Lacq CO_2 Pilot

An integrated CO_2 oxycombustion capture, transportation and storage project

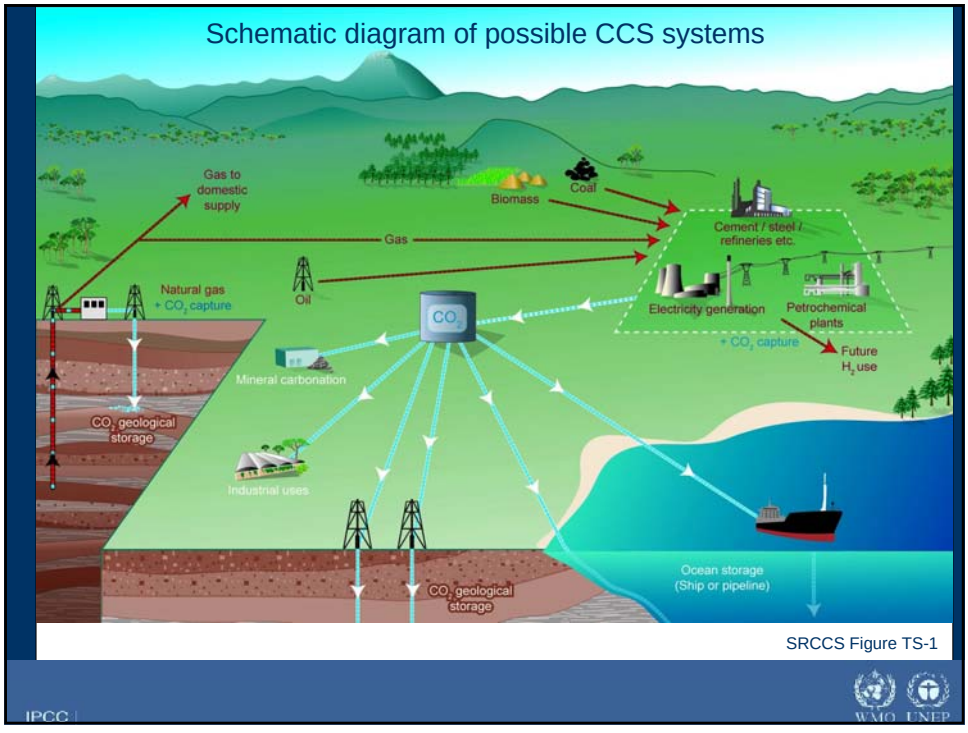
Frontiers in Geosciences – IPGP CCS seminar

Case studies sessions

March 19th, 2008

Nicolas AIMARD - Marc LESCANNE

TOTAL

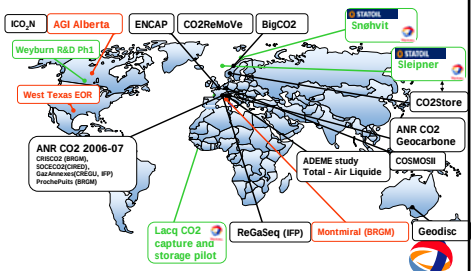


Climate change: Lacq pilot part of Total's contribution

- Promote a better understanding of climate change mecanism and bring our competences to potential solutions development
- Better manage our green house gas emissions in our facilities
- Help our clients manage their green house gas emissions
- Promote alternate and renewable energies

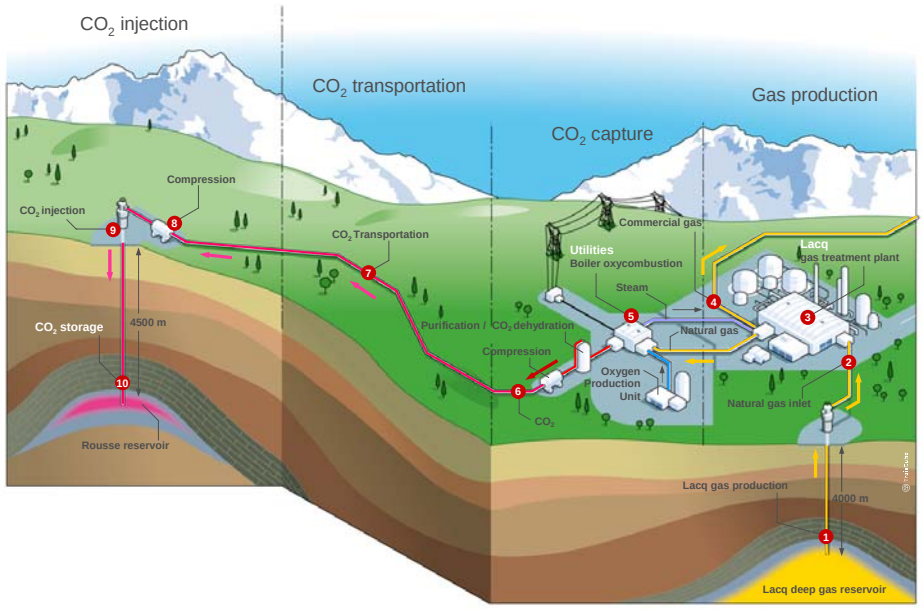
- <u>A portfolio of options to reduce our green house gas emissions</u> :
  - Gas flaring reduction (world bank GGFR) on existing facilities
  - Improve power efficiency
  - CCS as breakthrough technology

- <u>Dedicated CCS program since 2001</u> :
  - Capture technology development
  - CO_2 injection and storage
    - Storage integrity
    - Well integrity
    - Long term fate of CO_2
    - P&R, monitoring

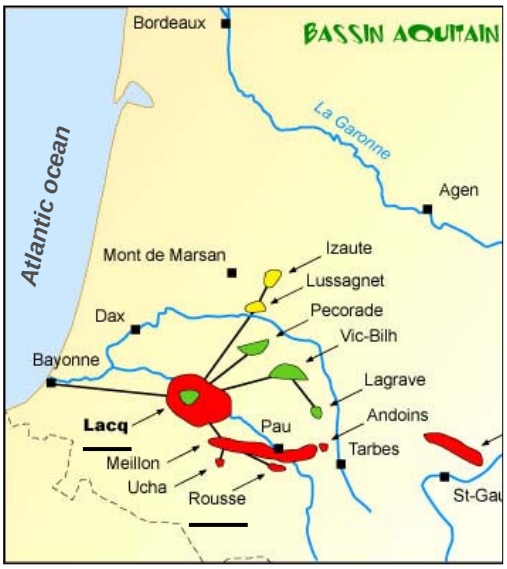


TOTAL

An integrated CCS project at Lacq



Pilot location
Total Exploration & Production in France



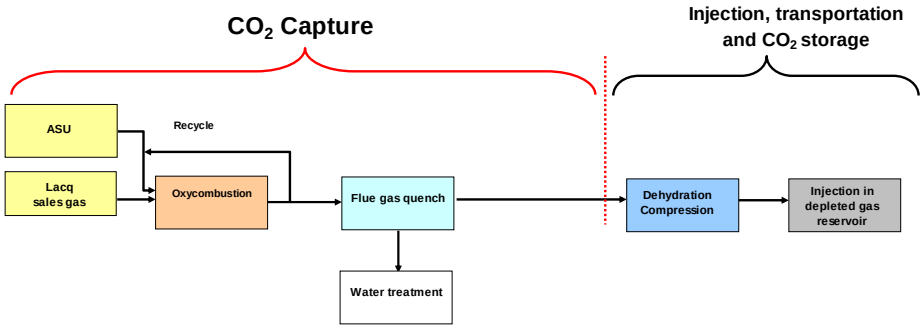
TOTAL

CO_2 pilot at Lacq general objectives

- **Demonstrate the technical feasibility and reliability of an integrated CO_2 capture, transportation, injection and storage onshore scheme for steam production at a reduced scale (1/10th of future facilities)**
- **Design and operate a 30MWth oxycombustion boiler for CO_2 capture**
  - 50% reduction of direct and undirect CO_2 emissions if undirect not captured
  - 50% reduction of capture cost compared to classical post capture technologies
- **Develop and apply geological storage qualification methodologies, monitoring and verification techniques on a real operationnal case to prepare future larger scale long term storage projects**

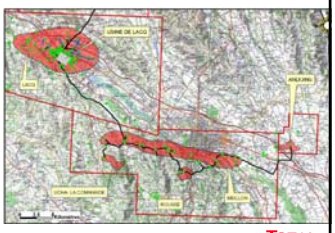
TOTAL

CCS Lacq pilot to start early 2009 after permitting



CHALLENGES

- ✓ Industrial scale 30MWth oxycombustion unit with gas
- ✓ Revamping of a 35MW+ conventional boiler
- ✓ First CO2 injection for storage in France
- ✓ French, europ. and international legislation under definition
- ✓ CO2 transport and injection into a Lacq satellite for 2 years
- ✓ 150 kt CO2 storage in a depleted reservoir

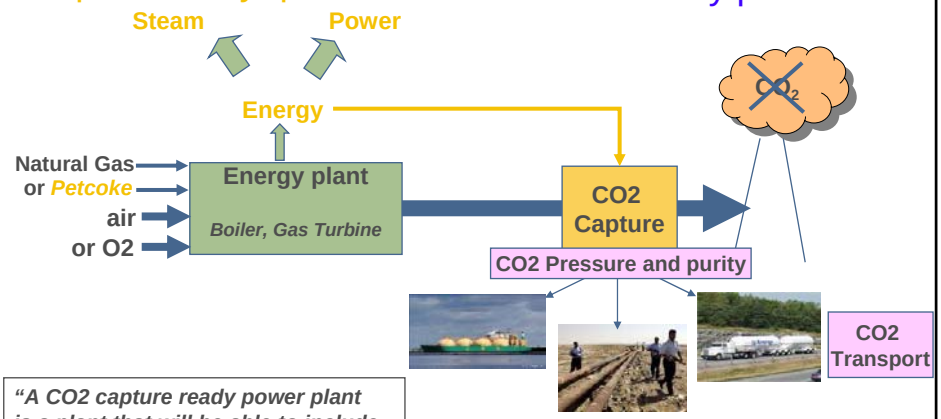


TOTAL

Definition

"Capture ready" plant….

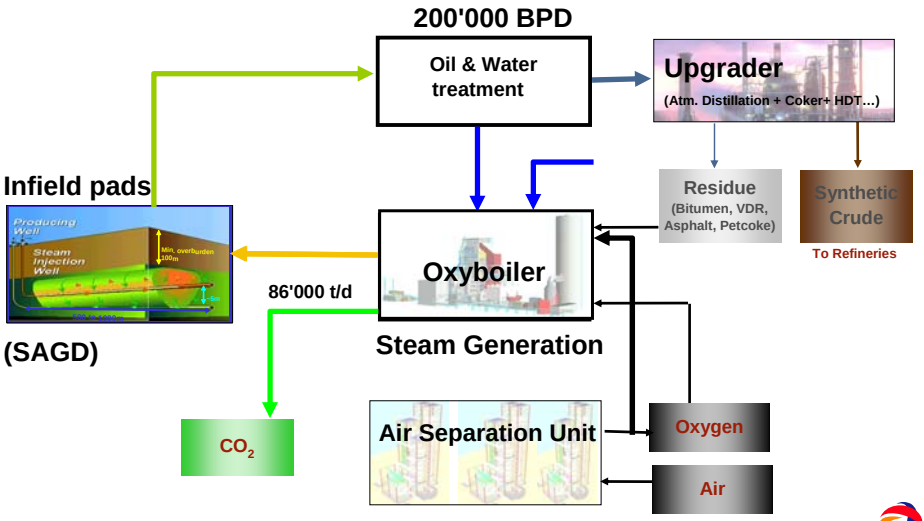
or CCS ready plant



"A CO2 capture ready power plant is a plant that will be able to include CO2 capture when the necessary regulatory and/or economic drivers are in place, thereby avoiding the risk of 'stranded'assets and consequent 'carbon lock-in'""

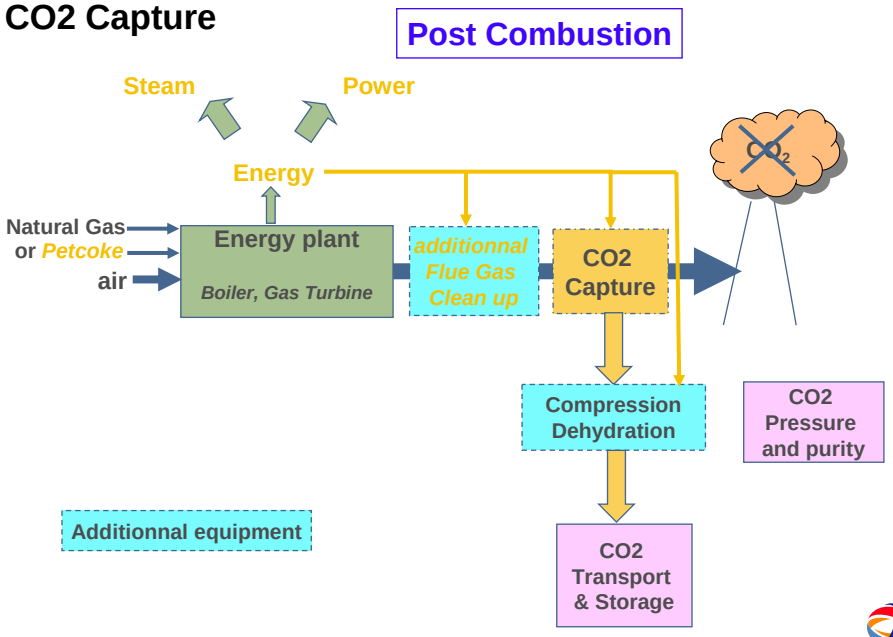
TOTAL

Oxycombustion as CO_2 capture technique in Extra Heavy Oil production schemes

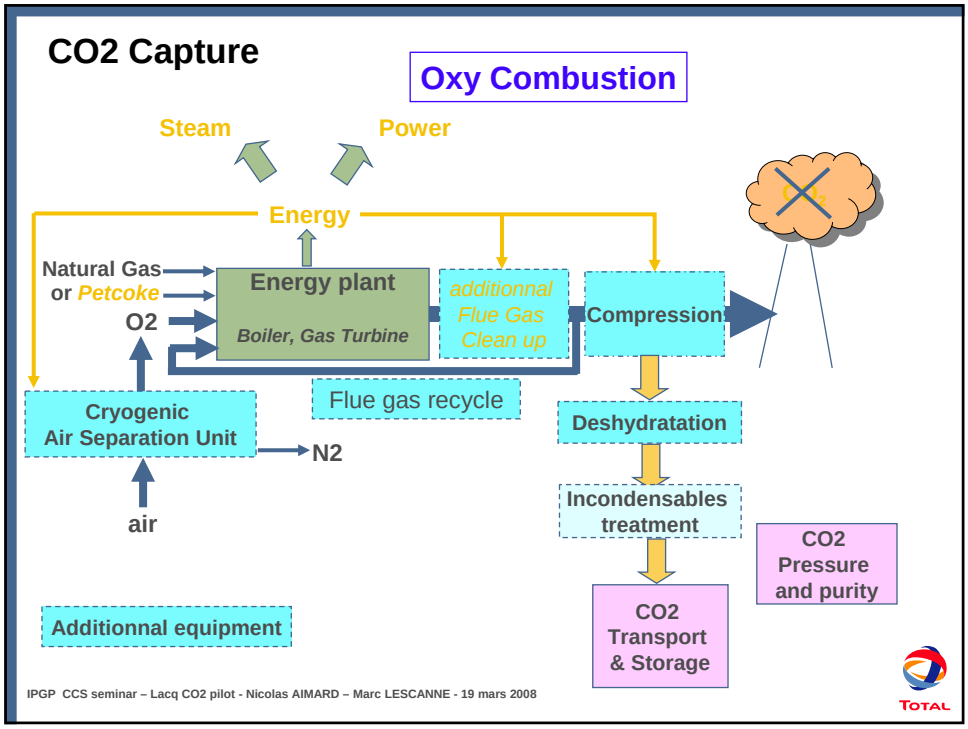


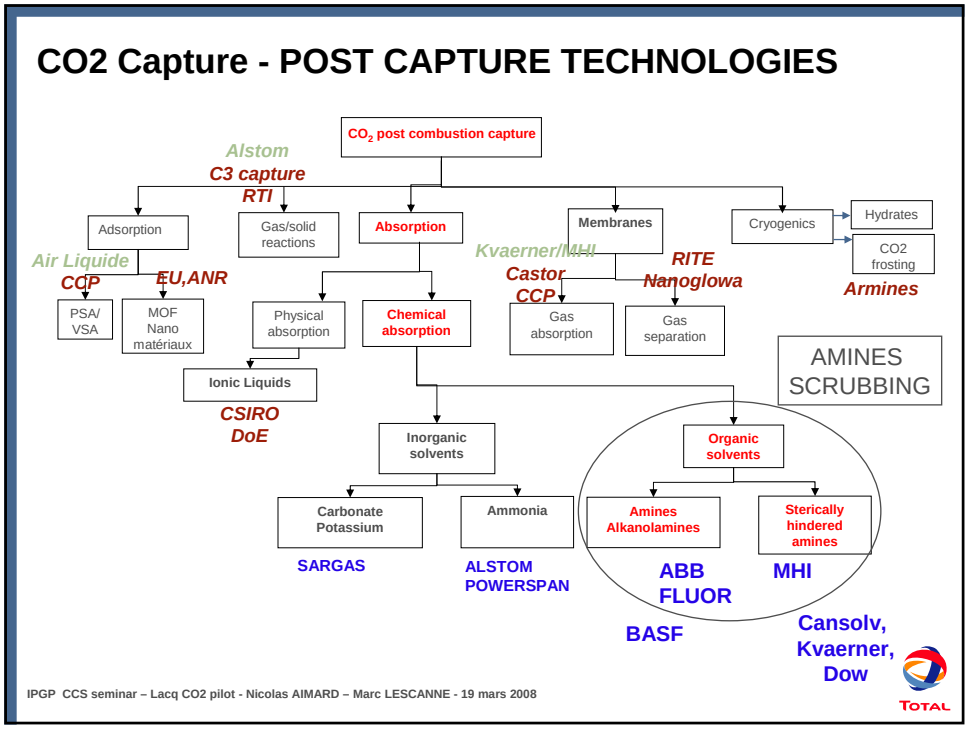
TOTAL

CO2 Capture



TOTAL


CO2 Capture
Oxy Combustion
Steam
Power
Energy
Natural Gas
or Petcoke
O2
Energy plant
Boiler, Gas Turbine
additionnal
Flue Gas
Clean up
Compression
CO2
Flue gas recycle
Cryogenic
Air Separation Unit
N2
air
Deshydratation
Incondensables
treatment
CO2
Pressure
and purity
CO2
Transport
& Storage
Additionnal equipment
IPGP CCS seminar – Lacq CO2 pilot - Nicolas AIMARD – Marc LESCANNE - 19 mars 2008
TOTAL


CO2 Capture - POST CAPTURE TECHNOLOGIES
CO2 post combustion capture
Alstom
C3 capture
RTI
Adsorption
Gas/solid
reactions
Absorption
Membranes
Cryogenics
Hydrates
CO2
frosting
Armines
Air Liquide
CCP
EU,ANR
PSA/
VSA
MOF
Nano
matériaux
Physical
absorption
Chemical
absorption
Kvaerner/MHI
Castor
CCP
RITE
Nanoglowa
Gas
absorption
Gas
separation
AMINES
SCRUBBING
Ionic Liquids
CSIRO
DoE
Inorganic
solvents
Organic
solvents
Carbonate
Potassium
Ammonia
Amines
Alkanolamines
Sterically
hindered
amines
SARGAS
ALSTOM
POWERSPAN
ABB
FLUOR
MHI
BASF
Cansolv,
Kvaerner,
Dow
IPGP CCS seminar – Lacq CO2 pilot - Nicolas AIMARD – Marc LESCANNE - 19 mars 2008
TOTAL

Amine capture units – ex. ABB Lummus

AES Shady Point Power Plant
Captures 2-3% of CO_2 from a 320MWe CFB plant
Panama, Oklahoma

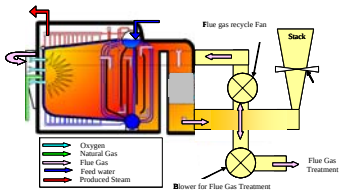
AES Warrior Run Power Plant
Captures 10% of CO2 from a 205 MWe (gross) CFB plant
Cumberland, Maryland

TOTAL

CO2 Capture - OXYCOMBUSTION TECHNOLOGIES

- **Oxycombustion industrial pilots on going**
  - Conventional boilers

  typically 30 MW – Lacq, Germany, Australia, US
  - Cryogenic air separation units
  - Natural gas, coal and bitumen



- **Oxycombustion technology future development**

"Classical" Oxycombustion
Cryogenic ASU + conventional boiler

Advanced oxyboiler
- oxy OTSG
- oxy CFB
- oxy GT

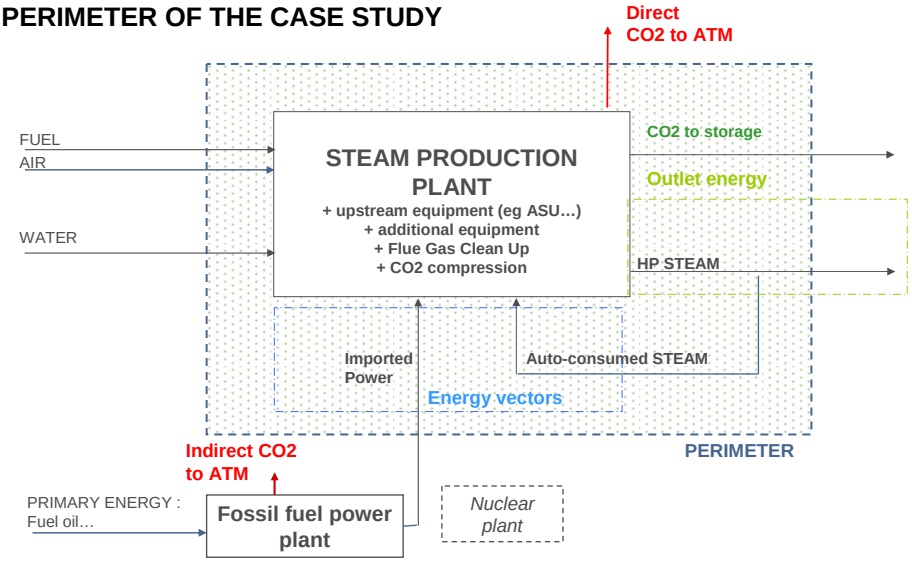
Advanced ASU : HT membranes
- ITM
- OTM
- CAR

- *Chemical looping*

TOTAL

Oxycombustion versus post capture

PERIMETER OF THE CASE STUDY

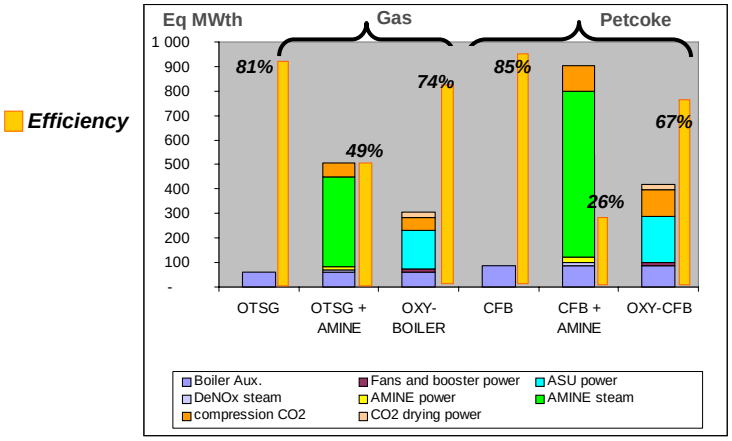


$$EFF = \frac{[\text{Produced - Consumed Steam}](\text{MWth}) + \text{Produced Power(MWe)} + Q_{H2} \times \text{LHV (MW)}}{Q_{\text{combustible}} \times \text{LHV (MWth)} + \text{Imported power(eqMWth)}} \times 100$$

CO2 Capture – example of a 1000 MW steam generation

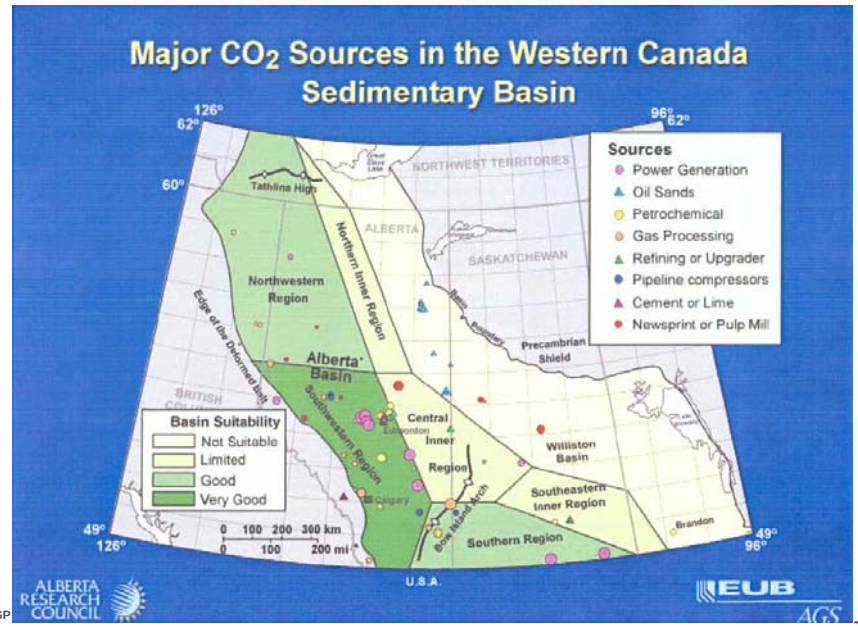
Energy consumptions and efficiency – Gas or Petcoke

Auto consumption steam - imported power – typical MEA / ASU 95%



$$EFF = \frac{[\text{Produced - Consumed Steam}](\text{MWth})}{Q_{\text{fuel}} \times \text{LHV (MWth)} + \text{Imported power(eqMWth)}} \times 100$$

CO_2 storage capacity in Alberta



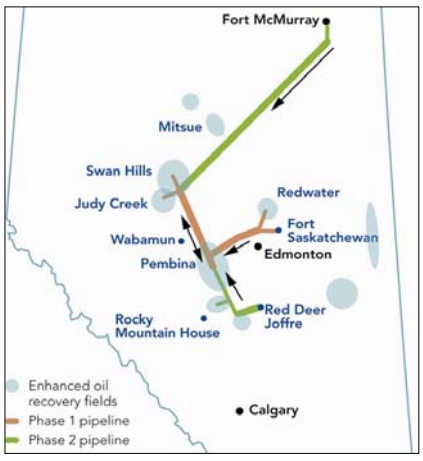
IPGP

CO_2 transport to storage sites in Alberta ?

- **THE ICO$_2$N INITIATIVE**

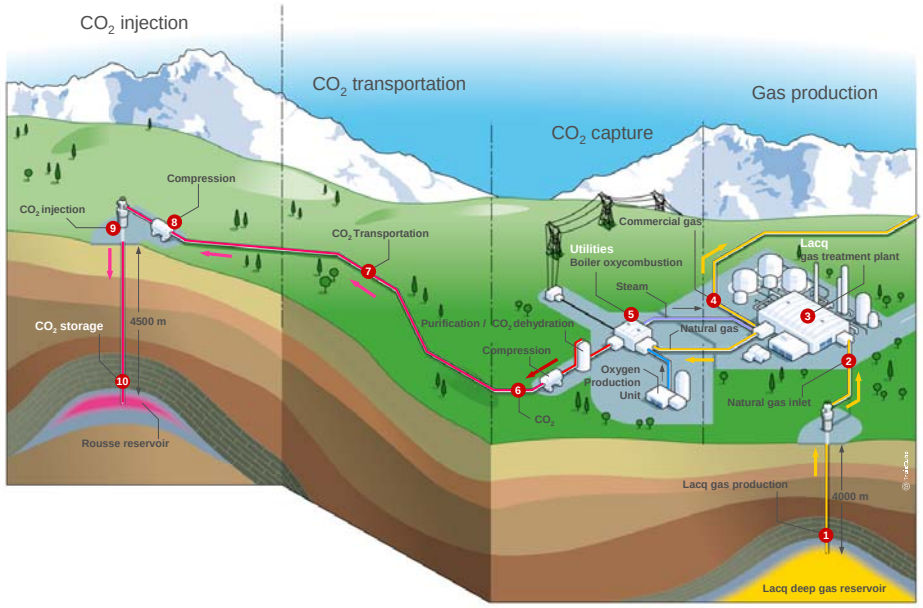
- **A large network that is planned from the beginning is a key recommendation of ICO$_2$N's analysis**
  - An open access CO_2 pipeline system to connect multiple capture and storage locations.
  - It can be built in phases,
  - Optimizes long term efficiency and effectiveness.
  - It will require multiple industry sectors and coordinated input from governments.

- **Conceptual studies of a 60Mt/y capacity pipeline from Fort McMurray to depleted O&G fields**



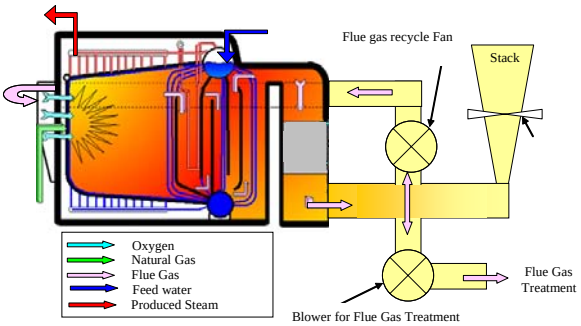
Potential CO_2 Pipeline Routing

An integrated CCS project at Lacq



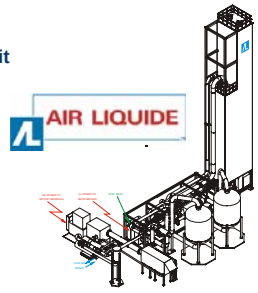
Boiler revamping

- Existing boiler revamping with CO2 recycling
- 40 t/h of steam 60b/450°C (30MWth) to HP steam network



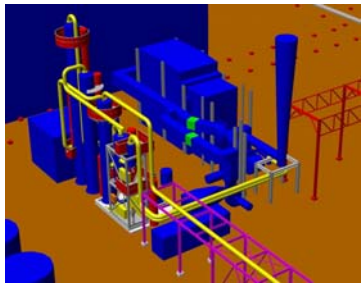
- ALSTOM in charge of boiler revamping works
- Cryogenic Air Separation Unit

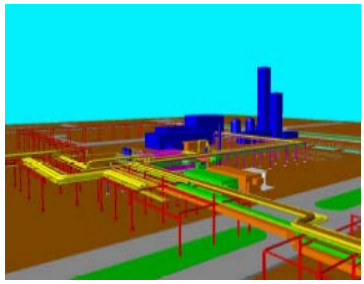
240t/day oxygen required



TOTAL

Capture facilities within Lacq existing utilities plant



TOTAL

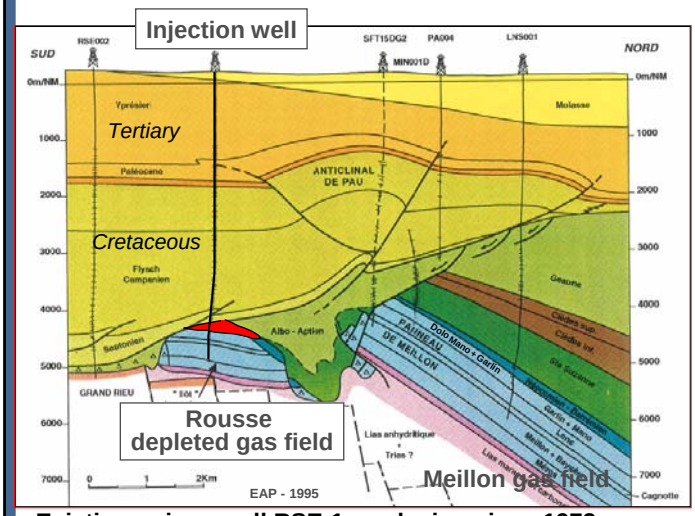
Transportation and injection into a gas depleted reservoir


Typical CO_2 composition

CO_2:	92.0 %
O_2:	4.0%
Ar:	3.7%
N_2:	0.3%

TOTAL

CO_2 injection into a depleted gas reservoir



Jurassic fractured dolomitic reservoir ***(in red)***

Thick cap rock ***(in green and orange)***

Depth # 4500m/MSL

Temp. # 150°C

Initial P = 485 barg

Current P # 30 barg

Initial CO_2 = 4,6%

No aquifer

Existing unique well RSE-1 producing since 1972

Well work over planned mid 2008

TOTAL

From pre-assessment to monitoring plan

- **Pre-assessment studies (geological and reservoir model, caprock integrity, fault reactivation, geochemical interactions, partial logging etc.)**

  Rousse reservoir selection criteria

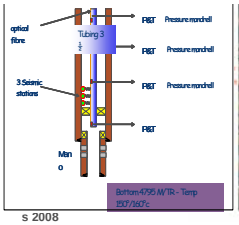
  - ***Production data and knowledge, reservoir and caprock cores, thick caprock***
  - ***Limited pressure at the end of pilot phase (# 70 barg) compared to initial pressure (480barg)***
  - ***No abandonned well; one single well with a proper completion; existing footprint***
  - ***Not connected to active aquifer***
  - ***Reservoir matrix initially in equilibrium with CO_2***

- **Scientific studies in collaboration before, during and after CO_2 injection (IFP, BRGM etc.)**

- **Scientific follow-up Comittee with external experts**

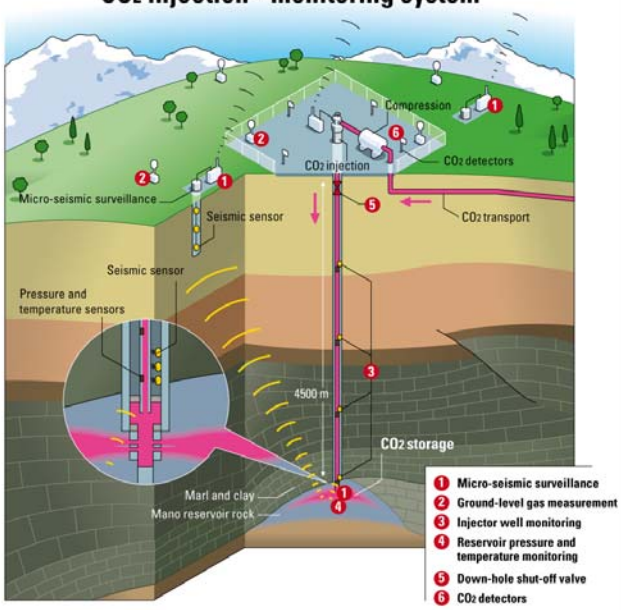
- **Monitoring plan base case**

  - **Monitor CO2 injection well**
  - **Monitor reservoir behaviour**
  - **Monitor storage integrity**



TOTAL

Lacq CO_2 pilot
CO_2 injection - monitoring system



TOTAL

Public acceptance of CCS and Lacq pilot

What is required ?

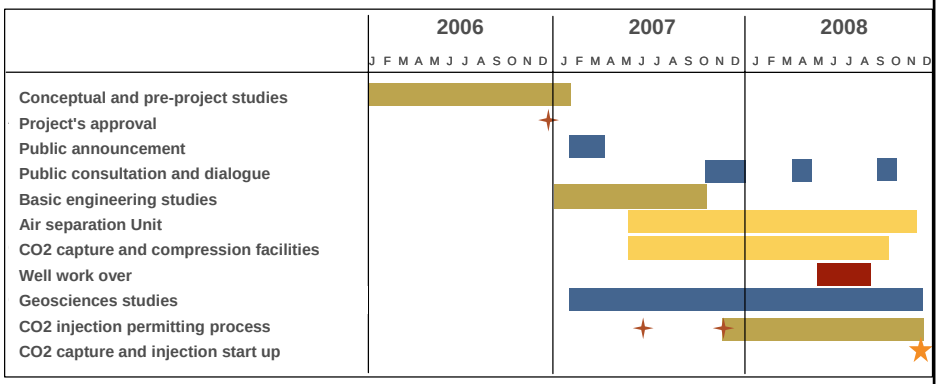
- Provide a better understanding of CCS technology context, issues and therefore promote the CCS technology deployment
- Share the opportunity of having such project in Lacq area and provide technical information of the Lacq pilot itself
- Have all questions raised to propose answers at different steps
- Provide information on short and longer term scientific follow up (dedicated scientific committee appointed with external experts) and monitoring
- Help identifying project possible contribution to local socio-economic development
- Demonstrate transparency and provide access to relevant information

Public consultation

- Large public consultation phase upstream permitting phase
  - Open dialogue with all stakeholders
  - Public meetings open to public
  - Transparency

TOTAL

Project schedule – tentative milestones



Project information also available on

www.total.com/corporate-social-responsibility

TOTAL