Pushing the limits

Impact of upstream technological advances on future oil supply
Reserves evolution

Volumes discovered in new fields

Produced volumes non-renewed by new discoveries

Oil

Gaz

Produced volumes renewed by new discoveries

Produced volumes non-renewed by new discoveries
Reserves evolution

Initial Content

Maximum Recovery

Produced

Reserves

Ressources

Discoveries

33 %

70 %

25 %

>> 25 %

Increasing drilling success

(Additional reserves)

Exploration

Production

Source: IFP 2007

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Exploration

Issues
- reduce the risk in exploration
- assess fluid composition and distribution

R&D challenges
- improve seismic imaging
- improve the knowledge of geological processes
  - complex tectonics
  - sedimentary deposit
- improve compositional modeling
- include diagenesis
Basin modelling towards full integration

Restoration

Stratigraphic modeling

OpenFlow platform

HC generation migration & trapping

Paleoclimate

LGR

Reservoir modeling
Renewing the reserves

- Better locate the accumulations
- Characterize the flow potential
  - Static & dynamic reservoir characterization

- Reduction of uncertainties on OIP & reserves

Reservoir management
  - Monitoring + interactive reservoir modeling

Redevelopment plans

Use of EOR processes
  - Thermal & chemical processes, Gas, CO2, N2, air injection

Increase recovery factor

Increase oil recovery

Optimize the production scheme to access OIP
  - Advanced well technology
  - Additional reserves

Optimize well productivity
  - Formation damage control
  - Completion strategy
  - Well profitability & Opex
Reservoir management

**Issues**
- complex reservoirs
  - structure
  - heterogeneity
  - diagenesis

**R&D Challenges**
- characterize the geology and the flow path
  - at different scale
  - taking into account the heterogeneity (geostatistics)
  - quantifying its impact (sensitivity analysis)
  - quantifying uncertainties
- include diagenesis
Characterization

- Pore-network-scale recovery
  - 10^{-3} m

- Block-scale recovery
  - 1 m

- Reservoir Panel scale

- Fracture swarms
  - 1 m

- Seismic faults
  - 10^{-3} m

- Sub-seismic faults
  - 10^{+3} m
Reservoir management

**Issues**
- improve the recovery factor
  - deal with complex fluids, complex recovery processes, heterogeneous reservoirs
  - assess and reduce the risk and uncertainties
- get the best from specialized simulators
  - open structure
  - interoperability

**R&D Challenges**
- improve the physical modeling
  - thermodynamics, flow processes in porous media, pore network modeling, upscaling
- improve the reservoir modeling workflow
  - taking advantage of interoperability to use the best technologies
  - updating the geological modelling using dynamic data
- couple basin to reservoir, surface to subsurface
Reservoir management

**Issues**
- Increase production through EOR
- produce reservoirs in a sustainable way

**R&D Challenges**
- carbonates
- heavy oils
- develop strategies that comply with environmental constraints
  - CO2 EOR/EGR
  - PWRI even with EOR
Optimize the production

Production in deep offshore and/or remote reserves

CO2 transport & re-injection

Gas Treatment

EOR

Separation water re-injection

Transport from subsea to beach

hybrid pipe

Clip™ riser

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Production

Issues

- extreme environment
  - deep water
  - deeply buried reservoirs (DBR)
  - arctic
  - sour gas

R&D challenges

- improve facilities
  - material
    - thermal insulation
    - weight (hybrid pipes, special metals, composites)

- improve flow assurance
  - hydrate transport
  - multiphase pumping
  - modelling opened platforms

- handle sour gas
  - energy efficient solvents
  - improved contactors
  - cryogenic process
Conclusions: technological advances contribution

- **Reduce the risk in exploration**
  - seismic imaging (fractures, subsalt, foothills, ...)
  - basin modelling chain
    - from seismic data to fluid migration & trapping up to the reservoir model based on good physics, using advanced computer sciences

- **Recover 70% of OIP**
  - use advanced quantitative reservoir characterization
    - including diagenesis
  - develop efficient & sustainable EOR processes
  - optimize reservoir production
    - "real time monitoring" including production data & 4D seismic
Conclusions: technological advances contribution

- Produce under extreme conditions
  - subsea & deep water
    - reduce the weight of offshore facilities
    - optimize subsea separation
    - manage flow assurance (hydrates transportability)
    - real time monitoring/operation: couple reservoir & process modelling
  - sour gas
    - reduce the energy consumption
  - heavy oils
    - optimize through better reservoir characterization & monitoring
Thank you!

Innovating for energy
WorkFlow based on an Opened platform

Geostatics → geological model → CondorFlow Loop → Dynamic simulation → Upscaling

Fractured reservoirs
Polymer flood: Field Results

Successful pilot calls for more than 100 wells a year to be drilled between 2007 and 2010 with total expenditures > $800 million.
Acid gas reserves with $\text{CO}_2 > 2\%$ and/or $\text{H}_2\text{S} > 100\text{ppm}$ (except North America)

40% of remaining gas reserves are sour

Reserves with $>10\% \ \text{H}_2\text{S}$: + 350 Tcf
Reserves with $>10\% \ \text{CO}_2$: + 650 Tcf

Source: Total - Iris 21 database from IHS Energy June 2004
Sprex®: Lacq pilot plant