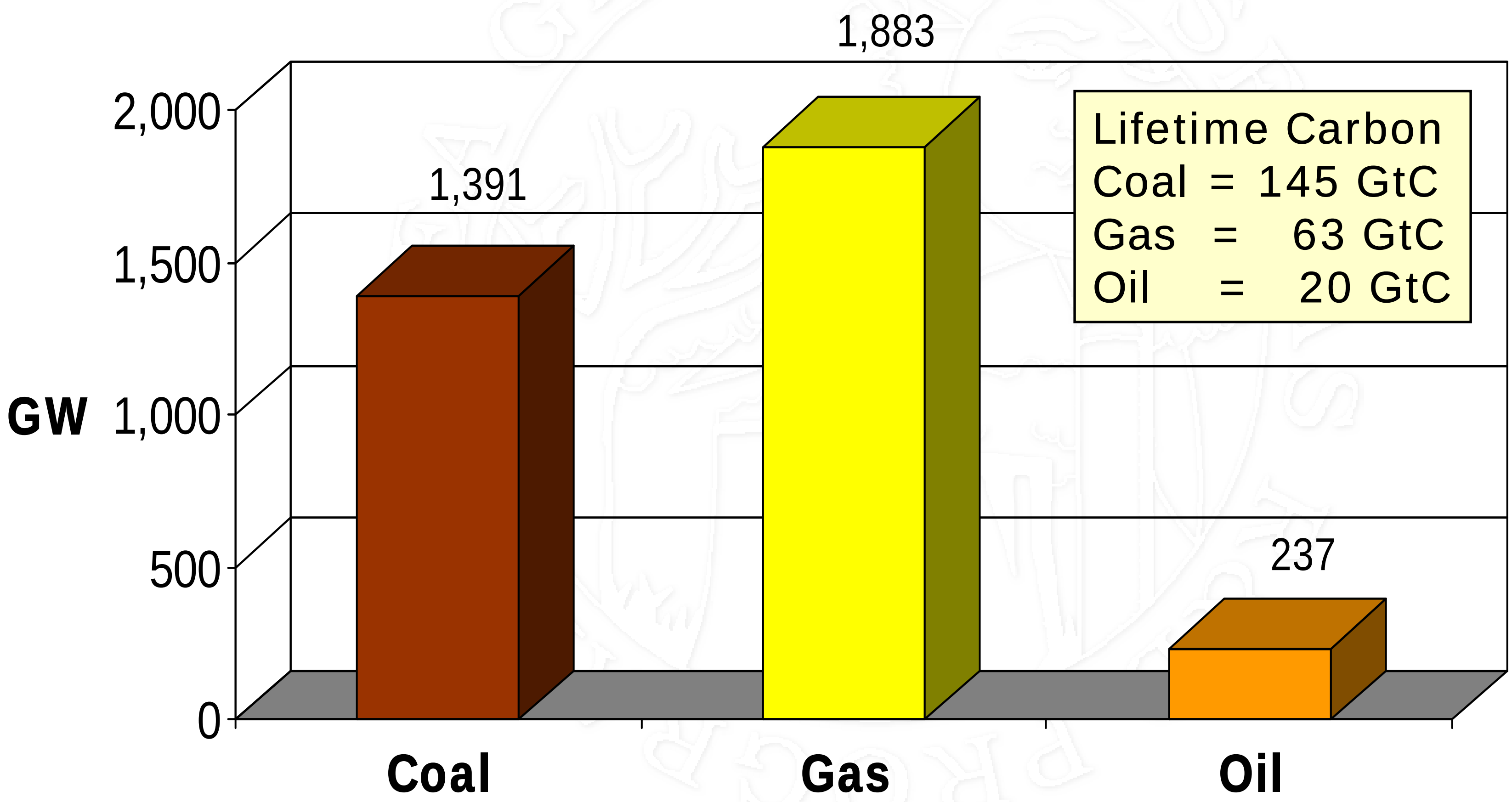
Characteristics of stabilization scenarios

Stabilization level (ppm CO_2-eq)	Global mean temp. increase at equilibrium (ºC)	Year CO_2 needs to peak	Year CO_2 emissions back at 2000 level	Reduction in 2050 CO_2 emissions compared to 2000
445 – 490	2.0 – 2.4	2000 - 2015	2000- 2030	-85 to -50
490 – 535	2.4 – 2.8	2000 - 2020	2000- 2040	-60 to -30
535 – 590	2.8 – 3.2	2010 - 2030	2020- 2060	-30 to +5
590 – 710	3.2 – 4.0	2020 - 2060	2050- 2100	+10 to +60
710 – 855	4.0 – 4.9	2050 - 2080		+25 to +85
855 – 1130	4.9 – 6.1	2060 - 2090		+90 to +140

- Mitigation efforts over the next 2-3 decades will have a large impact on opportunities to achieve lower stabilization levels

Source: IPCC 2007

Carbon Lock-in - New and replacement fossil fueled power plants 2003-2030



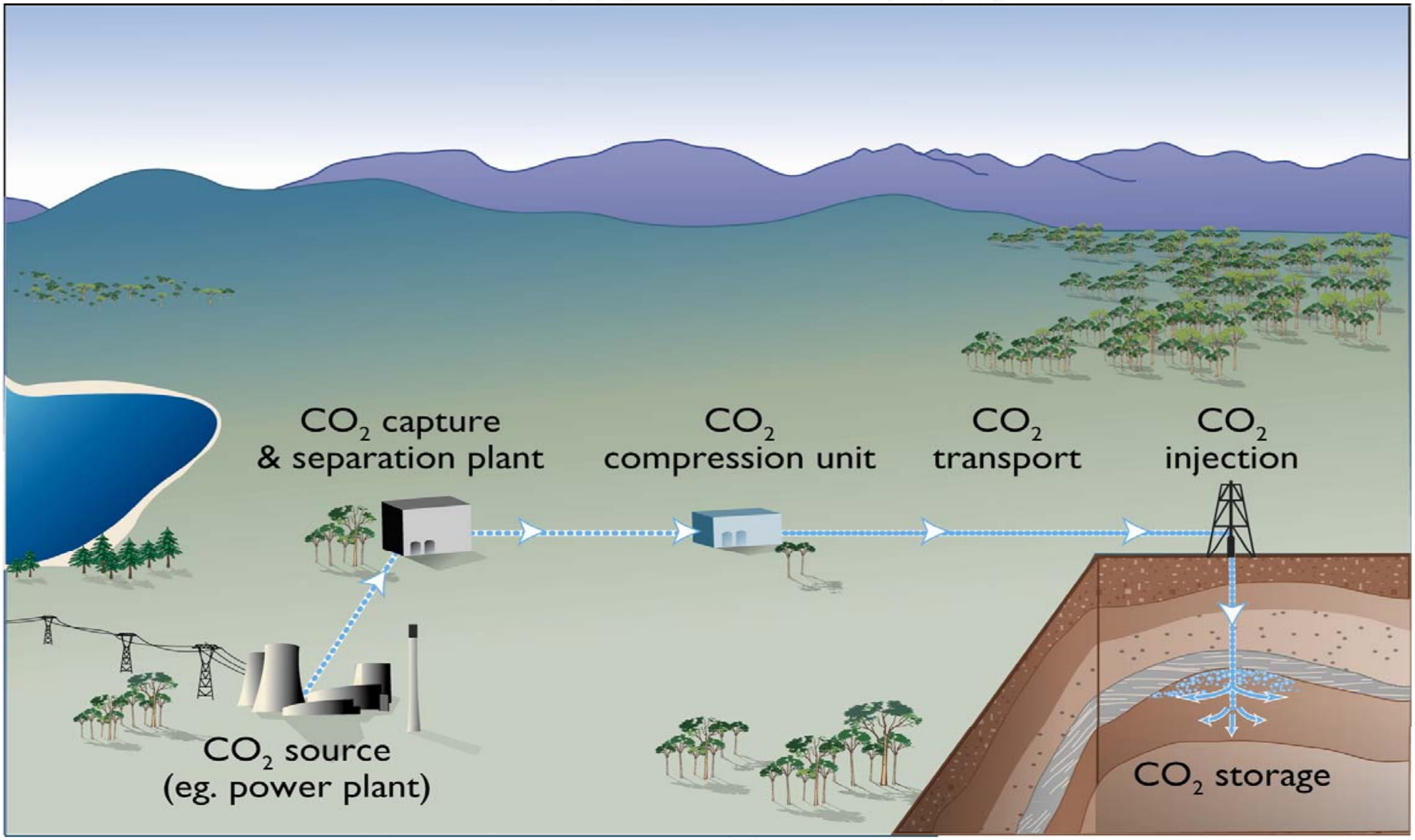
World Energy Outlook 2007 summary

- Global energy system is on an *increasingly* unsustainable path
- China and India are transforming the global energy system by their sheer size
- Challenge for *all* countries is to achieve transition to a more secure, lower carbon energy system
- New policies now under consideration could make a major contribution

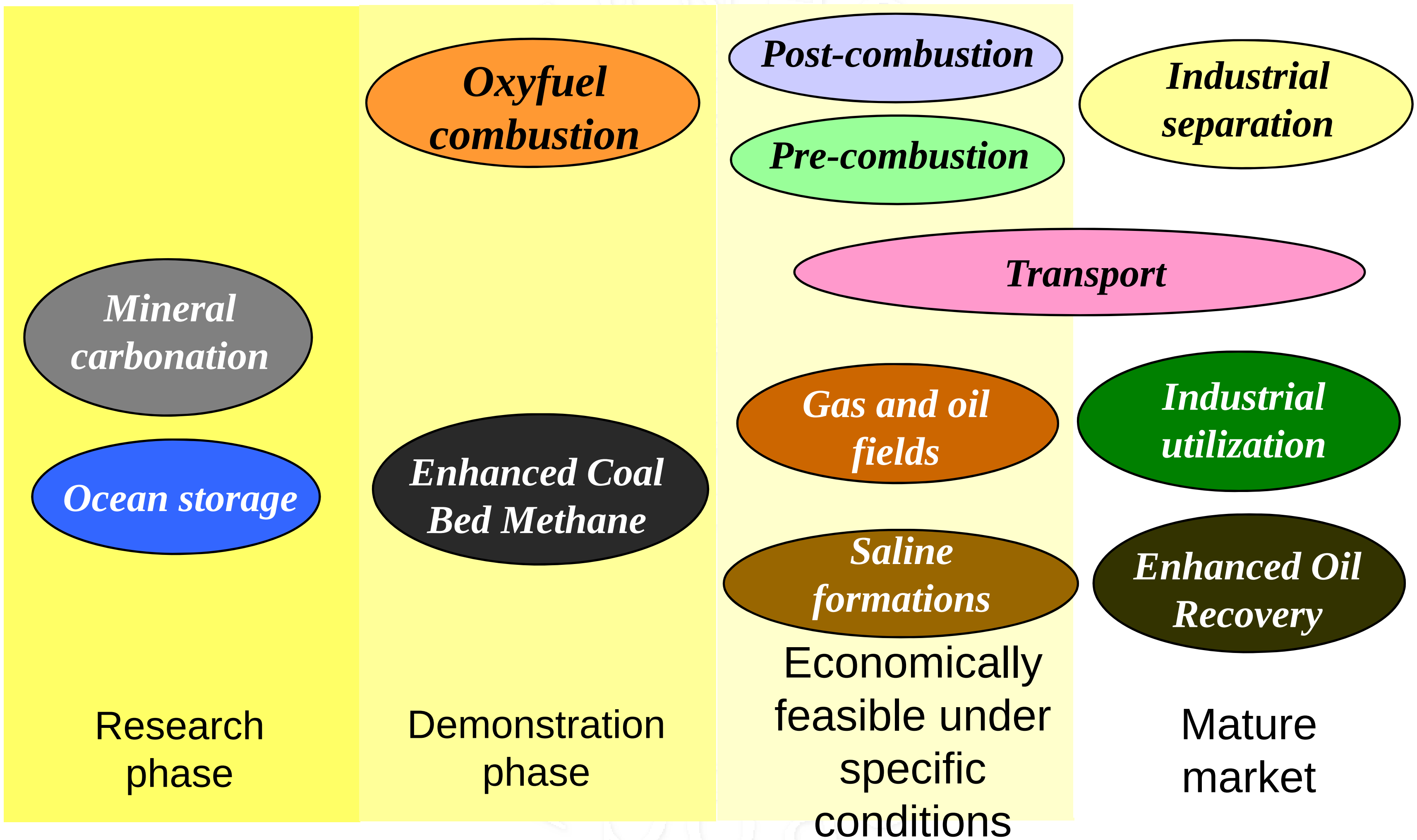
Next 10 years are critical

  - The pace of capacity additions will be most rapid
  - Technology will be "locked-in" for decades
  - Growing tightness in oil & gas markets

CCS technology components

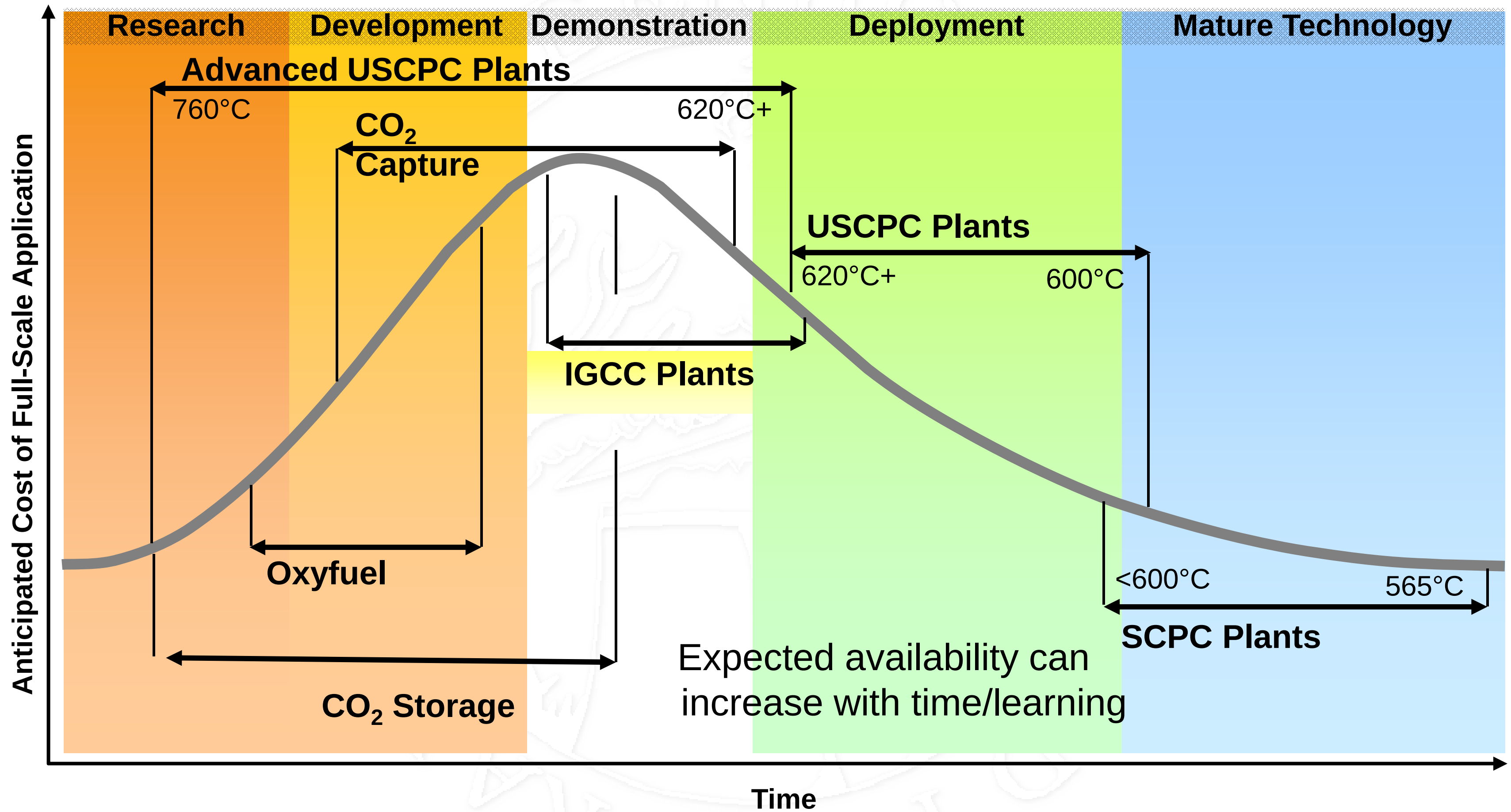


Maturity of CCS technology



IPCC CCS 2005

CCS in coal-fired power generation



Not all technologies at the same level of maturity.

After EPRI and others

Role of CCS in climate change mitigation

- IPCC Special Report (2005) – CCS contributing between **15-55%** of CO2 mitigation to 2100 and reduces mitigation costs by >30%
- IEA Technology Perspectives (2006) – CCS **20-28%** of mitigation to 2050. Second only to energy efficiency.
- Stern Report (2006) – CCS ~**10%** mitigation by 2025, ~**20%** by 2050. Marginal mitigation costs without CCS increase by ~60%.
- EC (2008) – Cost of meeting climate change commitments to 2030 will be 40% higher if CCS is not included.

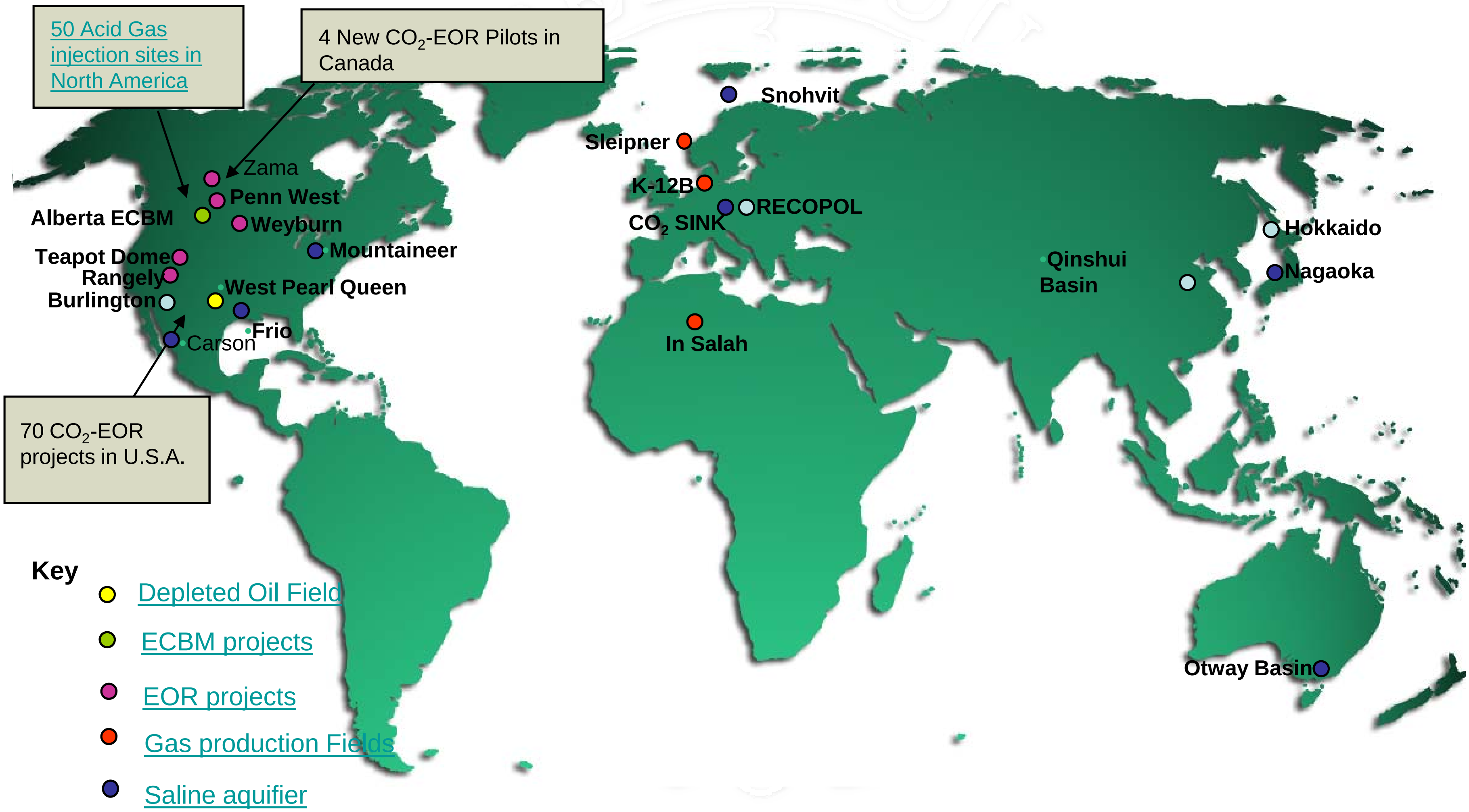
International Policy Developments

- International acceptance of CCS was seen as a major barrier to CCS deployment 2 years ago
- Situation has changed significantly in the last year
- Main International Environmental Treaty is the Kyoto Protocol
  - CCS accepted as a mitigation option in 2007
- Key International Marine Treaties, London Convention/OSPAR adopted amendments to allow CCS in sub sea geological structures
- EU Emissions Trading Scheme permits CCS with full acceptance planned from 2013

Development of CCS regulations

- USA – Existing Underground Injection Control programme for ground water protection adapted for pilot projects
  - Interstate Oil and Gas Compact Commission has developed recommendations for regulations for CO_2 storage at a State Level
  - USEPA are developing Federal level regulations for CO_2 storage
- Australia
  - Adapting Federal oil and gas laws, draft regulations for comment
  - State of Victoria has a consultation document for CCS, considering regulations
  - Queensland considering regulations
- Canada
  - Canada – acid gas injection and CO2-EOR already permitted in states like Alberta
  - Federal Task Force developing CCS regulations
- Japan
  - Adapted marine laws but has no oil and gas laws to adopt for CCS
- Most existing laws cover; permitting, construction, operational and abandonment phases but NOT post closure

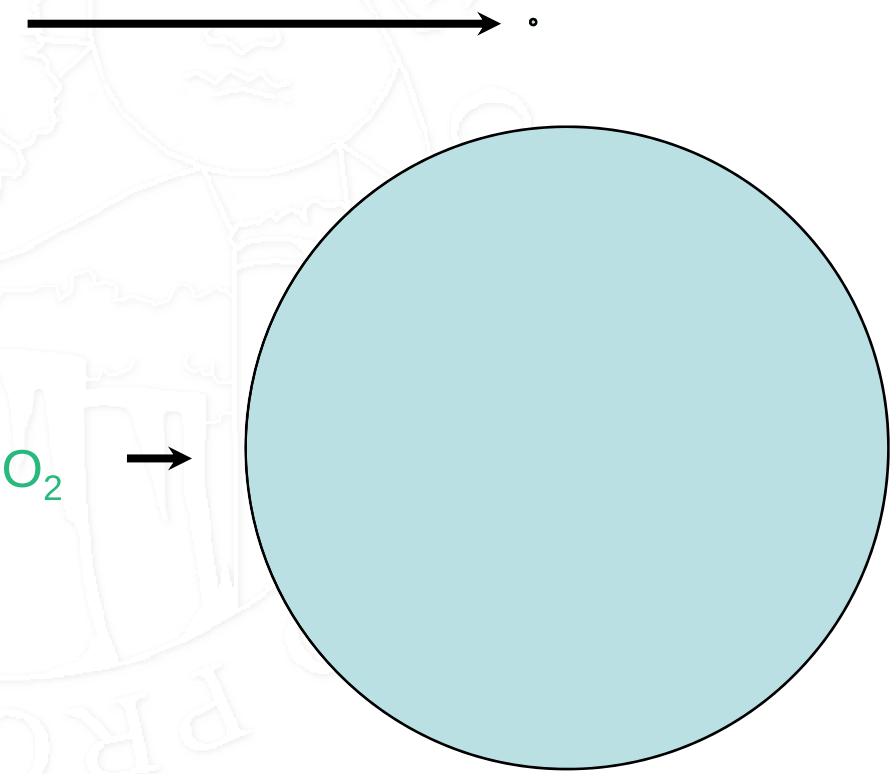
Current CO_2 Injection and Storage Projects



Size matters!

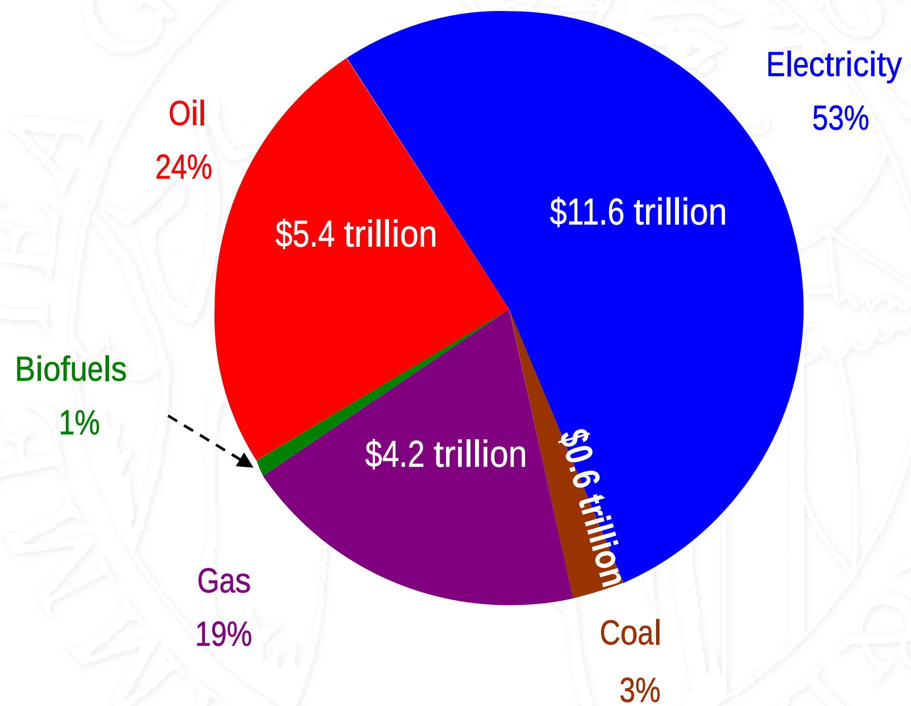
Cumulative globally sequestered CO_2

Cumulative global need to sequester CO_2



Proposed Integrated CCS Projects

IEA WEO 2007 Reference Scenario: Cumulative Investment, 2006-2030



Total investment = $21.9 trillion (in $2006)

CCS Commercialization

- Too few large scale demonstrations to accelerate deployment of CCS technologies
- This approach could result in risk of project failure
- High profile failures concerning CCS projects will result in a reluctance to invest in the deployment of CCS technologies
- We need a path forward to rapid commercialisation of CCS

Thank You!

Kelly Thambimuthu
IEA Greenhouse Gas R&D Programme

Financing CCS - May 28th 2008

Recent Project Developments in US.......

- Reconfigured FutureGen
- Hydrogen Energy – DF2
- USDOE Regional Carbon Sequestration Partnerships
  - 7 pilot to demonstration scale CCS projects
  - Storing between 1Mt and 5Mt of CO2
  - 21.9Mt stored total of CO2
  - Up to 5Mt CO2 stored/year total

Recent Project Developments in EU.......

- UK
  - CCS demo – full scale, coal, post-combustion, offshore storage
- Germany
  - Ketzin - injection
  - RWE planning a 450 MWe coal fired IGCC project with on-shore storage
  - Vattenfall have built a 30 MW CO_2 capture pilot plant
    - Plans to build a 300MW demonstration project in Germany
  - EON and Siemens – CO_2 capture pilot plant
- France
  - Lacq Project. Total. 2008. Oxyfuel. 150kt - CO_2 aquifer. 27km pipeline
- Netherlands
    - CO_2 injection into K12B field
    - NUON _ IGCC CO_2 capture

THE CONTRIBUTION OF CCS

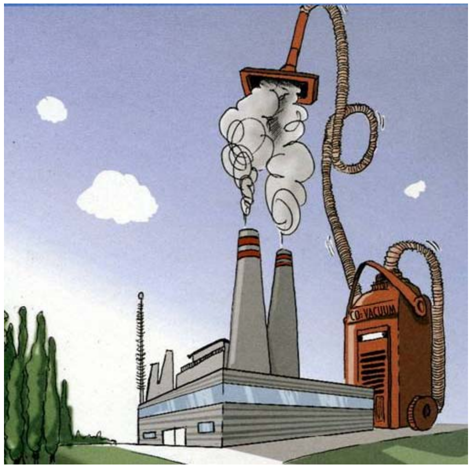
Expert Workshop on Financing Carbon Capture and Storage (CCS)
May 28, 2008
New Yorker Hotel New York

Jonathan Pershing

World Resources Institute

http://www.wri.org

jpershing@wri.org



Conclusions First

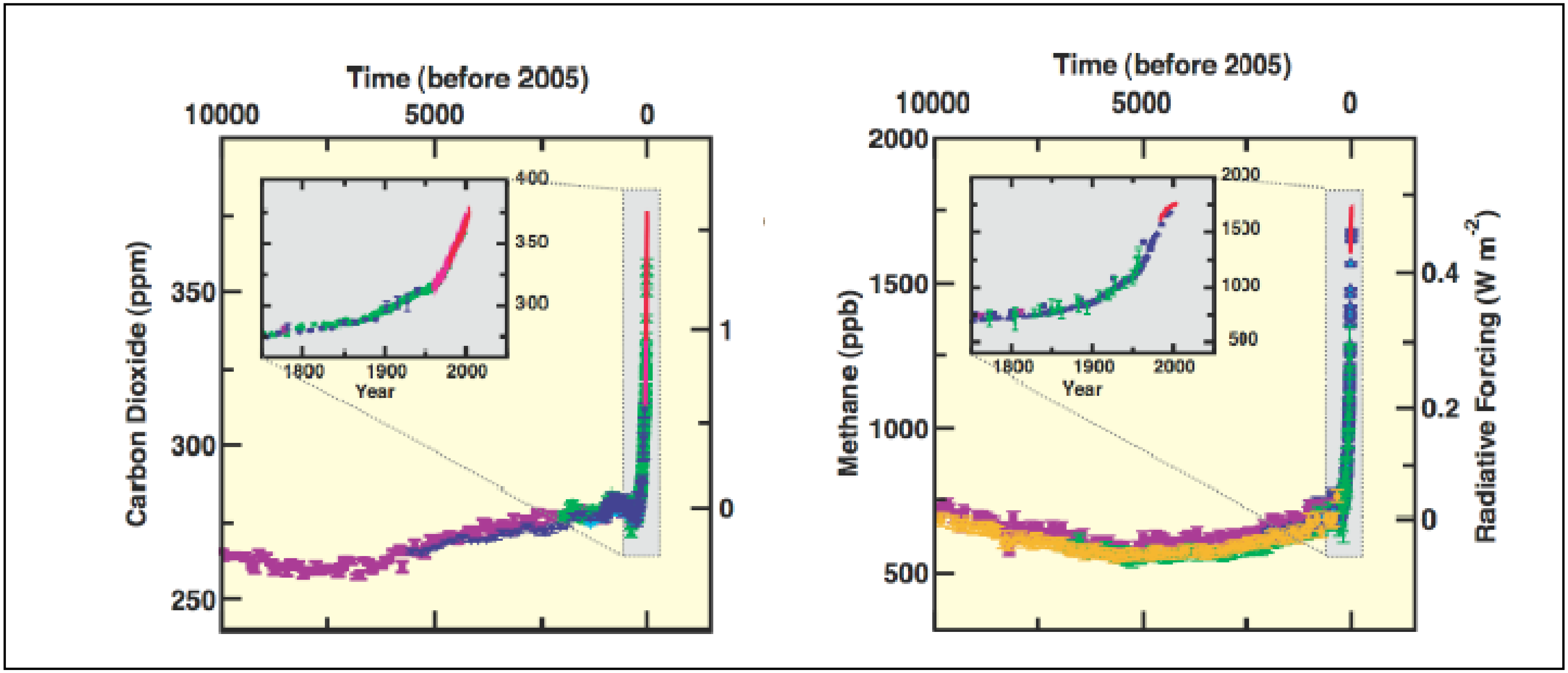
- Climate science is robust: it indicates a need for urgent and very large scale change
- A portfolio of actions will be necessary: we do not have the luxury of dismissing any promising mitigation options
- CCS will be part of the policy set: overcoming challenges of cost, gaining public acceptability, and scaling globally will be critical
- Policy will be needed to meet these challenges

WRI

Climate science is robust

W R I

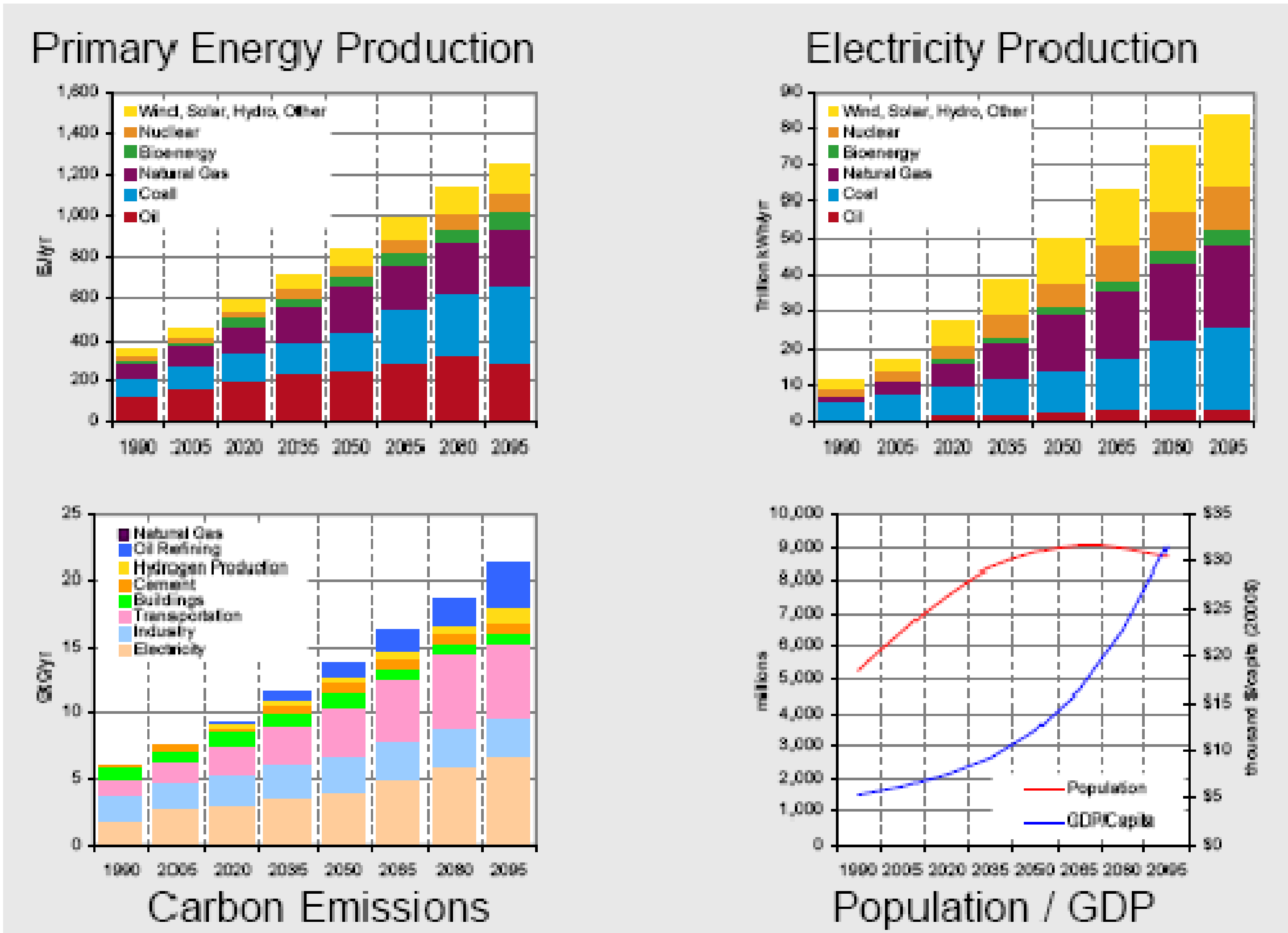
Change in GHG Concentrations



Source: IPCC, AR4

W R I

The global energy system



Source: PNNL, GTSP

W R I

U.S. Carbon Dioxide Emissions

(Million Metric Tons)

	Coal-Fueled Power Plants	Electric Power	Total U.S. CO2 Emissions
2005	1,944	2,375	5,945
2015	2,203	2,677	6,589
2030	2,927	3,338	7,950

Source: USEIA, Reference Case, 2007

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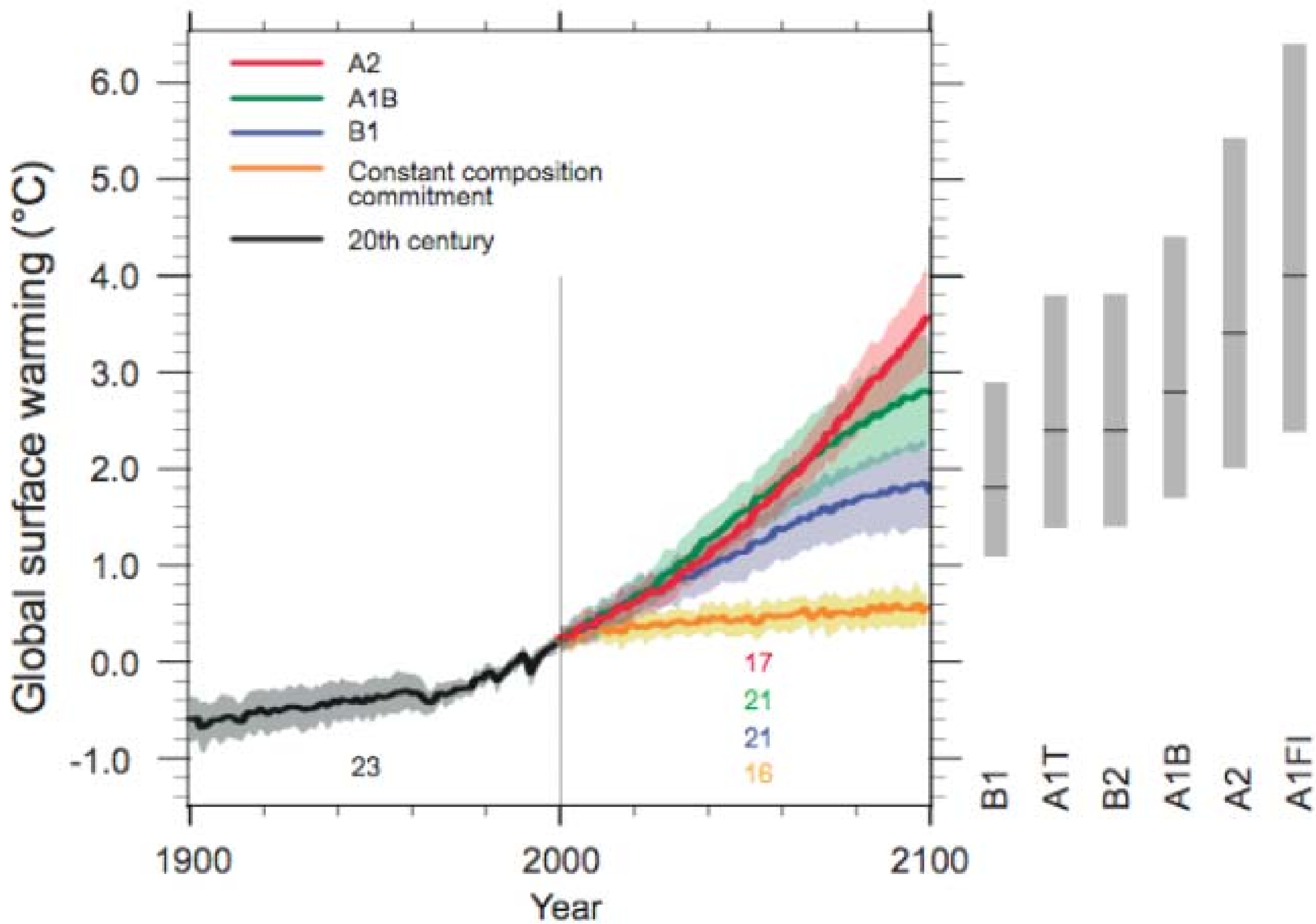
Projected future temperature



Source: IPCC, 2007

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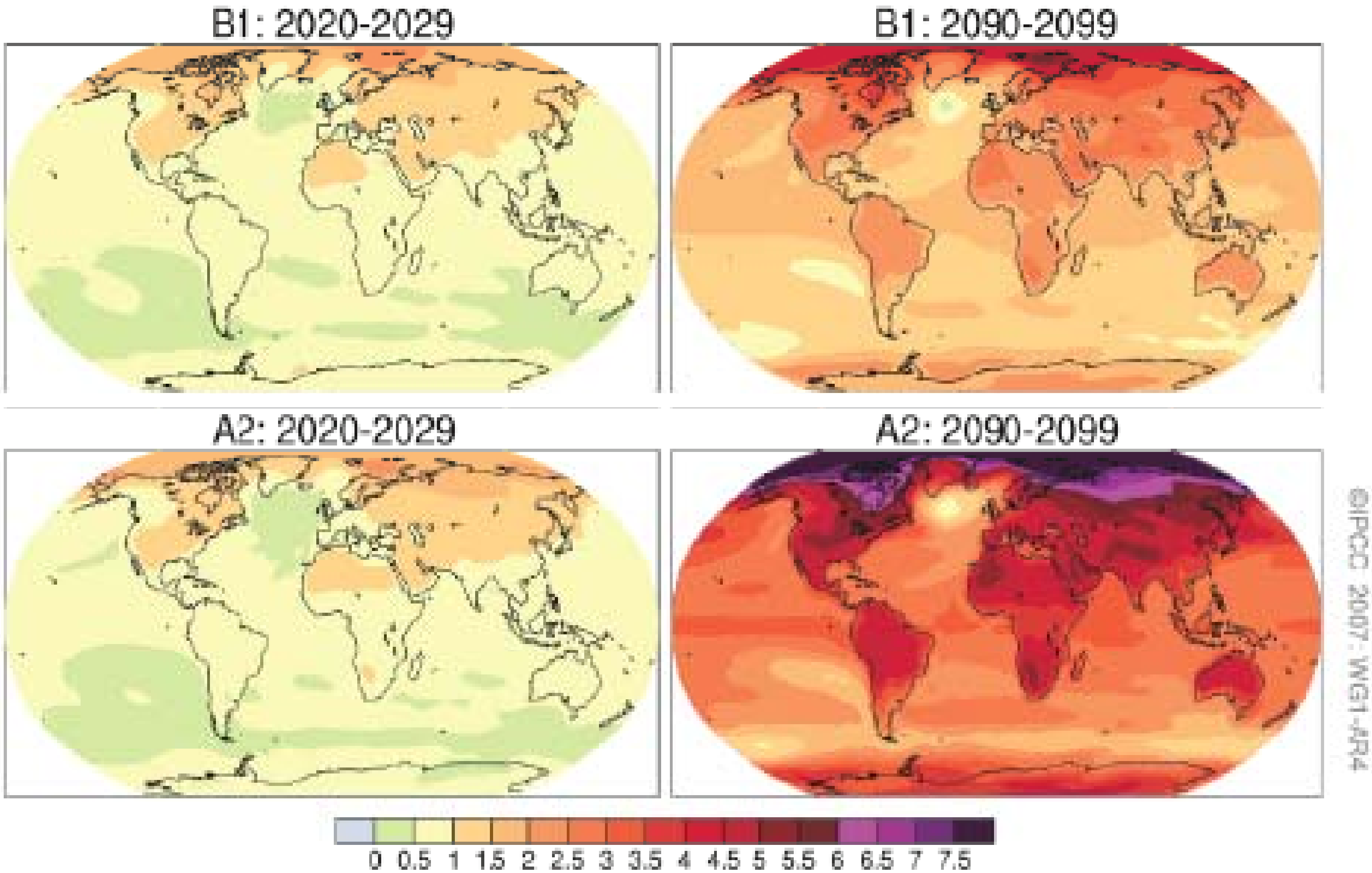
Projections of Surface Temperature



Source: IPCC, AR4, 2007

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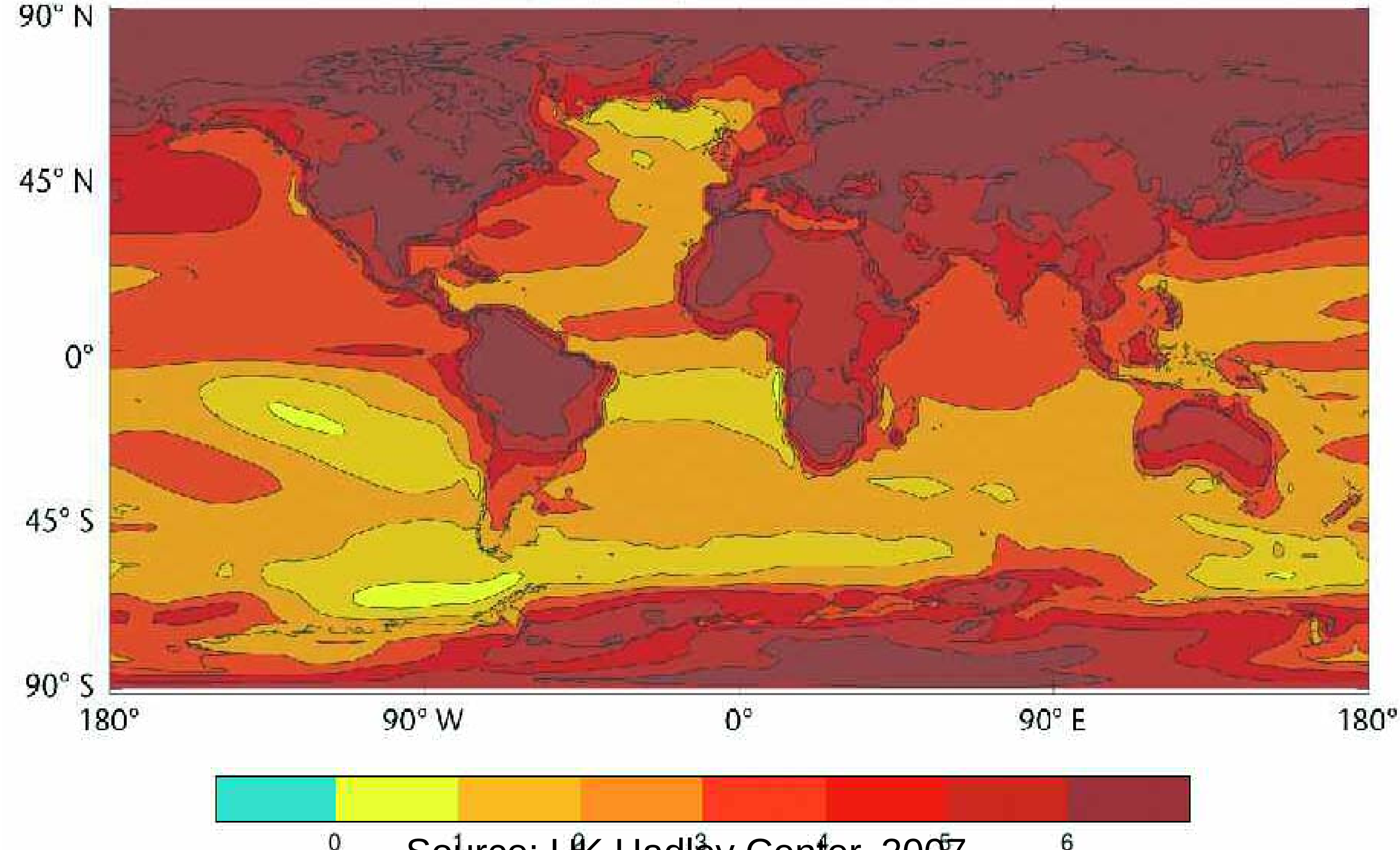
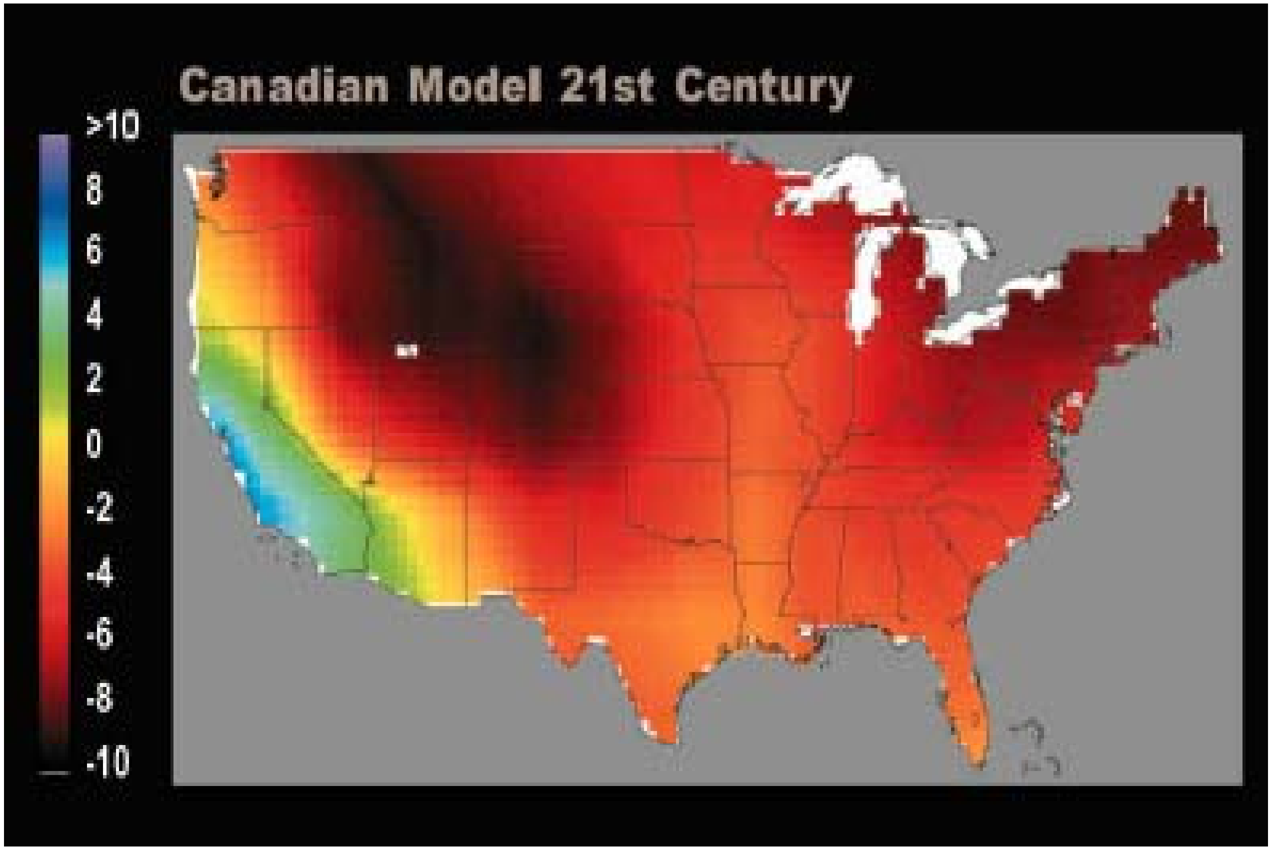
We are on the A1 FI Path: Temperature in 2080



Source: UK Hadley Center, 2007

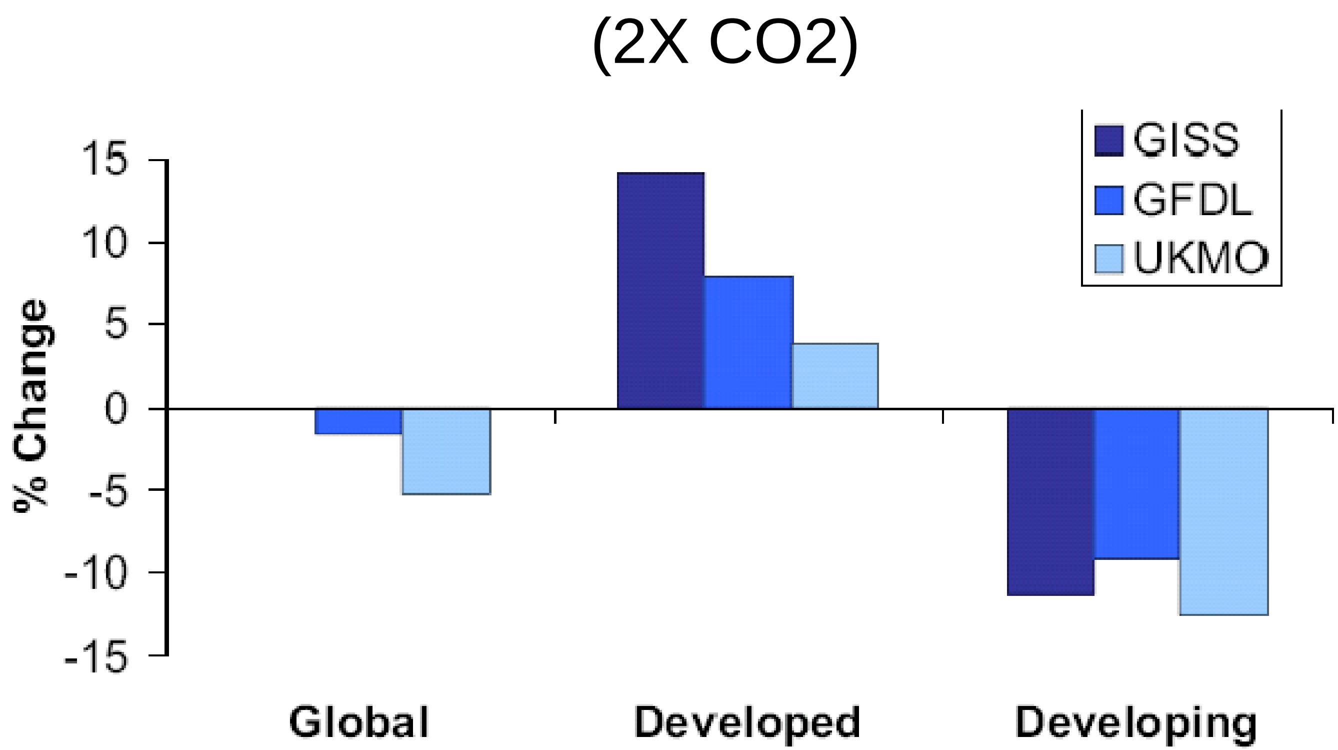
Drought Expectations



The Palmer Index is most effective in determining long term drought—a matter of several months—and is not as good with short-term forecasts (a matter of weeks). It uses a 0 as normal, and drought is shown in terms of minus numbers; for example, minus 2 is moderate drought, minus 3 is severe drought, and minus 4 is extreme drought.

WRI

Change in Cereal Production



Source: Stern Report, 2006

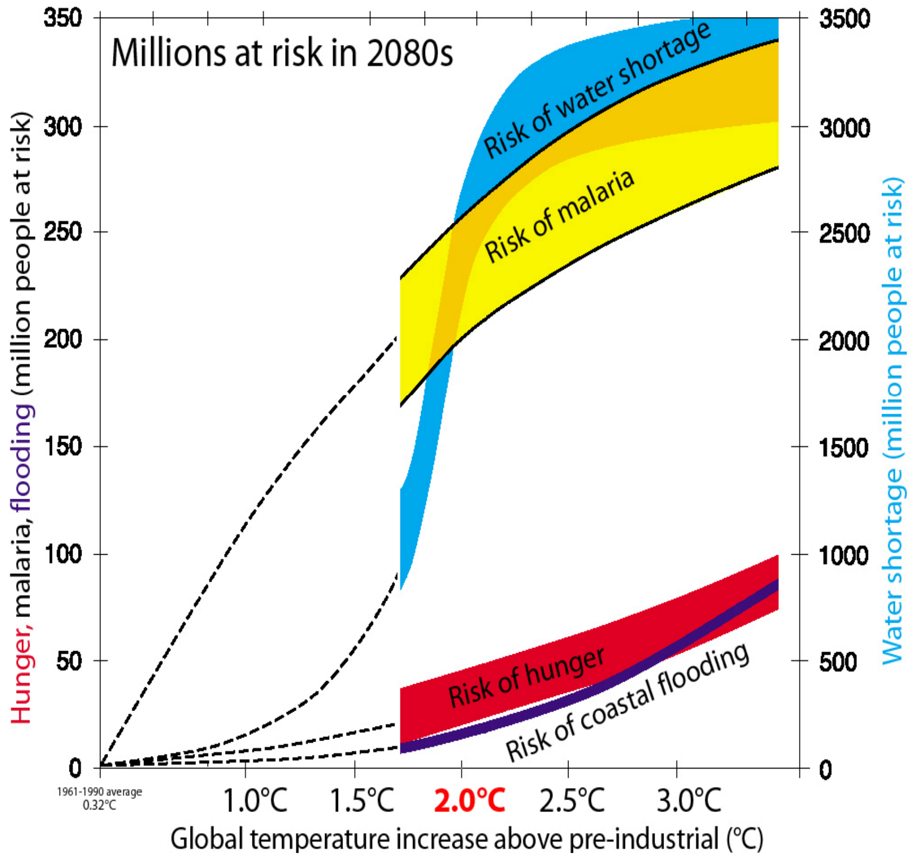
Food Riots

The World Bank estimates world food prices have risen 80 percent over the last three years and that at least thirty-three countries face social unrest as a result.

In recent weeks, food riots have erupted in Haiti, Niger, Senegal, Cameroon and Burkina Faso; protests have flared in Morocco, Mauritania, Ivory Coast, Egypt, Mexico and Yemen.

W R I

Risks from Global Warming



Source: Parry (2001), and IPCC WG 2, April 2007

- Water shortages harm up to 250 million in Africa by 2020
- Certain agriculture yields in Africa may fall 50% by 2050
- Decreased availability of fresh water in Asia might effect more than a billion people by 2050.
- Some areas of Europe are projected to lose up to 60% of their species by 2080.
- The Americas will see reduced snowpacks, leading to water supply problems by 2020

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Targets: The IPCC

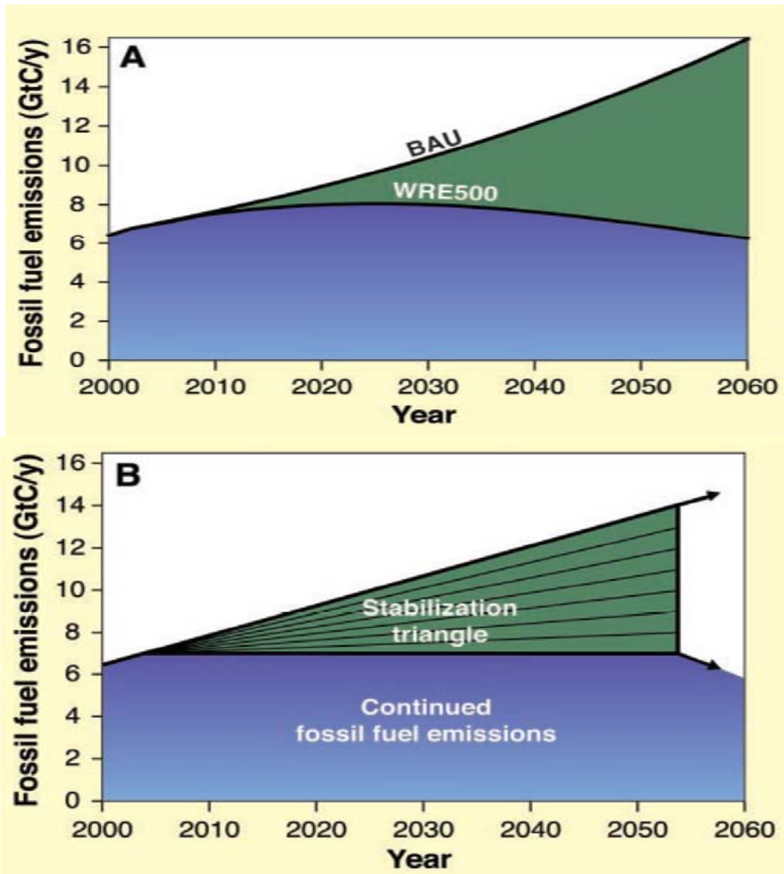
CO_2 Concentration at Stabilisation (2005=379 ppm)	CO_2-equivalent Concentration at Stabilization (includes aerosols; 2005=375 ppm)	Year in which global emissions peak	Global average temperature above pre-equilibrium	Change in global CO2 emissions in 2050 (% of 2000 emissions)
350 – 400	445 – 490	2000 – 2015	2 - 2.4 ºC	-85 to -50
440 – 485	535 – 590	2010 – 2030	2.8 - 3.2 ºC	-30 to +5
570 – 660	710 – 855	2050 – 2080	4 - 4.9 ºC	+25 to +85

Scenario category	Region	2020	2050
A-450 ppm CO_2-eq[b]	Annex I	–25% to –40%	–80% to –95%
	Non-Annex I	Substantial deviation from baseline in Latin America, Middle East, East Asia and Centrally-Planned Asia	Substantial deviation from baseline in all regions
B-550 ppm CO_2-eq	Annex I	-10% to -30%	-40% to -90%
	Non-Annex I	Deviation from baseline in Latin America and Middle East, East Asia	Deviation from baseline in most regions, especially in Latin America and Middle East

Source: IPCC AR4

A portfolio of actions will be necessary

Technology Opportunities

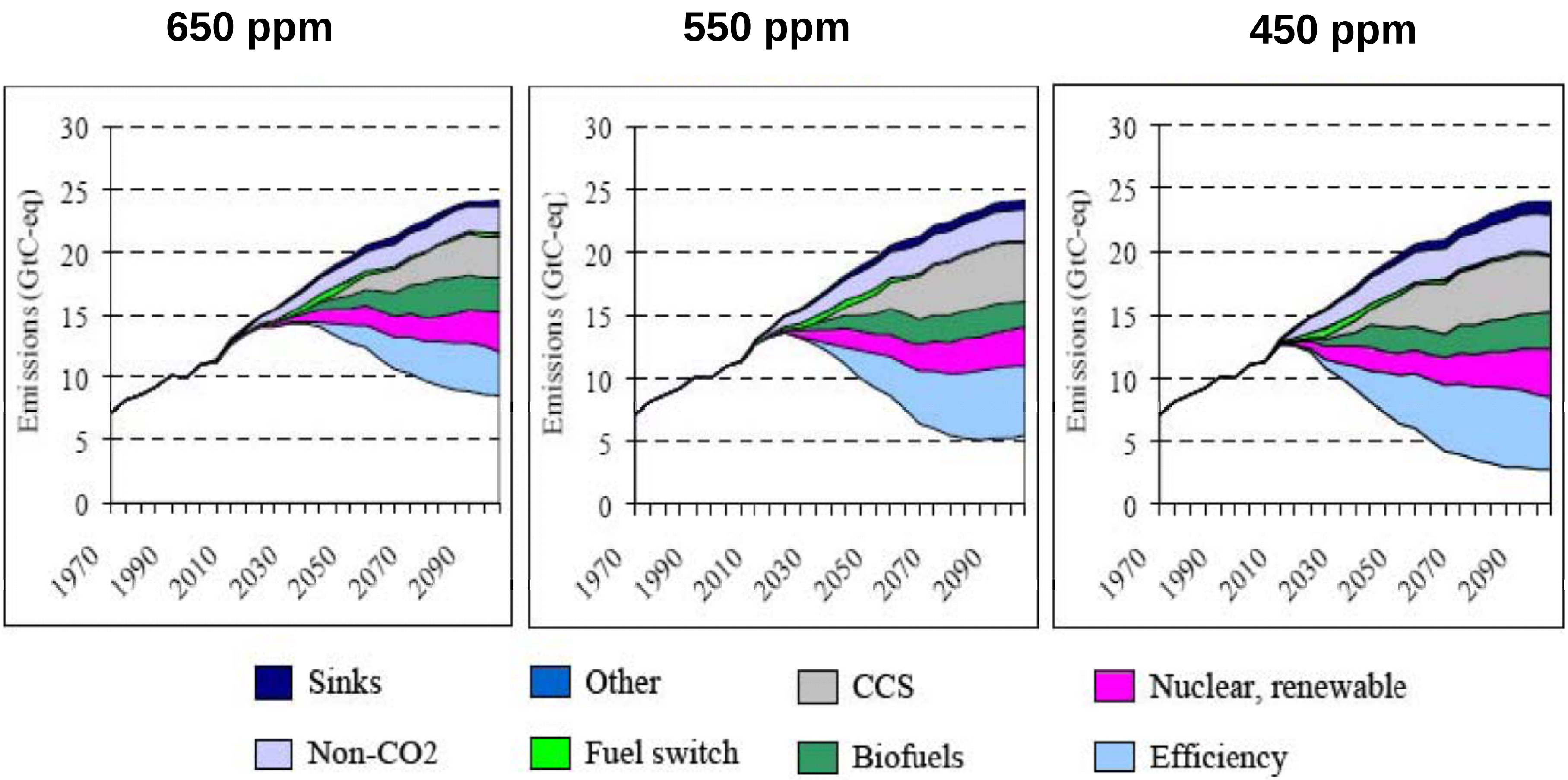


Today's Technology	Actions that Provide 1 Gigaton/year of Mitigation
Coal Plants	Replace1,000 conventional 500-MW plants with "zero-emission" power plants
Geologic Sequestration	Install 3,500 Sleipners, at 1 Mt of CO_2 per year
Nuclear	Build 500 1 GW plants
Efficiency	Deploy 1 billion cars at 40 mpg instead of 20 mpg
Wind	Install 750 x current

Source: Pacala and Socolow, Science, 2004

W R I

Filling the Wedges



Source: van Vuuren, den Elzen, Lucas, et al. 2006

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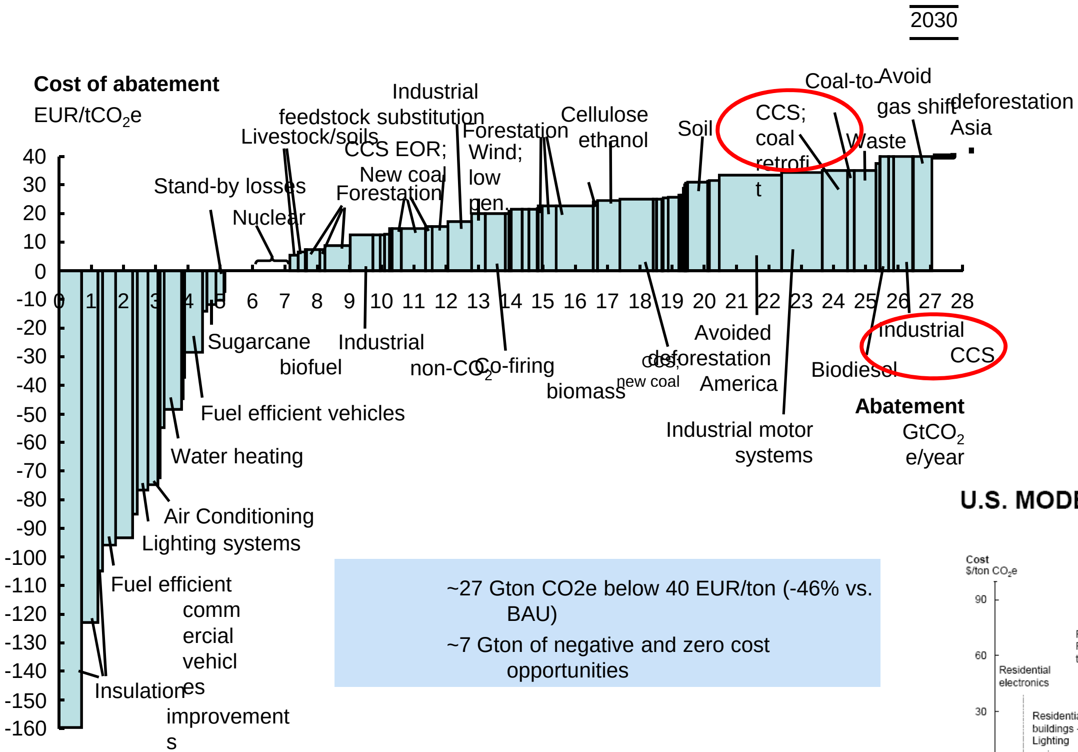
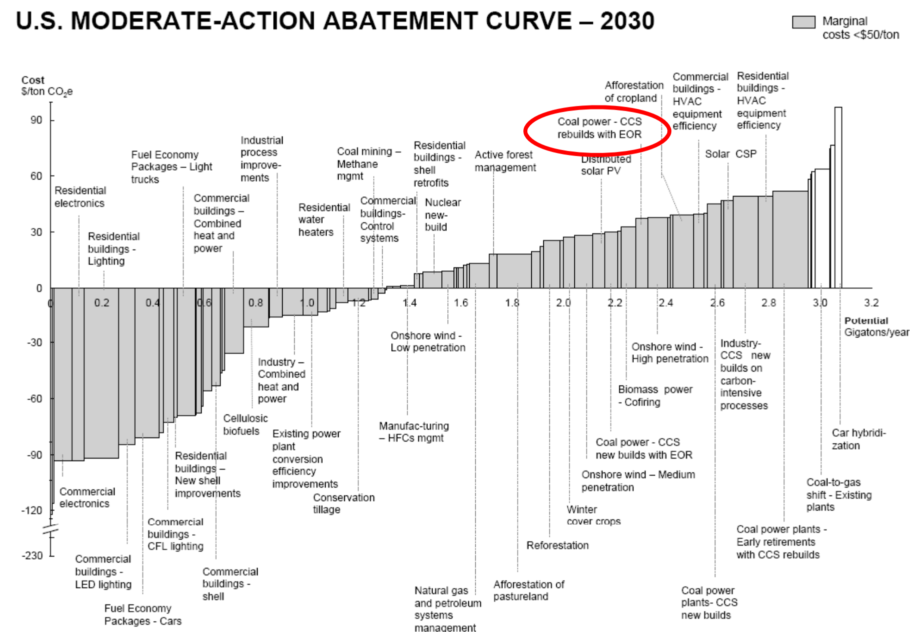
EU and US Abatement Curves



~27 Gton CO2e below 40 EUR/ton (-46% vs. BAU)

~7 Gton of negative and zero cost opportunities



Source: McKinsey, 2007

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A successful global CCS regime requires overcoming challenges:

- Cost
- Scale
- Public acceptability

Estimated Costs of Electricity
($/MWh)

	EPRI	MIT	S&P	Rubin *et al*
Pulverized Coal w/o Capture	39.3	47	58	53
Pulverized Coal w Capture	62	77	120	73*-96**
IGCC w/o Capture	45	51	67	55.5
IGCC w Capture	65.4	65	102	59*-79**

* Assuming EOR storage

**Assuming saline aquifer storage

W R I

Estimated Costs of CO_2 Avoided
($/ton CO_2)

	EPRI	MIT	S&P	Rubin *et al*
Pulverized Coal	39.3	47	80	29*-61**
IGCC	45	51	41-46	5* – 32**
NGCC	65.4	65	86	44*-72**

* Assuming EOR storage

**Assuming saline aquifer storage

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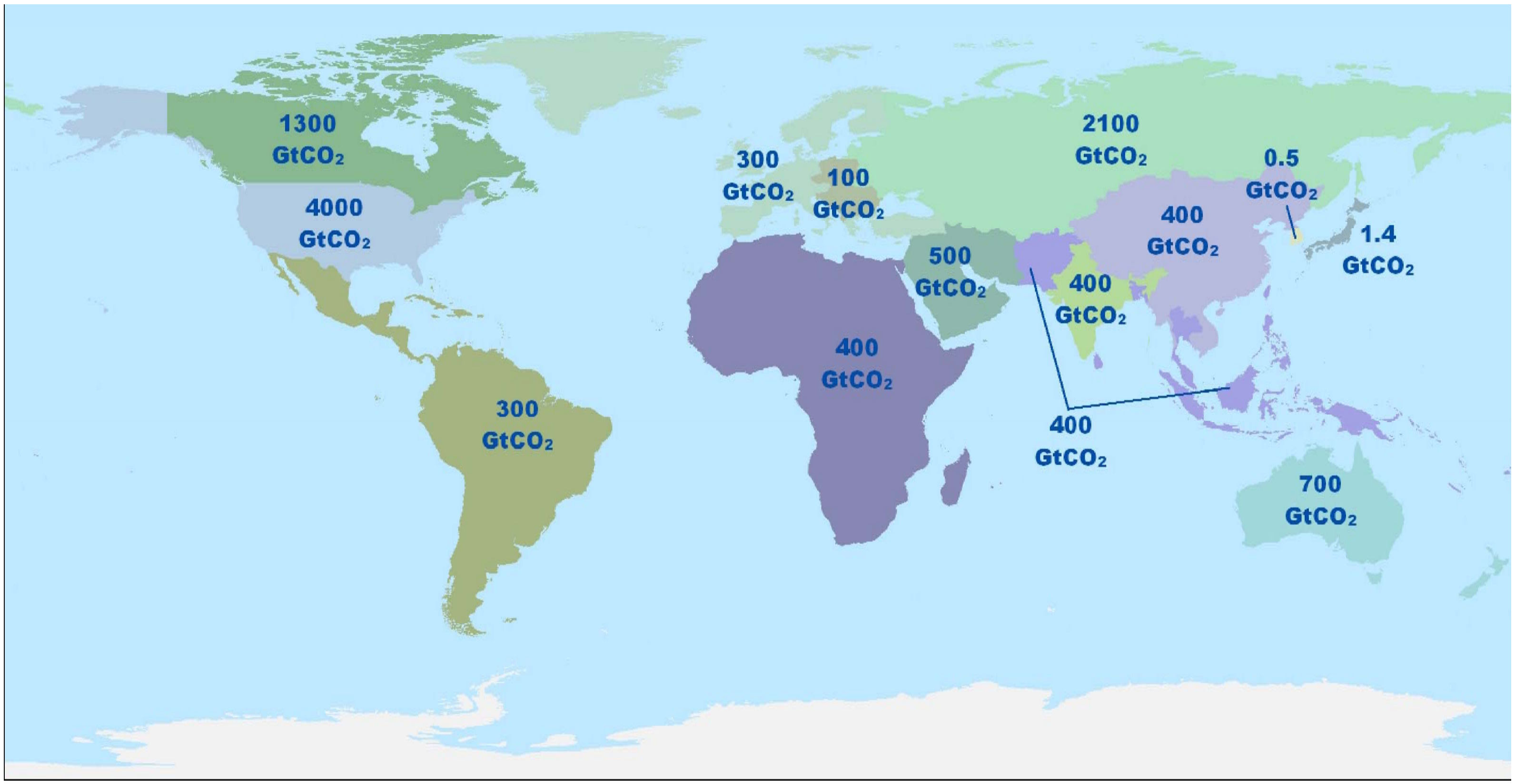
Suitable CCS sites are global…



Source: Jim Dooley, PNNL, Univ Maryland

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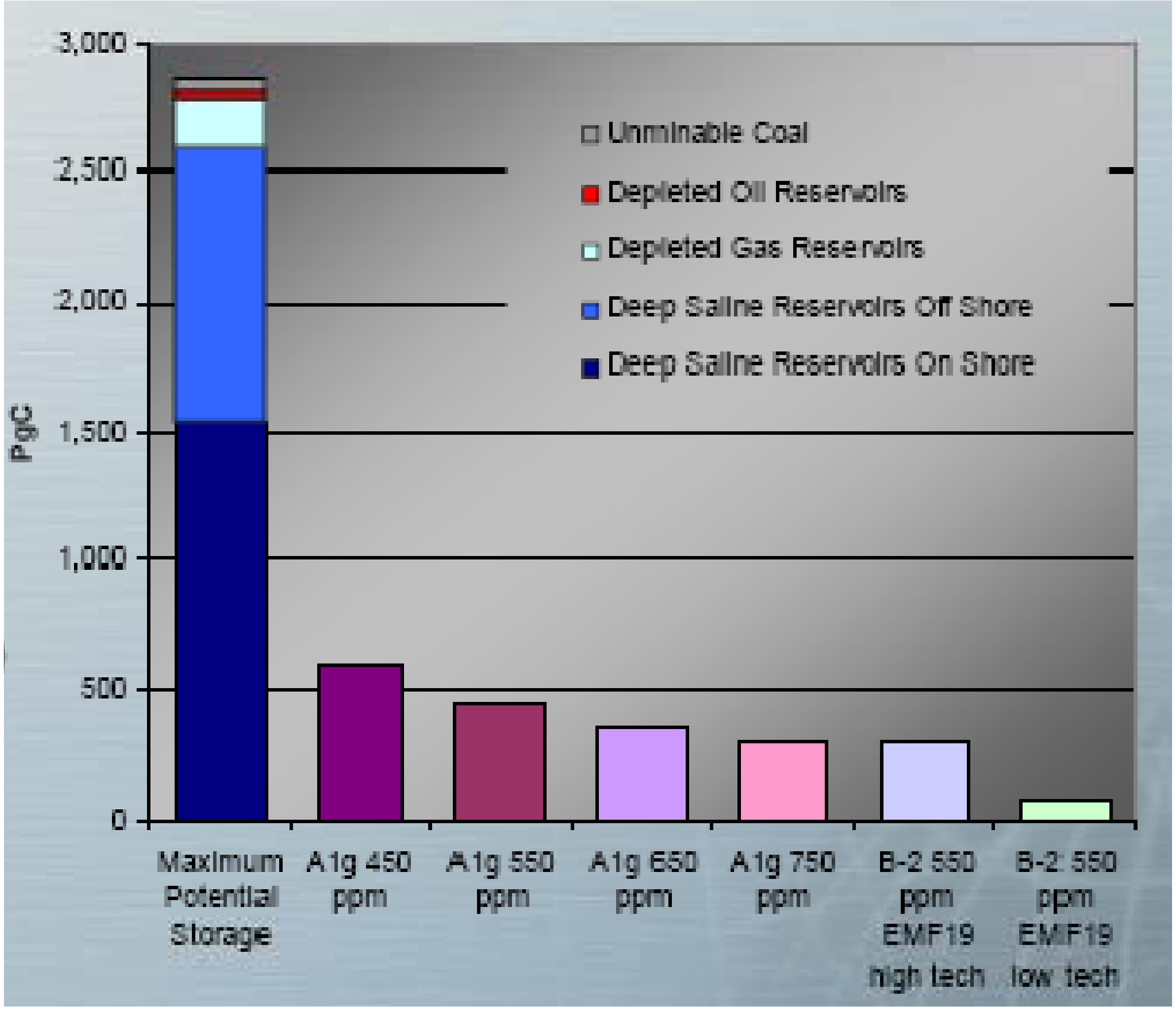
…with large storage potential



Source: PNNL, GTSP

CO2-EOR Projects Sequestering U.S. Anthropogenic CO2

State/ Province	Plant Type	CO_2 Supply		EOR Fields	Operator
		MMcfd	MMt/Yr		
Texas	Gas Processing	75	1.4	Sharon Ridge, Sacroc, Others	ExxonMobil, KinderMorgan
Colorado	Gas Processing	60	1.2	Rangely	Chevron
Wyoming	Gas Processing	180	3.5	Patrick Draw, Lost Solider, Wertz, Others	Anadarko
Michigan	Gas Processing	15	0.3	Dover	Core Energy
Oklahoma	Fertilizer	35	0.6	Purdy, Sho-Vel-Tum	Anadarko, Chaparral
North Dakota	Coal Gasification	145	2.8	Weyburn (Canada)	EnCana, Apache
TOTAL		**510**	**9.8**		

Source: Pew Climate Center, 2007

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Public acceptability

WRI Guidelines

- Inform emerging regulatory and best practice development
- Transparent forum, diverse stakeholders
- Build consensus on key issues and develop a comprehensive set of CCS guidelines
- Provide context and rationale behind each recommendation
- Public acceptability

Web site: http://wiki.wri.org/ccs/

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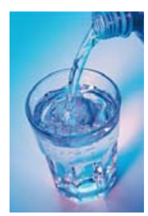
WRI CCS Guiding Principles

1. Protect human health and safety
2. Protect ecosystems
3. Protect underground sources of drinking water and other natural resources
4. Ensure market confidence in emissions reductions through proper GHG accounting
5. Facilitate cost-effective, timely deployment



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Public Acceptance: Capture, Transport

- Capture: Existing power plant regulation likely adequate; may require additional oversight (and monitoring) for inclusion on trading regimes
- Transport: existing pipeline regulation
  - Issues: eminent domain, classification of CO2, ownership

Public Acceptance: Storage

- Leakage
  - Issues: Groundwater contamination; induced seismicity; catastrophic or slow release; property damage
  - Manageable through careful siting, long term monitoring program
- Long term liability
  - During operations and closure phase and over longer term (>30-50 years)
  - Likely to require government assumption of liability (and therefore considerable confidence in robustness of reservoir)

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Policy will be needed to meet these challenges

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CCS Support Programs

United States

- DOE (Regional Partnerships, R&D, Futuregen, CSLF)
- EPACT (Tax Guarantees)
- State Incentives (e.g. NY, Illinois, Wyoming)
- Federal Legislation

Europe

- EU Directive on CCS
- Consideration of inclusion of CCS in the EU- ETS
- Incentives by member states

China

- R&D platforms:
- CSLF
- UK China near Zero Emissions Coal Project
- Greengen Project
- Shenhua CTL plant

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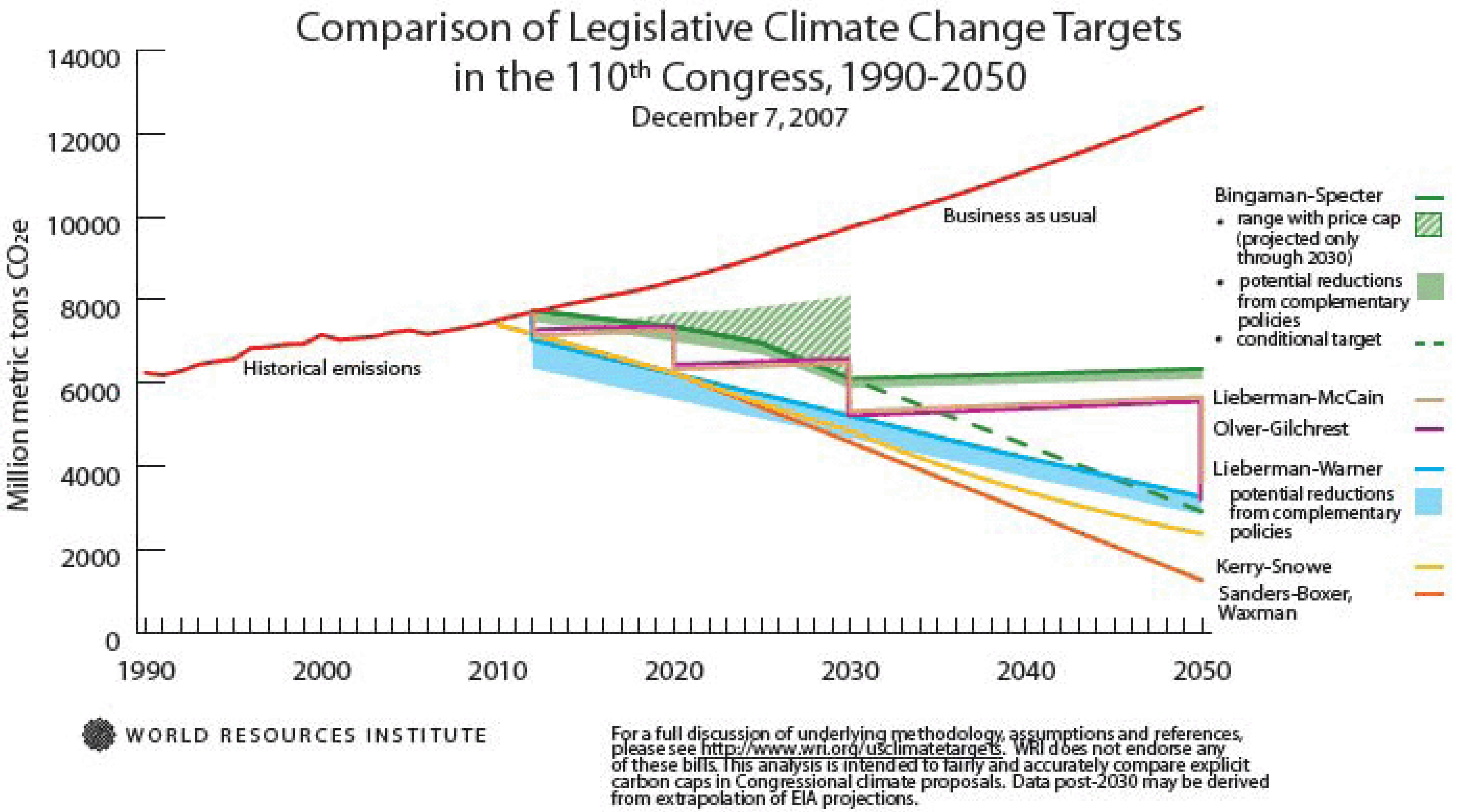
Congressional Action



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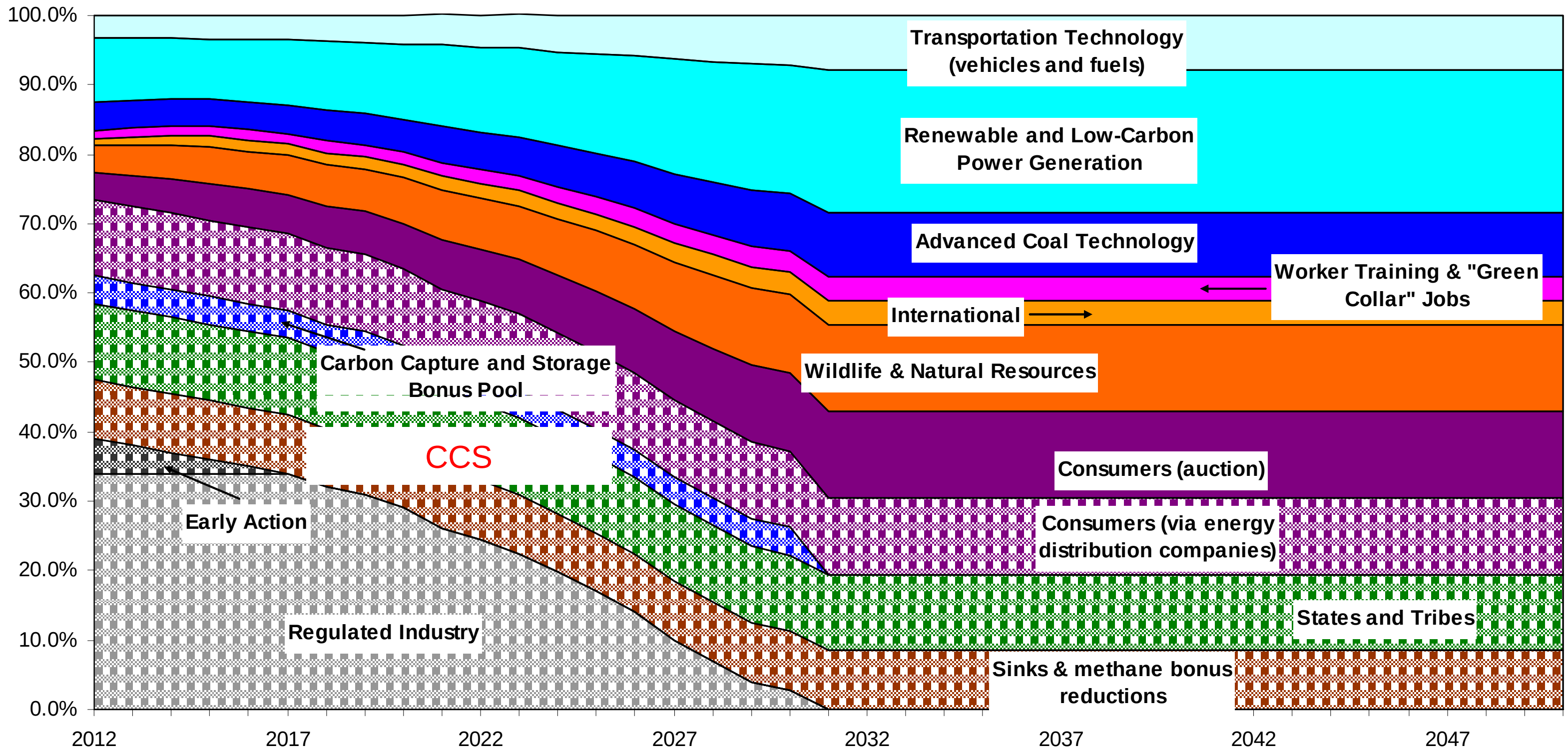
Lieberman Warner Bill: Allocations
(As reported out from Senate EPW Jan 23, 2008)

Note: Dashed color: direct allowances; Solid colors: Auction revenues



Note: revised bill has ~1.75 percent of allowances through 2030

Source: National Wildlife Federation

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Conclusions Reprised

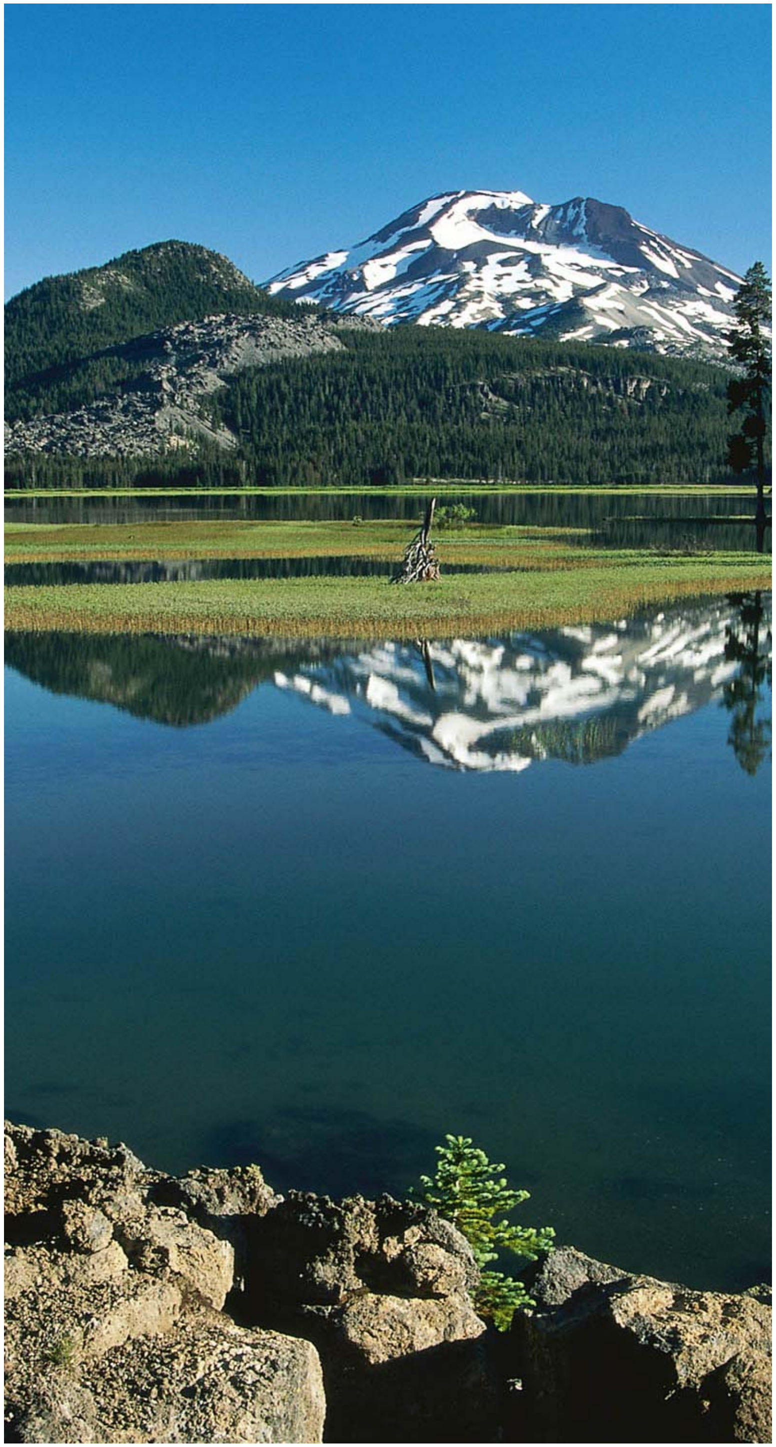
- Climate science is robust: it indicates a need for urgent and very large scale change
- A portfolio of actions will be necessary: we do not have the luxury of dismissing any promising mitigation options
- CCS will be part of the policy set: overcoming challenges of cost, gaining public acceptability, and scaling globally will be critical
- Policy will be needed to meet these challenges

W R I

Jonathan Pershing (jpershing@wri.org)

World Resources Institute

http://www.wri.org



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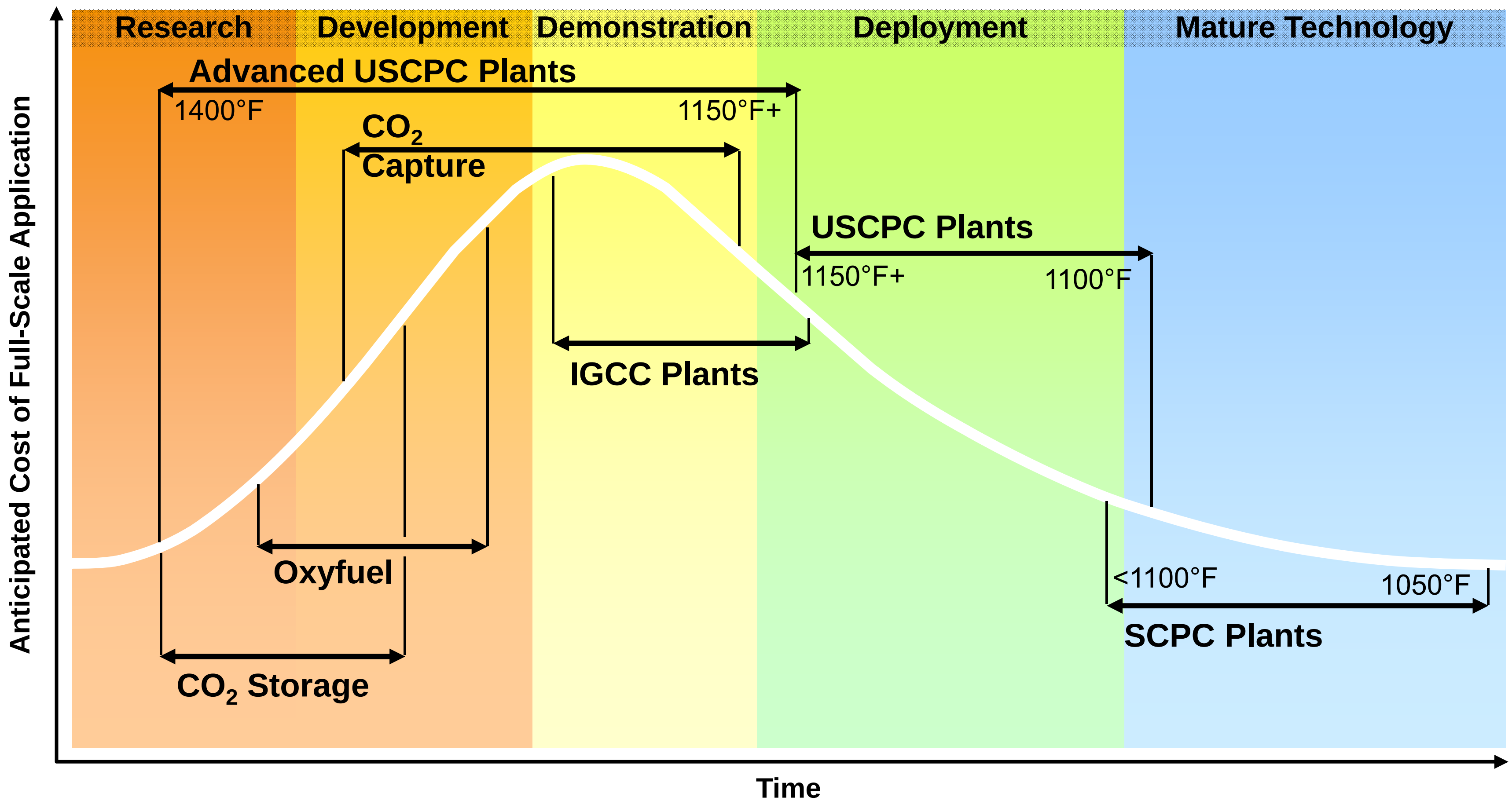
The Role, Status and Financing of CCS as a Mitigation Option in the United States

2nd Expert Meeting on Financing CCS Projects

May 28, 2008

Tom Wilson
Senior Program Manager

The "Mountain of Death" for New Technology Who is Going to Pay for Early Deployment?



Policy Trend in U.S.: Increasing recognition that we need explicit strategies for funding research, development, demonstration and early deployment

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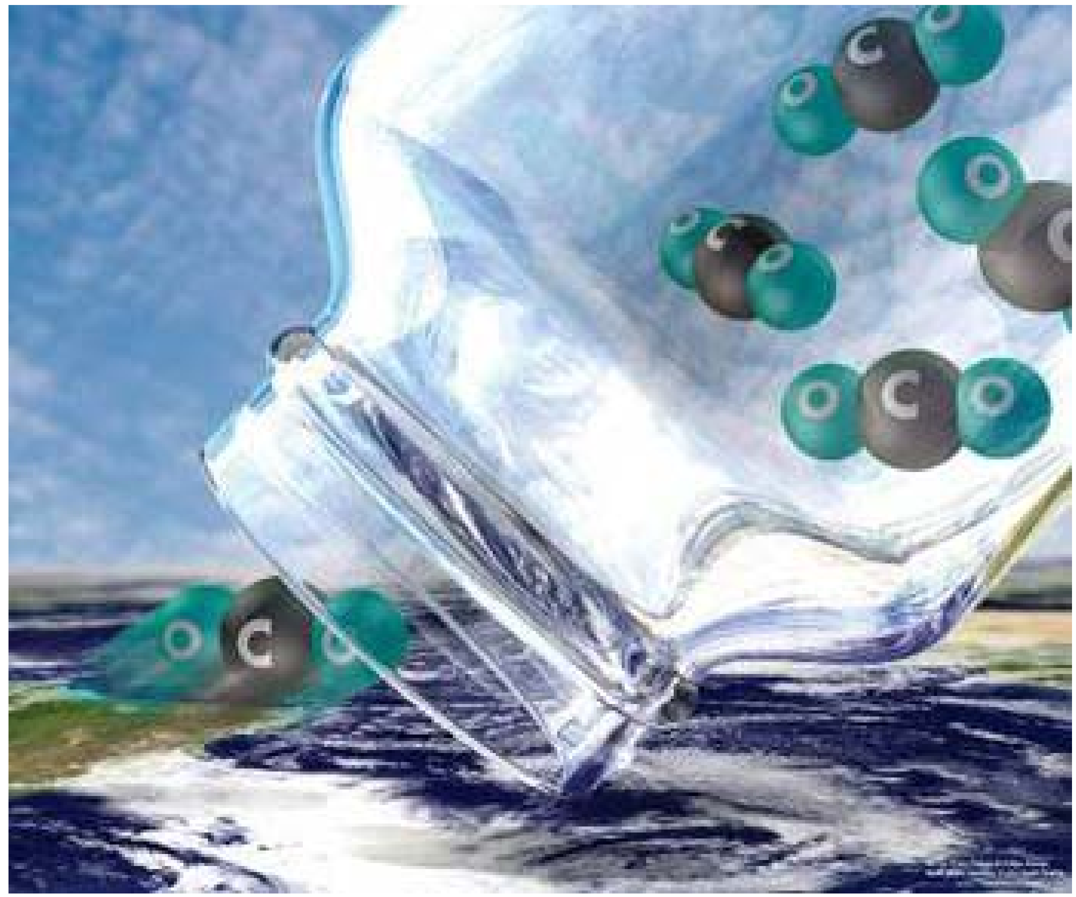
Topics

- CCS Cost
- Financing CCS
  - – Lieberman-Warner
    - CO_2 Price
    - Incentives
- Demo Activities
- Concluding Thoughts



Part I:
CCS Cost

Pleasant Prairie Chilled Ammonia, Post-Combustion Capture Demo

Dedicated in February 2008; Late 2007 photo, courtesy of Alstom

we energies

ALSTOM

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Capital Cost Estimates in Press Announcements and Submissions to PUCs in 2007–08—All costs are higher, more than would be predicted from indices (e.g., CEPCI)

Owner	Name/Location	Net MW	Technology/ Coal	Estimate Date	Reported Capital $ Million	Reported Capital $/kW	Notes/Status
AEP/ Swepco	Hempstead, AK	600	SCPC/PRB	Dec. 2006	1680	2800	CPCN issued
Southern Co.	Kemper County, MS	560	Air IGCC/ Lignite	Dec. 2006	1800	3000	FEED in progress
Duke	Cliffside, NC	800	SCPC/ Bit	May 2007	2400	3000	Permitted
Duke	Edwardsport, IN	630	IGCC/ Bit	May 2008	2350 In Service	3730	Permitted
AEP	Mountaineer, WV	630	IGCC/Bit	June 2007	2230	3545	Permit in Review
Tampa Electric	Polk County, FL	630	IGCC/Bit	July 2007	1613 (all $?) 2013 Serv	2554/ 3185	Shelved; now NGCC
Sunflower	Holcomb, KS	2 x 700	SCPC/PRB	Sept. 2007	3600	2572	Permit denied
Am. Muni. Power	Meigs County, OH	1000	SCPC/Bit & PRB	Jan. 2008	2900/3300	2900/3300	
Tenaska	Sweetwater County, TX	600	SCPC + CCS/PRB	Feb. 2008	3000	5000	

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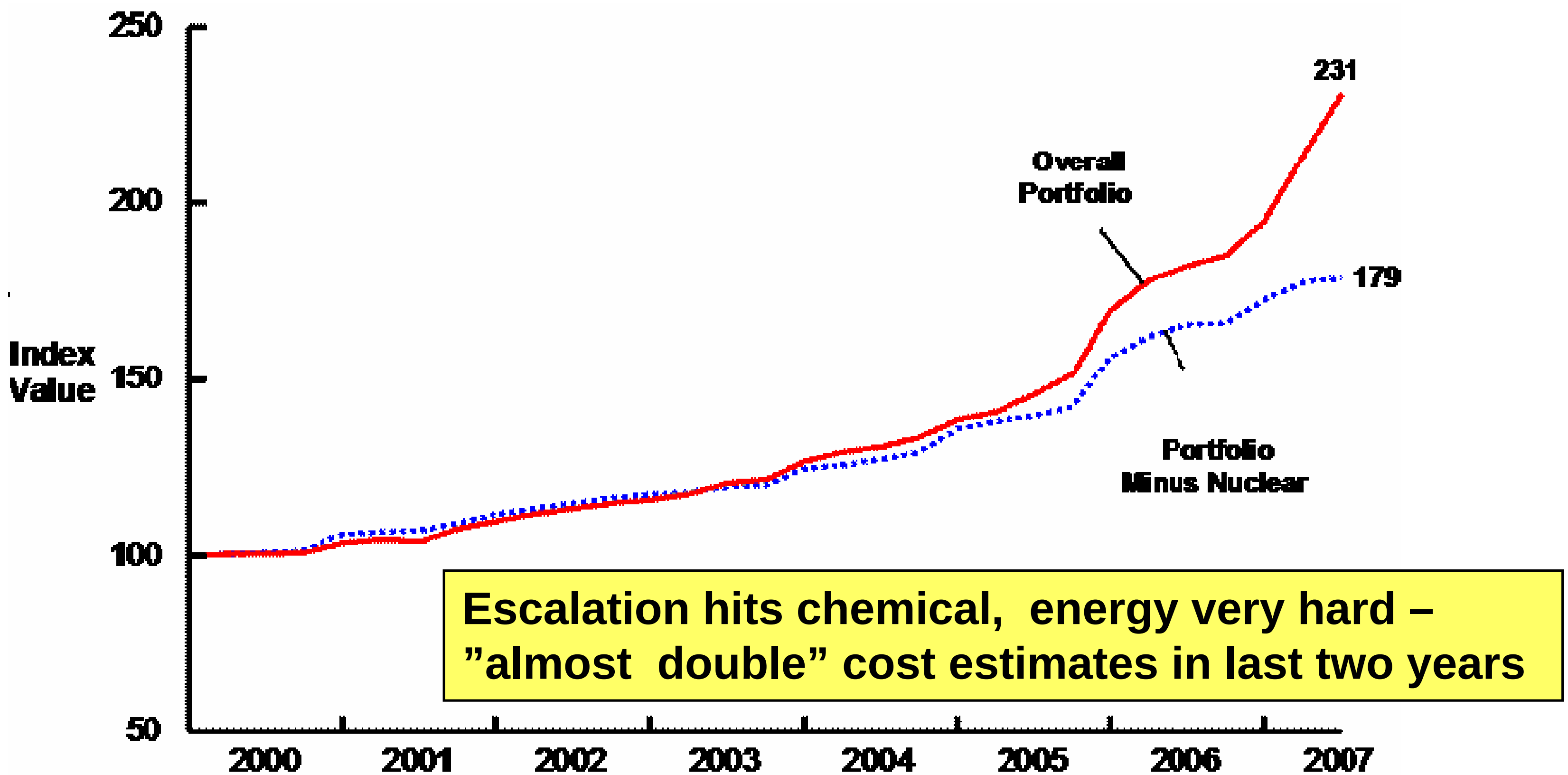
Energy Technology Costs Are Highly Uncertain: Are Today's Costs a New "Plateau" or a "Bubble"?

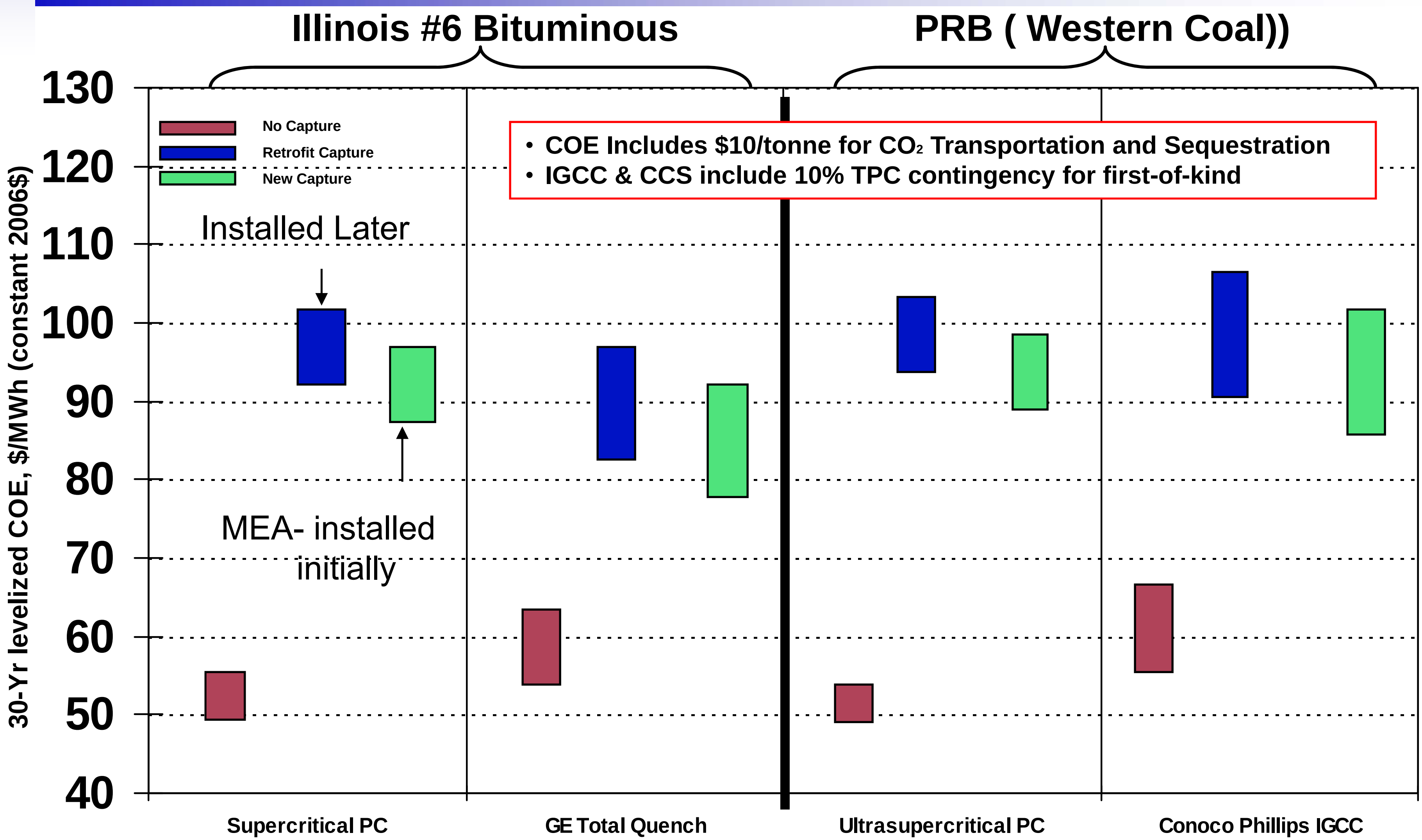
"North American Power Construction Costs Rise 27% in 12 Months"

"Continuing Cost Pressures Likely to Bring Delays and Postponements"



Source: IHS/CERA Press Release 2/14/08

With Current Technology CO_2 Capture Costly; No Clear Winners in Current Designs



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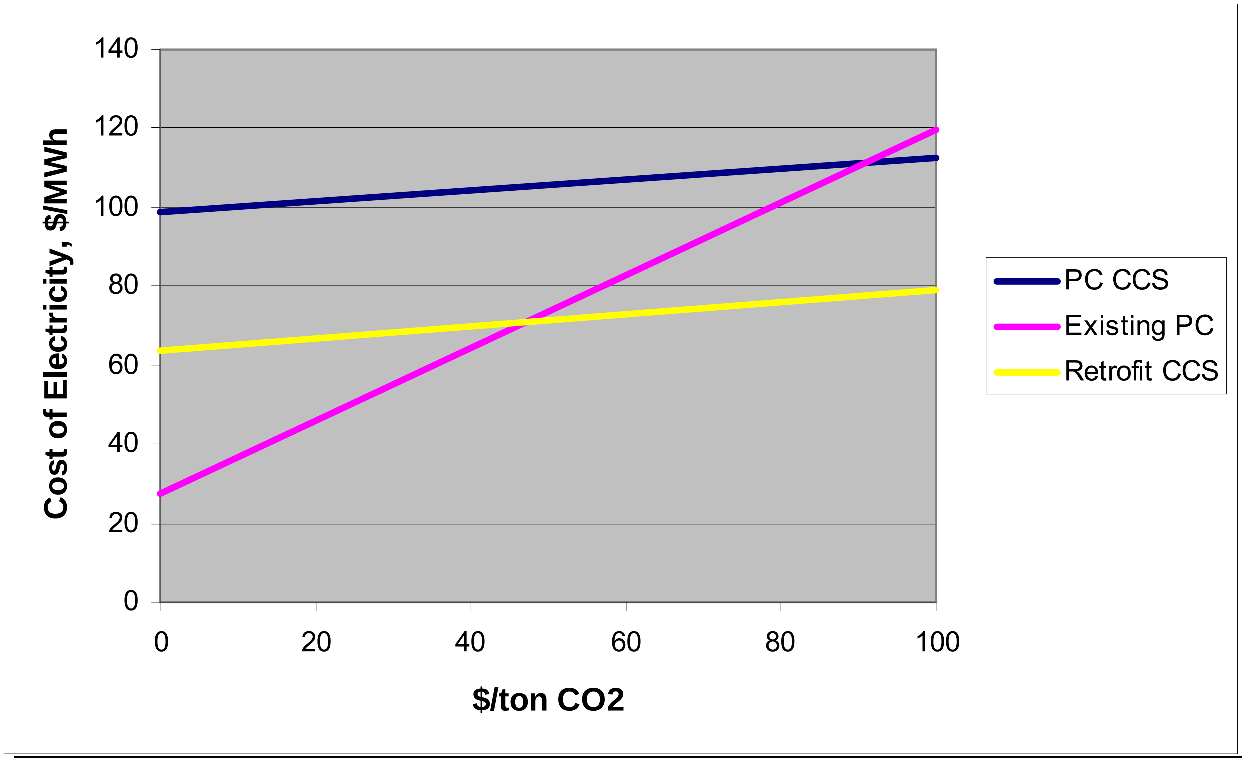
CCS Retrofit May Be Attractive for Some Plants ...
Cost of New PC w/ CCS versus Retrofit of Existing PC
(COE analysis, March 2008 Cost Estimates from G. Booras)

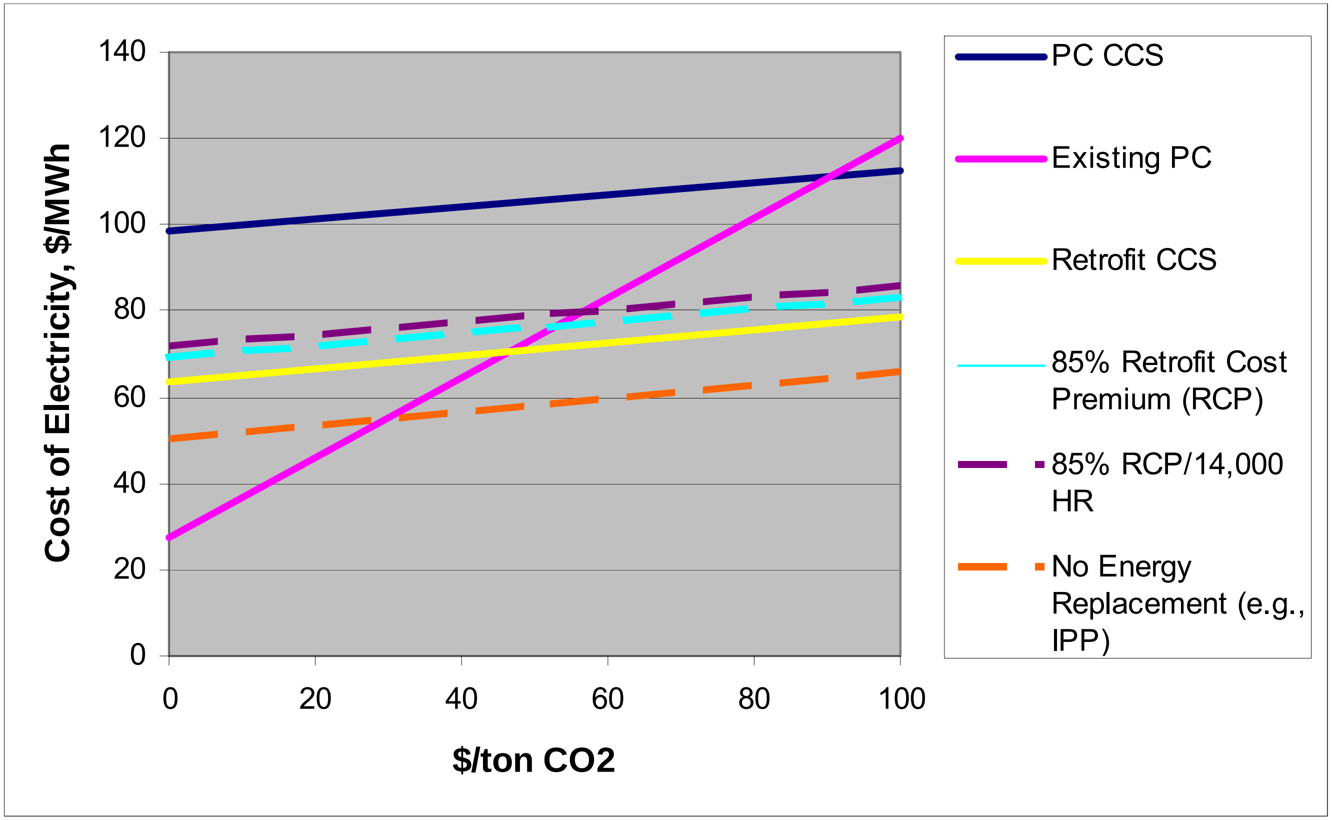


Analysis assumes:

- Retrofit MEA process in 2012
- 35% retrofit cost premium
- Replace capacity lost to retrofit w/ new PC w/ CCS

Plant	New PC w/ CCS	Existing PC	Retrofit CCS
MW	425	600	425
$/kW	4000	0	940 * 1.35
Btu/kWh	11,300	9,500	12,500

CCS Cost Sensitivity Analyses (dashed lines)



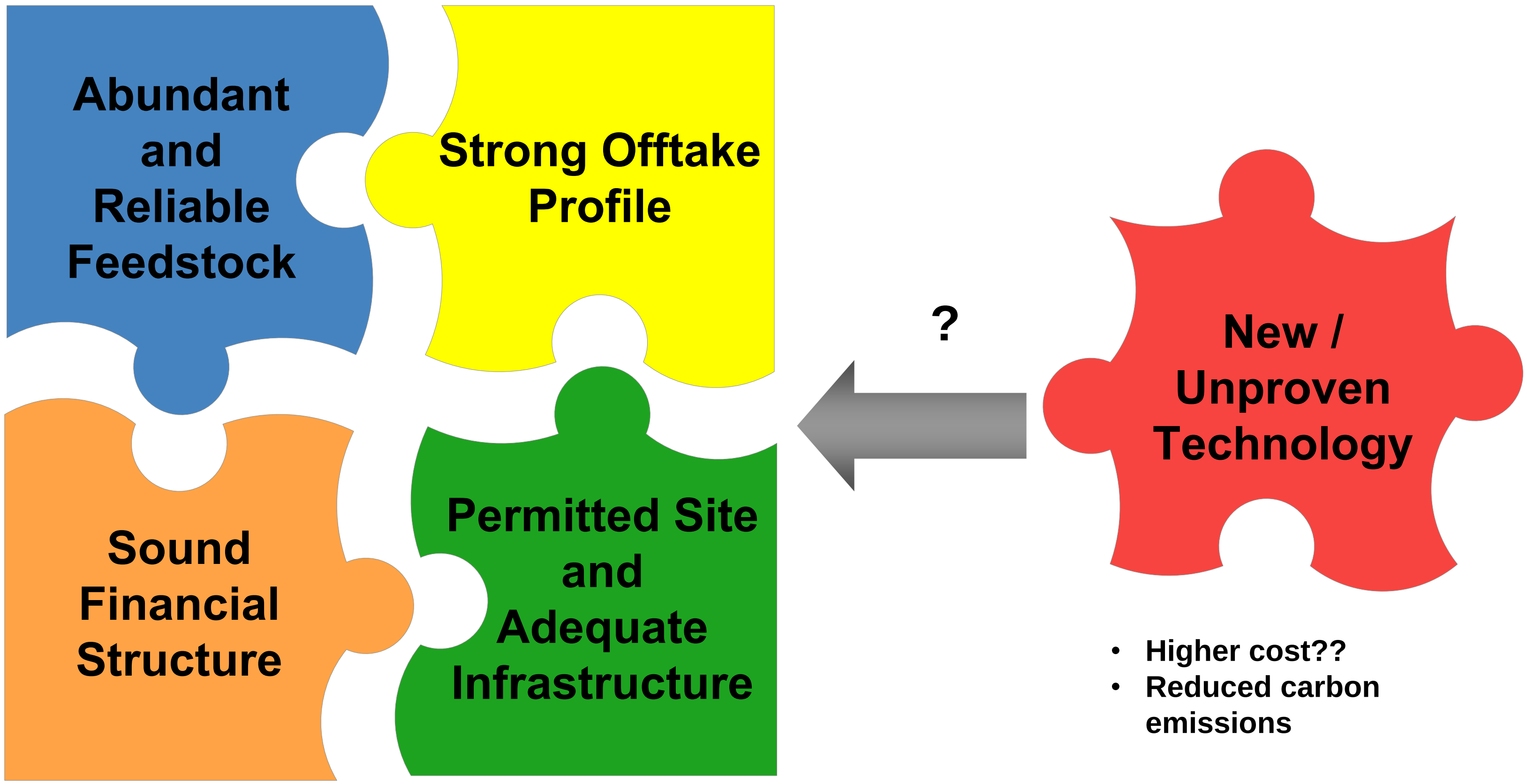
- COE is relatively insensitive to significant capital cost and heat rate retrofit penalties
- Energy replacement cost is a significant fraction of retrofit cost. Some companies may not consider this cost (e.g., IPP).

Retrofit Issues for Post-Combustion Capture (e.g., for Existing Coal Plants)

- Space
  - Where is there 6 acres near an operating 500 MW plant?
  - Have areas near stack been used for FGD, SCR retrofit?
- Steam
  - Where do you get half the steam currently used in the low pressure turbine (e.g., for an amine regenerator)?
- Energy
  - How do you make up the lost power?
- Cost
  - SO_2 Scrubbers retrofits were 1.2-1.8x as expensive as on new units
- Transport and Storage
  - How do you transport the CO_2 offsite in populated areas

Part II:
Financing CCS

Project Financing Elements



- Higher cost??
- Reduced carbon emissions

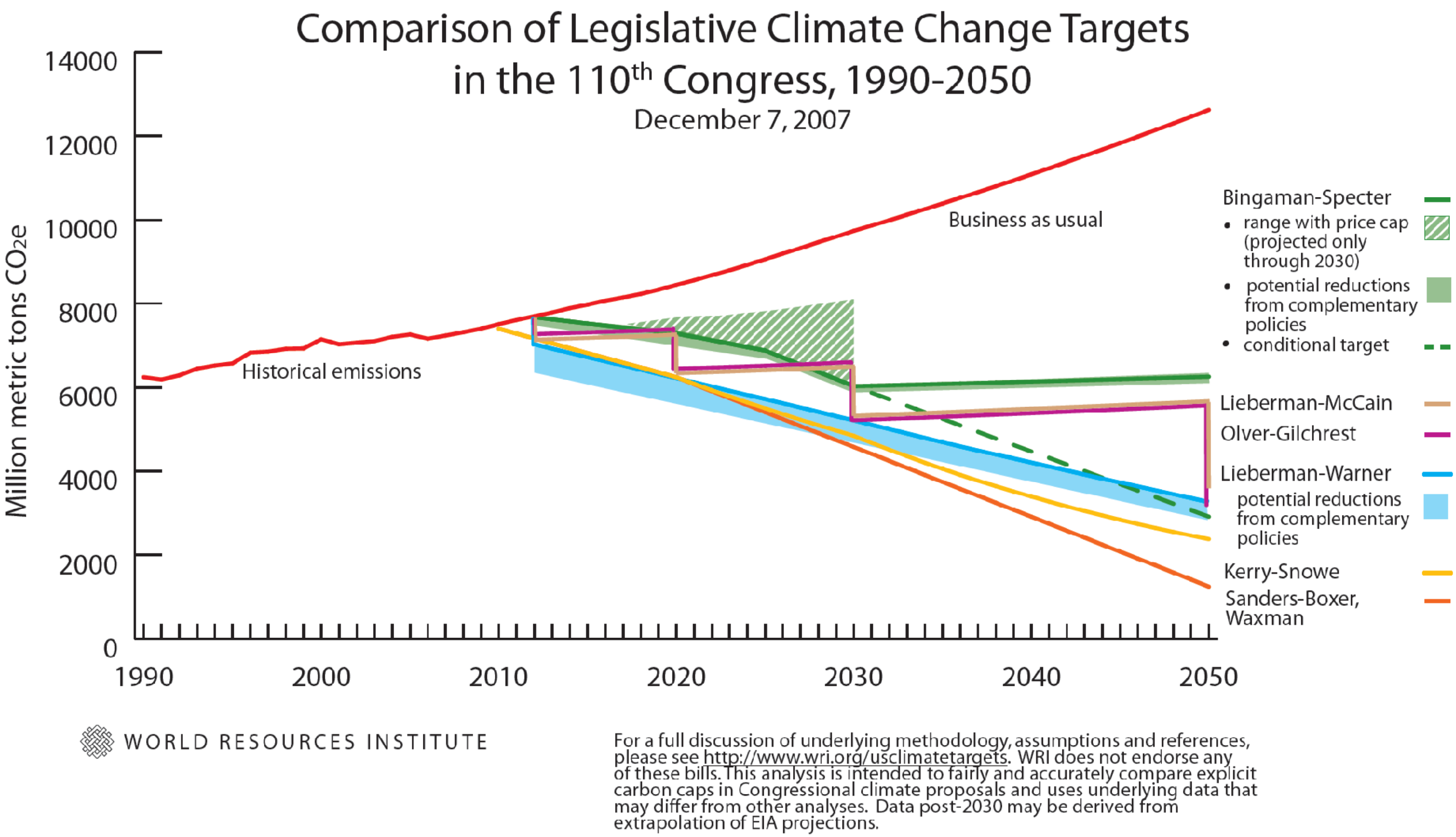
Source: Scully Capital

Sources of Funding/Economic Incentives

Funding Commercial-scale Projects will Likely Require a Combination of:

- Carbon price
- Carbon Tax/Allowance Proceeds
  - Lieberman-Warner R&D and Bonus Allowances
- Utility funding
- Federal funding
- State Incentives
  - E.g., Indiana – expedited processing, extra 3% rate of return on equity, incentives for Indiana fuels for gasification, CWIP for environmental investments
- Venture investment
- Risk Sharing Funds

U.S. Climate Policy Proposals Focus on Cutting Emissions Significantly Below Historic Levels



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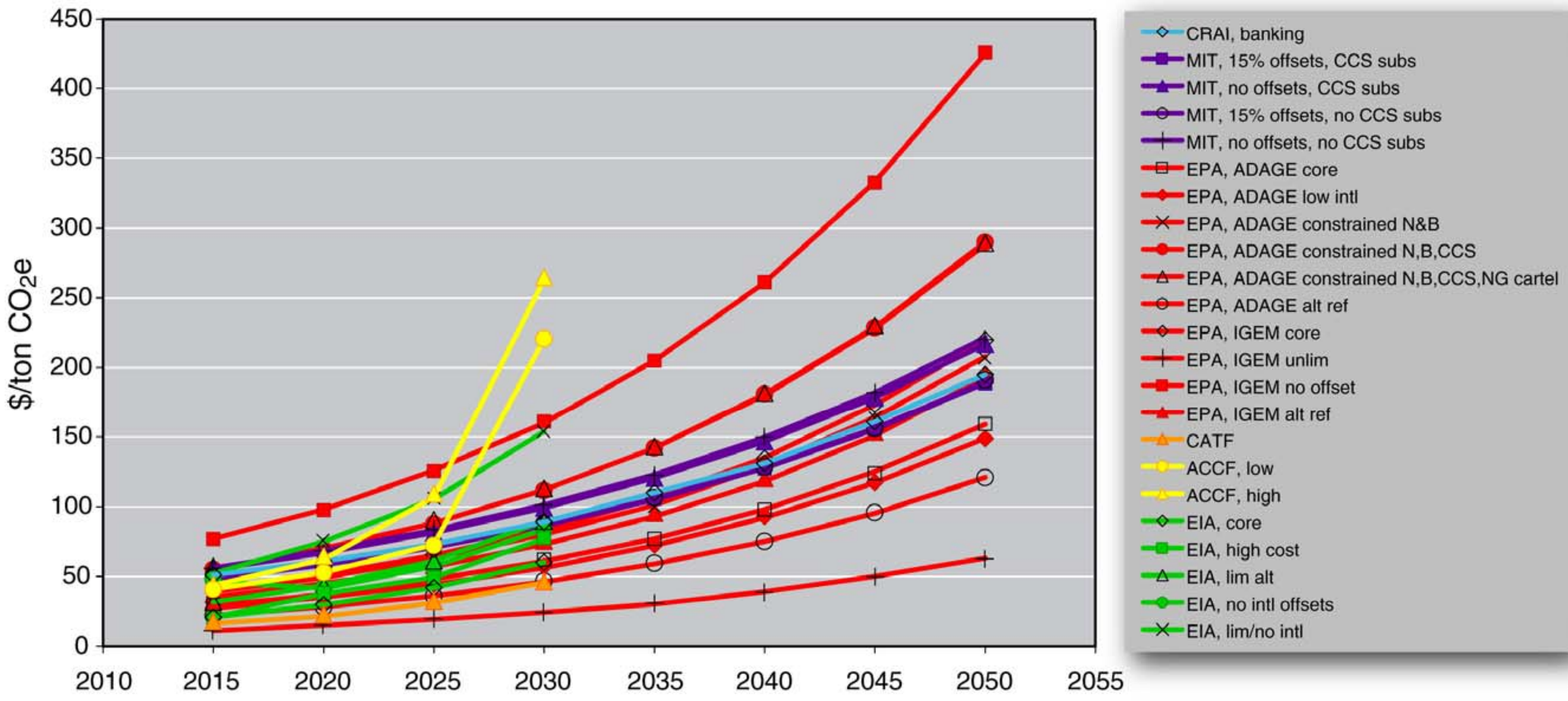
Elements of Lieberman-Warner Climate Security Act of 2007

- Economy-wide Coverage – about 87% of 2005 emissions
  - Downstream on coal (units > 5,000 tons/yr)
  - Upstream on oil, gas, F-gases, N_2O
- Cap-and-trade system
  - 22.5% auction phasing to 69.5% by 2030
  - Permits/auction revenues designated for a wide array of uses
- Permits to support CCS development and deployment
  - CCS Technology Fund – 1% of permits auctioned (120 days after enactment through 2022) to "kick-start" CCS
    - Goal: Rapid deployment of 5-10 commercial scale electric generation plants with CCS
  - Bonus Allowance Account – 3-4% of permits 2015-2030, 1% of permits from 2031-2050.
    - Goal: Provide bonus permits to qualifying CCS plants – maximum of 2 bonus permits annually, declining over time

And the Cost of Lieberman-Warner 2007 (L-W) is ….



For more information on L-W Cost Estimates, see www.epri.com

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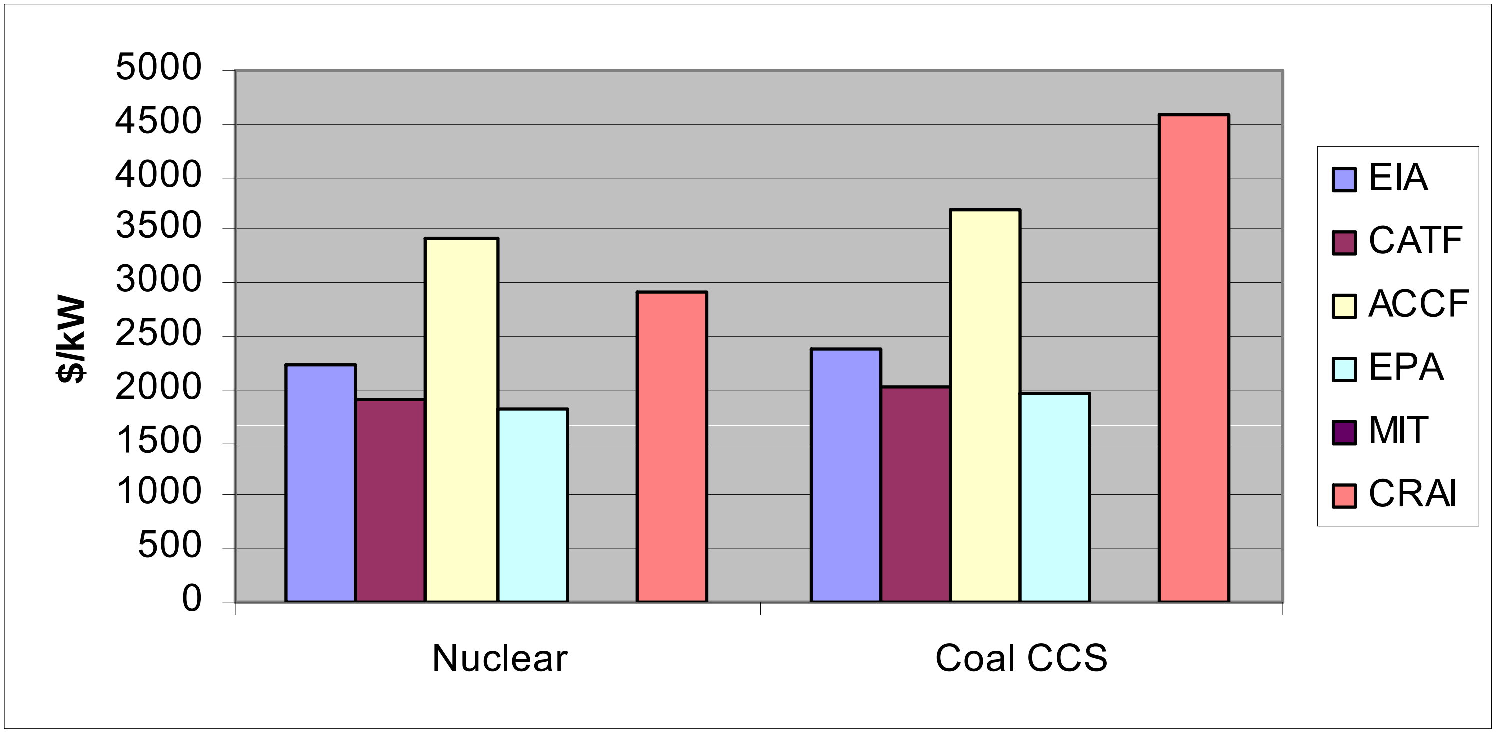
Reported and Guesstimated Technology Cost Estimates for L-W Analyses

Overnight Capital Cost (2008$/kW)



Caveats: Converted to 2008$

CATF= AEO2007, EPA/IPM= AEO2005, CRAI= updated AEO2007

Some costs decline rapidly over time, e.g., CRAI Coal CCS to $3203/kW by 2050

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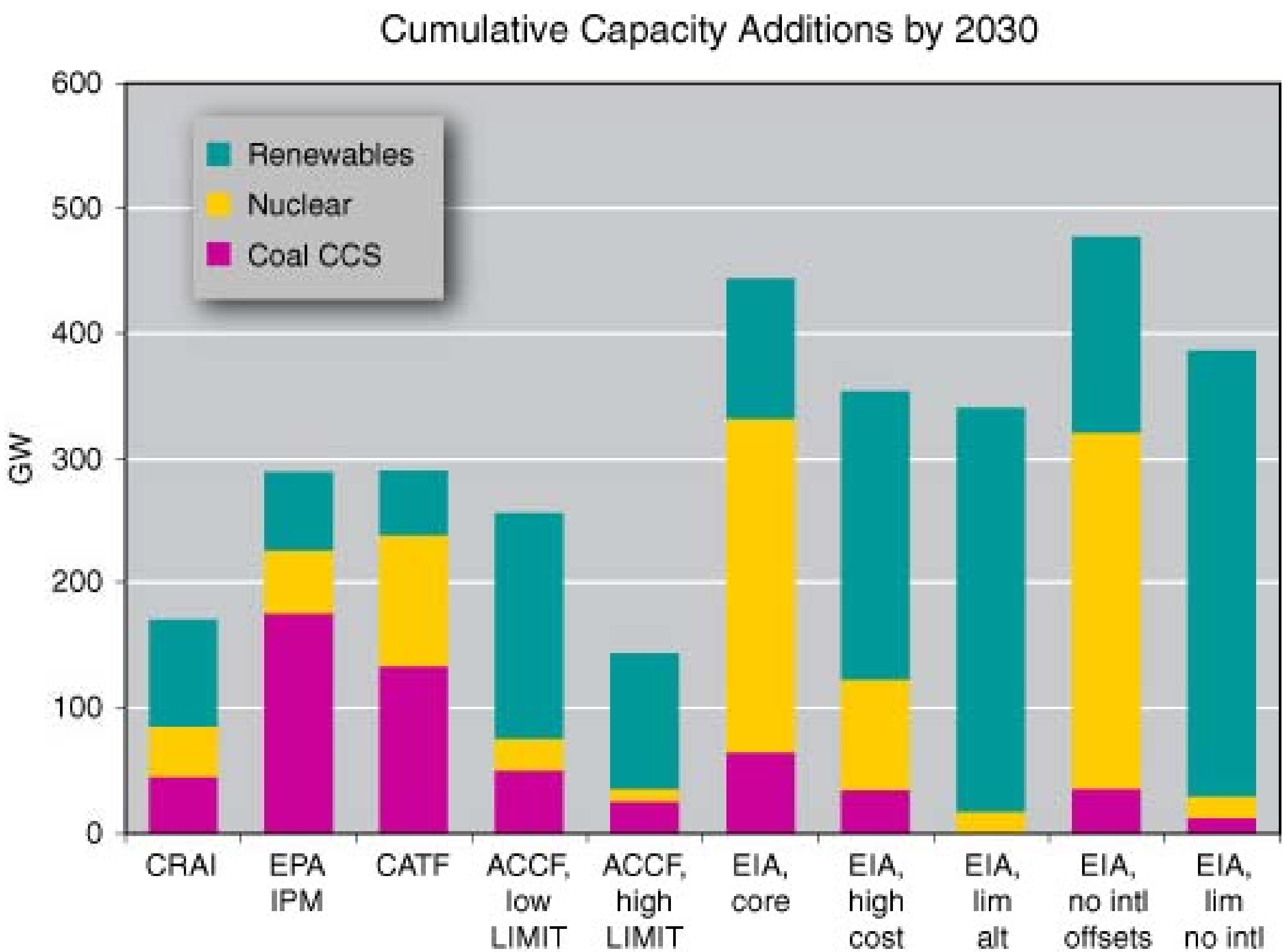
Cumulative Capacity Additions of Coal CCS, Nuclear and Renewables … includes no CCS Retrofits



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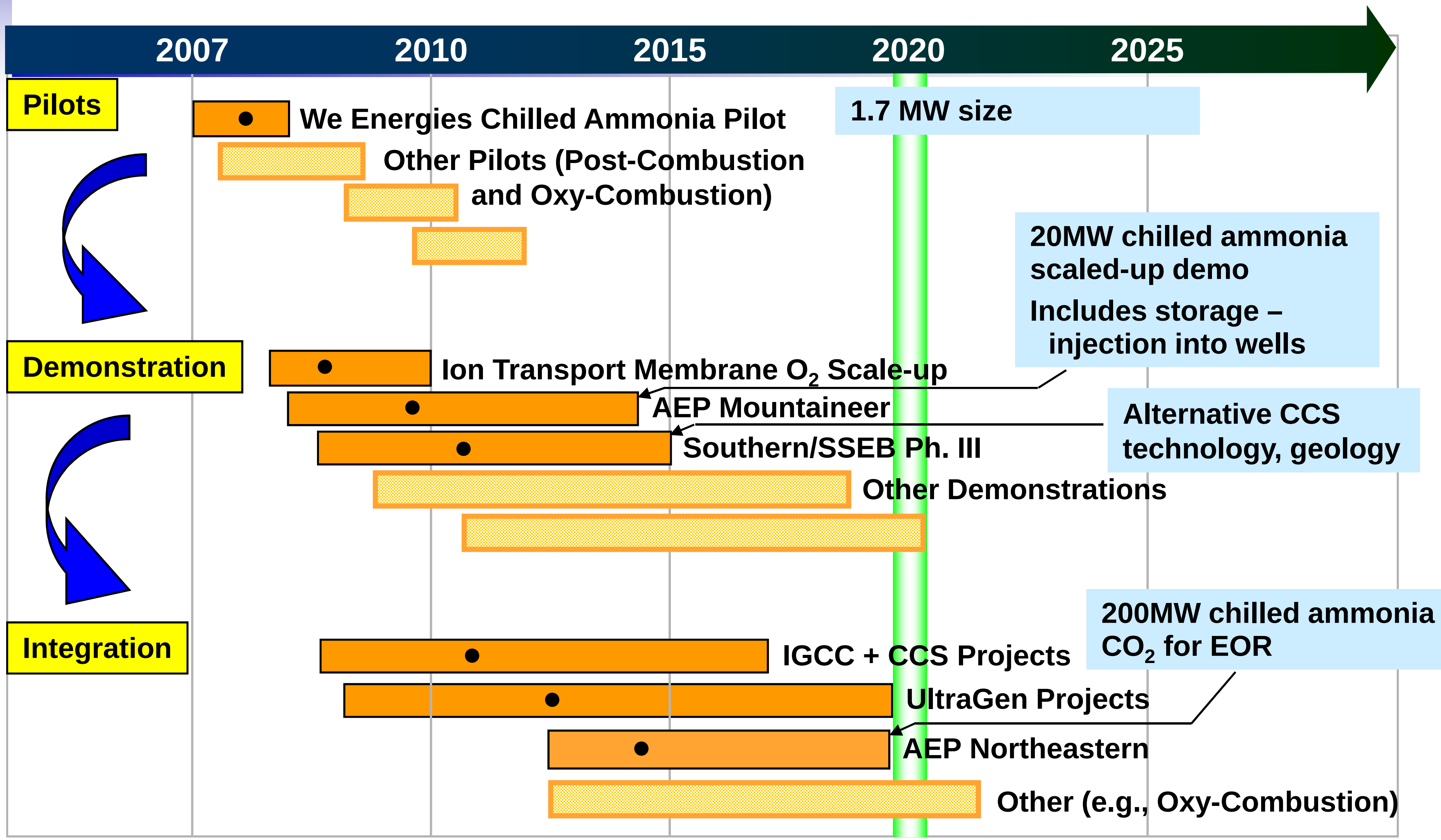
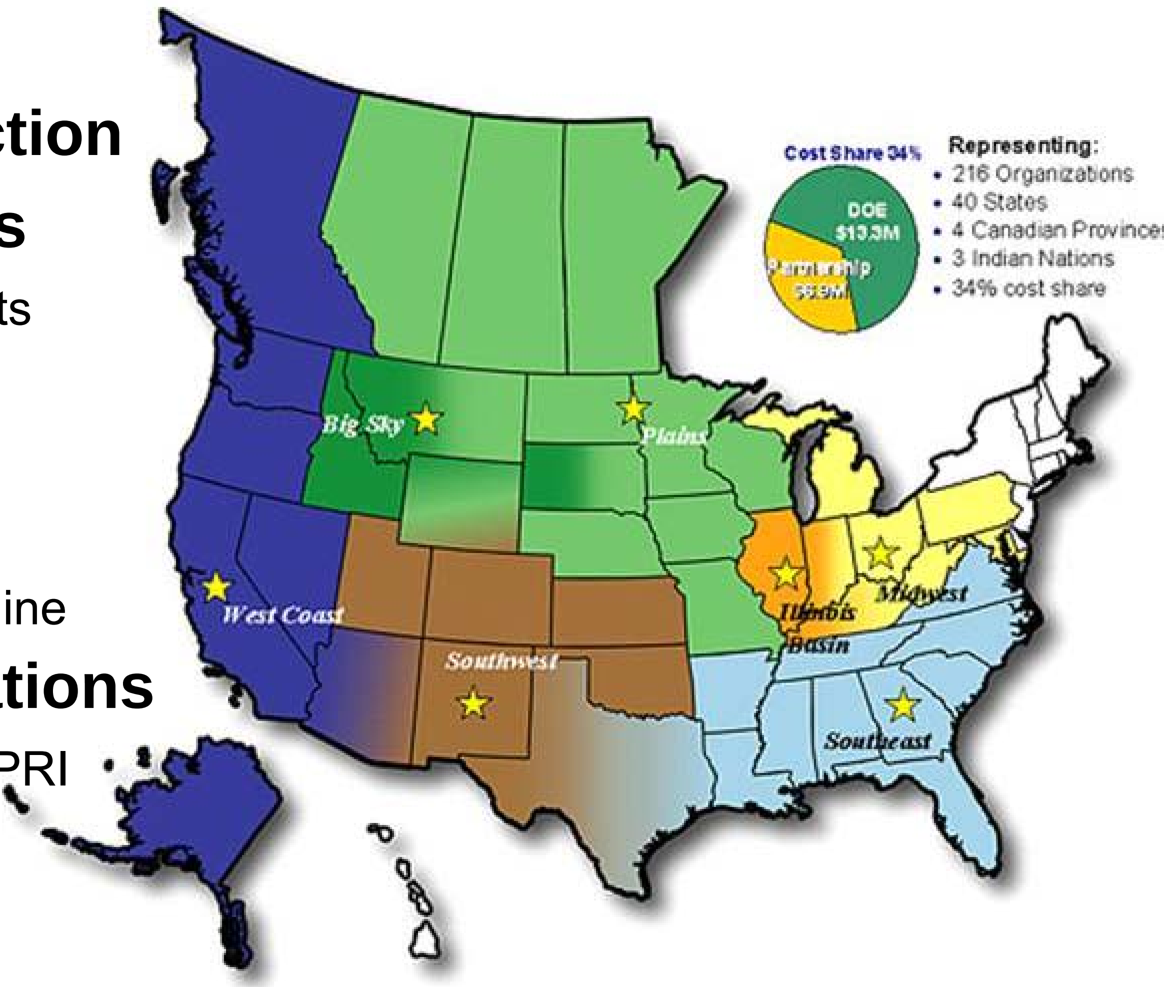
Part III:
Demo Activities



Goals – Affordable, Energy Efficient, Accepted

DOE Regional Carbon Sequestration Partnerships

- **Phase 1: Data collection**
- **Phase 2: Small pilots**
  - 22 Geologic Injection Tests
    - 8 EOR/Saline
    - 6 Saline reservoirs
    - 8 ECBM/EGR
  - EPRI involved in three saline
- **Phase 3: Demonstrations**
  - Several possibilities for EPRI involvement



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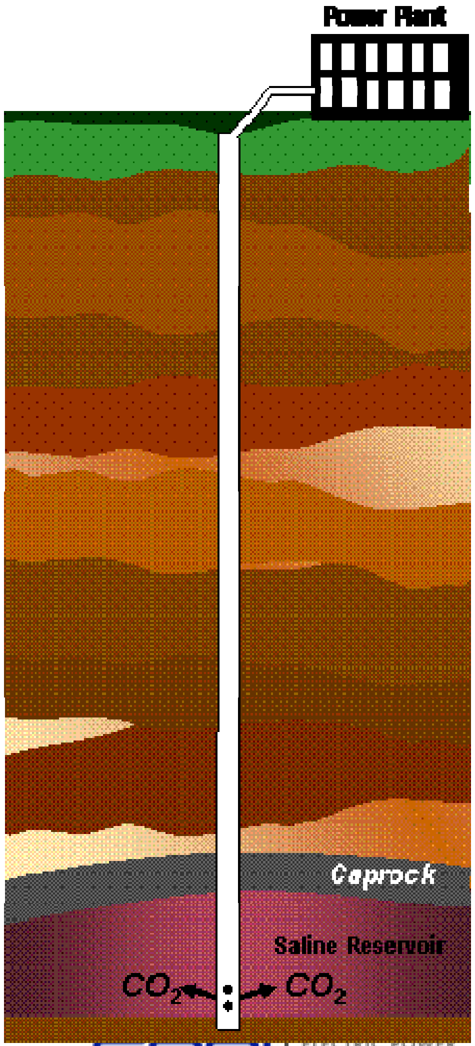
DOE Phase 3 Update

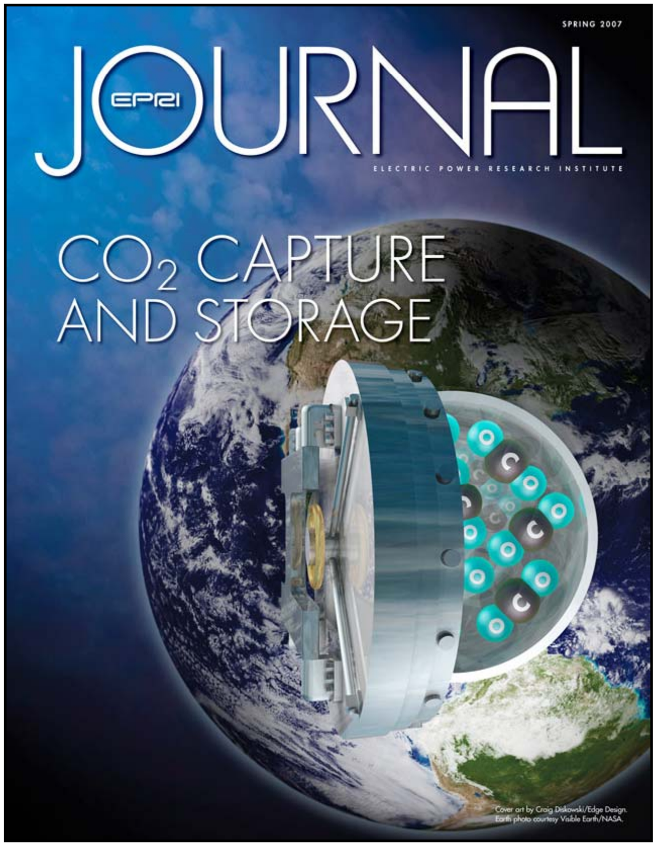
- **WESTCARB**
  - Original focus on BP Carson project, changed to Clean Energy Systems (CES)
  - 500k t/y for 4 years starting in 2010
- **SECARB**
  - Two part injection into same saline reservoir in two geologically separate locations
  - Cranfield: Purchased CO_2 @ 1Mt/y for 1.5 y
  - Another test: Inject 100-250 kt/y from a CO_2 capture pilot located at a Southern Company site



Concluding Thoughts

- CCS is a critically important technology to the U.S.
  - Large coal reserves
  - Large potential sequestration potential
- In the U.S., cost of coal with CCS (and other generation technologies) has ~doubled since 2000
  - CCS retrofit is being considered
- Lieberman-Warner could produce CO_2 price and incentives sufficient to spur CCS deployment, but need investment now for technology to be commercial by 2020

Questions?



See EPRI Journal Summer 2007 and Recent Congressional Testimony

Contacts

Tom Wilson – twilson@epri.com

General – askepri@epri.com

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ICO2N

The Integrated CO_2 Network: A Path Forward for Carbon Capture & Storage

May 28, 2008

Suncor Energy · TransAlta · Sherritt · Agrium · Air Products · Nexen · EPCOR · OPTI Canada Inc. · StatoilHydro · Shell · Husky Energy · ConocoPhillips · Syncrude · Esso Imperial Oil · Total · Canadian Natural · Chevron · Keyera

Agenda

- Introduction of ICO_2N
- Canadian Dynamic
- Policy Development
- Partnership as the path towards deployment

ICO_2N Overview

ICO$_2$N

- **18 leading companies from a variety of industries**
- **Represents:**
  - >100 Mt/yr of CO_2 emissions, 15% of Canada's emissions
  - >60% of Alberta's power generation
  - ~95% of oil sands production

ICO_2N's Mandate

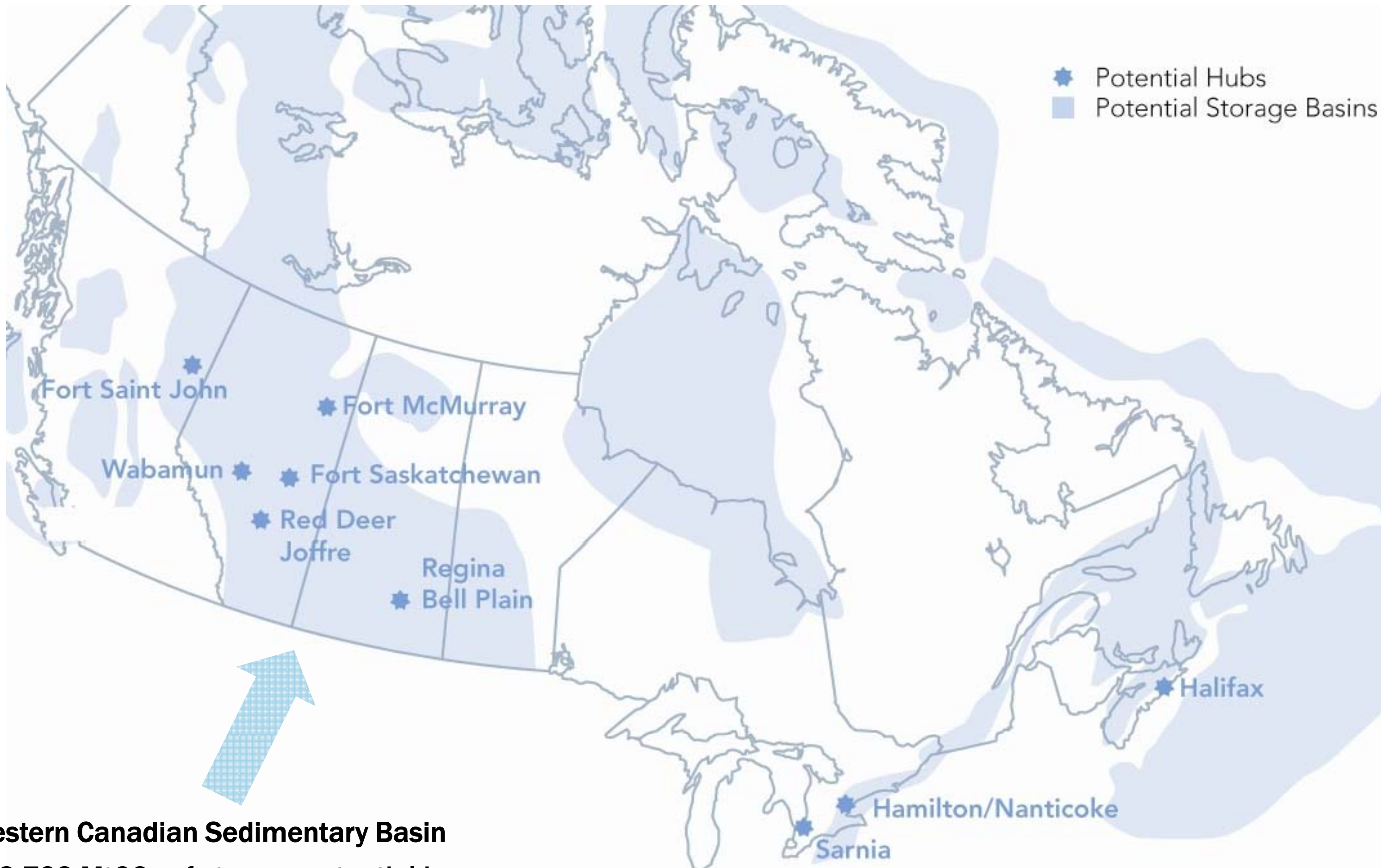
OBJECTIVE: ***Work proactively with governments and stakeholders to establish policy and risk-sharing for CCS that will encourage uptake in the near term***

and

set the stage for a functioning long-term Integrated CO_2 Network (ICO_2N) that can handle large volumes at minimal overall cost

The Canadian Dynamic

Long-term Vision of CCS Across Canada

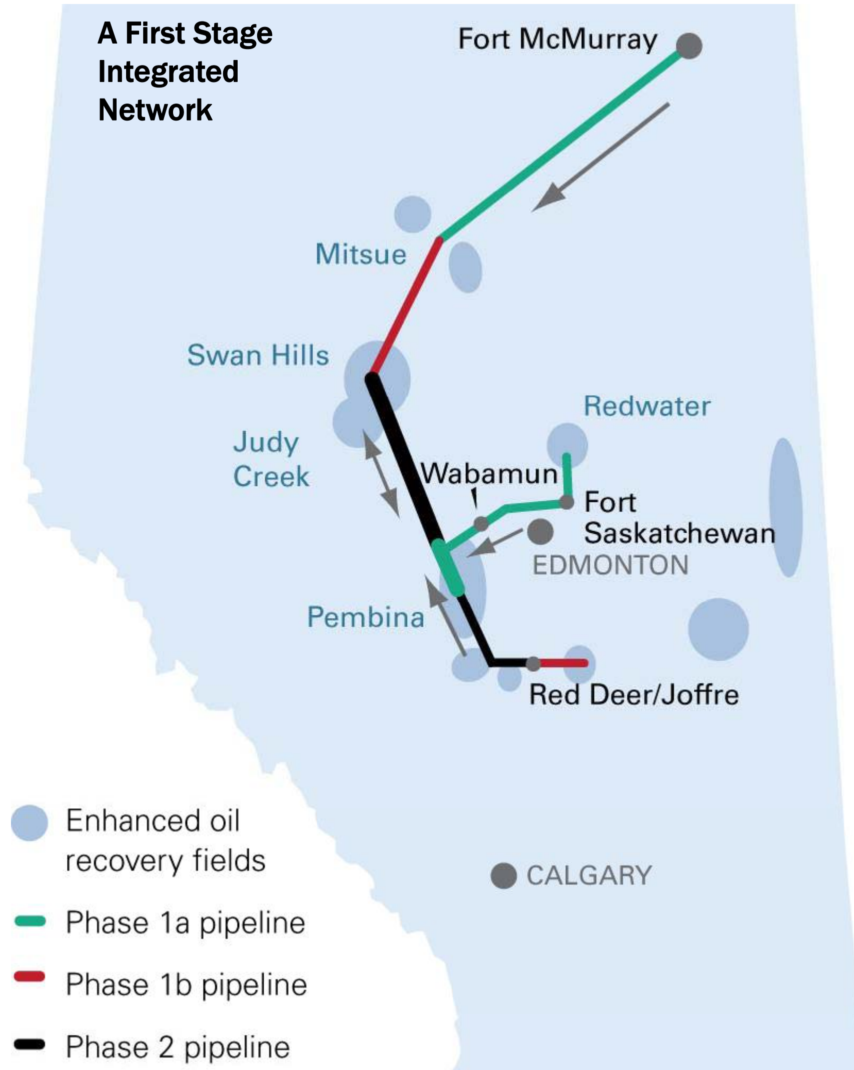


Western Canadian Sedimentary Basin

- 3,762 $MtCO_2$ of storage potential in oil and gas reservoirs alone

ICO$_2$N's Long-term Vision

A large-scale, long-term vision is essential to realize the full potential of CCS



CCS is Important

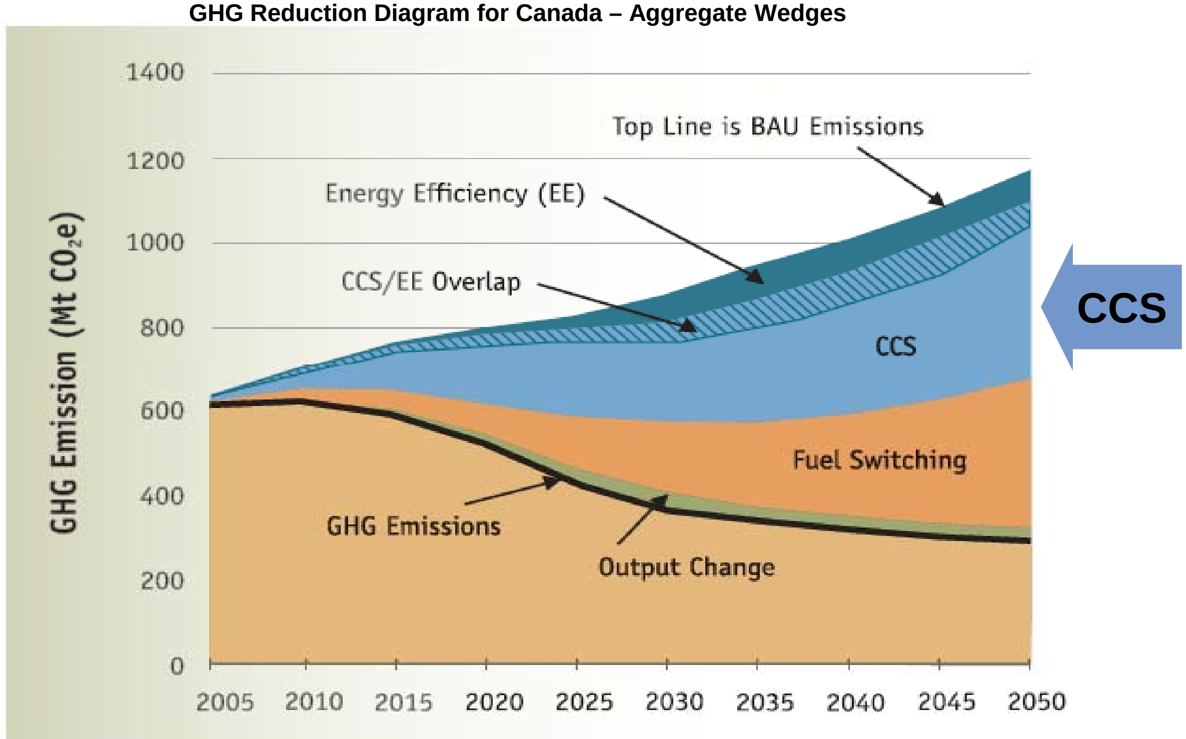
A Strategic Investment for Canada

1. **A critical component of Canada's GHG reduction strategy**

2. **A critical component of Canada's energy strategy**
   - ➢ Balancing economics with GHG reduction
   - ➢ Coal & Oil

3. **A 'Made in Canada' solution**

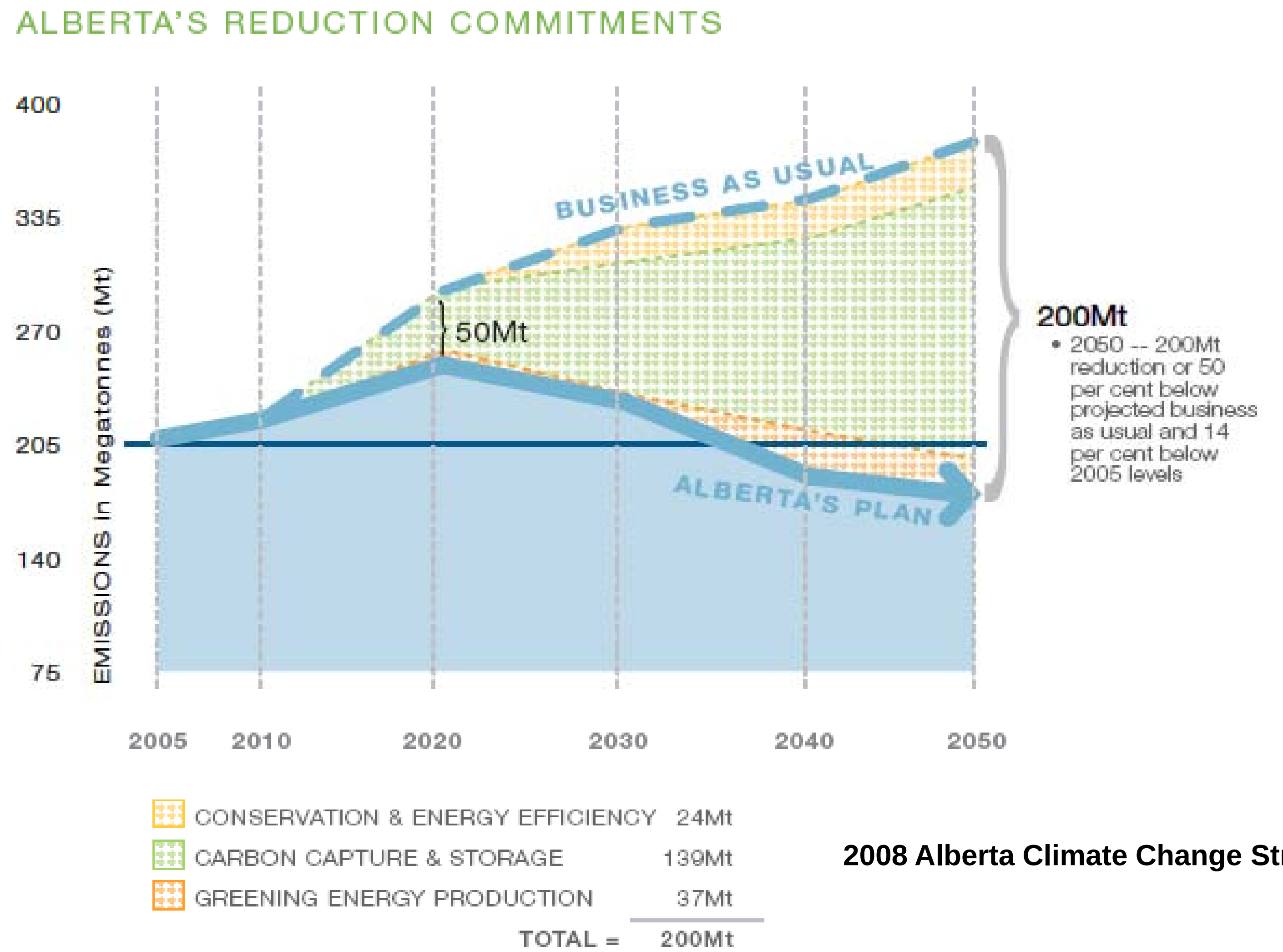
GHG Reduction Diagram for Canada – Aggregate Wedges



Source: NRTEE 'Getting to 2050: Canada's Transition to a Low-emission Future", 2008

ICO2N

The Alberta government emphasis on CCS….



2008 Alberta Climate Change Strategy

Politics

Canada is a Confederation

Canada is a federal state, however it is among the world's most decentralized federations

Jurisdictional issues are making timely adoption of a climate change policy challenging

ICO2N

National Climate Policy

National plan for 20% below 2006 emissions by 2020

- 330Mt from BAU projections
- 165Mt from industry with a focus on coal and oilsands

Industry targets:

1. Existing facilities (pre-2004)
   - 18% intensity reduction in 2010, decreasing by 2%/yr thereafter
2. Facilities operational between 2004 & 2011
   - Clean fuel (nat. gas) standard
   - 3 years to set emissions baseline, then 2%/yr intensity reduction
3. Facilities operational 2012 onwards
   - Clean fuel standard or CCS 'capture ready'. CCS equivalent by 2018

Canadian Provinces

Many Climate Change plans

- **Quebec**
  - Focus on hydroelectric
- **Ontario** – Phase out coal
  - Focus on Nuclear and natural gas
- **British Columbia** - 33% reduction by 2020 - Net zero electricity by 2018.
  - Carbon tax
- **Alberta** – operational cap and trade system (mid-2007)
  - Intensity targets, but less than federal

Alignment with the US

- Western Climate Initiative:
  - Quebec, Manitoba, British Columbia are members
  - Ontario and Saskatchewan as observers
- RGGI – Quebec and Eastern Provinces are observers

Policy to incent CCS Development

Canada/Alberta Task Force

- Reported to governments in January
- Goal of 5Mt by 2015
- $2B needed to cover the gap on the first 3-5 projects (allocated through an RFP)

Federal

- $125M RFP for large-scale CCS projects. Matching funds from industry and max government contribution of $30M
- $250M for SaskPower retrofit of a 100Mw coal-fired power plant
- Pre-certification credits to help cover the gap

Alberta

- Industry led 'Development Council' reporting back fall 2008
- Location of majority of future CCS activity

Current CCS Operations in Canada

Weyburn / Midale

- 2 Mt/yr CO_2 from gasifier in N. Dakota via 320km pipeline to EOR in SE Saskatchewan

SaskPower – Boundary Dam

- Retrofit 100 MW coal fired power plant with delivery to Weyburn area
- $250M Federal and $750M provincial funding announced

Glencoe

- Commercial project of 0.18Mt/yr - combining EOR & low cost CO_2

Proposed full scale projects

- TransAlta and EPCOR each moving ahead with CCS FEED studies
- Northwest Upgrading – gasifier to incorporate CCS (awaiting financing)
- Sherritt coal gasifier – on hold 'because of uncertainty'

Overcoming CCS Inertia

Overcoming CCS inertia

1. Investment Risk

- Large capital expenditures up front
- Uncertain policy future
- Early adoption may not pay

2. Technology Risk

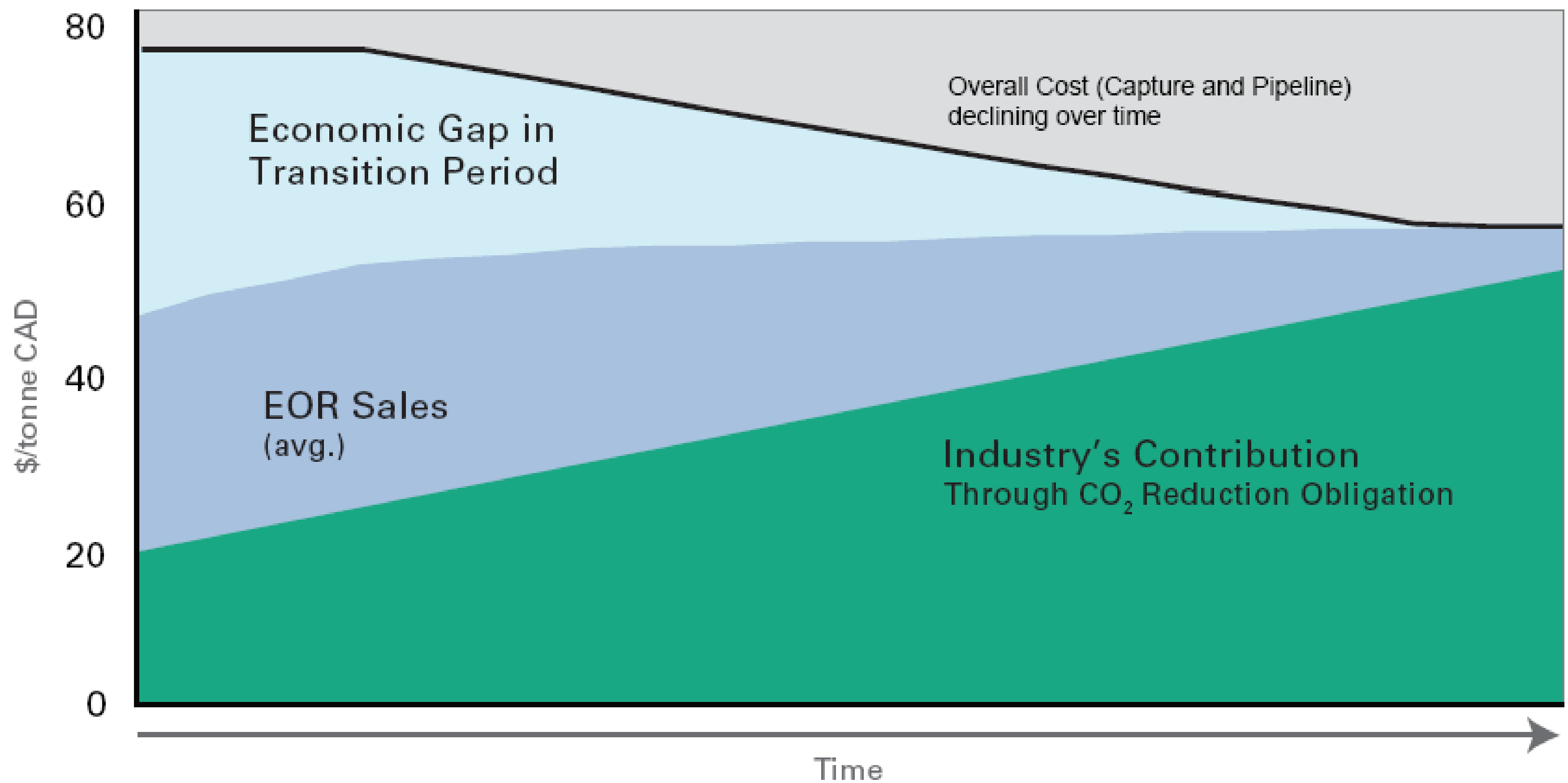
3. Economics

- Economic gap in foreseeable future
- Questionable EOR revenue sources

ICO2N

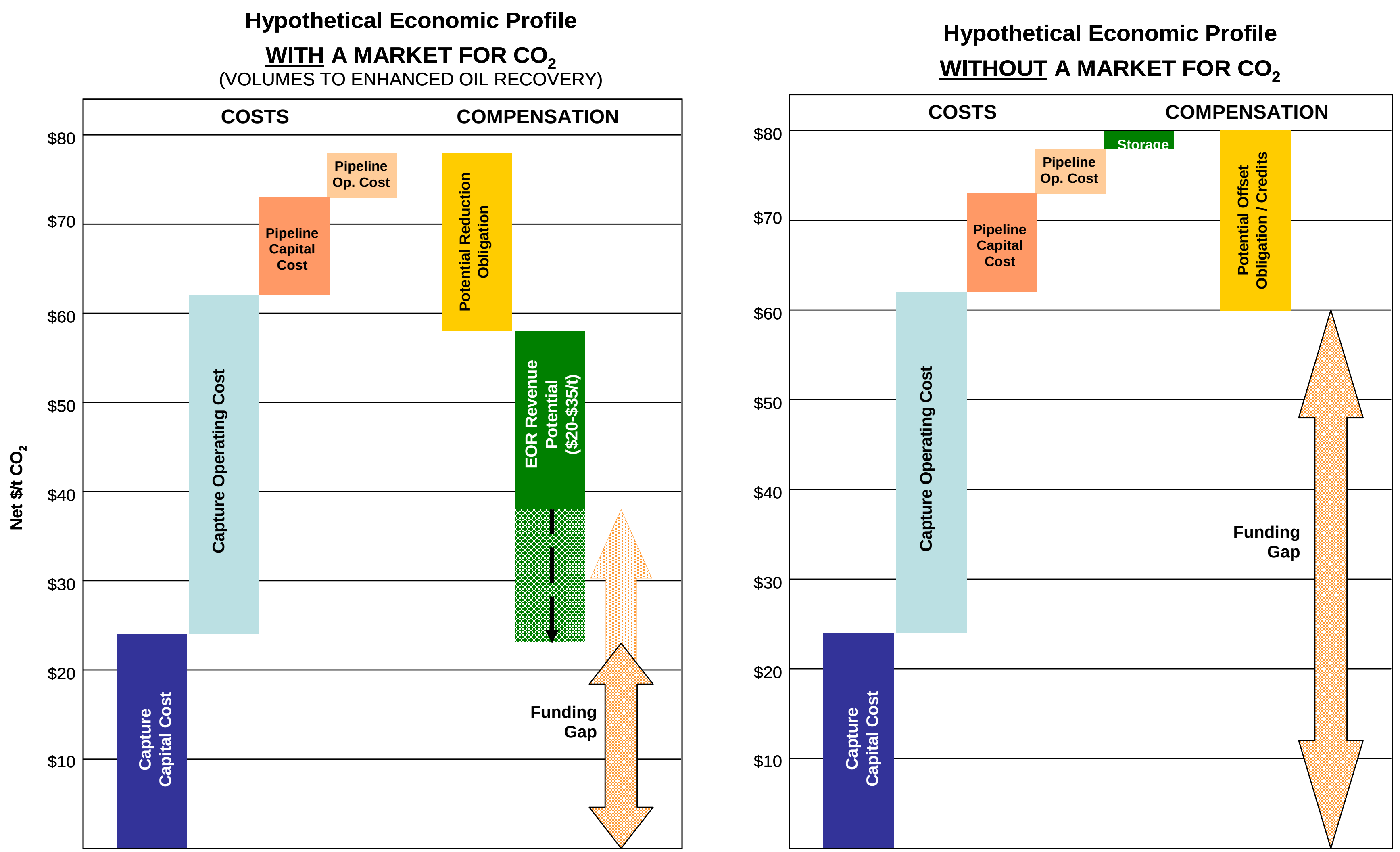
A Case for Partnership

Conceptual Portrayal of CCS Economics



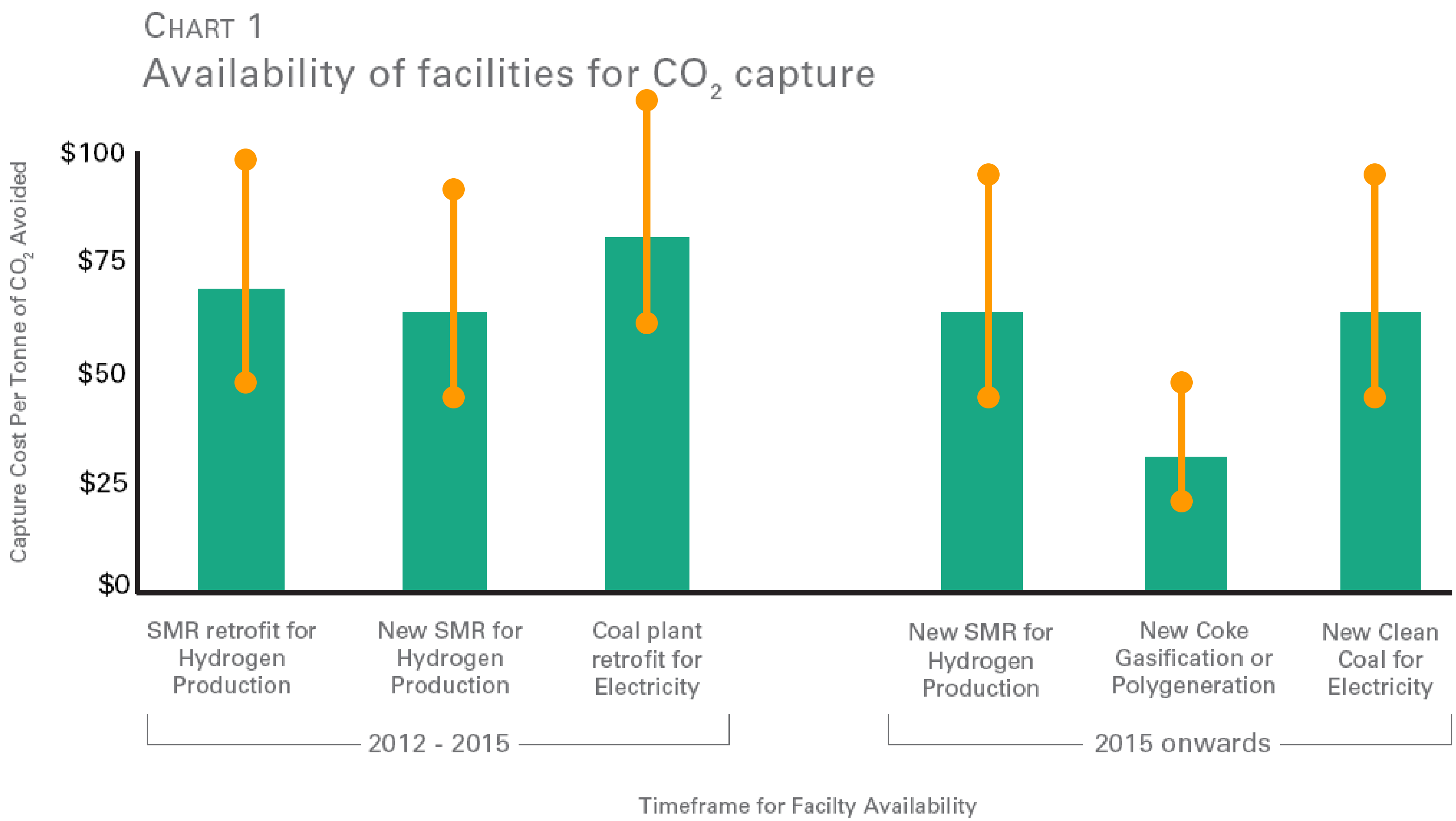
ICO2N

Conceptual CCS Economics



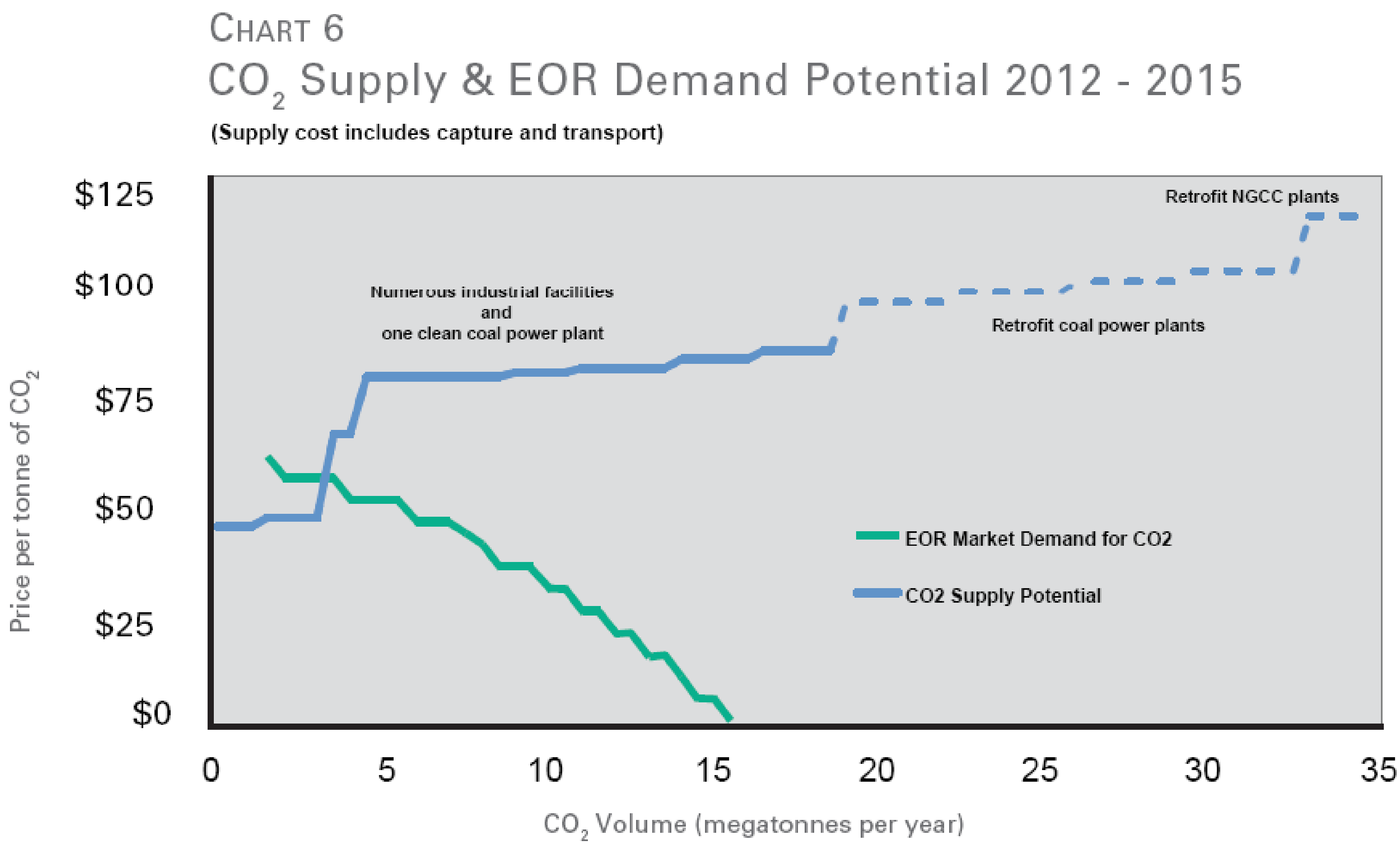
ICO2N

Capture Costs for Canada



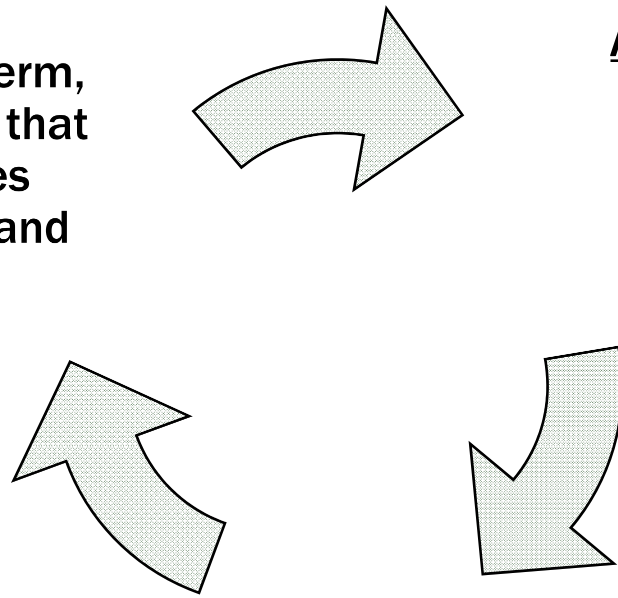
Notes: - Error bands are +50% -30%, better cost estimates will be site specific.
- Includes compression, excludes pipeline or injection/storage/monitoring costs

Balancing Supply and Demand



ICO_2N's Key Principles to Make CCS a Reality

<u>GOAL</u>: The staged development of a long-term, large-scale CCS solution that strategically addresses environmental, energy and economic growth.



<u>APPROACH</u>: A strong public-private partnership to drive initial deployment of an integrated approach to CCS

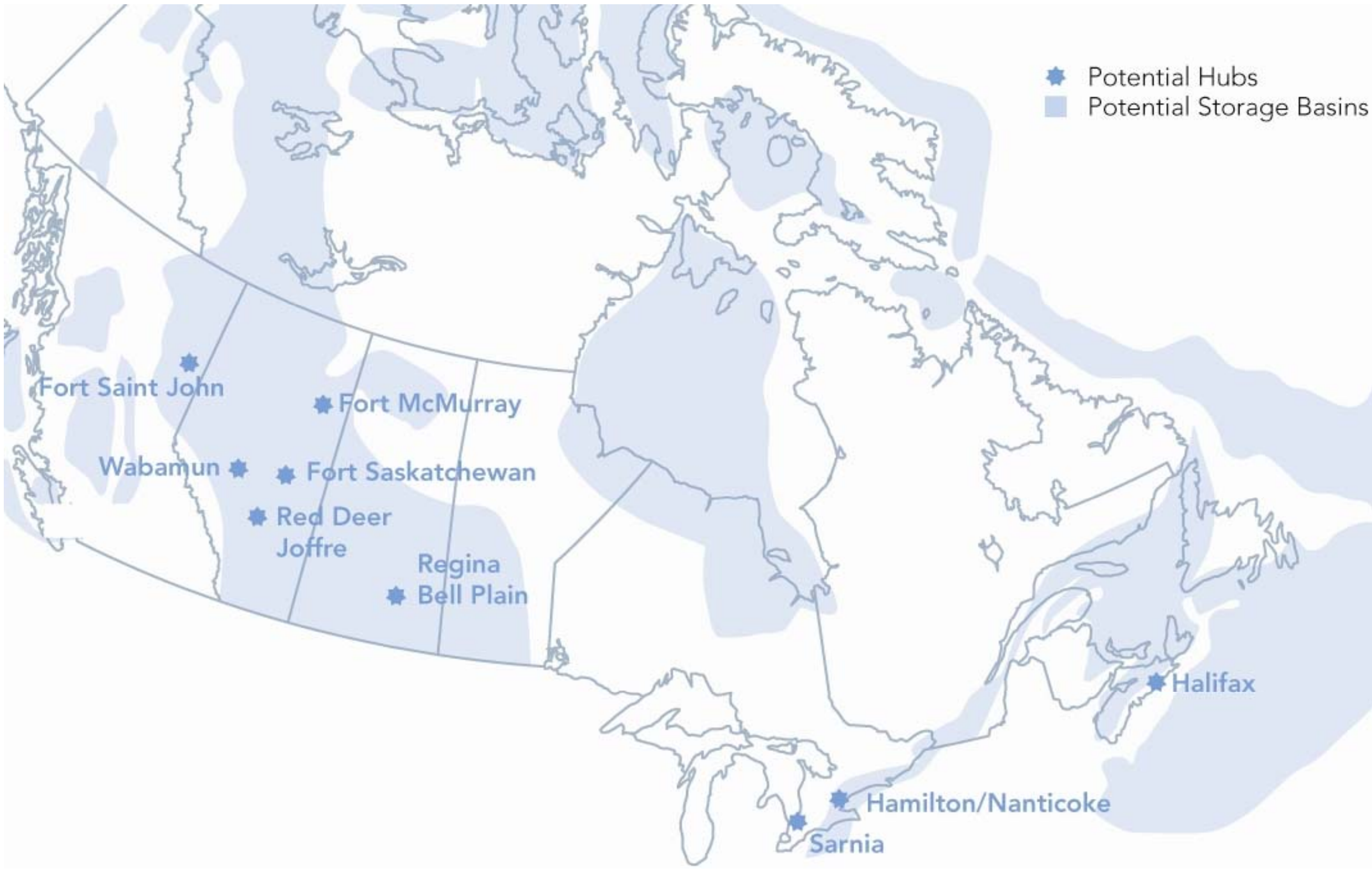
<u>IMPLEMENTATION</u>: Range of tools and policy innovation to encourage major investments in CCS

ICO2N

Moving Towards Deployment

- **Government direction on CCS has been established**
- **ICO$_2$N: Significant value in an integrated system.**
- **As much an oil sands issue as it is coal.**
- **Joint ventures a likely structure for initial deployment**
  - Spreads first-mover risk
  - Addresses issues of lumpy expenditures and timing
  - History of collaboration in the oil sector
- **Partnerships as the way forward**
  - Policy tools are being explored

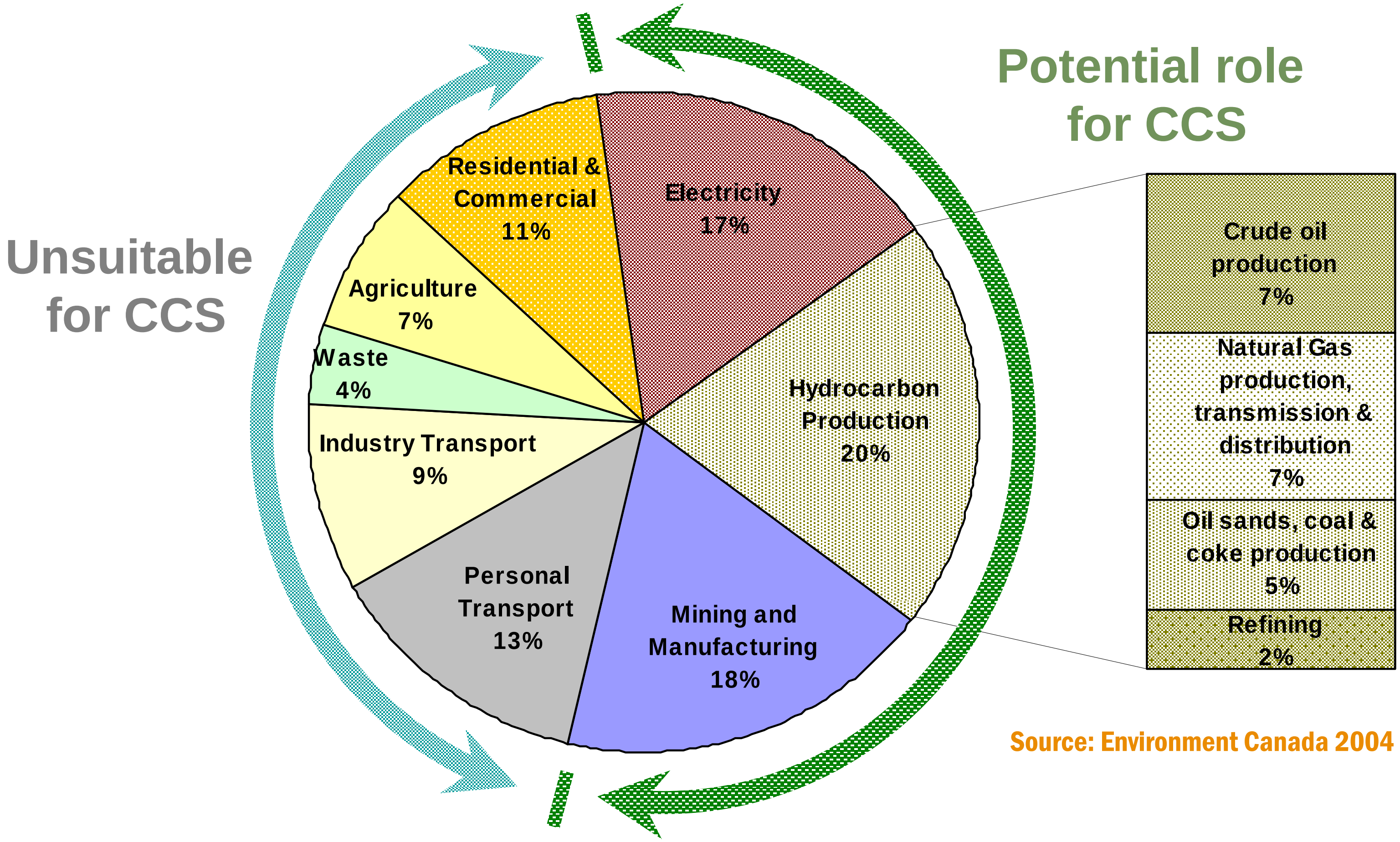
Canada: A potential leader in CCS deployment...



SUPPLEMENTARY INFORMATION

GHG Emission Sources in Canada

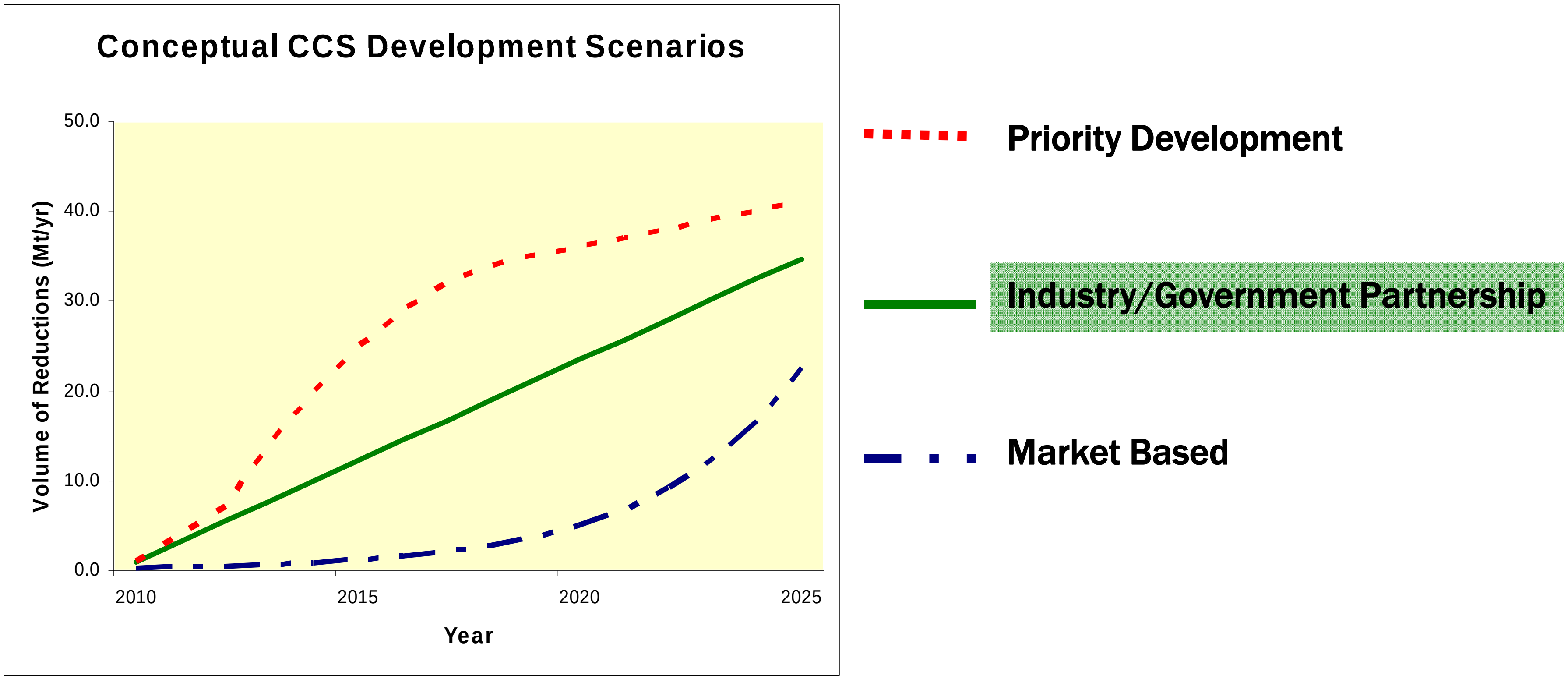
Only certain industries can pursue CCS



Source: Environment Canada 2004 CO_2 Emissions Inventory

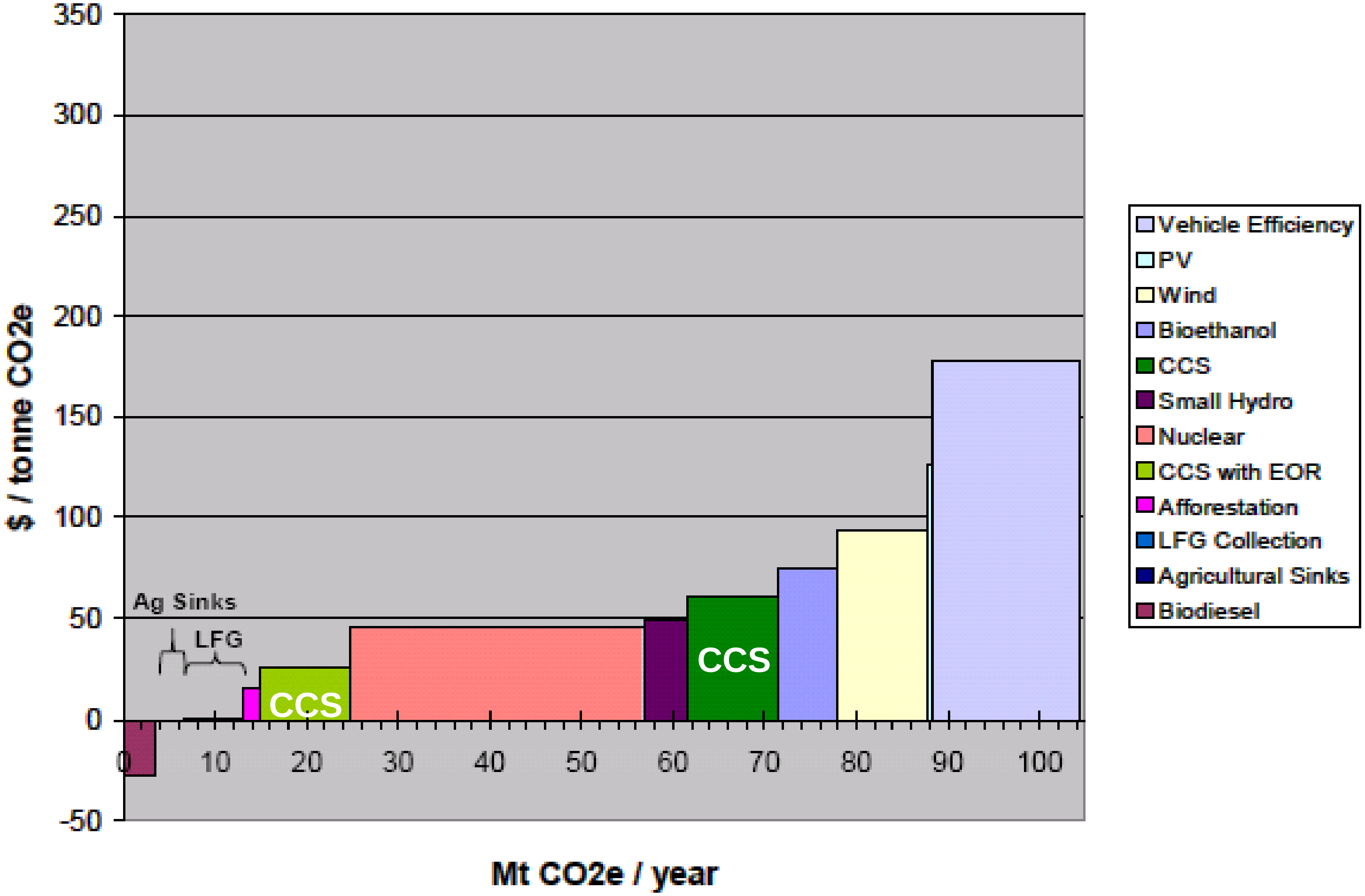
ICO2N

Vision of CCS Deployment:
Industry / Government Partnership



Choice of path affects ability to meet national emissions reductions and could protect energy sector growth.

CCS is cost and volume competitive



Delphi Report 2008

ICON2

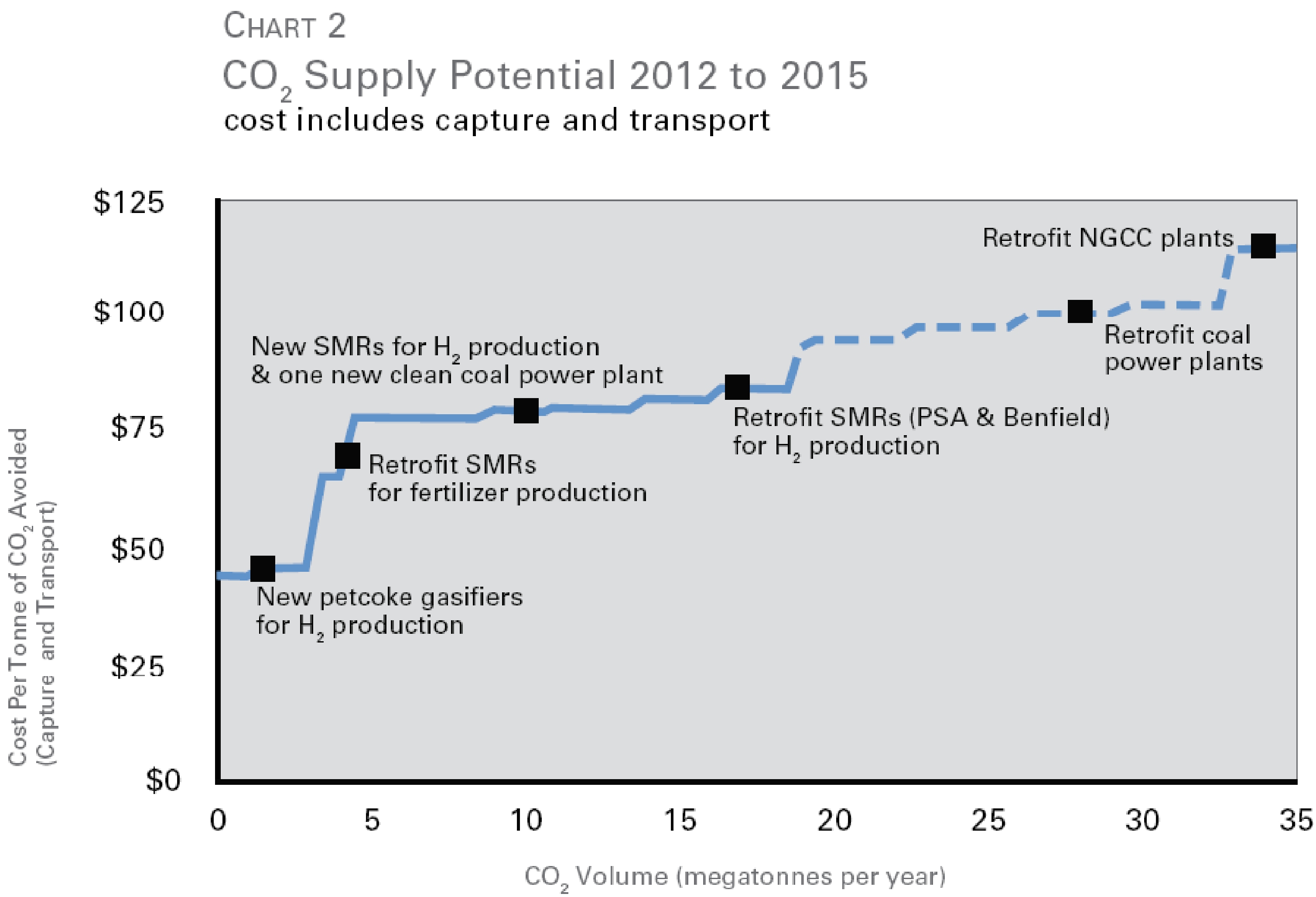
CCS – Nascent Market Development

	Mature Markets	Nascent Markets
Price disclosure	Open	Limited
Number of buyers and sellers	Many	Few of both
Transaction Costs	Usually low	Usually high
Supply/Demand Balance	Close	Can be widely divergent
Monopoly supply or demand	Infrequent	Typically an actual or effective monopoly
Market Growth rate	Low	High, and volatile
Technology	Mature, low rate of change	New, competing alternatives

CCS has characteristics of an immature market.
Government involvement can advance adoption.

Technology & Economics

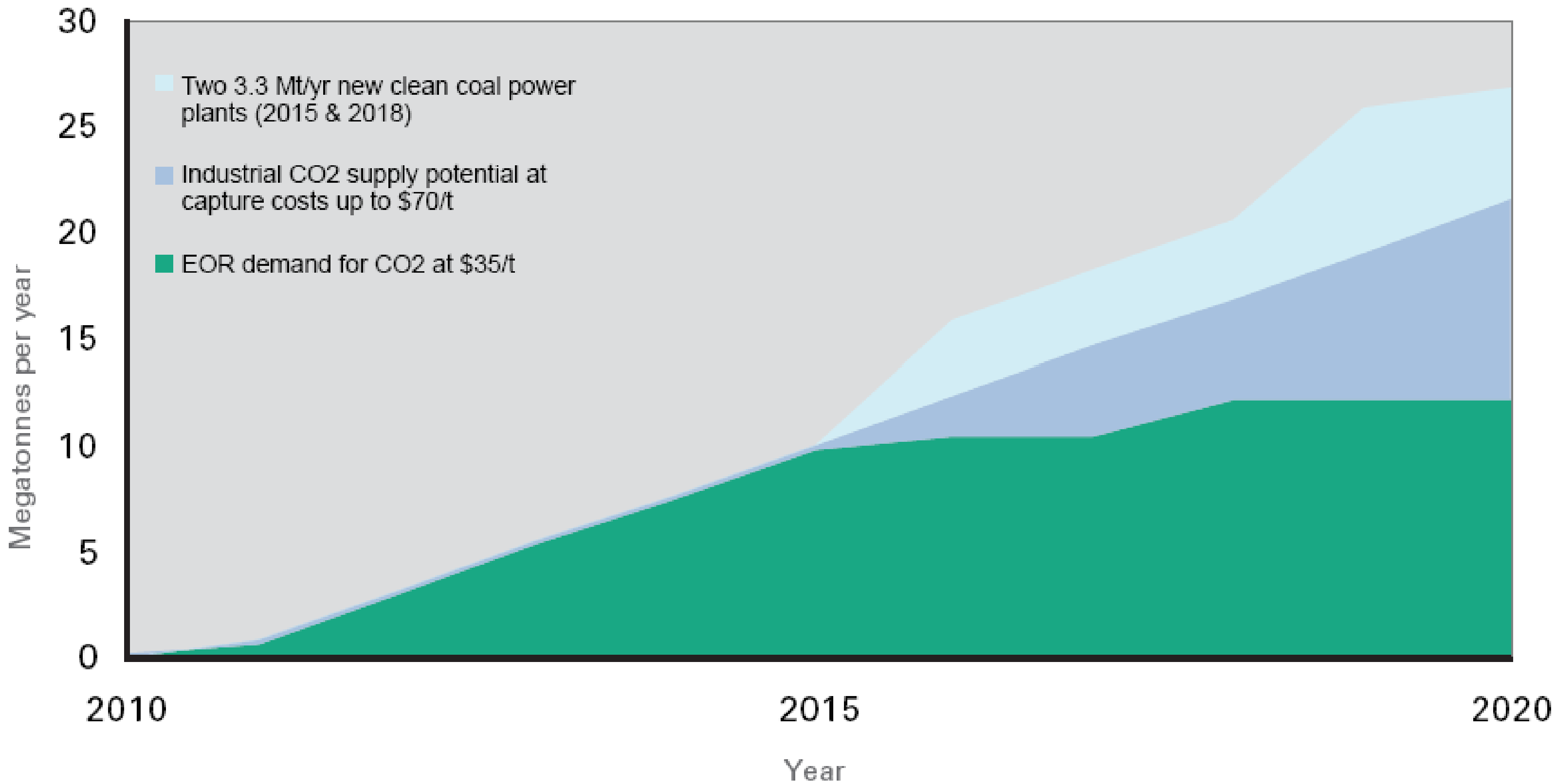
Capture Volumes



Issue of Oversupply

Chart 4

Conceptual Phasing of CCS

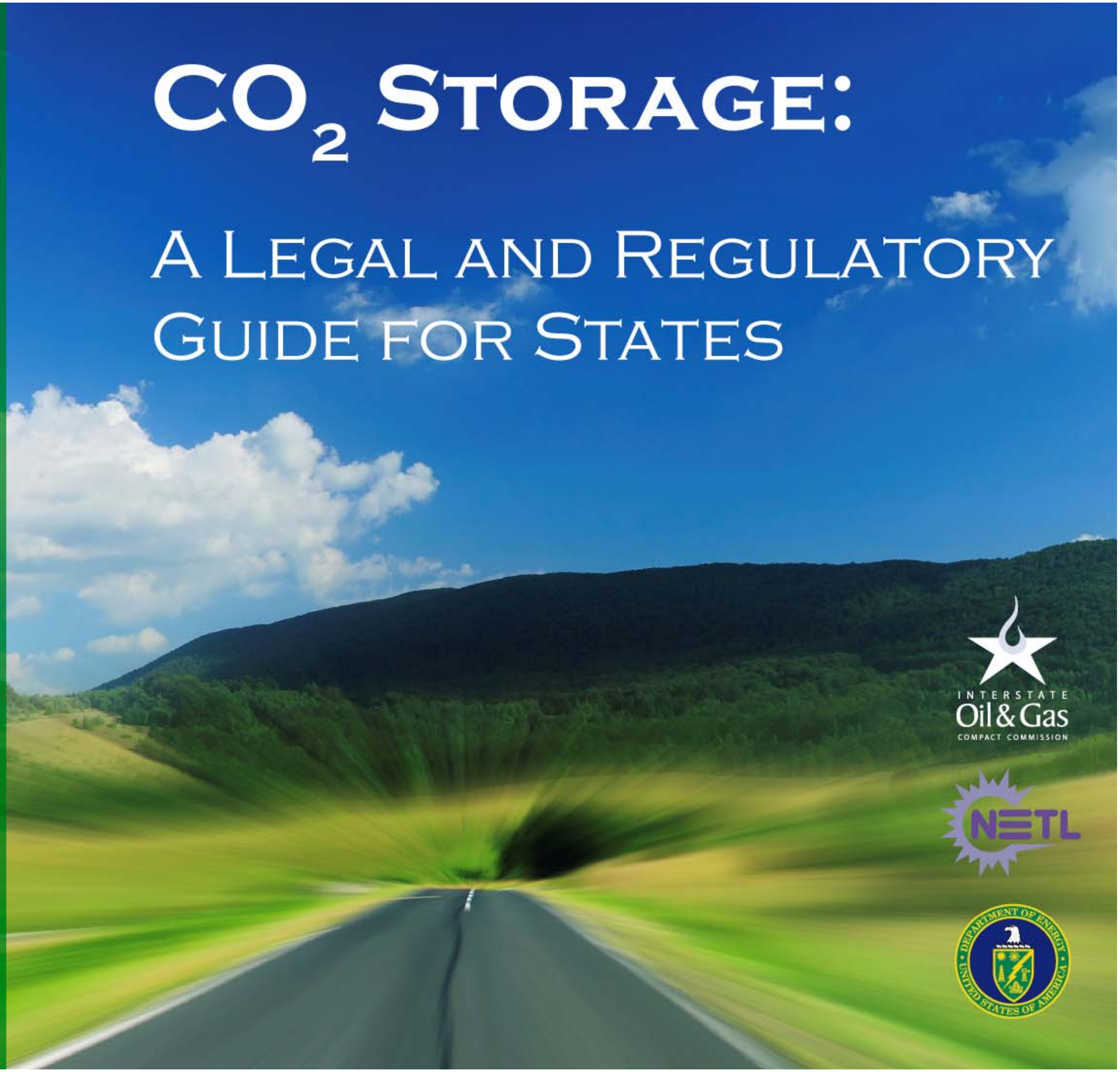


ICO2N

Road To A Greener Energy Future

CO_2 Storage:

A Legal and Regulatory Guide for States



Interstate Oil & Gas Compact Commission

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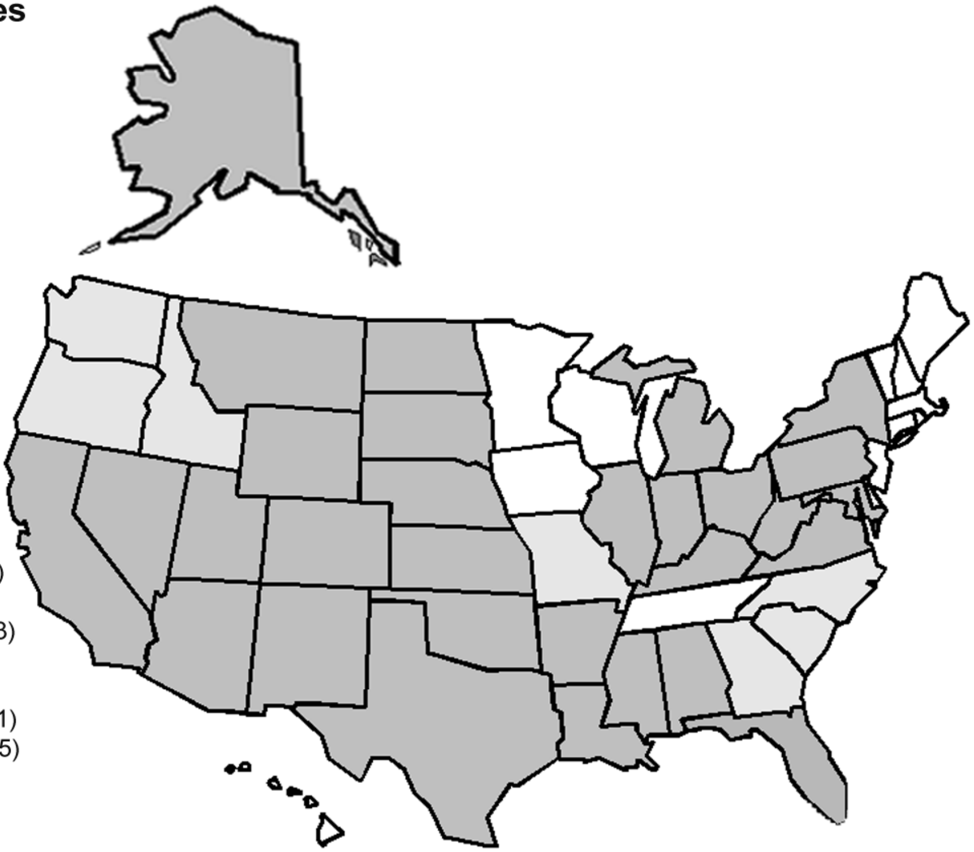
INTERSTATE OIL & GAS COMPACT COMMISSION

Member States

Alabama (1945)
Alaska (1957)
Arizona (1955)
Arkansas (1941)
California (1974)
Colorado (1935)
Florida (1945)
Illinois (1935)
Indiana (1947)
Kansas (1935)
Kentucky (1942)
Louisiana (1941)
Maryland (1959)
Michigan (1939)
Mississippi (1948)
Montana (1945)
Nebraska (1953)
Nevada (1955)
New Mexico (1935)
New York (1941)
North Dakota (1953)
Ohio (1943)
Oklahoma (1935)
Pennsylvania (1941)
South Dakota (1955)
Texas (1935)
Utah (1957)
Virginia (1982)
West Virginia (1945)
Wyoming (1955)



Associate States

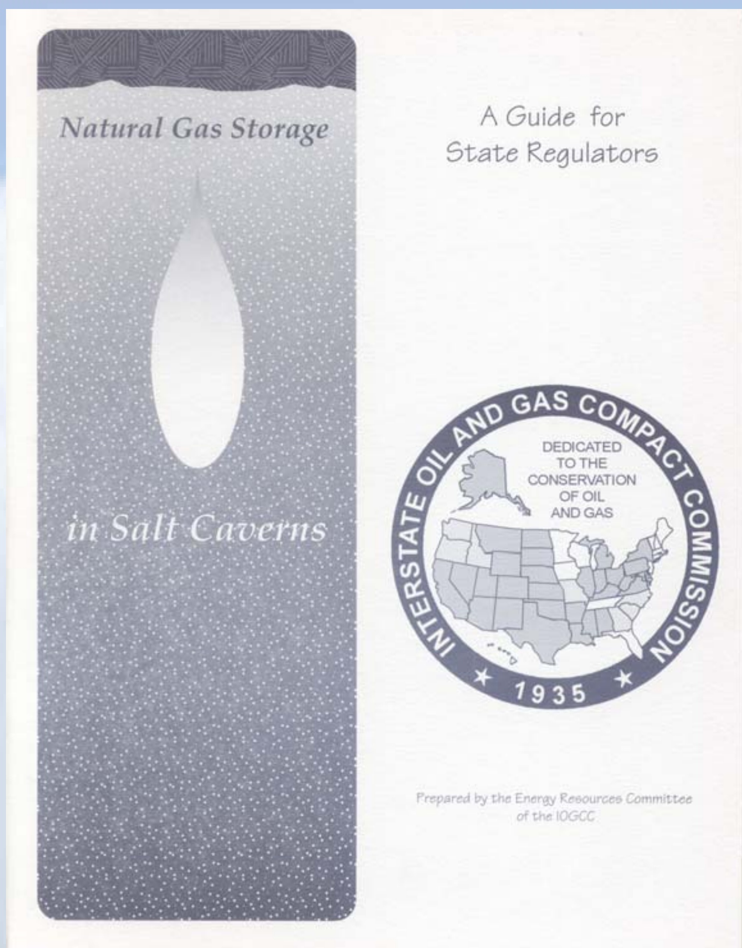
Georgia (1946)
Idaho (1960)
Missouri (1995)
North Carolina (1971)
Oregon (1954)
South Carolina (1972)
Washington (1967)

International Affiliates

Alberta (1996)
British Columbia (2002)
Egypt (1999)
Republic of Georgia (2001)
Newfoundland and Labrador (1997)
Nova Scotia (1997)
Venezuela (1997)

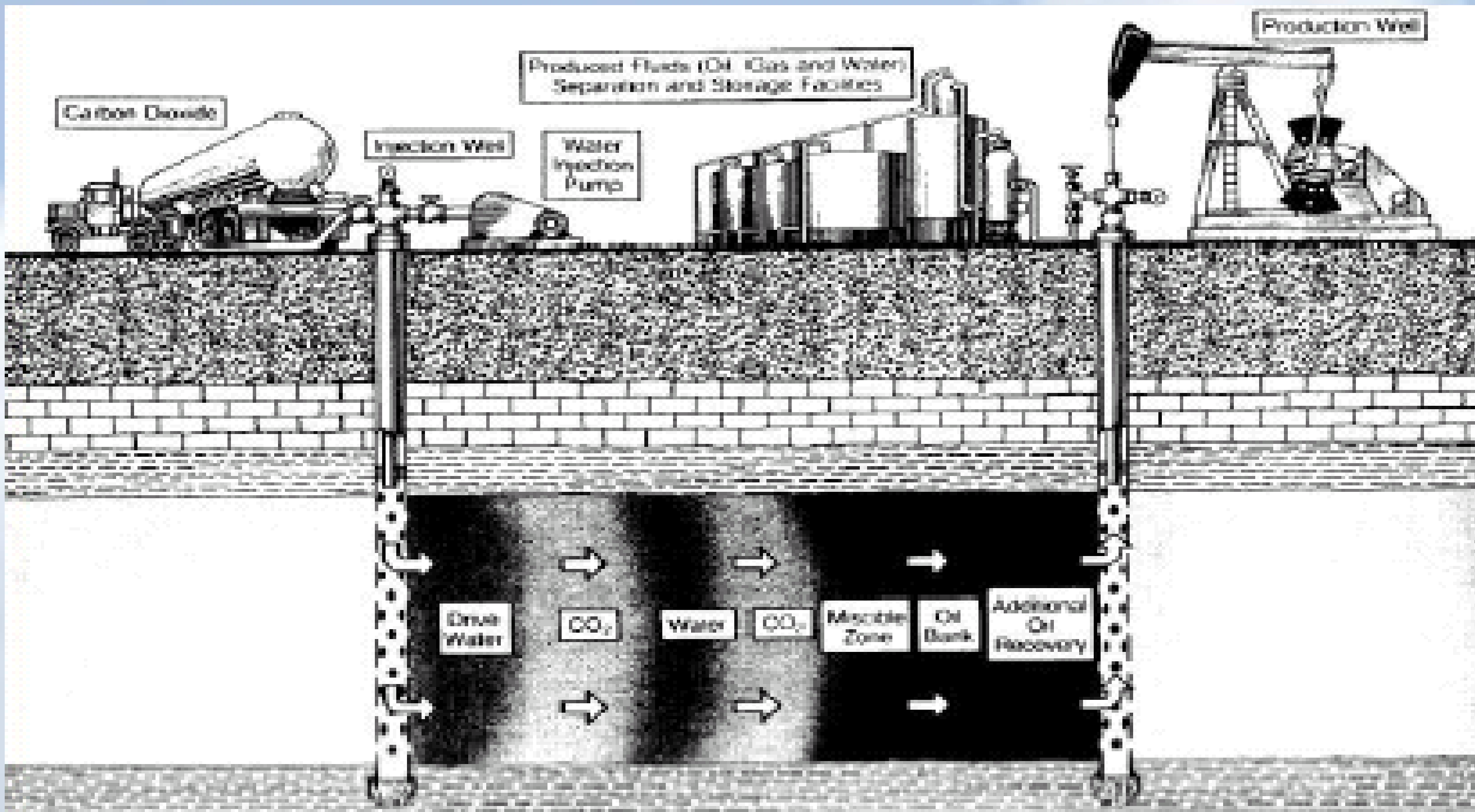
INTERSTATE Oil & Gas COMPACT COMMISSION

Model Regulatory Guidance



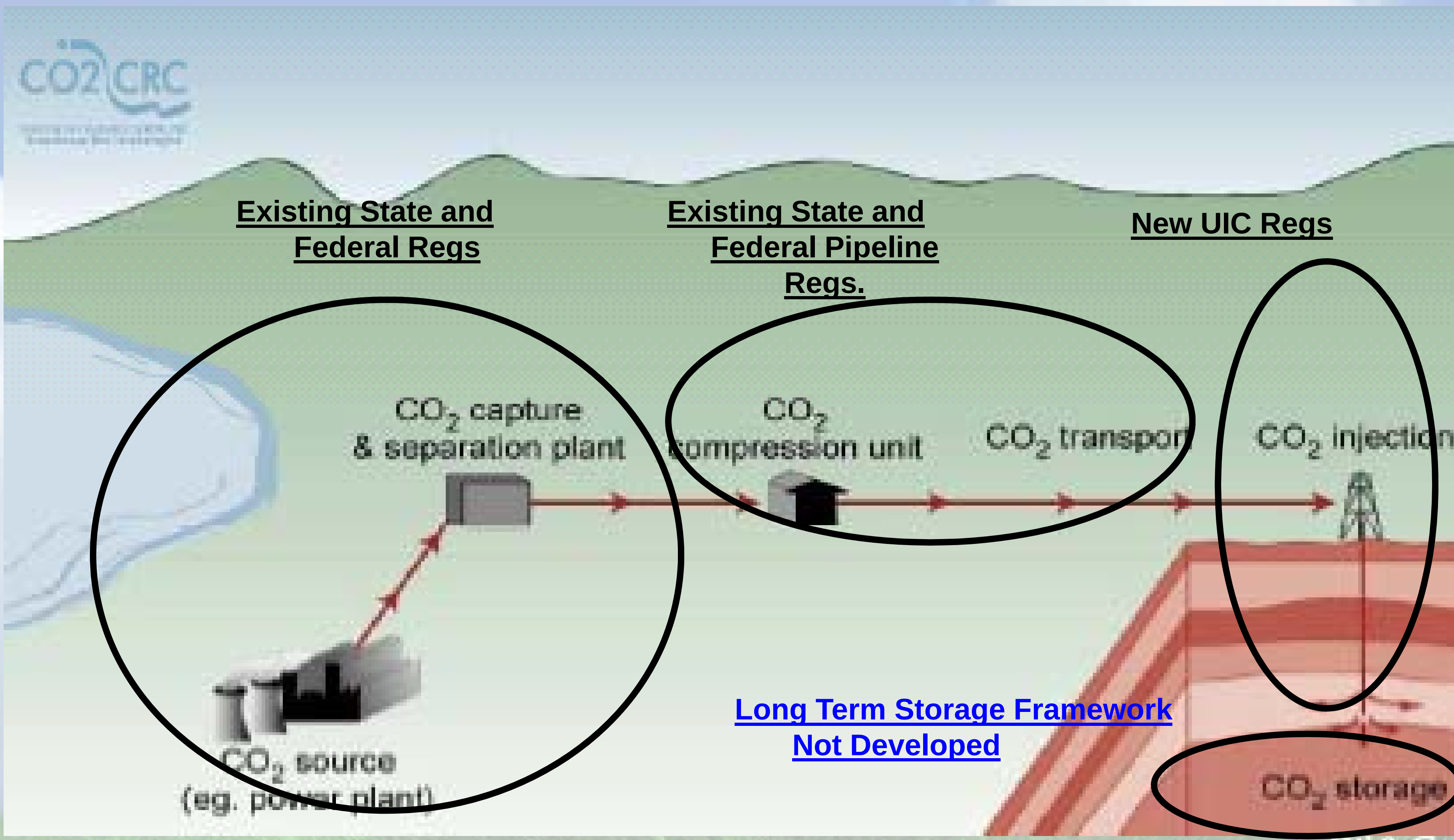
- One of many IOGCC regulatory guidance documents for states and provinces
- Helps ensure regulatory consistency among states and provinces.

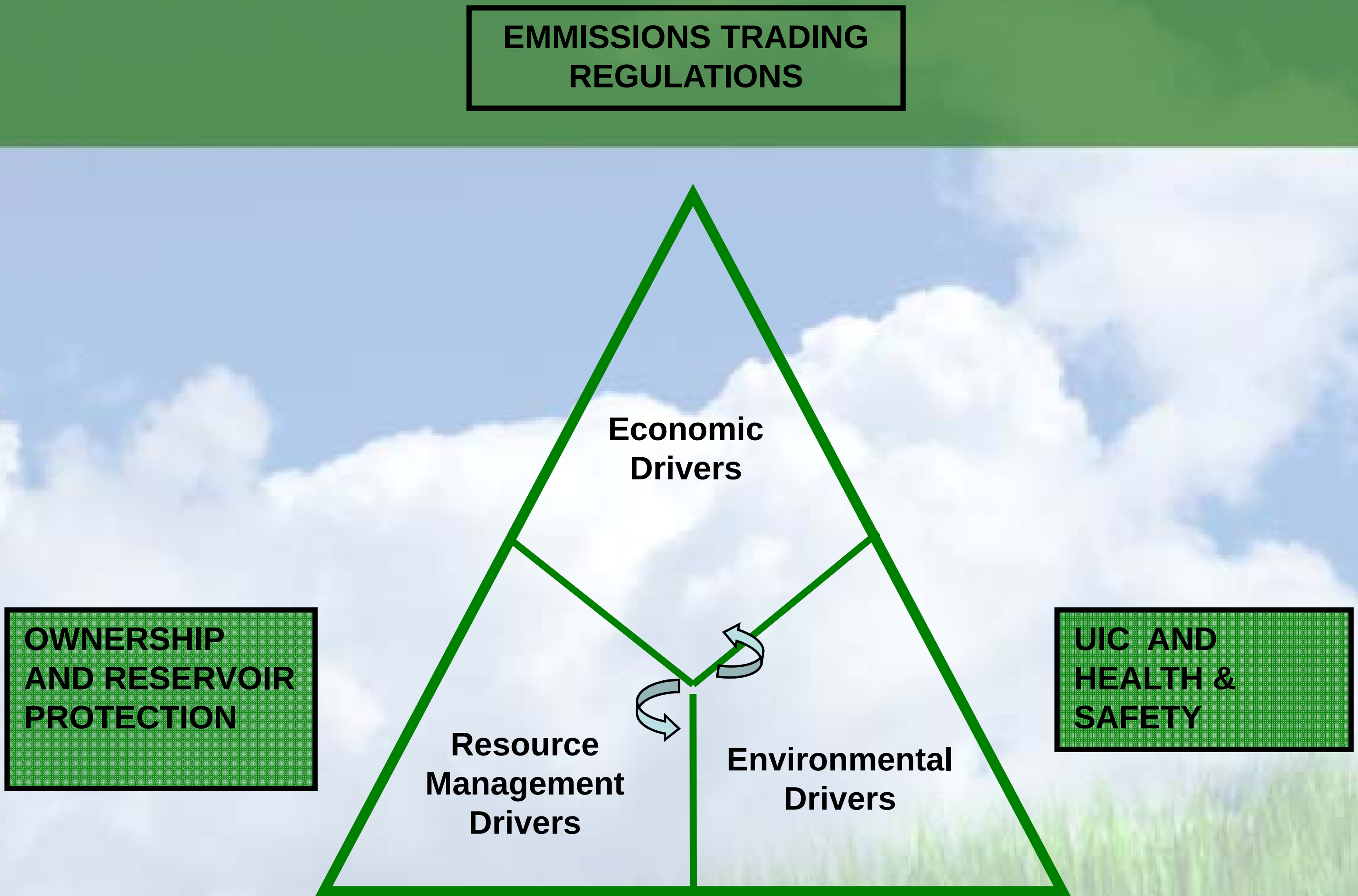
CO_2 ENHANCED OIL RECOVERY INJECTION



CURRENT US CO_2 SOURCES and PIPELINES
Industry knows how to handle CO_2

CO2 CAPTURE TRANSPORTATION AND GEOLOGIC STORAGE PROCESS





CCS REGULATORY FRAMEWORKS

Differences Between Policy, Legal, Regulatory and Liability Aspects

- **Policy:** What governments (should) do to encourage or discourage a particular activity
- **Legal:** The right to engage in a particular lawful activity on one's property
- **Regulatory:** Permission to engage in that particular activity if certain conditions are being met
- **Liability:** Who is responsible for what in case of failure

INTERSTATE Oil & Gas COMPACT COMMISSION

Carbon Dioxide: Commodity, Pollutant, or Hazardous Waste?

- **Commodity**
  - Commercial value for use in EOR / EGR, already active
- **Pollutant**
  - Recent U.S. Supreme Court ruling that EPA must make this determination
  - Crude oil, coal, and natural gas, if mismanaged
- **Hazardous Waste**
  - Makes handling, injecting, and sequestering far more expensive
  - Coupled with sequestration, encumbers EOR / EGR commercial opportunities in the U.S.

Task Force Representatives

- Representing 15 States
- IOGCC member state and provincial oil and gas agencies
- DOE sponsored Regional Carbon Sequestration Partnerships
- Association of State Geologists
- US DOE
- Independent experts
- US EPA
- US BLM
- Environmental organizational observer

IOGCC Resource Management Philosophy For CCS

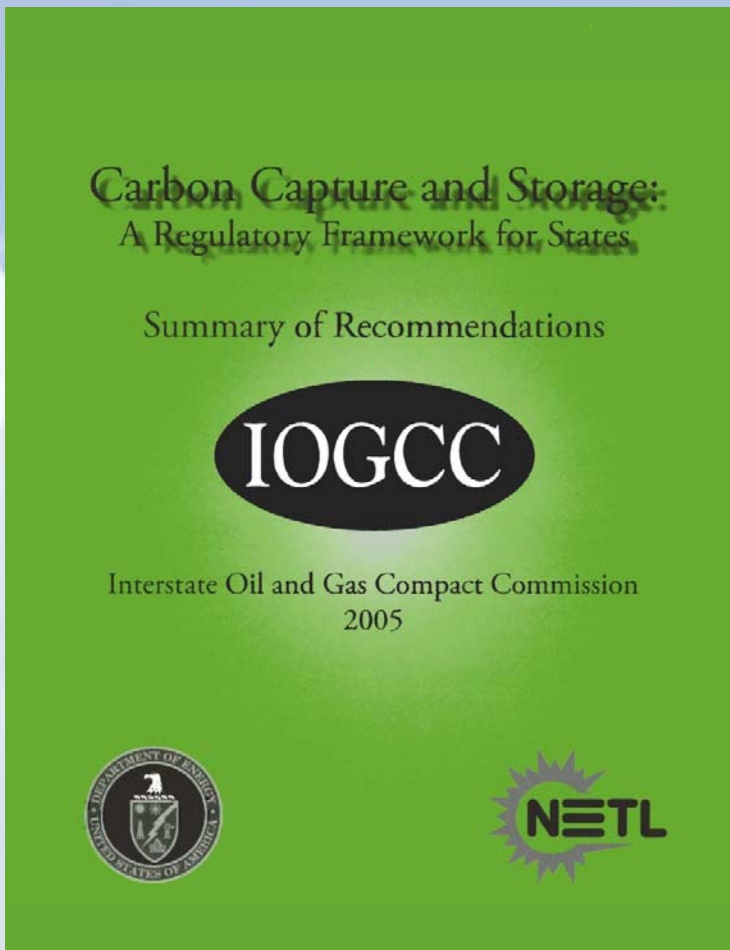
- Given the regulatory complexities of CO_2 storage including environmental protection, ownership and management of the pore space, maximization of storage capacity and long term liability, the Task Force strongly believes that **geologically stored CO_2 should be treated under resource management frameworks as opposed to waste disposal frameworks.**

- Regulating the storage of CO_2 under a waste management framework **sidesteps the public role** in both the creation of CO_2 and the mitigation of its release into the atmosphere and **places the burden solely on industry** to rid itself of "waste" from which an "innocent" public must be "protected".

- Such an approach **lacking citizen buy-in** with respect to responsibility for the problem as well as the solution **could well doom geological storage to failure** and diminish significantly the potential of geologic carbon storage to meaningfully mitigate the impact of CO_2 emissions on the global climate.

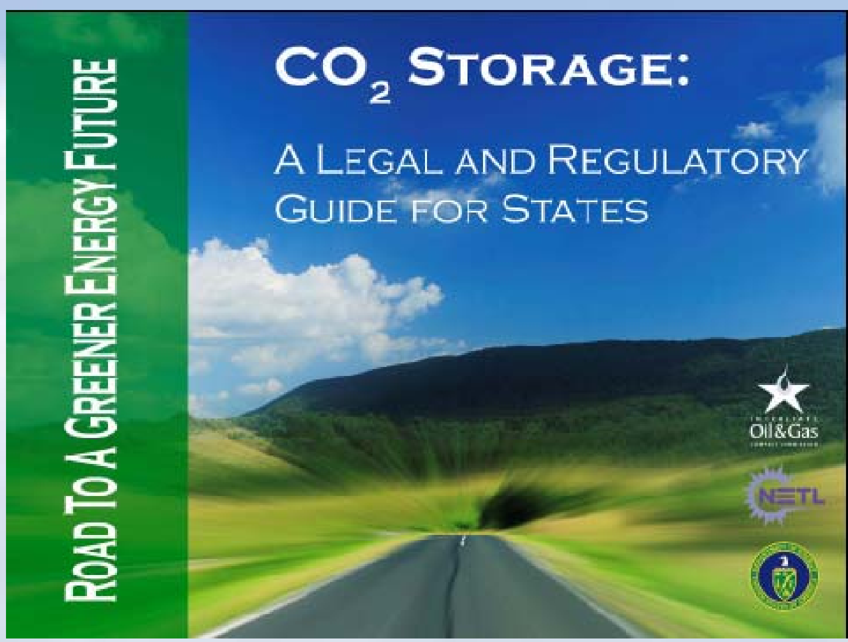
INTERSTATE Oil & Gas COMPACT COMMISSION

Brief Summary of Phase I Work and Recommendations



- Industry and states have 30 years experience in the production, transport and injection of CO.
- States have necessary regulatory analogues in place to facilitate development of a comprehensive CCGS regulatory framework.
- CO_2 should be regulated as a commodity to allow the application of oil and gas conservation laws which will facilitate development of storage projects.
- Involve all stakeholders including general public in the development of regulatory frameworks.

New IOGCC Phase II Report



- Released in January 2008
- Summary of the report and a copy of the full report on CD-ROM.

What the Guidance Document provides to states & provinces

Storage of Carbon Dioxide in Geologic Structures
A Legal and Regulatory Guide for States and Provinces

Topical Report

Reporting Period Start Date: April 14, 2006
Reporting Period End Date: August 20, 2007

Prepared by the IOGCC Task Force on Carbon Capture and Geologic Storage.
Principal authors: Lawrence E. Bengal, Berry H. Tew, Jr., Michael D. Stettner and Kevin J. Bliss

Report Issued: September 20, 2007

DOE Award No. DE-FC26-05NT42591

Interstate Oil and Gas Compact Commission
P.O. Box 53127
Oklahoma City, OK 73105

- Background on why states and provinces are the most logical “cradle to grave” regulators.
- Useful background on climate change and the importance of geologic storage.

Model Statutes and Regulations

Model Statute[1]

GEOLOGIC STORAGE OF CARBON DIOXIDE

Section 1. Legislative declaration; jurisdiction.[2]

(a) The Legislature of the State of _________ declares that (1) the geologic storage of carbon dioxide will benefit the citizens of the state and the state's environment by reducing greenhouse gas emissions; (2) carbon dioxide is a valuable commodity to the citizens of the state; and (3) geologic storage of carbon dioxide gas may allow for the orderly withdrawal as appropriate or necessary, thereby allowing carbon dioxide to be available for commercial, industrial, or other uses, including the use of carbon dioxide for enhanced recovery of oil and gas (EOR).

(b) The State Regulatory Agency shall have the jurisdiction and authority over all persons and property necessary to administer and enforce effectively the provisions of this article concerning the geologic storage of carbon dioxide. In exercising such jurisdiction and authority granted to it, the State Regulatory Agency may conduct hearings and promulgate and enforce rules, regulations, and orders concerning geologic storage of carbon dioxide.

Section 2. Definitions.

(a) *Carbon dioxide.* Anthropogenically sourced carbon dioxide of sufficient purity and quality as to not compromise the safety and efficiency of the reservoir to effectively contain the carbon dioxide.

(b) *Oil or gas.* Oil, natural gas, or gas condensate.

(c) *Reservoir.* Any subsurface sedimentary stratum, formation, aquifer, or cavity or void (whether natural or artificially created) including oil and gas reservoirs, saline

[1] Canadian provinces should replace "state" with "province" as appropriate.
[2] The purpose of this section is to make clear that the primary goal is to permanently store carbon dioxide to mitigate its impact on global climate change, however, given the commodity status of carbon dioxide, under certain circumstances states need statutory authority to regulate withdrawal of previously stored carbon dioxide for EOR and other uses that do not involve release to the atmosphere.

General Rules and Regulations

GEOLOGIC STORAGE OF CARBON DIOXIDE

Section 1.0. Applicability

The following rules and regulations shall govern the geologic storage of CO_2 in geologic reservoirs. These rules apply to all CO_2 storage operations occurring within the territorial jurisdiction of the state.[1]

Section 2.0. Definitions

The following terms, as used in these regulations for geologic CO_2 storage facilities, shall have the following meanings:
(a) **CO_2** means anthropogenically sourced carbon dioxide of sufficient purity and quality as to not compromise the safety and efficiency of the reservoir to effectively contain the CO_2.
(b) **CO_2 Facility** (CF) means, all surface and subsurface infrastructure including wellhead equipment, down hole well equipment, compression facilities and CO_2 flow lines from injection facilities to wells within the Geological Storage Unit (GSU), monitoring instrumentation, injection equipment, and offices. CF does not include the main transportation pipeline to the GSU and pump stations along that pipeline.
(c) **CO_2 flow lines** means the pipeline transporting the CO_2 from the CF injection facilities to the wellhead.
(d) **CO_2 injection well** means a well used to inject CO_2 into and/or withdraw CO_2 from a reservoir.
(e) **CO_2 Storage Project** (CSP) means the project in its entirety, including CF and GSU.
(f) **CSP Closure Period** means that period of time (10 years unless otherwise designated by the State Regulatory Agency {SRA}) from the permanent cessation of active CSP injection operations until the expiration of the CSP performance bond, unless monitoring efforts following the operational period demonstrate to SRA that a different time frame is appropriate.
(g) **CSP Operational Period** means the period of time in which injection occurs.
(h) **CSP Operator** means that entity required by SRA to hold the permit.
(i) **CSP Permit** means the permit issued by the state or province to operate a CSP.
(j) **CSP Post Closure Period** means that period of time after the release of the CSP performance bond.

[1] This document is drafted using the word "state". Canadian provinces should substitute either the word "province" or "provincial" as required. Similarly, Canadian provinces should substitute as appropriate the definitions of Underground Sources of Drinking Water (USDW) and Safe Drinking Water Act (SDWA) here and in the following text.

INTERSTATE Oil & Gas COMPACT COMMISSION

Overview and Storage Rights

Part 2: Overview and Explanation of the Model General Rules and Regulations

Regulations Overview

The Interstate Oil and Gas Compact Commission's Task Force on Carbon Capture and Geologic Storage has prepared this guidance document. Much of the work has been accomplished by the Task Force's Model Regulations Working Group. The Task Force began its work June 28-30, 2006, in Dallas, Texas, at which time the tasks and responsibilities of the Model Regulations Working Group were defined. The group held three meetings: a kick-off meeting on September 5-8, 2006, in St. Louis, Missouri; a mid-point meeting on October 18, 2006, in Austin, Texas; and a joint wrap-up meeting with the entire Task Force on May 5, 2007, in Point Clear, Alabama.

The guidance document is being prepared for IOGCC member states, including its affiliate member provinces. Although references throughout this document are, for the most part, to "state" or "states", it is the intent of the Task Force that the comments and provisions are equally applicable to Canadian provinces. Specific notation of this is made in both the Model Rules and Regulations and Model Statute attached. Additionally, in Canada, protection of both groundwater resources and deep injection fall entirely within provincial jurisdiction, and there is no federal equivalent of the U.S. Safe Drinking Water Act and the UIC program. Accordingly, regulations may vary from province to province, but their essence is the same and comparable with the U.S. regulations.

This overview section is followed by an appendix consisting of three parts. Appendix I provides a draft model statute for the Geologic Storage of Carbon Dioxide. It contains legislative language necessary to enable a State Regulatory Agency to implement the draft model rules and regulations. Appendix II contains the draft model rules and regulations for geologic CO_2 storage. Taken together, Appendices I and II are the principal deliverable work products of the Task Force. Appendix III contains background material on the "Analysis of the Ownership of Storage Rights Relating to the Storage of CO_2 in Geologic Structures".

The following provides an overview, explanation, and rational for the various sections in Appendix II (Model Rules and Regulations).

Section 1.0. Applicability

Part 1: Analysis of Property Rights Issues Related to Underground Space Used for Geologic Storage of Carbon Dioxide

Prepared by

David Cooney

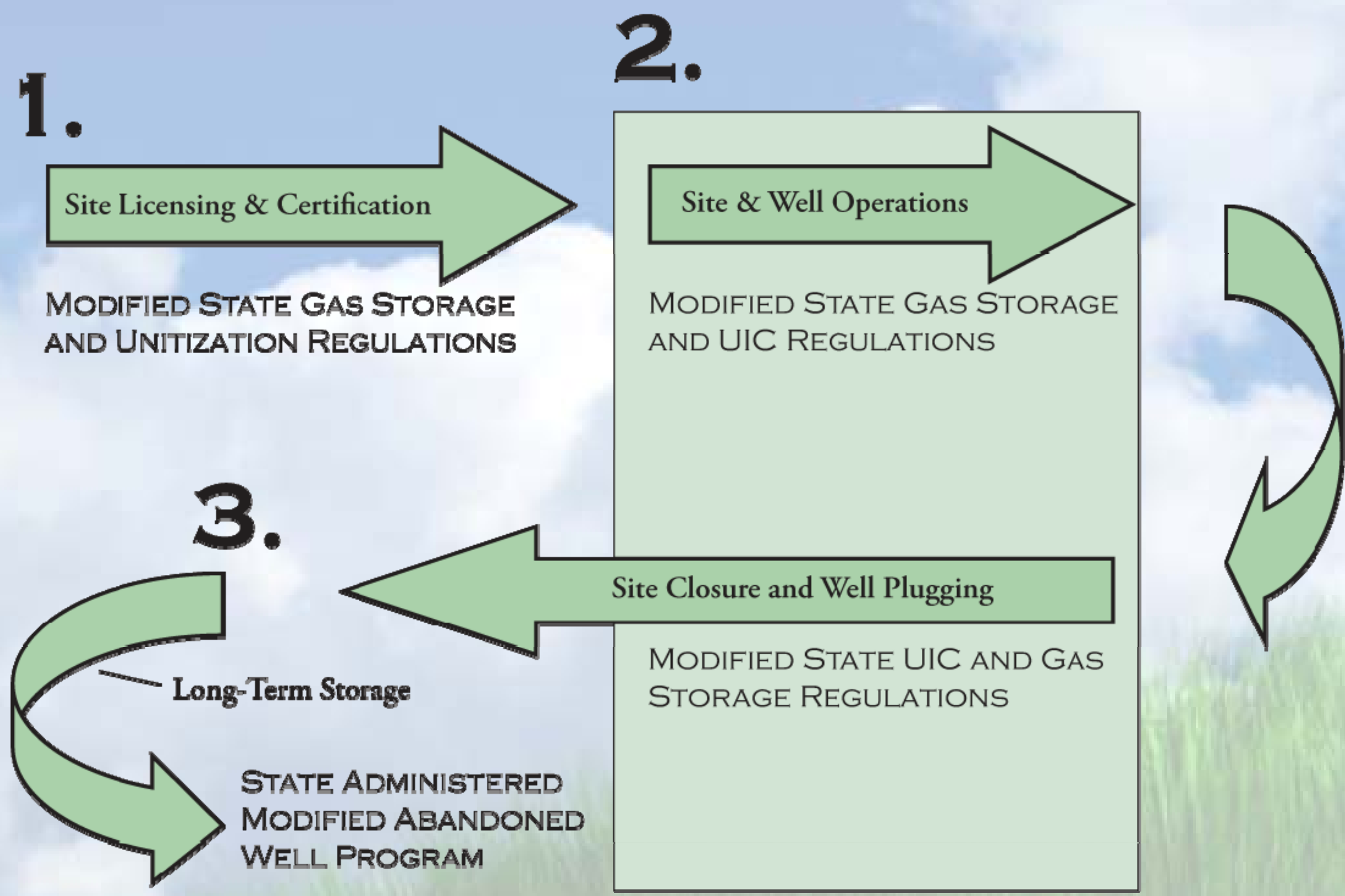
IOGCC Task Force on Carbon Capture and Geologic Storage
Subgroup of State Oil and Gas Attorneys
Marvin Rogers, David Cooney, Cammy Taylor

Several legally recognized interests might exist in property where underground pore space in a particular interval or intervals is to be used for geological storage (GS). Surface owners, mineral owners, lessees of solid minerals, oil and gas lessees, and owners of non-operating interests in production all might have legal rights that could be affected by GS.[1] Because the law recognizes an ownership interest in subsurface pore space, a regulatory program that manages storage (as opposed to water protection) should include clear rules about how these rights will be recognized and protected, as well as a process for assuring that the storer secures the legal property right to store CO_2.

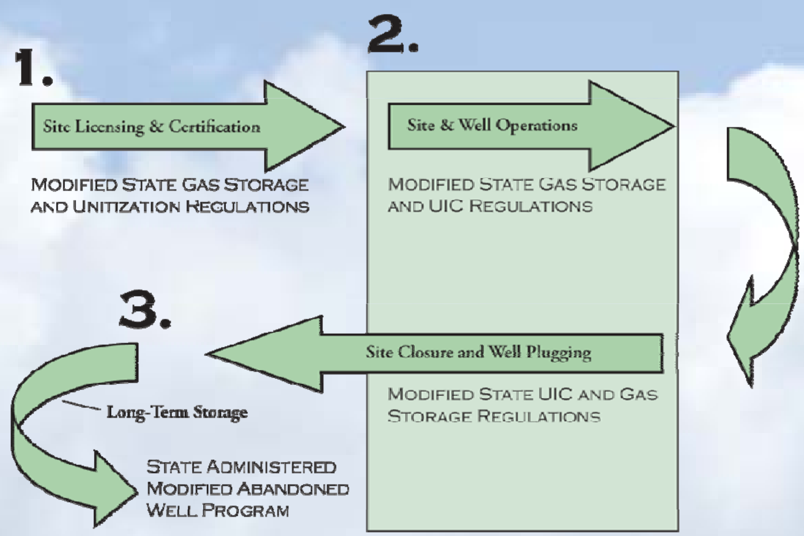
The Interstate Oil and Gas Compact Commission (IOGCC) Geological CO_2 Sequestration Task Force identified three working models that can provide technological and regulatory guidance for GS: (1) injection of CO_2 into underground formations for enhanced oil

[1] See Williams and Meyers, Oil and Gas Law Vol. 1, §222 (Matthew Bender, 2006), for identification of property interests related to storage of natural gas in geologic reservoirs.

CGS Regulatory Framework

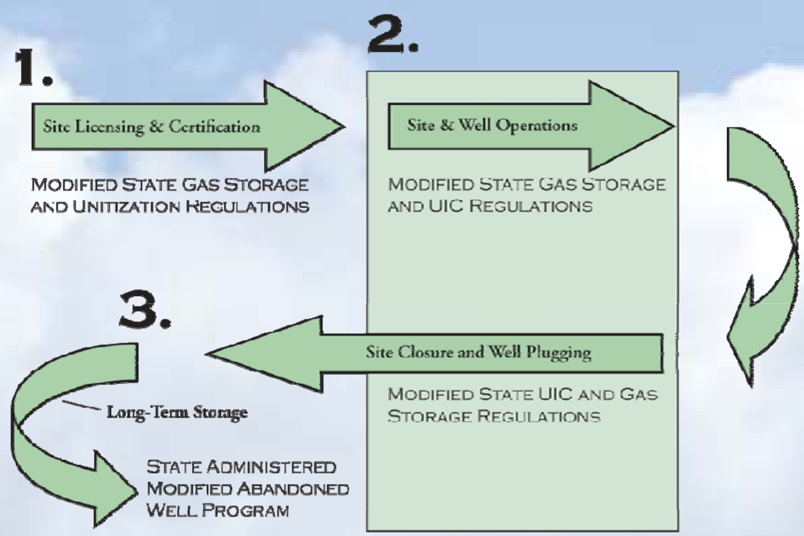


Phase I: Site Licensing including amalgamation of storage rights



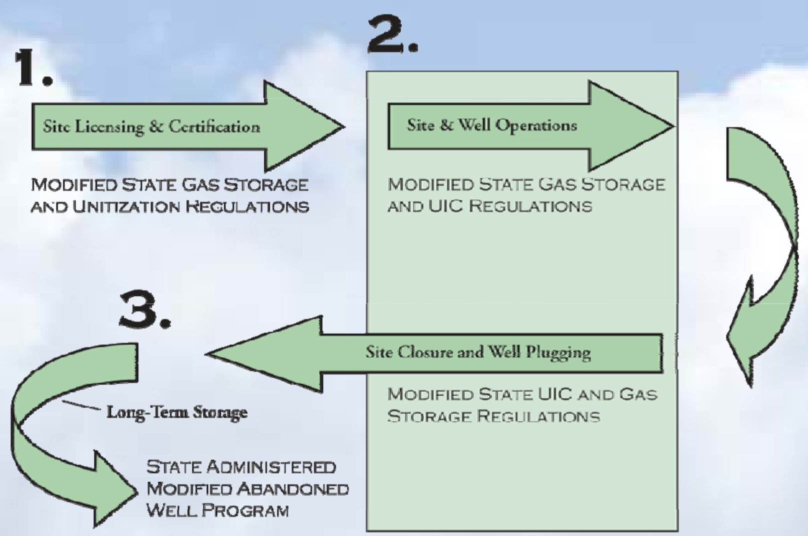
- Licensing of entire reservoir (purchase &/or eminent domain)
- Submission of detailed engineering and geological data along with a CO_2 injection plan
- Operational bond
- Primarily State jurisdiction

Phase II: The Storage and Closure Phase



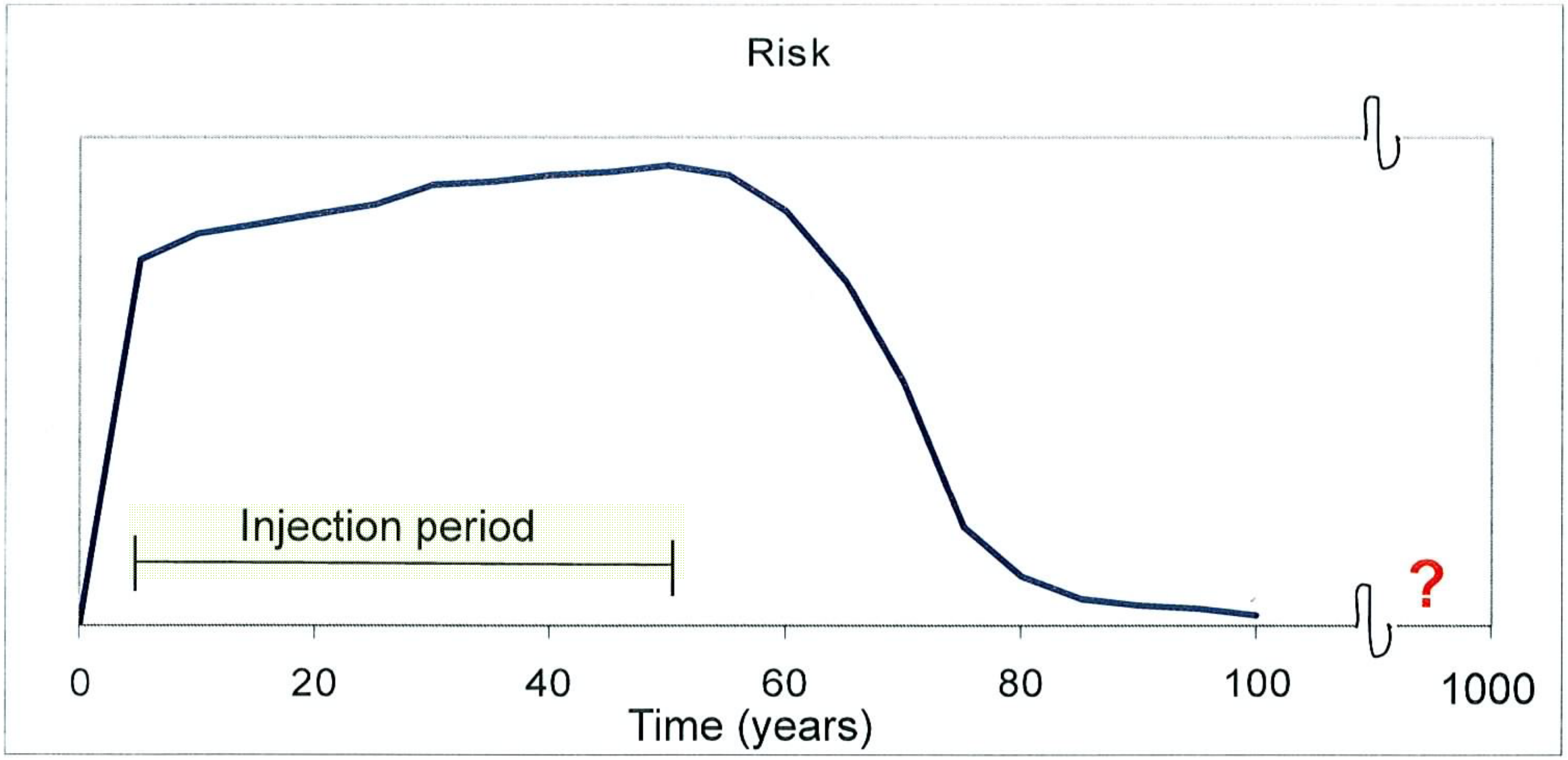
- The phase where the project is developed, operated and closed
- Regulation to safeguard life, health, property and the environment
- EPA regulatory overlap in this phase under Safe Drinking Water Act (UIC)

Phase III: Long Term "Care Taker" Phase



- When the operator is no longer the responsible party and the long term care taker role is assumed by government
- Costs in this phase covered by state-administered trust fund.
- Funded by injection fee assessed to operator on per ton basis of CO_2 injected over life of project.

The risk timeline for leakage is heavily-laden in early times.



Why does it look like this?

Pressure driver during and post injection

Most “changes” occur in early phase

Long-term effects trap larger quantities of CO_2

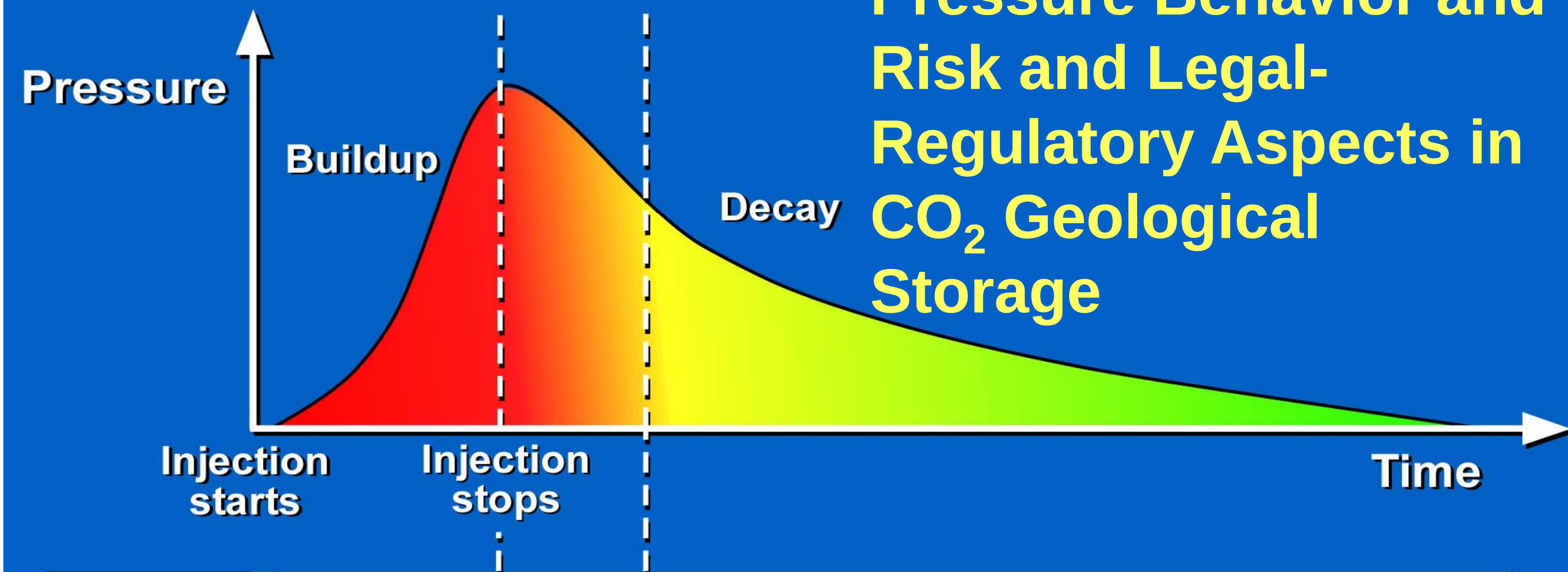
Seals may be affected over long-term

NETL

2K-2571

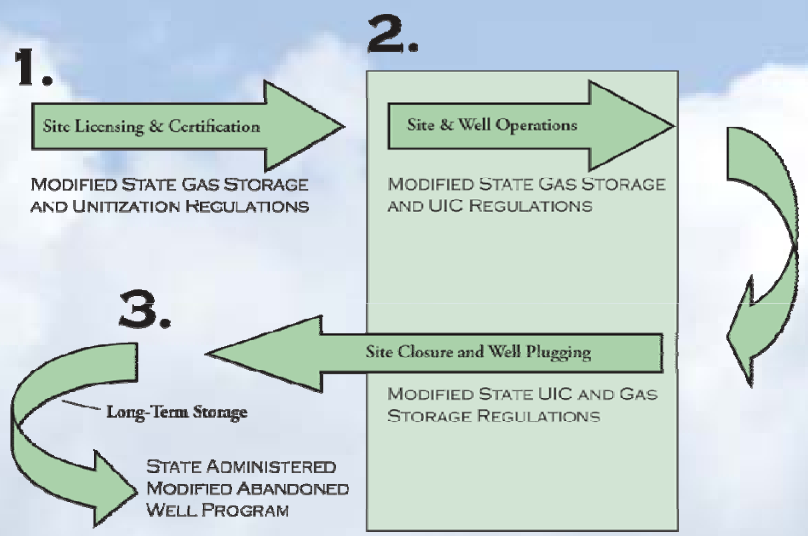
Source: Dr. Bachu - ERCB

Relation between Pressure Behavior and Risk and Legal-Regulatory Aspects in CO_2 Geological Storage



Operational Period	Active	Closure	Post-Closure
Trapping Mechanism Dominance	Primary		Increasingly Secondary
Risk	Increasing		Decreasing
Monitoring Frequency & Resolution	High	Targeted	Decreasing
Liability	Operator and /or Emitter		State Agency

EPA Regulatory Overlap



- EPA authority under SDWA in green box
- Will ensure national consistency and protection of drinking water for operational phase
- State and EPA regulatory frameworks systems can work “seamlessly”.

PROJECTED USEPA RULE DEVELOPMENT TIMELINE

- **JULY 2008** - PROPOSED RULE PUBLISHED - FOLLOWED BY 90 – 120 DAY PUBLIC COMMENT PERIOD
- **2009 (date uncertain)** – PUBLISH NOTICE OF DATA AVAILABILITY (NODA) – FOLLOWED BY 60 – 90 DAY PUBLIC COMMENT PERIOD
- **2010 (late) or 2011 (early)** – FINAL RULE PUBLISHED

INTERSTATE Oil & Gas COMPACT COMMISSION

ISSUES USEPA PROPOSED RULE WILL NOT ADDRESS

Due To Limitations in Federal Safe Drinking Water Act

- **Overall Site Licensing, Property Right Issues, Eminent Domain** - (AOR modified to extend over entire area projected to be impacted by total volume of CO_2 to be stored)

- **Long Term "Caretaker" Responsibility** (Post Closure Liability) for the time period beyond the established regulatory post closure period - (Class I 30 years most likely analog)

Observations concerning Proposed EPA CS Regulations

- **<u>CO2 EOR will remain Class II</u> under UIC**
- **CS wells will most likely be a <u>new class</u>, for which states will apply for primacy**
- **Regulations will <u>allow for conversion</u> from Class II to new storage classification – rule will define when storage begins and EOR ends**
- **Regulations will <u>not determine</u> if CO2 EOR will qualify for <u>CO2 credit</u> – future federal or market based system**
- **<u>Long-term "caretaker" role</u> will not be addressed – <u>Industry or state role at present time i</u>f projects undertaken**
- **At present a <u>state with UIC primacy can permit CS wells</u> under UIC using existing or combination of UIC well classes.**

Barriers to Deployment

- Policy development
- Public acceptance
- Economic and financial (high cost)
- Legal and regulatory
- Scientific and technological
- Capacity

States and Provinces Currently Developing Regulatory Systems Using IOGCC Model Legislation and Regulations

- California
- Indiana
- Michigan
- Montana
- New Mexico
- New York
- North Dakota
- Oklahoma
- Texas
- Alberta
- British Columbia
- Nova Scotia
- Saskatchewan

States Which Have Enacted CO2 Storage Legislation

- **Illinois**
- **Kansas**
- **Ohio**
- **Utah**
- **Washington (also has draft rules out for public comment)**
- **West Virginia**
- **Wyoming**

IOGCC Task Force – Next Steps

- **The Guidance Document will continue to be perfected based on experience of the states and provinces.**
- **DOE and other funding sources sought to continue work of the Task Force.**
- **Task Force is continuing public outreach efforts and assisting states with legislation and rule development.**

CONTACT INFORMATION

Interstate Oil and Gas Compact Commission

Headquarters Address:
PO Box 53127
Oklahoma City, OK 73152

Washington DC Office Address:
1333 New Hampshire Ave NW
#510B
Washington, DC 20036

Phone:202-484-1026
Email:iogccdc@verizon.net

www.iogcc.state.ok.us

Interstate Oil & Gas Compact Commission

Directorate-General for Energy and Transport

CCS Projects in Europe and the Issue of Finance

Kai TULLIUS
Policy Officer – Coal and Oil

28/05/2008

EUROPEAN COMMISSION

Content

- EU Policy Context: Energy and Climate Change

- Deploying CCS in Europe
  - » Legislative Framework
  - » Long Term Economic Viability

- Financing CCS demonstration projects

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Policy Context

Objectives agreed for 2020

- 20% GHG reduction compared to 1990
  - Independent commitment
- 20% reduction in primary energy consumption
- 20% renewables in energy mix
- 10% biofuels in transport
  - If production is sustainable
  - If second generation biofuels commercially available

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Policy Context

- **2007 Spring European Council**
  - » target of 20% cut in greenhouse gas emission by 2020
  - » enabling low-CO2 power generation from fossil fuels by 2020
  - » up to 12 CCS demonstration plants in operation by 2015
- **Summer-Autumn 2007**
  - » Evaluation and Impact Assessment period
- **November 2007: Strategic Energy Technology Plan**
  - » R&D efforts to focus on low carbon technologies
  - » CCS one of strategic technologies: large-scale demos next priority
- **23 January 2008:** Commission adopts a set of proposals including the CCS Communication and the CCS Directive

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Costs and benefits of CCS

- **Costs:**
  - R&D (€1bn) and demonstration (€10-20bn) to reduce costs
  - further investment to roll out CCS on a wide-scale
- **Benefits:**
  - 20-28% of the achievable global CO2 emission reductions by 2050 (IEA)
  - solution for both power generation and energy intensive industries
  - for managing future CO2 emissions of dynamically developing coal users (China, etc.)
- **Policy goal =** CCS commercially feasible by 2020:
  - CCS in retrofits and newbuild thereafter
  - capture-readiness in the meantime

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Obstacles / EC Proposals

- **Legislative Hurdles**
  - **CCS Directive**

- **Non legislative Hurdles**
  - » Long term economic viability
    - **Emission Trading System (ETS)**
  - » Industrial Scale CCS Demonstration Projects (all main technology routes (Pre-, Post-, Oxyfuel-Combustion))
  - » General and Industry Awareness
  - » Public Acceptance
    - **CCS Communication**

CCS-Directive - 1

- **Enabling Framework**
  - Member States determine whether and where CCS will happen
  - Companies decide whether to use CCS on the basis of conditions in the carbon market
- **Objectives and Principles**
  - Legislative Framework for managing environmental risks
  - Overcame existing legal barriers
  - Use existing frameworks where possible
- **Focus on Storage**
  - Capture regulated under IPPC Directive
  - Transport regulated as for natural gas transport (by Environmental Impact Assessment and at Member state Level)
- **Novel element is CO2 storage, main focus of proposes directive**

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CCS Directive - 2

- **Content**
  - Site Selection
  - Authorisation for Storage
  - Monitoring plan to confirm expected CO_2 behaviour
  - Liability measures in case sites do leak
  - Transfer of Responsibility to the state
  - Access for third parties

- **CCS-not mandatory, but member states need to**
  - assure, that enough space is available on site to retrofit plant with capturing and compression facilities
  - verify, if storage capacities and transport facilities are available and retrofitting is technological feasible
    - **CAPTURE READINESS**

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EU Emission Trading System

- **ETS Phase III proposal**
  - » from 2013 full auctioning of CO_2 certificates for the power sector
- **CCS under the ETS:**
  - » CO_2 captured, transported and safely stored considered as not emitted
  - » no allocation to capture, transport and storage
  - » ETS allowances must be surrendered for any leakage
  - » monitoring and reporting guidelines under preparation
- **ETS auctioning revenues**
  - » major potential source of funding for CCS demonstration projects
  - » EC suggestion: 20% earmarking to low-CO_2 technologies

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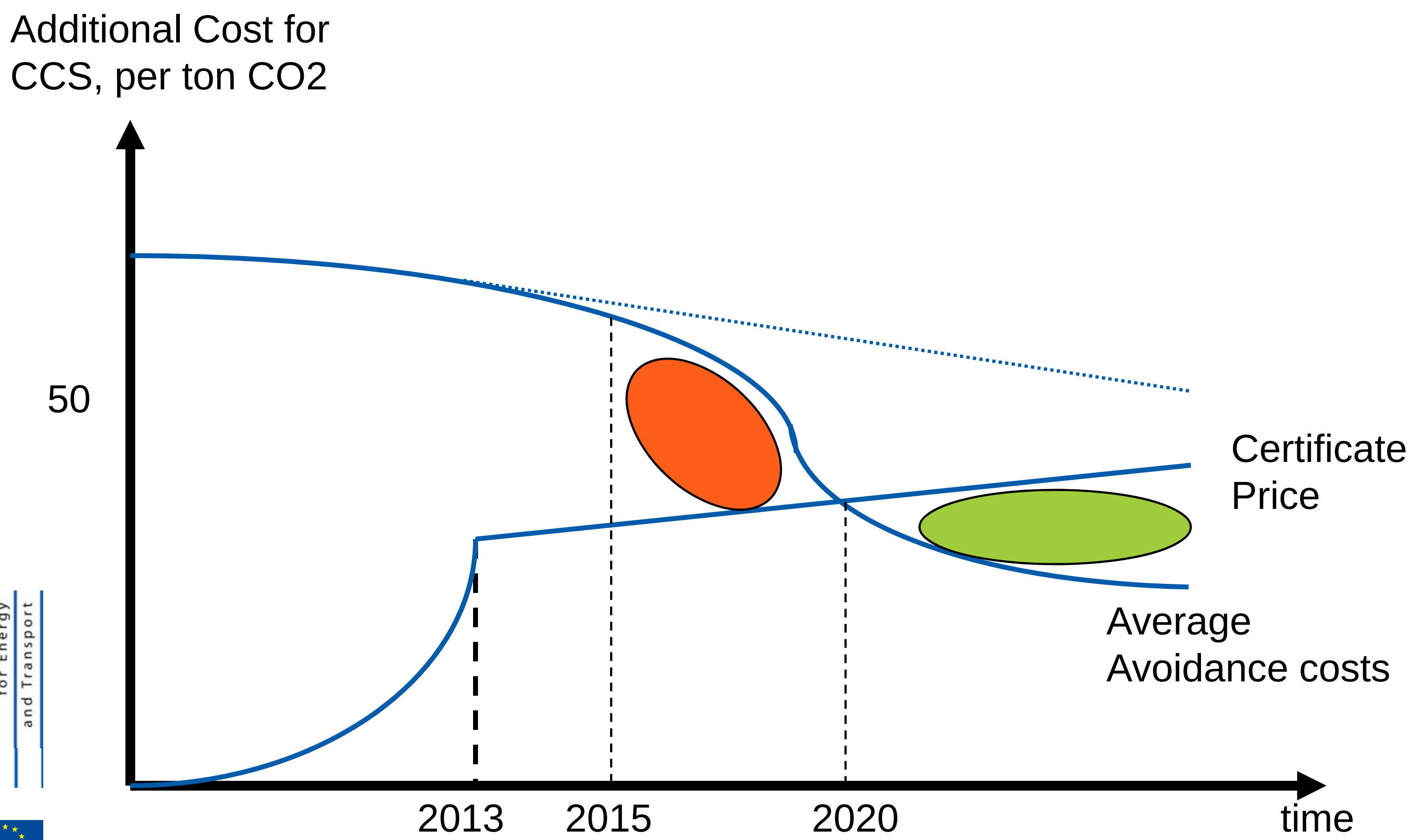
Economic viability of CCS under ETS



Financing CCS demonstration projects

- **Economics of early demonstration**
- **Sources of financing**
  - **Industrial commitments**
    - ETP-ZEP: a vital initiative with commitments to the issue
    - still needed: clear, early and decisive commitments by individual players to concrete large-scale demonstration
  - **Member States' involvement**
    - MS-level crucial given budgetary reality and size of challenge
    - Commission guidelines facilitate state aid to CCS
    - ETS revenues + structural policies hinted as suitable
  - **EU-level financing**
    - limited availability for the time being
      - FP7 + EU structural funds
      - EU financial institutions for specialized cases
      - Communication on financing low-carbon technologies

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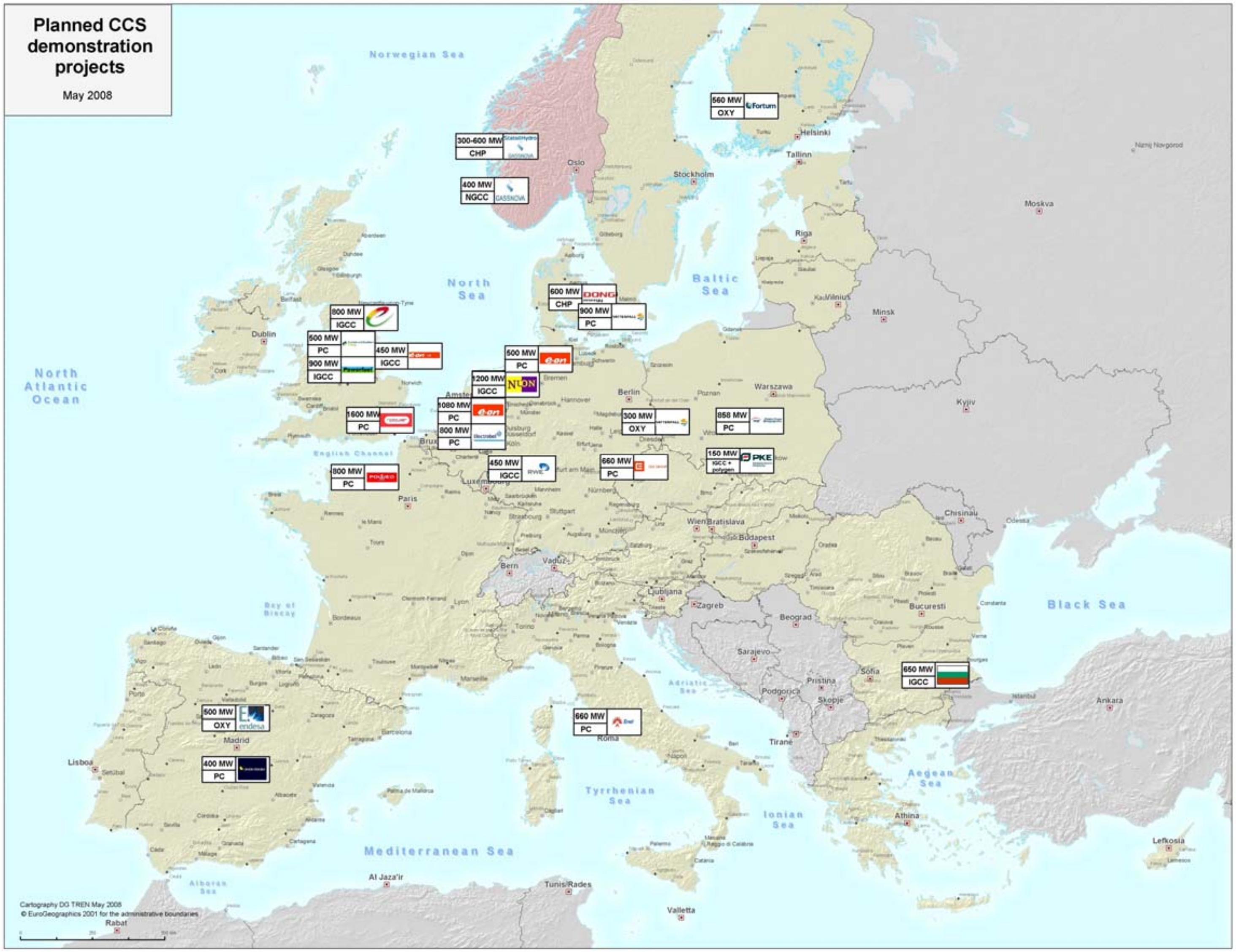
Potential CCS demonstration projects



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Conclusion – Executive summary

- **CCS: priority of strategic importance**
  - » CCS can be commercially viable by 2020
  - » opportunities and challenges:
    - early effective demonstration
    - timely and bold industry and public investment
    - market-based stimuli to avoid CO2 emissions
- **Commission / Council / EP:**
  - » CCS regulatory framework
  - » CCS in ETS
  - » revised Community guidelines on state aid for environmental protection
  - » revision of TEN-E guidelines (transport infrastructure)
  - » European Industrial Initiative on CCS
- **Early demonstrations**
  - » major financial commitments
    - • decisive commitments from industry to trigger public contribution
    - • national schemes by Member States
  - » continued R&D

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Thank You for Your Attention

Session 2
Panel on National and Regional Initiatives

Expert Meeting on
Financing Carbon Capture and Storage

New York, New York
May 28, 2008

Key Points from IEA Regulators Workshop Paris May 13-15, 2008

Conclusions of G8-IEA-CSLF Workshops:
Need for regulatory certainty and resolution of key legal issues.

- Most countries will build on existing legal/regulatory frameworks.
  - Australia: Build on Offshore Petroleum Act of 2006; ETS in 2010
  - Canada: Action at both Federal and Provincial level (Alberta and BC)
  - United Kingdom: Storage offshore; government taking long-term liability
  - Japan: Storage offshore with environment ministry responsibility
  - Norway: Build on existing offshore oil and gas regulation.
- A level playing field is needed for CCS

Agenda

- The Role, Status and Financing of CCS as a Mitigation Option in the United States
  - *Tom Wilson, Senior Technical Leader, EPRI*
- Canadian Perspective on Financing CCS
  - *Eric Beynon, ICO2N Group*
- The IOGCC Guidelines on Permitting CCS
  - *Lawrence Bengal, IOGCC*
- CCS Projects in Europe and the Issue of Finance
  - *Kai Tullius, Project Officer, European Commission*
- Panel Discussion

EcoSecurities

GHG Markets and CCS – A Launch Pad, A Cash Flow, or a Clean Miss?

Dr. Mark C. Trexler
Managing Director, EcoSecurities Global Consulting Services Group

London, May 28, 2008

EcoSecurities Business Profile

- > Originate, Implement, and Commercialize CERs – 350+ projects
  - First registered CDM project (Nova Gerar, Brazil)
  - First issuance of CERs (La Esperanza, Honduras)
  - Ongoing sectoral and project R&D efforts
- > Originate, Implement, and Commercialize VERs
  - Stonyfield Farm, Shaklee, AES Power Direct, Climate Neutral Network, TransAlta, Sumitomo, Entergy, Fannie Mae
- > Inform, Support, and Implement Business/Market Strategies
  - TransAlta, PacifiCorp, SCE, PG&E, NWPCC, JPower, TEPCO, World Bank, Barrick Gold, Statoil, PEMEX, JBIC, Mizuho Bank, many others

ECO SECURITIES

Inform → Support → Implement

- > First Mitigation Deals in U.S. and Globally
- > Leaders in Project, PDD, and Methodology Development
- > Won First GHG Regulatory Proceeding
- > Designed a Major GHG Early Action Crediting Program for U.S.
- > Took First Company Climate-Neutral
- > Completed First Major GHG Offset Portfolio
- > Supported First Utility-Based GHG Business Unit
- > Developed First GHG Market Supply-Demand Model
- > Point Carbon - Best CDM Project Developer 2006
- > Envtl Finance – Best GHG Advisory Firm 2001 - 2006

A Local Presence in a Global Market

ECO SECURITIES

Table of Contents

1. Setting the Stage for CCS

2. Forecasting GHG Markets

3. How Does CCS Fit?

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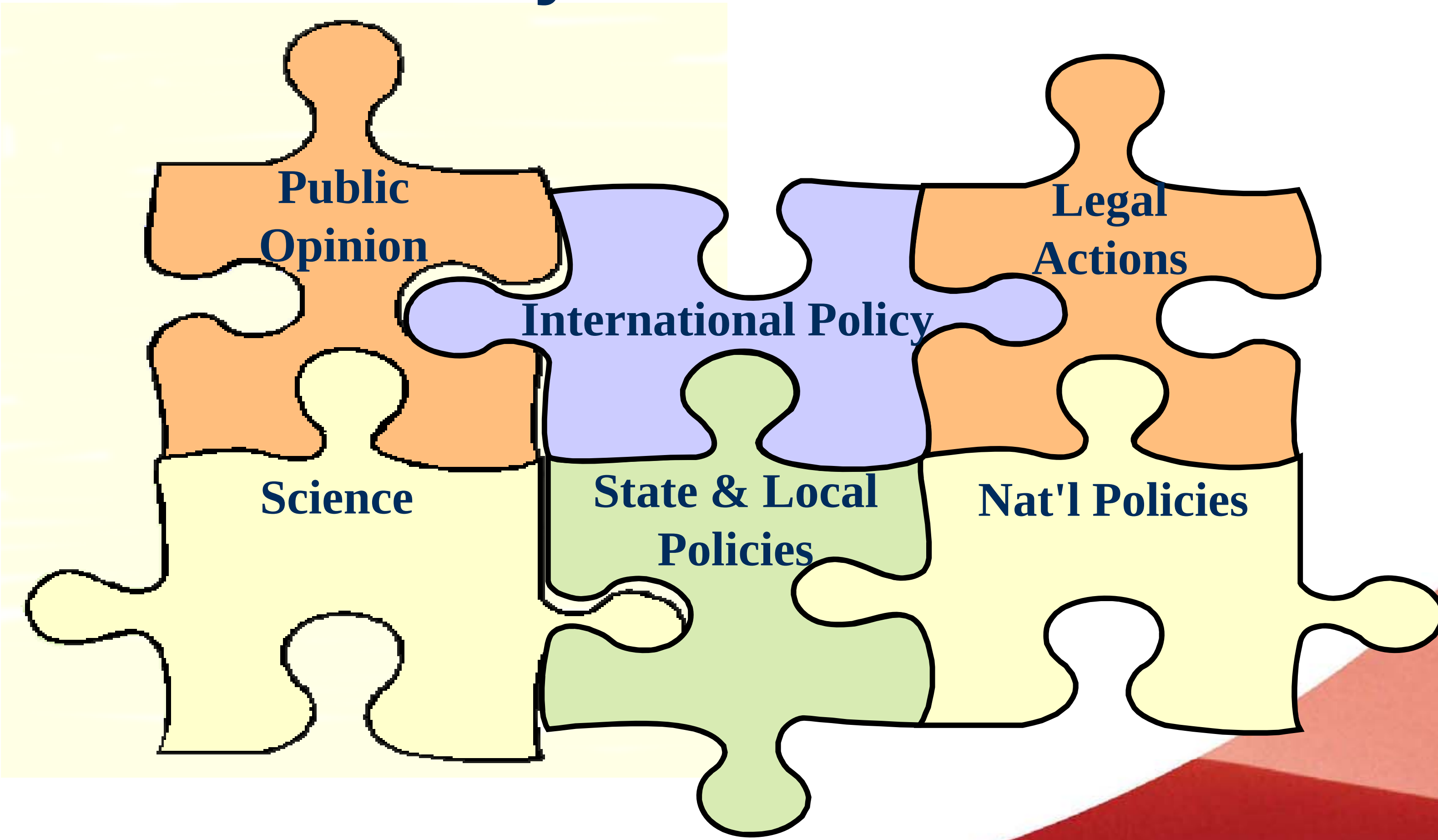
1. Setting the CCS Stage

Will The Policy Pieces Fall Into Place?



Scenario 1 – Policy Stalemate

> Major Political and Economic Challenges

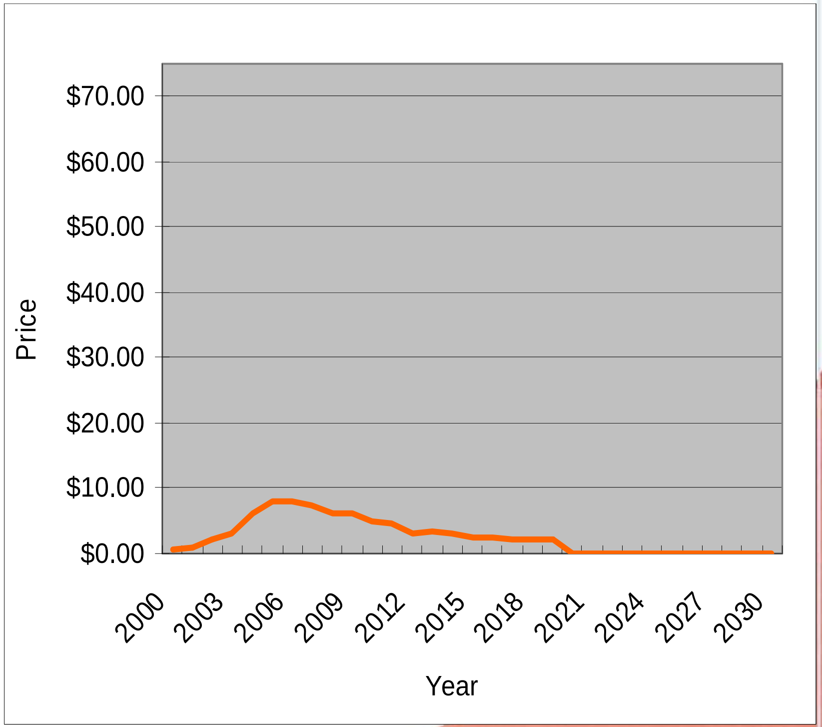
> Could Challenges Lead to Stalemate in Int'l and Domestic Policy Momentum?

– Absent a scientific reversal, hard to see

– Broad public support for action on this issue

> The Odds: Increasingly Low

> Note: Scenario Subject to Sudden Reversal



Scenario 2 – Political Status Quo

> Issue is Here to Stay
  - Numerous policies and measures pursued

> Will Affect Many Sectors in Material Ways
  - Range of Cost Estimates: $5-30/ton CO_2

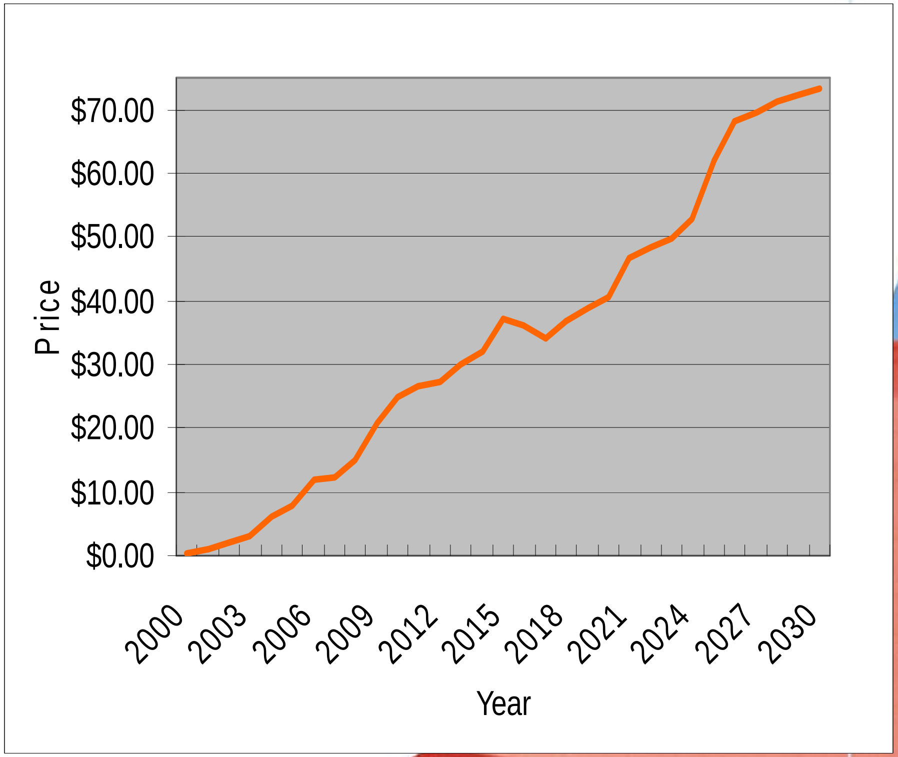
> But Policy Unable to Achieve CO_2 Stabilization

> The Odds: High

> Note: Scenario Subject to Sudden Reversal

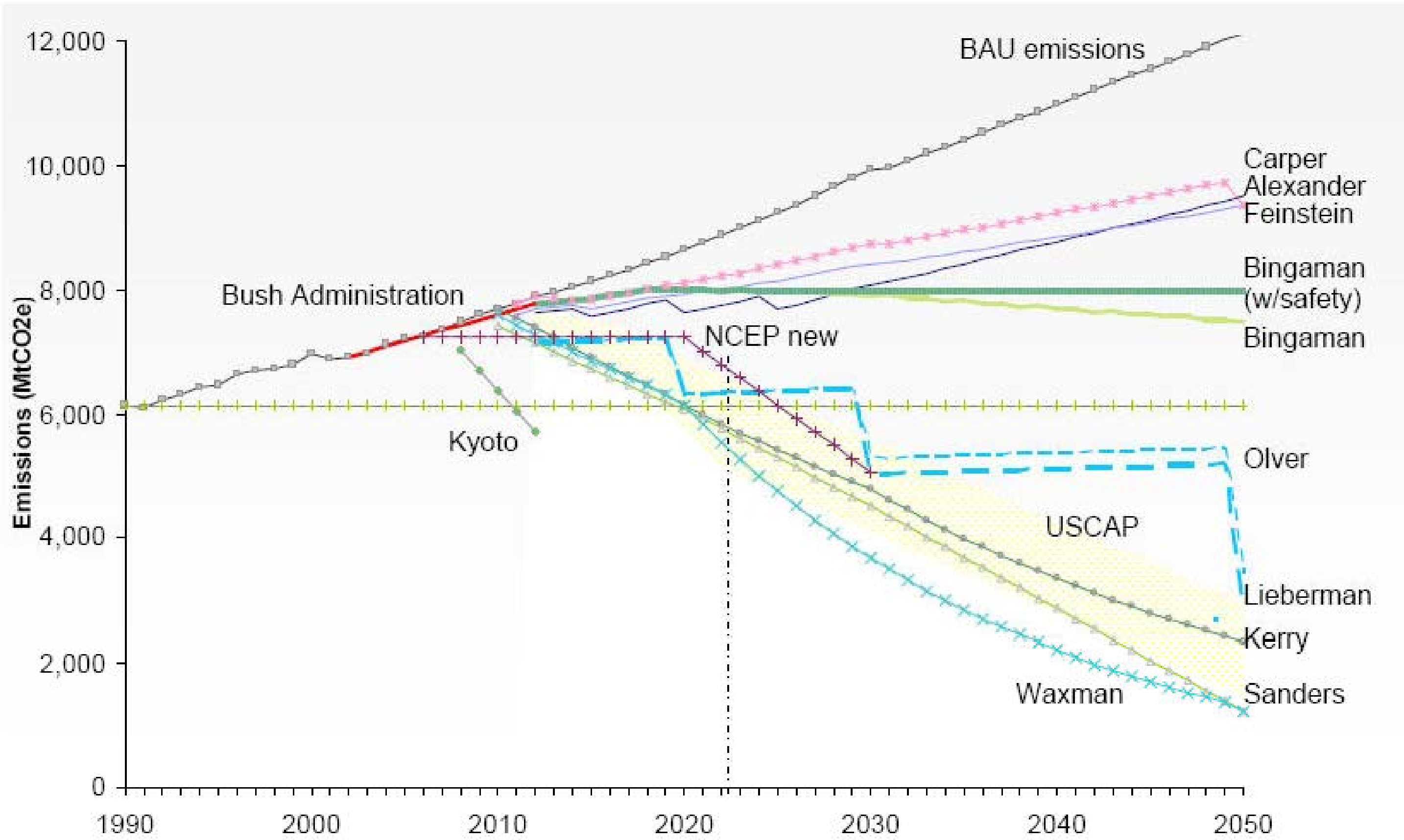
Scenario 3 – Atmospheric Stabilization

> Political Will Exists to Tackle
  – Aggressive reductions
  – Aggressive technology
  – Aggressive markets
> Material Economic Impacts
  – Stanford Modeling Forum: $75-100/ton CO_2
> The Odds: Modest at Best?



Proposed Federal GHG Bills

Comparison of US 2007 Climate Change Bills – Emissions versus Targets



Source: New Carbon Finance. Notes: BAU = business as usual greenhouse gas emissions; Projections based on EIA and BEA data, and NEF extrapolations; NCEP new = National Commission on Energy Policy's revised recommended targets; USCAP = US Climate Action Partnership's recommended targets.

ECO SECURITIES

The Context for CCS as a Key Option

> In What Context is CCS Being Viewed?
  – Based on current market value of EOR CO2 ($15)?
  – Based on simple cost of injection of almost pure CO2 (<$10)?
  – Based on current carbon markets ($5-10 voluntary, $15-30 regulatory)?
  – Based on current (estimated) costs of capture through storage?
    • Pulverized coal: $30-70
    • Gasified coal: $15-55
    • Natural gas: $40-90
  – There's a big gap between current CCS $$s, and current GHG $$s

> There's a Big Gap Between Where CCS Wants to Go, and Market Has Gone So Far When it Comes to Technology Promotion

> Can CCS Fit Into Carbon Markets? If So, How?

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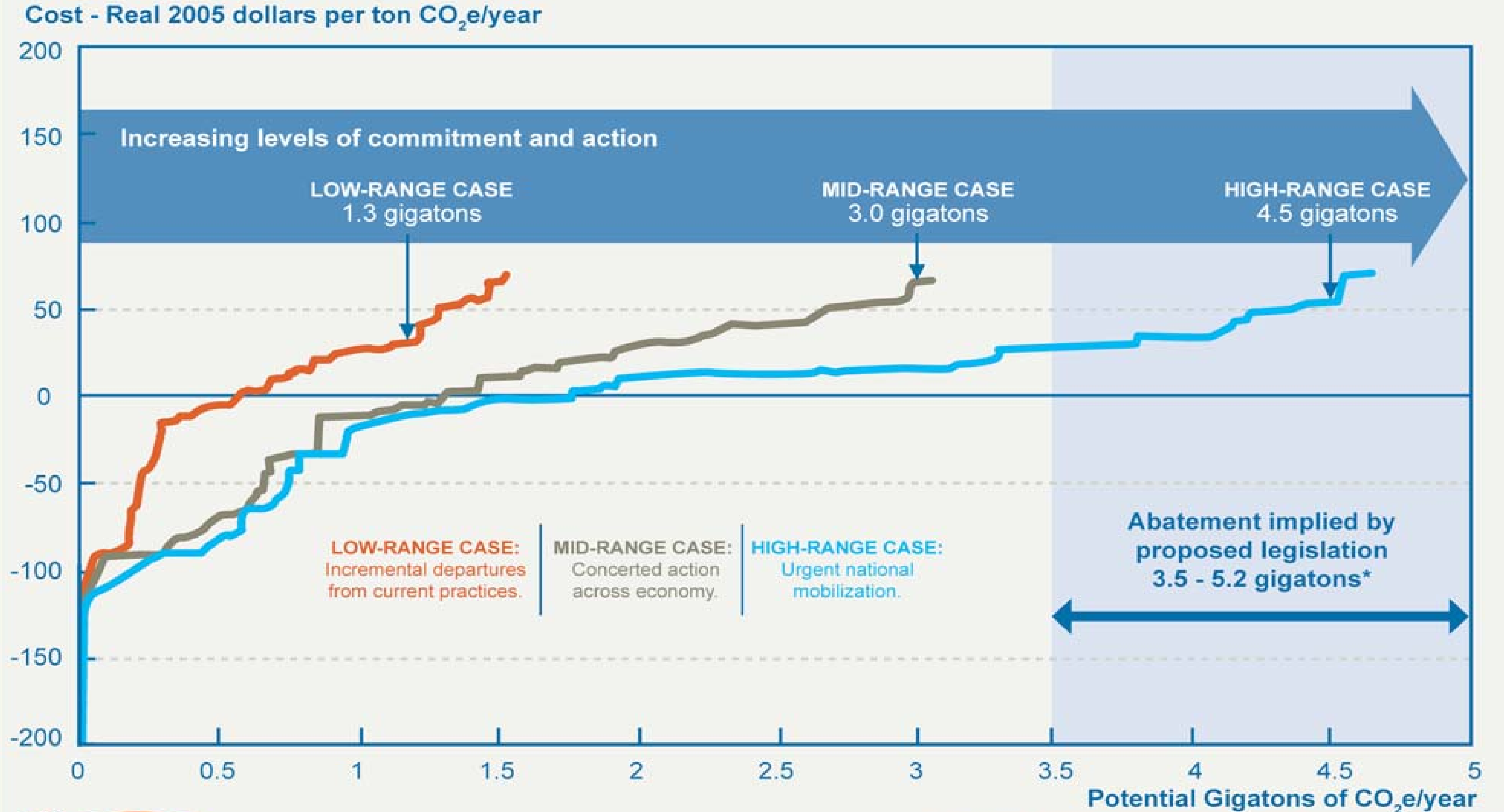
2. Forecasting GHG Markets

ECO SECURITIES

U.S. GREENHOUSE GAS ABATEMENT POTENTIALS - 2030



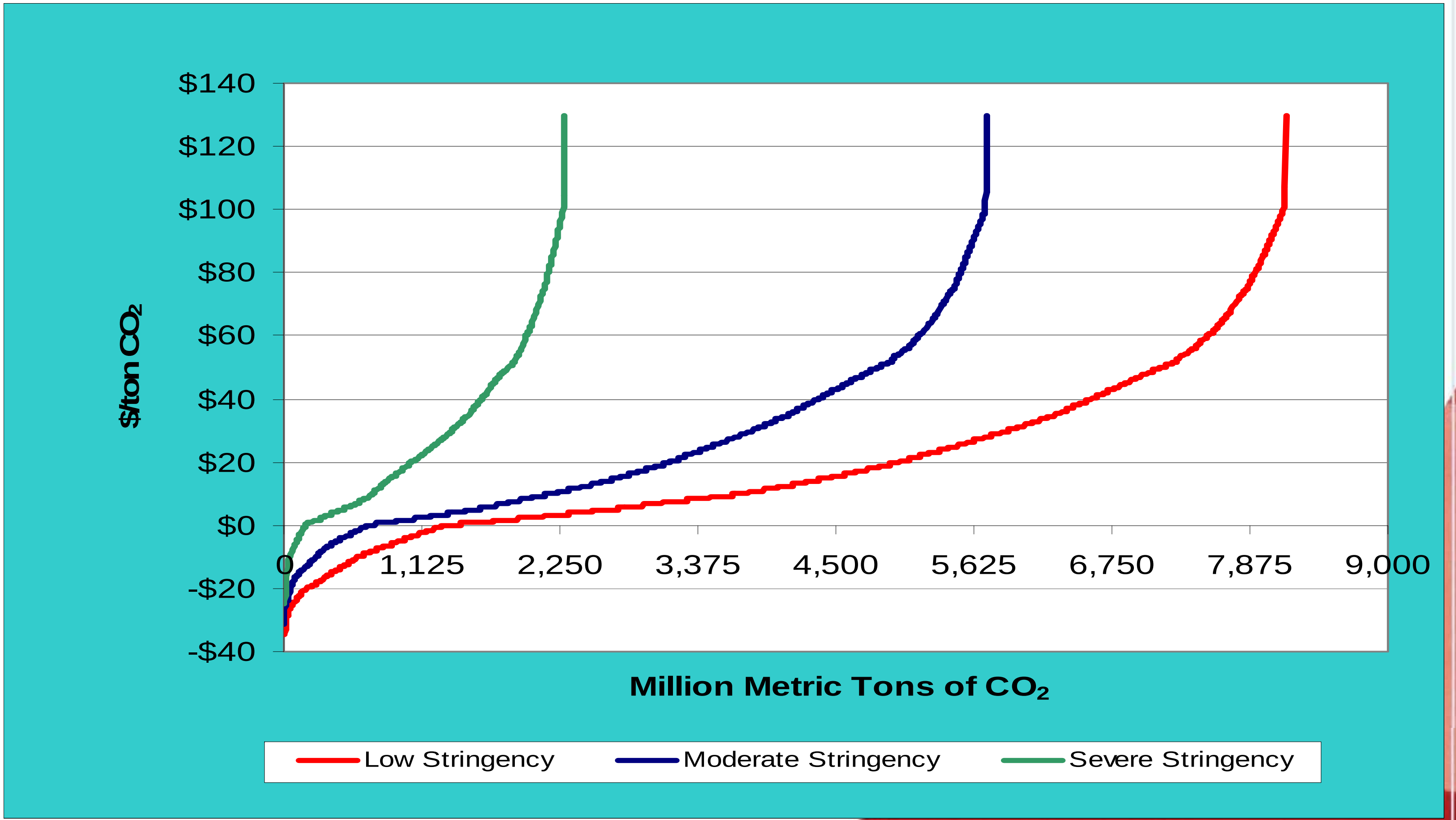
*Based on bills introduced in Congress that address climate change and/or GHG emissions on an economy-wide basis and have quantifiable targets; targets calculated off the 2030 U.S. GHG emissions of 9.7 gigatons of CO_2e/year (reference case) SOURCE: McKinsey Analysis

3Degrees. Bringing Climate Solutions Down To Earth.

Market Variables

> Context Variables
  – Science, media, public opinion, policy
> Demand Variables
  – Growth, fossil prices, targets, U.S.- D.C. role
> Technology Variables
  – Costs, R&D spending, deployment support
> Supply Variables
  – What counts, how counted, rules, behavior, psychology
> Transaction Variables
  – Costs, delays, taxes, certainty of rules

2010 GHG MAC Curve



Carbon Credit Price Forecasting

- > While a Supply and Demand Approach Makes Sense…
  - Demand is (obviously) largely a function of policy decisions
  - But (much less obviously) so is supply
    - What is a “credit”?
    - How are “credits” qualified?
    - How are “credits” quantified?
- > This Makes the GHG Commodity Very Different
  - Price forecasting meaningless w/o policy context
  - Can’t think of as predictable commodity
- > There is an Upside. Carbon Markets are Policy Markets, and We Could Use Them Accordingly

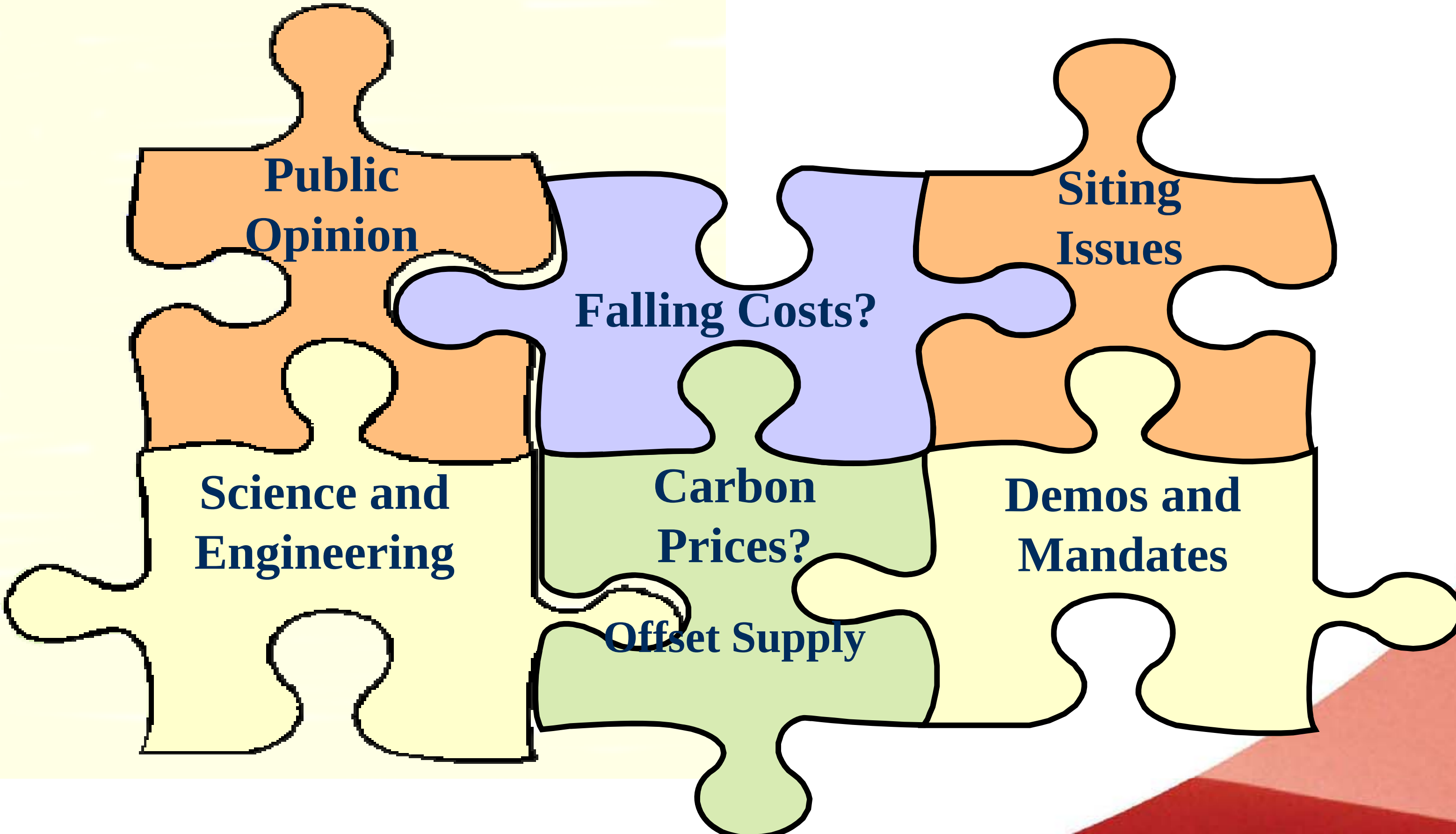
Table of Contents

3. How Does CCS Fit?

From the Carbon Market's Perspective

As We Resolve the Technical Issues, How Should We Be Anticipating CCS's Role in Carbon Markets and Business Decisions?

Will The CCS Puzzle Fall Into Place?



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How to Think About CCS?

- Carbon Market Financing Very Susceptible to Risk, Uncertainty
  - Timing, risks, capital commitments?
- Carbon Markets Very Unlikely to Overcome This Uncertainty
  - Overcoming "Mountain of Death" will require subsidies, risk offloading
  - Front loading an interesting option(s), but faces real obstacles, even though perfectly legitimate in a "policy market"
- If You Build It, Will They Come?
  - CCS plausibly fits into a plausible GHG supply curve
  - But, there are "disruptive" technologies out there (oceans, REDD, nuclear)
  - And A LOT starts to happen at $30/ton, and at

    $130/barrel oil that may compete with CCS

ECO SECURITIES

So What's The Answer?

- > So It All Comes Back to Policy, Expectations About Policy, Associated Market Demand, Supply, and Expectations About Supply
- > If We Really Believed That CO2 Would Soon Have a Value of >$50/ton in the Relatively Near Term, The World Would be a Very Different Place

- > Carbon Market as a Launch Pad? Highly Unlikely
- > Carbon Market as a Cash Flow? Much More Possible
- > Carbon Market a Clean Miss? Hopefully Not, but Possible

For More Information

> Mark C. Trexler
> Managing Director, Global Consulting Services
> EcoSecurities
> Mark.trexler@ecosecurities.com
> 503-231-2727
> www.climateservices.com
> www.ecosecurities.com

A Trust Fund Approach for Accelerating the Demonstration and Adoption of CCS

Edward S. Rubin
Department of Engineering and Public Policy
Carnegie Mellon University
Pittsburgh, Pennsylvania

Presentation to the

Expert Meeting on Financing Carbon Capture and Storage Projects
New York, NY

May 28, 2008

Outline of Talk

- The need for full-scale CCS deployment
- Why the urgency?
- Options for accelerating CCS deployment
- A CCS Trust Fund approach
- Where do we go from here?

Premise

- Coal-based power plants will continue to provide the major share of electricity demand for decades to come
- Large reductions in CO_2 emissions from such plants are urgently needed to address global climate change
- Only CCS has promise to enable significant continued use of coal while addressing global climate change

The need for full-scale CCS deployment

Deployment is Needed to . . .

- Establish the reliability and true cost of CCS in utility applications at commercial scale, for:
  - Alternative technologies (PC, IGCC; new, retrofit)
  - Different coal types (bituminous, sub-bit, lignite)
  - Different geological settings
- Establish the legal and regulatory requirements for geological sequestration at significant scales
- Reduce future cost of CCS via learning-by-doing plus sustained R&D

The Good News

- A variety of CCS projects are underway or planned in different parts of the world

But ...

- Only a small number of coal-fired power plant projects are currently funded at large-scale
- Full funding is still uncertain (to differing degrees) for most/all(?) proposed large projects

Project Name	Location	Feedstock	Size MW	Capture Process	CO2 Fate	Start-up
Total Lacq	France	Oil	35	Oxy	Seq	2008
Vattenfall Oxyfuel	Germany	Coal	30/300/1000	Oxy	Undecided	2008
AEP Alstom Mountaineer	USA	Coal	30	Post	Seq	2008
Callide-A Oxy Fuel	Australia	Coal	30	Oxy	Seq	2009
GreenGen	China	Coal	250/800	Pre	Seq	2009
Williston	USA	Coal	450	Post	EOR	2009-15
NZEC	China	Coal	Undecided	Undecided	Seq	2010
E.ON Killingholme	UK	Coal	450	Pre	Seq	2011
AEP Alstom Northeastern	USA	Coal	200	Post	EOR	2011
Sargas Husnes	Norway	Coal	400	Post	EOR	2011
Scottish& So Ferrybridge	UK	Coal	500	Post	Seq	2011-2012
Naturkraft Kårstø	Norway	Gas	420	Post	Undecided	2011-2012
ZeroGen	Australia	Coal	100	Pre	Seq	2012
WA Parish	USA	Coal	125	Post	EOR	2012
Coastal Energy	UK	Coal/Petcoke	800	Pre	EOR	2012
UAE Project	UAE	Gas	420	Pre	EOR	2012
Appalachian Power	USA	Coal	629	Pre	Undecided	2012
Wallula Energy	USA	Coal	600-700	Pre	Seq	2013
RWE npower Tilbury	UK	Coal	1600	Post	Seq	2013
Tenaska	USA	Coal	600	Post	EOR	2014
BP Rio Tinto Kwinana	Australia	Coal	500	Pre	Seq	2014
UK CCS project	UK	Coal	300-400	Post	Seq	2014
Statoil Mongstad	Norway	Gas	630 CHP	Post	Seq	2014
RWE Zero CO2	Germany	Coal	450	Pre	Seq	2015
Monash Energy	Australia	Coal	60 k bpd	Pre	Seq	2016
Powerfuel Hatfield	UK	Coal	900	Pre	EOR	Undecided
ZENG Worsham-Steed	USA	Gas	70	Oxy	EOR	Undecided
Polygen Project	Canada	Coal/Petcoke	300	Pre	Undecided	Undecided
ZENG Risavika	Norway	Gas	50-70	Oxy	Undecided	Undecided
E.ON Karlshamn	Sweden	Oil	5	Post	Undecided	Undecided

Source: MIT, 2008

The Bad News

CCS Project Cancellations, 2007–2008

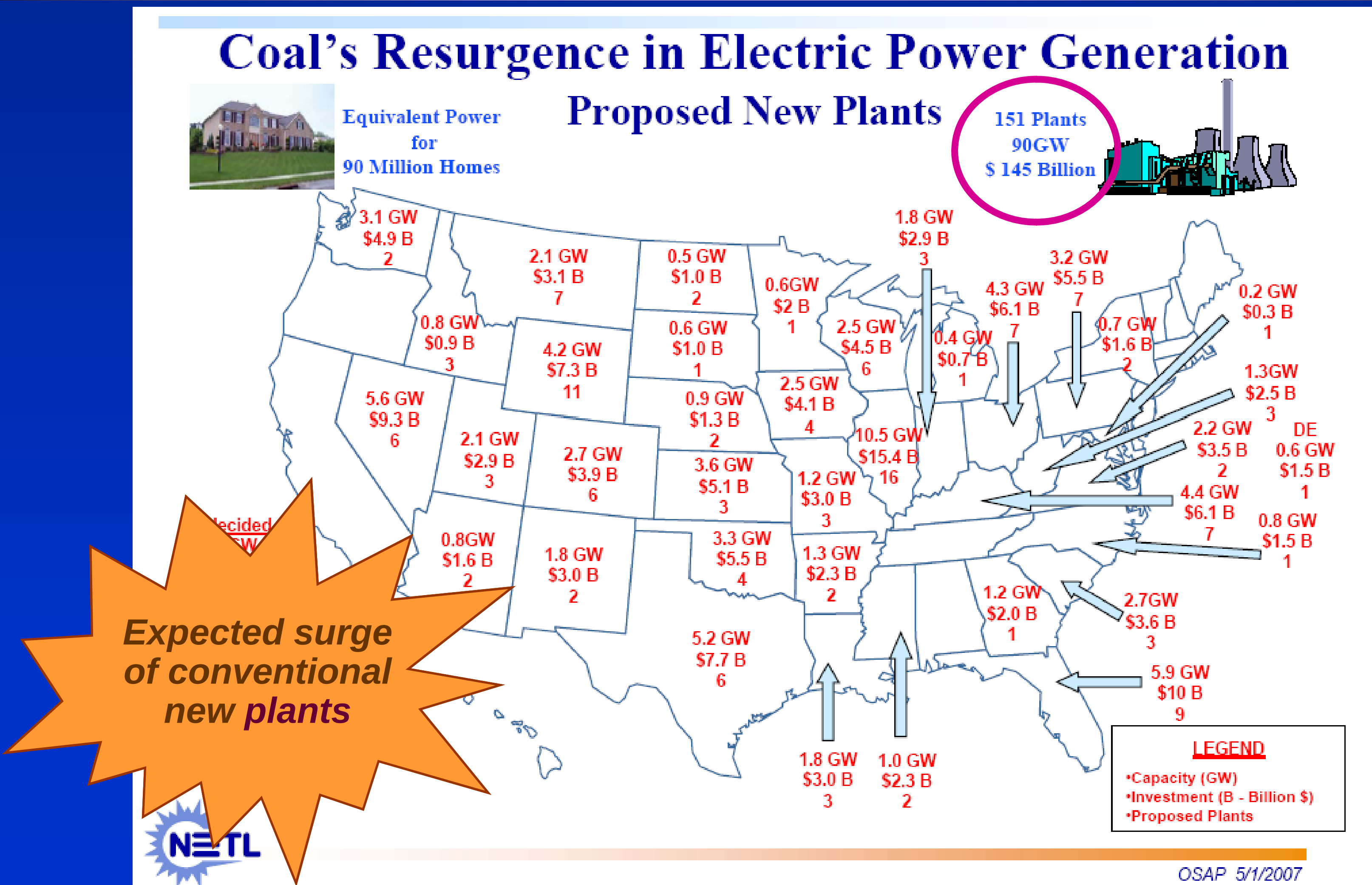
Project	Location	Technology	CCS Type	Developers
FutureGen	USA	275 MW coal IGCC	Pre-/ Aquifer	FG Alliance, DOE
Clean Coal	Canada	450 MW lignite PC	Oxy-/ Geol.	SaskPower + others
Peterhead	UK	475 MW gas IGCC	Pre-/ EOR	BP, SSE
Halten	Norway	860 MW gas NGCC	Post-/ EOR	Statoil, Shell

No certainty that currently proposed projects will be fully funded and completed as planned

Why the urgency?

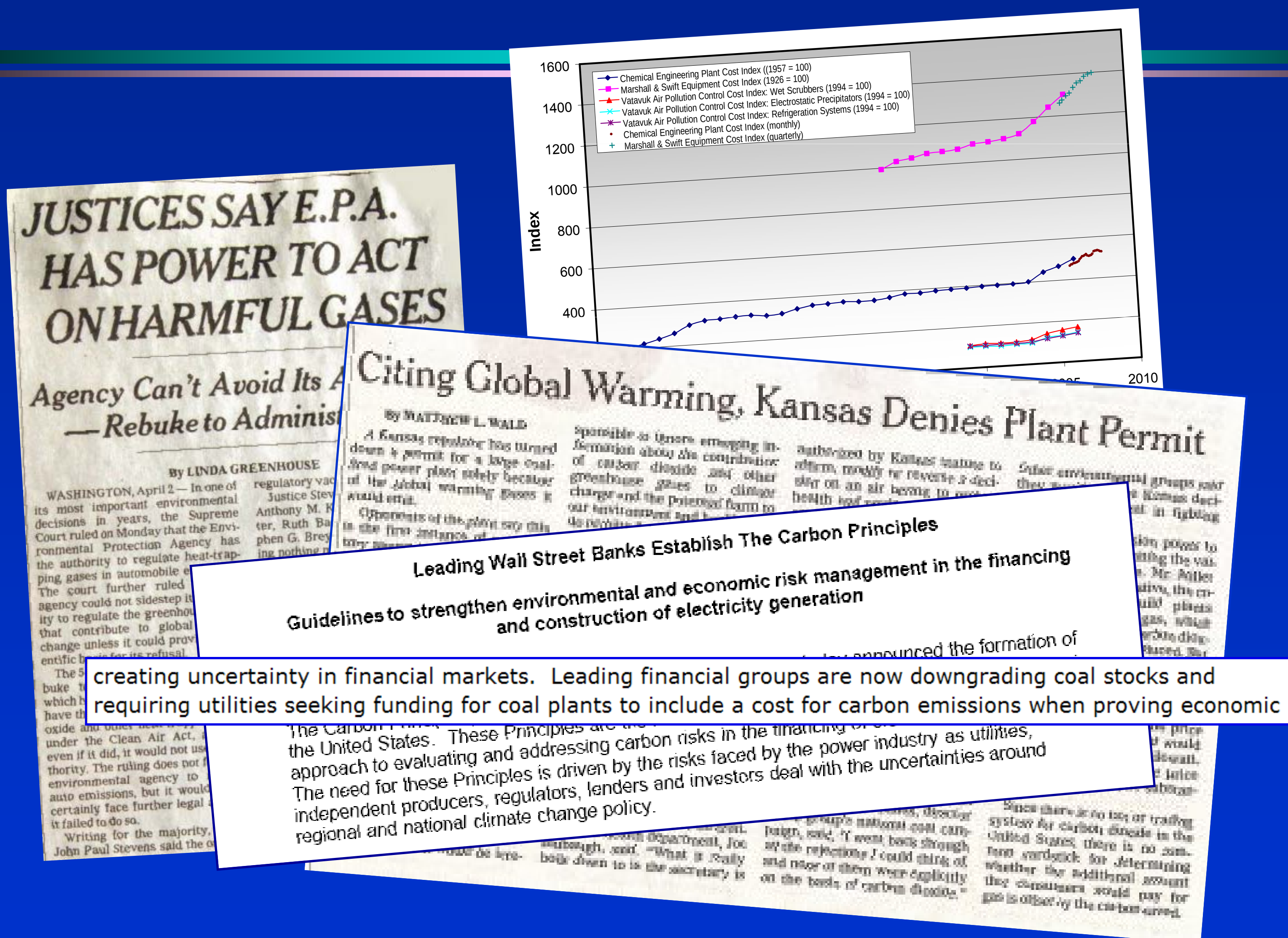
Remember the Good Old Days ?

(One year ago !)



E.S. Rubin, Carnegie Mellon

What a Difference a Year Makes



Opposition to conventional coal has become more vocal


There are over 150 new coal-burning power plants currently on the drawing board.

Let's keep them there.

Don't fund global warming.

Stop investment in all new coal-burning power plants.

Coal-burning power plants are the world's largest greenhouse gas polluters and a direct threat to our future. Yet prominent financial institutions, including JPMorgan Chase, Goldman Sachs, Citigroup, Morgan Stanley, Merrill Lynch, Credit Suisse and Lehman Brothers, are eager to finance their construction. The truth is, every dollar invested in coal is a dollar that could be invested in energy efficiency and wind and solar power. Help us make sure these coal-burning power plants are never built. Tell Wall Street that investing in coal is simply too risky. Visit www.ran.org to join the fight.

RAINFOREST ACTION NETWORK

NO NEW COAL

RAN 221 Pine Street, #500, SF, CA 94104 www.ran.org

THE NEW YORK TIMES OP-ED FRIDAY, MARCH 23, 2007


...p of potential builders look over the proposed site of a coal-fired plant near Great Falls, Mont. Below, Richard D. ... who owns the Windwalker Ranch near the planned site, is a vocal, and unusual, opponent of the power plant.

Strangers as Allies

...ght Against Coal Plants Is Creating Diverse Partnerships

By SUSAN MORAN

...EAT FALLS, Mont. — Richard D. ...t turned his back against a hard ...he other day, adjusted his black ...d gazed across golden fields of ...plaining why he is against con... ...on of a big coal-burning power ...ast of town, Liebert sounded ...e more voice from the green ...ent.

... more I learn about global ...g and watch the drought affect ranchers and farmers, I see that it's wind energy, ... plants, that can help with ...omic development. Besides, ...t to roll the dice with the one ...ve got?"

... Liebert, despite his senti... nobody's stereotype of an ...ntalist. He is a Republican, ...ncher and a retired Army ...olonel who travels to South ... in soldiers to fight in Iraq. ... is also an example of a rising phenomenon in the West. An increasingly vocal, potent and widespread anti-coal movement is developing here. Environmental groups that have long opposed new power plants are being joined by ranchers, farmers, retired homeowners, ski resort operators and even religious groups.

Activists say the increasing diversity of these coalitions is making them more effective.

"You're seeing a convergence of people who previously never worked together or even talked to each other," said Anne Hedges, program director of the Montana Environmental Information Center, which is spearheading three lawsuits aimed at blocking construction of the power plant near Great Falls. "They're saying these coal plants don't make any sense, whether from an economic or environmental or property-rights standpoint."

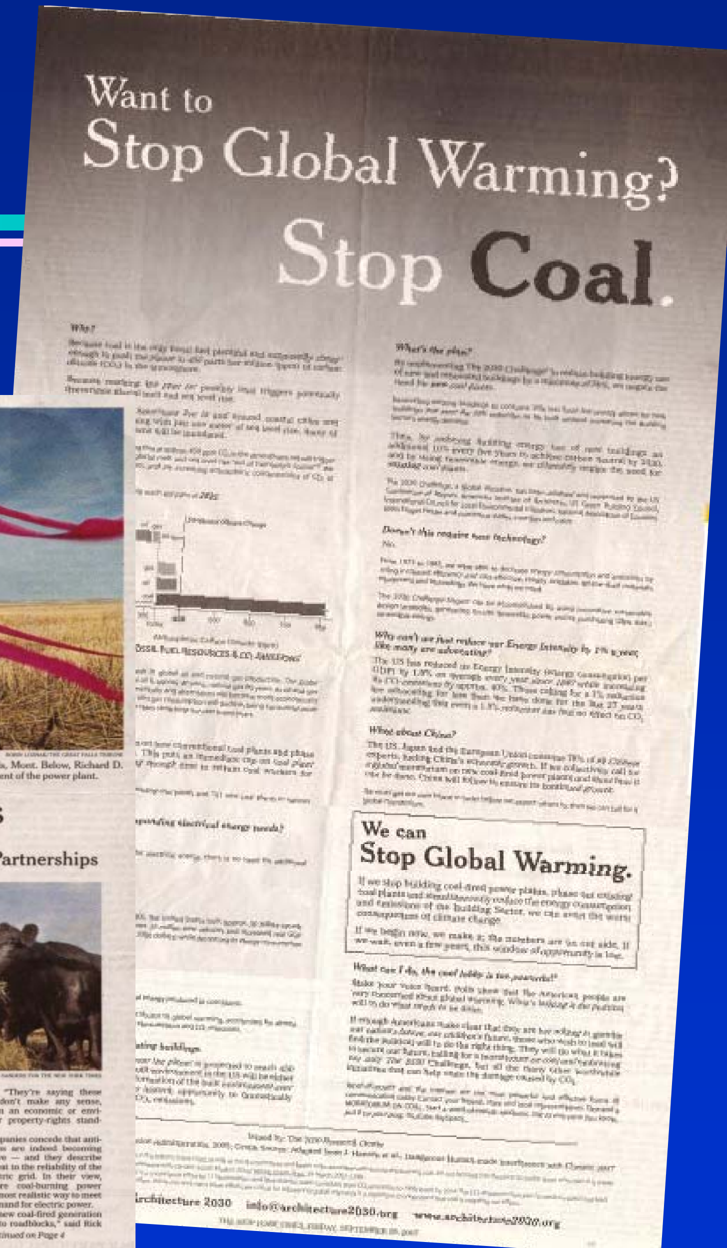
Power companies concede that anti-coal coalitions are indeed becoming more effective — and they describe that as a threat to the reliability of the nation's electric grid. In their view, building more coal-burning power plants is the most realistic way to meet the rising demand for electric power.

"It's clear new coal-fired generation is running into roadblocks," said Rick

Continued on Page 4

KANSAS PLANT REJECTED

A Kansas regulator turned down a permit for a coal-fired power plant because of global warming. Page B4.


Want to Stop Global Warming?

Stop Coal.

Why?

What's the plan?

Doesn't this require new technology?

No.

What about China?

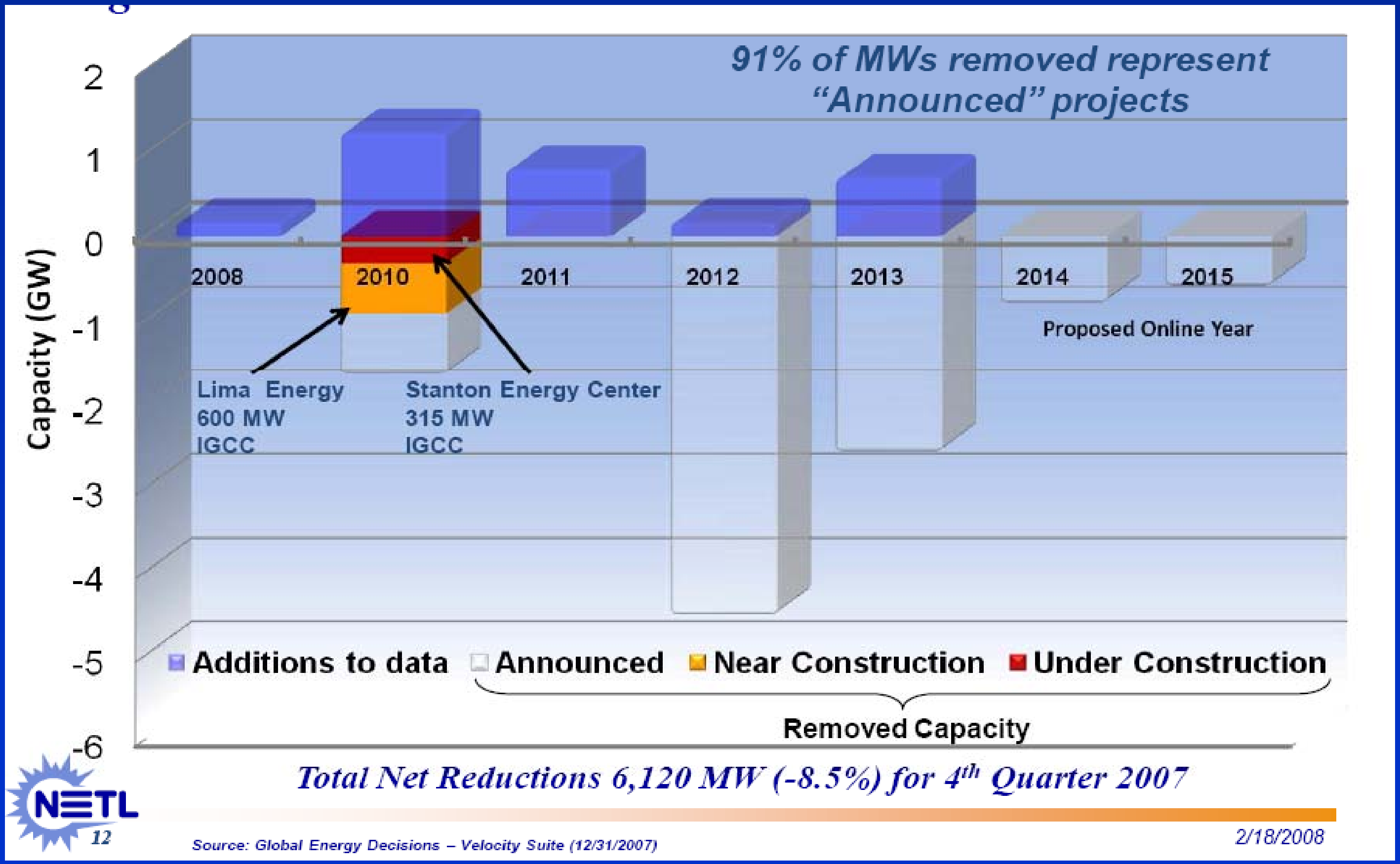
We can Stop Global Warming.

What can I do, the coal lobby is too powerful?

architecture 2030 info@architecture2030.org www.architecture2030.org

Many Projects Now Being Cancelled

Changes in projected U.S. capacity in 4th quarter 2007



The U.S. Outlook

- It will be very difficult—and perhaps impossible—to undertake large new coal-fired power projects that do not include CO_2 capture and sequestration
- Reserve margins soon will be compromised in several parts of the country if no new plants built

So …

- *Learning sooner rather than later what CCS* ***really costs****, and how well it* ***really works*** *in full-size utility applications, is an urgent priority !*

How can we accelerate funding of large-scale CCS projects?

Options for Accelerating CCS

- Expand traditional “technology policy” options (e.g., tax credits, subsidies, etc.)
  (as in Energy Policy Act, USDOE CCTI program, etc.)
- Set new regulations requiring CCS (e.g., generator CO_2 performance standards)
  (as in California CO_2 stds, NSPS for major pollutants, etc.)
- Adopt sufficiently stringency cap-and-trade program w/ CCS bonus allowances and/or a tech. fund (e.g., from auction of allowances)
  (as in Lieberman-Warner bill and others.)
- Establish a CCS Trust Fund with fees used to pay full added cost of early CCS projects
  (proposed here; under consideration by Congress and EPA)

— Focus of this study is on the Trust Fund option —

Why a Trust Fund ?

Advantages of a CCS Trust Fund

- Can raise large amounts of money via small fees on the use of coal for power generation
  (historical gov't. incentives are insufficient and not reliable)
- Not coupled to stringent CO_2 reduction mandate — can start rapidly with well-defined revenues
  (accelerates learning and significantly reduces future costs)
- Can ensure that funds will benefit payees
  (all coal-based entities benefit, making fees more tolerable)
- Can ensure reliable multi-year funding stream
  (avoids annual appropriation process by imposing fees not taxes)
- Managed by independent (or quasi-public) entity
  (can employ private-sector standards for contracting and hiring)

Examples of U.S. Trust Funds

- *The Highway Trust Fund.* Created to finance interstate highway system; supported by automotive fuel taxes
- *Abandoned Mine Reclamation Fund.* Projects administered through the U.S. Department of Interior Office of Surface Mining
- *Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources.* Fund managed by a consortium of stakeholders (called RPSEA) under DOE oversight
- *Tobacco Master Settlement Agreement.* Payments and outlays managed by a private entity (National Association of Attorneys General)
- *The Propane Education and Research Council.* A privately administered fund created to support industry R&D and outreach

Lessons Learned from Past Programs

- Self-financing is necessary for costly programs
- Clear objectives must be established, and fees should terminate once objectives are reached
- Avoid the annual federal appropriations process (to ensure reliability of funding; impose fees not taxes)
- Use an independent or quasi-public entity (allows private-sector contracting and hiring standards)

How Would It Work for CCS ?

- A CCS Trust Fund would be established to pay the full incremental costs of installing and operating CCS systems at a selected number of coal-based plants
- Costs would be supported by a fee on coal-based (or other types of) electricity generation or fuel use
- The Fund would be managed by an independent (quasi-public) group that would select, fund and manage appropriate projects to meet program goals
- Results and experience would be shared widely
- The Fund would terminate after a fixed period of time

Proposed Program Elements

- CO_2 Sources:
  - Commercial power generation units (~ 400 MW_{net})
  - Optional storage-only projects at large industrial sources with high-purity CO_2 vents (e.g., ethanol plants, ammonia and fertilizer plants, natural gas processing plants, etc.)
- Incremental costs to be covered:
  - Capital costs to install capture equipment
  - Reimburse loss of net generation capacity
  - Additional plant O&M costs (~5 years)
  - CO_2 transport and injection costs (~5 years)

What Would It Cost?

- Total incremental cost of building and operating CCS at a 400 MW_{net} plant—including cost of the "energy penalty" (replacement power) plus CO_2 transport and aquifer storage costs for 5 years:

≈ 0.7 to 1.0 billion USD
per project

- Cost of additional projects using existing CO_2 from industrial sources (compression, transport, storage) ≈ 100 million USD per project (based on 2 $MtCO_2$/yr for 5 yrs)

Average Initial Cost of Projects

(Millions of 2006 U.S. dollars per ~400 MW plant)

Per Plant Incremental Costs of CCS	Based on New Plants	Based on Plant Retrofits
Capital Costs		
- Capture equipment	$210	$250
- Net capacity loss	$185	$360
Plant O&M Costs	$150	$150
Transport, Storage; Admin.	$190	$190
TOTAL (per plant)	**$735**	**$950**

Source: Kuuskraa, 2007

Total costs and fees evaluated for two program levels

Smaller-Scale Program

- Scope: 10 power plants (different plant types, coals, capture systems, storage sites); +5 industrial sites; ~10-year program
- Objectives
  - Establish true cost and reliability of CCS options
  - Obtain design and integrated CCS operating experience
  - Develop public and regulatory experience with CCS
- Cost
  - \$8-10 billion: \$0.4 to \$0.5 per MWh (~\$1B/yr)
    (based on current coal-fired generation and a 10-yr program)
  - *Increase for average residential household* ≈  per day

Larger-Scale Program

- Scope: 30 power plants (multiple "generations" of plants and CCS technologies); +10 industrial sites; 10–15 year program
- Additional Objectives
  - Significantly reduce CCS costs and generation losses
  - Build public confidence in technology and regulations
  - Reduce emissions by 100 $MtCO_2$/yr by end of program
- Cost
  - \$23–30 billion: \$1.2 to \$1.5 per MWh (\$2–3B/yr)
    (based on current coal-fired generation and a 10-yr program)
  - *Increase for average residential household ≈*

Program Design Issues

- Administrative structure of the Fund
- Who pays the fee?
  - Only coal-fueled units?
  - Only fossil-fuel based generation?
  - All electricity providers/purchasers?
  - Only units with CO_2 above a specified level or rate?
- What mix of projects to support (and when)?
  - Technologies (PC, IGCC; pre-, post, oxyfuel)
  - Plant vintages (new, retrofit, repower)
  - Coal types (bituminous, sub-bituminous, lignite)
  - Sequestration sites & type (aquifers, EOR; regional mix)
- Options for cost-sharing, re-payment, etc.

Pew Center Evaluation Criteria

Policy options evaluated based on their:

- Effectiveness in reducing emissions
- Cost and cost-effectiveness
- Familiarity (precedents)
- Equity (regions, firms, technology)
- Ease of implementation
- Timing of implementation
- Linkage to other policies
- Impact on utility coal use

Details Described in Recent Reports
(Available at: www.pewclimate.org)

E.S. Rubin, Carnegie Mellon

Recent Support

- "Congress should immediately create a CCS Early Deployment Fund... The quasi-governmental Fund would … generate $1 billion annually [to] cover the additional costs of CCS for at least 5 to 10 full-scale early commercial demonstrations of various technologies [at mainly] coal-based electricity generators."
  – Recommendation of the USEPA Advanced Coal Technology Work Group (an independent advisory group), January 2008
- "Reps. Rick Boucher (D-VA), John Murtha (D-PA), and Nick Rahall (D-WV) are drafting legislation that would create a multi-billion dollar fund to encourage the use of CCS technology at power plants. Under the plan, a small fee would be imposed on electricity users and the proceeds would be kept outside of the Congressional appropriations process."
  -Van Ness Feldman, Washington, DC, April 2008

Where do we go from here ?

Take-Home Messages

- There is an urgent need to demonstrate at large scale a range of integrated CCS technologies at coal-based power plants (>10 projects at >100 MW_e)
- Current government and industry programs do not provide the level of funding that is required
- We need to aggressively pursue additional options to raise roughly $10–30 billion to support selected and carefully-timed projects over the next 10–15 years
- A CCS Trust Fund supported by fees on electricity generation merits attention as an option for doing this quickly and effectively

Comments Welcomed

rubin@cmu.edu

Acknowledgements:
This work was supported by the Pew Center on Global Climate Change, with major contributors by Naomi Pena (Pew Center) and Vello Kuuskraa (Advanced Resources International, Inc.)

CCS and US Cap-and Trade Proposals

By Robert M. Sussman
Senior Fellow
Center for American Progress
Washington DC
bsussman@americanprogress.org

Current Status of CCS Under US Law

- CCS at demonstration project stage in US
- Little incentive now to install CCS at new coal plants
  - Capital cost increases
  - Reduced efficiency and output
  - Higher electricity costs
  - Uncertainties about technology
  - Liability concerns
- CCS not likely to move forward until drivers/incentives change

A New Policy Framework to Push CCS Forward

- Overall Challenge:
  - How do we put in place policy drivers that change economic calculus of plant developers and spur adoption of CCS?
- Key focus in US:
  - Using cap-and-trade programs to encourage CCS
- Key policy question:
  - Will putting a price on carbon under allowance trading system eliminate current economic barriers to CCS and drive deployment?

S. 2191– Lieberman-Warner Climate Security Act

- Leading US legislative proposal – will be considered by US Senate starting on June 2
- Recently modified by Boxer Substitute (S. 3036)
- Establishes cap-and-trade system covering 87 percent of US emissions
- Would achieve US emission reductions below 2005 levels of –
  - 17-19 percent by 2020
  - 57-63 percent by 2050

How Does Cap-and-trade Work under S. 2191?

- Year-by-year reduction in allowable emissions by covered sources (the “cap”)
- Covered sources must hold *allowances* equal to their emissions. They include:
  - Upstream producers/importers of petroleum and natural gas – must hold allowances for downstream emissions
  - Users of coal (electric utilities) -- must hold allowances for direct emissions from coal combustion
- EPA establishes an Emission Allowance Account for each calendar year
  - Total allowances decline as yearly cap declines
  - 5.775 billion allowances in 2012 declining to 1.732 billion in 2050
- Allowances can be bought, sold or held by anyone

How Allowances Are Distributed

- L-W distributes allowances by --
  - Free allocation to certain entities and
  - Annual auction process
- Auction conducted by Environmental Protection Agency
- Percentage of allowances auctioned increases over time
  - 26.5% in 2012
  - 41% in 2022
  - 69.5% in 2031

Free Distribution of Allowances to Industry ("Transition Assistance")

- Portion of total allowances distributed for free to industry declines over time
  - 43% in 2012
  - 28.5% in 2022
  - 0% in 2031
- Largest share of free allowances goes to
  - Fossil-fueled power plants (18%)
  - Carbon intensive manufacturing (11%)

Use of Auction Revenues

- Revenue stream will grow as allowance prices and size of auction increase
- One estimate is that auction revenues will be –
  - 38B in 2012
  - 63B in 2022
  - 111B in 2030
- Auction revenues will be used for multiple purposes, including
  - Tax relief for energy consumers
  - Deficit reduction
  - Advanced technology deployment

Would Cap-and-Trade Alone Promote CCS?

- Cost per ton of CCS is estimated to be ~ $40-55
- US Environmental Protection Agency projects that allowance prices under S. 2191 will be:
  - $17 per ton in 2012
  - $28 per ton in 2020
  - $37 per ton in 2025
  - $46 per ton in 2030
- CCS will likely not be cost-competitive with other options before 2030
- It would be more economic to build an uncontrolled conventional coal plant and offset emissions by purchasing allowances
- CONCLUSION: Even with cap-and-trade, carrots and sticks are needed for wide deployment of CCS and to discourage conventional coal plants

Going Beyond Cap-and-Trade: Three Mechanisms to Accelerate CCS Deployment

- Issue free bonus allowances
- Require CCS through emission performance standard for new plants
- Provide subsidies using revenues from auctioning of allowances

Bonus Allowances under S. 2191: Program Details

- "Bonus allowances" issued to reward CO_2 capture and storage
- 3-4% of total allowances set aside
- Program expires in 2039
- Number of allowances awarded based on "bonus rate"
  - Starts at 2 allowances per ton sequestered
  - Gradually declines to zero in 2040
- Facilities must capture at:
  - 60% rate for facilities beginning construction before 2018
  - 85% rate if construction starts after 2018
- Bonus allowances distributed for 10 years after start of plant operations

Bonus Allowances: Rationale

- CCS will be accelerated because dollar value of allowances will close "cost gap" between CCS and uncontrolled plants
- But how will bonus allowances really work?
  - How much CCS would we get and at what cost?
  - Are the incentives too great or not great enough?
  - Would conventional coal plants still be built?

Bonus Allowances: CAP Critique

- Would subsidize a limited amount of new coal through 2030 (around 80 Gigawatts)
- Bonus allowances for all plants would be worth $60-80 billion between 2012 and 2030 (EPA allowance price projection)
- Bonus allowance subsidy is greater than necessary to close “cost gap” between CCS and regular coal
- If allowance prices are higher than predicted, bonus allowances would be worth even more
- Windfall allowances could be used to offset emissions at existing coal plants and delay reductions
- New plants could still be built without CCS

Emission Performance Standard Proposed by CAP

- Would require new coal plants to capture and sequester emissions at level of best performing CCS technology
- Would apply to all plants entering construction after date of enactment of legislation (2008)
- Would provide flexibility in timing of CCS implementation
  - Plants would implement CCS by 2016 or four years after start of operations, whichever is later
  - Phase-in would provide lead-time for demonstration projects and site testing
  - Many experts believe CCS will be ready for wide deployment by 2020

Closing the Cost Gap through Subsidies

- Subsidies would perform same function as bonus allowances
  - provide “carrots” for CCS deployment
  - Offset higher costs of building/operating coal plants with CCS
- Subsidy should cover cost gap between CCS and conventional plants, including cost of purchasing allowances – but NOT provide windfall
  - With emission performance standard, no need to pay “premium” to encourage CCS
- Subsidy should decline over time as price of carbon rises and cost of technology goes down
- Subsidies could only be used for CCS – would NOT provide free allowances to offset emissions at existing plants

How to Pay For Subsidies

- Best revenue source: allowance auction proceeds under cap-and-trade program
- CAP estimate: Can subsidize 150 GW of new coal capacity for $29 billion between 2016 and 2030
- Cost of subsidy much lower than cost of bonus allowances
  - Reason: No windfall above actual cost differential
- Subsidies from auction proceeds could also be used for existing plant retrofits
- Latest version of L-W would provide $15.7 billion from auction proceeds to kickstart CCS demonstration projects
  - But full-scale deployment would be encouraged by bonus allowances

Conclusions

- Cap-and-trade will not automatically result in CCS and discourage conventional coal
- "Carrots" needed to close CCS cost gap
- Free bonus allowances will produce windfalls for some plants but not necessarily fund large-scale deployment
- Door still open for conventional coal
- Best approach: performance standard requiring CCS for new plants plus subsidy to close cost gap
- Best source of subsidy: Revenues from auctioning of allowances

Financing CO_2 infrastructure: *A CCP2 case study*

Paul Zakkour, Principal Consultant, ERM Energy & Climate Change

IEA GHG CCS Financing Workshop, 28th May 2008, New York

Overview of work plan

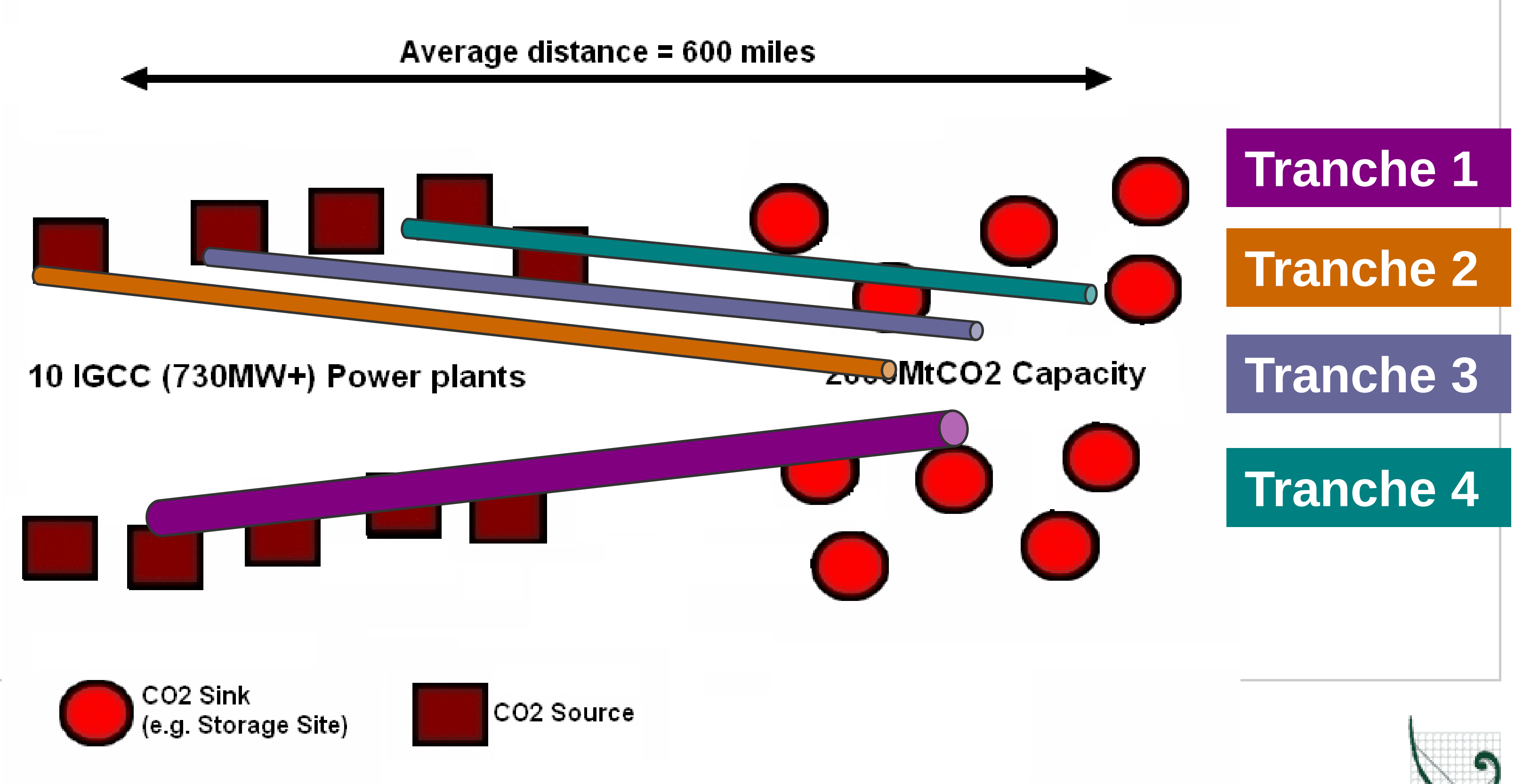
- **Aim:**
  - To assess financial aspects of building CO_2 pipeline networks including backbone pipelines
- **Tasks:**
  1. Review O&G financing models via case studies
  2. Review public/private project financing models via case studies
  3. Assess simple business models for CO_2 pipeline networks
  4. Interview financial service industry personnel on CCS financing perspectives

Assumptions and scenarios

Option 1:

Point to Point Pipelines

- **1 x 24 inch pipeline (tranche 1)**
- **3 x 18 inch pipelines (tranches 2, 3 and 4)**

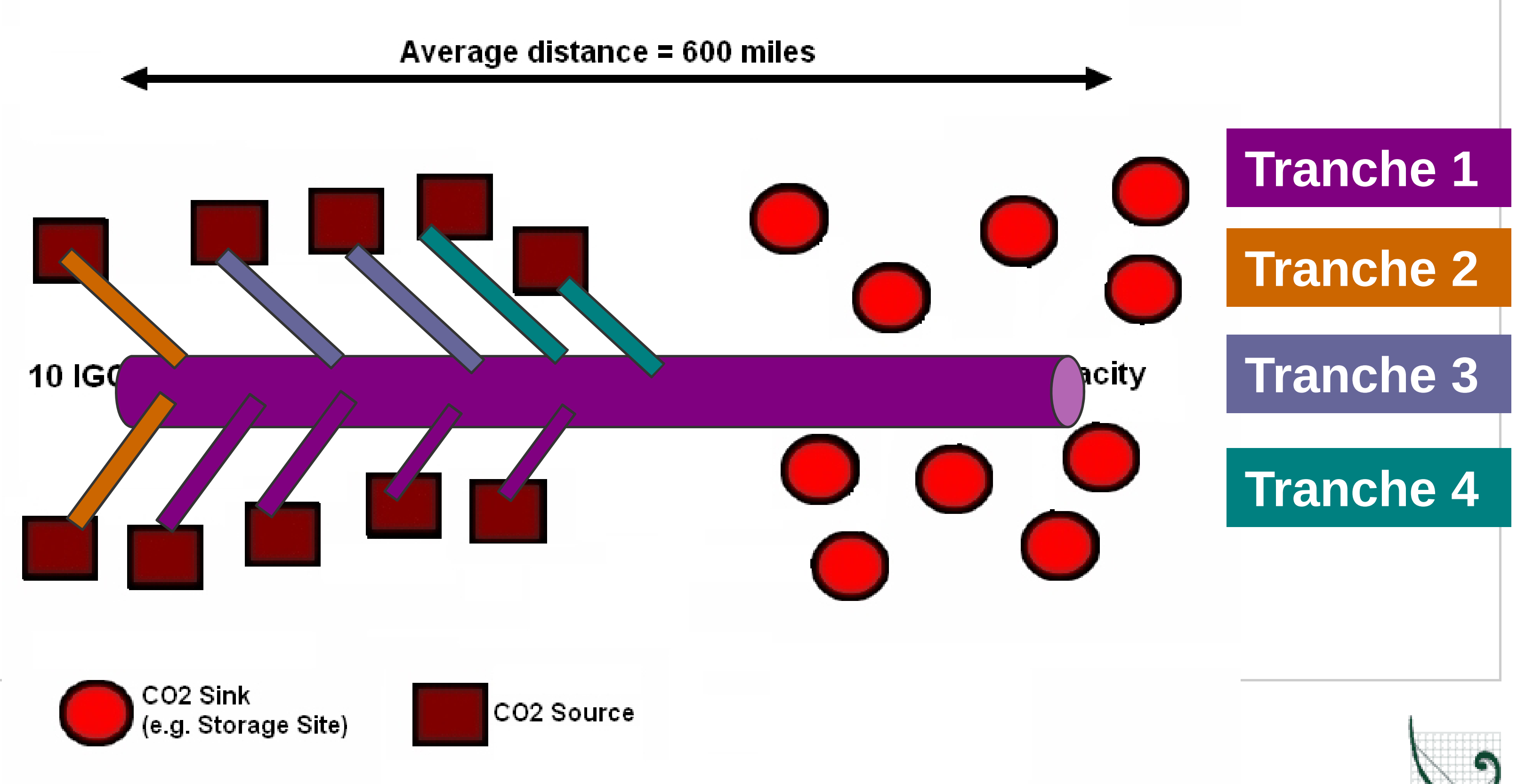


Assumptions and scenarios

Option 2:

Backbone network

• 1 x 34 inch pipeline for all tranches



Assumptions and scenario

Project time length	**20 years (financial), 40 years (operational) (i.e. this does not influence cash flows and NPV)** ***Cost of service calculated for each option at zero 20 year NPV***
Cost of Equity	**15%**
Cost of Debt	**9.57% (Libor + 4%)**
Financing base case **Other casess**	**Base: 70% debt, 30% equity** **Balanced: 50% debt, 50% equity** **High Equity: 30% debt, 70% equity** **Public Private Partnership (PPP): 10% equity, 40% debt, 50% govt bonds** **Government Funding: (Govt guaranteed bonds 100%)**
CO_2 Supply Scenario	**10 IGCC Power Plants (730MW+), connecting in 4 tranches:** **Yr 1 – 4 plants,** **Yr 3 – 2 plants;** **Yr 5 – 2 plants;** **Yr 7 – 2 plants.**
CO_2 Pipeline Development Options/Scenarios	**1) Point-to-point pipelines: each tranche develops a pipeline at 98% utilisation.** **2) Backbone pipeline: the developer of tranche 1 develops network with the option for subsequent tranches to connect, to reach 98% utilisation**
CO_2 Sink Scenario	**45 Injection wells in one or more geological formations (O&G fields) with total storage capacity ~2000 $MtCO_2$**
Assumed Actual/Max Injection Rate	**1.1/1.3 $MtCO_2$/yr**

1st mover disadvantage to build backbone

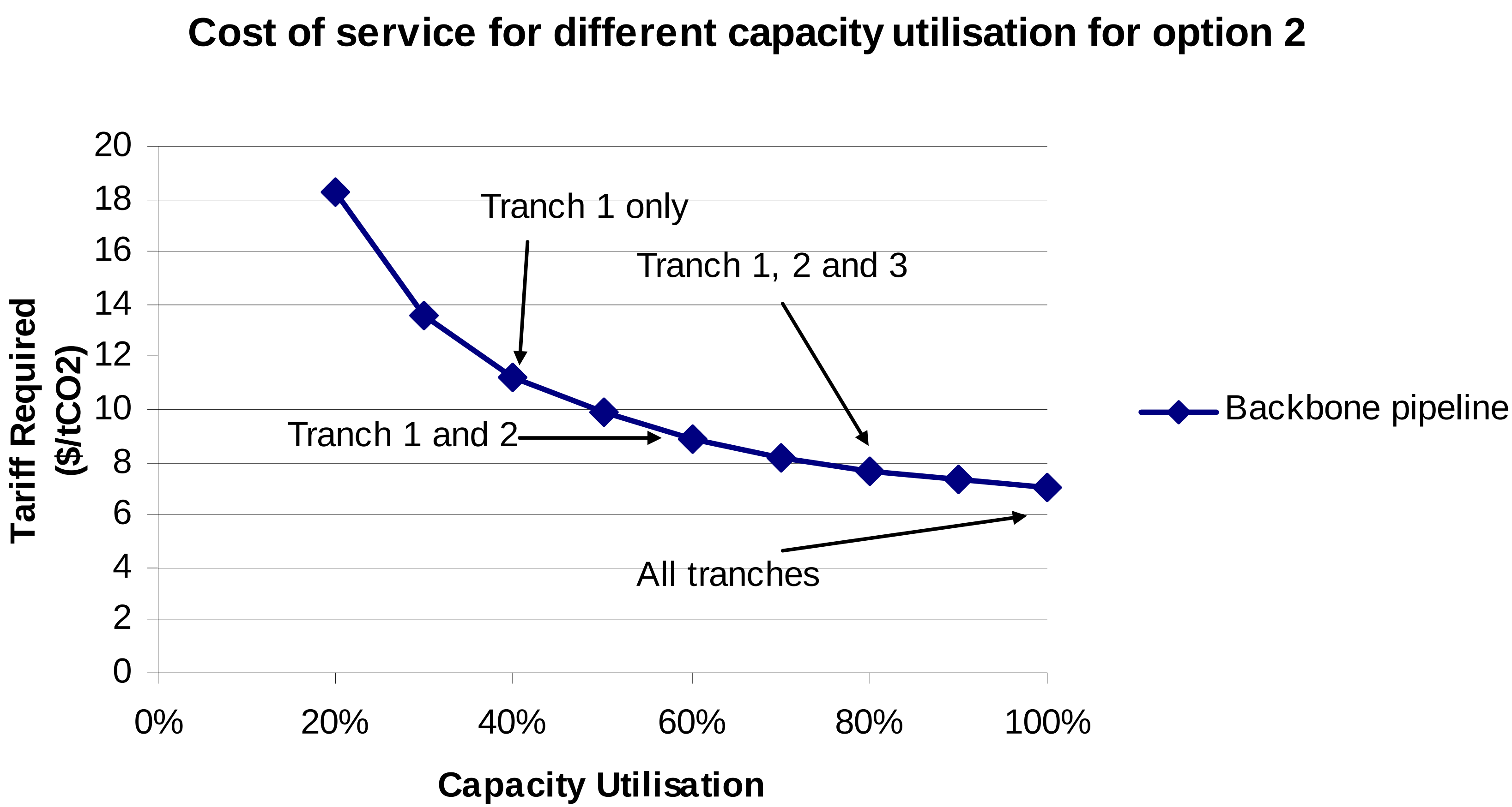
Pipeline option	Capex (for all tranches; $ M)	Capex required (in year 1; $ M)
Option 1 (point to point)	**$3,112.7**	**$1,030.9**
Option 2 (backbone)	**$2,321.8**	**$1,560.6**

Overall system development cost much higher for point-to-point deployment ($1.2 billion)

Significant capex burden on early mover (ie. Tranche 1) - $0.5 billion extra CAPEX required

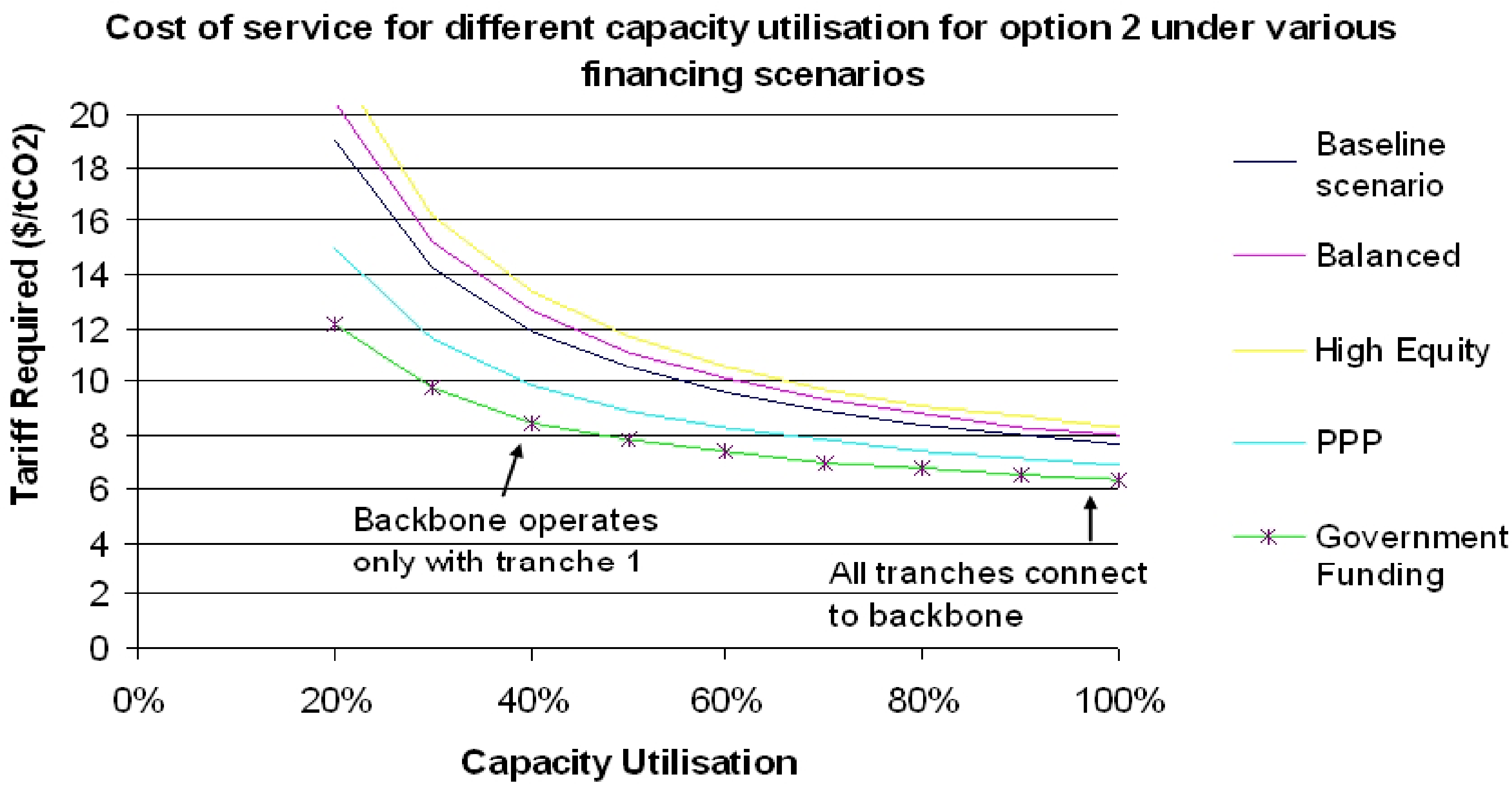
Significant additional capital costs imposed on first mover (i.e. tranche 1), which could affect financing capability

Sensitivity to reduced capacity utilisation



If later tranches are not realized, significant risk for early mover. Cost of service much higher ($11.3)

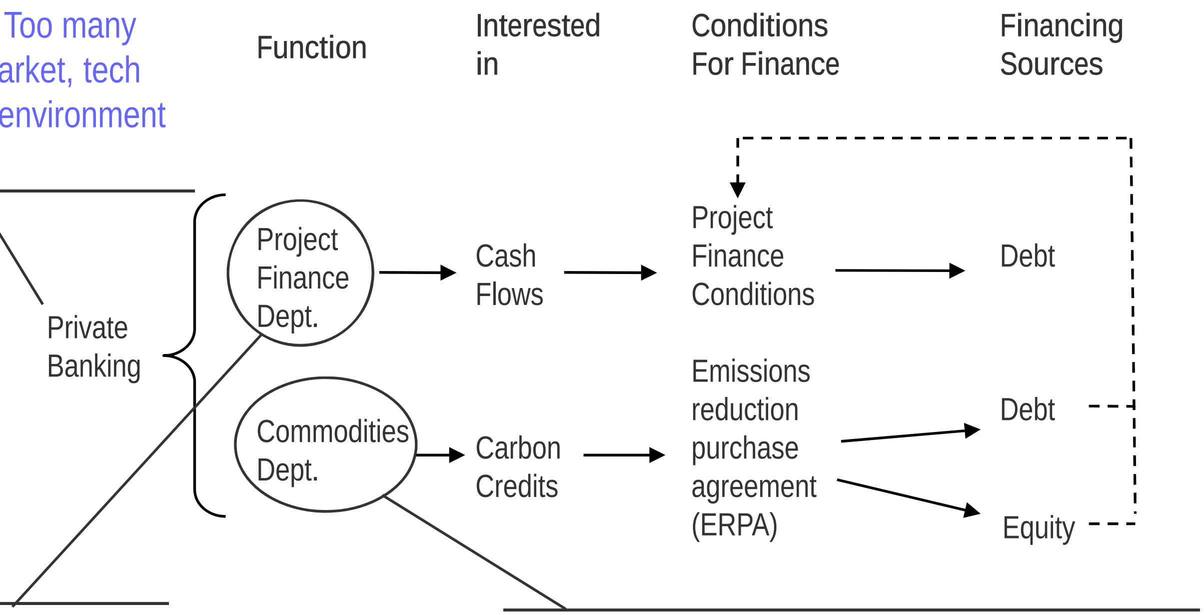
Sensitivity – alternative financing mech's



Altering funding approaches can change cost of service and reduce risk for early mover (e.g. govt funding reduces cost of service to $8.2 for just Tranche 1 with the Option 2 (i.e. only 4 plants connected to the backbone)

Investor perspectives – private banks

Overall private banks said it's too early to consider. Too many unknowns esp. market, tech efficacy, regulatory environment etc

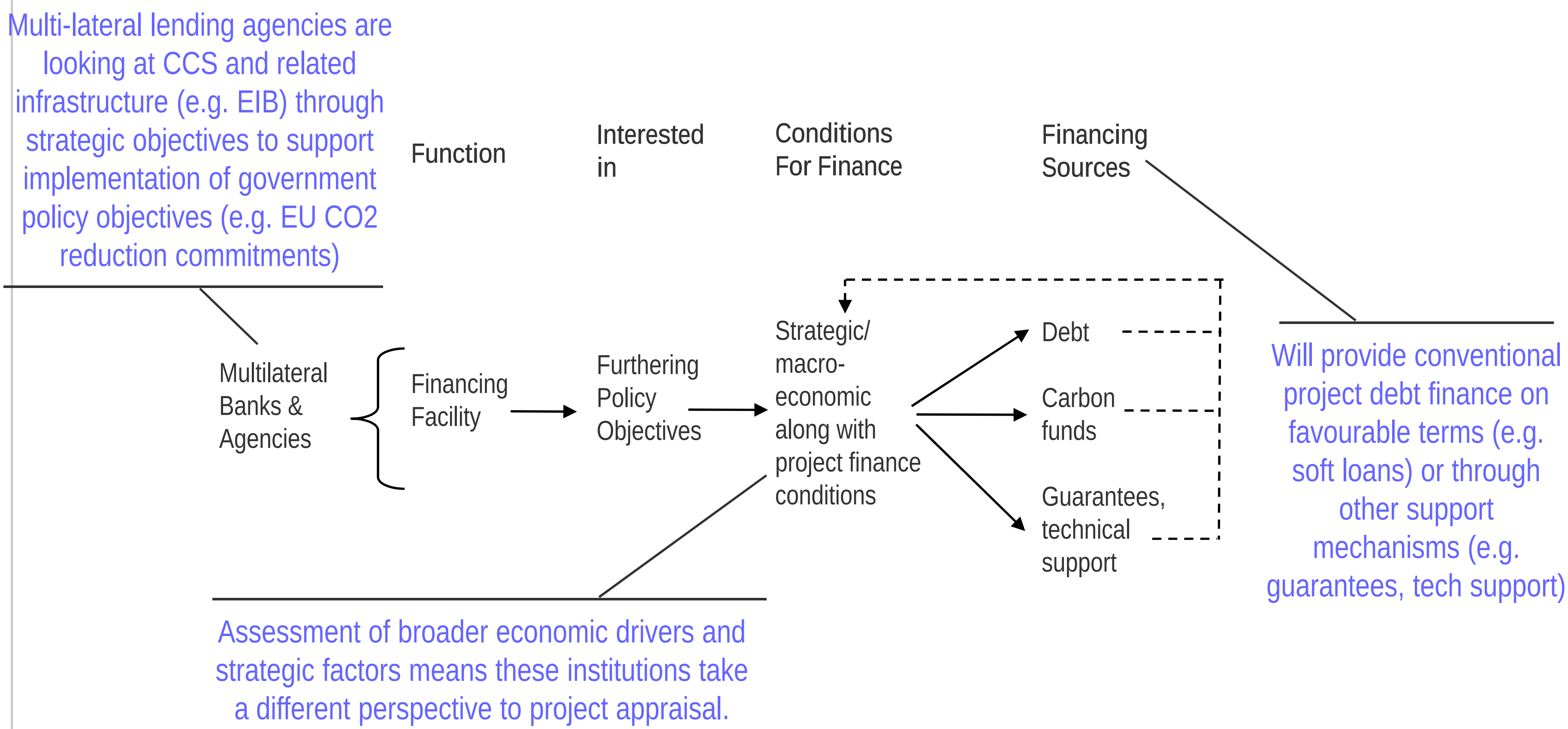


Project finance depts. have project finance drivers (e.g. debt repayment and cash flows). Would apply standard project finance metrics (e.g. NPV etc.).

Commodities depts. will have strategic drivers. Take equity in asset to secure commodity take-off and trading (e.g. do already for LNG terminals; coal transporters). BUT, will require debt finance to support this

Pure project finance may be applicable as market and technology evolves. Risk may be reduced through equity interest from investors for credit offtake

Investor perspectives – multilateral lenders



Ready to finance CCS demonstration plants and other experimental clean coal technologies (primarily as RDI projects) provided they meet environmental, economic, technical and financial criteria, including credit risk criteria.

Key messages

- **Integrated backbone pipeline networks may be most efficient long-term option.**
  - Will need "guaranteed" capacity utilisation in order to be economically viable.
  - Point-to-point pipelines will be funded on project-by-project basis by individual developers because of certainty over capacity utilisation.
- **Public policy that encourages development of optimised networks will be needed.**
  - Government incentives, loan guarantees will support with commercial appraisal of backbone infrastructure
  - Government support in first years when capacity is ramping up will be important to commercial viability
- **CO2 pipeline projects, if they can be reduced in terms of carbon price risks, will become the same in terms of risks as any other oil & gas pipeline project**
- **Banks and financial institutions view such projects as having significant regulatory and market (carbon price) risks.**

Financing CO_2 infrastructure: *A CCP2 case study*

Paul Zakkour, Principal Consultant, ERM Energy & Climate Change

Email: paul.zakkour@erm.com

Tel: +44 20 7465 7200 (London)

ERM Climate Change (North America)

Email: lisa.campbell@erm.com

Tel: +1 919-233-4501 (Raleigh)

Delivering sustainable solutions in a more competitive world

ERM

Carbon Capture & Storage: Legal and Regulatory Issues

IEA Clean Coal Centre/IEA GHG R&D Programme
Expert Meeting on Financing CCS
New York, NY
28-29 May 2008

Tom Kerr
Energy Technology Office

Legal & Regulatory Issues

- Property rights for transport and storage
- Environmental permitting, risk management
  - Onshore and offshore
- Pipeline access, health & safety regulations
- Long-term liability frameworks
- Jurisdictional issues
- Need to develop regulatory models for early projects and adapt as knowledge is gained

All of these issues impact financing/cost

Current Developments

- EU "Enabling" Framework
  - Member States determine whether and where CCS will happen
  - Companies decide whether to use CCS on the basis of conditions in the carbon market
  - Permitting for CO_2 storage
    - Monitoring and reporting guidelines under EU-ETS in order to quantify any leaked emissions (proposal expected end 2008)
  - ETS auctioning revenues major potential source of funding for CCS demonstration
  - Transfer of responsibility to the state under clear conditions to avoid distortion of competition

Current Developments Cont'd.

- USA
  - Jurisdictional issues:
    - Capture - US EPA's Clean Air Act
    - Transport - US Department of Transportation
    - Storage - US EPA's Safe Drinking Water Act
      - State/federal split of responsibility
      - *Proposed rule for CO_2 published by summer 2008, final 2010*
  - Legislation likely needed
    - Treatment under the Clean Air Act
    - Accounting for Injection and Any Leakage
    - Long-term Liability

Current Developments Cont'd.

- **Australia**
  - Will build from Offshore Petroleum Act platform
  - Acreage release, property access
    - Oil & gas and CO_2 storage activities will overlap
  - Legislation will provide the regulator with broad powers to direct the project to take mitigation and remedial actions
- **Canada**
  - Lack of financing for demonstration projects
  - New federal GHG regs will require CCS at new oil sands and coal-fired electricity plants by 2018
  - Liability for storage sites
    - Need to clarify, likely provincial (GHG fed'l)
  - Need to establish M&V standards

Current Developments Cont'd.

- Japan - Adopted legislation implementing London Protocol amendment
  - Min. of Environment will issue permits
    - Site selection report
    - Environmental impact assessment report
    - Explanation for no appropriate disposal is available other than sub-seabed storage
    - Financial capability of the applicant
    - Technical capability of the applicant
    - Project lifetime document
  - CO2 purity requirement : ≥99%

Current Developments Cont'd.

- **London Protocol/OSPAR 2007 Amendments on CCS: CO_2 now may be dumped at sea, but:**
  - Disposal must be into a sub-seabed geological formation
  - Disposed matter must be "overwhelmingly" CO_2
  - No wastes or other matter may be added
  - Disposal must be permitted by national authority
- **UNFCCC – including CCS in the CDM**
  - May 2006 Workshop highlighted following issues
    - Project boundary concerns
    - Accounting for leakage resulting from the additional energy required
    - Ensuring the permanence of stored CO2
  - Series of workshops/consultations; next submissions 6/08
  - Path forward: a simplified CCS project method

IEA Secretariat CCS Work

- High-level recommendations for G8
- Legal & regulatory frameworks
  - *Legal Aspects of CO_2 Storage* publications
  - 13-14 May 2008: International CCS Regulators' Network launched
    - Future web conferences on specific topics
      - 10 July: CO2 transportation health & safety issues
    - Global updates on regulatory/legal developments
    - Outreach to developing regions
    - Annual meeting
  - October 2008: new CCS publication
    - CCS/GHG market mechanisms analysis
  - March 2009: high-level CCS Summit

Thank You

tom.kerr@iea.org

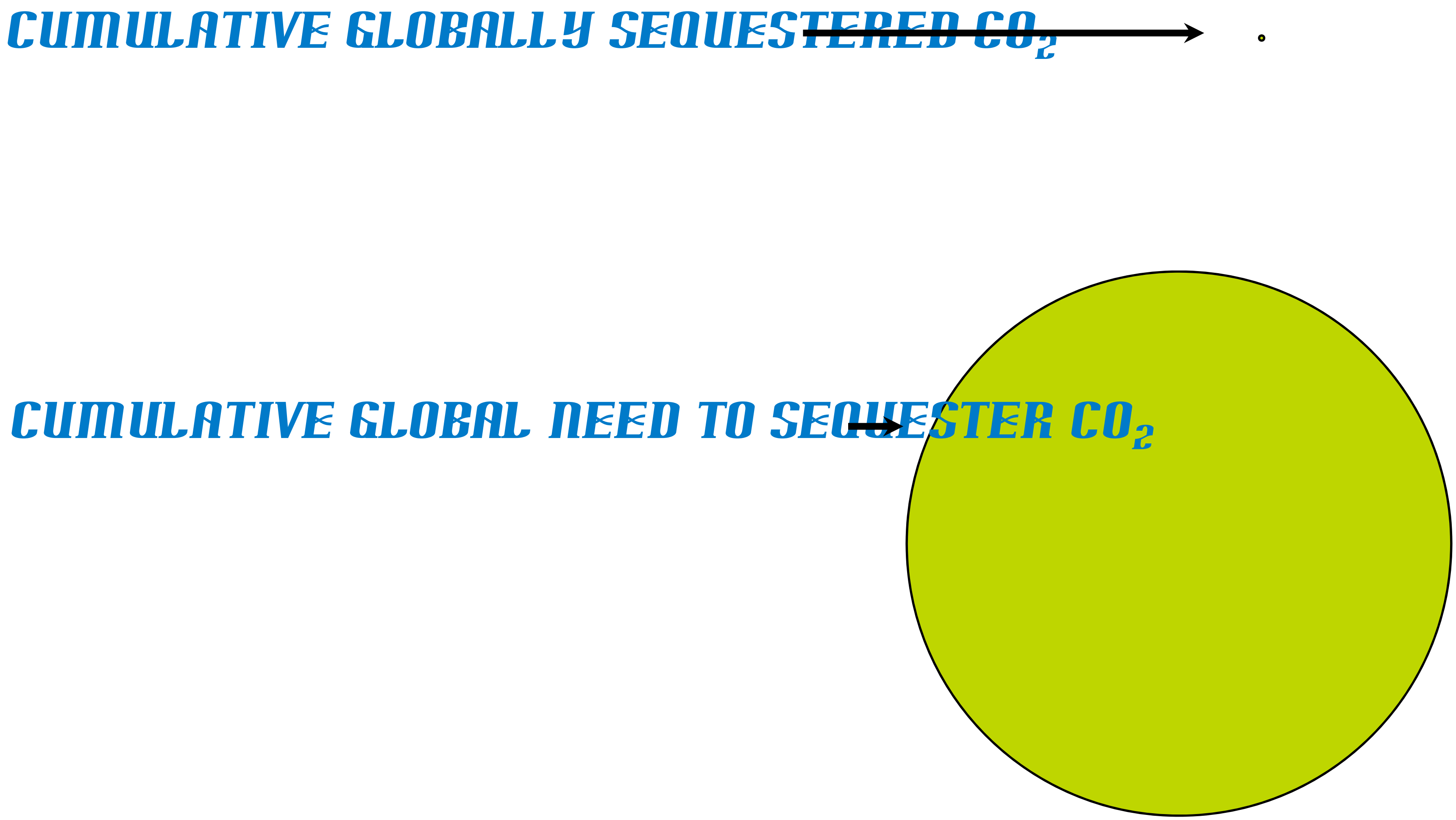
www.iea.org/Textbase/subjectqueries/cdcs.asp

Abu Dhabi and California Projects; the Commercial Aspects of Making it Work and What is Needed from Governments

Preston Chiaro
Chairman, World Coal Institute

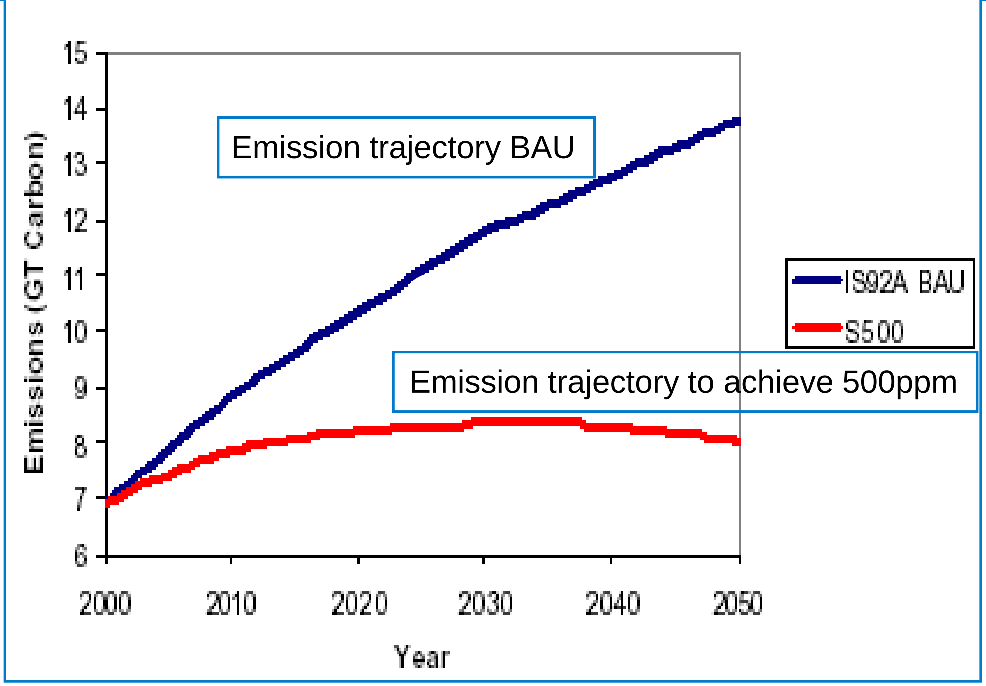
29 May 2008

WE NEED TO DEPLOY CCS TECHNOLOGY

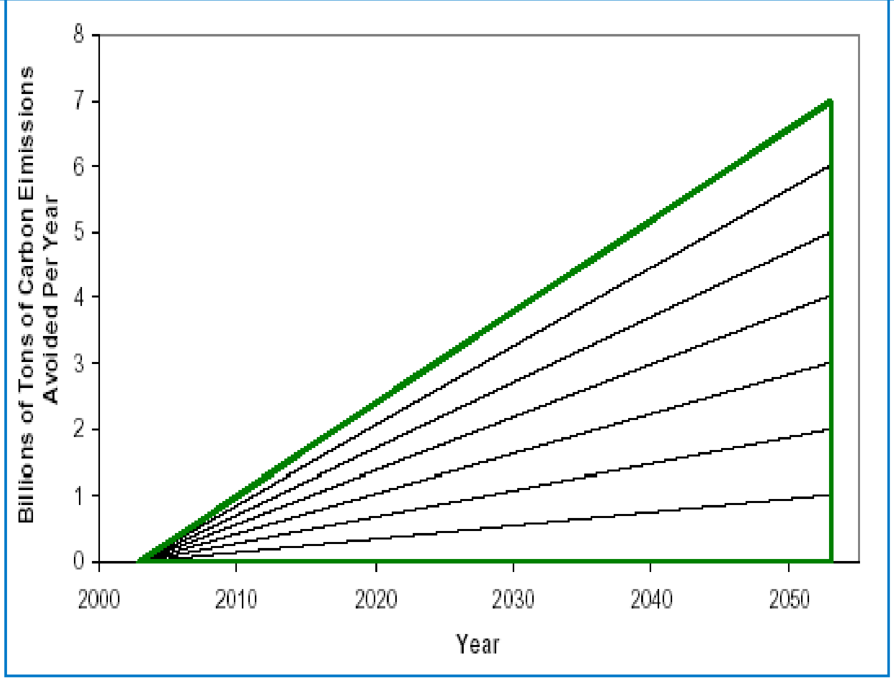


PRINCETON WEDGES: TECHNOLOGY OPTIONS FOR GHG STABILIZATION

The Stabilisation Wedge



1 GtC Slices of the Stabilisation Wedge

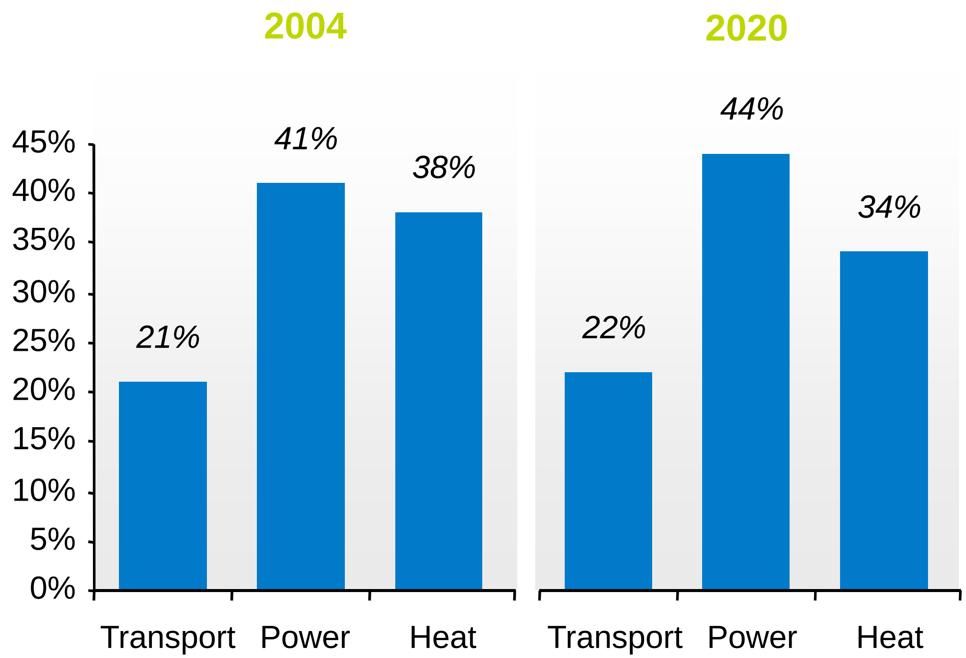


HOW BIG IS A WEDGE?

Examples of Lower Carbon Slices	Scale for 1GtC Reduction by 2050
Increased **energy efficiency** across the economy	2 billion gasoline/diesel cars achieving 60 mpg
Fuel switching natural gas displacing coal for power	1400GW fuelled by natural gas instead of coal
Solar PV or Wind replaces coal for power	1000x scale up PV, 70x scale up for wind
Biofuels to replace petroleum based fuels	$200x10^6$ ha growing area (equals US agricultural land)
Carbon Capture and Geological Storage	CO_2 captured from 700 1GW coal plants; storage = 3,500x In Salah/Sleipner or CCS applied to 5% of new power growth
Carbon Free Hydrogen for transport	1 billion H_2 carbon free cars; H_2 from fossil fuels with CO_2 capture and storage or from renewables or nuclear
Nuclear displaces coal for power	700 1GW plants (2x current)
Bio-sequestration in forests and soil	Increased planted area and/or reduce deforestation

THE ENERGY SECTOR EMISSIONS CHALLENGE

CO_2 EMISSIONS BY SECTOR

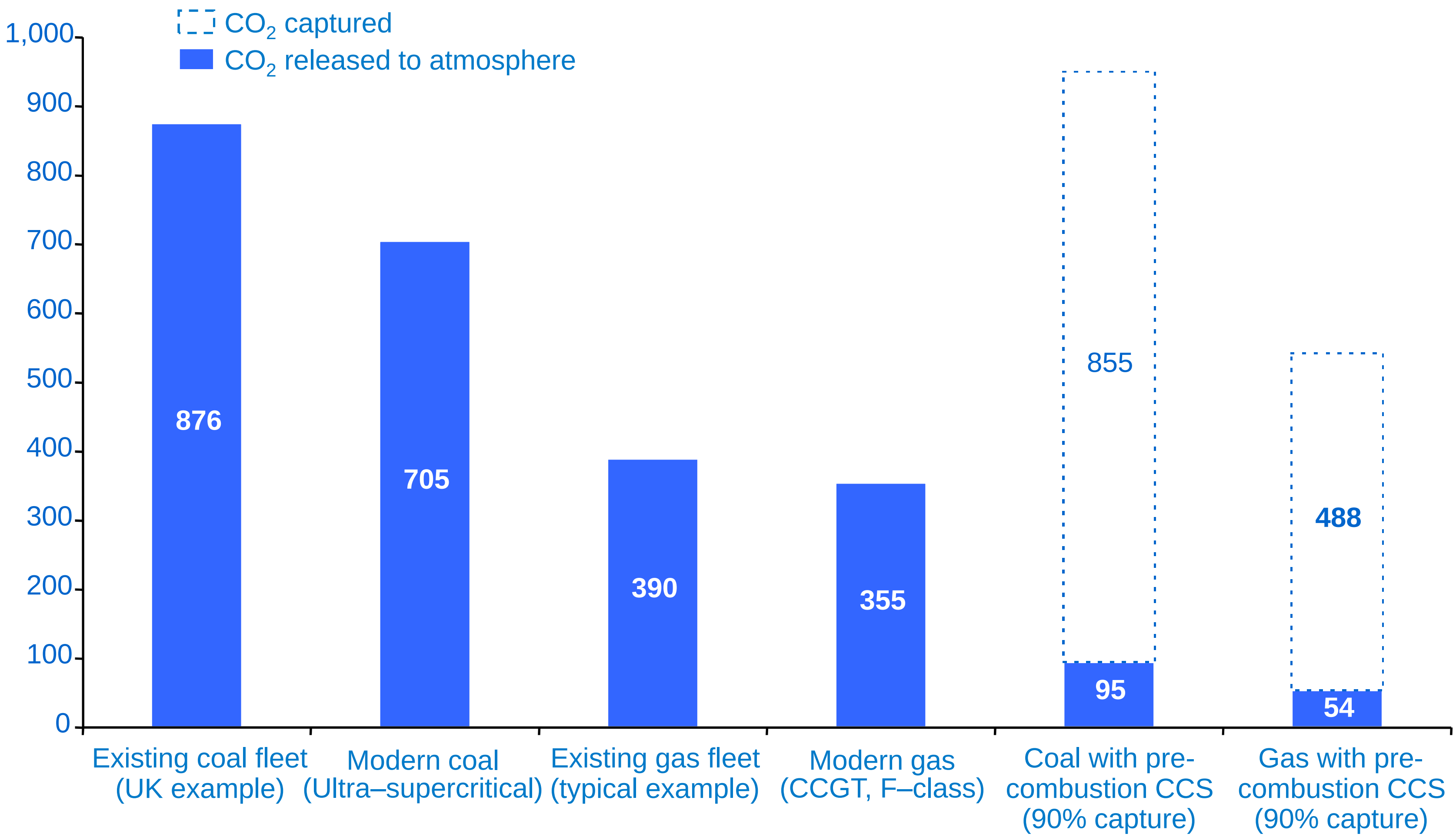


Source: IEA World Energy Outlook, 2004

- THE POWER SECTOR IS ALREADY THE LARGEST CONTRIBUTOR OF CO2
- GROWTH IN COAL-FIRED GENERATION IS PROJECTED TO BE THE SINGLE LARGEST CONTRIBUTOR OF NEW GHG EMISSIONS OVER THE NEXT FIFTEEN YEARS
- CCS IS A KEY SOLUTION FOR THIS INDUSTRY

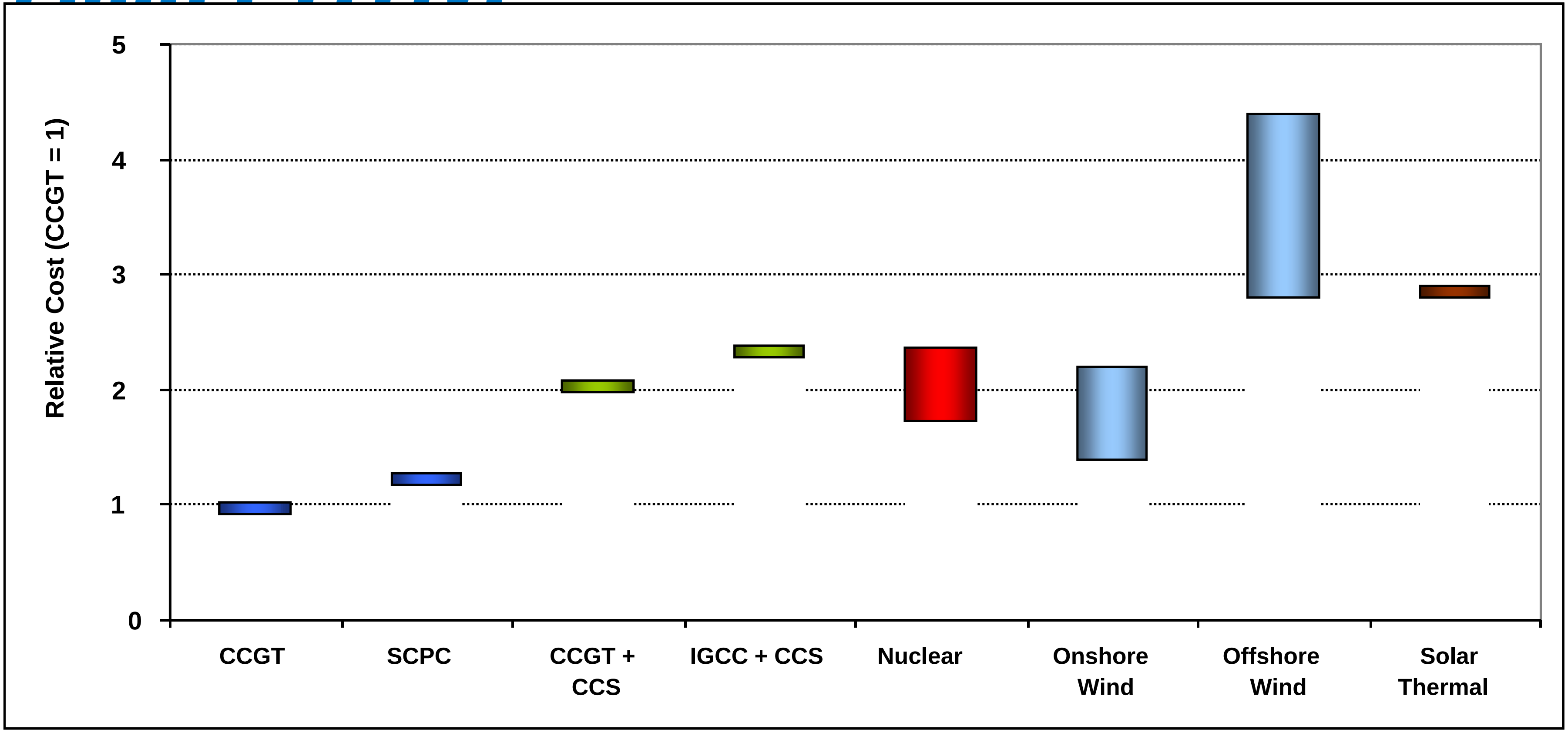
COMPARISON OF CO_2 EMISSIONS

CO_2 emissions from fossil–fuel power generation
g / kWh net electricity generation



Source: DTI (March 2006); Foster Wheeler; Hydrogen Energy analysis

THE COST OF ELECTRICITY WITH CCS IS COMPETITIVE



WE ARE ENTERING A VITAL PERIOD IF CCS IS TO TAKE OFF...

SO WHAT ARE WE DOING

hydrogen energy

hydrogen energy

bp

RIO TINTO

a joint venture

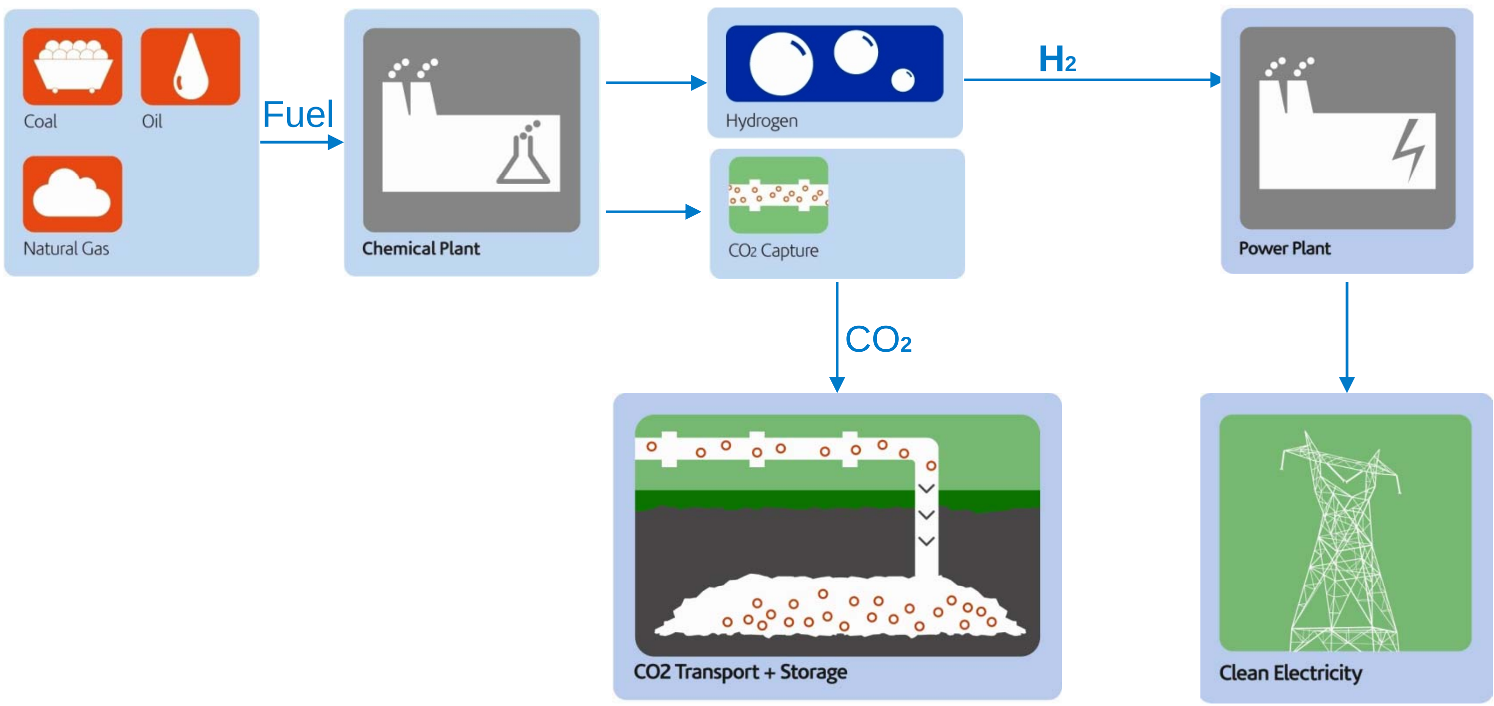
WHAT IS HYDROGEN ENERGY?

hydrogen energy

A COMPANY JOINTLY OWNED BY BP AND RIO TINTO

- ESTABLISHED TO SUPPLY LOW CARBON HYDROGEN FUEL TO THE POWER SECTOR
- USING FOSSIL FUELS AND CARBON CAPTURE AND STORAGE

HYDROGEN ENERGY - WHAT DOES IT DO?

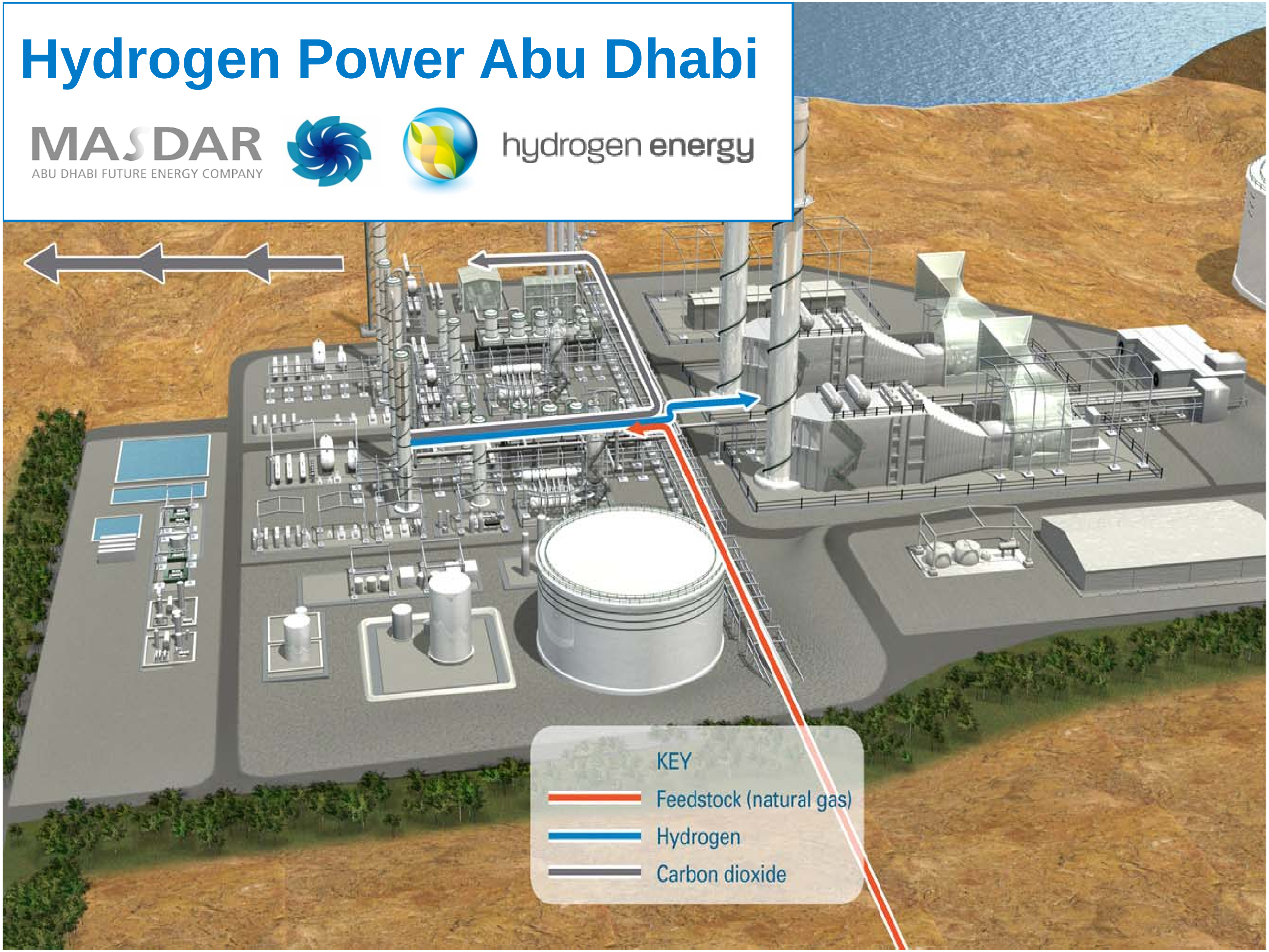


A joint venture between
BP Alternative Energy and Rio Tinto

Hydrogen Power Abu Dhabi

MASDAR
ABU DHABI FUTURE ENERGY COMPANY

hydrogen energy



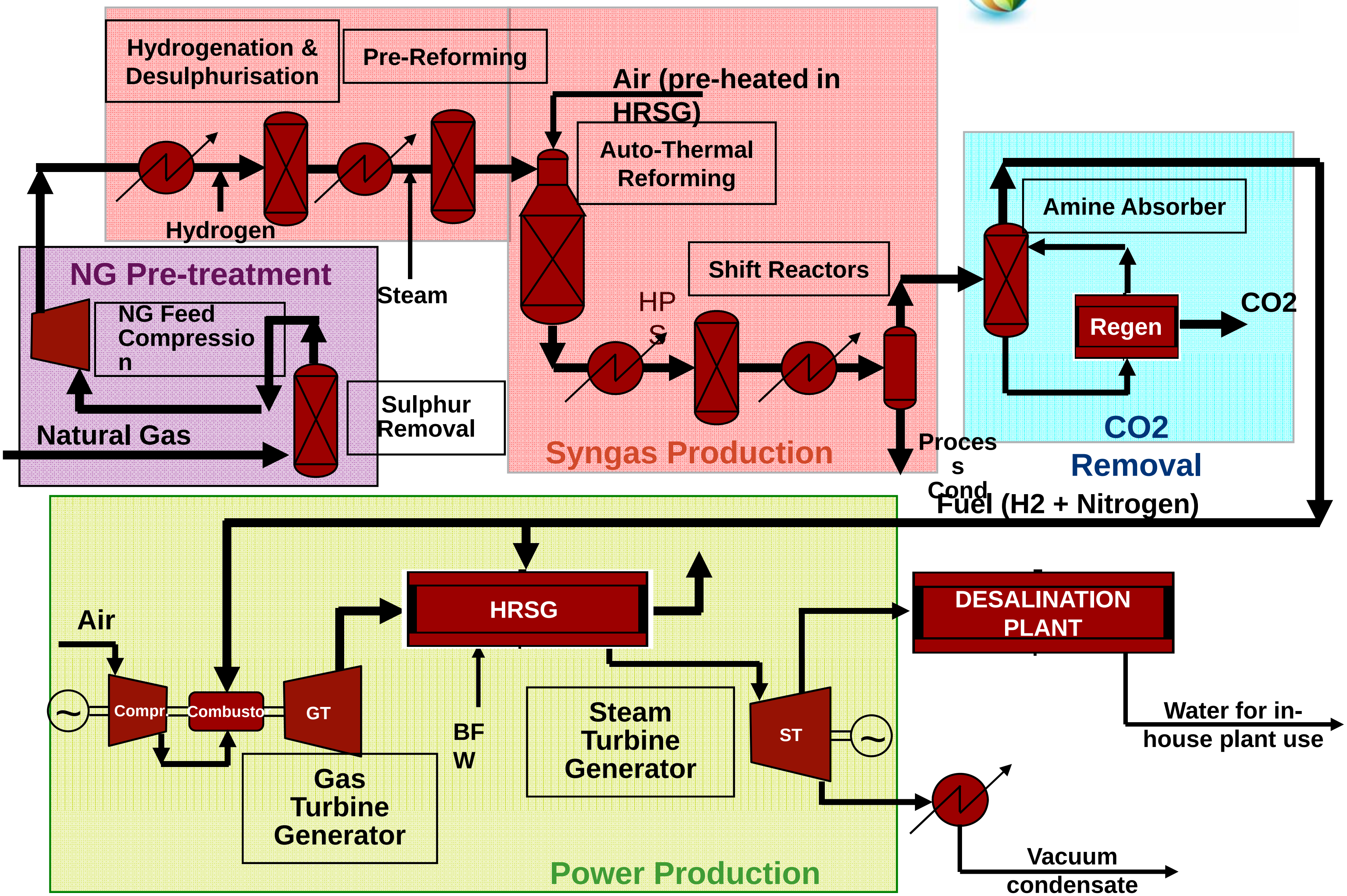
hydrogen energy

HYDROGEN POWER ABU DHABI PROJECT

- RELOCATING AND LEVERAGING PETERHEAD LEARNINGS
- GEOGRAPHY - MIDDLE EAST
- FUEL – NATURAL GAS
- SIZE – 500 MW POWER PRODUCTION
- TECHNOLOGY – GAS REFORMING/COMBINED CYCLE TURBINES
- SEQUESTRATION – OIL FIELD WITH EOR BENEFIT
- HE FOCUSED ON POWER AND CO2 SALES
- L COMMITMENT

PROJECT SCOPE

hydrogen energy

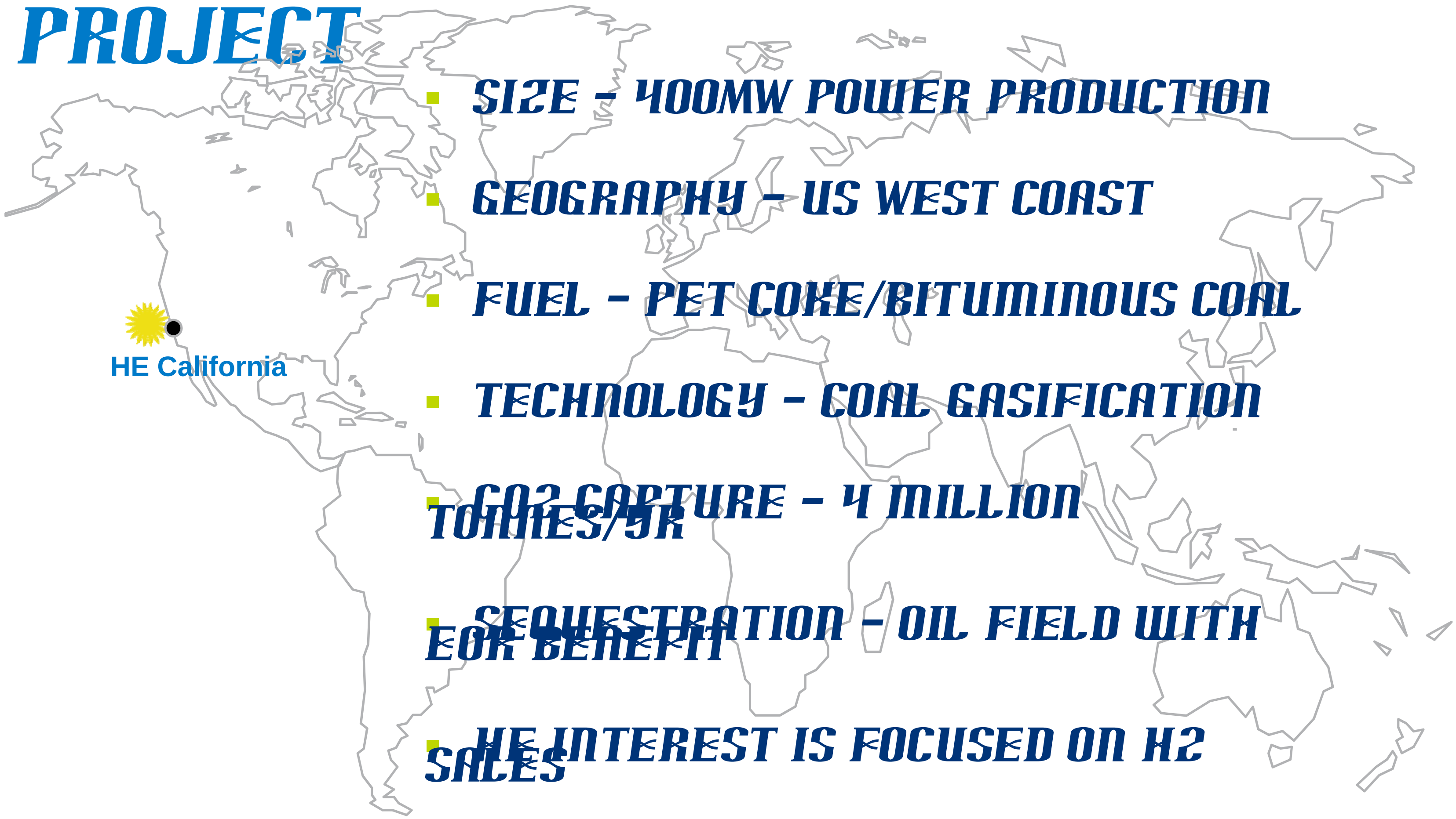


hydrogen energy

HYDROGEN ENERGY CALIFORNIA PROJECT

- ADJACENT TO OCCIDENTAL ELK HILLS FIELD AND CO2 INJECTION POINT AND EOR REVENUE
- AREA PROVIDES PROXIMITY TO FEEDSTOCKS AND INTRASTATE TRANSMISSION
- LOW POPULATION DENSITY
- UTILIZE LOCAL AREA PETCOKE SUPPLY AND/OR RAILED COAL FOR FEEDSTOCK

HYDROGEN ENERGY CALIFOR…… PROJECT



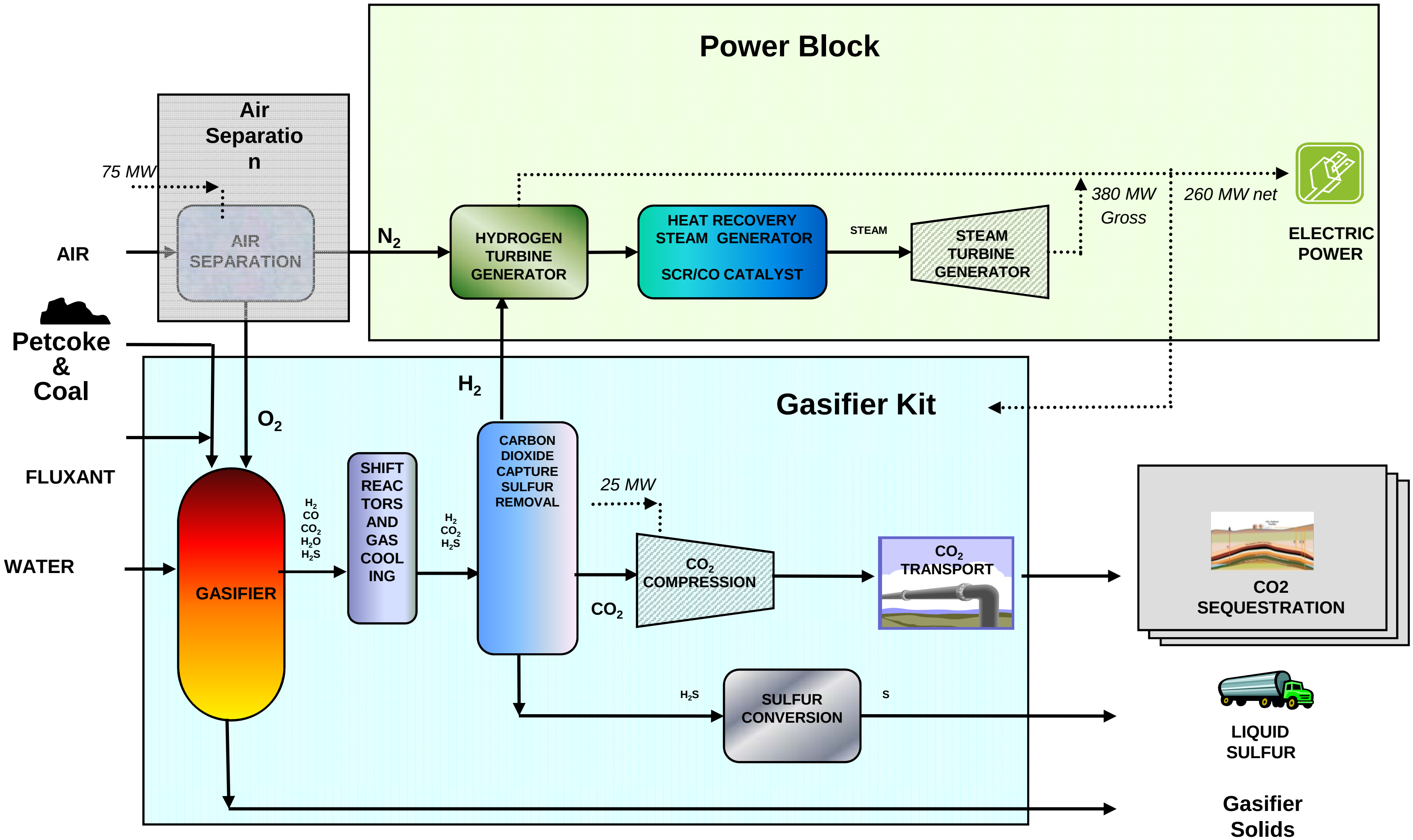
- SIZE – 400MW POWER PRODUCTION
- GEOGRAPHY – US WEST COAST
- FUEL – PET COKE/BITUMINOUS COAL
- TECHNOLOGY – COAL GASIFICATION
- CO_2 CAPTURE – 4 MILLION TONNES/YR
- SEQUESTRATION – OIL FIELD WITH EOR BENEFIT
- HE INTEREST IS FOCUSED ON H_2 SALES
- STRONG POLITICAL ENVIRONMENT

hydrogen energy

bp RIO TINTO A joint venture between BP Alternative Energy and Rio Tinto

PROJECT SCOPE

hydrogen energy



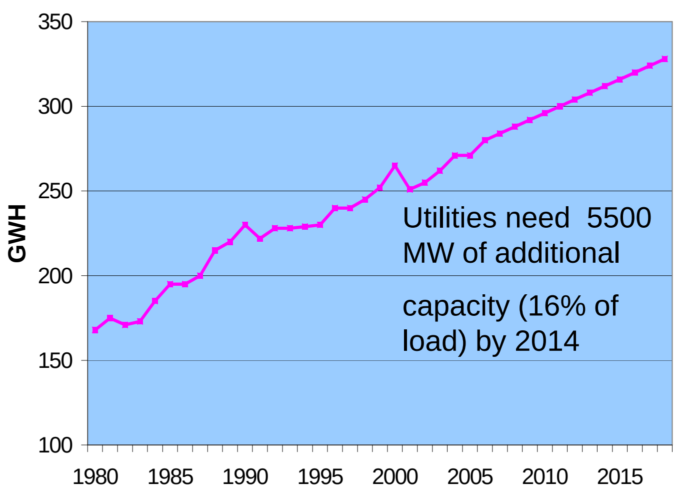
bp RIO TINTO A joint venture between BP Alternative Energy and Rio Tinto

CA POLITICAL ENVIRONMENT IS RIGHT

hydrogen energy

Political support

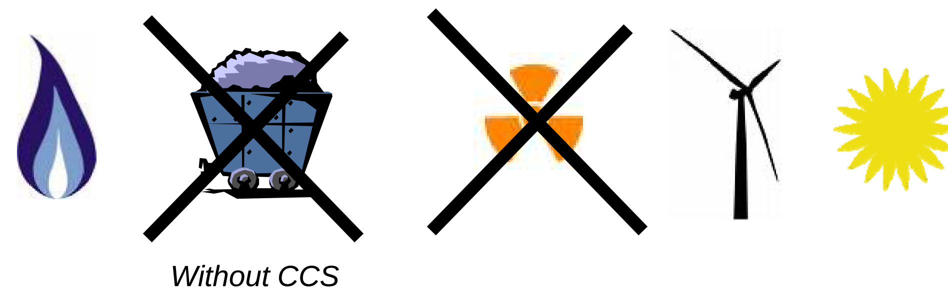
Power demand



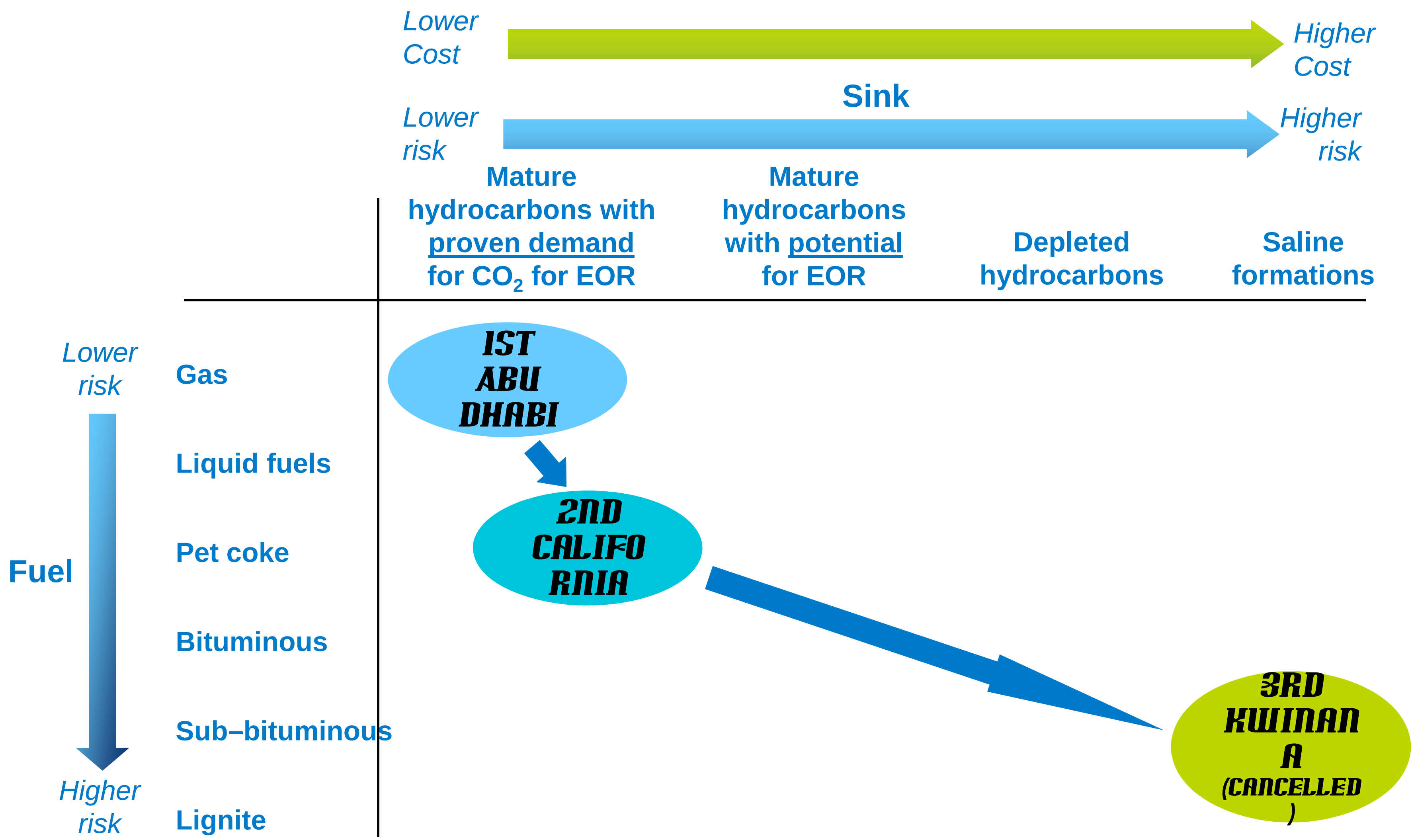
California environmental policies

- California Energy Action Plan I and II
- AB 32: Global Warming Solutions Act
- SB 1368: GHG Emissions Performance Standard
- California Loading Order
- California Policies Supportive of Carbon Capture and Storage
- AB 1925: Carbon Capture and Sequestration Legislation

Limited options in California

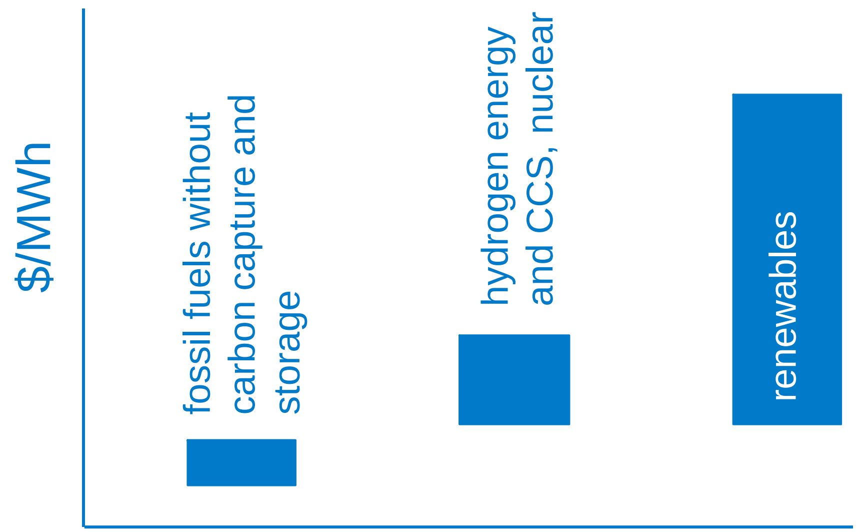


HYDROGEN ENERGY PROJECT EVOLUTION



HOWEVER POWER PROJECTS WITH CCS NEED SUPPORT TO DEVELOP

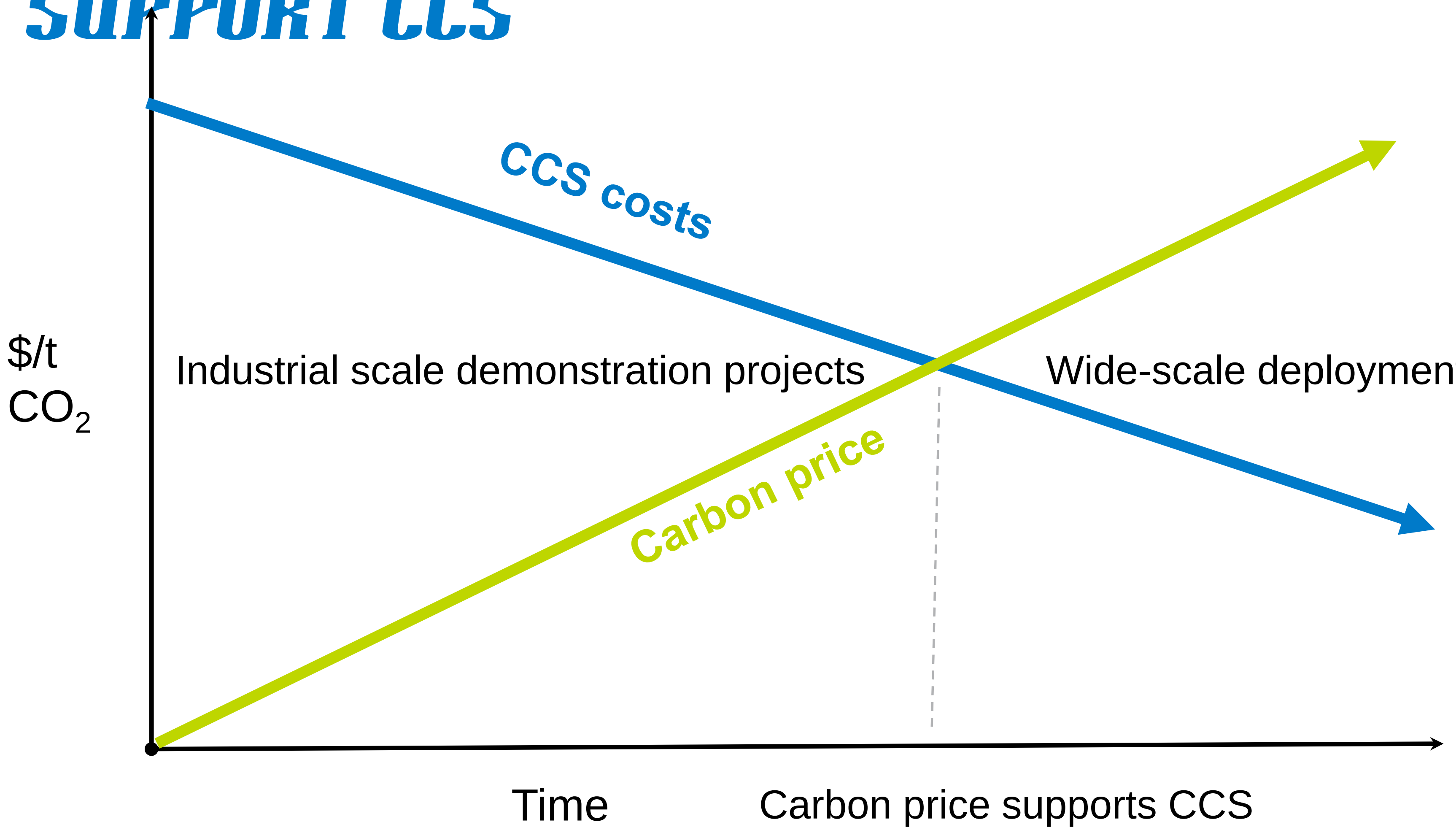
Comparable costs for electricity



- Support already provided to renewables
- Over time, experience gained from building and operating the first plants of this type, and technology advances will help to bring the cost of hydrogen energy and CCS (and renewables) down

Sources: BP Estimates, Navigant Consulting, Deloitte and Touche LLP

EVENTUALLY CARBON PRICE WILL SUPPORT CCS



OTHERS' VIEWS ON COSTS

INTERNATIONAL ENERGY AGENCY

- US$16 TRILLION WILL BE NEEDED TO MEET GLOBAL ENERGY DEMAND NEXT 30 YEARS
- US$1.5 TRILLION OF THAT FOR COAL-FIRED POWER GENERATION

PRINCETON UNIVERSITY (SOKOLOW) / COLUMBIA UNIVERSITY (SACHS, LACKNER)

- CARBON EMISSION CHARGES OF ABOUT US$100/TC (I.E. ABOUT US$30/TCO$_2$) WOULD ENABLE COMMERCIALISATION OF CCS AND ALL OTHER NECESSARY TECHNOLOGIES

SHELL / RWE

- EARLY PROJECTS LIKELY TO REQUIRE A LEVEL OF SUPPORT EQUIVALENT TO $100 – 150 / TONNE CO$_2$

IN THE NEAR TERM — A RANGE OF SUPPORT MECHANISMS ARE AVAILABLE

TYPE OF MECHANISM	EXAMPLES
MANDATED REQUIREMENTS FOR NEW PLANT TO BE LOW CARBON	• EU SUGGESTION THAT ALL NEW PLANT BE LOW CARBON FROM 2020 (EU ETS WOULD COVER EMISSIONS FROM EXISTING AS WELL AS NEW PLANT) • PORTFOLIO STANDARDS IN US
CARBON PRICING	• TRADABLE ALLOWANCES • TAXES • HYBRIDS OF TAXES AND TRADABLE ALLOWANCES • POTENTIALLY SUPPORTED BY OTHER FINANCIAL INSTRUMENTS
INDUSTRIAL POLICY SUPPORT	• CAPITAL GRANTS • TAX BREAKS • GOVERNMENT OR PUBLIC UTILITY EQUITY
SUPPORT FOR NEW TECHNOLOGIES, ESPECIALLY RENEWABLES	• RESERVED MARKET (MAY BE IMPLEMENTED WITH TRADABLE CERTIFICATES) • PREMIUM PRICE SET BY REGULATOR (E.G. FEED-IN TARIFFS) • PREMIUM PRICE SET BY AUCTION, TENDER OR NEGOTIATION

Sources: Deloitte and Touche LLP

THE SUPPORT MECHANISMS CAN BE FUNDED IN DIFFERENT WAYS

Customers	• electricity prices are higher due to the carbon price • additional costs from quantity obligations (e.g. Renewable Portfolio Standards or Green Certificate Schemes) • the cost of premium priced contracts (e.g. feed in tariffs) passed through • separate tax or levy on the retail price or wires business charges
Tax payers	• general or earmarked taxation may fund support as grants, premium price payments or tax breaks (capital or per MWh support) • government or publicly owned utilities may provide cheap capital (debt or equity)
Shareholders	• surplus created by free allocation of allowances can be appropriated by means of auctions, windfall taxes or price floor arrangements and channelled to clean generation

Sources: Deloitte and Touche LLP

POINTERS TO WIDESPREAD POLICY SUPPORT

SUMMARY

- CONTRIBUTION TO TACKLING CLIMATE CHANGE FROM CCS CAN BE CONSIDERABLE
- EARLY INDUSTRIAL SCALE COMMERCIAL PROJECTS READY TO BE DEVELOPED
- GOVERNMENT AND POLICY INCENTIVES NEEDED TO ENABLE CONSTRUCTION AND OPERATION OF THESE EARLY PLANTS
- LONG TERM INSTRUMENTS SUCH AS A HIGHER CARBON PRICE SHOULD EVENTUALLY BE SUFFICIENT TO SUPPORT WIDESPREAD DEPLOYMENT OF CCS

ZeroGen
smarter, cleaner power

Challenges for Early Movers

The ZeroGen Experience

Presentation to the

Expert Meeting on Financing Carbon Capture and Storage

by Dr Anthony Tarr, Chief Executive Officer, ZeroGen Pty Ltd

Challenges for Early Movers

ZeroGen
smarter, cleaner power

- Global and national setting
- Project overview
- Project deployment challenges
- Some important `open` issues

ZeroGen - global and national setting

- Ratified Kyoto Protocol – 2010 emission trading scheme
- Climate change - public policy and business decision makers
- State energy policies – new coal-fired power stations w/o CCS
- Funding – Federal, State and industry funding commitments
- Australian coal industry
- Integrated Gasification Combined Cycle (IGCC) + Carbon Capture and Storage (CCS), in the future energy mix

Project Overview

- **Location:** Queensland, Australia
- **Current structure:** owned by Queensland Government
- **Technology approach:** IGCC + CCS
- **Timeline:** Stage I - 2012, Stage II -2017
- **Substantial industry support:** ACALET, ACA, Shell

Project Overview – Project Participants

ZeroGen
smarter, cleaner power

Queensland Government

STANWELL CORPORATION LIMITED

WorleyParsons resources & energy

agr ASIA PACIFIC

URS

Australian COAL Association

RLMS

AGFORCE

Rockhampton Regional Council

CHRC

MBA petroleum consultants

Project Overview

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2008

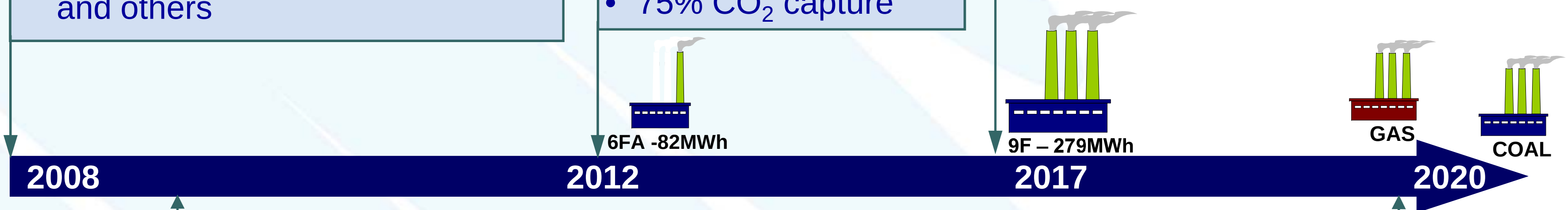
- Initial feasibility 6FA
- Financial planning
- Initial funding from ACALET & ACA
- Approval for 9FA
- Conceptual JV term sheet
- Agreement with Shell
- Discussions with GE, Honeywell and others

2012 – Stage I

- 6FA 82MWh
- Construction competed
- Operation for 5 years
- Location already determined
- Partial funding in place
- 75% CO_2 capture

2017 – Stage II

- 9F 279MWh
- 90% CO_2 capture
- Location TBD
- Funding structure TBD



2009

- Stage I feasibility study
- Composition of investors mix
- Funding programme initiation
- Stage II feasibility study (2012)

2020 – Stage III

Future competitive landscape

- Fuel costs
- CO_2 costs
- Technology costs

Project deployment challenges

ZeroGen
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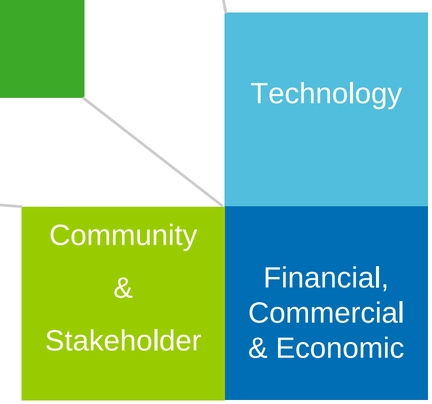
- ZeroGen IGCC + CCS identified by Australian coal industry as priority technologies for development
- Challenges for deployment exist in relation to:

Project deployment challenges

Political, Legal and Regulatory

- Permits and regulatory framework
- Consensus and joint undertakings
- Approvals issued for IGCC / CCS
- Fragmented global CO_2 policy
- Globally relevant regulations



Project deployment challenges

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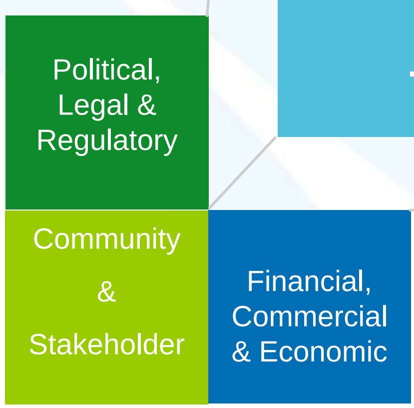
Technology

- IGCC technology
- CCS
- Geosequestration
    - Exploration
    - Injection
    - Well design

Location and technology integration

- Site selection
- Construction
- O&M



Project deployment challenges

ZeroGen
smarter, cleaner power

Political, Legal & Regulatory	Technology
	Financial, Commercial & Economic

Community & Stakeholders

- Investment and public community confidence in CCS
- Over 200 interest and stakeholder groups
- Current support from
  - Government
  - Public
  - Industry
  - Commercial
  - Union

Project deployment challenges

ZeroGen
smarter, cleaner power

Political, Legal & Regulatory

Technology

Community & Stakeholder

Financial, Commercial & Economic

Financial: Revenue and profitability dependent on:

- carbon pricing
- government subsidies
- technology efficiency improvements (CapEx, OpEx)

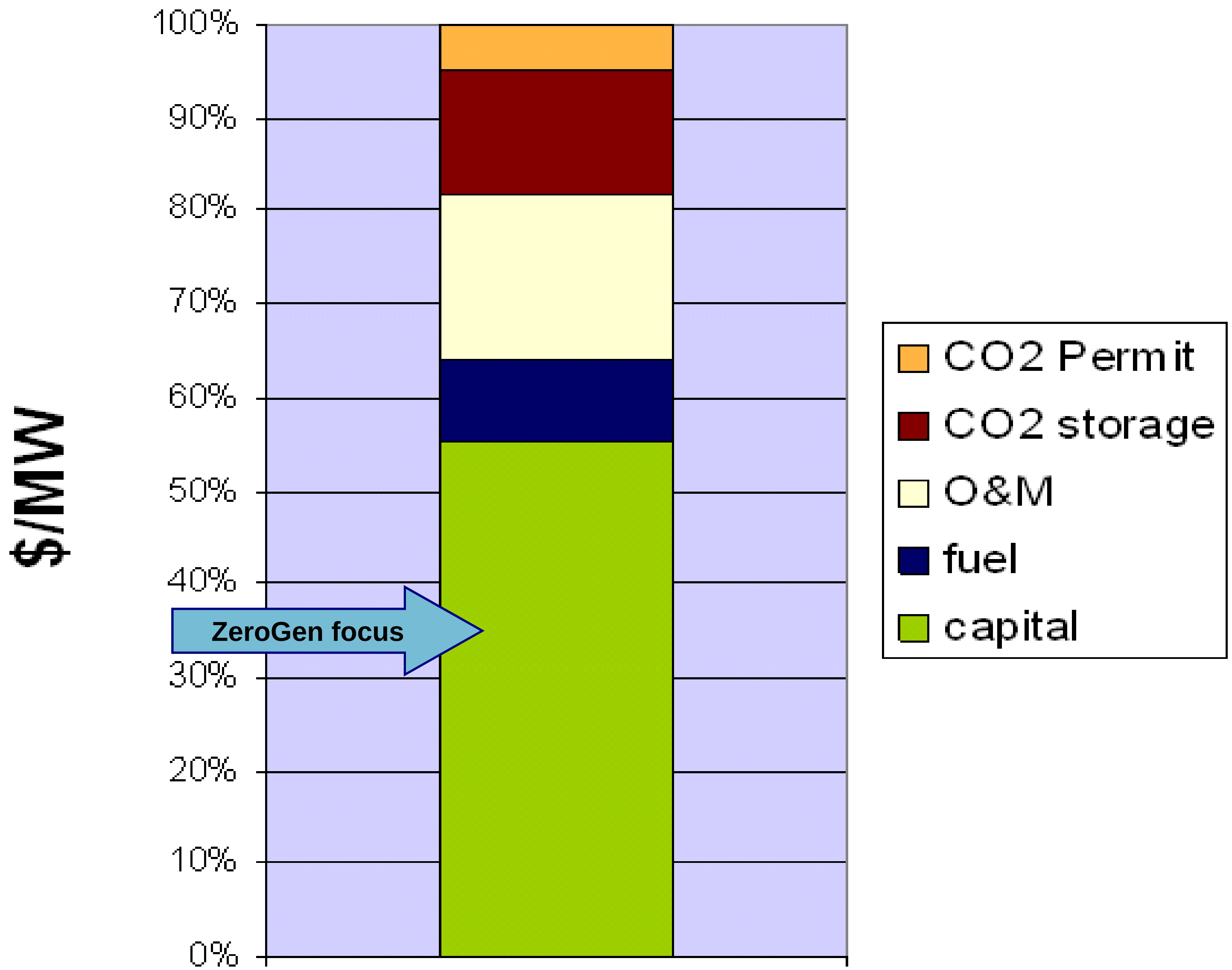
Financial risk: Technical, Financial (loan & interest, bankability)

Commercial: Identifying L-T investor

Economic: Input optimisation of Australian economy and coal industry

Project deployment challenges

IGCC with CCS cost breakdown



Some important `open` issues

Investment structuring - funding options and schemes

- Grants enhanced ETS credits
- Industry participants
- Loan guarantees
- Private parties
- ETS for direct investment
- Clean Development Mechanism (CDM) credits

- Funding options will be discussed with Government funds, and commercial banks
- Need for innovative ideas to address bankability of demonstration projects

Thank you

Climate Change and Carbon Capture and Storage (CCS) Technology

Mountaineer Plant - New Haven, WV

AEP AMERICAN ELECTRIC POWER

Northeastern Plant - Oologah, OK

Bruce Braine

Vice President - Strategic Policy Analysis

Expert Workshop on Financing CCS

May 29, 2008

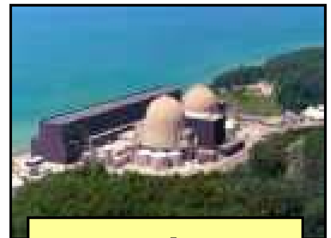
Company Overview

Coal/Lignite

67%

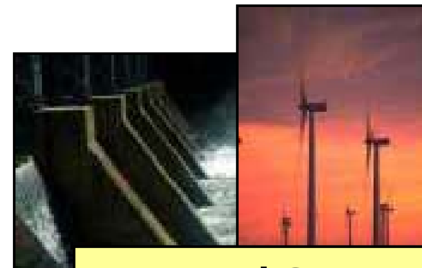
Nat. Gas/Oil

24%



Nuclear

6%

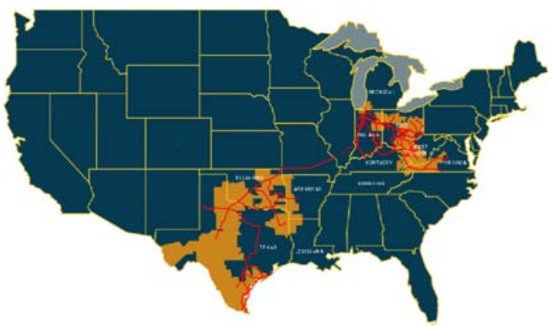


Pumped Storage/ Hydro/Wind

3%

AEP's Generation Fleet

38,388 MW Capacity



5.1 million customers in 11 states

Industry-leading size and scale of assets:

Asset	Size	Industry Rank
Domestic Generation	~38,300 MW	# 2
Transmission	~39,000 miles	# 1
Distribution	~208,000 miles	# 1

AEP's Climate Strategy

FutureGen™ ALLIANCE
Clean Energy for a Secure Future

GLOBAL ROUNDTABLE ON CLIMATE CHANGE

CLIMATE LEADERS®
U.S. Environmental Protection Agency

CCX™ Chicago Climate Exchange

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

- Being proactive and engaged in the development of climate policy
- Investing in science/technology R&D
- Taking Voluntary action now, making real reductions thru CCX (2003-07: 40 MM Tons reductions); 2011 Voluntary Commitment (additional 5 MM Tons/year reductions).
- Investing in long term technology (e.g., IGCC, Ultra-supercritical PC and CCS)

AEP®

AEP must be a leader in addressing climate change

AEP's Climate Position

- A certain and consistent national policy for reasonable carbon controls should include the following principles:
  - Comprehensiveness
  - Cost-effectiveness
  - Realistic emission control objectives
  - Monitoring, verification and adjustment mechanisms
  - **Technology development & deployment**
- Inclusion of adjustment provision if largest emitters in developing world do not take action

A reliable & reasonably-priced electric supply is necessary to support the economic well-being of the areas we serve.

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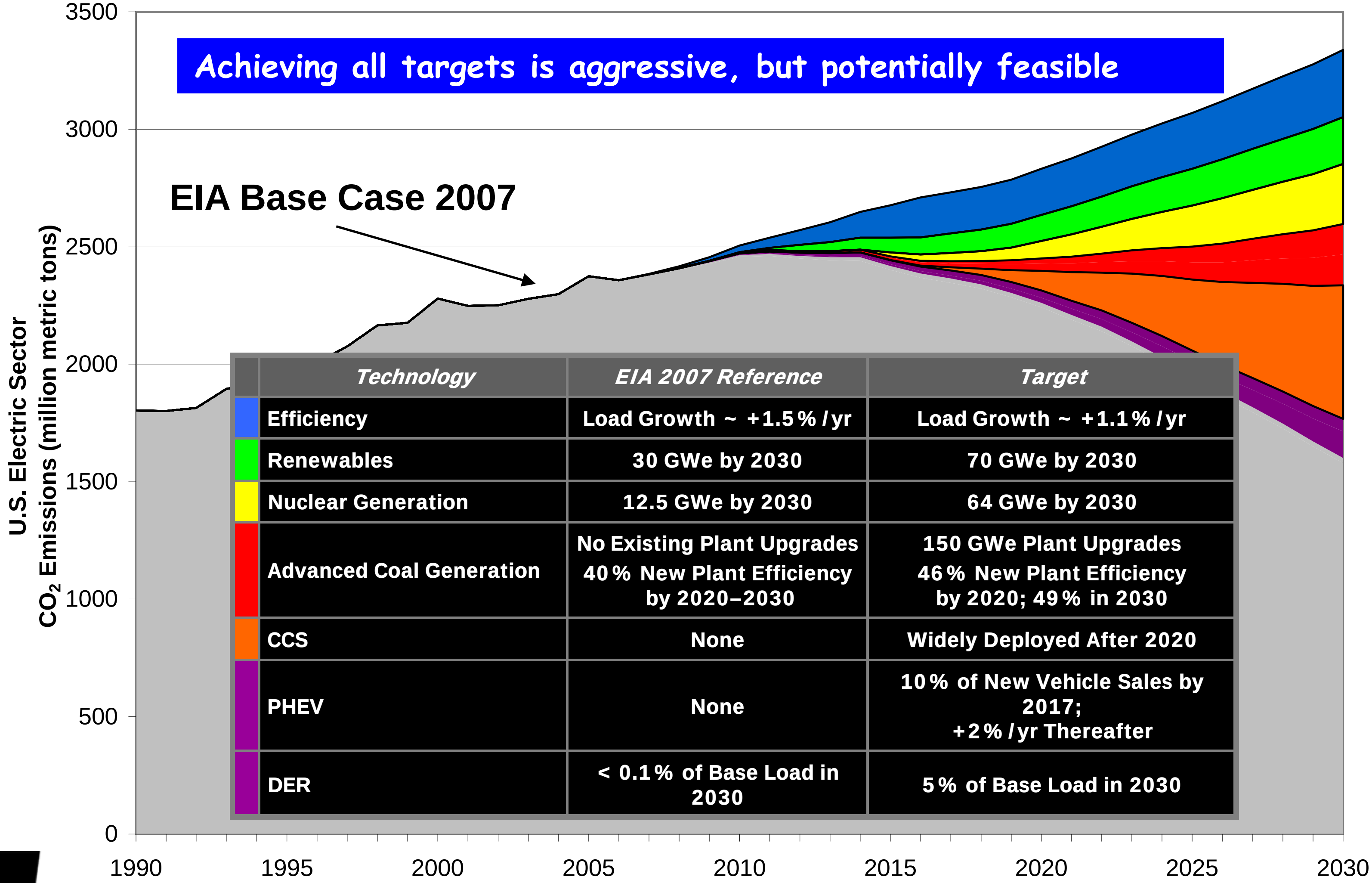
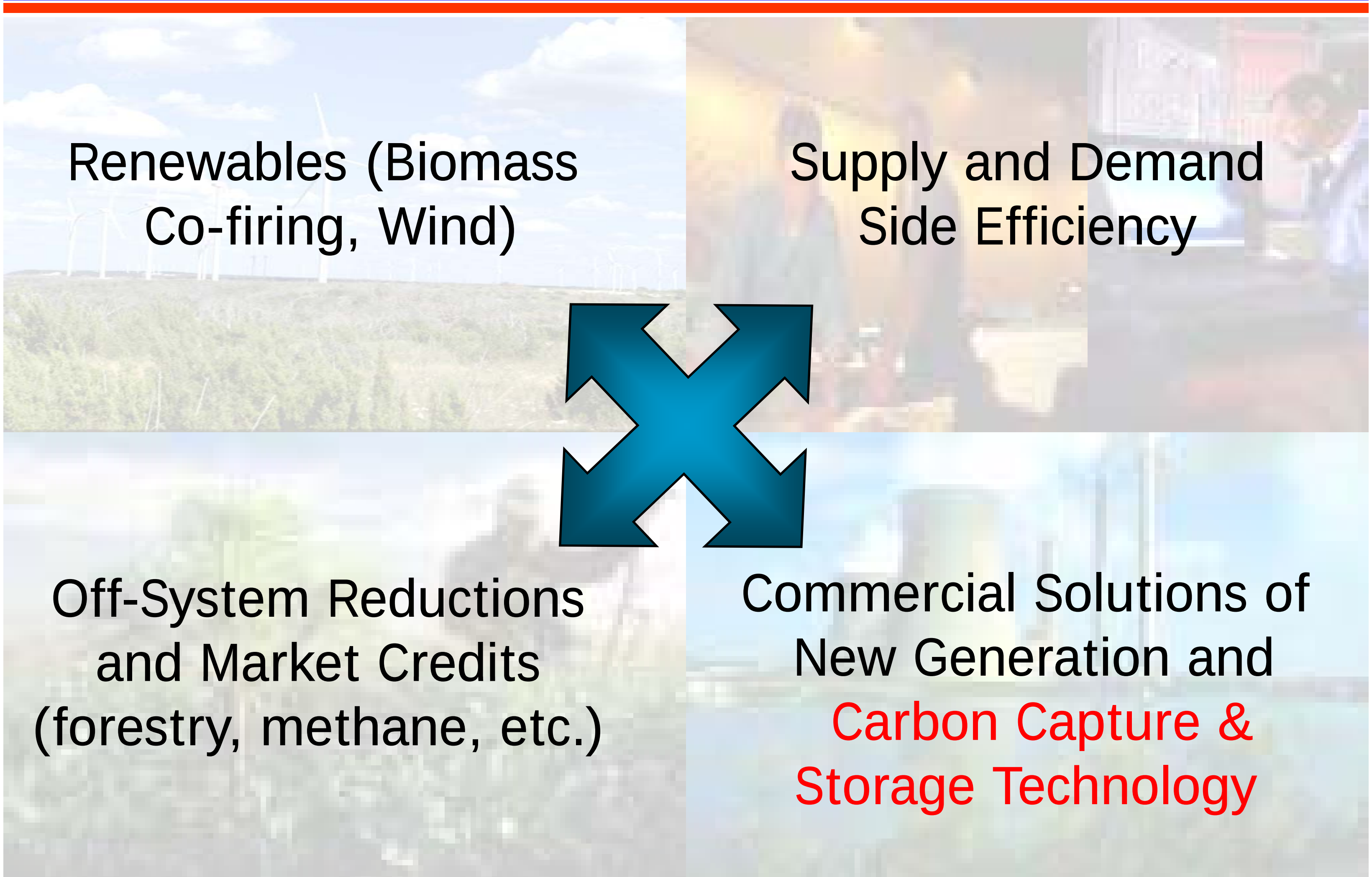
EPRI CO_2 Reduction "Prism"



Technology	EIA 2007 Reference	Target
Efficiency	Load Growth ~ +1.5%/yr	Load Growth ~ +1.1%/yr
Renewables	30 GWe by 2030	70 GWe by 2030
Nuclear Generation	12.5 GWe by 2030	64 GWe by 2030
Advanced Coal Generation	No Existing Plant Upgrades 40% New Plant Efficiency by 2020–2030	150 GWe Plant Upgrades 46% New Plant Efficiency by 2020; 49% in 2030
CCS	None	Widely Deployed After 2020
PHEV	None	10% of New Vehicle Sales by 2017; +2%/yr Thereafter
DER	< 0.1% of Base Load in 2030	5% of Base Load in 2030

AEP's Long-Term GHG Reduction Portfolio



AEP

AEP is investing in a portfolio of GHG reduction alternatives

AEP Leadership in New Technology: IGCC and USC

NEW ADVANCED GENERATION

• **IGCC --** AEP first to announce plans to build two 600+ MW IGCC commercial size facilities in US (OH and WV) by mid next decade

• **USC** -- AEP will be first to employ new generation ultra-supercritical (steam temperatures >1100°F) coal plant in U.S (AR)

AEP®

CO_2 Capture Techniques

Post-Combustion Capture - *Conventional or Advanced Amines, Chilled Ammonia*

- Relatively low CO_2 concentration in flue gas – Thus difficult to capture
- Amine technologies commercially available in other industrial applications
- **High parasitic demand**
  - Conventional Amine ~30-35%, Chilled Ammonia target ~10-15%
- Amines require **very** clean flue gas, Chilled Ammonia less sensitive to contaminants

Modified-Combustion Capture - *Oxy-Coal*

- Technology not yet proven at commercial scale
- Creates stream of very high CO_2 concentration
- High parasitic demand, >25%

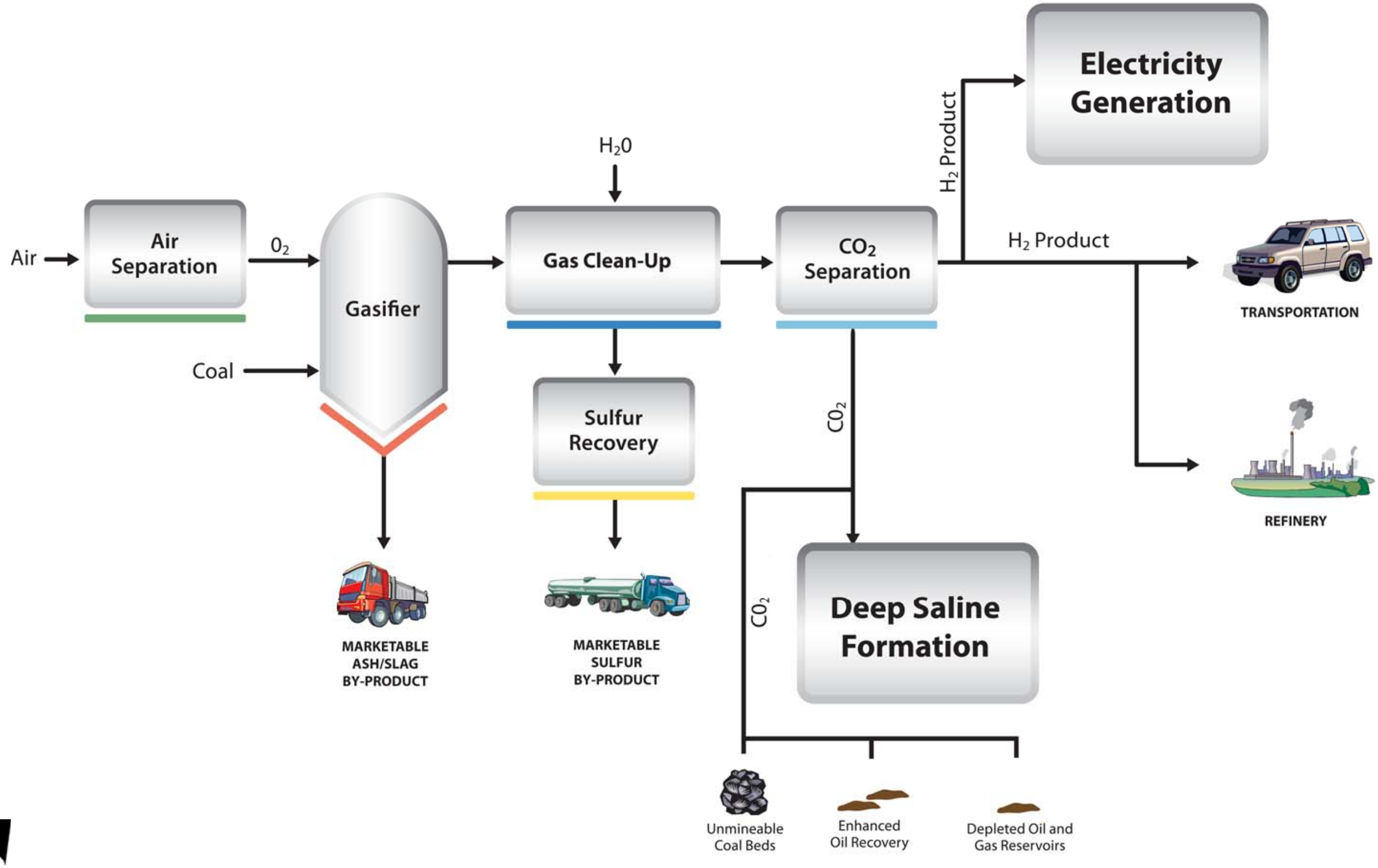
Pre-Combustion Capture - *IGCC with Water-Gas Shift*

- Most of the processes commercially available in other industrial applications
  - Have never been integrated together
- Turbine modified for H_2-based fuel, which has not yet been proven at commercial scale
- Creates stream of very high CO_2 concentration
- Parasitic demand (~15-20%) for CO_2 capture - lower than amine or oxy-coal

AEP®

IGCC Water-Gas Shift Process

Pre-Combustion Capture



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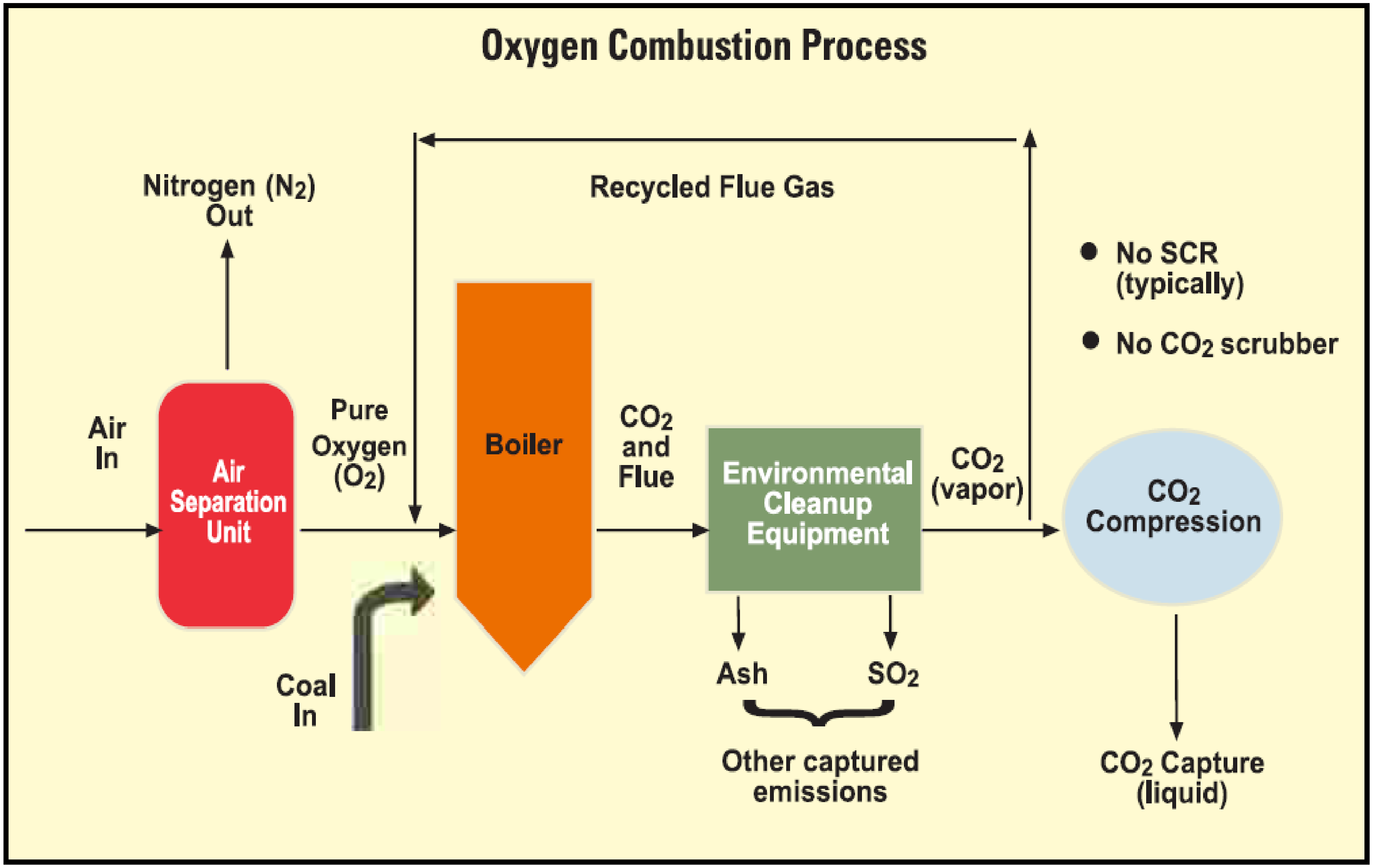
Babcock & Wilcox Oxy-Coal Process

Modified Combustion Capture



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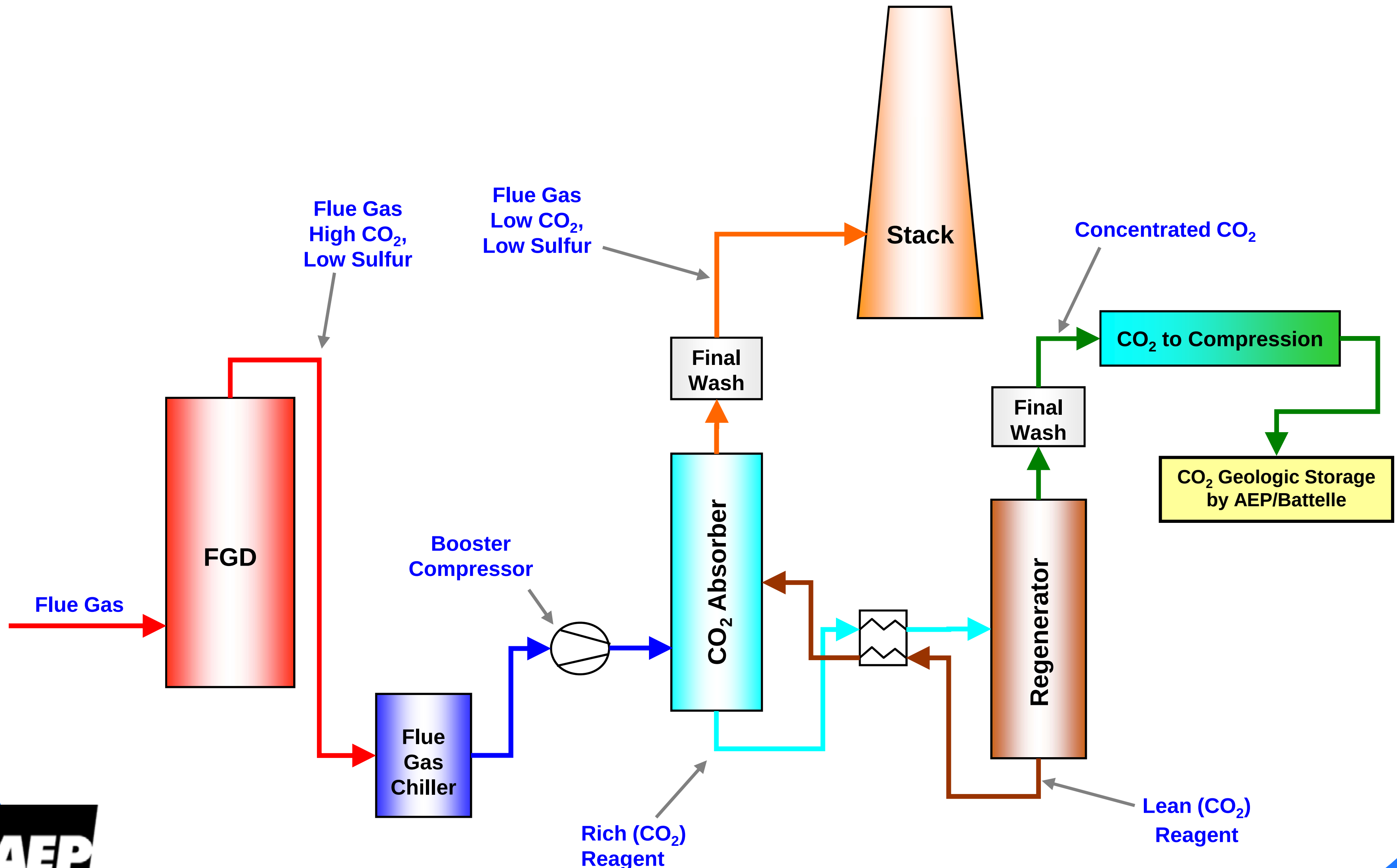
Alstom's Chilled Ammonia Process

Post-Combustion Capture



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AEP Leadership in New Technology: Chilled Ammonia CCS

Phase 1

2009 Initial Operation

1300 MW Mountaineer Plant (WV) → MOU (Alstom) **Chilled Ammonia 20MWe scale**

CO_2 Storage (Battelle)

Captures and Stores ~100,000 metric tons of CO_2 /yr.

Phase 2

2012 Commercial Operation

450 MW Plant (AEP-West) → MOU (Alstom) **Chilled Ammonia ~300MWe scale** → EOR

CO_2 Storage

Captures and Stores 1.5 Million metric tons of CO_2 /yr.

AEP®

The Challenge: CCS is Expensive

$50+

$/ton CO_2e

$0

- Carbon Capture w/ Geologic Sequestration
- Other renewable, advanced geothermal and/or solar
- Carbon Capture for Enhanced Oil Recovery
- New Biomass Generation
- Dispatch of additional gas vs. inefficient coal
- Biomass Co-firing
- Biological Sequestration (e.g. Forestry)
- New Wind
- Energy Efficiency
- Methane Offsets

Nuclear?

AEP®

CCS: The Business Case

- CO_2 Legislation Requiring Very Substantial Long Term Reductions is Likely
- A Portfolio of Reduction Options Will Be Needed
- Future Electricity Demand Requires New “Baseload” Power Options (Predominantly Coal and Nuclear)
- Half of Existing Demand is Met By Coal and Early Retirement of Coal is Expensive. Thus, Retrofit CCS becomes essential.

AEP®

Key Issues for CCS Development

- Overcoming the "Economic" Hurdle—Bonus Allowances and Other Financial Support
- High Up-Front Capital Investment - Getting Adequate Financing and Recovery in Rates
- Commercial Demonstrations of CCS at Large Coal-Fired Power Plants
- National Standards for Permitting of Storage Reservoirs
- Potential Institutional, Legal and Regulatory Barriers to Carbon Storage

AEP®

Ongoing CO_2 Capital and Transport Costs

Gary Loop
Senior VP and Chief Operating Officer
Dakota Gasification Company

IEA GHG Financial Conference

May 28 & 29, 2008
New York

DAKOTA GASIFICATION COMPANY

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

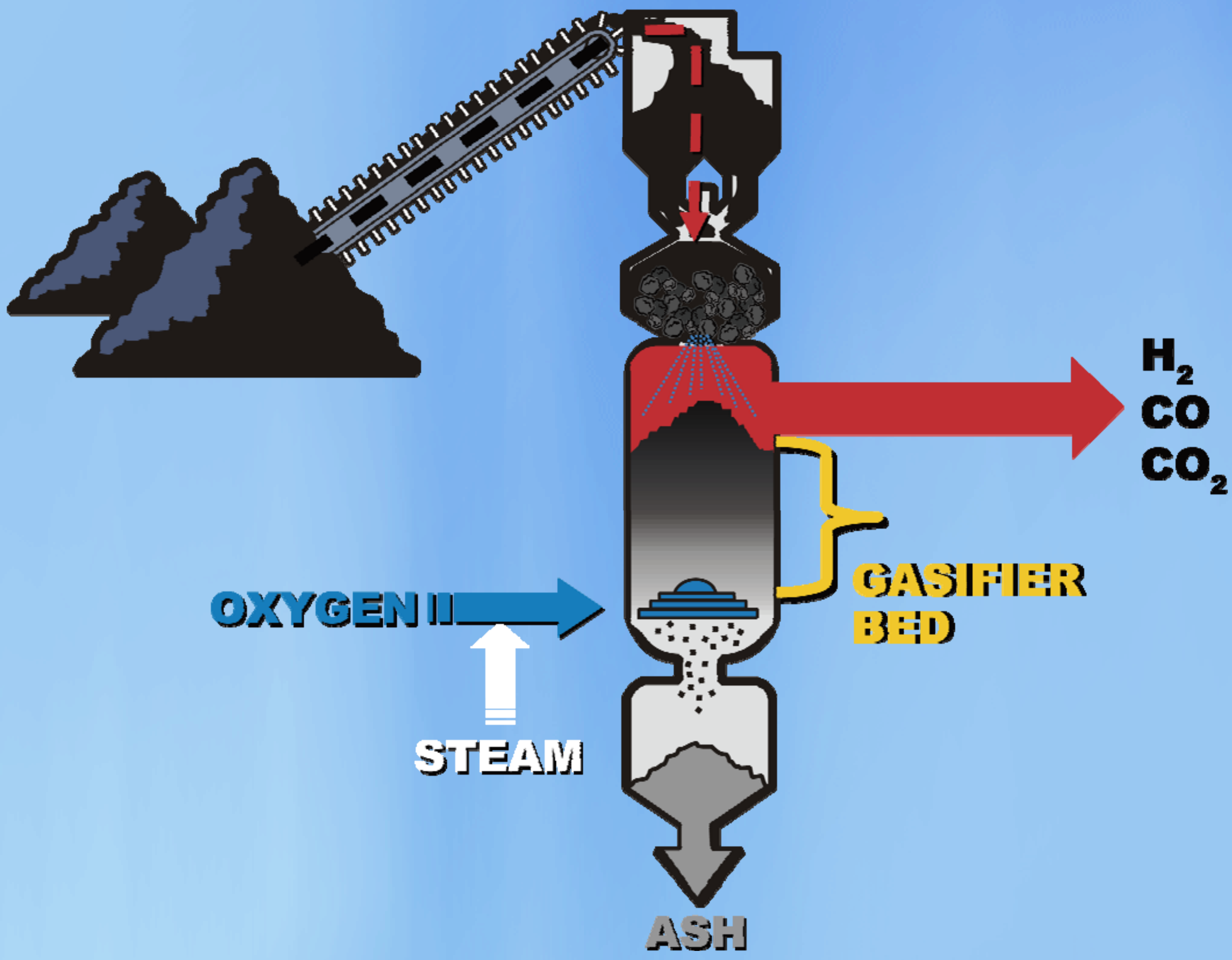
Overview

- **Carbon capture in place today**
  - Dakota Gasification Co. coal to gas facility
  - Largest carbon capture and storage project in the world
- **Carbon capture technology cost comparisons**
  - Pre-combustion (IGCC)
  - Post-combustion (SCPC)
- **Demonstration of post-combustion technology**
  - Unique opportunity in Williston Basin
- **Financial incentives to consider**
  - Tax credits
  - Investment tax credits

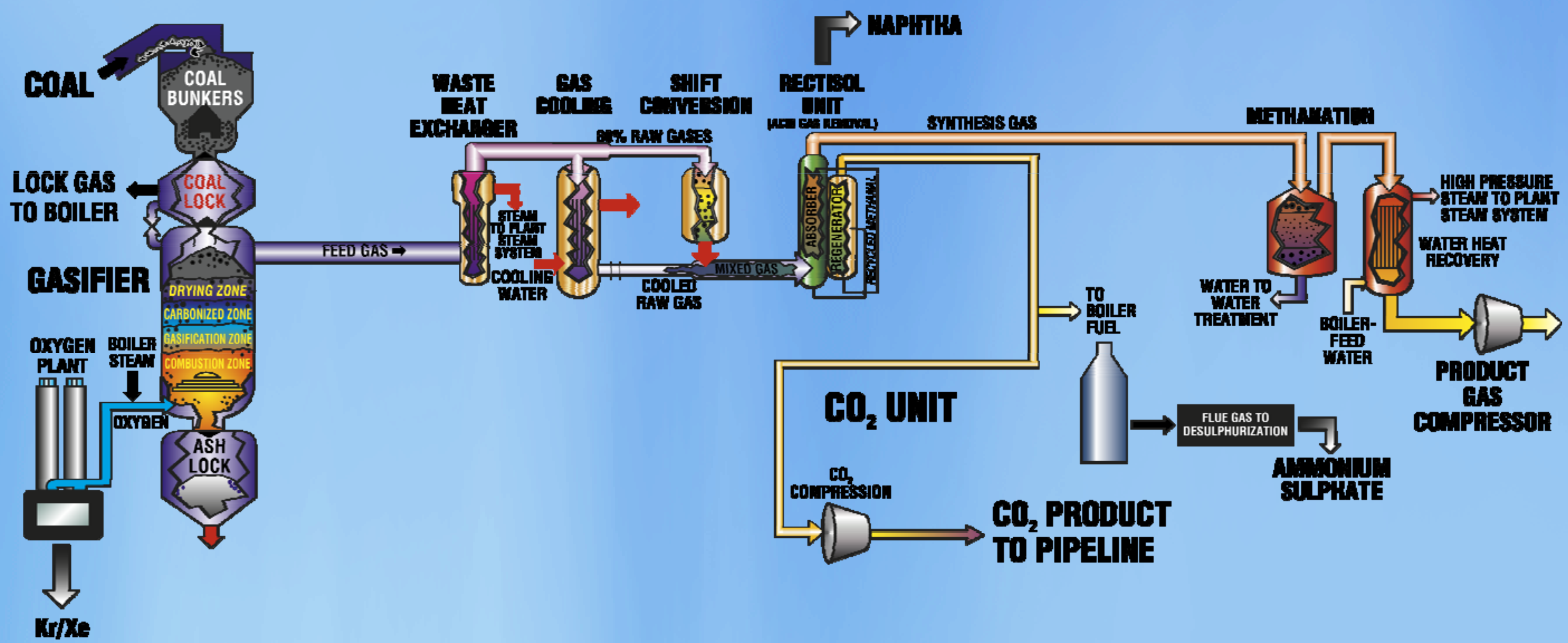
Dakota Gasification Company's Great Plains Synfuels Plant

- **Operates 14 gasifiers to produce synthetic natural gas (SNG)**
- **Capture 4½ million tons CO_2 per year**
- **Delivers 3 million tons CO_2 per year for EOR**
- **Only commercial scale anthropogenic CO_2 sequestration in western hemisphere**
- **Largest CO_2 sequestration project in world**

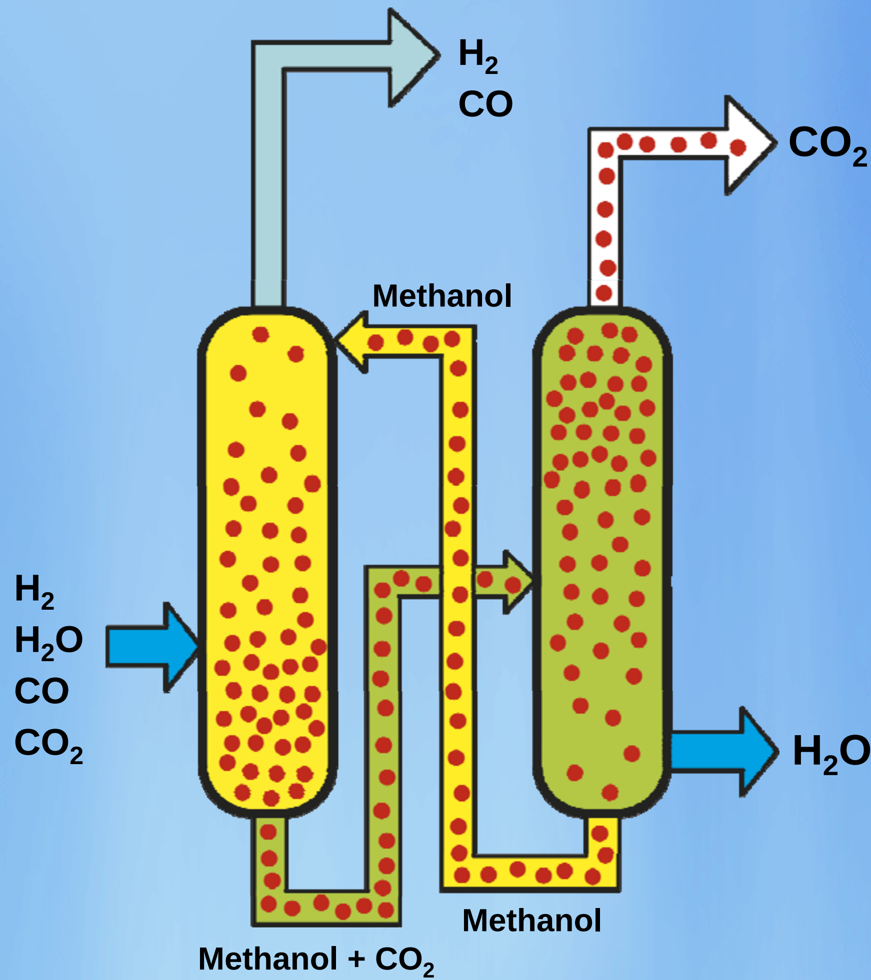
Gasification Process



Coal Gasification



Capture CO_2 from Raw Gas Stream



- Low gas volume
- High % CO_2
- High pressure
- Capture 95+% of CO_2

Dakota Gasification Company

World's Largest Carbon Sequestration Project

Weyburn, Saskatchewan
13 million tons sequestered to date

5 million tons/yr.
Pipeline capacity

CO_2 PIPELINE

Current flow rate:
3 million tons/yr.

Compressors

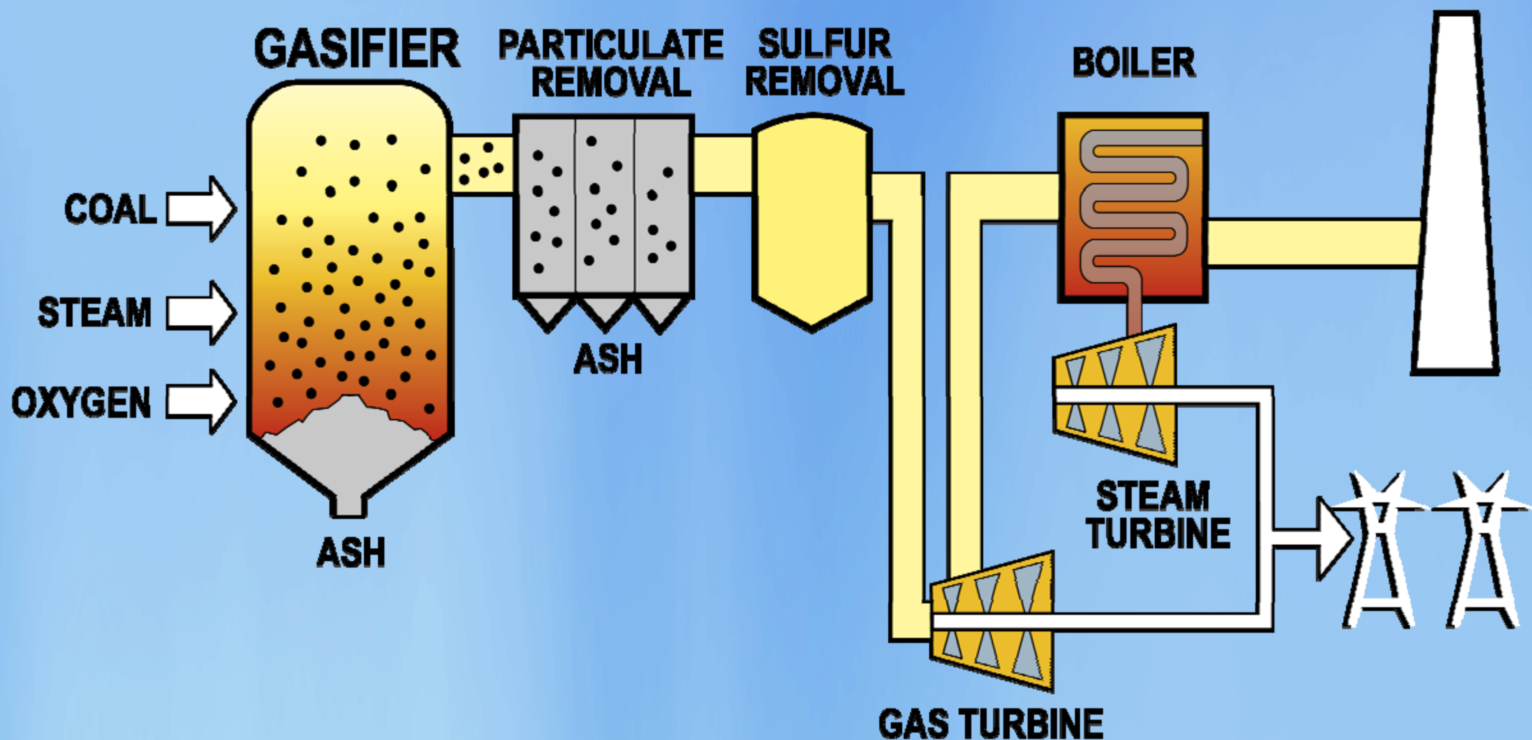
CO_2

Capture Technology

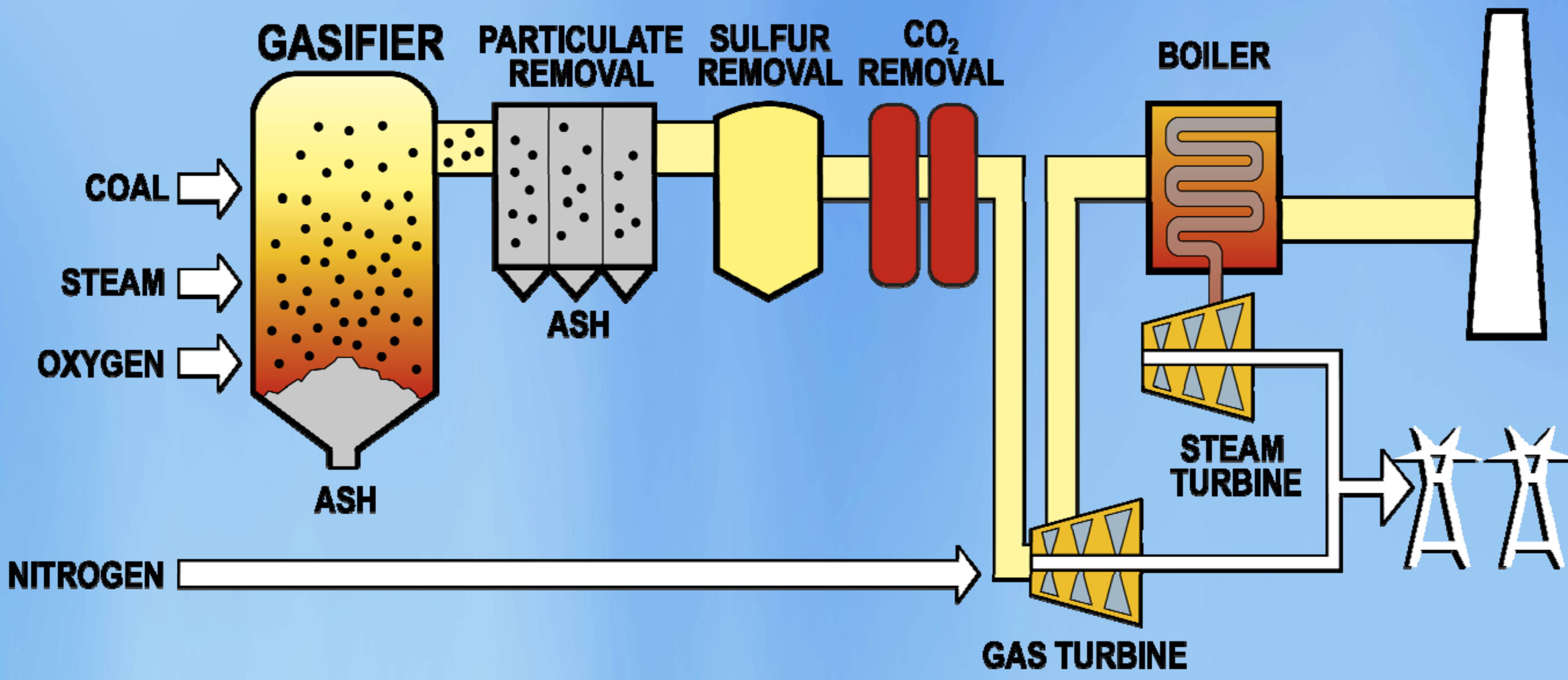
Rectisol capture costs

	Capture $/ton
Capital	**$4**
O&M	**$4**
TOTAL	**$8**

Integrated Gasification Combined Cycle

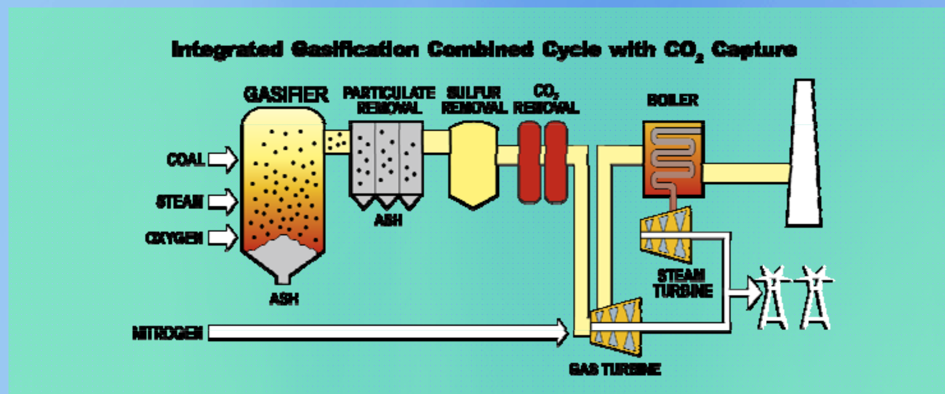


Integrated Gasification Combined Cycle with CO_2 Capture



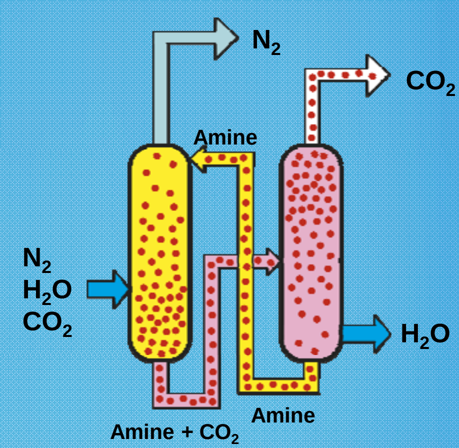
CO_2 Capture – Methodologies

Pre-combustion capture

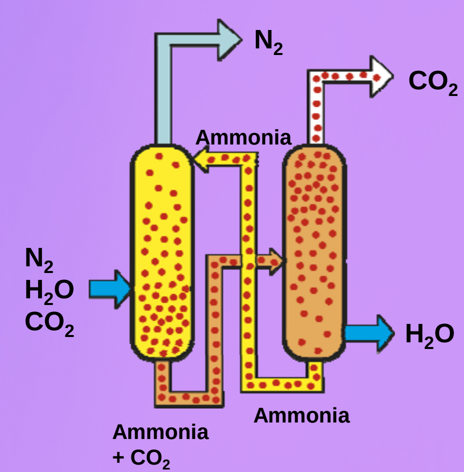


Post-combustion capture

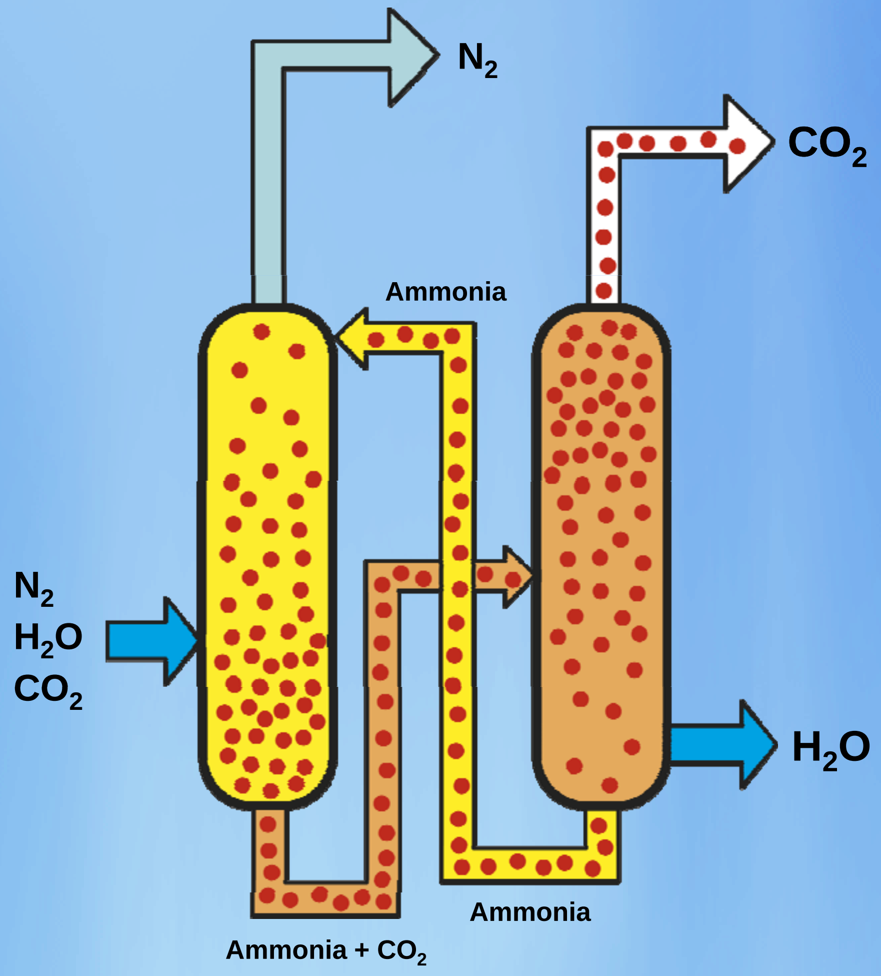
Amine



Ammonia

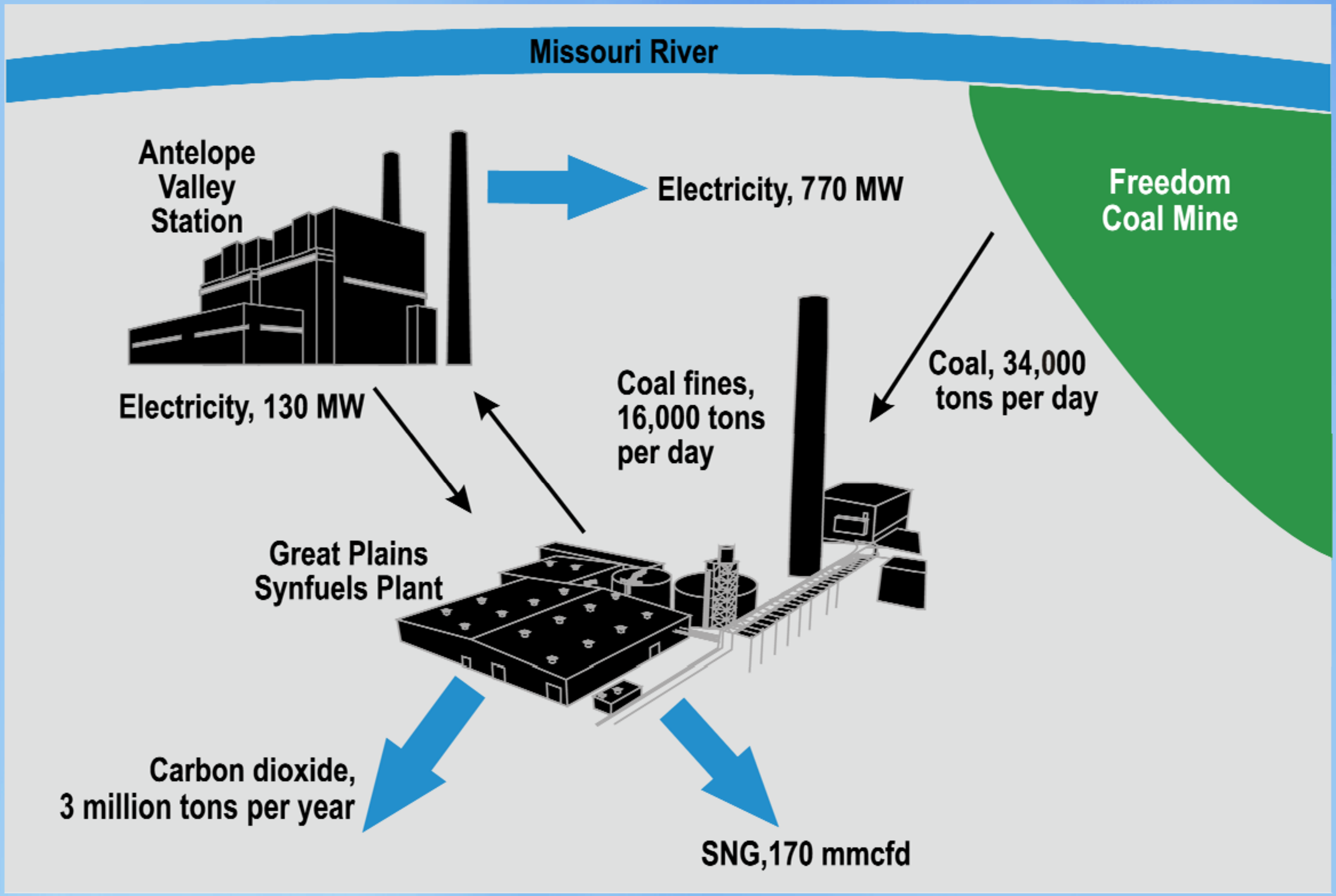


Capture CO_2 from Flue Gas

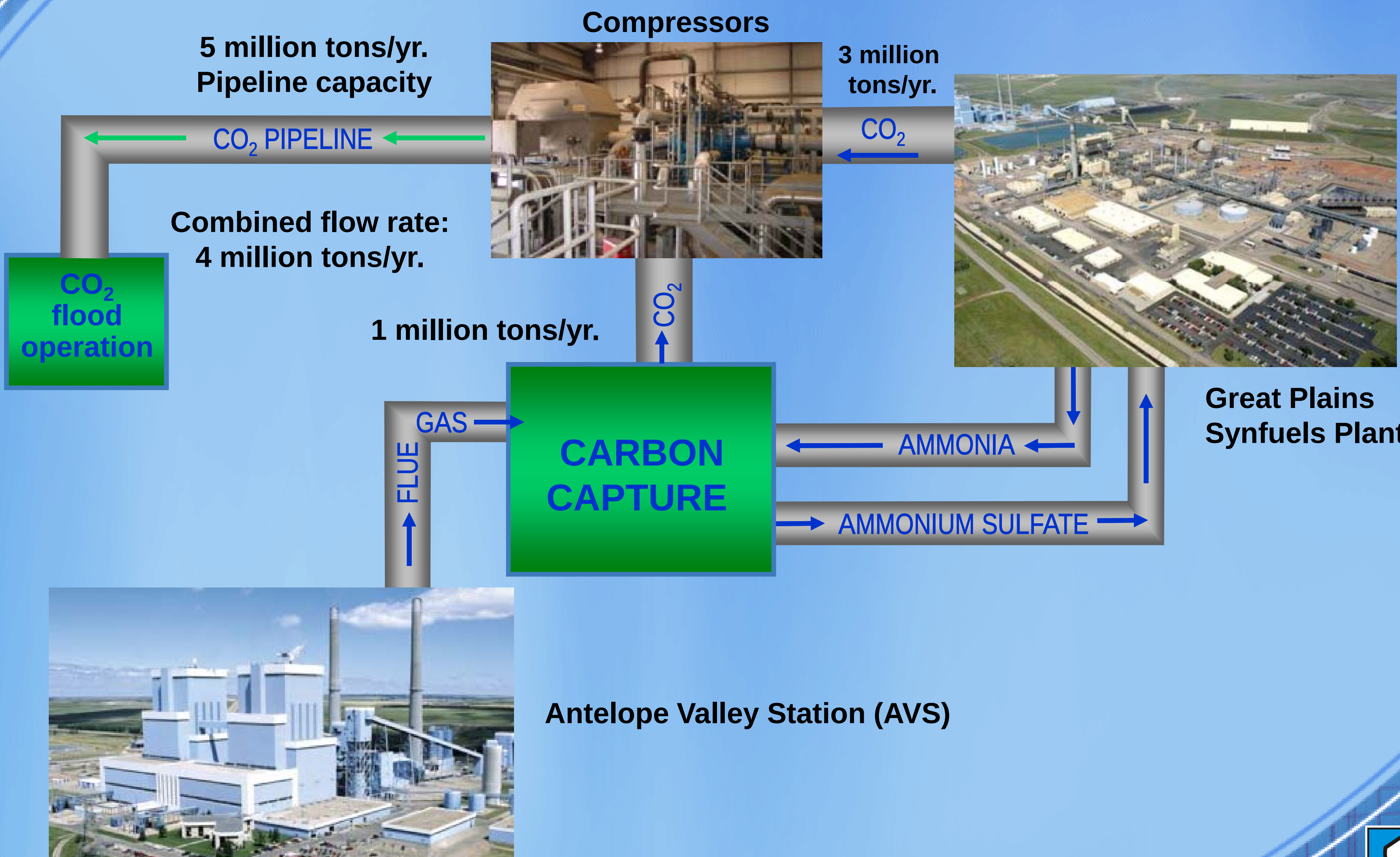


- High gas volume
- Low % CO_2
- Low Pressure
- Capture 90+% of CO_2

AVS-DGC Relationship



Carbon Capture Optimization Project



Commercial Demonstration of Ammonia CO_2 Capture

- **Flue gas stream for 120 MW**
- **1 million tons CO_2 removed**
- **$200 to $300 million in capital**
- **$25 to $35 per ton CO_2**

Antelope Valley Station (AVS)

Capture Technology

$/ton	Ammonia high	Ammonia low	Amine high	Amine low	Rectisol
Capital	$13	19	15	24	4
O&M	$12	16	15	26	4
TOTAL	$25	35	30	50	8

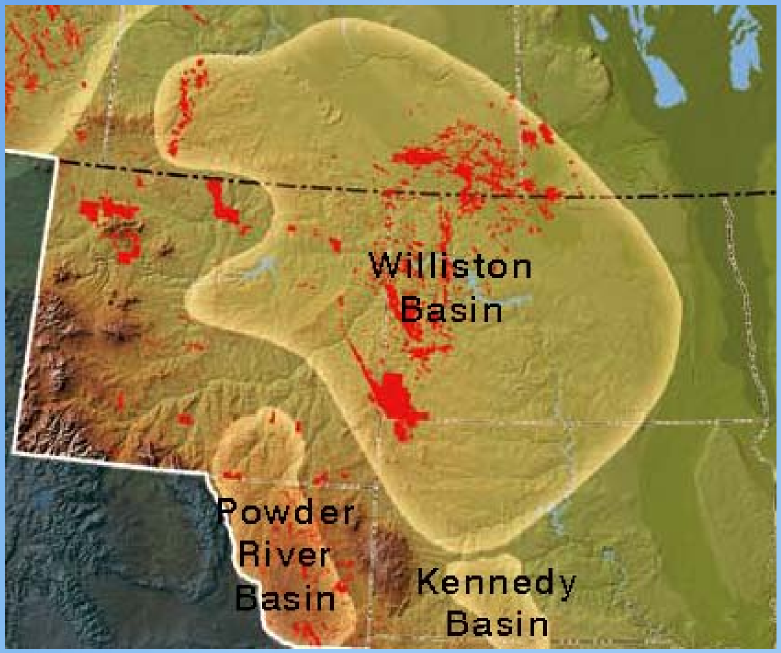
Advantages to AVS Post Combustion Demonstration Plant

- **DGC facility has established CO_2 transport technology within Williston Basin**
- **DGC facility produces ammonia required for CO_2 removal process**
- **DGC facility has ammonium sulfate production capacity to handle sulfur resulting from CO_2 removal**

Williston Basin Offers Good Match

- All CO_2 currently produced can be stored in EOR sites for over 50 years

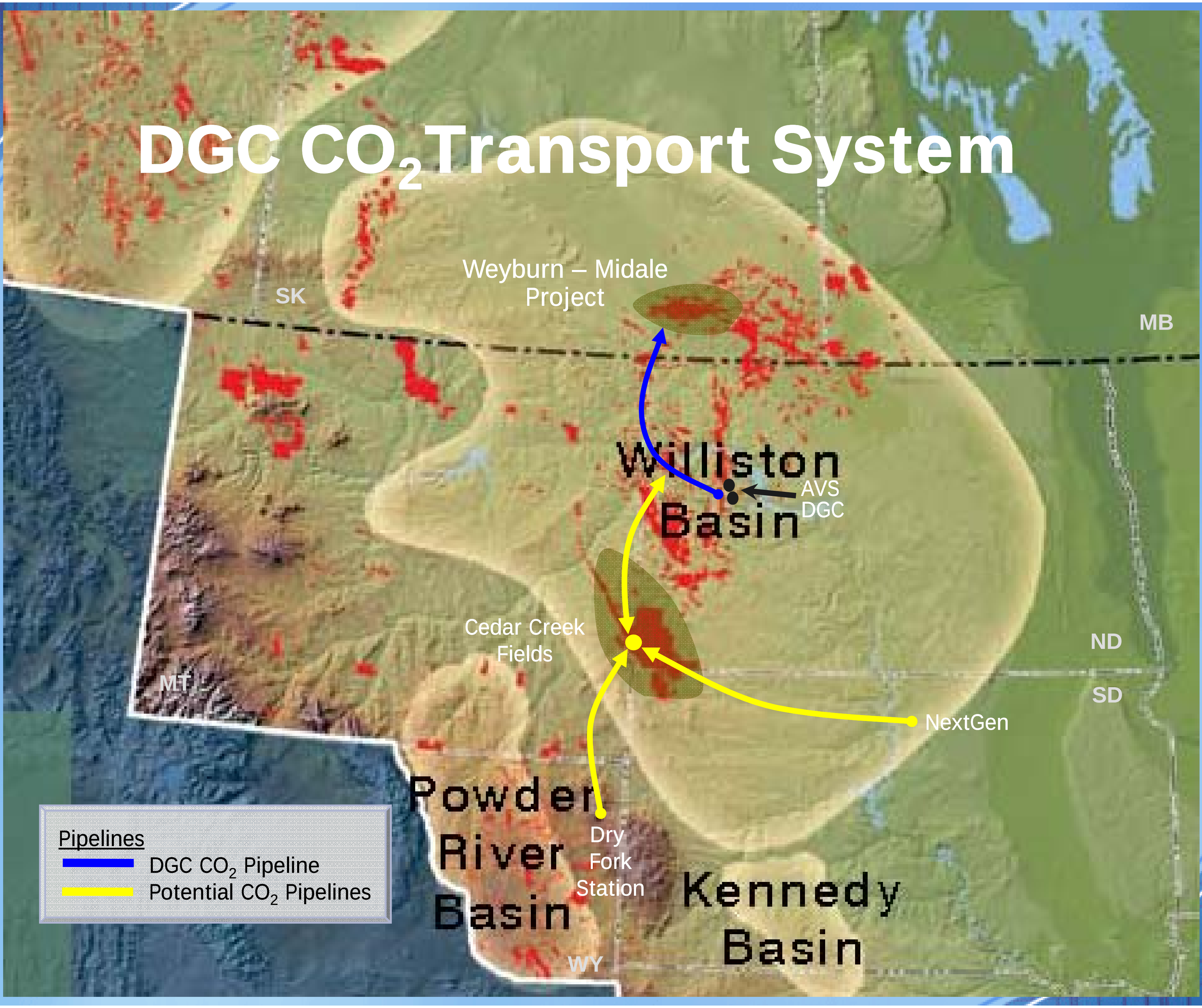
- CO_2 from burning all coal in basin can all be sequestered in Saline Aquifers within Williston Basin



Timing is Right

- Oil prices are above historical levels and enhance the value of CO_2 as an EOR solvent
- Ammonia technology is ready for CO_2 capture demonstration
- Existing pipeline with excess capacity within basin that can be tapped for connection

DGC CO_2 Transport System

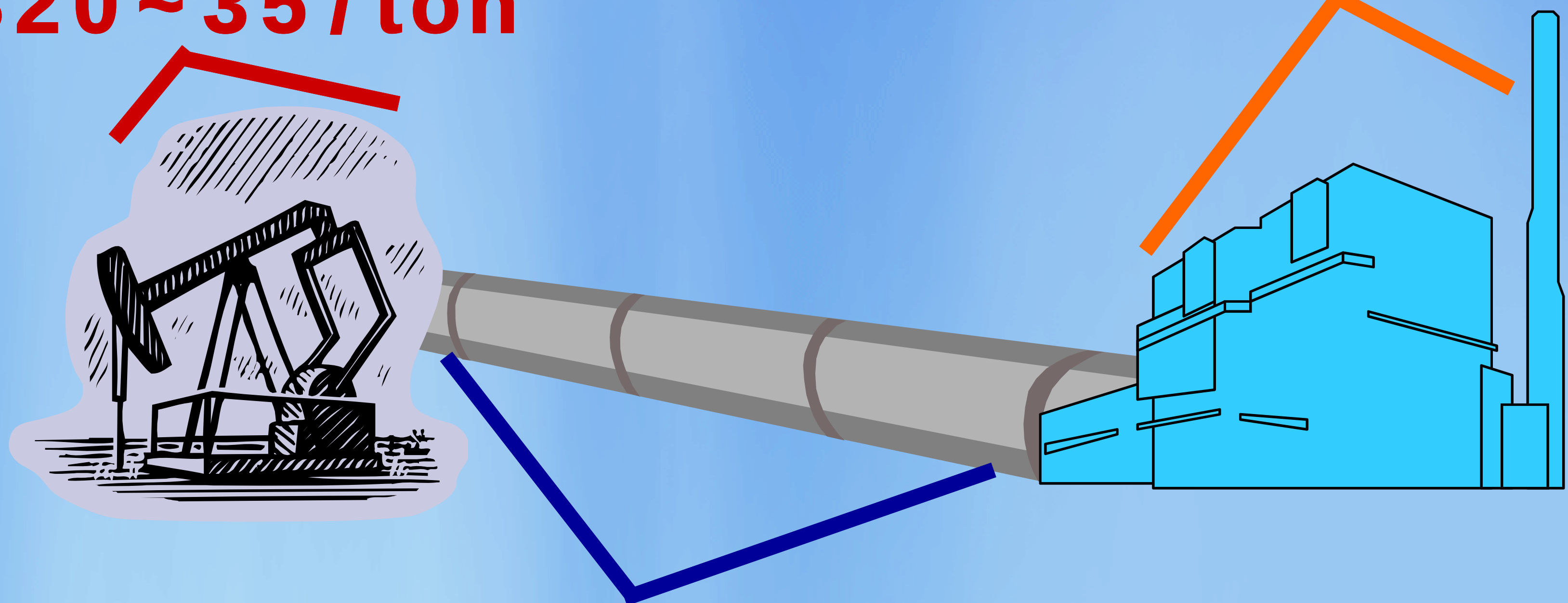


Estimated Costs

$5~60/ton

$20~35/ton

$25~50/ton



$15-30/ton

Demonstration Plant Economics

	$/ton	
Capture Cost	($25)	($35)
Transport Cost	($10)	($15)
Cost of CO_2	($35)	($50)
Revenue	$35	$25
Net Gain (Loss)	$ 0	($25)

Financial Incentives to Consider

- Tax credit of \$15/ton CO_2 can stimulate sites to prove evolving technologies
- 30% investment tax credit for demonstration plant can stimulate sites as well

Demonstration Plant Economics

	$/ton	
Capture Cost	($25)	($35)
Transport Cost	($10)	($15)
Cost of CO_2	($35)	($50)
Revenue	$35	$25
Net Gain (Loss)	$ 0	($25)
Incentive	$15	$15
Net Gain (loss)	$10	($10)

Thank you

LIABILITY (RISK) MANAGEMENT:
Ensuring Financial Responsibility for GS

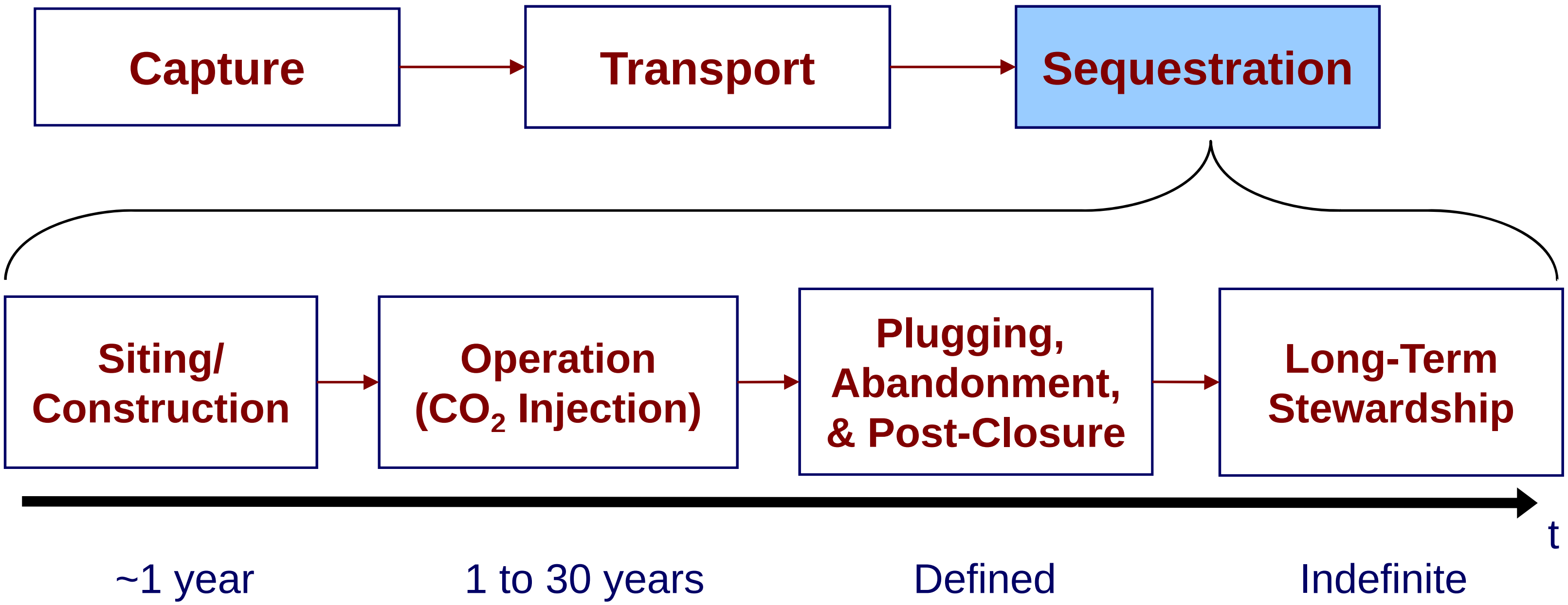
May 2008

Chiara Trabucchi
Industrial Economics, Incorporated
ctrabucchi@indecon.com | 617.354.0074

Common Language? Are you Sure?

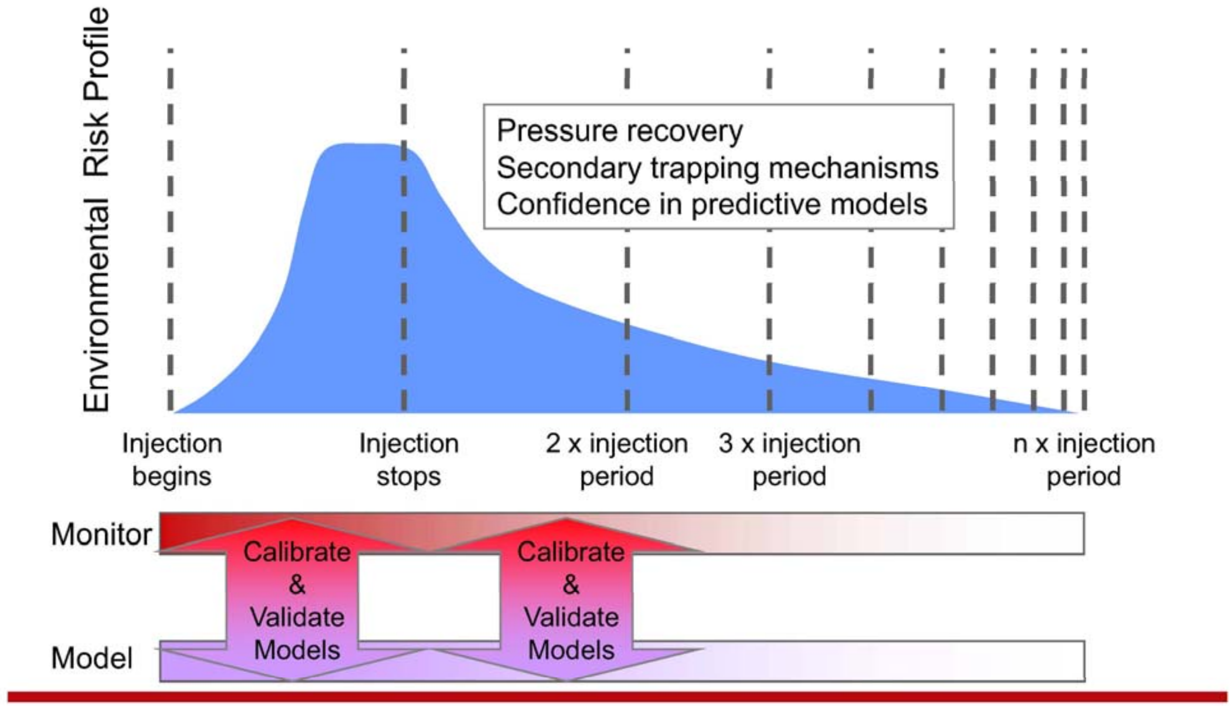
- **RISK –** Of what?
  - Non-performance / default? Underperformance? Defect? Other contractual liability? Tort Liability for Bodily Injury (BI), (first party) Property Damage (PD), Ecological / Natural Resource Damage? Endangered Species Issues?
  - **Moral Hazard** – Will the party be better off in the event of loss / failure? Is the party indifferent, and therefore won't try to prevent or mitigate certain losses?
- **FINANCIAL RESPONSIBILITY –** To whom, for what? When?
- **LIABILITY –** Statutory? Common law? Civil law jurisdiction?
- **HARM / INJURY –** BI or PD or other?
- **DAMAGES –** Nature? Type?
- **INDEMNITY –** Contractual? Governmental? First dollar? Excess of retained amount? Insurance? Public / Private?

GS Project Life Cycle



- Industry Sectors – Utility v. EOR/EGR
- Early movers (pilots) v. commercial-scale deployment
- Existing statutory implications – SDWA, CAA, RCRA, CERCLA

Risk Profile for GS Sites



Benson, 2007

- **Shape of the curve will vary by GS site**
- Early movers (pilots) will site in favorable zones
- **Liability frameworks** must balance incentives that foster early deployment with the potential for adverse site selection (with increasingly risky profiles) due to **moral hazard** as commercial-scale deployment evolves.

Liability
(Uncertainty of Interplay with Existing Statutes)

- **Numerous Potential Claimants, Causes of Action.**
  - Nuisance, trespass, negligence, other torts
  - Statutory liability (SDWA, CAA, RCRA, CERCLA, ESA; local statutes; potential “cap” of Cap-and-Trade)
  - Contractual and “New” Potential Carbon Market Exposures – required purchase of offsets, penalties / fines
- **Spans State & Federal Authority**
  - Jurisdiction, nature of the harm and attendant damages will interact to determine liability, compensability, and which (if any) party can transfer, release or assume liability.

Financial Responsibility (Certainty of a Sort…)

- **An effective liability (risk management) framework will assure funds are available to pay for the necessary activity to:**
  - **Minimize potential for releases** of the injectate from the containment zone over the long-term (post operational acts and confirmed stabilization); and
  - **Detect problems** before they adversely impact public welfare or the environment (MMV).
- **The remaining challenge?** Corrective (remedial) action, and to the extent necessary how damages will be redressed & up to what limit?

Liability (Risk) Management Options

Financial Responsibility Mechanisms	**GS Project Phases**		
	MMV (Injection / Operation)	Plugging, Abandonment & Post-Closure	Long-Term Stewardship (<u>after</u> prescribed post-closure)
1. Third-Party Instruments (Trust Funds, LOCs, Insurance, Bonds)	✓	✓	✓
2. Self-Insurance (Financial Test, Corporate Guarantee)	✓	✓	✗
3. Public/Private Hybrids ▸ Compensation Funds ▸ Risk Pooling Models	✗	✗	✓

Notable Liability Frameworks:

Each Has Strengths and Weaknesses; Risk Profile is Key

<Public / Private Frameworks>

1957 | Price-Anderson
Nuclear Indemnity

1968 | NFIA
Indemnity/Risk Pool

2002 | SAFETY ACT
Risk/Litigation Management

<Compensation (Trust) Funds>

1974 | SDWA
UIC Program

1980/1986 | CERCLA/SARA
Superfund

1990 | TAPAA/OPA
OSLTF / TAPLF

2007 | IRGC / IOGCC
State Compensation Funds

Insurance and Liability

- What are the risks? What risks are insurable?
- What does the insurance industry need in order to formulate insurance products for CCS projects?
- What kind of policy environment is needed to develop these insurance products?
- What is government's role, if any, in insuring CCS projects?

Australian COAL Association

Coal Technology Investment: Developments & Issues Concerning CCS in Australia

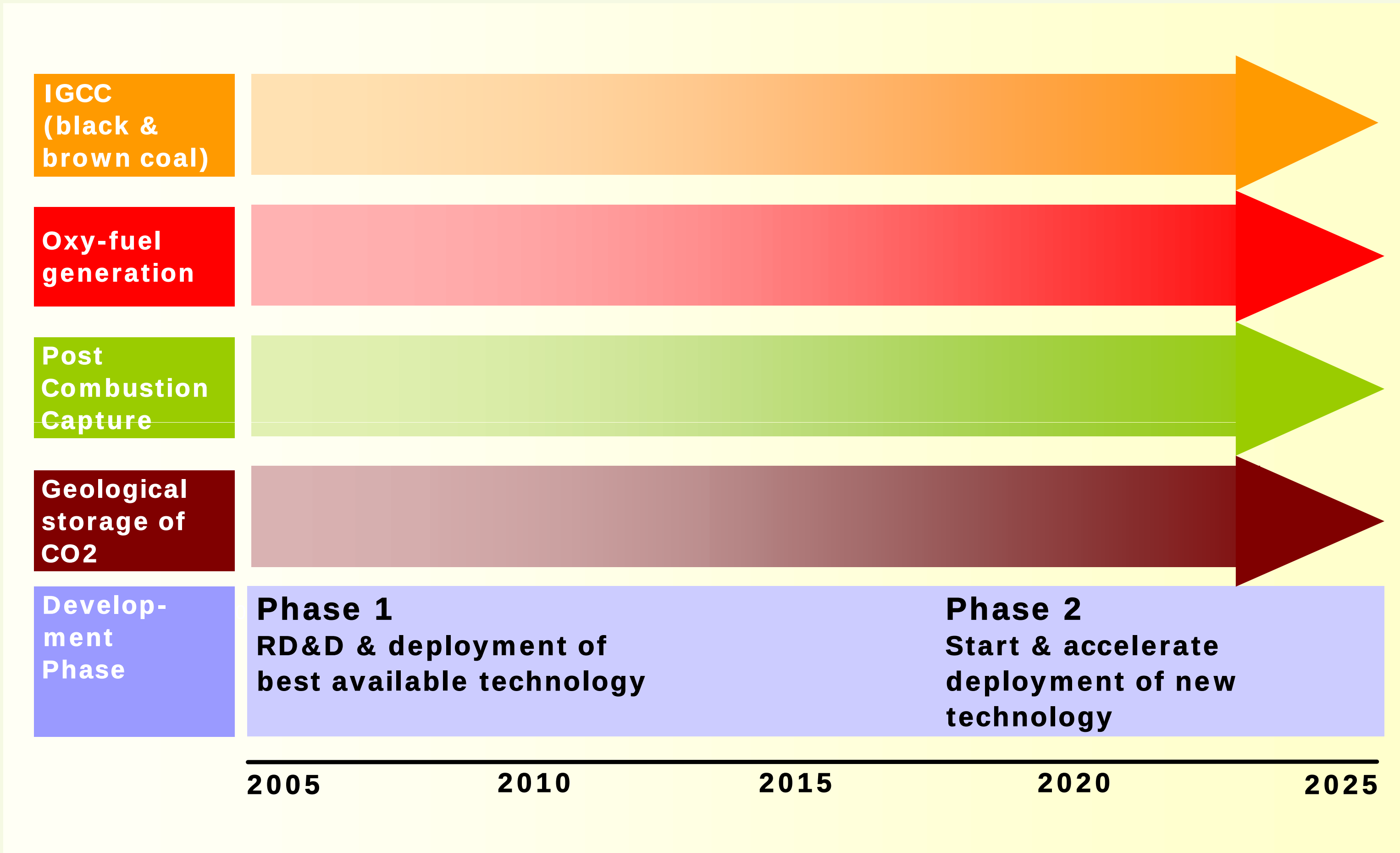
Ross Willims
Chair, ACA Low Emissions Technology Ltd

WCI/IEA Workshop: Financing Carbon Capture & Storage
New York, 31 May 2008

COAL21 Objectives

- Australian National Action Plan for Low Emissions Coal Tech (LET)
- Inform, engage & align govts and industry
- Facilitate LET demonstration & uptake
- Promote supporting R&D
- Foster greater public awareness
- Promote international collaboration

COAL21 Action Plan

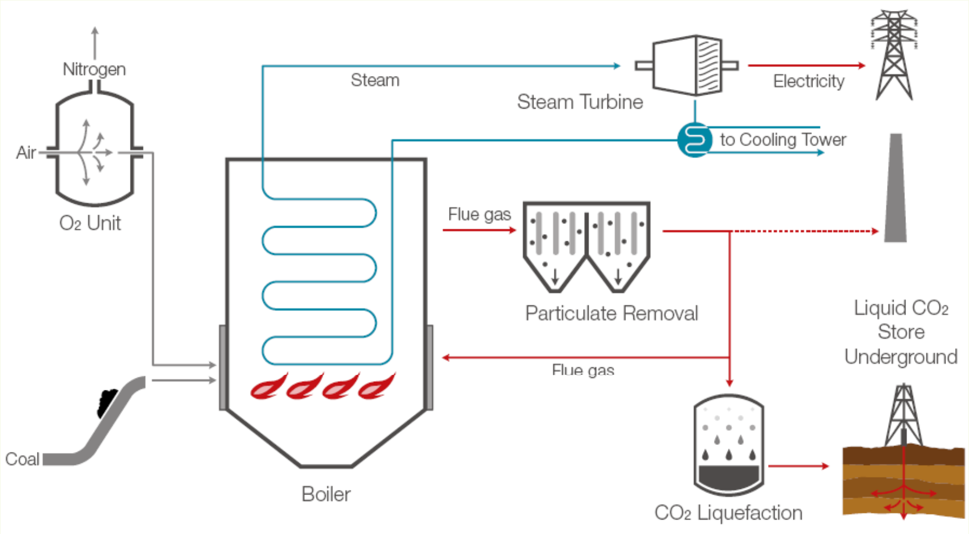


COAL21 Fund

- Voluntary levy on Aus coal production (> 95% buy in)
  - Initial 5yr / AU$300 million increased to 10 yr / $1 billion
- For coal LET demonstration projects & supporting R&D
- Managed by ACA Low Emissions Technology Ltd (ACALET)
  - Board (coal co. executives)
  - Tec Advisory Committee (expert advice bought in as needed)
  - Technology Manager
  - Administered by Aus Coal Assoc
- Supported projects:
  - Oxy-fuel - CS Energy Callide Oxyfuel Project
  - IGCC – ZeroGen
  - PCC - CSIRO Post Combustion Capture Project
  - Storage - Otway Project & Geological Reservoir Mapping

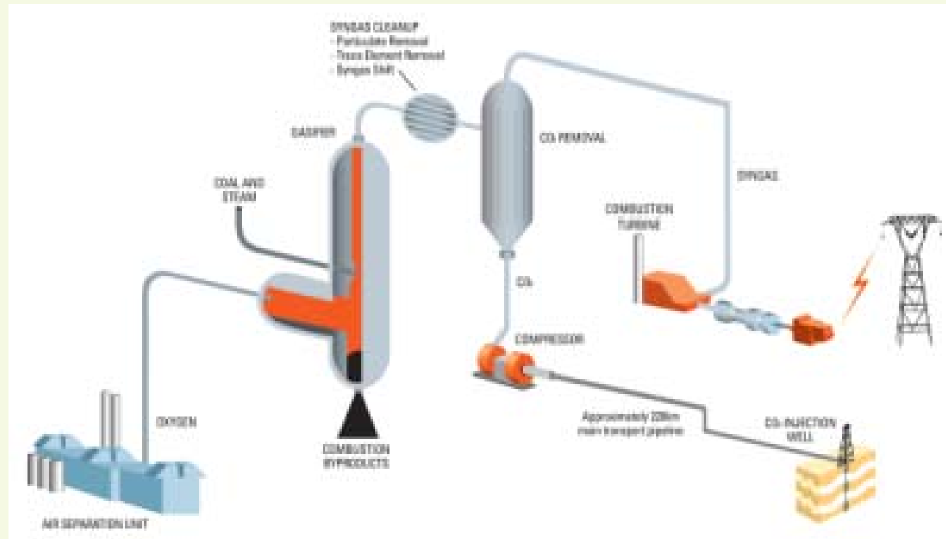
CS Energy Oxy-fuel Project:

- Retrofit oxy-fuel & CO_2 capture to Callide A power station in Queensland
- Partners
  - CS Energy
  - IHI
  - JPower
  - Xstrata
  - Schlumberger
- Funders:
  - COAL21 Fund - AU$68M
  - Aus Govt - $50M
  - CS Energy/Qld Govt/others - $88M
- Status:
  - Feasibility, pilot plant testing done
  - Storage site investigations underway
  - Plant construction to start late 2008
  - Generation from 2010
  - Geosequestration from 2011



ZeroGen Project

- Two stage approach to accelerate large-scale IGCC/CCS
- Stage 1 (by 2012)
  - ➢ 80 MW IGCC demo plant
  - ➢ CCS (~ 75% CO_2)
  - ➢ GE 6FA gas turbine – pathway to Stage 2



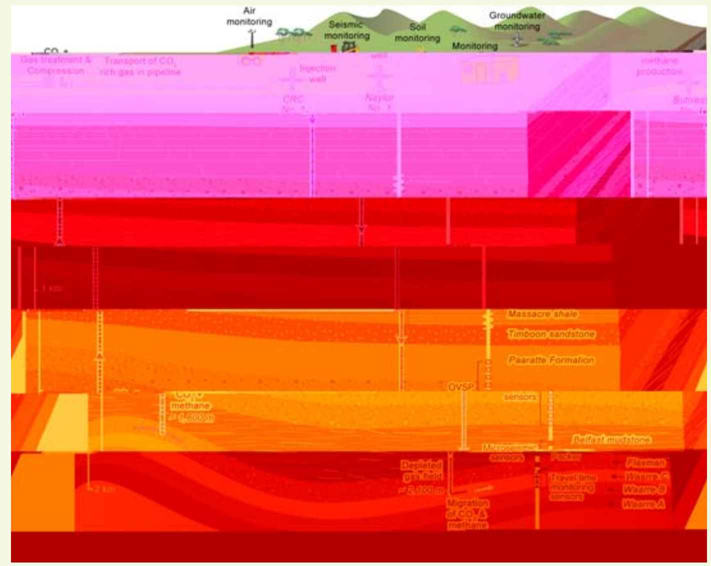
- Stage 2 (by 2017)
  - ➢ 300 MW IGCC
  - ➢ CCS (~ 90% CO_2)
  - ➢ Next generation large scale high H_2 turbine
- Partners (so far):
  - ➢ ZeroGen (Qld Govt/Stanwell Corp)
  - ➢ Shell Development Aus
  - ➢ COAL21 Fund (AU$300M)
- Next steps
  - ➢ Complete Stage 1 feasibility & fund build
  - ➢ Stage 2 Pre-feasibility

New South Wales Post Combustion Capture Project

- Partners (~ AU$150M)
  - NSW Govt
  - Delta Electricity
  - CSIRO
  - COAL21 Fund ($50M)
- Pilot capture plant
  - Munmorah power station
  - Ammonia based absorption suited to Aus conditions
- Storage assessment/characterisation
  - Build on previous basin studies
  - Identify test well site by mid-2010
- Integrated PCC & storage demo
  - Install PCC on existing power station
  - Scalable to commercial size
  - Operational by 2014

Geological storage

- Otway Project (CO2CRC)
  - Stage 1 demo underway (injection into Victorian natural gas reservoir)
  - Stage 2 to target a saline aquifer (enhanced monitoring & verification)
- Regional storage assessments
  - Queensland & New South Wales
  - Assess storage potential
  - Develop storage capability
  - Understand & manage risks
  - Identify large scale/acceptable storage sites



Otway Project Schematic
www.co2crc.com.au

Vision of success – key elements

- Political framework & support
  - Qld & NSW Clean Coal Councils
  - National Low Emissions Coal Council
  - National Storage Taskforce (ACA, WWF, mining union, The Climate Institute)
- Effective collaboration
  - Genuine cooperation, not competition
  - All key players (govts, producers, generators, OEMs, researchers)
- Clear aspirations for commercial plant
  - Demos are crucial, but not the objective
  - Demos must be on pathways to commercialisation
- Financial incentives
  - Including emissions trading, but ET alone is not enough
  - Upfront support is essential to overcome market failure
- Supporting regulation
  - Federal (offshore) CCS legislation has been drafted
  - State (onshore) legislation under development

Threats to success – key challenges

- Plant costs
  - Worldwide equip/infra cost escalation
  - Widens the cost gap between conventional & new generation (demo & commercial) plant
- Long project lead times
  - Increasing urgency for meaningful GHG reductions
  - Early significant progress is important
  - Momentum must be sustained
- Stakeholder buy-in
  - Generators
  - Equipment suppliers
  - NGOs
  - Public
- Public understanding/acceptance
  - Outreach & education is as important as the technology
- Lack of urgency globally
  - Are we taking baby steps?

Take-aways

Australia is moving on all the key technologies for coal, but it's just the beginning of a decades long program.

A nation-building approach to carbon capture and storage is needed, based on public enthusiasm, political commitment and a shared vision of success.

Coal technologies must demonstrate significant early progress & sustained momentum if they are to stay relevant to the debate – we cannot risk being on the slow train.

Emissions limits and trading are necessary, but not sufficient - supplementary targeted CCS programs are essential.

building a CCS industry

29/5/08

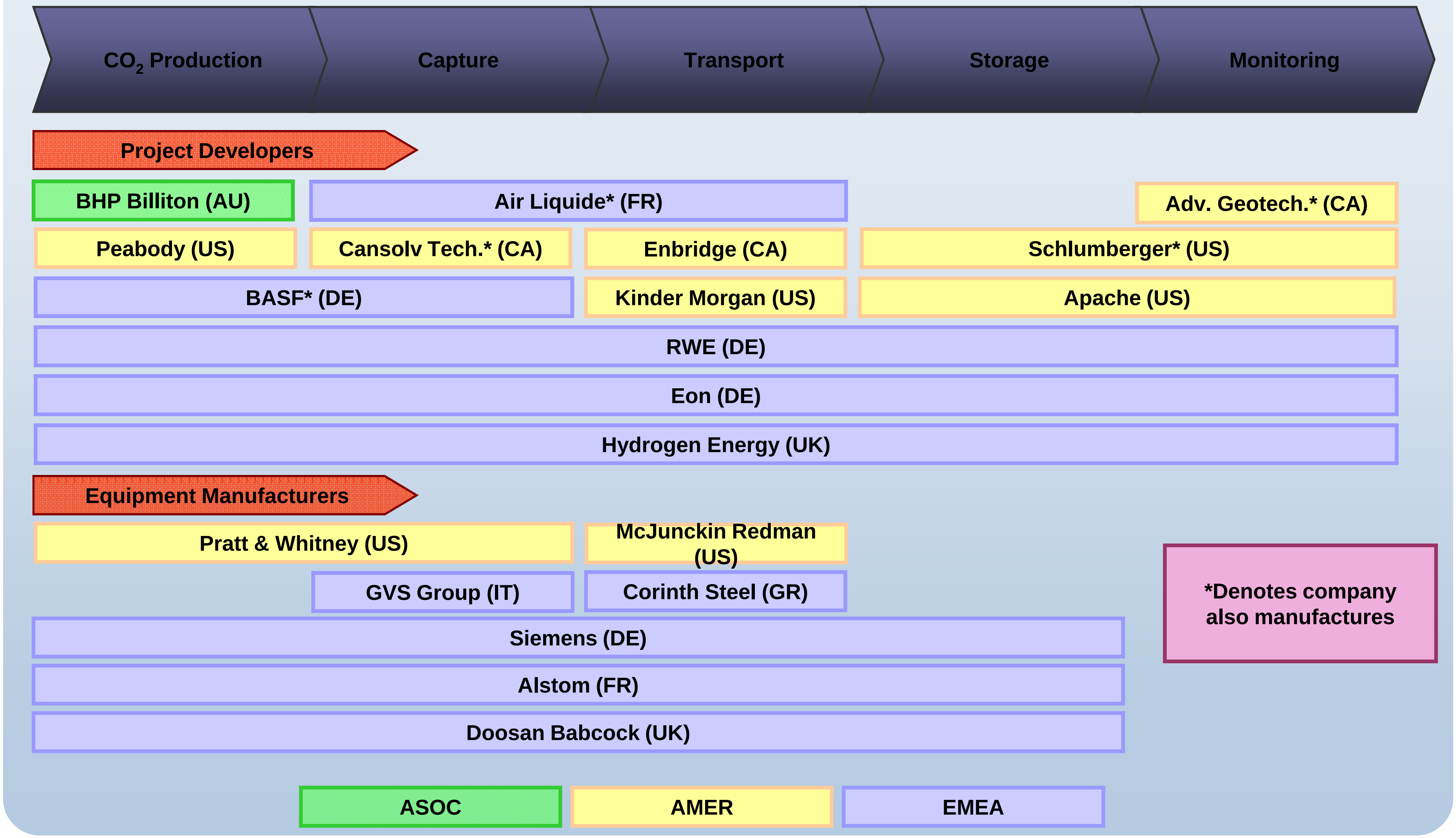
new energy finance




Mark A. Taylor

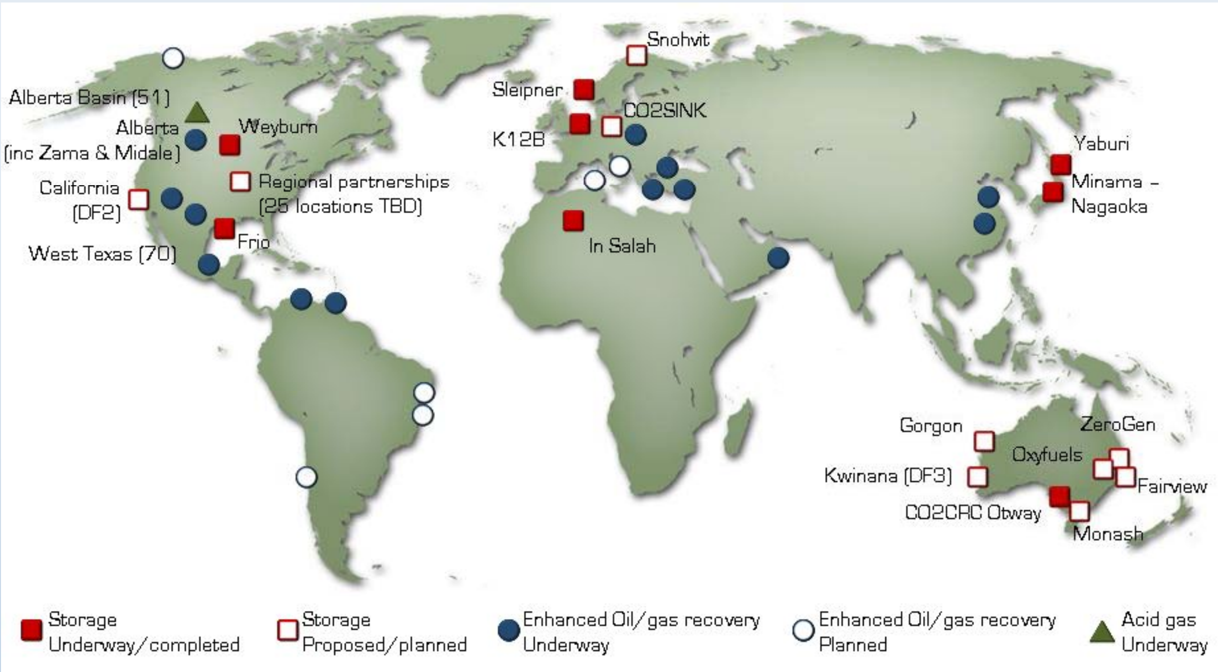
new energy finance

who is doing these projects?



Source: New Energy Finance 2008

there are over 65 CCS projects announced worldwide



- Over 65 projects announced worldwide
- Total cost exceeds $42bn
- By 2016, cumulative injection could exceed 67 MtCo2/yr

0.25% reduction in annual emissions from fossil fuel usage at 2004 levels (based on 27 GtCo2/yr EIA estimate)

Source: New Energy Finance 2008; Map: Geologic Storage of Carbon Dioxide, IEA Greenhouse Gas R&D Programme

building investor confidence

the first commercial scale plant will likely be the catalyst to get several more built

Source: New Energy Finance 2008

new energy finance

outcomes of a commercial scale project

- determine actual cost
- gain public acceptance
- refine regulatory definitions
- prove technical/logistical feasibility
- build investor confidence!!!

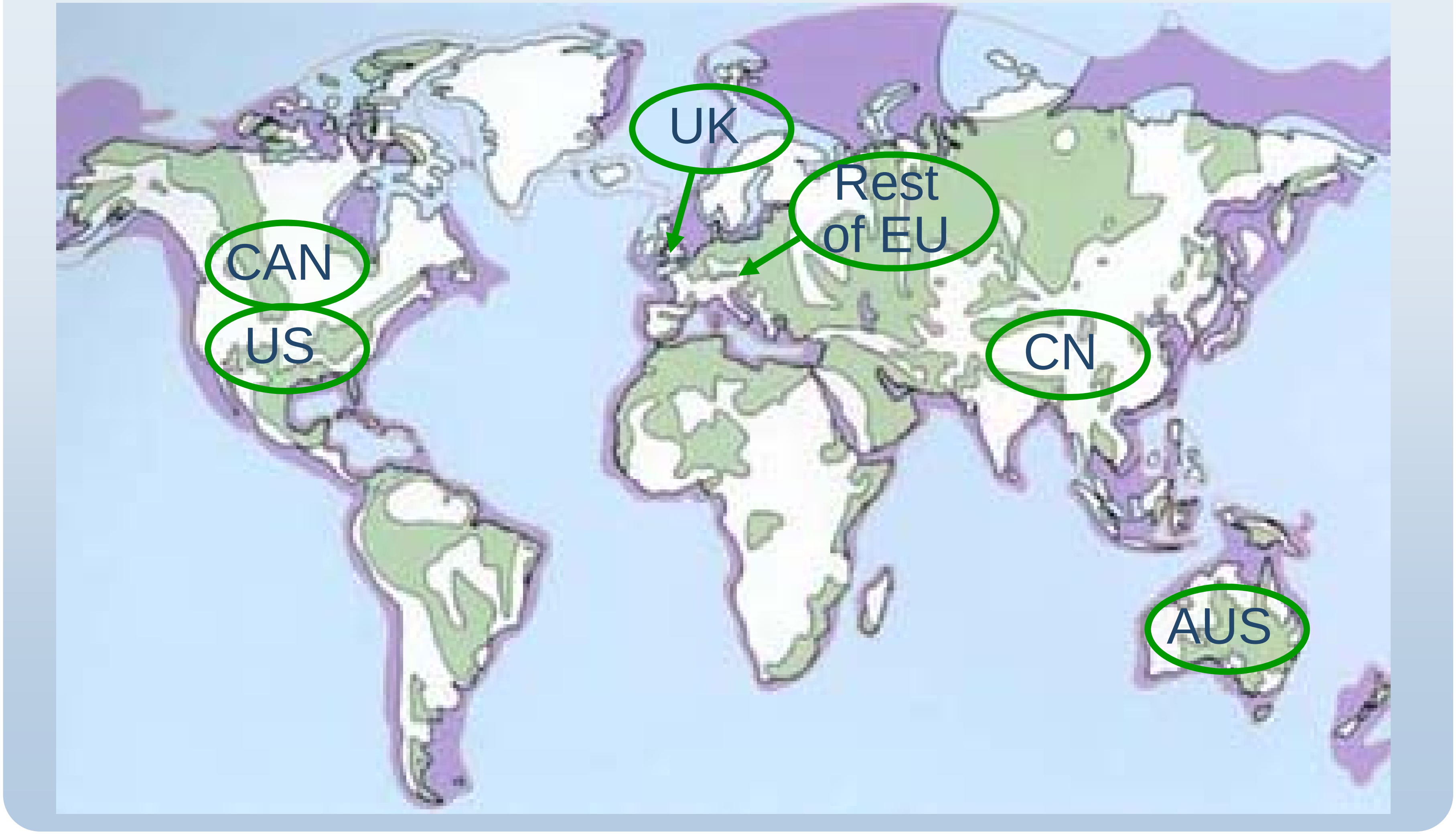
Source: New Energy Finance 2008

what is needed for a robust CCS investment environment?

1. sustainable demand for fossil fuels
2. set emissions standards/reduction goals
3. legislation/regulatory framework
4. progress toward commercial-scale project(s)
5. funding for projects and infrastructure

Source: New Energy Finance 2008

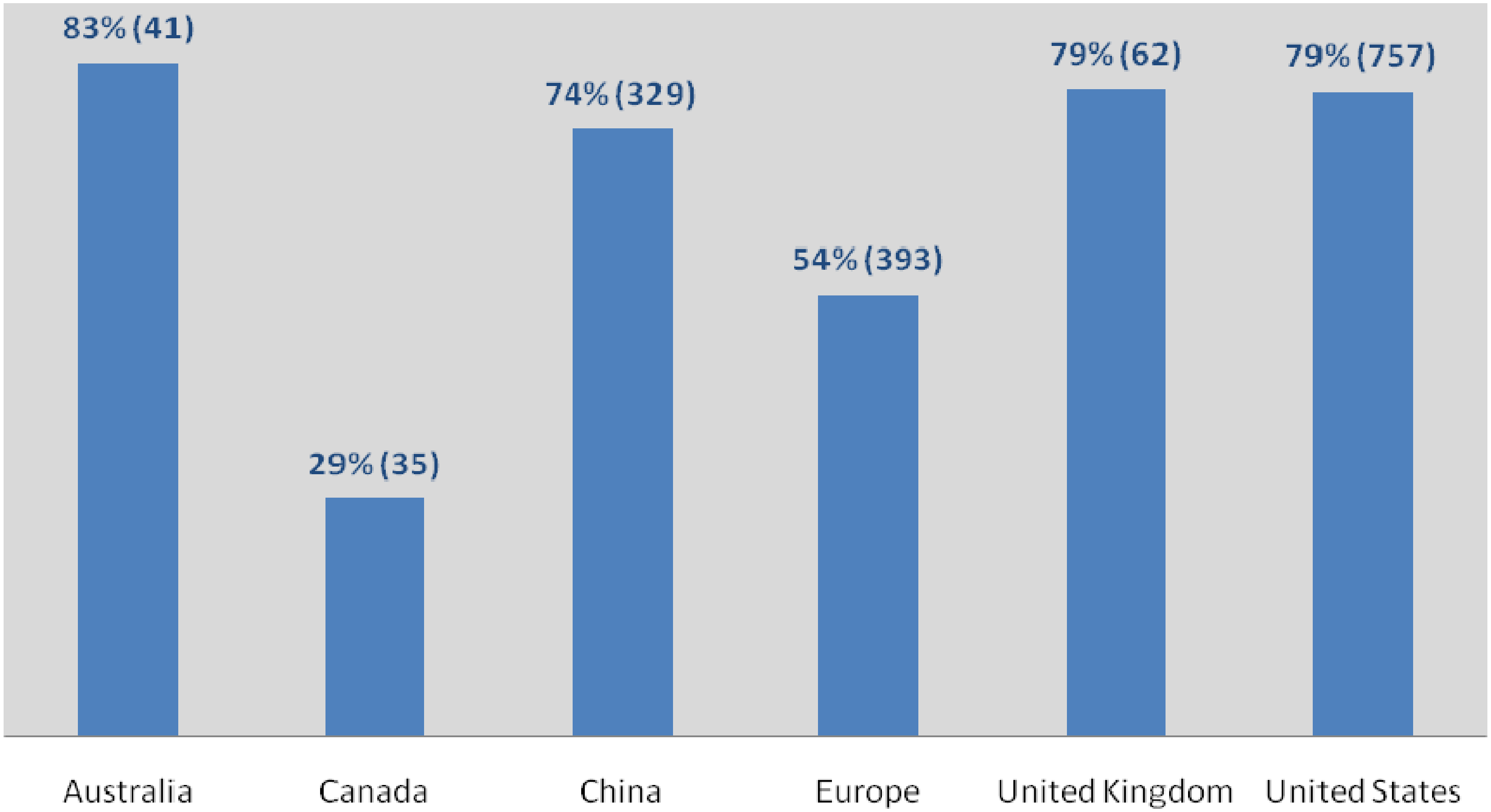
six likely candidate regions



Source: New Energy Finance 2008; Map: Schlumberger

new energy finance

sustainable demand for fossil fuels: % (GW), 2005 levels



Source: EIA, New Energy Finance 2008

new energy finance

emissions standards/reduction goals

- AU: signed Kyoto – 108% of 1990 levels between 2008-2012
- CA: signed Kyoto – 20% emissions reduction on 2006 levels by 2020
- CN: signed Kyoto – 20% emissions reduction on 2005 levels by 2010
- EU: signed Kyoto – 20% emissions reduction on 1990 levels by 2020
- UK: signed Kyoto – 20% emissions reduction on 1990 levels by 2020
- US: soft commitment to 18% emission intensity reduction

Source: New Energy Finance 2008

legislation/regulatory framework

- AU: $70m to establish ETS to begin in 2010 (cap & trade); draft legislation for CCS regulatory framework
- CA: Climate Change and Emissions Act, Regulatory Framework for Air Emissions
- CN: government initiatives
- EU: EU ETS; currently setting-up legal/regulatory framework
- UK: EU ETS; in talks to establish all-UK regulatory framework
- US: drafts at state level; bills hitting congress floor

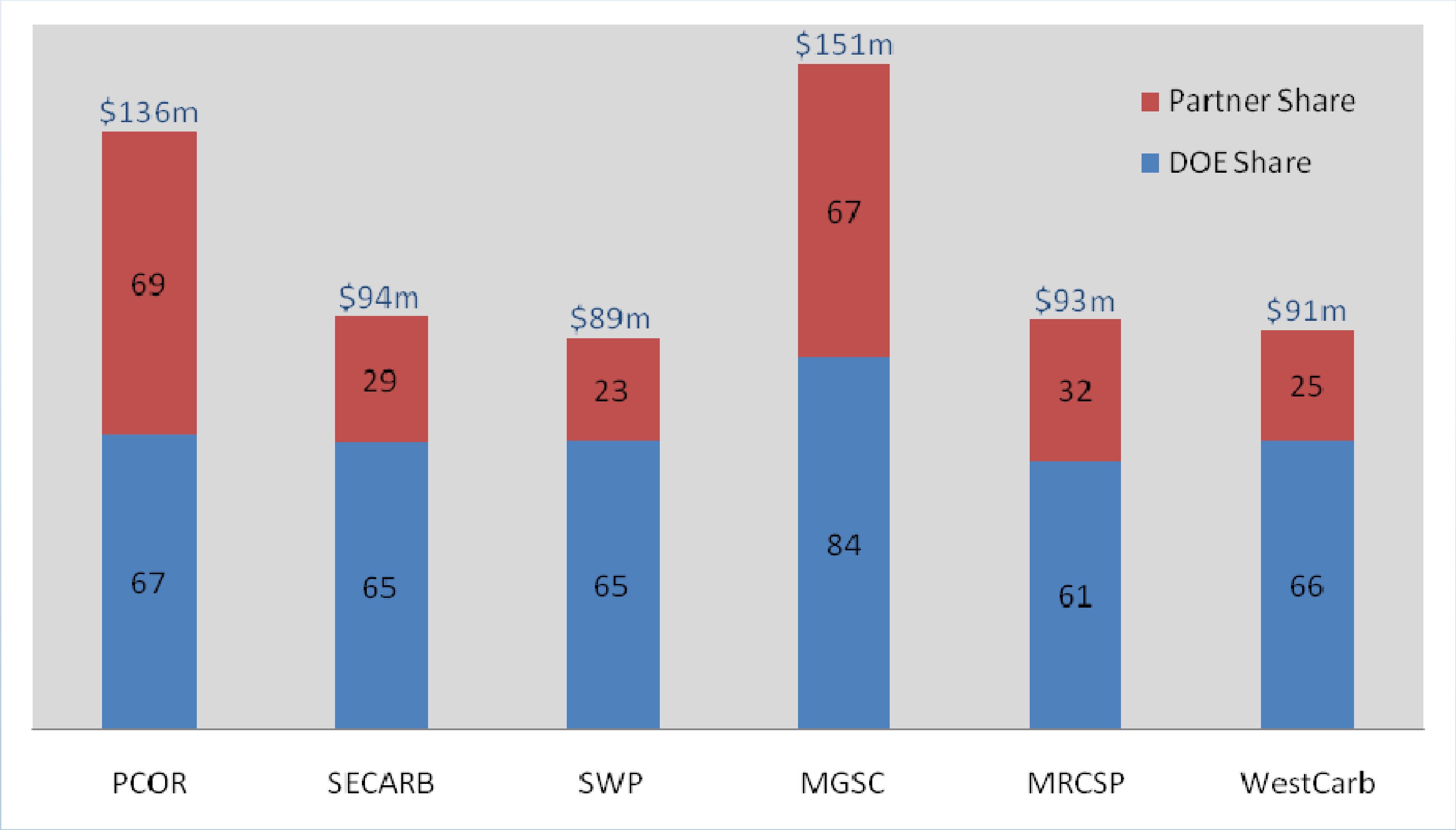
Source: New Energy Finance 2008

progress toward commercial-scale project(s)

- AU: ZeroGen Mark II
- CA: Belle Plaine, ASAP, Heartland
- CN: GreenGen
- EU: up to 12 demonstration plants commissioned by 2020 costing €6-10bn ($9.4-15.6bn)
- UK: government contest to fund up to 100% of CCS portion of commercial scale PCC plant
- US: seven large-scale research projects, and restructured FutureGen likely to bring more

Source: New Energy Finance 2008

projects funded mainly through public/private consortia



Source: New Energy Finance 2008

new energy finance

funding for projects and infrastructure

- AU: $2.3bn for climate change, territory funding
- CA: CAD250m from federal government in 2008, nothing from Alberta; Alberta formed CCS Development Council
- CN: GreenGen approved by two government agencies as ‘national high-tech industrialisation program’
- EU: revenues from EUAs; budgetary difficulties
- UK: government to pay for CCS portion of project; industry dissatisfaction
- US: $1.3bn in support to new projects (starting w/ $250m)

Source: New Energy Finance 2008

simplified summary

	Fossil Demand	Reduction Targets	Legislation	Projects	Funding
AU	+	+	+	+/-	+/-
CA	+	+	+/-	+	+/-
CN	+	+	+/-	+	+/-
EU	+	+	+	+/-	+/-
UK	+	+	+	+/-	+/-
US	+	+/-	-	+	+/-

Source: New Energy Finance 2008

Mark A. Taylor/associate/mark.taylor@newenergyfinance.com

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www.newenergyfinance.com

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CCS Alliance for Risk-based Policy

Risk Evaluation for Commercial Deployment of CCS

Innovative Approaches to Mobilize Financing for Early Plants

Presentation to IEA – WCI CCS Experts Group with IEA GHG R&D Program (New York)

Preliminary Risk Rating Results:
Coal-based Plants with CCS
May 28-29 2007

CONTACTS:
Fred Eames
Hunton & Williams
202-955-1500
Washington, DC
feames@hunton.com

Andrew D. Paterson
Econergy
202-822-4980 x311
Washington, DC
adpaterson@econergy.com

Dr. Maria Dubravka Pineda,
Research direction

econergy

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ECONERGY'S BUSINESS

OFFICES & PROJECTS

Consulting

- Access deal flow
- Provide intellectual capital to company and clients
- Support development of U.S. Strategy

Carbon Services

- Broker carbon credits in regulated and voluntary markets
- Carbon project identification and development support

CleanTech Fund

- Raising capital for small-scale generation projects in Latin America
- Invested in 3 projects

Renewable Power Production

- Build, own and operate an asset base of renewable energy projects
- Scope, opportunity and in-house expertise to become a leading developer of clean energy assets
- Wind & hydro in Latin America
- Biomass in U.S.

Raised $100M on London AIM in Feb. 2006

$25M in revenues for 2007, from $3M in 2005.

Baseline without Regulations on Carbon: 104 GW of coal added by 2030

EIA 2008 Projection: MORE fossil use by 2030 in N.America

EIA has reduced projections of natural gas use and raised forecasts for coal.

AEO 2008:
In the AEO2008 reference case, electricity generation from natural-gas-fired power plants increases sharply from 2006 to 2008 and then flattens for the next decade, growing by 3 percent from 2008 to 2016. After 2016 generation from new coal, nuclear, and renewable plants displaces some natural-gas-fired generation (Figure 7). In the AEO2008 reference case, 741 bkwhs of electricity is generated from natural gas in 2030, 21 percent less than the 937 bkwhs in 2030 in the AEO2007 reference case. Additions to coal-fired generating capacity in the AEO2008 reference case total 104 GW from 2006 to 2030.

Figure 1. Energy prices, 1980-2030 (2006 dollars per million Btu)

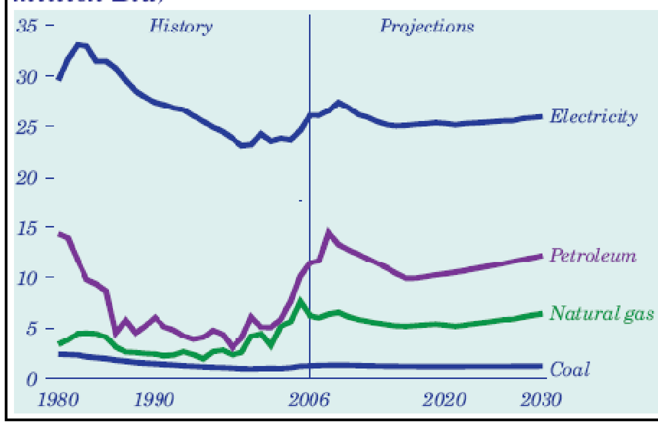


Figure 4. Electricity generation by fuel, 1970-2025 (billion kilowatthours)

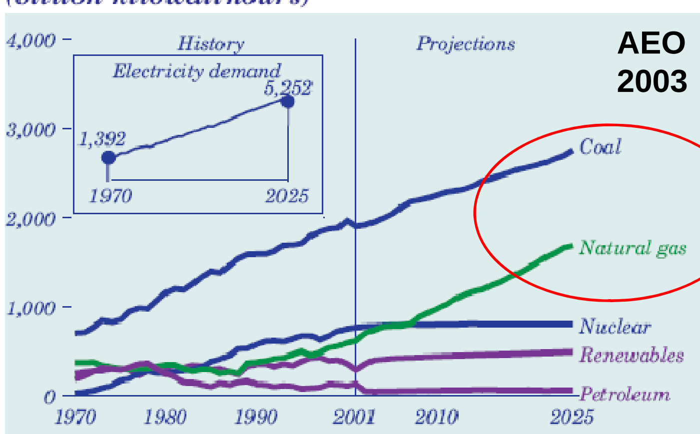
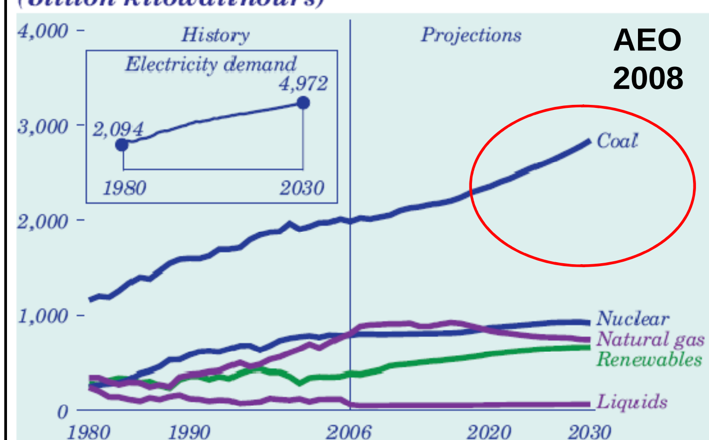
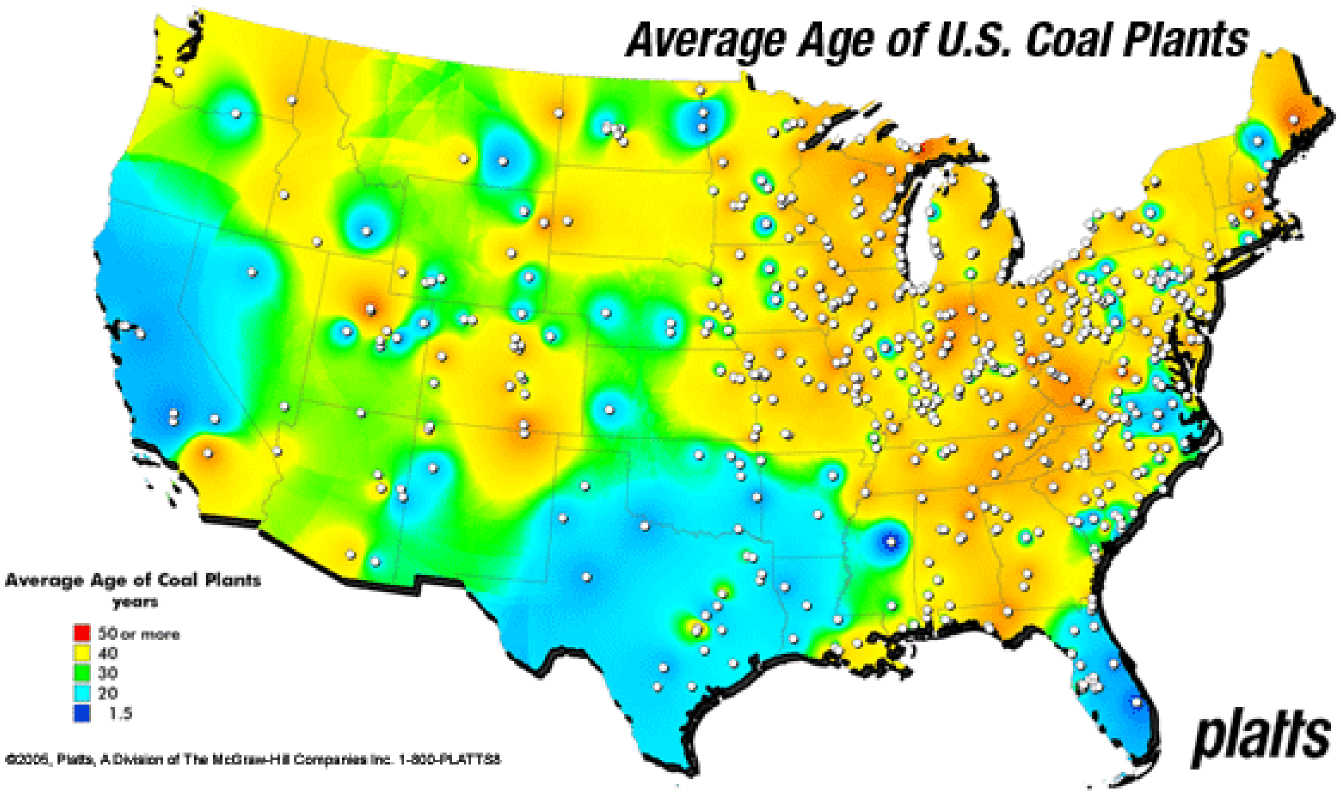


Figure 7. Electricity generation by fuel, 1980-2030 (billion kilowatthours)



Average Age of U.S. Coal Plants (320 GWe)

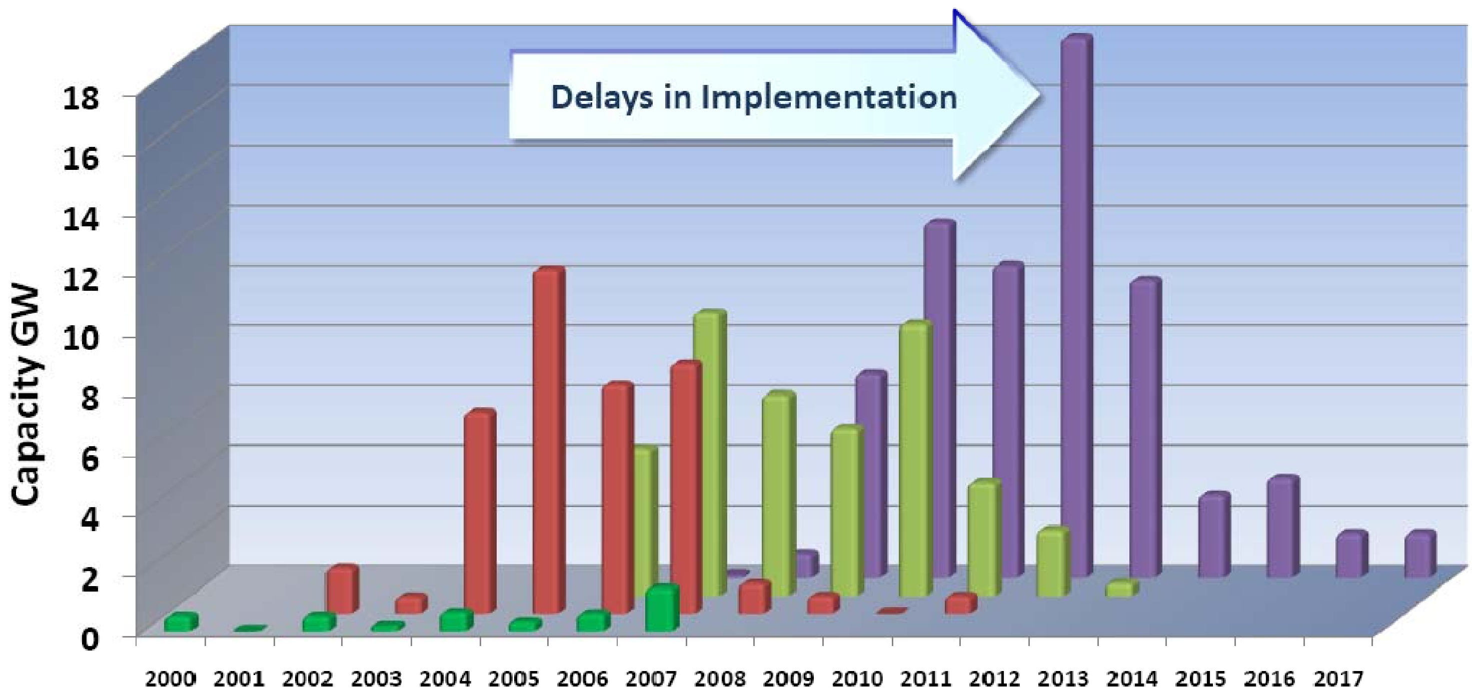


http://www.clean-coal.info/pubs/presentations/Hayes_Coal_PWC_11th_School_of_Mines_May1007.pdf

Planned Coal Plants Delayed

Past Capacity Announcements vs. Actual

Figure 1



Historically, actual capacity has been shown to be significantly less than proposed capacity. For example, the 2002 report listed 11,455 MW of proposed capacity for the year 2005 when actually only 329 MW were constructed.

Actual ■ 2002 Report ■ 2005 Report ■ October 2007

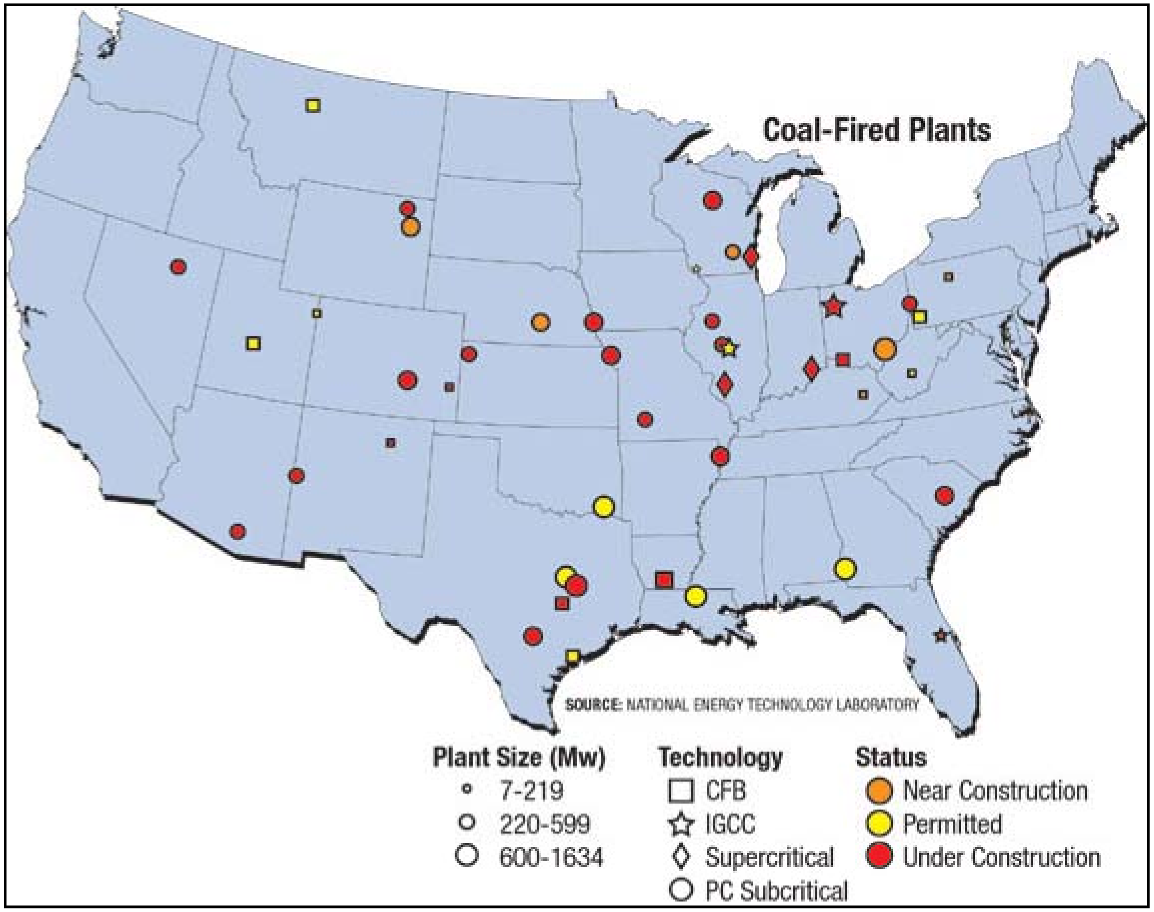
NETL

Source: 2007 data Global Energy Decisions – Velocity Suite
2002 – 2005 data – Previous NETL Tracking New Coal-Fired Power Plants Reports

OSAP 10/10/2007

ENR: Coal Plants Under Construction (Feb. 2008)

Despite numerous cancellations, some plants are underway, but CCS is seen as too costly.



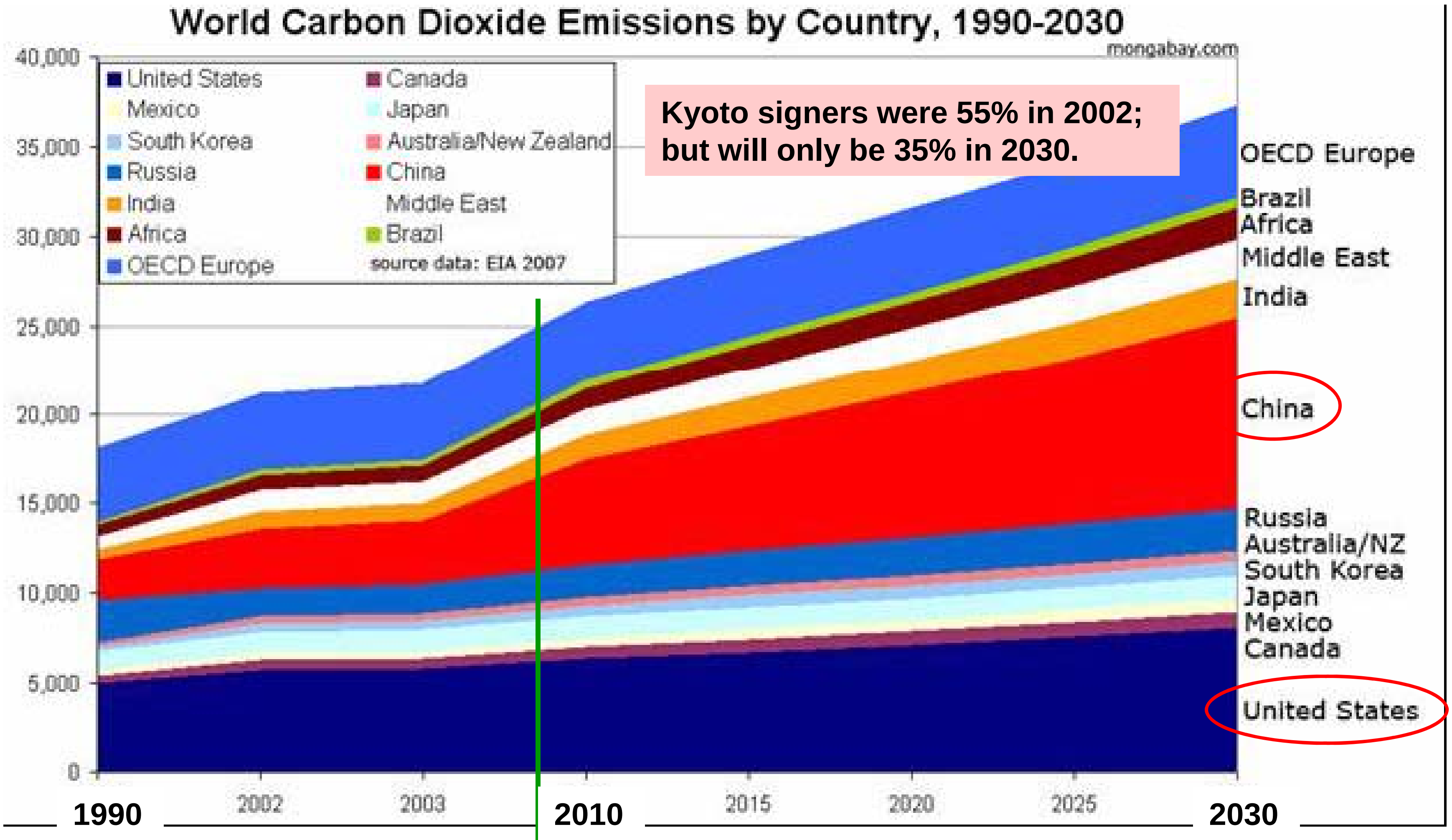
ENR (2/27/08):
"For construction contractors, the immediate situation is not dire. About 25 major coal projects totaling more than 15,000 MW now are under construction. Twenty other projects totaling more than 10,000 MW have secured most of their major permits and are poised to enter construction soon."

"Coal projects that are well under way include:
- CPS Energy's 750-MW J.K. Spruce Unit 2 in San Antonio, TX;
- Santee Cooper's 600-MW Cross Unit 4 in Cross, SC;
- Springfield (IL) City Water Light & Power's 200-MW Dallman Unit 4;
- East Kentucky Electric Cooperative's 278-MW Spurlock Unit 4 plant in Maysville, KY. "

http://enr.construction.com/features/powerIndus/2008/archives/htm/080227p1.asp

Projected CO2 Emissions, 1990 – 2030

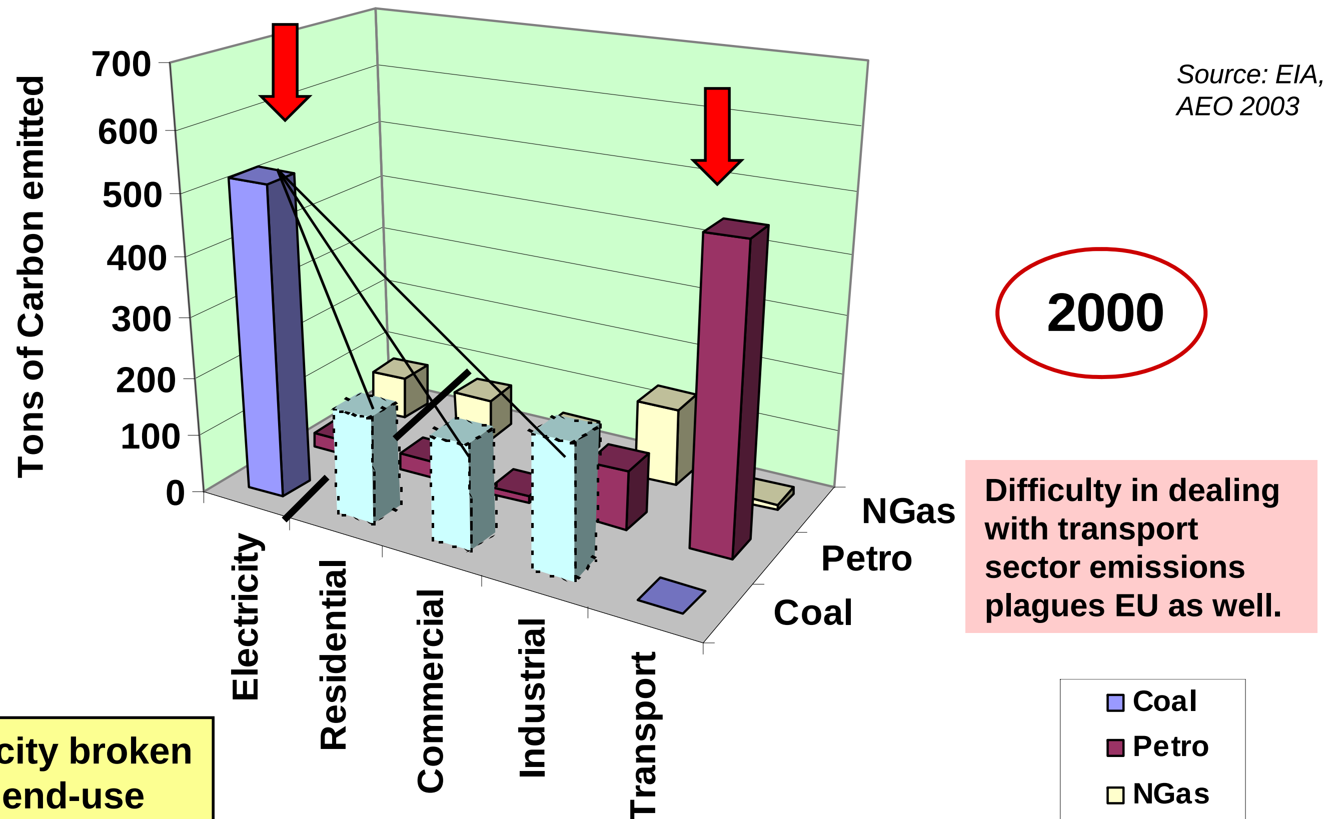
“Major Emitters” (Top 10) matter most. U.S.+China = 50% in 2030



“Where are the U.S. CO2 Emissions”

EIA Baseline: U.S. CO2 Emissions by Sector, 2000

Power sector drew early attention, but transportation is crucial also.



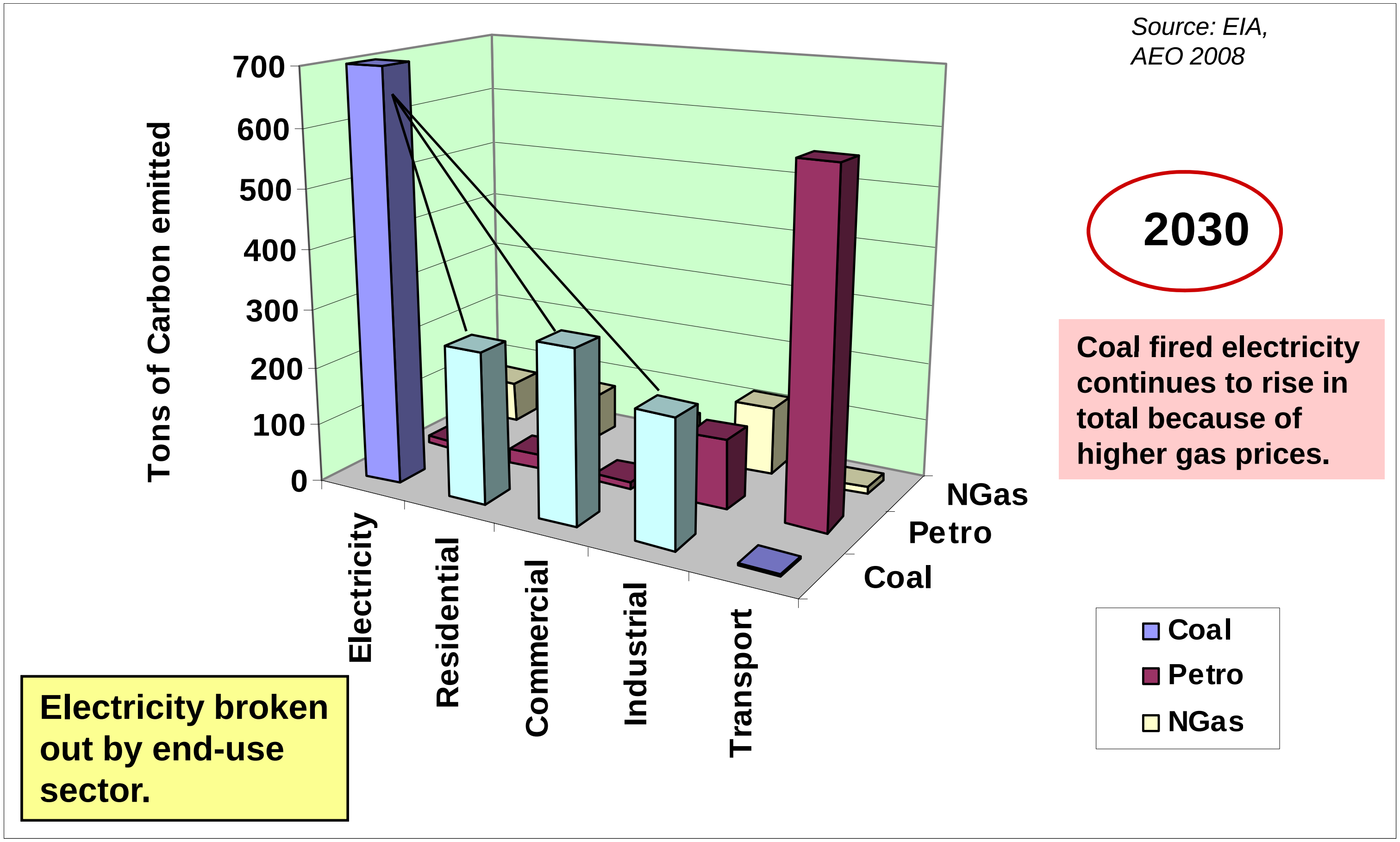
Difficulty in dealing with transport sector emissions plagues EU as well.

Electricity broken out by end-use sector.

“Where are the U.S. CO2 Emissions”

EIA: U.S. CO2 Emissions by Sector, 2030 est.

Absent a massive turnover in equipment, CO2 emissions keep rising.

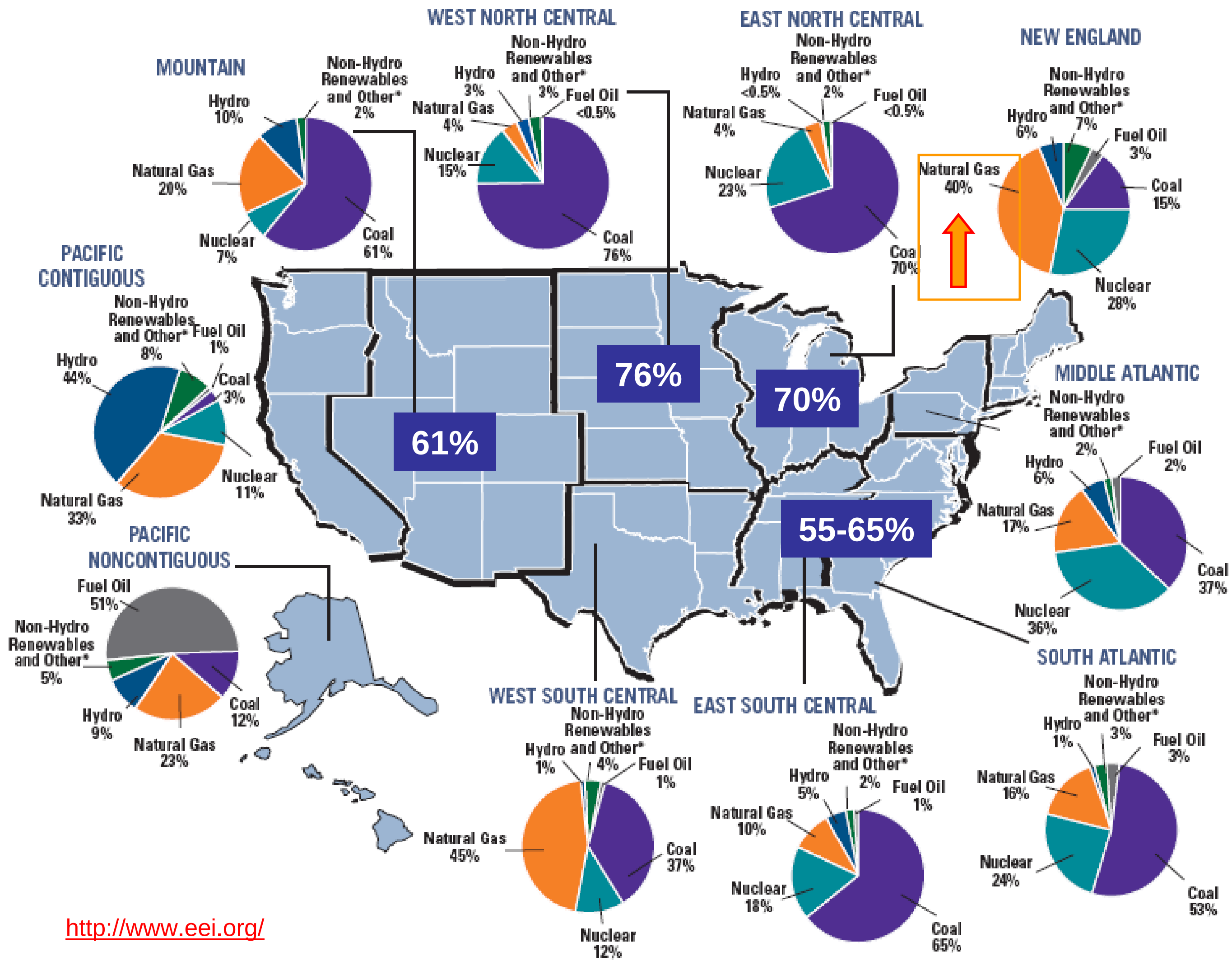


“Inconvenient” Challenges for North America…

1. ***Retail*** **electricity competition and merchant power mostly failed in the U.S., with major bankruptcies (PG&E, SCE)… and many states remain committed to rate regulation, especially for baseload.**
2. **Consumers don’t buy electricity based on price, anyway; it’s an essential good – and many utilities mask price signals.**
3. **New electricity supply is heavily constrained due to natural limits (wind, sunlight, resources) and regulations no matter the option.**
4. **EE and DSM are vital, but are not sufficient with growth… nor can they replace a lot of “old coal” units (>200,000 MWe).**
5. **U.S. regional differences in electricity fuel mix, prices, and access to renewable resources are <u>severe</u>. Several regions use coal for >60%.**
6. **“Urgent” cap and trade (2012, 2020) in the EU is a mixed bag: emissions are not lower, and other measures (feed-in tariffs, regulations, direct subsidies, local tax policy) are in the mix.**
7. **Because of a huge U.S. budget deficit and national debt, federal fiscal options are limited; <u>need risk-based incentives</u>.**

National averages mask very sharp regional differences

Differing Electricity Mix by Region (EEI), 2005



http://www.eei.org/

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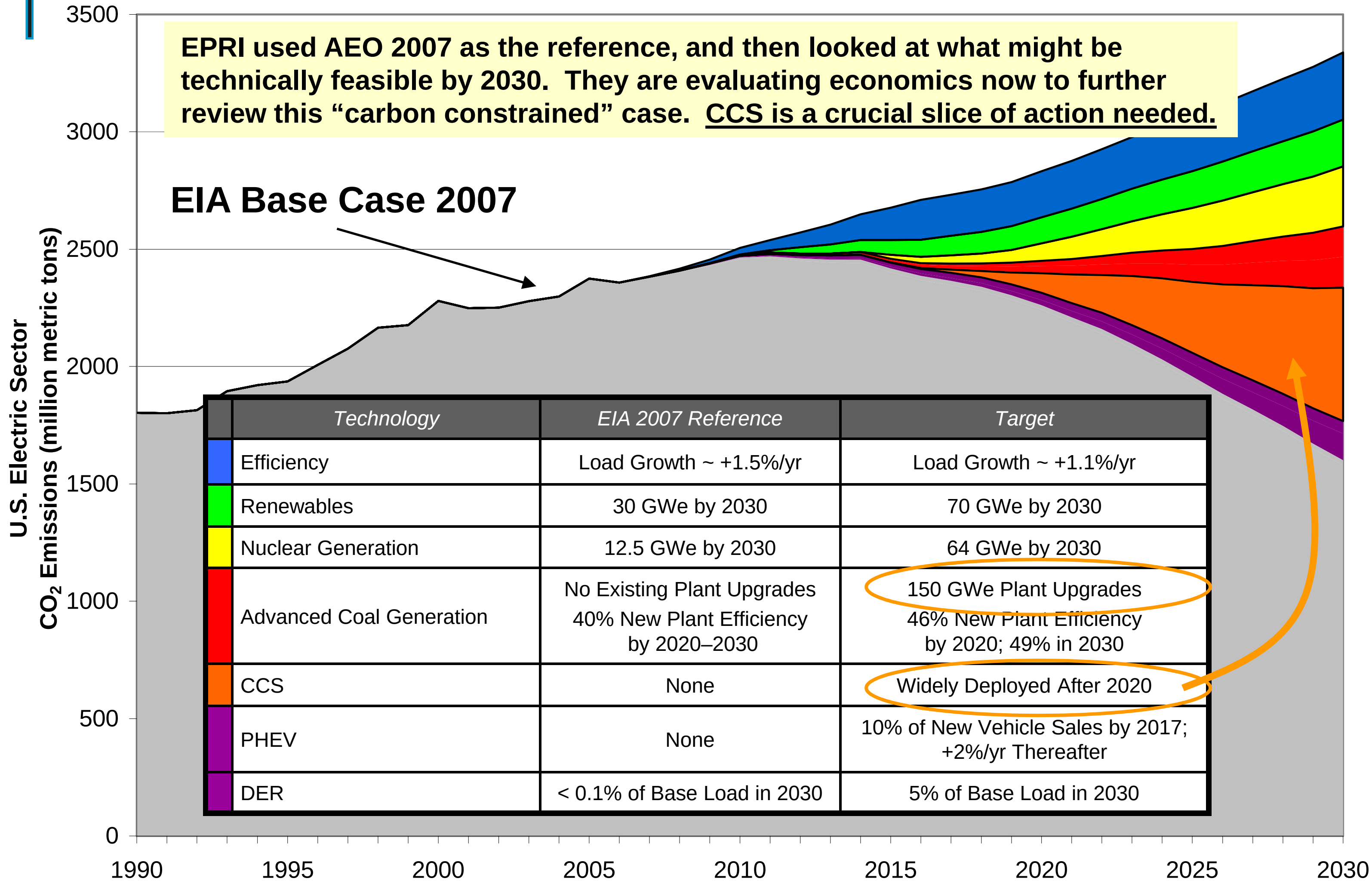
U.S. carbon emission reduction goals cannot be met without CCS

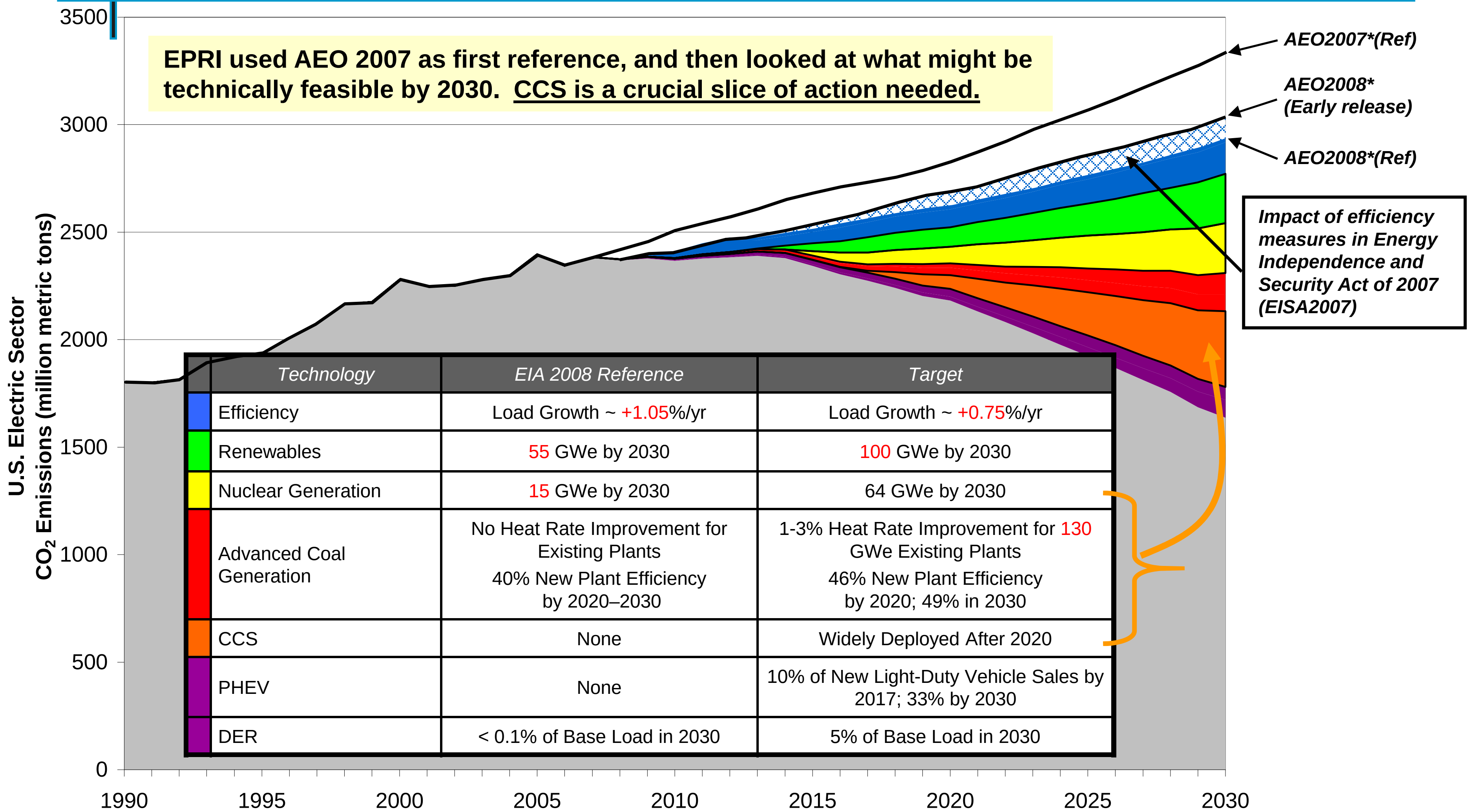
EPRI "Carbon Constrained" Scenario for Electricity



	Technology	EIA 2007 Reference	Target
(blue)	Efficiency	Load Growth ~ +1.5%/yr	Load Growth ~ +1.1%/yr
(green)	Renewables	30 GWe by 2030	70 GWe by 2030
(yellow)	Nuclear Generation	12.5 GWe by 2030	64 GWe by 2030
(red)	Advanced Coal Generation	No Existing Plant Upgrades 40% New Plant Efficiency by 2020–2030	150 GWe Plant Upgrades 46% New Plant Efficiency by 2020; 49% in 2030
(orange)	CCS	None	Widely Deployed After 2020
(purple)	PHEV	None	10% of New Vehicle Sales by 2017; +2%/yr Thereafter
(purple)	DER	< 0.1% of Base Load in 2030	5% of Base Load in 2030

** Achieving all targets is very aggressive, but potentially feasible.*

2008 Updated Prism...Technical Potential for CO_2 Reductions

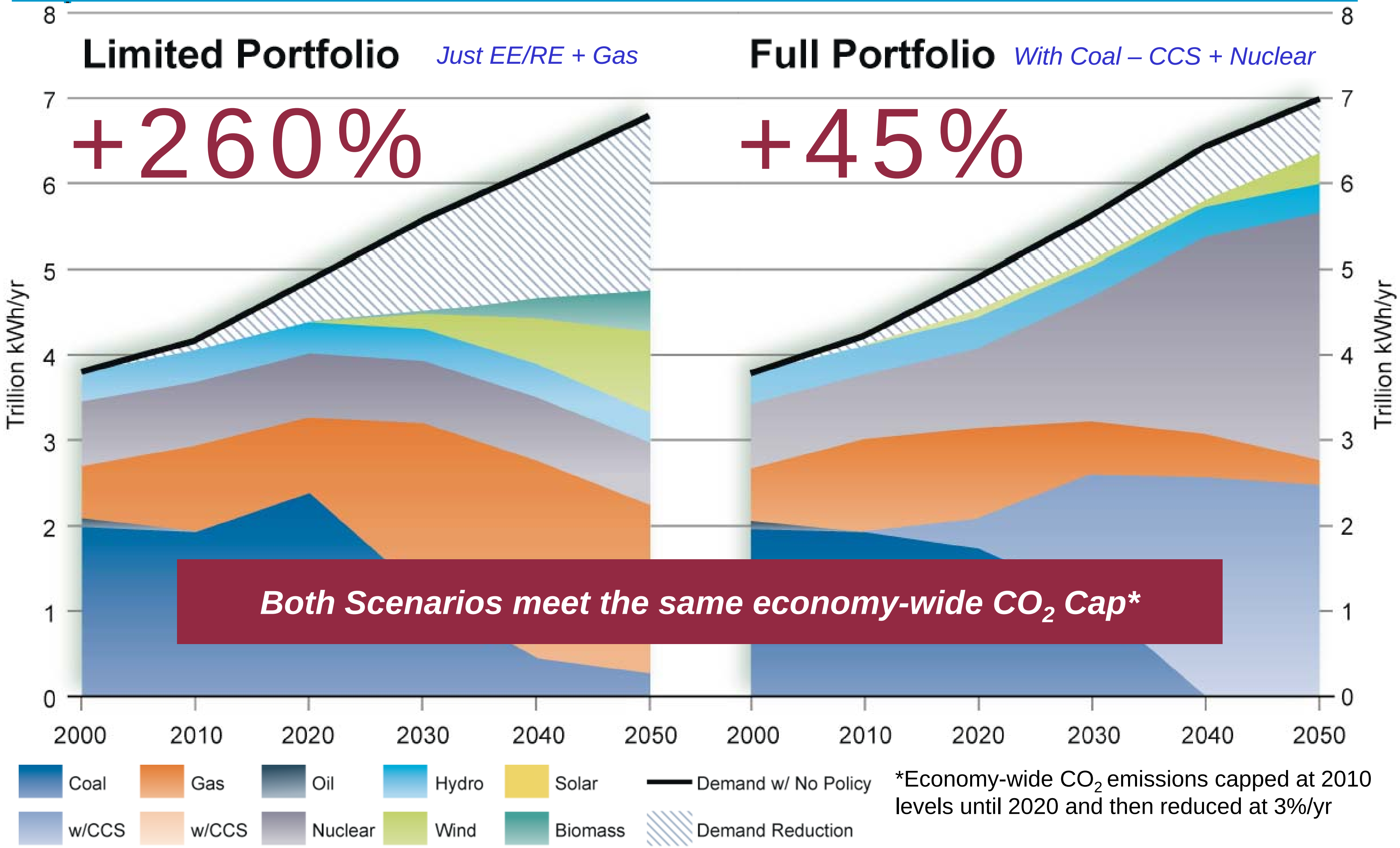


	Technology	EIA 2008 Reference	Target
	Efficiency	Load Growth ~ +1.05%/yr	Load Growth ~ +0.75%/yr
	Renewables	55 GWe by 2030	100 GWe by 2030
	Nuclear Generation	15 GWe by 2030	64 GWe by 2030
	Advanced Coal Generation	No Heat Rate Improvement for Existing Plants 40% New Plant Efficiency by 2020–2030	1-3% Heat Rate Improvement for 130 GWe Existing Plants 46% New Plant Efficiency by 2020; 49% in 2030
	CCS	None	Widely Deployed After 2020
	PHEV	None	10% of New Light-Duty Vehicle Sales by 2017; 33% by 2030
	DER	< 0.1% of Base Load in 2030	5% of Base Load in 2030

***Energy Information Administration (EIA) Annual Energy Outlook (AEO)**

Costs of natural gas and electricity ***without*** CCS will run much higher.

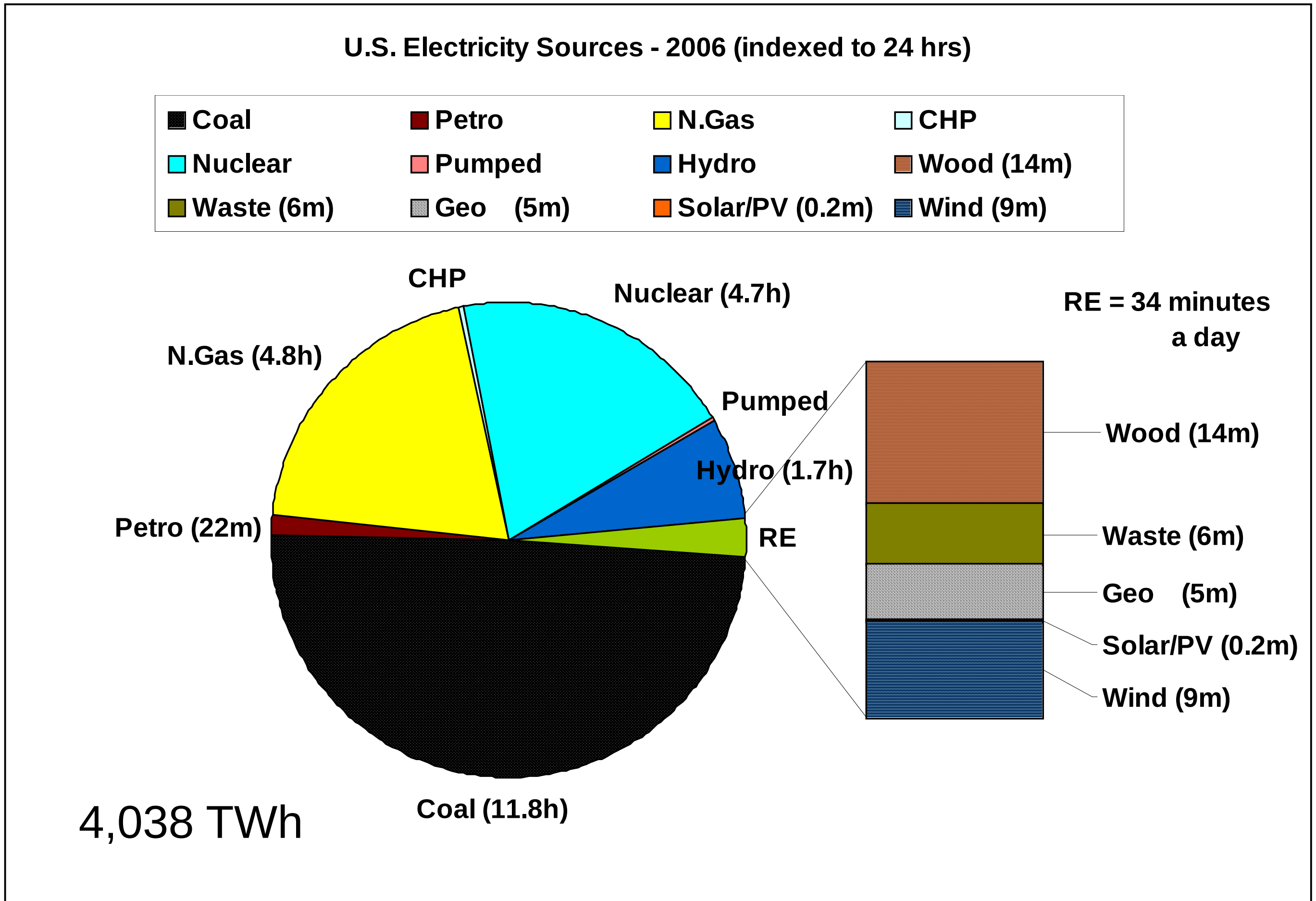
EPRI: Increase in Real Electricity Prices…(2000 to 2050)



*Economy-wide CO_2 emissions capped at 2010 levels until 2020 and then reduced at 3%/yr

U.S. Electricity Sources (2006) – *compressed to 24 hours*

Natural gas accounts for most growth since 1990; overall demand +33%
"Sure, we are more efficient… then we plug more stuff in or buy more."



At 34 minutes a day, Renewables (non-hydro) have a long way to go to replace coal (~12 hours a day). More likely, RE will curb carbon emissions some, and help diversify our fuel base further. Most importantly, <u>RE can help dampen gas price volatility</u>, and reduce some LNG imports.

Regional access to RE differs widely.

Biofuels cannot replace transport fuel rapidly.

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Drivers Differ in EU vs. USA… and how to engage Asia ?

EU is pushing an "urgent" cap:

- **They can't harmonize 27 national tax systems (social contracts)**
- **An "urgent" (2020) cap is a policy mandate that serves to maintain coalition parliamentary governments**
- **They want CDM as a means to channel funds to emerging nations**
- **They are shifting from coal to gas, with market pricing of electricity, rather than regulated pricing**
- **EU economies face demographic decline, and are stagnant – only 10 million added in EU per decade**
- **EU is casting energy security on Russian/FSU gas, and need to tax profits from fossil economy – with some interest in coal with CCS.**

USA can choose and engage Asia:

- **We have a common federal tax system (and active tax lawyers)**
- **State incentives can supplement and help tailor approaches**
- **U.S. will be at 50% coal for power, and China, India are using more coal**
- **USA and Asia are still growing ! But, U.S. growth is concentrated in "Red" states; …"Blue" states are older, colder and losing young people. N.America will add 40-50 million people per decade**
- **Asia leads in building new reactors and U.S. has big stake in nuclear for national security… and GHG gains**
- **Our future requires baseload *and* RE, including PHEVs (electrify transport), -- a "steady" cap geared to capital markets (2040) would be useful**

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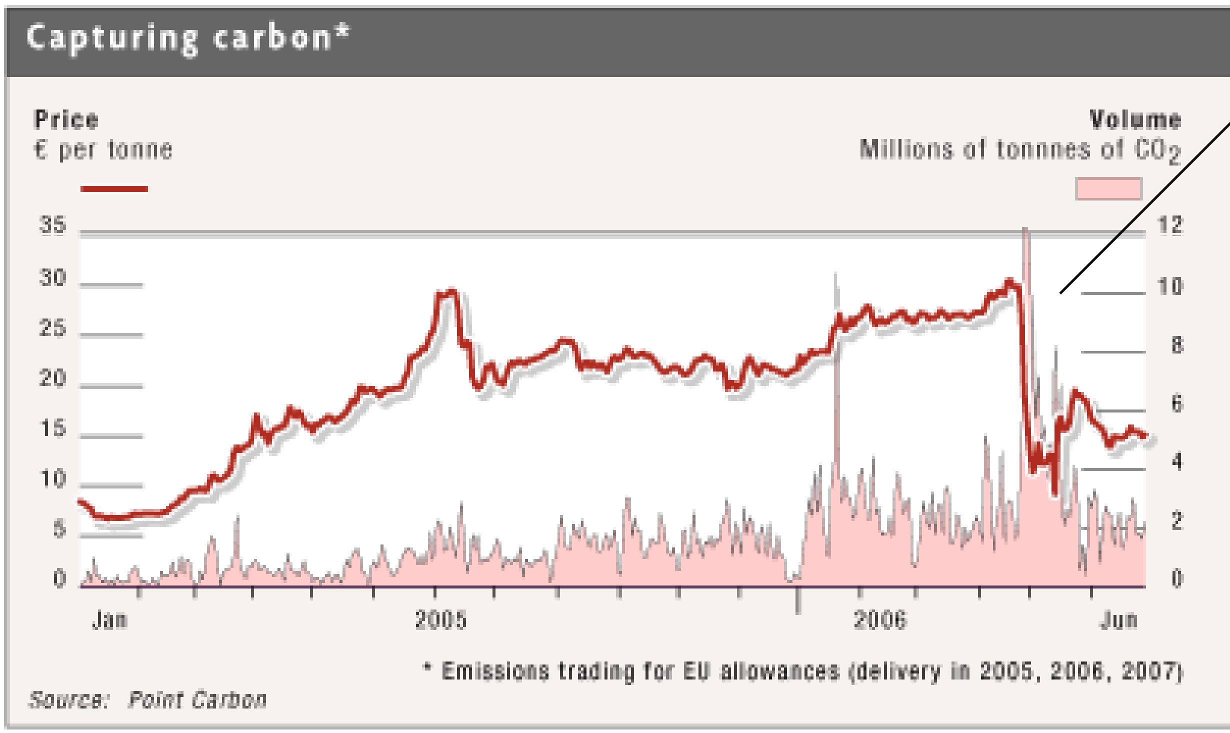
<u>Public sector "gaming"</u>

Turmoil in EU Carbon Market (May 2006)

Europe hopes to avert a false economy in carbon

By Fiona Harvey, June 28 2006 19:38 | *Financial Times of London*

"What came close to putting the scheme on life support was data released between late April and mid-May which showed that last year – the first the scheme had been in operation – businesses covered by it had been given more permits than they needed <u>because member states had overestimated demand</u>."



"The problem with <u>short term cap and trade (2020)</u> is that it does not give a *stable* price for carbon – price volatility makes it ***more*** difficult to attract lenders for new systems and innovative technology."

The next "credit" crisis: carbon credits ? (March 2008)

UK Regulator (FSA) Posts Risks on Carbon Trading

UK watchdog warns on carbon trading / March 2008
By Fiona Harvey and Ed Crooks
Published: March 31 2008 22:05 | *Financial Times of London*

The fast-growing market in carbon dioxide emissions poses risks that could threaten other commodities markets, the FSA, Financial Services Authority, warned on Monday. The watchdog said problems including investors being sold unsuitable products, confusion over the regulation of emissions traders, and insufficient official data created risks to both the fledgling global emissions markets and to related commodities such as gas and electricity.

EU traders in fossil fuels and electricity, for instance, factor carbon permit prices into their deals, which can hit consumers. "Cap and trade" systems, which place a limit on the amounts of carbon that companies produce, are widely seen as one of the most promising ways of curbing greenhouse gas emissions at the lowest cost, and have been embraced since 2005 by the EU. In the EU the market is regulated by the European Commission. The FSA does not have a direct hand in regulating the market, and said it had no plans to do so. But it said in a paper published on Monday that "the emissions markets justifiably demand the FSA's continued attention".

The emissions markets have been beset by difficulties, for example in 2006 when it was revealed that more carbon permits had been issued for the first phase of the EU's scheme than were needed. This led to a steep fall in the price of the permits. Among problems cited by the FSA is that some companies authorised for other financial markets may have misled customers by citing their FSA authorisation in relation to carbon trading. The paper warned: "Aside from being misleading and leading to potential enforcement action, this type of behaviour undermines confidence in the market." There was a strong reputational risk to the carbon market from unsuitable products being sold to investors, the FSA said.

U.K. FSA lists risks of carbon trading:
The Financial Services Authority does not govern the carbon market but the watchdog listed risks in a report on carbon regulation:

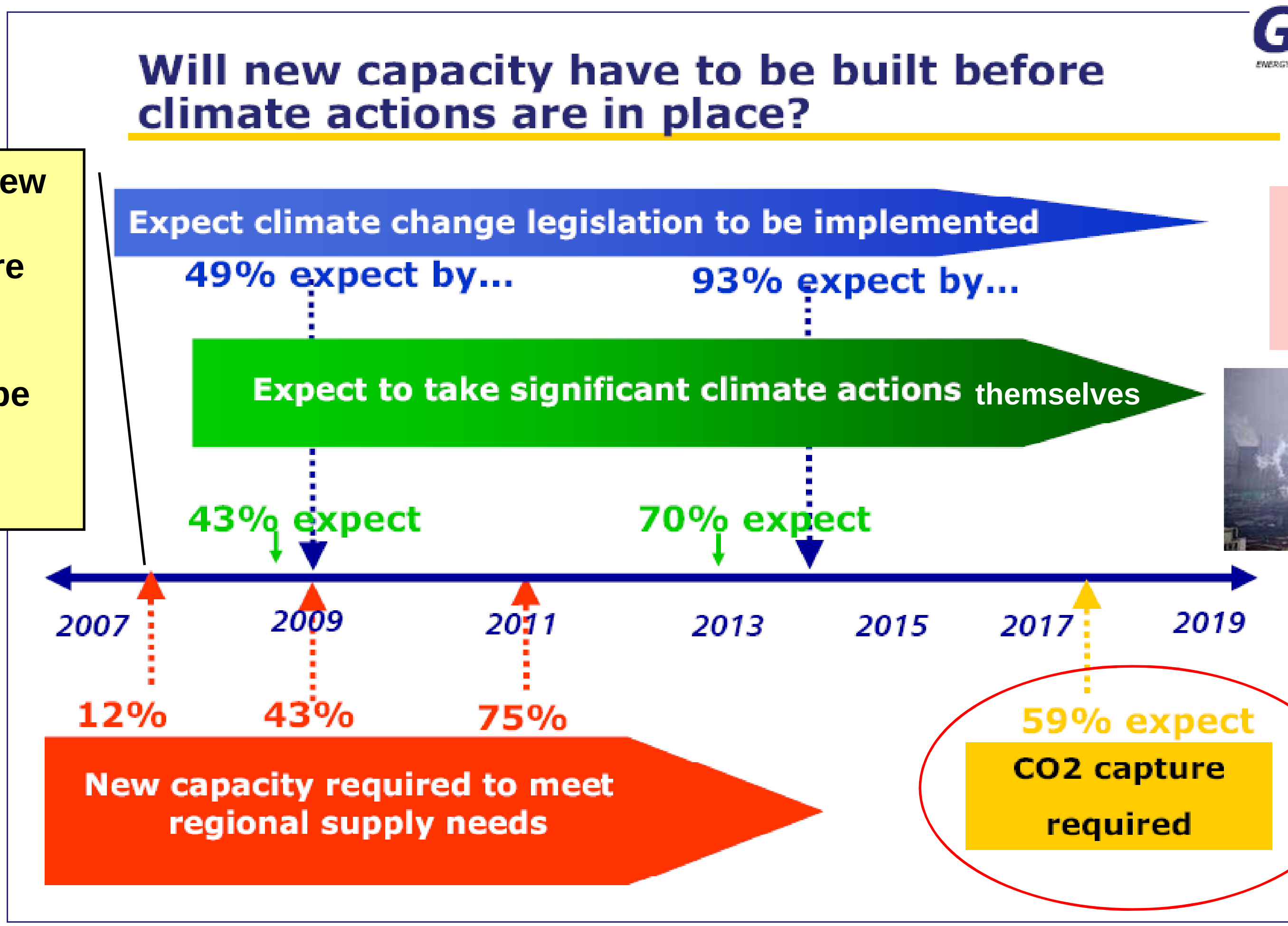
- The lack of links between emissions trading markets;
- Some companies authorised for other financial markets may have misled customers by citing FSA authorisation;
- Unsuitable products being sold to investors, which could "potentially lead to damage to consumers or to disorderly trading, and a lack of confidence in market";
- The potential lack of appropriate experience among practitioners;
- The quality of information available about emission quantities and allowances;
- The lack of market liquidity.

(also on p.A1 of WSJ, April 12, 2008)

http://www.ft.com/cms/s/b03dbc7a-06cf-11db-81d7-0000779e2340.html

Outlook on U.S. Carbon Policy Timing: Survey of Utility Execs (2007)

Challenge: New capacity is needed before federal legislation is expected to be resolved and litigated.



How do we avoid "high carbon lock in" globally ?

Source: Survey by GF Energy of Utility Executives in North America, April 2007

Opportunities & Challenges for CCS

- Opportunities for CCS in New Baseload
- We need to build new baseload to meet new demand, retire "high carbon" units
- Natural gas price volatility and prices provide an opening to build alternatives
- *"Plenty o' capital"* is available and can be mobilized if risks are addressed

- Challenges
- *Long-term* CCS remains unproven; large scale demos, RD&D needed
- Geological feasibility, transport affects plant siting and technical designs
- Uncertainty over CCS liability later must be addressed to arrange financing now…

- Approach
- Risks can be delineated, addressed based on experience and insurance models
- Utilize carbon offsets and state incentives to bolster mitigation mechanisms
- Price signals to the CAPITAL markets are more important than to consumers

- Key Threats
- Consumers and PUCs don't want to pay more, and vote against higher rates
- Regional differences and lack of political will run high – consensus is elusive

Lehman Brothers Roundtable at NARUC (Nov. 2007), “A Day at the Bond Market”

Bond Market Roundtable on Energy & CCS

$2 Trillion under management

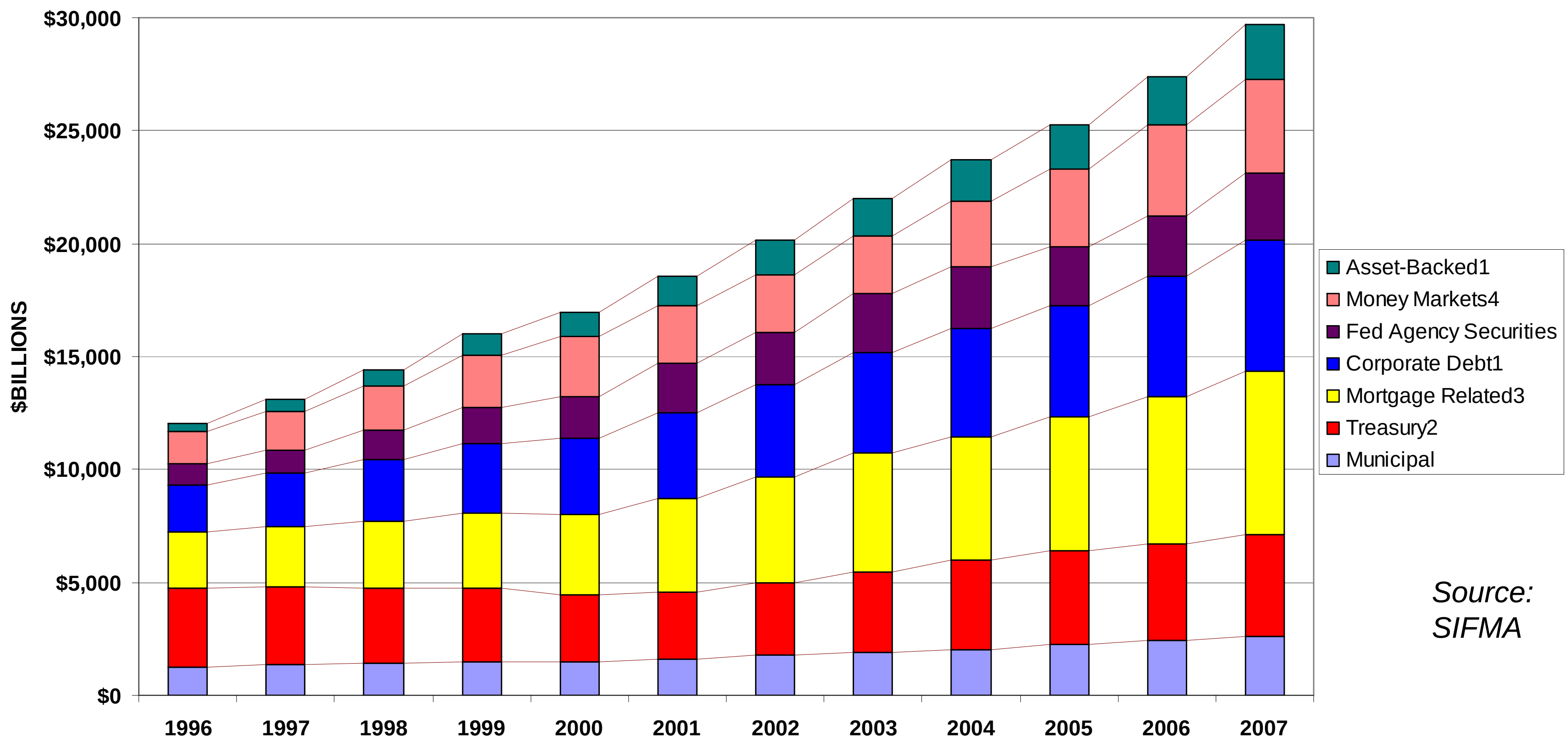
Roundtable participants: Doug Cortez, formerly with Fluor Engineering; Dan Ford, Lehman Brothers; Jim Hempstead, Moody’s; Sandy Hochstetter, Arkansas Electric Coop; Lindene Patton, Zurich America; Barbara Tyran, EPRI; Klaus Lambeck, Ohio Public Utilities Commission staff; Mike Smith, Southern States Energy Board; Julie Jorgensen, Excelsior Energy; Faith Klaus, Lehman Brothers. With 32 bond fund managers. Moderator: Andrew Paterson, Econergy

How big is the U.S. Bond Market (1996 – 2007) ?

U.S. Bond Market: Big Enough at $30 Trillion

Energy infrastructure is financed in bond market, which sees $6-7T a year in new bond issuance, about $80-100B for power providers.

U.S. Bond Market Debt Levels (Market Size)



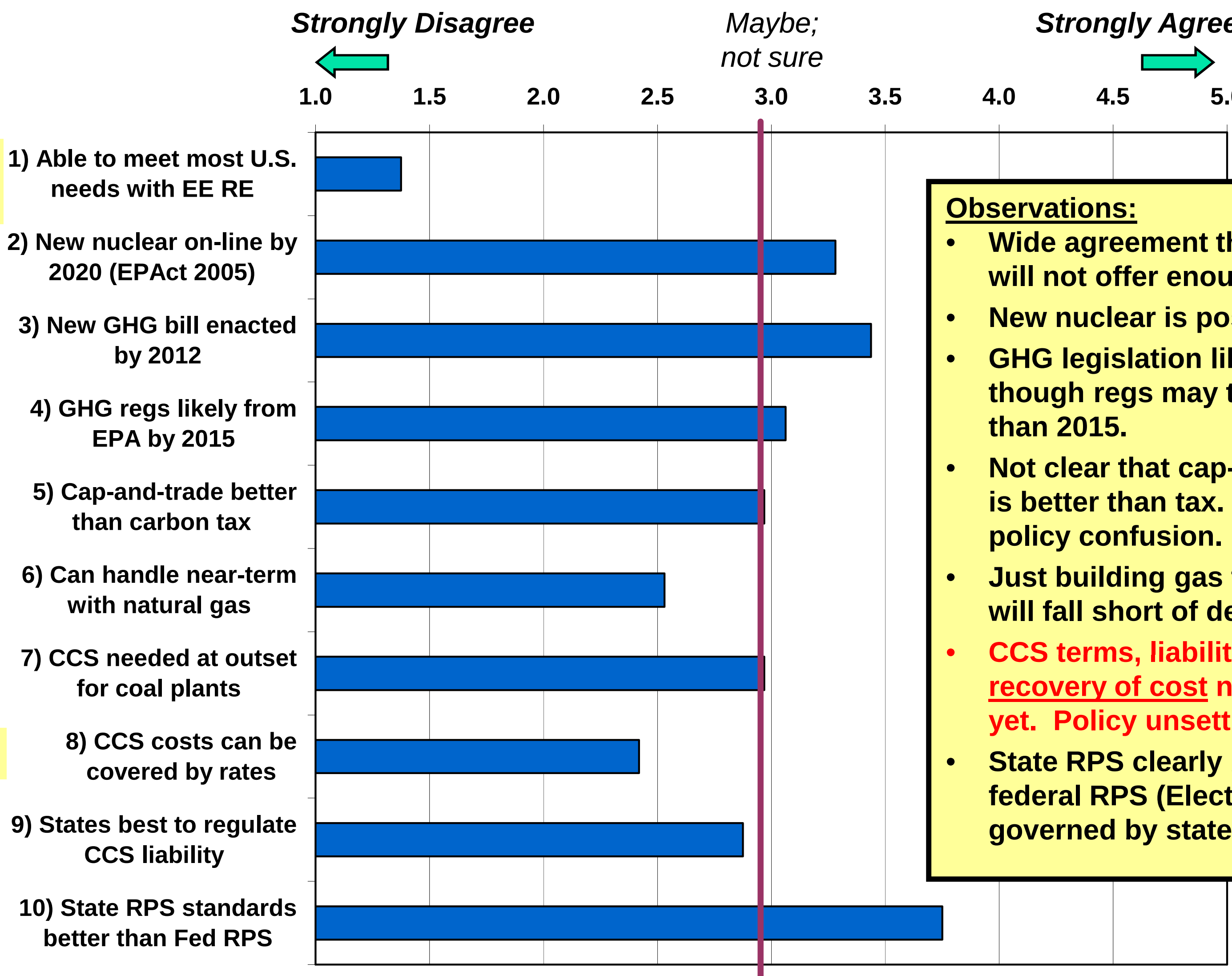
Source: SIFMA

Bond Fund Viewpoints (32 responses; > $2 Trillion under management)

Bond Market on Energy Policy *(Lehman Roundtable at NARUC, Nov 2007)*

Least variance ➔ (high agreement)

Most variance ➔



Observations:

- **Wide agreement that EE / RE will not offer enough.**
- **New nuclear is possible.**
- **GHG legislation likely, though regs may take longer than 2015.**
- **Not clear that cap-and-trade is better than tax. Lot of policy confusion.**
- **Just building gas turbines will fall short of demand.**
- **CCS terms, liability, and recovery of cost not clear yet. Policy unsettled.**
- **State RPS clearly better than federal RPS (Electric rates governed by states).**

CCS Alliance for Risk-based Policy

For Deployment of Coal-based Projects with CCS

Risks ➔ Mitigation Approaches ➔ Actions Needed

CCS Alliance Scope:

I) Risk Study for CCS Deployment (coal power plants or energy projects with CCS)

II) Legal research on critical issues, risks and formulation of mitigation options

A) Risk Analysis

Risk Type	**Key Risks**
1) Tech-CCS	Capital cost with CCS too high
2) Reg-CCS	State rules on CCS not clear
3) …	
4) …	

Analysis based on Interviews of key actors:
(results of Risk Study)

		Preliminary (21 respondents)			
		Risk Ratings (2008) for	P	I	P x I = S
Q #	Q Type	**Coal Gen with CCS**	**Probability**	**Impact**	**Severity**
			5 pt. max	**5 pt. max**	**25 pt. max**
13	Reg - CCS	Uncertain EPA carbon regs	4.2	4.1	**17.4**
7	Tech - CCS	Capital costs on CCS high	4.0	4.3	**17.1**
18	Reg	Nat'l subsidies lag on plants	3.8	4.1	**15.6**
17	Reg - CCS	State regs on CCS not clear	3.8	4.0	**15.2**
19	Reg - CCS	Nat'l incentives for CCS lacking	3.9	3.9	**14.9**
15	Reg	CO2 allowances don't fund CCS	3.6	4.0	**14.5**
28	Market	Finance difficult (equity, terms)	3.5	4.0	**13.9**
31	Market-CCS	EPA regs unclear on CCS	3.4	4.1	**13.8**
34	Market-CCS	CCS liability threatens financing	3.2	4.2	**13.7**
33	Market-CCS	EOR revenue inadequate for CCS	3.9	3.4	**13.2**
16	Reg	Regional support lags on plants	3.4	3.7	**12.6**
27	Market-CCS	Market/PUC rates low for CCS	3.2	3.9	**12.5**
14	Reg - CCS	Future carbon limits tighter	2.8	4.2	11.8
4	Tech	High cost of basic materials	3.3	3.6	11.7
1	Tech	High capital cost (w/o CCS)	3.1	3.8	11.6
		Overall Average	**2.9**	**3.6**	**10.5**
12	Reg	State air permitting delays	3.0	3.3	10.2
10	Tech - CCS	"Thin" EPC system warranty	3.1	3.1	9.6
8	Tech - CCS	CCS equipment downtime	2.4	3.8	9.1
20	Reg	Water use regs tightened	2.8	3.3	9.1
26	Market	Interest rates rise (to 2012)	2.6	3.5	9.1
5	Tech	Constrained EPC capacity	2.9	3.2	9.0

B) Mitigation Mechanisms

Government

- Loan guarantees
- Grants (DOE, etc.)
- Tax subsidies
- Injection regulations
- Permitting approaches
- Carbon emission rules
- Federal "Energy Bank"
- Revolving loans

Industry / Investors

- Insurance / bonding
- Engineering backups
- Long-term contracts
- Site review, feasibility
- Collateral, backup supply

C) Government Actions needed for Mitigation

(Match actions with mechanisms)

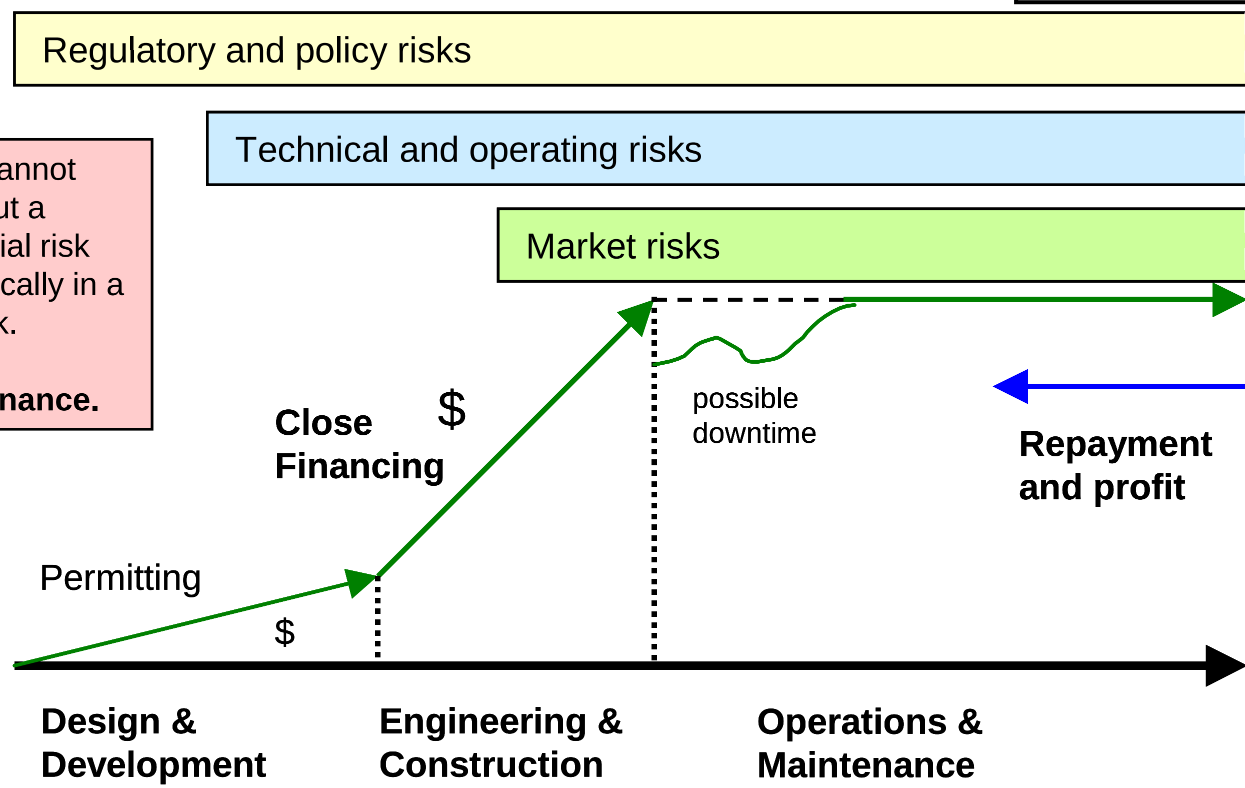
Near-term / Long-term

- Appropriations
- Legislation
- Tax bill
- Regulation
- Agency action
- Executive order (?)
- Reserves (e.g., SPRO)
- Others ?

For Deployment of Coal-based Projects with CCS

Approach to Commercial Risk Framework

Energy Project Development Timeline → **Risk Analysis of Project Development Stages** → **Rating and Ranking of Risks by Stages** → **Evaluation, Application of Risk Mitigation Mechanisms**



Coal projects with CCS cannot complete financing without a comprehensive commercial risk analysis by creditors, typically in a project finance framework.

Deployment = project finance.

Source: Scully Capital

Plot of Risks Based on their Attributes (Likelihood, Severity of Impact)

Negotiating space for public and private sectors

Lower Likelihood
Higher Impact

Accidents

(Plant fires, or spikes in feedstock costs or a gas price slump with loss of competitiveness)

High Likelihood
High Impact

"Show-Stoppers"

(e.g., high capital costs with CCS, or lack of clarity about carbon regs)

Probability of Event

Impact if Event Occurs

Low Likelihood
Low Impact

Marketing and Operations

(Workforce issues, coal transport, transmission congestion, etc.)

Higher Likelihood
Lower Impact

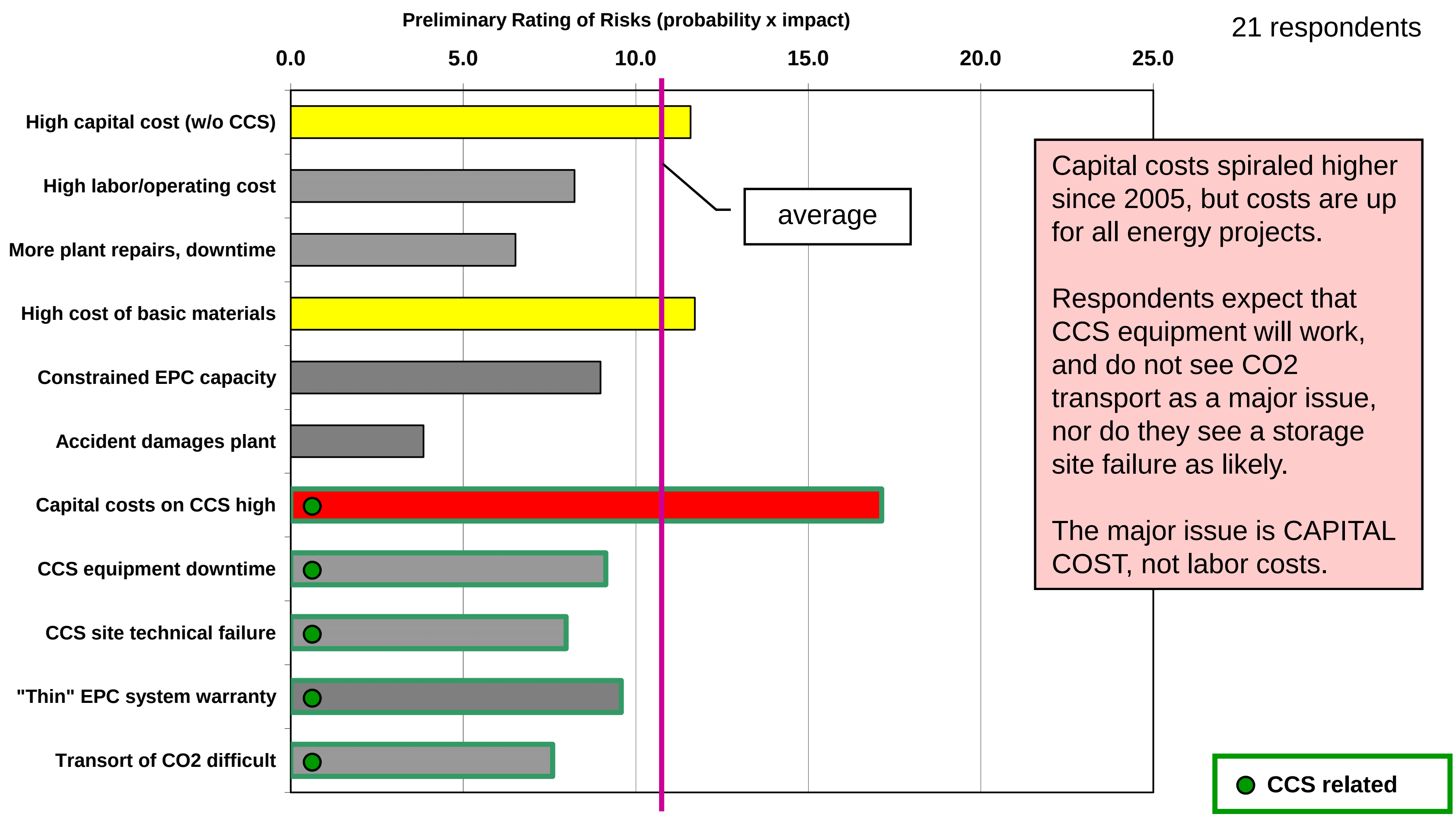
Externalities (e.g., pollution)

Or lax enforcement, lack of standards

Risk Ratings: TECHNICAL

Deploying CCS creates a large drain on plant production, so capital costs run much higher.

21 respondents

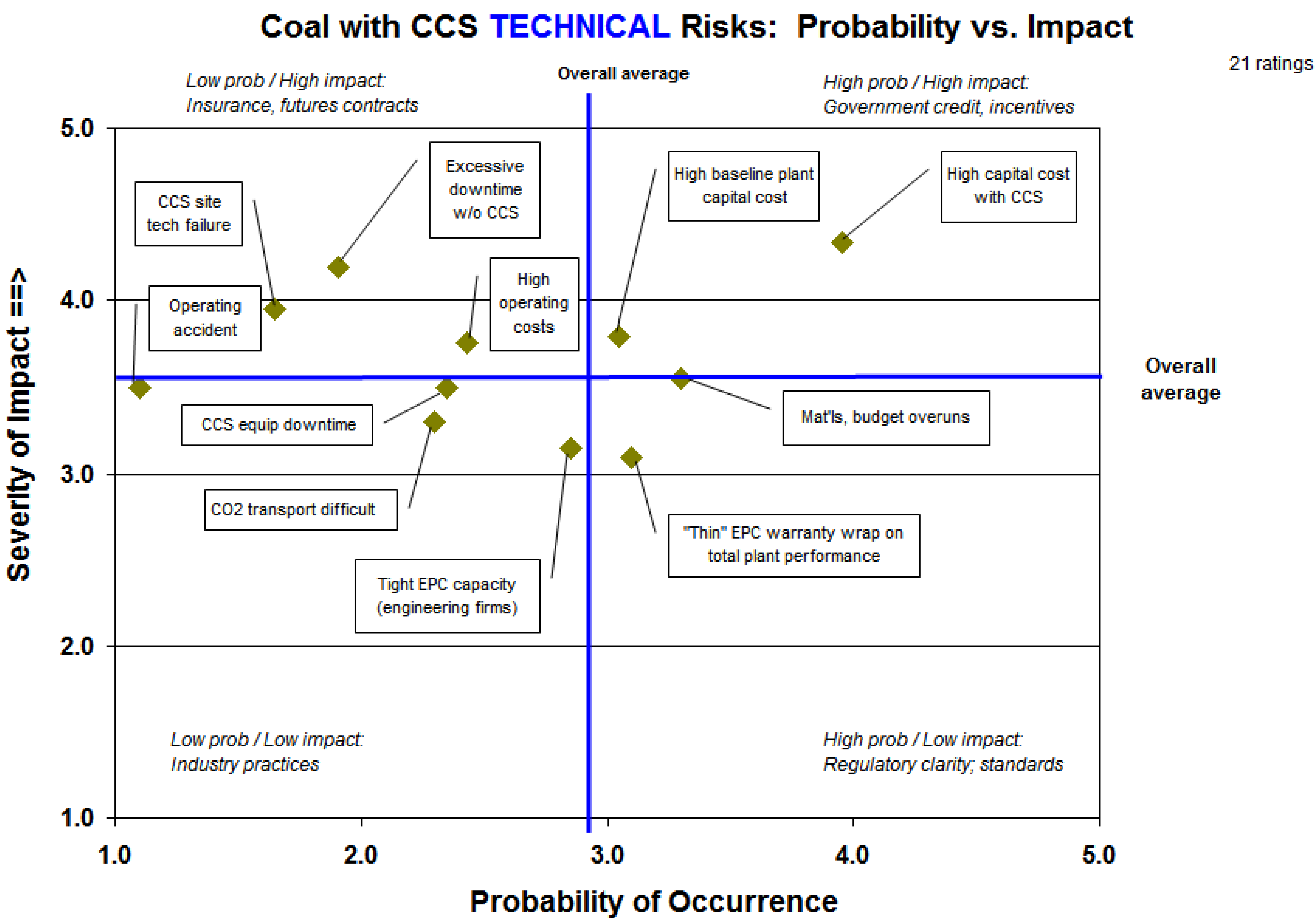


Capital costs spiraled higher since 2005, but costs are up for all energy projects.

Respondents expect that CCS equipment will work, and do not see CO2 transport as a major issue, nor do they see a storage site failure as likely.

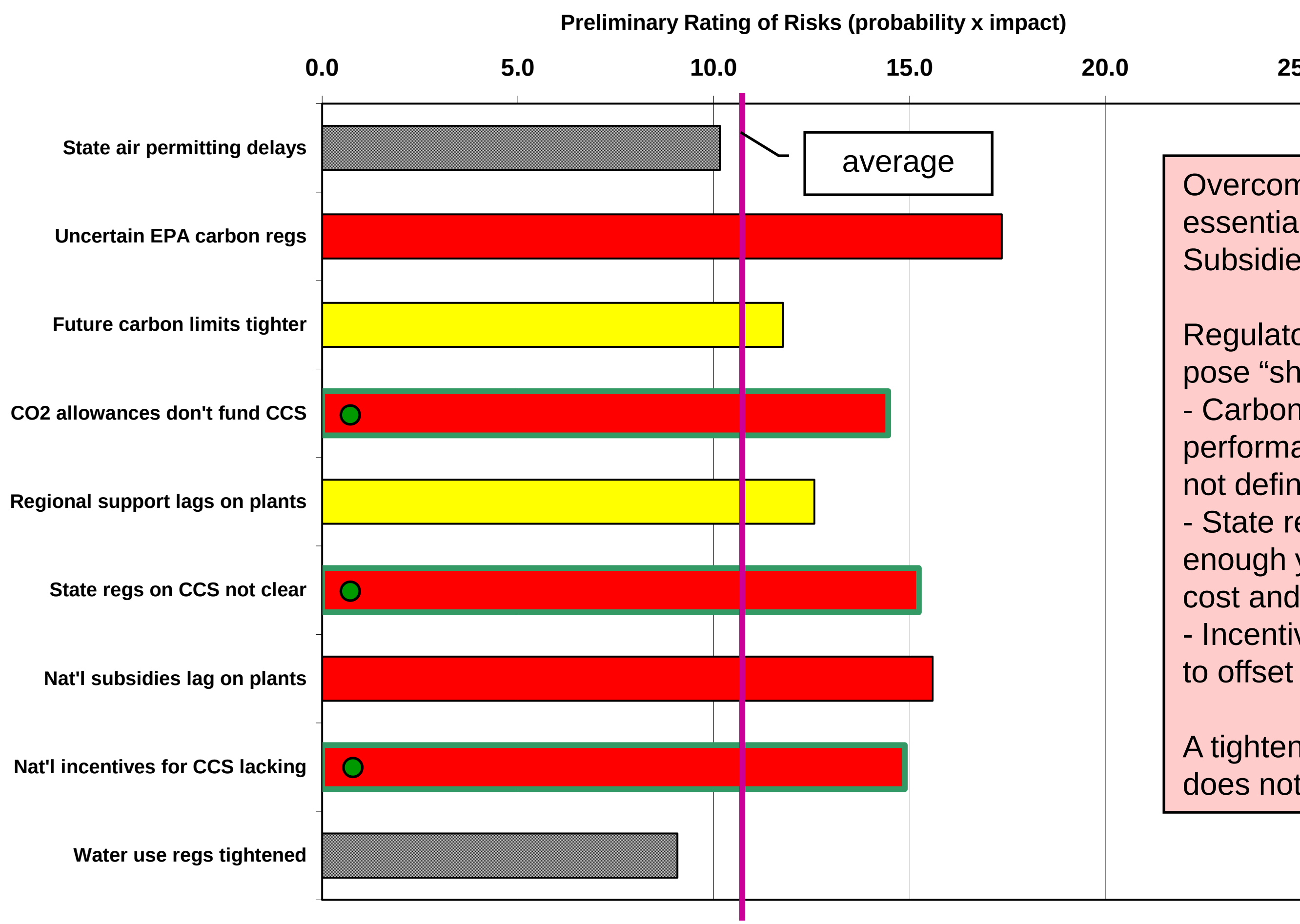
The major issue is CAPITAL COST, not labor costs.

For Deployment of Coal-based Projects with CCS



Risk Ratings: REGULATORY

Regulatory uncertainties (federal + state) about CCS costs and liability threaten financing.



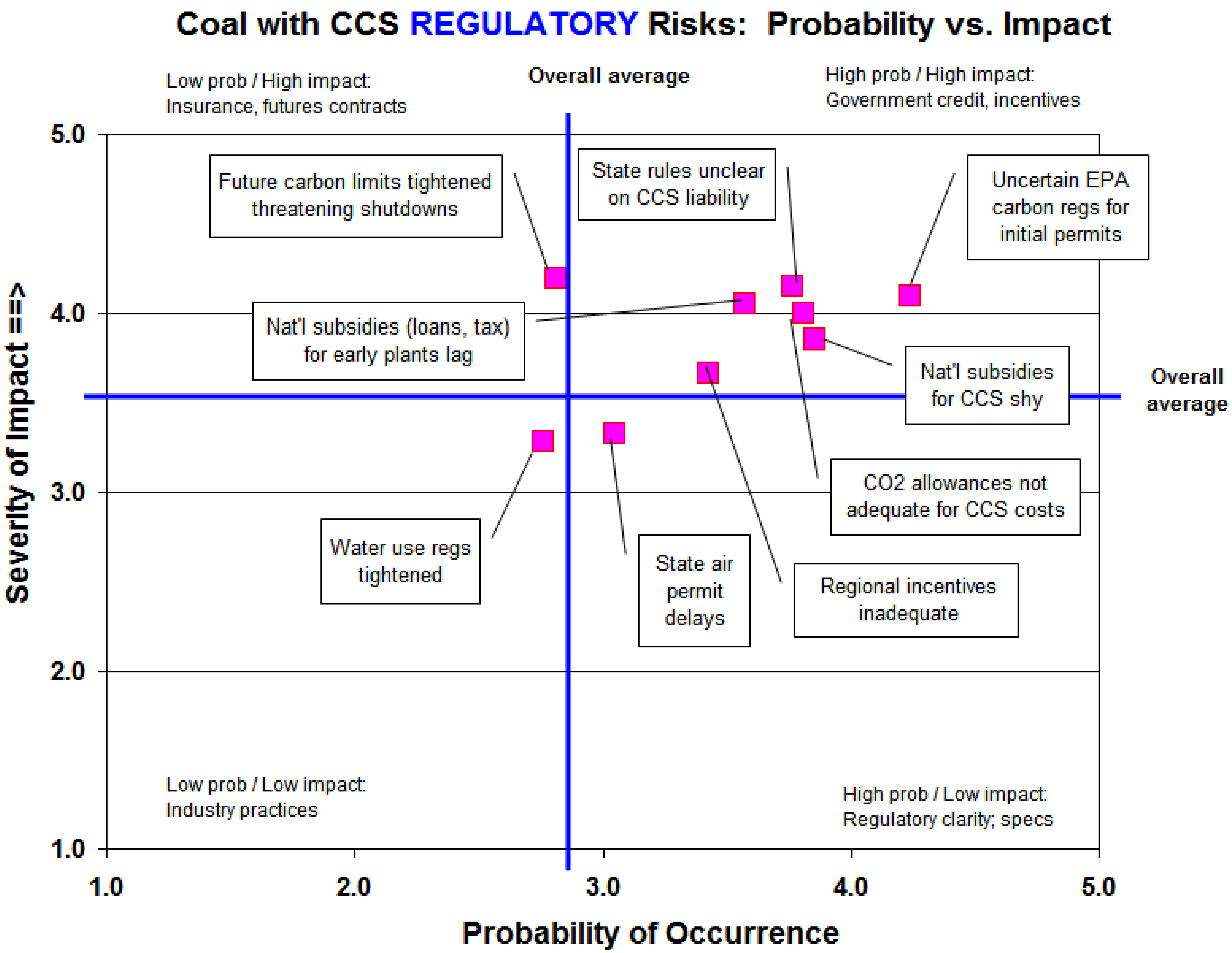
21 respondents

Overcoming higher costs is essential but not enough. Subsidies are needed.

Regulatory uncertainties pose "show stopper risks":
- Carbon legislation and EPA performance standards are not defined.
- State regs are not clear enough yet to resolve CCS cost and liability issues.
- Incentives are not in place to offset CCS costs.

A tightening of water regs does not pose much risk.

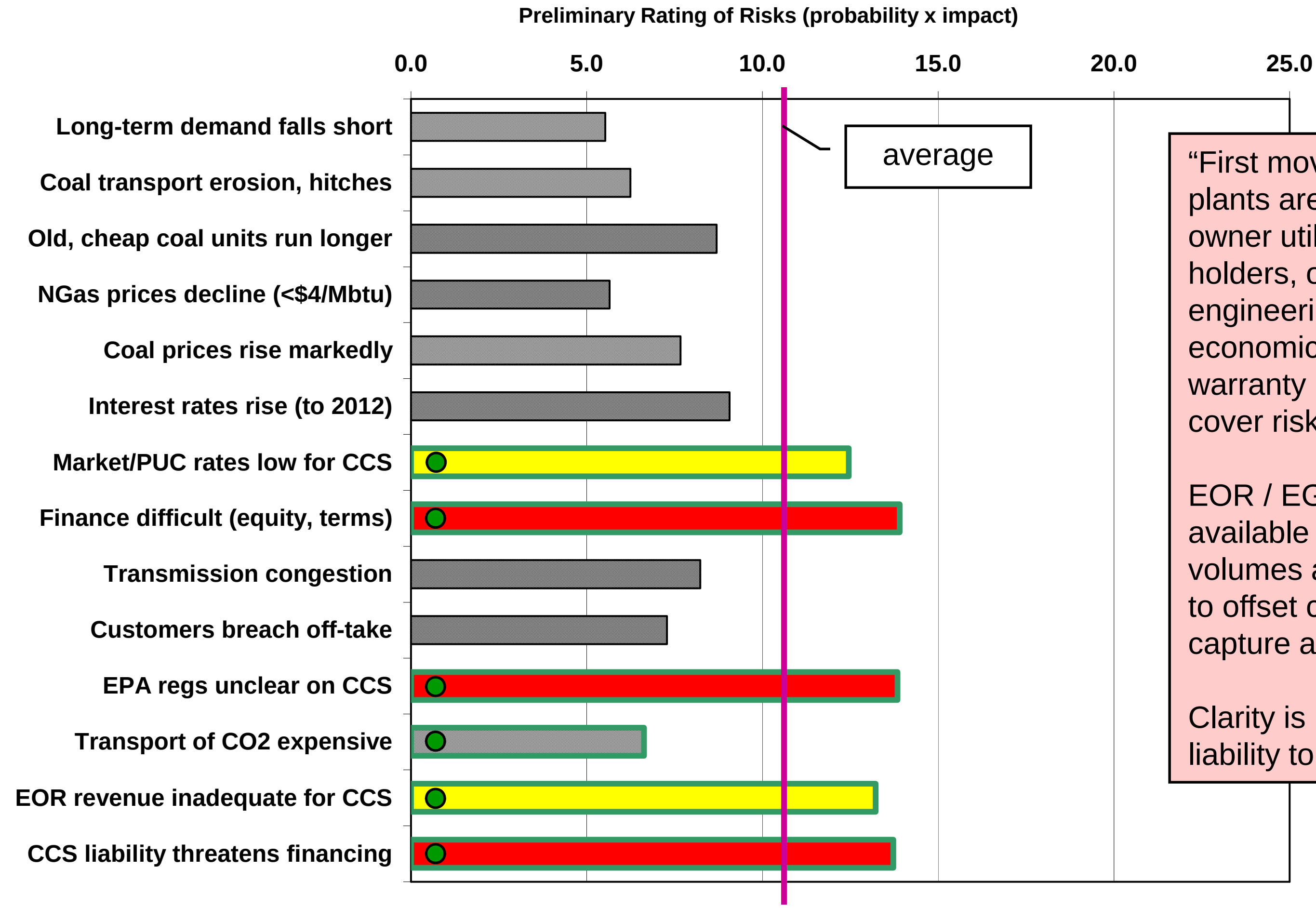
For Deployment of Coal-based Projects with CCS



Risk Ratings: MARKET

Lack of subsidies and uncertainty about liability for CCS make financing very difficult.

21 respondents



"First mover" risks on early plants are prohibitive for owner utilities, bond holders, or PUCs; and engineering firms cannot economically offer enough warranty (or "wrap") to cover risks feasibly.

EOR / EGR is not readily available in all regions, or volumes are not adequate to offset costs of carbon capture and storage.

Clarity is needed on CCS liability to close financing.

● CCS related

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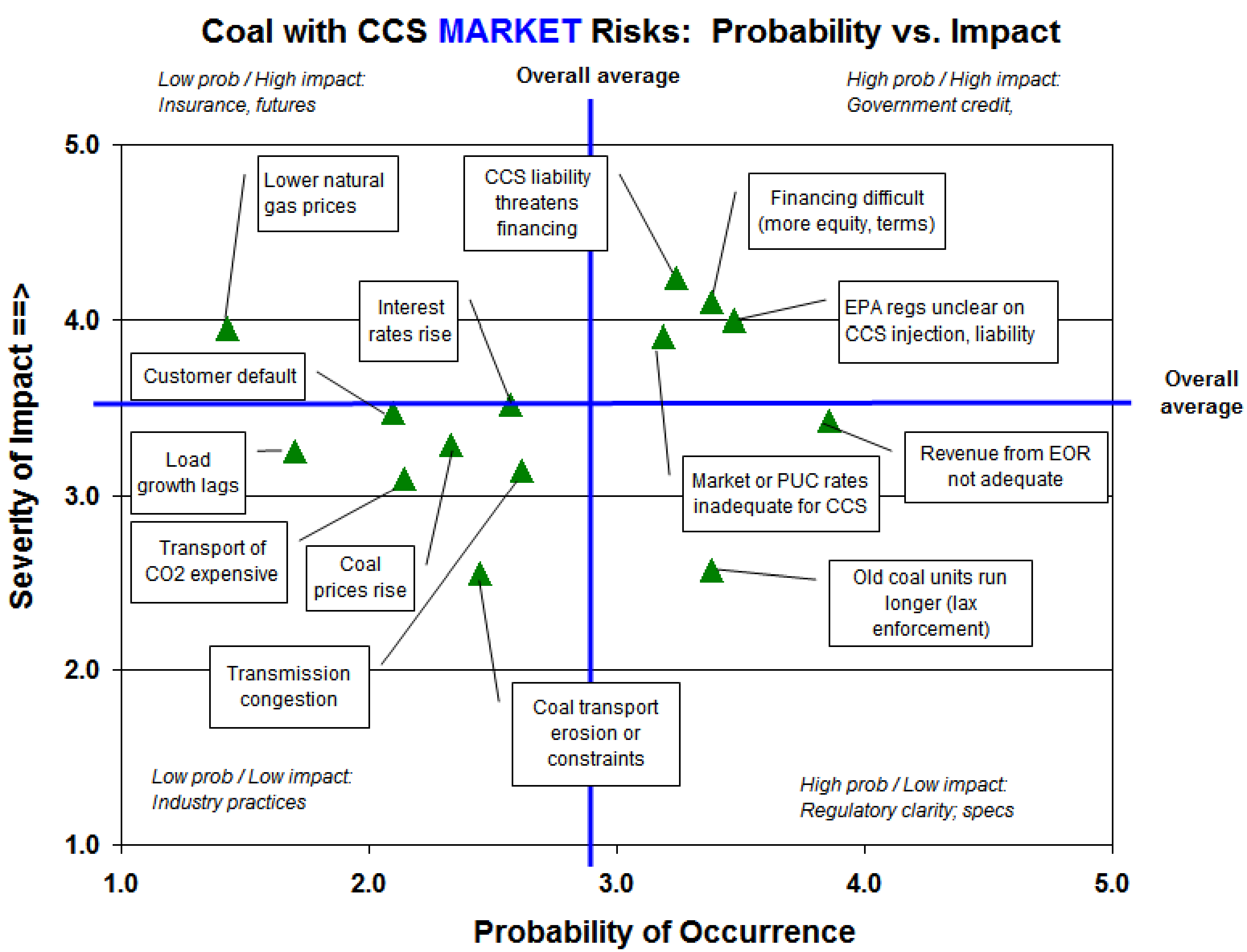
For Deployment of Coal-based Projects with CCS



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For Deployment of Coal-based Projects with CCS

Risk Study: Technical, Regulatory, Market Risks

		Preliminary (21 respondents)			
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1	Tech	High capital cost (w/o CCS)	3.1	3.8	11.6
		Overall Average	**2.9**	**3.6**	**10.5**
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26	Market	Interest rates rise (to 2012)	2.6	3.5	9.1
5	Tech	Constrained EPC capacity	2.9	3.2	9.0

From interviews of key actors (owners, builders, financial entities, agencies, states) critical risks in three major areas are evaluated in a project finance credit analysis framework. Risks are rated (1 to 5) for "likelihood" and "impact" if a risk event occurs. The product (25 point scale) provides a "severity" of risk for specific events affecting deployment with CCS.

Sample respondents: Conoco, GE, Siemens, Air Liquide, Warley Parsons, CH2M Hill, GTC, Excelsior Energy, Burns & McDonnell, Oglethorpe, Eastman Chemical, Hensley, Pace Energy, and EPRI, WCI.

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Preliminary Risk Ratings on CCS – SUMMARY

- **Capital costs have run up since 2005, but costs are up for projects worldwide.**
- **Respondents expect that CCS equipment will work, and do not see CO2 transport as a major issue, nor do they see a CCS site failure as likely. CAPITAL COST for the plant with CCS is the key barrier, not labor costs.**
- **Subsidies are needed to overcome higher costs, but that is not enough.**
  (Subsidies could be paid for by injection fees on CO2, or user levies on coal)
- **Regulatory uncertainties pose "show stopper" risks for deployment of CCS:**
  - Carbon emission legislation and EPA regulatory rules on CCS are not defined.
  - State regulations are not clear enough yet to resolve CCS cost and liability issues.
  - Incentives (tax credits, loans, allowances) are not in place to offset higher CCS costs.
  - A tightening of water regulations does not pose much of a risk currently.
- **"First mover" risks are prohibitive for owner utilities, bondholders, or PUCs; and engineering firms cannot economically offer enough warranty (or "wrap") to cover risks. Few owners want to finance <u>early</u> CCS demos and plants.**
- **<u>EOR is not readily available in all regions</u>, or demand is not adequate to absorb costs and volumes needed for carbon capture and storage from power plants.**
- **Clarity is needed on CCS liability to close financing – perhaps a "showstopper".**
- **Increases in coal prices or interest rates were not rated high risks.**
- **Lower NGas prices (<$5) would pose competitive problems; not seen as likely.**

Risks rated previously WITHOUT CCS

Summary: Risk Ratings for Coal Gasification (2005-06)

	25 pt. scale (5 x 5 = 25)	Co-Prod'n	Co-Prod'n	20		50Rs
	Risk Area for IGCC	A	B	**2006**		**2005**
Q#	**Highest Risks**	**Probablty**	**Severity**	**Rating**		**IGCC**
1	High capital cost	3.6	4.5	**16.0**		**14.9**
3*	Excessive downtime	2.5	3.7	8.9	↓	**13.1**
6	Lack of EPC capacity to build	3.6	3.7	**13.1**	↑	6.5
8	Materials & budget overruns	3.6	4.0	**14.2**		10.9
10	Thin EPC / vendor wrap	3.4	3.5	11.7		9.5
12*	State air permitting delays	2.2	3.4	7.2		**13.0**
18*	Regional policy on sequest lag	3.0	2.7	7.8		11.4
19	Nat'l incentives on plants lag	3.3	4.2	**13.7**		11.8
28	Financing difficult (equity, terms)	3.0	4.2	**12.4**		**13.0**
29	DOD purchase agreement thin	4.0	3.9	**15.2**		NR
30	Long-term off-take inadequate	3.4	4.1	**13.9**		NR
	Overall Average	**2.6**	**3.3**	**8.7**		**9.0**

- Concerns about high capital cost rate highest for co-production plants.
- Concerns about cost overruns and tight EPC capacity also are elevated.
- Uncertainties about off-take and incentives add to financing challenges.
- Combined, these risks explain why plants are not being built, unaided.

Source: Scully Capital, also David Berg

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Plot of Risks Based on their Attributes (Likelihood, Severity of Impact)

Lower Likelihood
Higher Impact

Accidents

(Insurance, long-term or futures contracts, backup supplies, spare subsystems, site surveys)

High Likelihood
High Impact

"Show-Stoppers"

(Requires government subsidies, risk-sharing, credit support, rate-based or long-term off-take agreement)

Probability of Event

Impact if Event Occurs

Low Likelihood
Low Impact

Marketing and Operations

(Well-grounded management practice, internal audits, training)

Higher Likelihood
Lower Impact

Externalities (e.g., pollution)

(Regulatory clarity, system standards – like EPRI CoalFleet UDBS)

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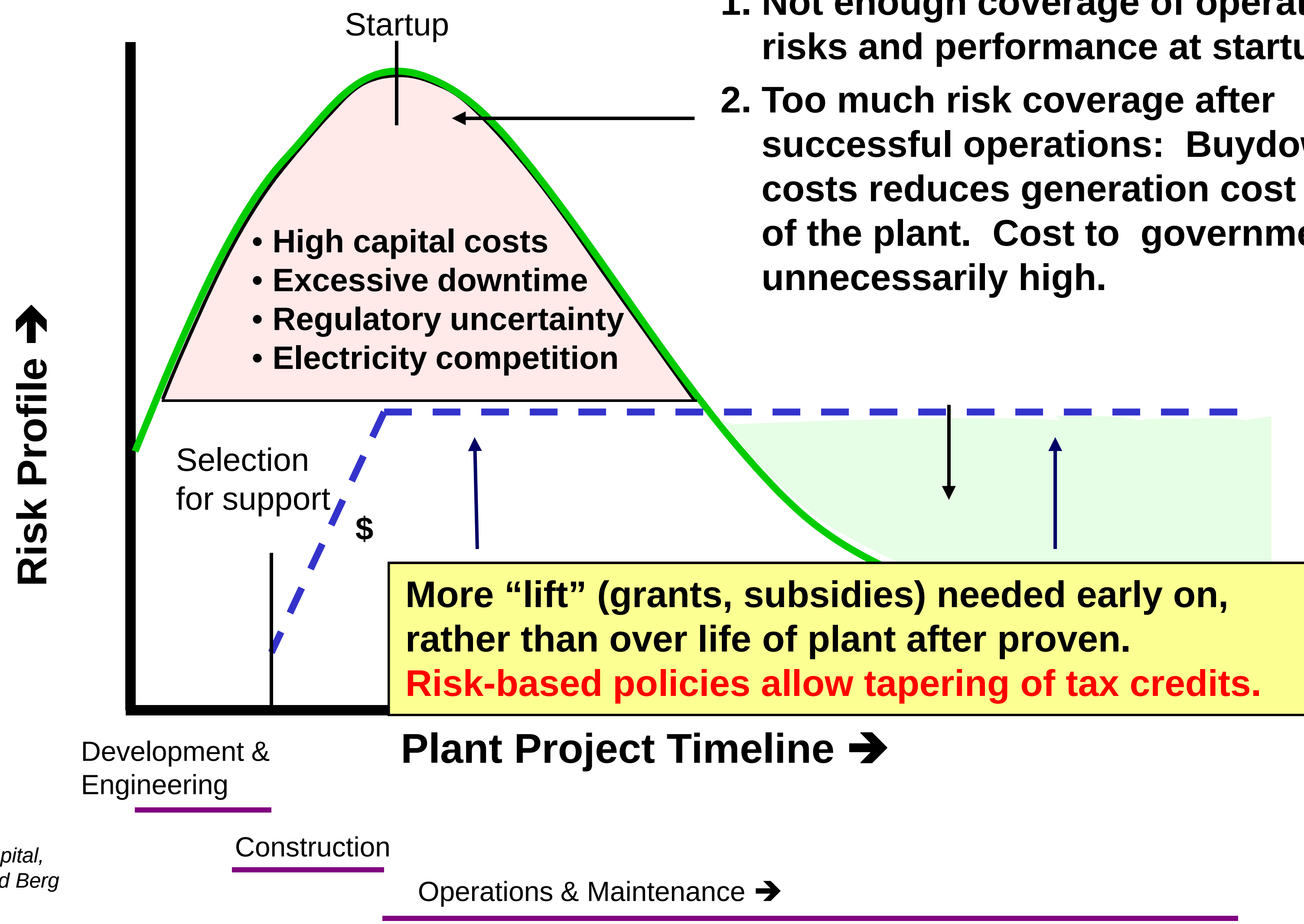
Why risk-based?

First of a Kind Systems: High Risk Early

1. Not enough coverage of operating risks and performance at startup.
2. Too much risk coverage after successful operations: Buydown of costs reduces generation cost over life of the plant. Cost to government unnecessarily high.



More "lift" (grants, subsidies) needed early on, rather than over life of plant after proven.
Risk-based policies allow tapering of tax credits.

Source: Scully Capital, also David Berg

econergy

HUNTON & WILLIAMS

Different Risks Require Different Approaches

Risk-based approaches are more complex, require more work, but cost less and/or spread benefits to more states more regions, more projects with broader impact for the same budget cost. Policy mechanisms overlap, but a risk-based negotiation spreads the benefits.

Key risks	Cost-based Policies	Risk-based Policies
High plant capital costs for CCS	Grants, ITCs (tax credits)	Loans, preferred equity
"First of a kind" plant costs	Federal RD&D, grants	Loan guarantees, preferred equity
Excessive downtime	Federal RD&D, grants	Standby credit, backup systems
Feedstock shortages, poor quality	Capacity payments	More storage, alternative supply
Shifting regulations on feedstocks	Grants, waivers	Alternative supply, waivers
Higher transport costs of feedstock	Subsidies	Infrastructure investment
High processing / operating costs	Property tax relief, PTCs	Engineering, demonstrations
EPC contractor constraints	Educational programs (engrs)	RD&D, feasibility study grants
Revenue uncertainty, price flux	Government off-take	Financing more storage
Lagging private investment	Grants, ITCs, early PTCs	Loans, preferred equity
Revenue and off-take uncertainty	Purchase agreements by gov't	Standby (step-in) agreements
Uncertain CCS regulatory regime	Prescribed rules (e.g., EPA UIC)	Private insurance + gov't backstop
Carbon emission policy uncertainty	Cap with safety valve	Long-term capital subsidies (ITCs)

CCS Alliance

Wrap-up Points for CCS Deployment

- **With dependence in U.S. on coal-based electricity for 12 hours a day (50% of supply), CCS is vital for progress on carbon emissions.**
- **The current pace of electricity demand and the sharp rise in natural gas prices require that advanced coal plants be built now.**
- **If risks are addressed through a mix of policies and demos, early plants can be built with CCS to demonstrate feasibility.**
- **CCS is not economic and subsidies will be needed for first plants.**
- **Grants and tax credits are easy for industry to ask for, but are difficult for Congress to fully fund. Levies on coal may be needed; but those funds would need to be sequestered for coal projects.**
- **Risk-based policies (such as loan guarantees, capacity payments) can help stretch limited government funds <u>across more projects</u>.**
- **Utility bond holders require certainty on CCS liability with no indefinite, long-term exposure. Private owners and insurance can manage first losses, states may want to play to encourage plants.**
- **Some tools are in place, but legislation is needed to resolve uncertainties. Financing is key: No financing = no CCS deployment.**

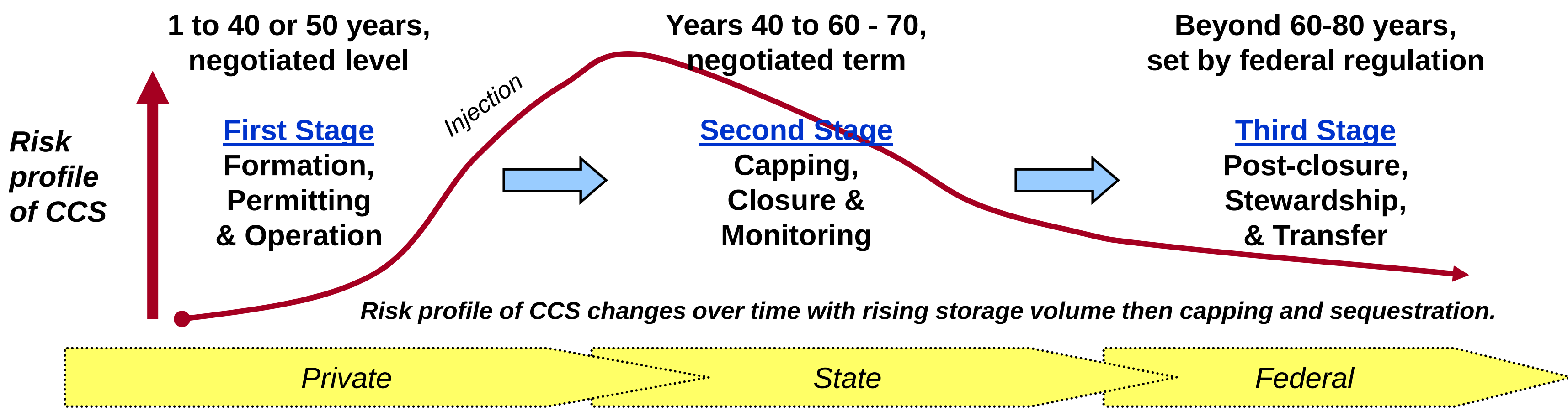
Path Forward Must Mobilize Debt Capital

- **Set a long-term cap (2040), economically and physically feasible**
- **Use "output-based" regulatory performance standards for fossil use**
- **Provide capital incentives for GHG emission mitigation**
- **Use fees on fossil use to fund capital incentives via dedicated trust**
  - Fees would be geared to carbon emitted (Ed Rubin et. al., CMI)
  - Trust fund prevents governments from misusing receipts (prevents earmarking)
  - Some receipts could be used to support low income households
- **Use the bond market to finance infrastructure with carbon mitigation**
- **Lenders / bond holders demand "predictable, steady cash flow" with strong, creditworthy off-takers**
- **WBCSD: Forge an international trading market built on national policies among top 10-12 "Major Emitters". Use treaties (vs. U.N.)**
- **Allow carbon offsets in developing countries to be traded among the Major Emitters (Maintain CDM / JI process in growing nations)**

  [Curbing consumption for growing nations is a form of oppression]

Insurance / bond can transfer CCS Risk Over Time →

Insurance or bonding enacted regionally and chartered by state can be utilized to spread risk and negotiate the cost and liability for carbon leakage over time. Bonding (cash + carbon offsets) can be transferred over time.



Privately managed
Insurance or bonding
Mitigation of CCS risks

"State chartered" bonding, regulated by state insurance commissioners, with site monitoring, annual fiscal reporting
- Capitalized by private sector as a "first loss reserve" for CCS leakage or damages; multiple plants/sites could capitalize same bond or risk pool.
- Each site brings multiple policy holders
- Federal backstop helps provide finite risk level for initial financing of plant

Optional: State Supervision
Insurance or bonding
Mitigation of CCS risks

States supervise permitting of capping and closure
- To encourage initial financing states can negotiate eventual transfer terms
- Trust assets are available for transfer with the potential liability
- Gathering assets and liabilities from multiple projects with CCS helps diversify risk across multiple sites

Federal Repository
Assumption or bonding
Mitigation of CCS risks

Federal backstop beyond first reserve handles long-term major uncertainties
- Long term assumption by a federal agency (or Treasury) boosts financing for new energy infrastructure with CCS
- Shared risk avoids the "moral hazard" of dumping all liability to a federal agency. And, the long-term risk is manageable for the federal government with bond assets.

IOGCC CCS Legal Framework (State-based)

September 2007:

The thirty member states and four Canadian affiliate member provinces of the IOGCC are well suited for regulation of CO2 because of their jurisdiction, experience, and expertise in the regulation of oil and natural gas production, particularly in the use of enhanced oil recovery (EOR), which uses carbon storage.

Scott Anderson, an Energy Policy Specialist for Environmental Defense and an observer to the Task Force deliberations, said that state oil and gas regulators have developed a set of model carbon storage requirements that are thoughtful, rigorous and not a walk in the park for industry.

"The IOGCC model rules will certainly be subject to revision as they are reviewed by more people and as more knowledge about geological sequestration is made. IOGCC's work, however, is a strong, major step forward in the ongoing conversation about how to do carbon sequestration right," said Anderson.

The report recommends that states and provinces actively solicit public involvement in the process as early as possible and that the process is as transparent as possible. In addition the report stresses that CO2, which is generally considered safe and non-toxic, be viewed in a manner that allows beneficial uses of CO2 following removal from regulated emission streams. Contaminants and pollutants such as hydrogen sulfide, NOx and SOx should remain regulated for public health and safety and other environmental concerns, the report says.

Additionally, the Task Force has proposed a two-stage Closure Period and Post-Closure Period to deal with long-term monitoring and liability issues. The operator of the storage site would be liable for a period of ten years after the injection site is plugged, unless otherwise designated by the state regulatory agency. At the end of the Closure Period, the liability for ensuring that the site remains a secure storage site during the Post-Closure Period would transfer to the state. A [bonding instrument] that is industry-funded and state administered would provide the necessary oversight during the Post-Closure Period. The bonding could be funded by an injection fee assessed to the Carbon Storage Project operator and calculated on a per ton basis.

Wrap-up: Capital Incentives First, with Long-term Cap

- The fundamental issue is accelerating the turnover of "High Carbon" energy infrastructure to low-carbon, efficient systems:
  - **Renewables, Power generation with CCS and grid upgrades are all needed**
  - **End-use efficiency in buildings extends time to turnover capital stock**
  - **Regulation for CCS is critical to mobilizing debt capital in the bond market**
- Large energy infrastructure is built with debt, not risk-oriented capital
- Capital incentives promote economic growth, which is needed to fund innovation and regional infrastructure, and change demand
- Capital incentives foster engineering and innovative technology
- OECD capital markets are large, liquid, and efficient
- Short-term cap & trade can create bureaucratic inefficiencies and incentives for "gaming" and is very difficult to monitor and enforce
  - **Economy-wide reporting and monitoring costs are extensive – what to do with cheaters**
  - **Uneven impact creates large scale winners and losers by region and sector**
- Natural sources of carbon are vast and not "capped"
- Incentives engage big developing economies (China, India, etc.)
- A long-term cap (2040) with stable prices mobilizes the bond market

Background References

- Coal plants under construction by type (ENR)
- IPCC Technical Risk Framework for CCS
- GCEP Technical Mitigation Framework (Stanford)
- Carbon Price Volatility
- Utility Cap Ex 2006 – 2008

ENR: Coal Plants Under Construction (Feb. 2008)

Despite numerous cancellations, some plants are underway, but CCS is seen as too costly.

Net Power Output of Combustion Projects Currently Under or Near to Construction

	Bitum.	Sub-bitum	Lignite	Pet coke	Total MW (% of total)
Supercritical PC	4,150	2,100	1,600	-	7,850 (50.2)
Subcritical PC	1,620	4,040 (1)	-	-	5,660 (36.2)
CFB	850 (2)	40	630	600	2,120 (13.6)
Total, MW (% of total)	6,620 (42.4)	6,180 (39.5)	2,230 (14.3)	600 (3.8)	15,630

(1) Includes 280 MW of sub-bituminous waste
(2) Includes 290 MW of bituminous waste

Table 1-6 Net Power Output of Combustion Projects with Permits

	Bitum.	Sub-bitum	Bitum waste	Pet coke	Total MW (% of total)
Supercritical PC	338	1,987			2,325 (43.5)
Subcritical PC	600	600			1,200 (22.5)
CFB	270	250	465	830	1,815 (34.0)
Total, MW (% of total)	1,208 (22.6)	2,837 (53.1)	465 (8.7)	830 (15.6)	5,340

Source: NETL, EPRI

IPCC Overview of CCS Risks

The risks due to leakage from storage of CO2 in geological reservoirs fall into two broad categories: global risks and local risks. Global risks involve the release of CO2 that may contribute significantly to climate change if some fraction leaks from the storage formation to the atmosphere. In addition, if CO2 leaks out of a storage formation, local hazards may exist for humans, ecosystems and groundwater. These are the local risks. With regard to global risks, based on observations and analysis of current CO2 storage sites, natural systems, engineering systems and models, the fraction retained in appropriately selected and managed reservoirs is very likely to exceed 99% over 100 years, and is likely to exceed 99% over 1000 years. Similar fractions retained are likely for even longer periods of time, as the risk of leakage is expected to decrease over time as other mechanisms provide additional trapping.

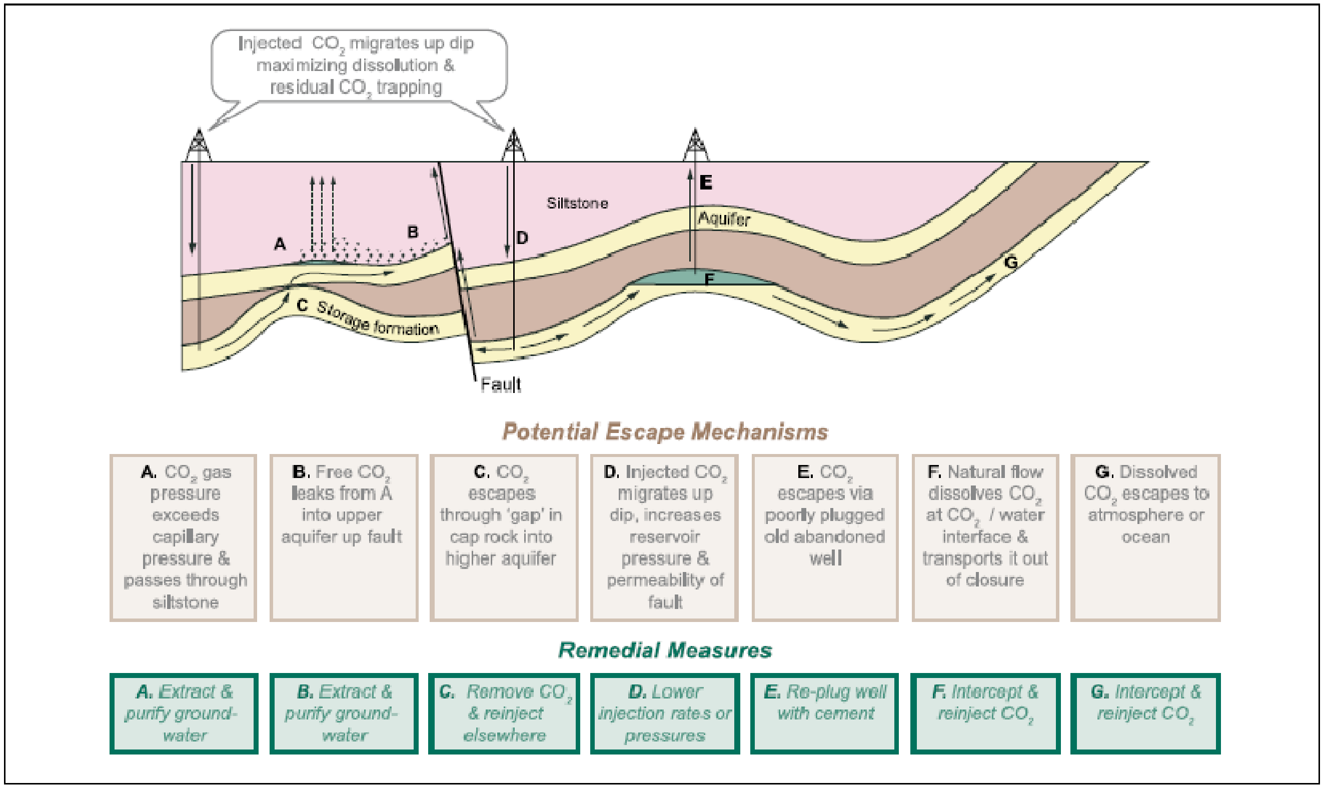
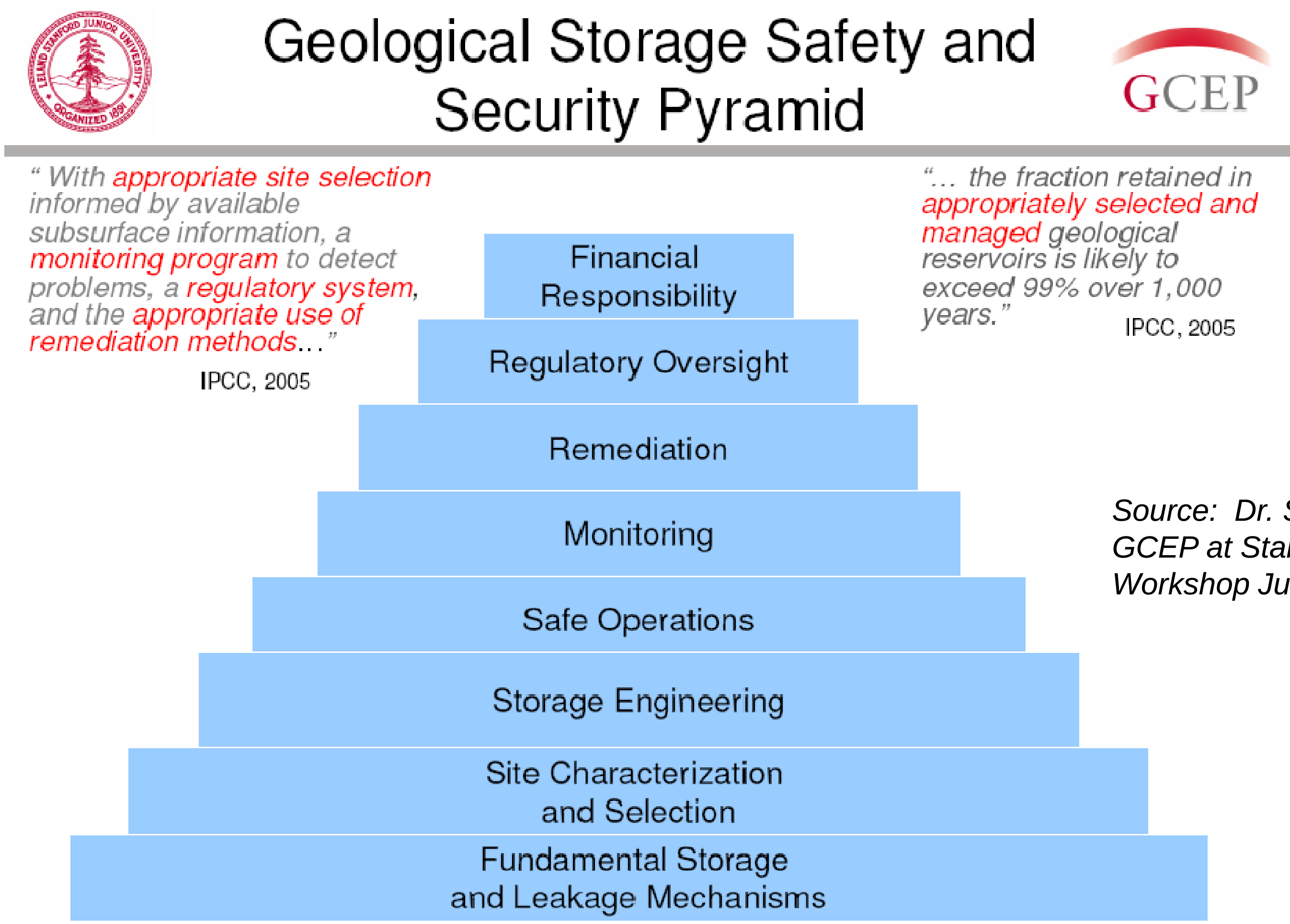


Figure TS.8. Potential leakage routes and remediation techniques for CO_2 injected into saline formations. The remediation technique would depend on the potential leakage routes identified in a reservoir (Courtesy CO2CRC).

Mitigation Built on Science, Industrial Experience

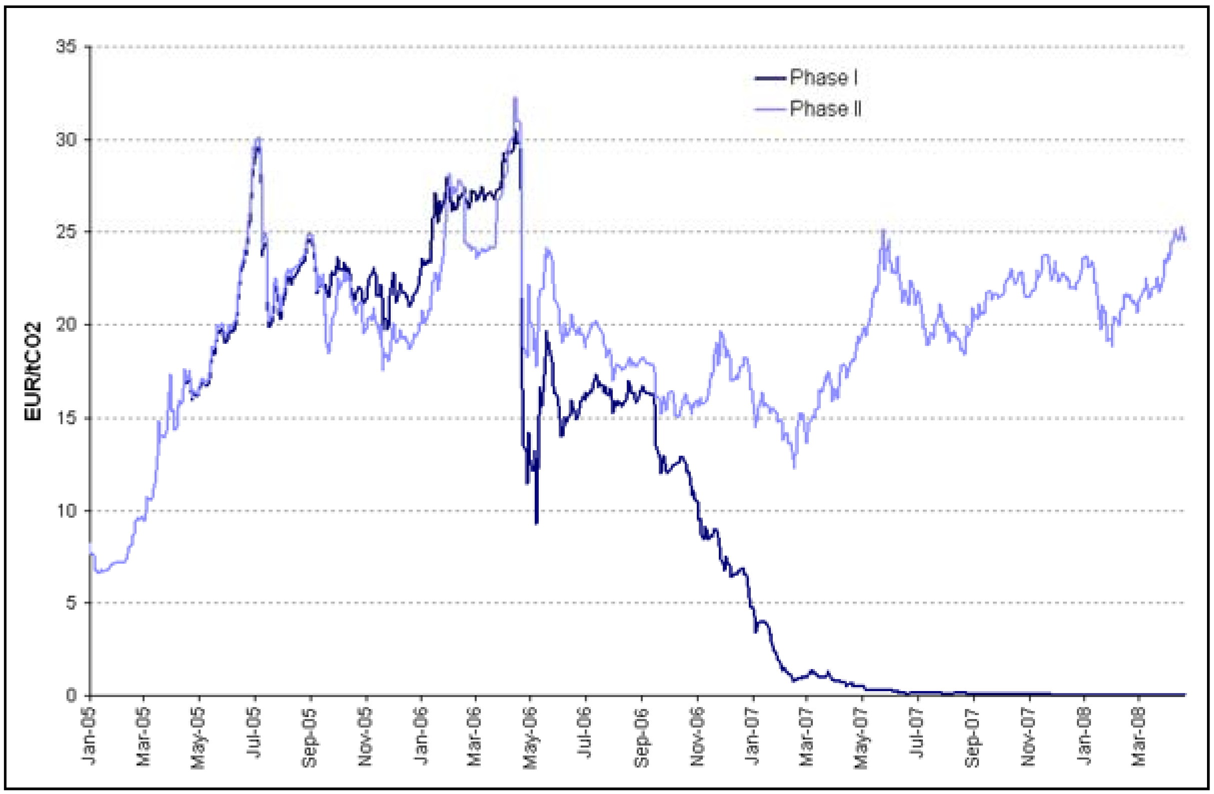
A sound risk mitigation strategy can be built on scientific methodologies and industrial experience.



Source: Dr. Sally Benson, GCEP at Stanford, in WRI Workshop June 5, 2007

Recent (Apr 2008) Phase II EU Carbon Prices

Note: A short-term cap-and-trade (i.e., geared to 2020 vs. 2040) without a safety valve will not generate a stable price for carbon emissions, but volatile prices instead – particularly because consumers cannot easily switch away from current consumption and new supply takes a long time to come online. This creates MORE uncertainty for bond investors seeking to evaluate investments in long-lived coal-fired power plants with CCS. A long-term cap-and-trade (2040) regime is better geared to the capital markets and thus will mobilize more debt capital for low-carbon systems.



Utility CapEx Forecast: 2006 – 2008

Source: Lehman Brothers

Rank	**Company**	States	NERC area	Building Coal?	($Mil) **2006**	($Mil) **2007E**	($Mil) **2008E**	($Mil) **Sum**	06 to '08 **Growth**	**% Total**
1	Dominion Resources	VA	**SERC**	Yes	$4,052	$4,400	$4,600	$13,052	$548	
2	American Electric Power	OH, TX	RFC	Yes	3,528	3,867	3,026	10,421	-$502	
3	FPL Group, Inc.	FL, SC	FRCC	No (was)	3,507	5,198	4,258	12,963	$751	
4	Duke Energy	IN, OH, NC	**SERC**, RFC	Yes	3,381	3,500	3,500	10,381	$119	
5	Southern Company	GA, MS	**SERC**	Yes	2,994	3,911	4,525	11,430	$1,531	
6	Edison International	CA	WECC	No (but BP)	2,536	3,161	2,951	8,648	$415	
7	Exelon Corp.	PA, IL	RFC	No	2,418	2,801	2,801	8,020	$383	
8	PG&E	CA	WECC	No	2,402	3,200	2,800	8,402	$398	
9	TXU Corp.	TX	ERCOT	Yes	2,180	2,870	3,400	8,450	$1,220	Top 10
10	Consolidated Edison	NY	NPCC	No	1,921	1,800	1,800	5,521	-$121	55%
11	Xcel Energy	MN, CO	MRO, WECC	Yes	1,626	1,900	1,900	5,426	$274	
12	Entergy Corp.	AL, AR, LA	**SERC**	No?	1,614	1,738	2,001	5,353	$387	
13	Progress Energy	NC, SC	**SERC**	Yes?	1,425	2,400	2,500	6,325	$1,075	
14	DTE Energy	MI	RFC	Yes?	1,403	1,500	1,500	4,403	$97	
15	PPL Corp.	PA	RFC	??	1,394	1,747	1,398	4,539	$4	
16	Ameren Corp	PA	RFC	No	1,284	1,300	1,300	3,884	$16	
17	FirstEnergy Corp.	OH	RFC	Yes	1,170	1,451	1,722	4,343	$552	
18	Constellation Energy	MD	RFC	No?	1,149	265	490	1,904	-$659	
19	Centerpoint Energy	TX, OK?	SPP	No	1,121	1,055	1,016	3,192	-$105	Top 20
20	Public Service Enterprise Group	NJ, PA?	RFC	??	1,015	1,343	1,681	4,039	$666	80%
21	Sierra Pacific Resources	NV	WECC	??	986	1,512	1,800	4,298	$814	
22	Wisconsin Energy	WI	MRO	Yes	929	1,400	1,030	3,359	$101	
23	Northeast Utilities	WI, MN?	MRO	??	880	1,300	1,128	3,308	$248	
24	Puget Energy	WA	WECC	??	834	650	625	2,109	-$209	
25	CMS Energy	MI	RFC	??	670	847	795	2,312	$125	
26	Arizona Public Service Co.	AZ	WECC	??	667	950	950	2,567	$283	
27	Scana Corp.	SC	**SERC**	??	485	728	841	2,054	$356	
28	Great Plains Energy	ND	MRO	??	476	832	1,075	2,383	$599	
29	Pepco Holdings	DC, MD	RFC	??	475	655	664	1,794	$189	
30	TECO Energy	FL	FRCC	??	454	538	678	1,670	$224	95%
31	Allegheny Energy	PA	RFC	??	447	1,030	1,120	2,597	$673	
32	Energy East	??	NPCC	??	408	496	533	1,437	$125	
33	Alliant Energy Corp.	IA	MRO	??	398	580	1,085	2,063	$687	
34	DPL, Inc.	DE	RFC	??	352	355	195	902	-$157	
35	Integrys Energy	WI, MI	RFC	??	342	539	494	1,375	$152	
36	Idacorp	ID	WECC	No	225	307	540	1,072	$315	
	Totals ($millions)				$51,148	$62,126	$62,722	$175,996	$11,574	
	Growth					21.5%	1.0%			