11- an international roadmap
Existing Pilot plants in operation or under development:

Synfuel: Board Energy Corp. (Vancouver): 5 109 $ at walls hill (OHIO)
   Power: 50 000 b/day

Rentech Inc (Los Angeles), Plant Natchez (Mississippi):
   30 000 b/day starting 2011

Methanol: Mitsui Che: mitsui ceramic inc 1.5 109 yen

Methanol to olefin (USA - China): 1.6 109 T/Year to 60 000 T/Year of
   C2H4, C3H6

Synfuel: to Fisher Tropsch (gasification of coal and waste (South Africa, US))

Syngas from high power arc plasma: 10 to 20 megawatt (Russia, Tech Rep, CEA)
in an Huaneng Group: China biggest electricity provider: scale up its
   Shidongkou n°2 to capture existing coal plant in Shanghai: 3000 T/Y

Shanhua Group: China biggest coal producer: IGCC process for coal to liquid
   1 million ton of diesel per year in Mongolia
GreenGen: an integrated gasification combined cycle (IGCC) in China

- IGCC plant was approved by the Chinese government last June 2009
- Construction in Tianjin
- IGCC turns coal into gas which allows easy separation of CO2 from combustible gases
- This project is the leading carbon capture for coal fired power

- Science 25 sept 2009 VOL 325 p 1646
This opportunity needs a value chain

Petroleum Value Chain:
- Exploration
- Production
- Transport
- Refining
- Blending

CO₂/CH₄ Value Chain:
- Recycle
- Collection
- Transport
- Electrolysis/Methanation
- CH₄ for power

- No hurdles
- Infrastructure
- Scale
- Stack recovery
- Transport cost
- Vessel compatibility
- Storage
- Electrode system
- Catalyst system
- Heat provision
- Oxygen management
- Water management
- No hurdles
Figure 1. Possible route of production and usage of methanol.

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Raw material and energy storage

- **Electrical power**
- **Carbon source**
  - CO2
- **Active chemical species**
  - H2
- **Energy balance kWh low cost/kWh upper cost**
  - CO2 30% to 70%
  - CO2 = 0%
  - CO2 # 30 to 50%
  - CO2 # 30 to 70%
  - CO2 30% To 70%

- **Processes**
  - Electrolysis of sea water
  - Non equilibrium thermal plasma process
  - CH3OH or CH4 Energy storage by catalysis
  - CO/H2
  - CO/H2
  - CO/H2
  - CO

- **Processes**
  - Fisher Tropsch
  - Synthesis of hydrocarbon
  - Energy storage Heat capacity of the ceramic Hoven
  - Energy storage High speed of thermal transfer
  - CO-CH4

- **Economical aspects**
  - Three phase arc plasma 600 KW - 1000 KW
  - 1000 m³/h
  - Energy balance kWh low cost/kWh upper cost
  - Bitume sand added value
  - Tar valorisation by CO2 recycled
  - Coal treatment on fluidized Bed process
  - Added value by energy storage
  - Chemical synthesis
  - Oil production from waste (baril > 40 $)
  - Evaluation 500000 T on coal
Liquid CO₂

Sequestration
and new ciment for CO₂ storage
(0,6 T/T ciment)
(magnesium silicate)

Solvant properties

Cooling fluid

Chemical synthesis

- Area synthesis (fertilizant)
- HCOOH formic acid (HCOOH)
- H₂O₂ synthesis
- C₂H₅OH synthesis
- Polycarbonate polymer with insulating properties
- Copolymérisation epoxide + CO₂ → polycarbonate aliphatique biodégradable properties (30 to 50 % weight CO₂) and good mecanical properties
Liquid CO₂

Energy processes

Syngas production

CO₂ ⇄ CO

(CO + H₂)

Fisher Tropsch Process
for synfuel hydrocarbons

3

Coal gazeification
Waste or wood gaseification

(C + CO₂ ⇄ 2 CO)

1

Energy storage by Redox processes

CO₂ ⇄ CH₄

Electrosynthesis
(electrolysis H₂O → H₂)

CO₂ + H₂ → CH₄

Electrosynthesis
CO₂ + H₂ → CH₃OH

2

Plasmas processes
direct energy storage

CO₂ ⇄ CO