Carbon Sequestration Technological Development in Petrobras

Business Perspectives on CO_2 Capture and Geological Storage (CCS) Enabling Widespread Application – IPIECA Side Event/ COP 13 - UNFCCC
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Carbon Sequestration Capacitation and Technological Development (I)

- Gas & Energy and Sustainable Development Department / Biotechnology and Environmental Treatments group - Carbon Sequestration and Ecosystem Conservation activities(2003)
- Environment Technological Program with the establishment of the Systemic Projects of Carbon Sequestration and Ecosystem Conservation (2003)
- R&D CO_2 capture in partnership with Regina University/Canada
- R&D carbon biomass fixation in different Brazilian Ecosystems (since 2003)
- Petrobras affiliation to the Joint Implementation Project CO_2 Capture phase 2/UK (2005)
- CCS group in Gas & Energy and Sustainable Development Department (2006)
- **Petrobras 1st Carbon Sequestration International Seminar- Oct/2006**
- **Public Perception on CCS** (since Oct/2006)
- **Petrobras Research Center Climate Change and Carbon Sequestration Technologies Network (2006)**
- **Implementation of four R&D centers for CO2 Capture (absorption and chemical looping), geological storage and carbon biomass fixation**
- Climate Change and Carbon Sequestration Brazilian Seminars and CCS courses – Natal/RN, Apr/ 2007 and Cuiabá/MT, Aug/2007
- CCS Recôncavo Basin Project with French Institute of Petroleum – IFP, Aug/2007
- Carbon Sequestration Capacity building on May 2007 in Pittsburgh/USA, with the visit to the DOE's National Energy Technology Laboratory

CO_2 and Carbon Sequestration Capacity Building Process and Technological Development in Brazil (II)

- Establishment of PETROBRAS Strategic and Technological Program on Climate Change Mitigation with focus on CCS - **PROCLIMA** (Sept/2007)
- CCS Capacity building with DOE/USA and the Carbon Sequestration Leadership Forum(CSLF) in Porto Alegre/RS, Oct/2007
- Petrobras, Pontifical Catholic University of Rio Grande do Sul and Brazilian Coal Association agreements with DOE/NETL (in negociation)
- **CO_2 Storage and Ethics** Workshop, Rio de Janeiro, Oct/2007
- Brazilian **CCGS Roadmap** Workshop, Porto Alegre, Oct/2007
- **Brazilian Sustainability CCGS Roadmap Worshop, Rio de Janeiro, Nov/2007**
- **Petrobras 2nd Carbon Sequestration International Seminar-** Sep/2008
- **Development of CCS methodology (to be started in 2008)**
- **CO_2 capture technologies laboratory for demonstration scale tests in Petrobras facilities (in negotiation)**
- **Petrobras Pilot and Demonstration CCS in Aquifer, Petroleum Reservoirs and Coal Seams (to be started in 2008)**

PRO

Objectives (2007-2012) :
To provide technological solutions to minimize carbon risk in Petrobras' processes and products, aiming to contribute to increase the sustainability of its business and the achievement of Company's strategic goals related to global climate change

Program Focuses

- **Carbon Sequestration**
- **Energy efficiency**
- **Climate Change: Impacts, vulnerabilities and adaptation**
- **Evaluation of environmental performance on the fossil fuel and renewable energies life cycles**

CLIMA

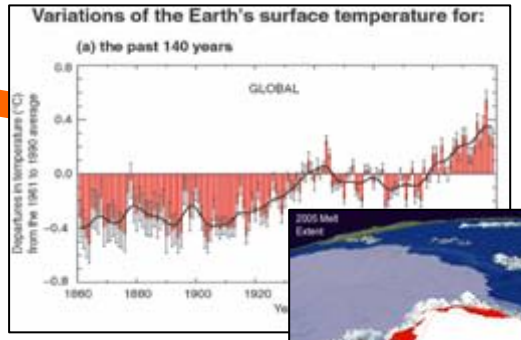
Main Goals of PROCLIMA related to carbon sequestration	MILESTONES
1. To develop technologies of CO_2 separation and capture that allow a significant cost reduction on current capture prices (50% reduction) to be used on the GHG avoided emissions on industrial units	• Demonstration: 2009 (250 tons CO_2/day) • Industrial: 2012 (900 tons CO_2/day)
2. To develop CO_2 storage technologies, risks evaluation, measurement, monitoring and verification, assuring the geological storage security.	• Pilot: 2008 (350 tons CO_2/day) • Demonstration: 2012 (900 tons CO_2/day)
3. To implant a pilot/demonstration reforestation project to evaluate the biomass carbon fixation and attainment of carbon credits	. Demonstration : 2009 (1,000 ha)

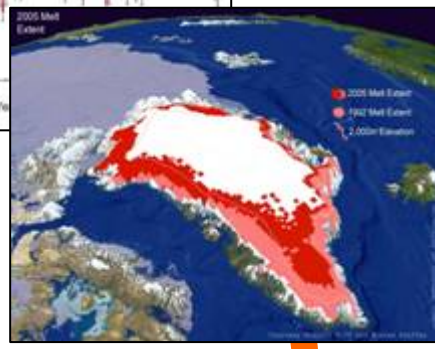
XXI Century's Interconnected Challenges

Sustainable Consumption of Resources

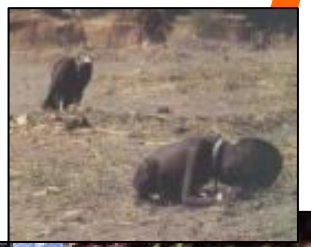
Energy

Climate Change



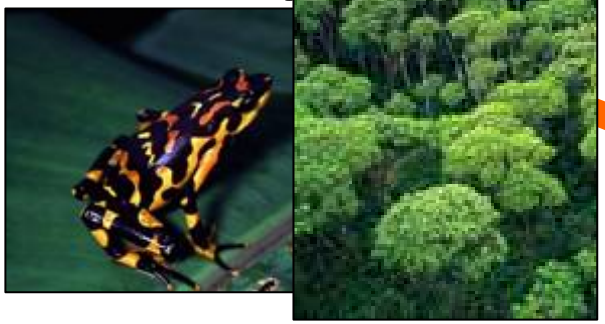


Hunger



Social Inequality

Biodiversity



Ref.: Adapted of **Ricardo Castello Branco in "The importance to Petrobras of R&D with focus in biodiversity" at The Biodiversity and the Oil and Gas Industry's Seminary, Rio de Janeiro, June, 2006**

Petrobras Climate Change Mitigation Approach for Energy and Mobility with Sustainability

PETROBRAS

Brazilian Approach for developing Climate Change Mitigation through CO_2 Capture and Geological Storage (CCGS) technologies

Energy and Mobility <u>Sustainability Principles</u> considering some of the XXI Century Challenges :

- **Economical Growth** on the energy and fuels business

- **Social responsibility** applied in CCGS projects, taking into account the challenges:
  - to implement the CO_2 storage projects educating and creating a technological base with investments in infrastructure, R&D projects, capacity building and job generation for CCGS in Brazil.
  - to implement the CO_2 storage projects involving the surrounding communities to generate jobs, alimentary security and wealth, considering the local conditions and possibilities.

- **Environmental responsibility** trought the development of climate changeless energy and mobility activities without impacts to Earth. Also, to establish compensation measures for the advent emissions of the "new fossil fuels produced in the CCGS activities" (EOR and ECBM), through:
  - reforestation with native species associated with perennial oilseeds and food specimens (agro forests);
  - conservation of ecosystems
  - agricultural practice changes in the production of bio-fuels for GHG emissions reduction

We are preparing the 1st "CCGS Sustainability Road Map" in the World

Development of CCS methodology (to be started in 2008)

PETROBRAS CCS Potential Projects Portfolio (under negotiation)

More than 10 Mt CO_2 / year from 2014!

1,9 Mt CO_2/year*
Potiguar Basin
Projeto Potiguar

3,4 Mt CO_2/year*
Campos Basin
Campos Project

3,1 Mt CO_2/year*
Recôncavo Basin
Phases 2 e 3
Miranga Field

0,043 Mt CO_2/year
Reconcavo Basin
Phase 1
Aquifer – Rio Pojuca

0,14 Mt CO_2/year
Paraná Basin
Phase 1
CarboMetano

0,14 Mt CO_2/year
Paraná Basin
Phase 1
CarboGis

0,7 Mt CO_2/year
Paraná Basin
Phase 2
CarboMetano

0,7 Mt CO_2/year
Paraná Basin
Phase 2
CarboGis

*To be reached in 2014

2008 2009 2011 2014

PETROBRAS PETROBRAS PETROBRAS PETROBRAS PETROBRAS PETROBRAS PETROBRAS PETROBRAS

World Technological Development Stage (CCS projects) WORLD ROAD MAP

Demonstration

Industrial

CARSON (4,0 mil.ton/year); 2011 – EUA;

CAMPOS (3,9 mil. ton/year); 2008 – Brazil (PETROBRAS);

MIRANGA (2,9 mil. ton/year); 2008 – Brazil (PETROBRAS);

HALTEN (2,5 mil. ton/year); 2012 - Norway;

POTIGUAR (1,9 mil. ton/year); 2011 – Brazil (PETROBRAS);

WEYBURN (1,8 mil. ton/year); 2000 to 2004 – Canada

SALT CREEK (1,8 mil. ton/year); since 2004 – EUA;

PARANA (1,4 mil. ton/year); 2014 – Brazil (PETROBRAS);

IN SALAH (1,2 mil. ton/year); since 2004 – Algeria;

MILLER (1,3 mil. ton/year); 2009 – Scotland;

MONGSTAD (1,3 mil. ton/year); 2014 – Norway;

FUTUREGEN (1 - 2,5 mil. ton/year); 2013 – EUA;

SLEIPNER (1,0 mil. ton/year); since 2006 – Norway;

Pilot

RIO-POJUCA AQUIFER; 2007 – Reconcavo Basin (PETROBRAS);

ECBM; 1997 to 2007 – Canada

ECBM; since 2002 – China;

CASTOR; since 2004 – Europe

CANMET; since 2004 Canada

CO_2 SINK; since 2004 – Germany

CARBOMETANO BRASIL PROJECT (ECBM); 2009 – Paraná Basin (PETROBRAS);

ITC CO_2 CAPTURE; since 1999 – Canada

CCS ON BASALTIC FORMATIONS; since 2006 – India

PROJETO FRIO; 2002 to 2003 – EUA;

RECOPOL; 2001 to 2004 – Poland;

LACQ BASIN; 2008 – France

ZAMA; since 2006 – Canada;

CARBOGIS (UCG + CCS); 2011 – Paraná Basin (PETROBRAS & LLNL NETL)

R&D

CCP II

CLIMATE CHANGE AND CARBON SEQUESTRATION NETWORK

ENCAP Integrated Project

Updated – Dez/2007

Discussion

Brazil doesn`t have target obligations to reduce its emissions (UNFCCC common but different responsibilities principle) but it is committed to climate change mitigation.

Indeed we have a very clean energy matrix: 95% hydroelectricity , the PROALCOOL with 24% addition to gasoline since the 70's and now the Biodiesel in 2% added to Diesel.

Brazil has a particular emissions profile: 75% comes from deforestation and land use change and only 25% from fossil fuels. And from those approximately 15% only are from stationary sources and so CCS is not a technology to be largely implemented in Brazil .

But for Petrobras and other industries, and considering the local development that can come with CCS projects implementation (with EOR and ECBM activities, and our discussions that are beginning on social and environmental aspects of the sustainability of CCS and perhaps a sort of compensation of future hydrocarbon emissions to be used after their production on those activities) CCS is an important technology for climate change mitigation.

Conclusions

PETROBRAS, a company with environmental and social focus, is in a transition stage from oil company with CO_2 emissions to a clean and sustainable energy company, developing its business with profitability in a climate changeless scenario. CCS will play an important role in this transition

The company believes that carbon sequestration brings us the possibility to accomplish this transition, becoming viable to society a sustainable energy source, that will not cause irreversible damage to the environment. A climate changeless energy and mobility world.

The proposed projects – CCS in the Recôncavo Basin, Campos Basin, Potiguar Basin and Paraná Basin to be implemented until 2014, will allow an ammount of almost 10 million tons of CO_2 avoided emissions/year, 18% of the Petrobras emissions in 2006

In 2014, Petrobras will be managing some of the world's biggest CO_2 geological storage projects, all together equivalent to almost ten times the Sleipner Project

Thank You

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