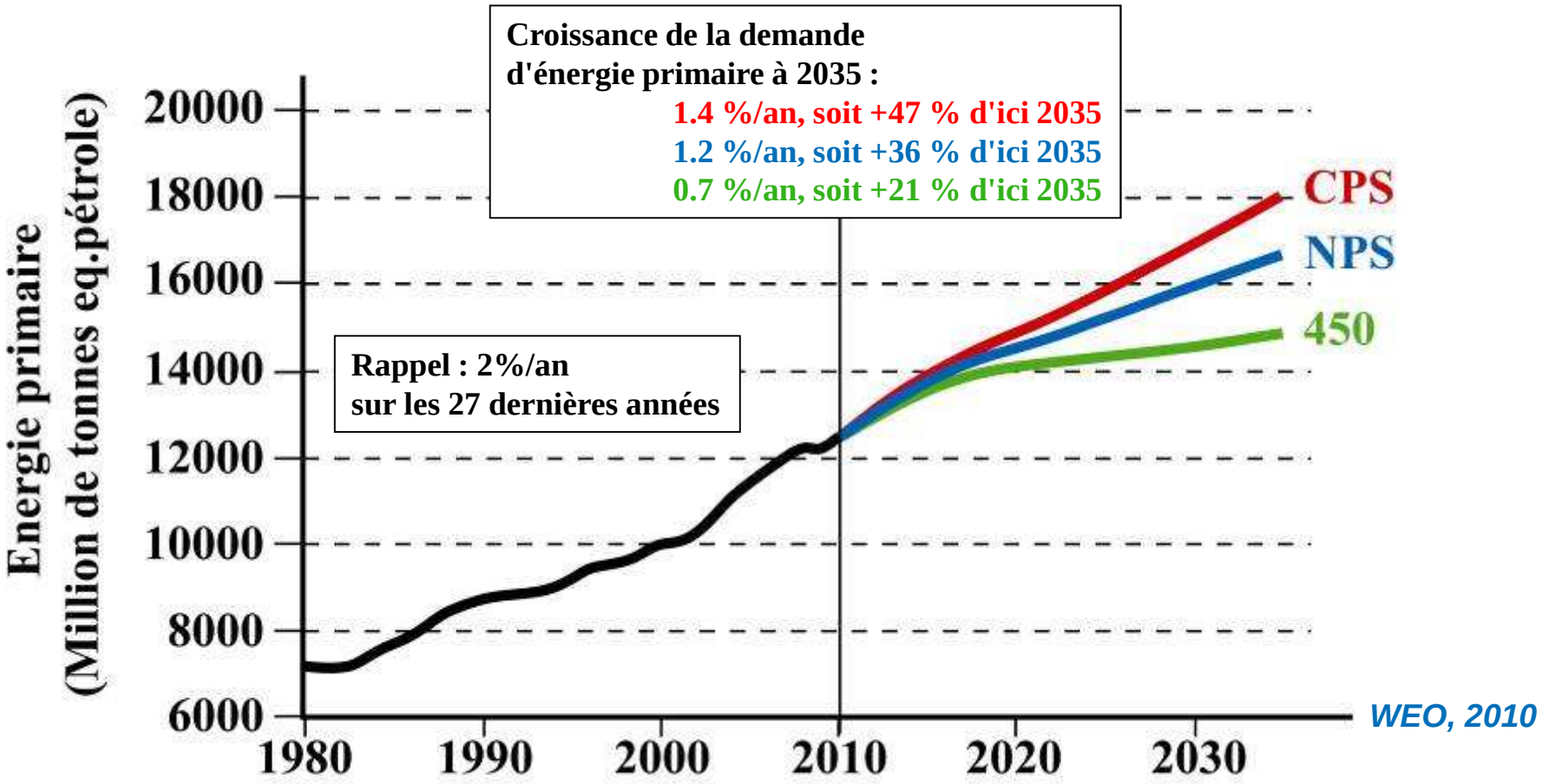
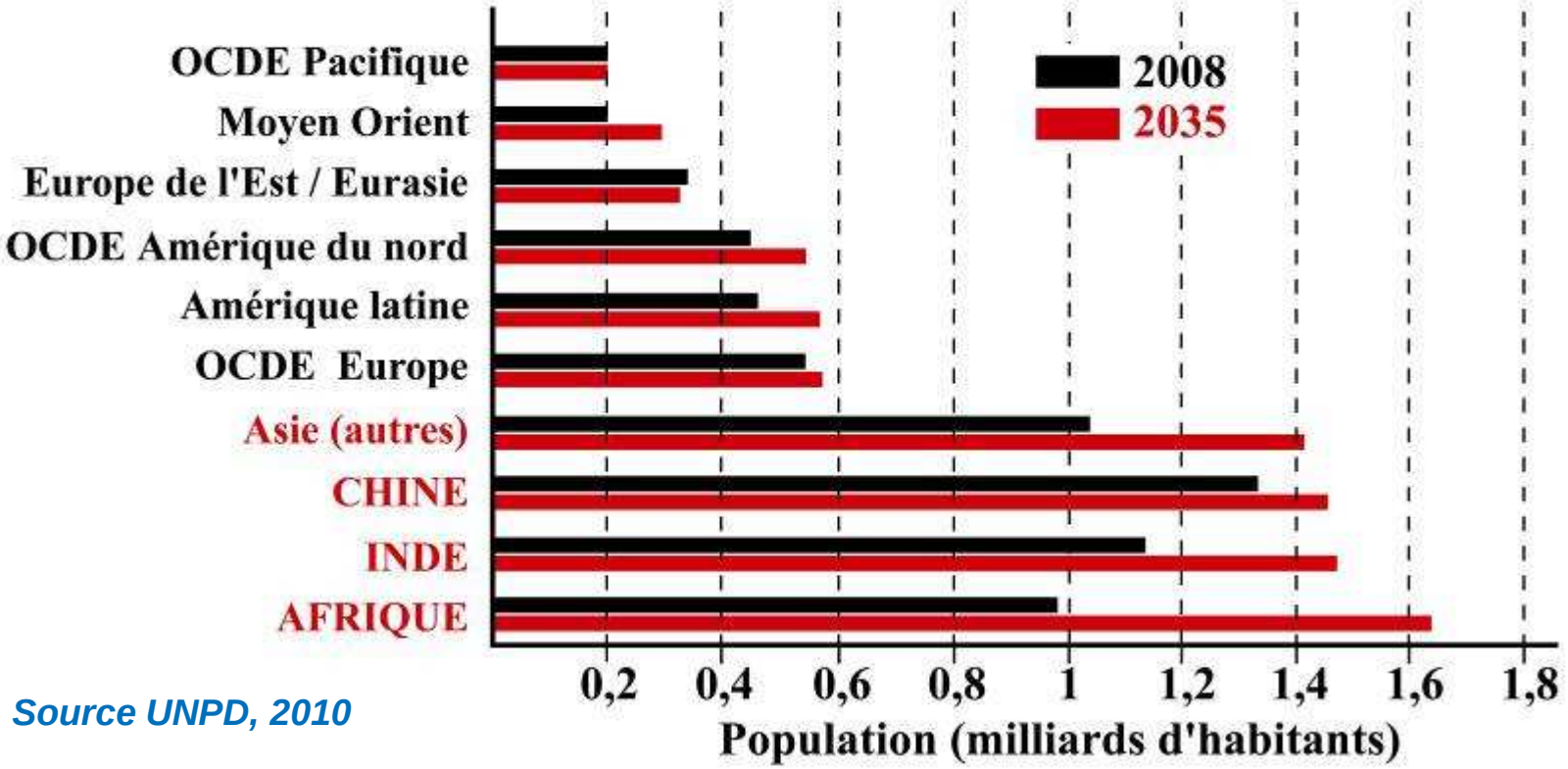
Le rôle des hydrocarbures de roche-mère dans l'approvisionnement mondial

Roland Vially, IFP Energies nouvelles

La demande en énergie primaire continue a augmenter quel que soit le scénario retenu



Une tendance lourde : L'augmentation de la population

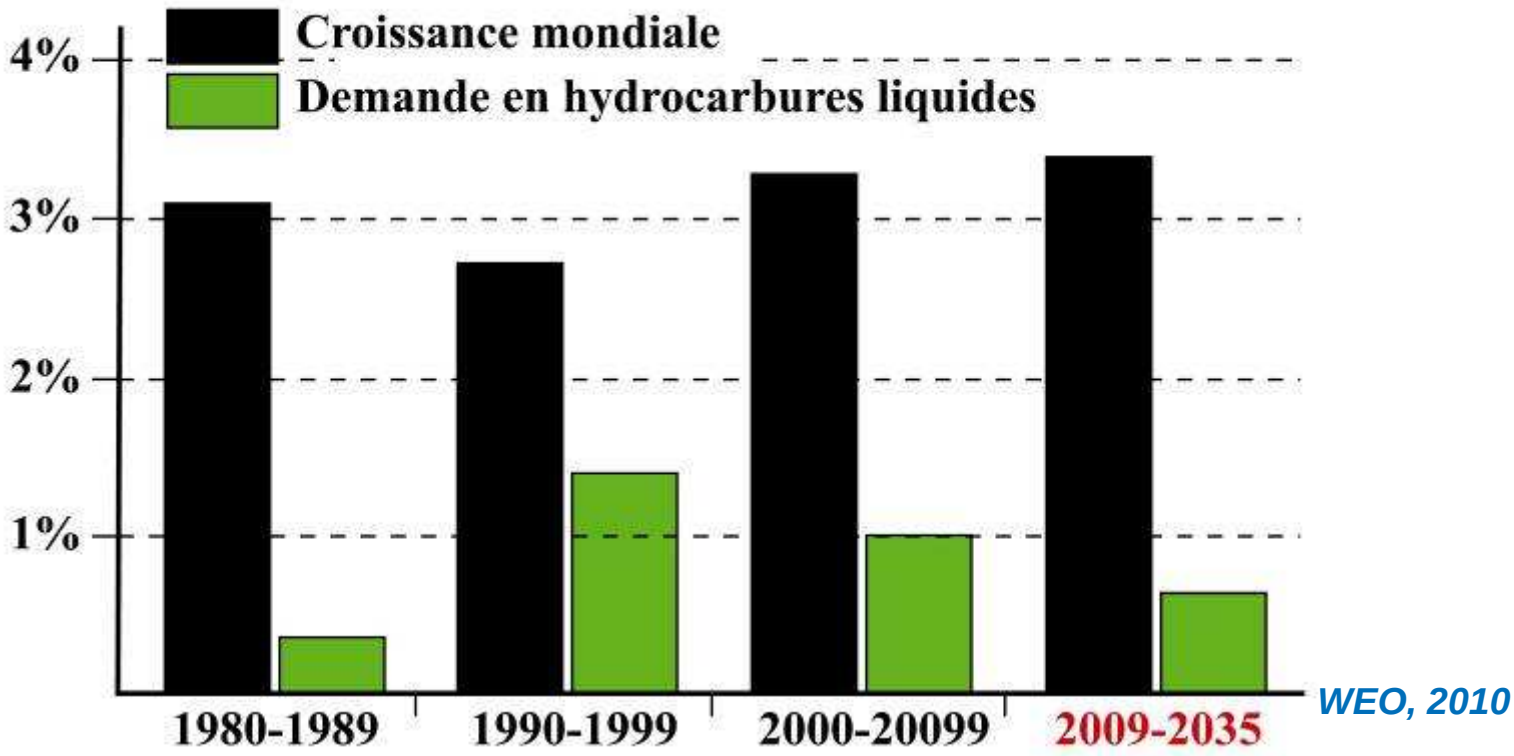


Source UNPD, 2010

L'augmentation annuelle de la population sera de l'ordre de 1% jusqu'en 2035

La population devrait atteindre les 8,5 milliards en 2035

Une autre tendance lourde : La croissance économique mondiale

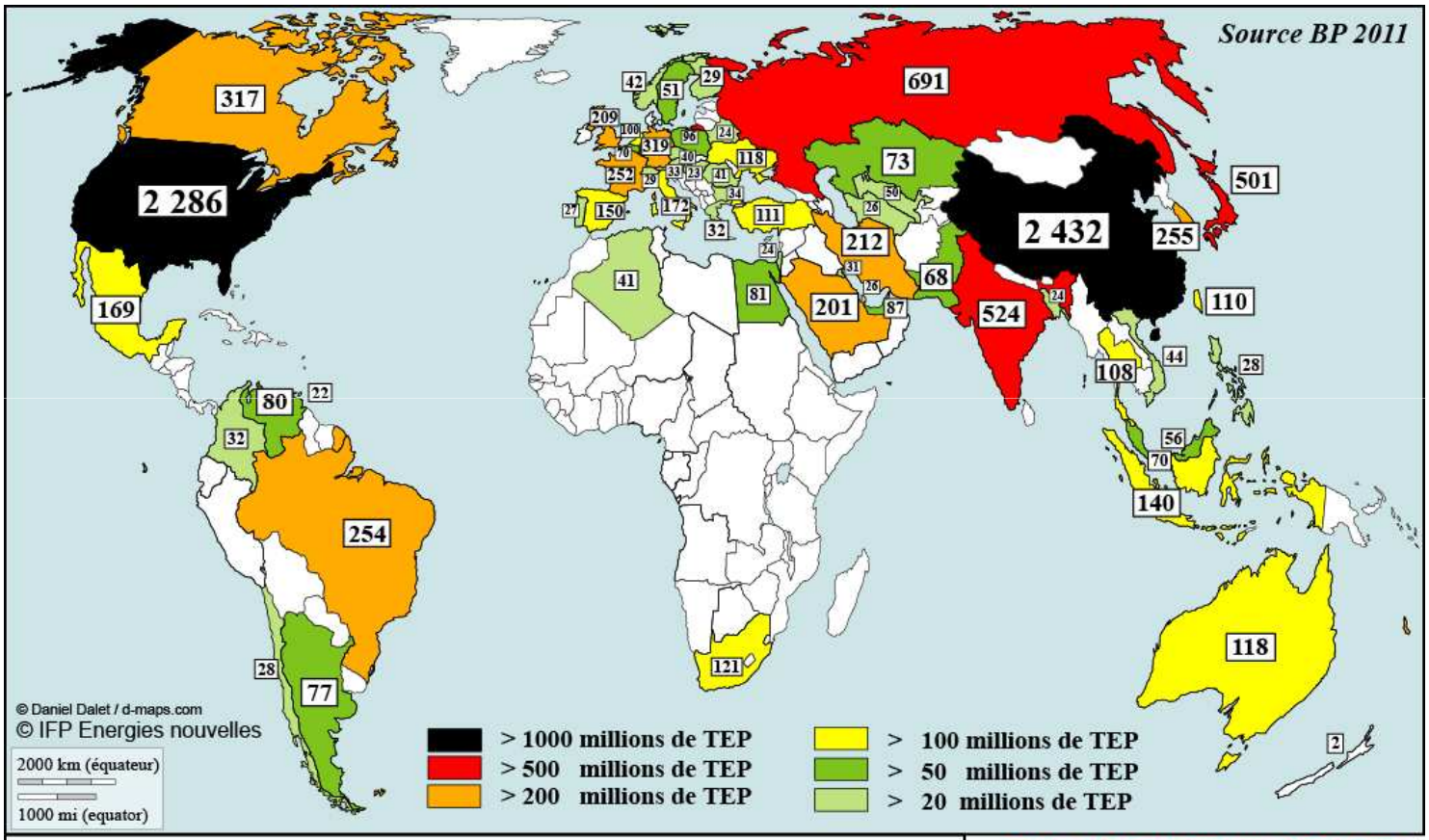


WEO, 2010

L'augmentation annuelle de la croissance mondiale devrait être de l'ordre de 3,2% sur la période 2009-2035

L'augmentation annuelle de la demande en hydrocarbures liquides ne devrait être que de 0,6%

La demande mondiale en énergie primaire

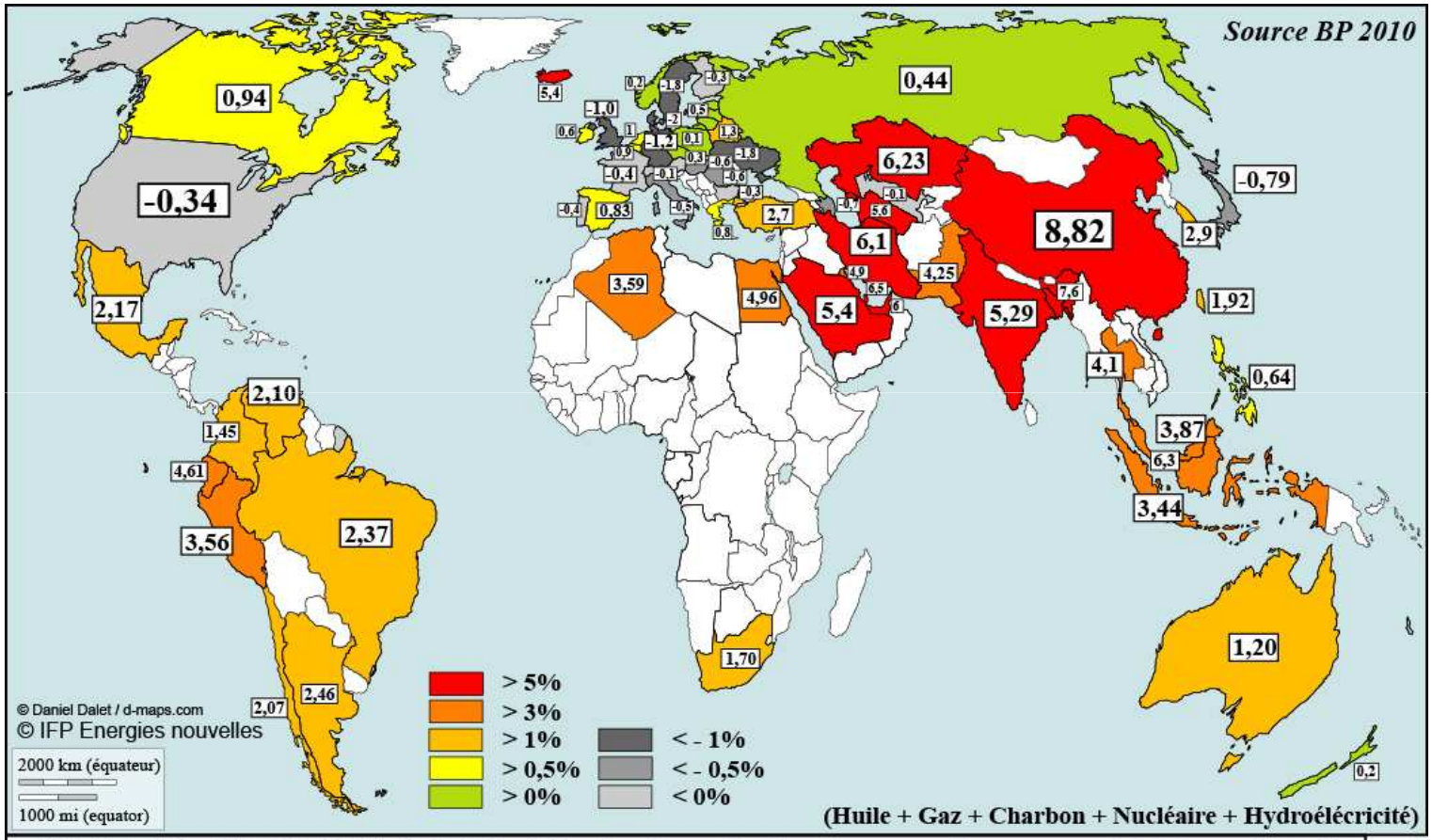


ENERGIES PRIMAIRES : Consommation (2010)

Huile + Gaz + Charbon + Nucléaire + Hydroélécricité : 12 002 MTep

Chine	: 2 432 Millions de TEP	Japon	: 501 Millions de TEP	Brésil	: 254 Millions de TEP
USA	: 2 286 Millions de TEP	Allemagne	: 319 Millions de TEP	FRANCE	: 252 Millions de TEP
Russie	: 691 Millions de TEP	Canada	: 317 Millions de TEP	Iran	: 212 Millions de TEP
Inde	: 524 Millions de TEP	Corée du Sud	: 255 Millions de TEP	Grande Bretagne	: 209 Millions de TEP

Variation de la demande durant la dernière décennie



ENERGIES PRIMAIRES : Variation de la demande entre 1999 et 2009)

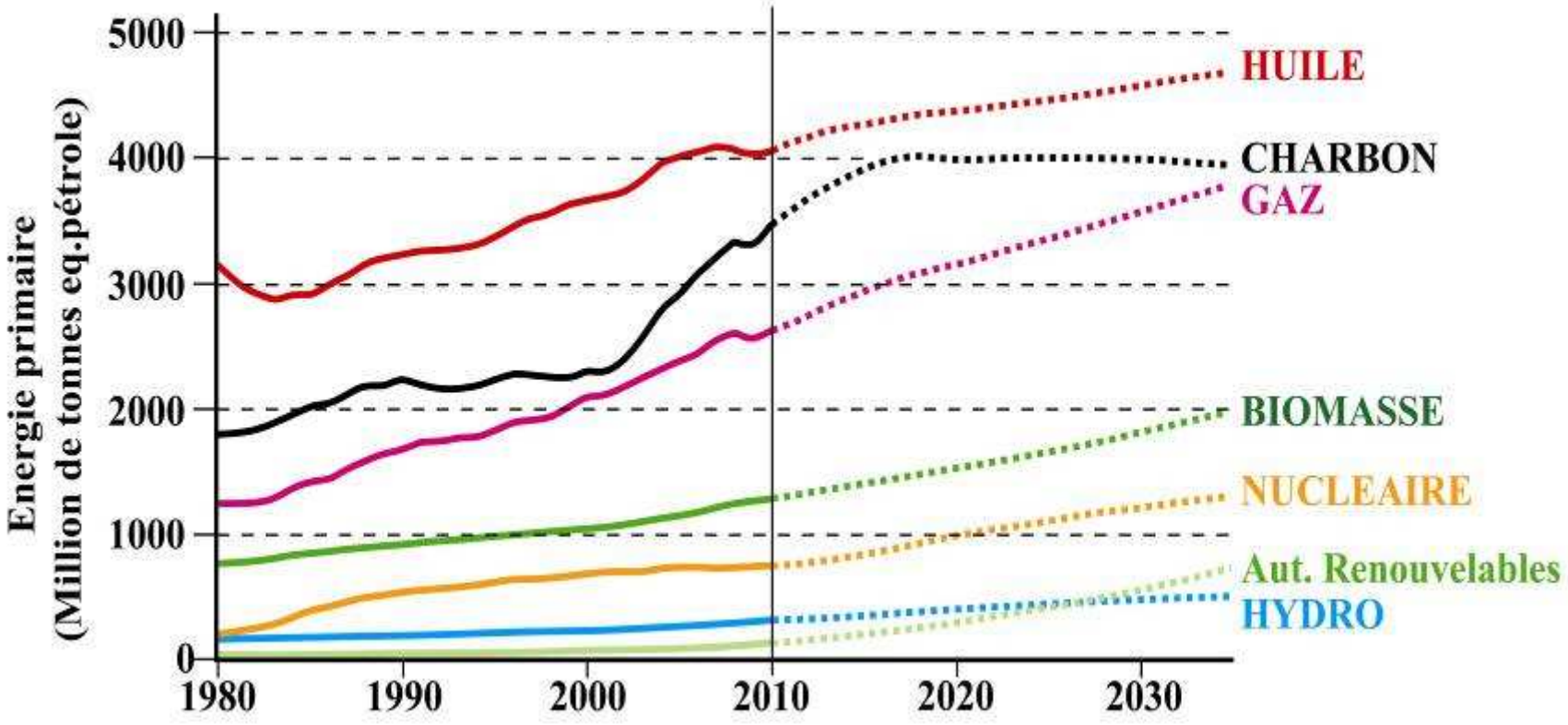
Exprimé en % d'augmentation annuelle . Moyenne mondiale + 2,14% par an.

ASIE - PACIFIQUE : + 5,30 %	AFRIQUE : + 2,69 %	Europe et Eurasie : + 0,04 %
MOYEN - ORIENT : + 5,25 %	AM. Cent. et Sud : + 2,38 %	AM. du Nord : - 0,06 %

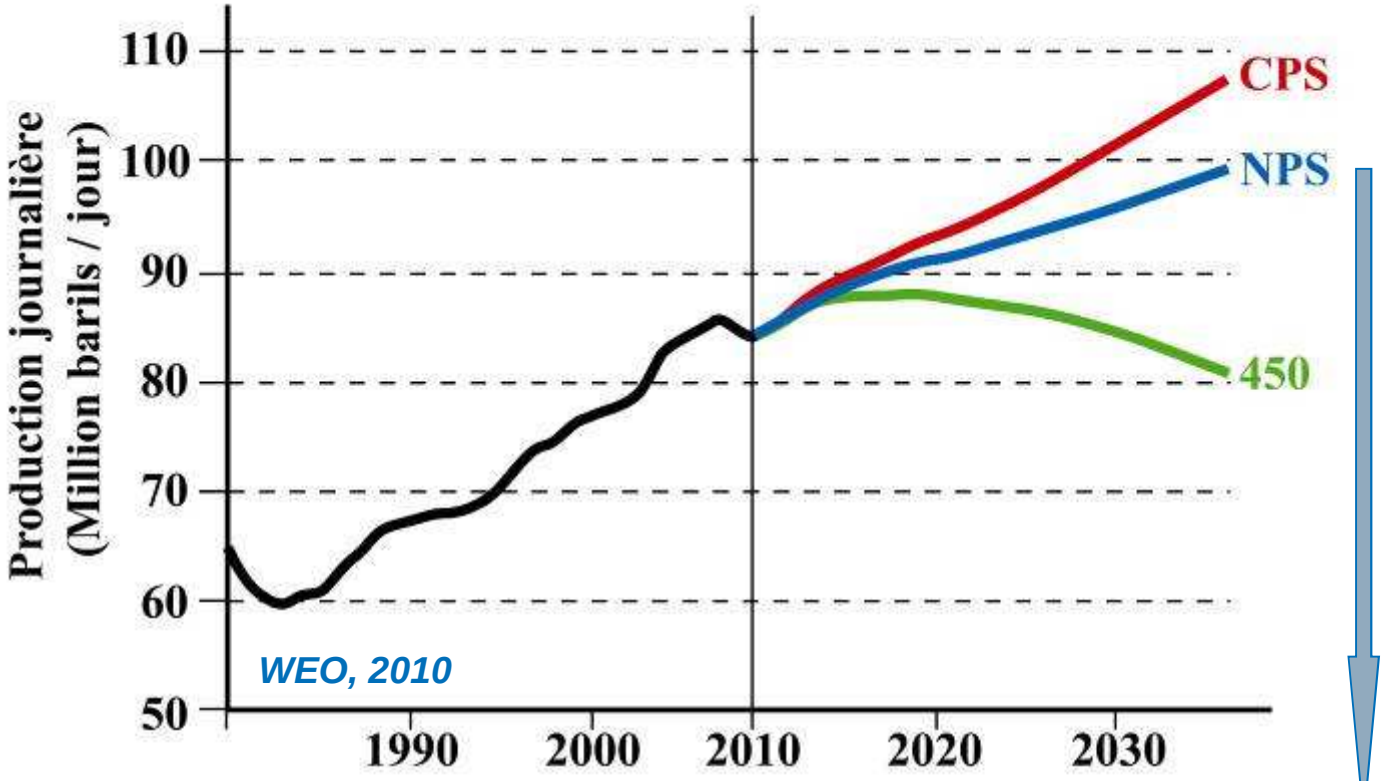
Malgré une baisse relative de l'importance des hydrocarbures leur consommation continue à progresser.

60% ***54%*** ***50%***

85% ***81%*** ***74%*** **En. fossile**



La demande en hydrocarbures liquides continue à progresser.

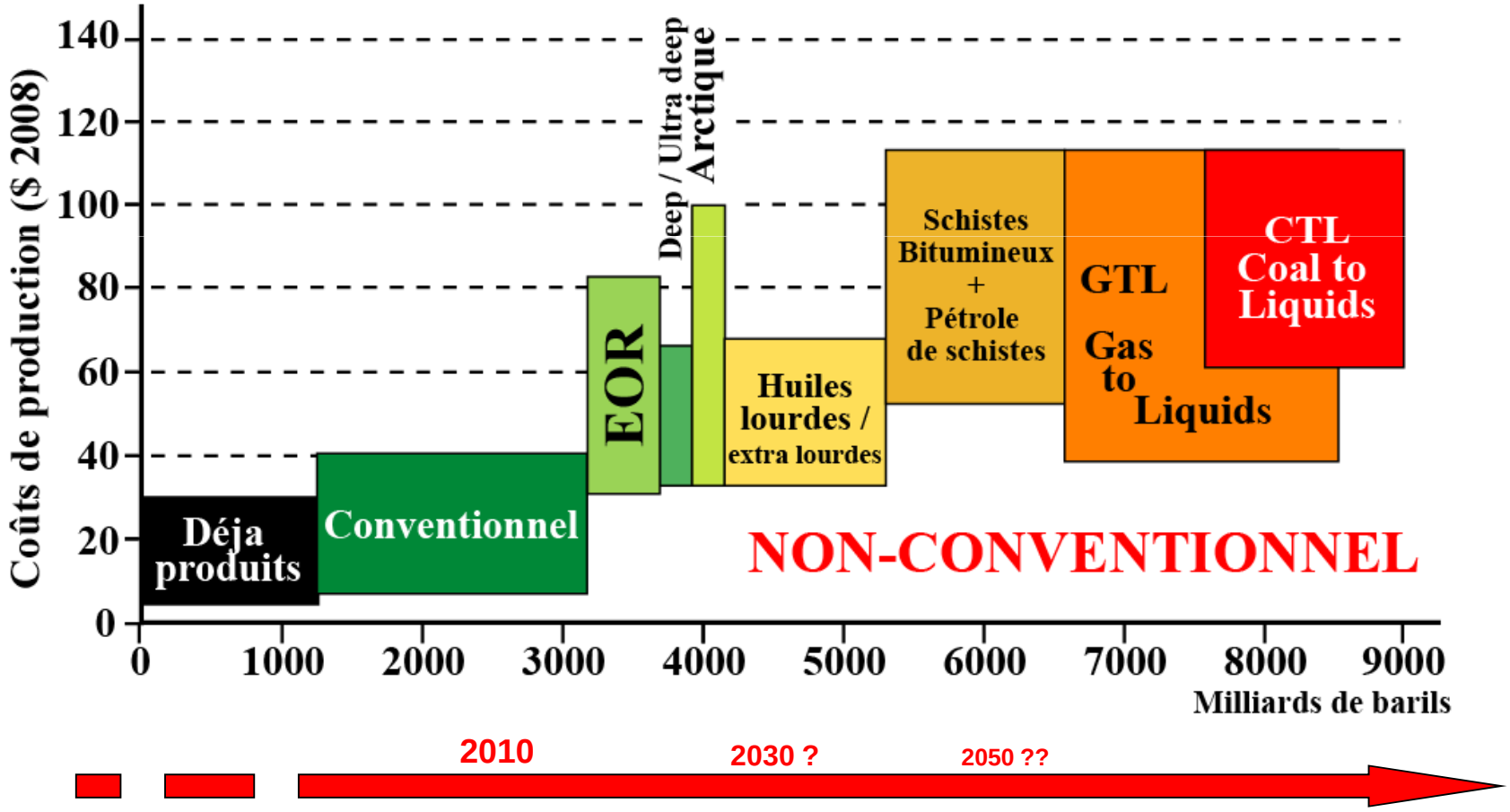


Hypothèse NPS : 99 millions barils / jours en 2035

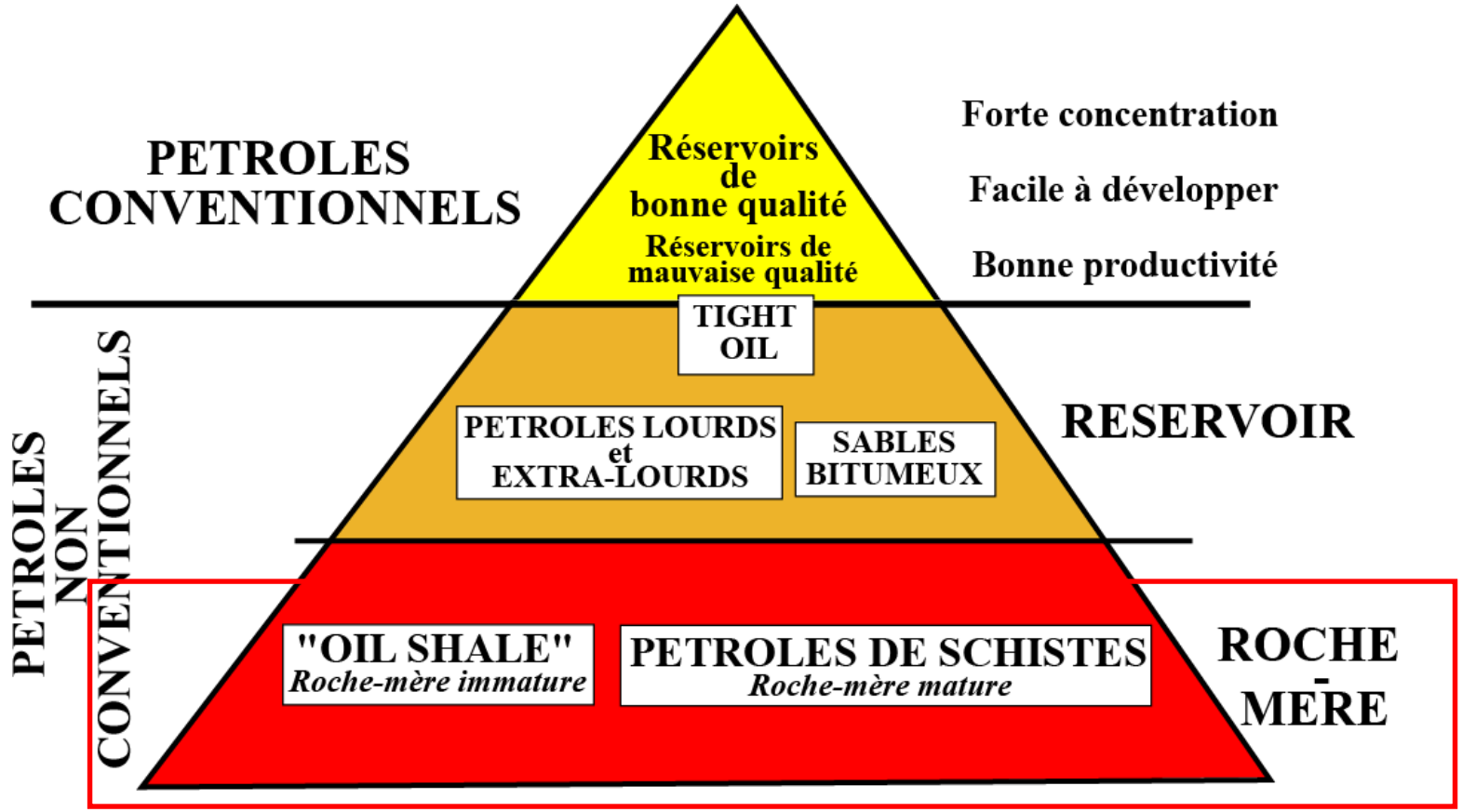
Les ressources en hydrocarbures liquides seront-elles suffisantes ?

Les ressources ultimes récupérables

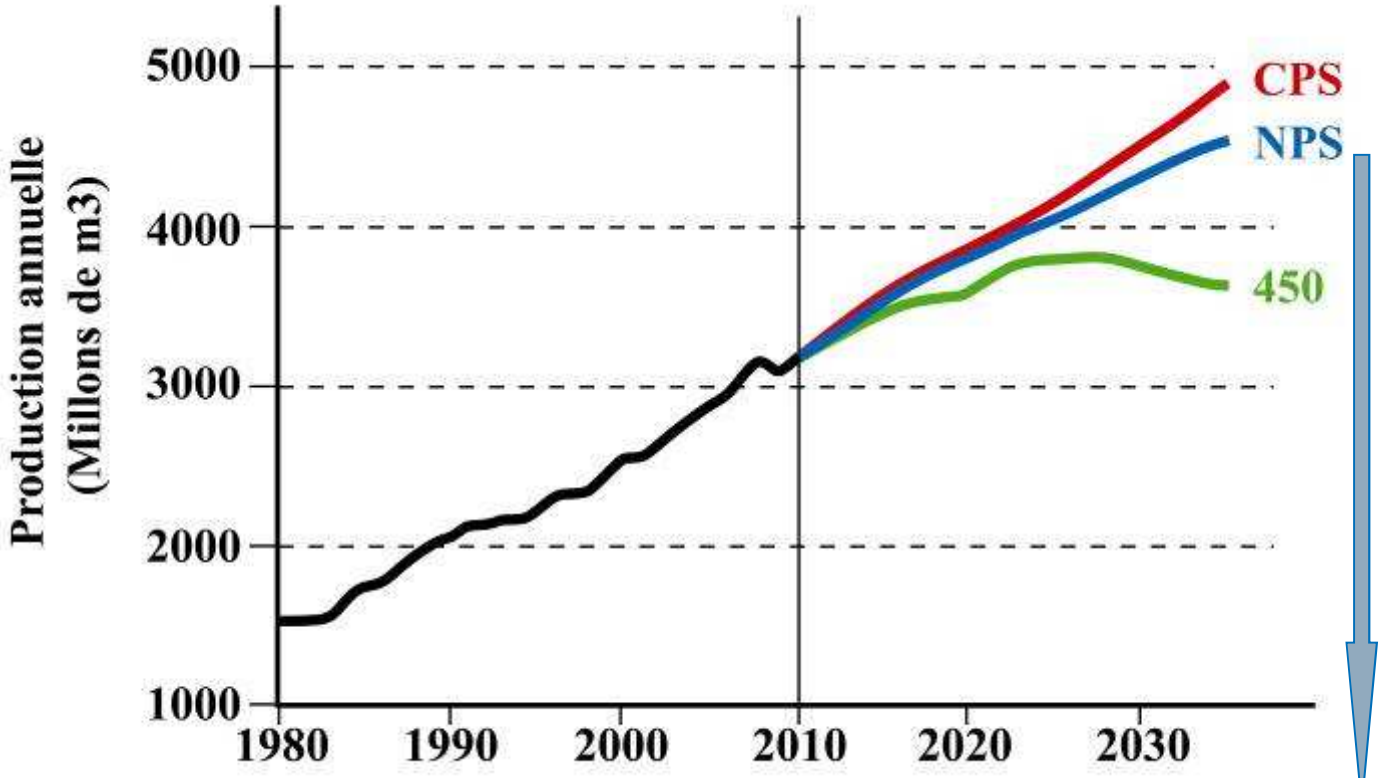
Des ressources certainement très importantes mais....seront-elles transformées en réserves et en production ?



Les hydrocarbures liquides non conventionnels



La demande en hydrocarbures gazeux augmente fortement...

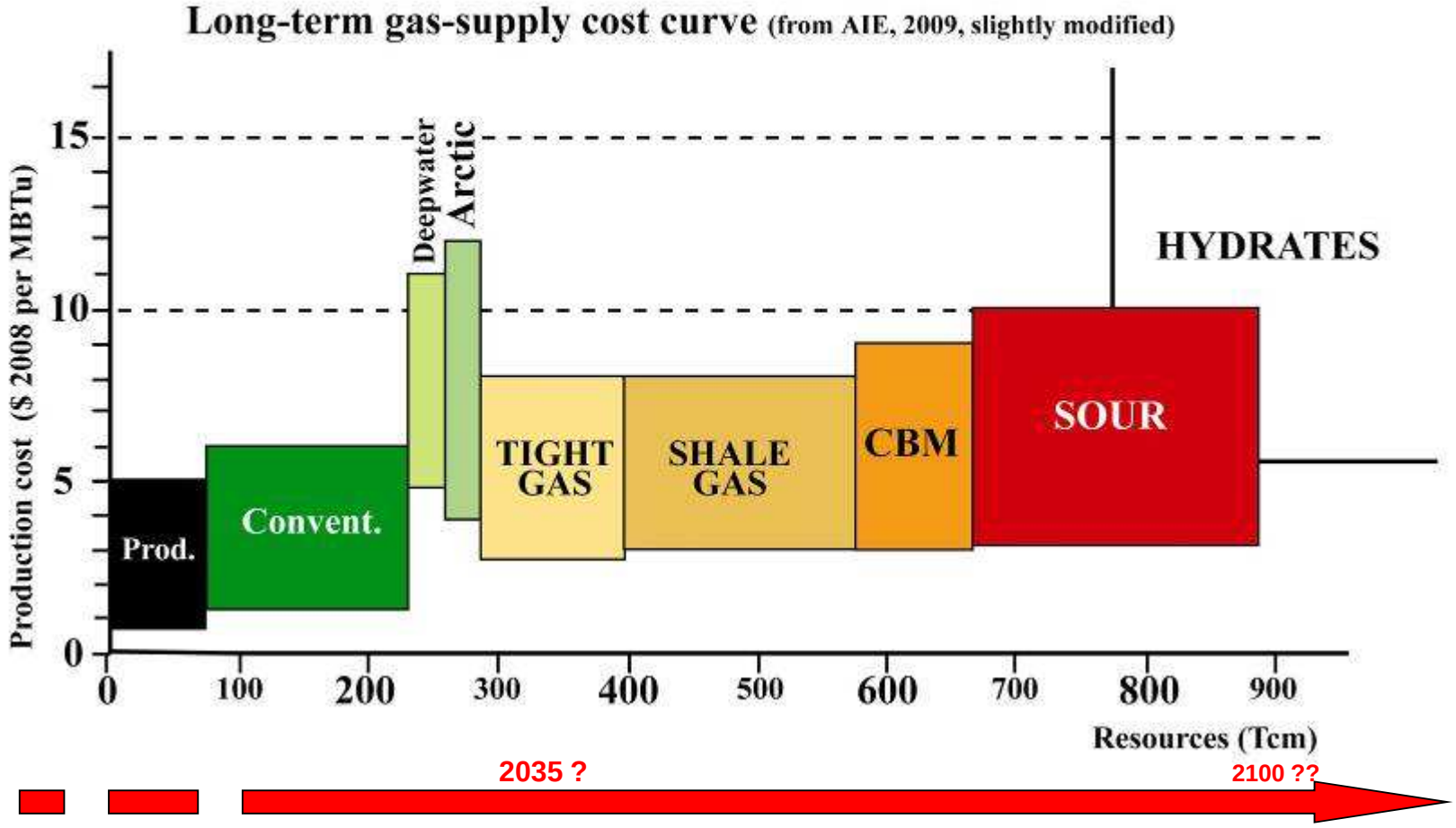


Hypothèse NPS : 4,6 Tcm/an en 2035
(+50% en 25 ans)

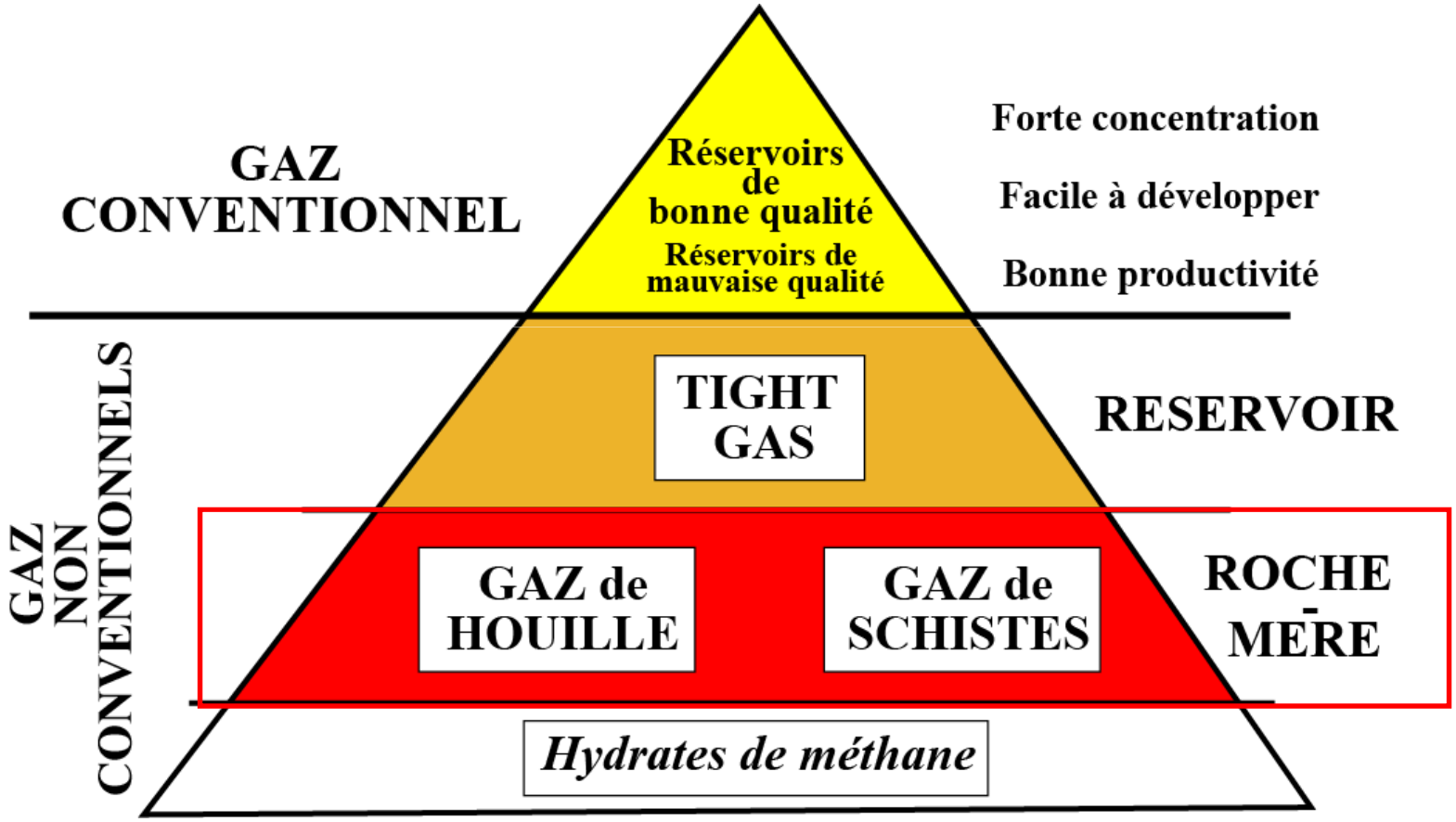
Les ressources en gaz seront suffisantes (au moins jusqu'en 2035)

Les gaz non conventionnels

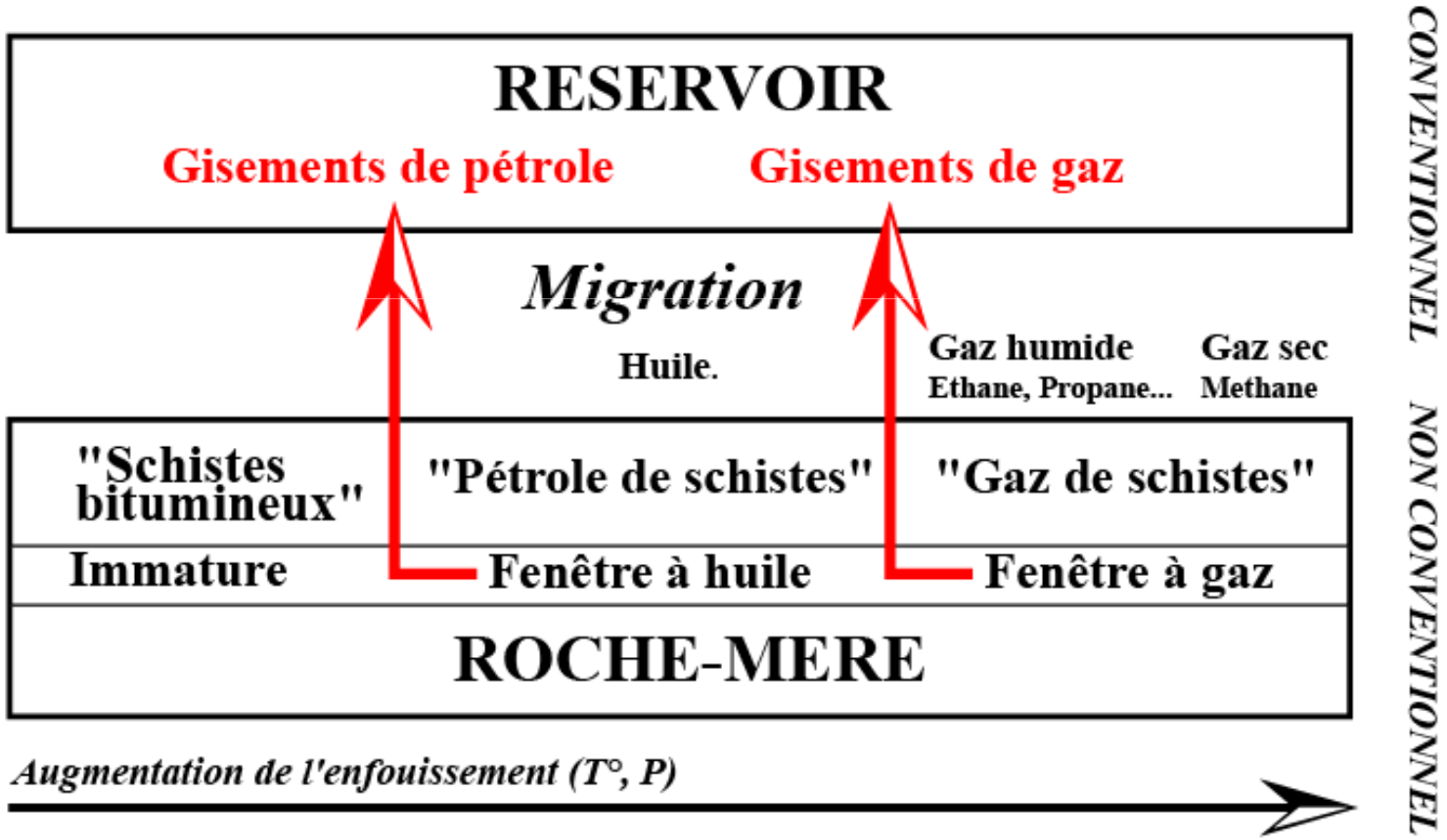
Des ressources considérables mais....seront-elles transformées en réserves et en production ?



Les hydrocarbures gazeux non conventionnels



Les hydrocarbures de roche-mères



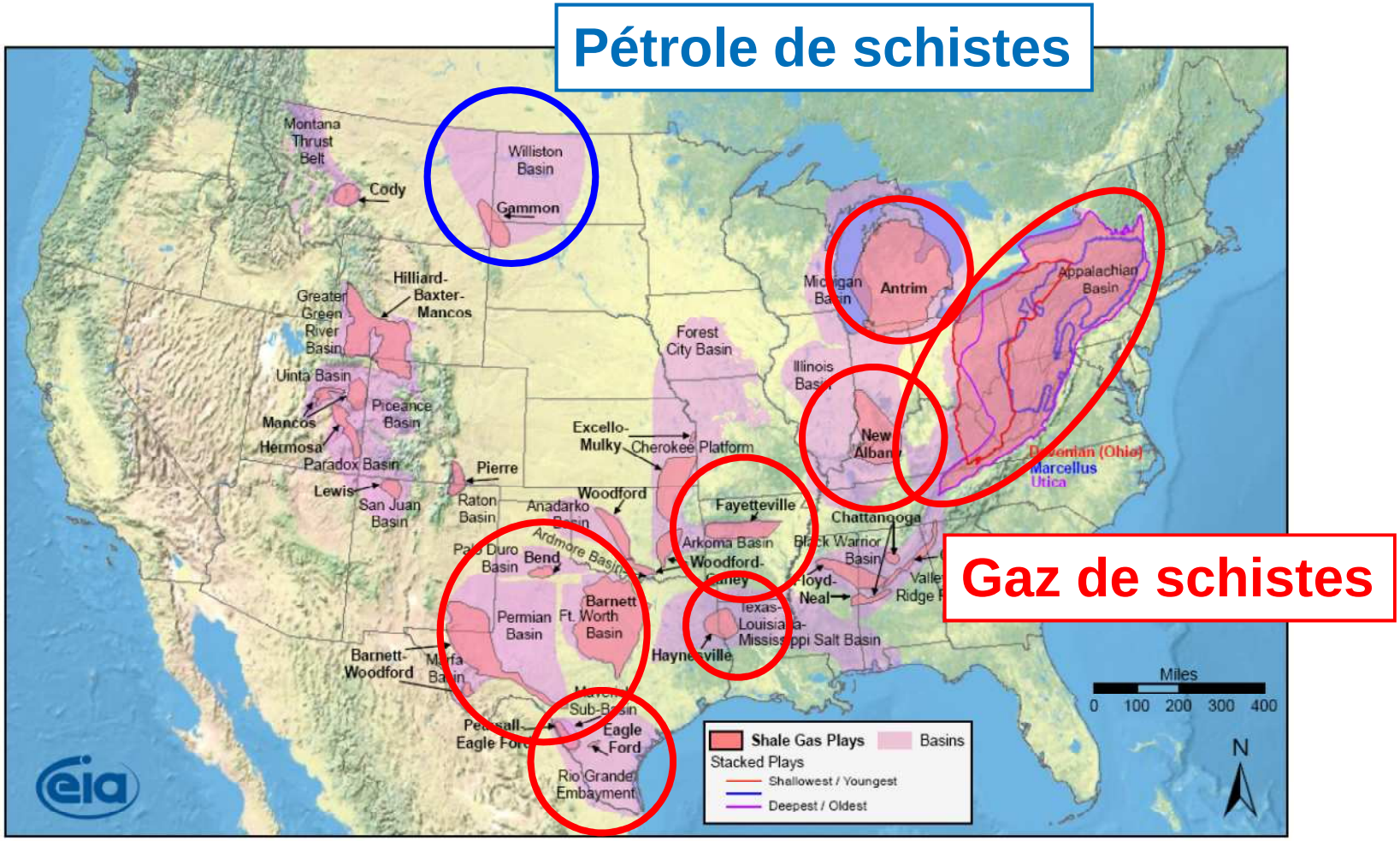
Les gaz de schistes : Une tradition américaine

Plaque commémorative du premier puits de gaz naturel aux USA

1821 : Premier puits de gaz naturel aux Etats-Unis dans la commune de Fredonia (NY).
D'une profondeur de 9 mètres il fut creusé à la pelle.
Il alimentait en gaz d'éclairage 2 magasins, 2 entrepôts et un moulin à farine.

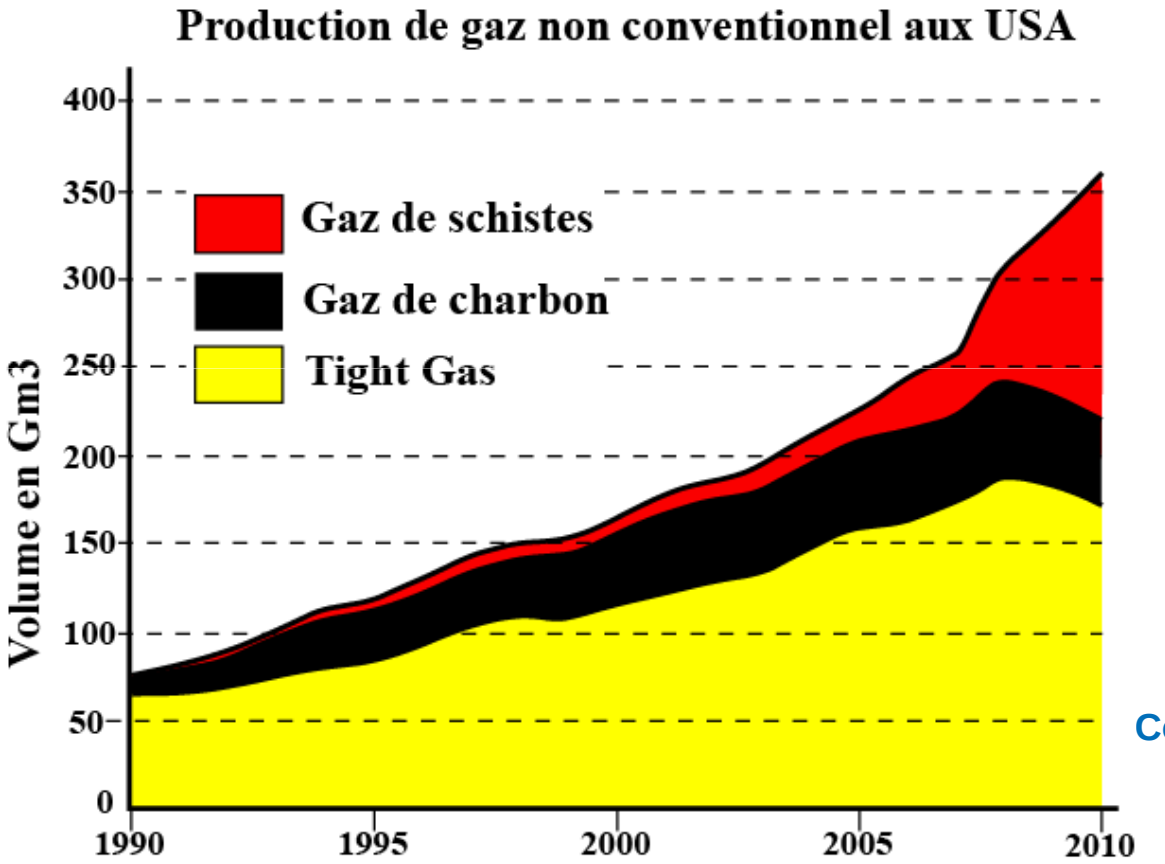
1858 : Première compagnie gazière aux Etats-Unis, la **Fredonia Gas Light Company** alimentait les réverbères de la commune.

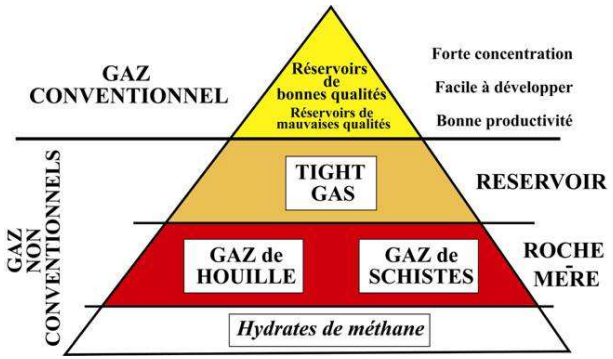
Les gaz de schistes : Des bassins sédimentaires favorables



Source: Energy Information Administration based on data from various published studies
Updated: May 28, 2009

Le gaz de schistes : Une réussite américaine

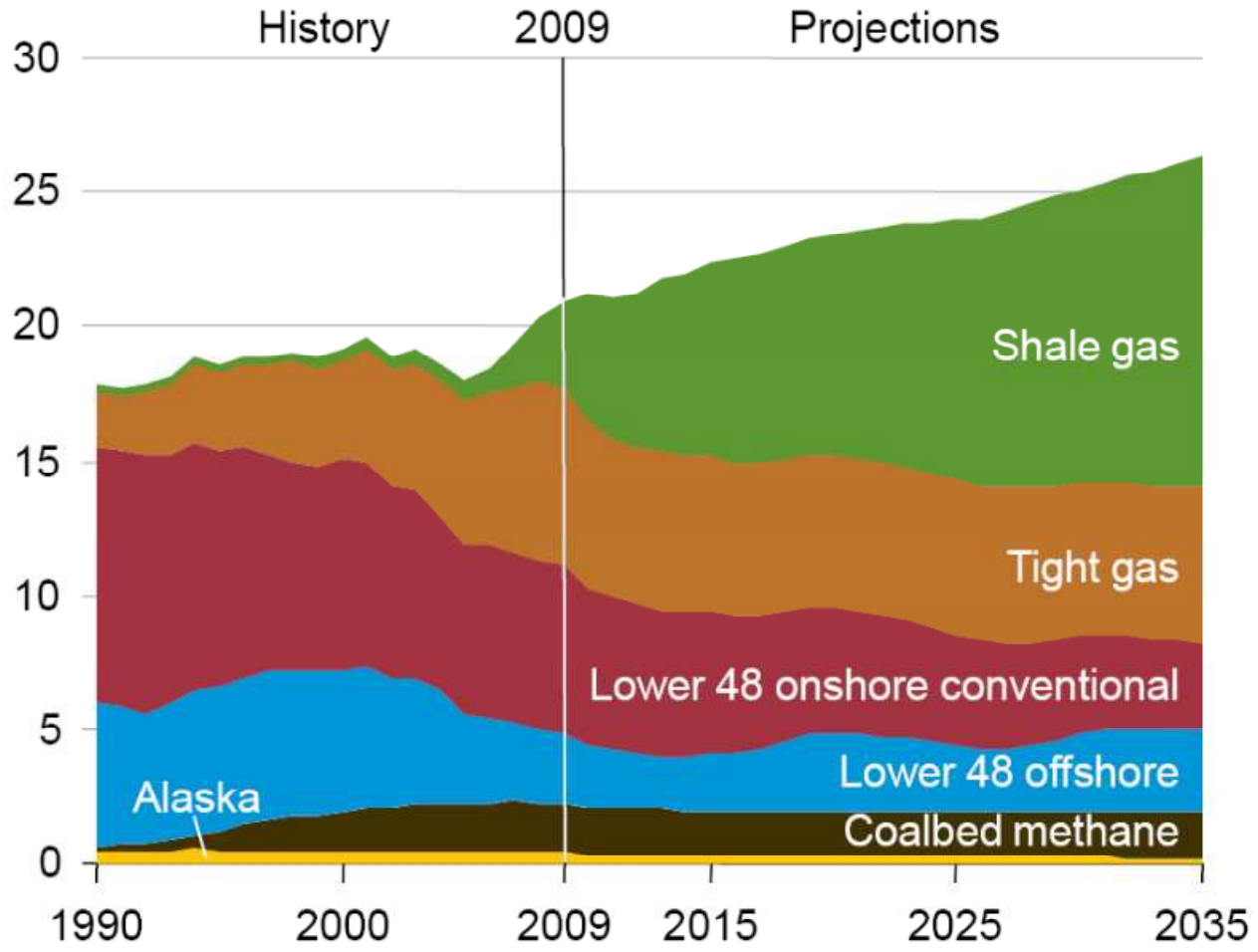




Consommation France : 50 Gm3

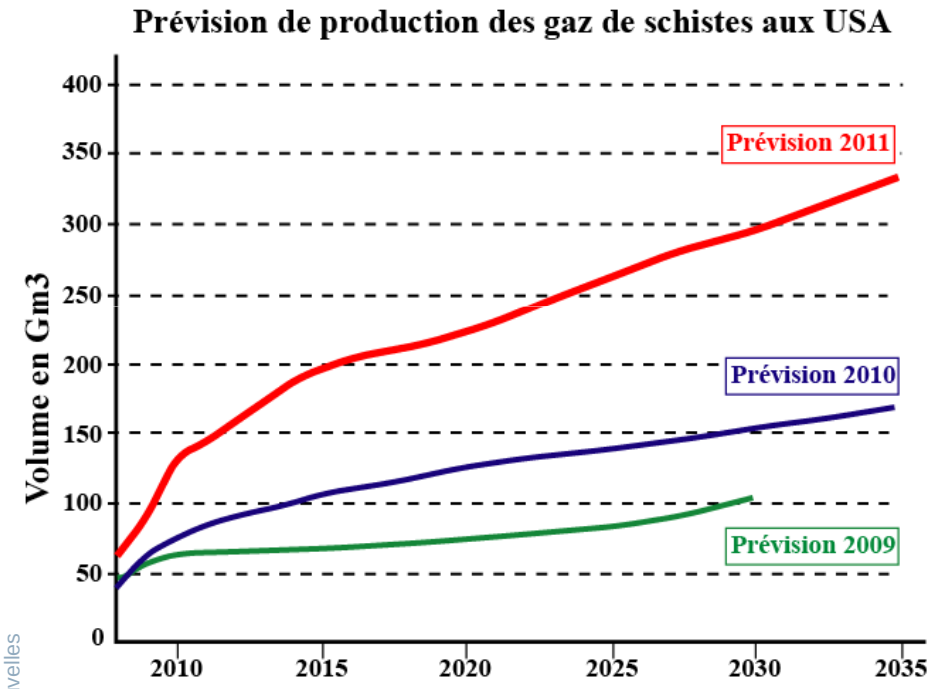
54% de la production de gaz aux USA est d'origine non conventionnelle

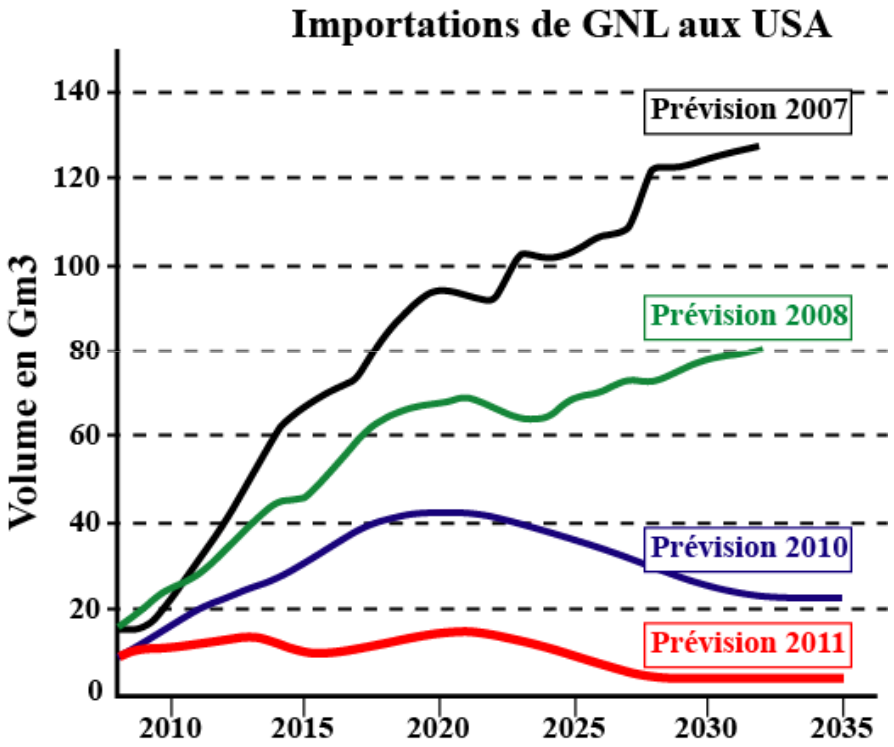
Le gaz de schistes : Un bel avenir aux USA



Annual Energy Outlook, 2011

Gaz de schistes aux USA : Impact sur le marché gazier





Une prévision de production constamment revue à la HAUSSE

Une prévision des importations de GNL revue à la BAISSE

Gaz de schistes : Une révolution planétaire ?

GAZ EN PLACE (GIP)

RESERVES PROUVEES
gaz conventionnel

190 Tcm

Non Conventionnel

GAZ COMPACT
210 Tcm

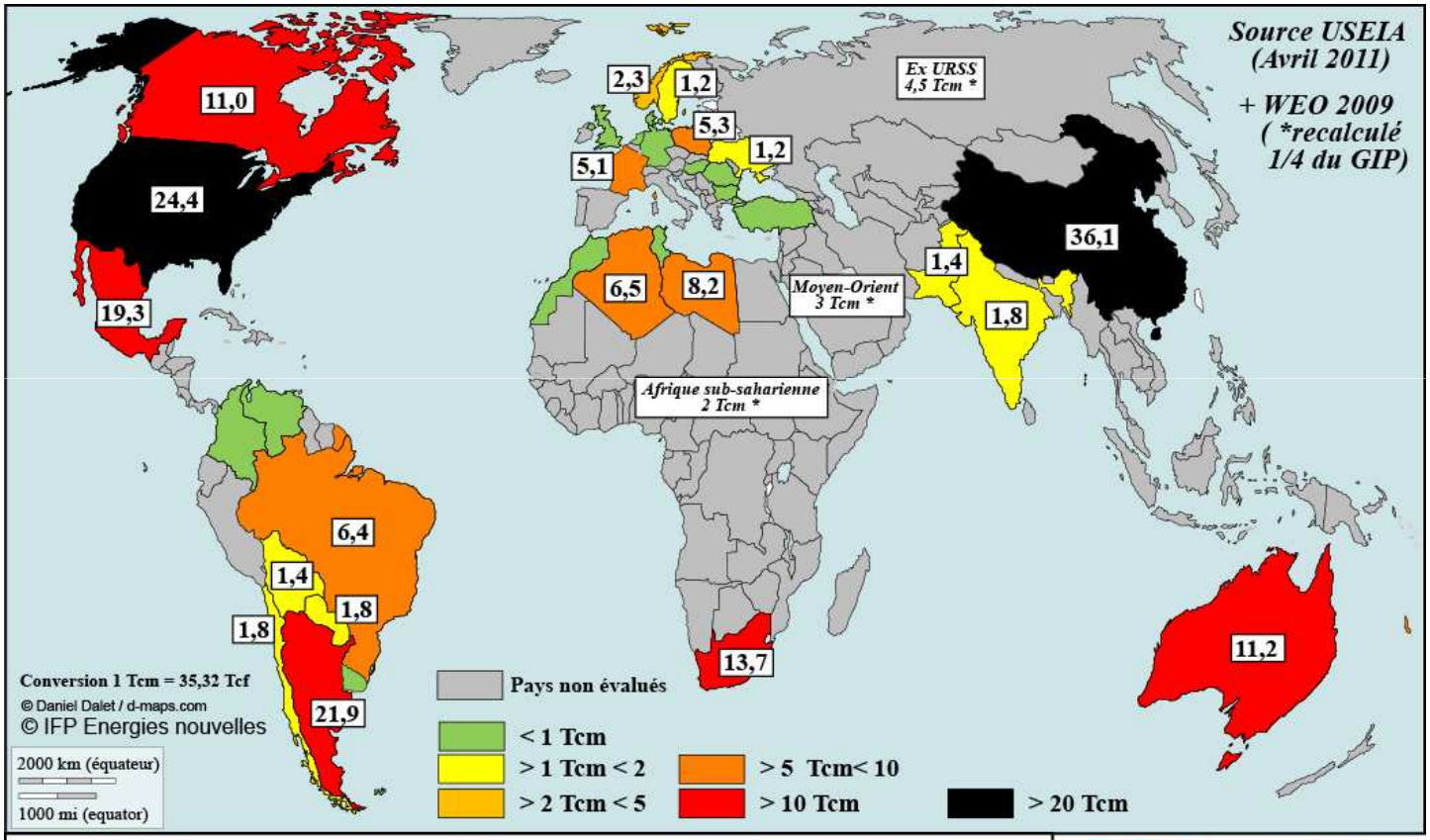
GAZ DE HOUILLE
256 Tcm

GAZ DE SCHISTES
456 Tcm

Ressources récupérables
(90 à 110 Tcm)

WEO,2010

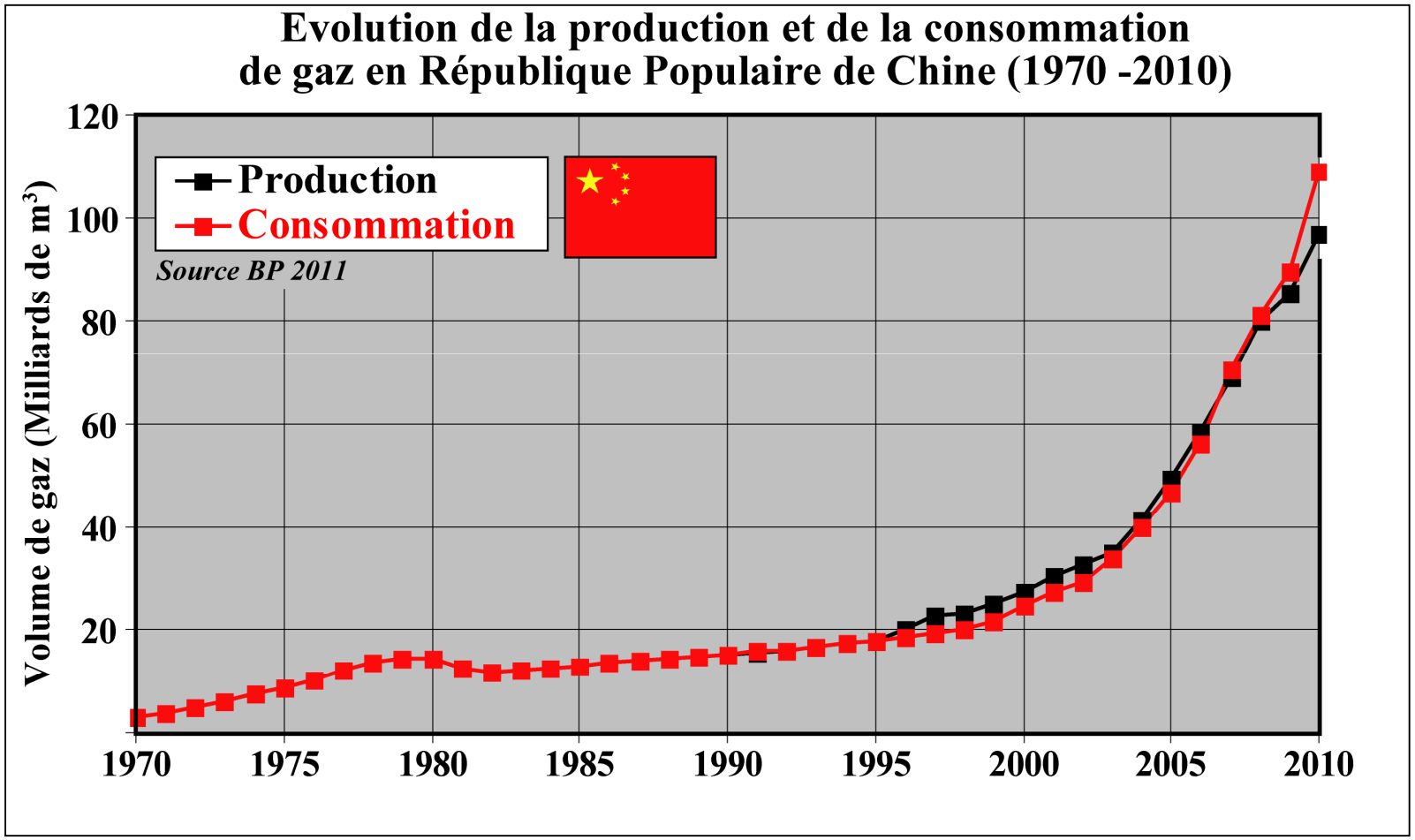
Gaz de schistes : Une révolution planétaire ?



GAZ DE SCHISTES : Ressources Récupérables (2011) — **TOTAL PAYS : 197 Tcm**

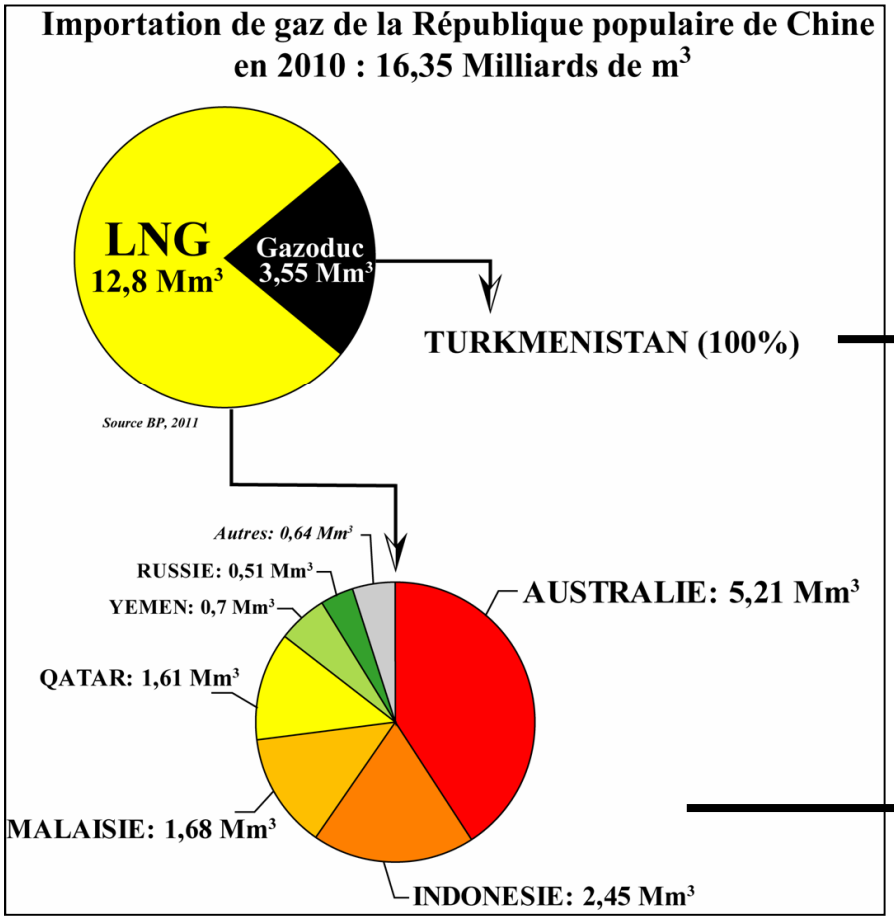
Chine	: 36,1 Tcm	Afrique du sud	: 13,7 Tcm	Algérie	: 6,5 Tcm	Norvège	: 2,3 Tcm
USA	: 24,4 Tcm	Australie	: 11,2 Tcm	Brésil	: 6,4 Tcm	Chili	: 1,8 Tcm
Argentine	: 21,9 Tcm	Canada	: 11,0 Tcm	Pologne	: 5,3 Tcm	Inde	: 1,8 Tcm
Mexique	: 19,3 Tcm	Lybie	: 8,2 Tcm	FRANCE	: 5,1 Tcm	Paraguay	: 1,8 Tcm

Gaz de schistes : Quand la Chine s'éveillera...



Une production domestique qui ne suit plus l'augmentation rapide de la demande.

Gaz de schistes : Quand la Chine s'éveillera...

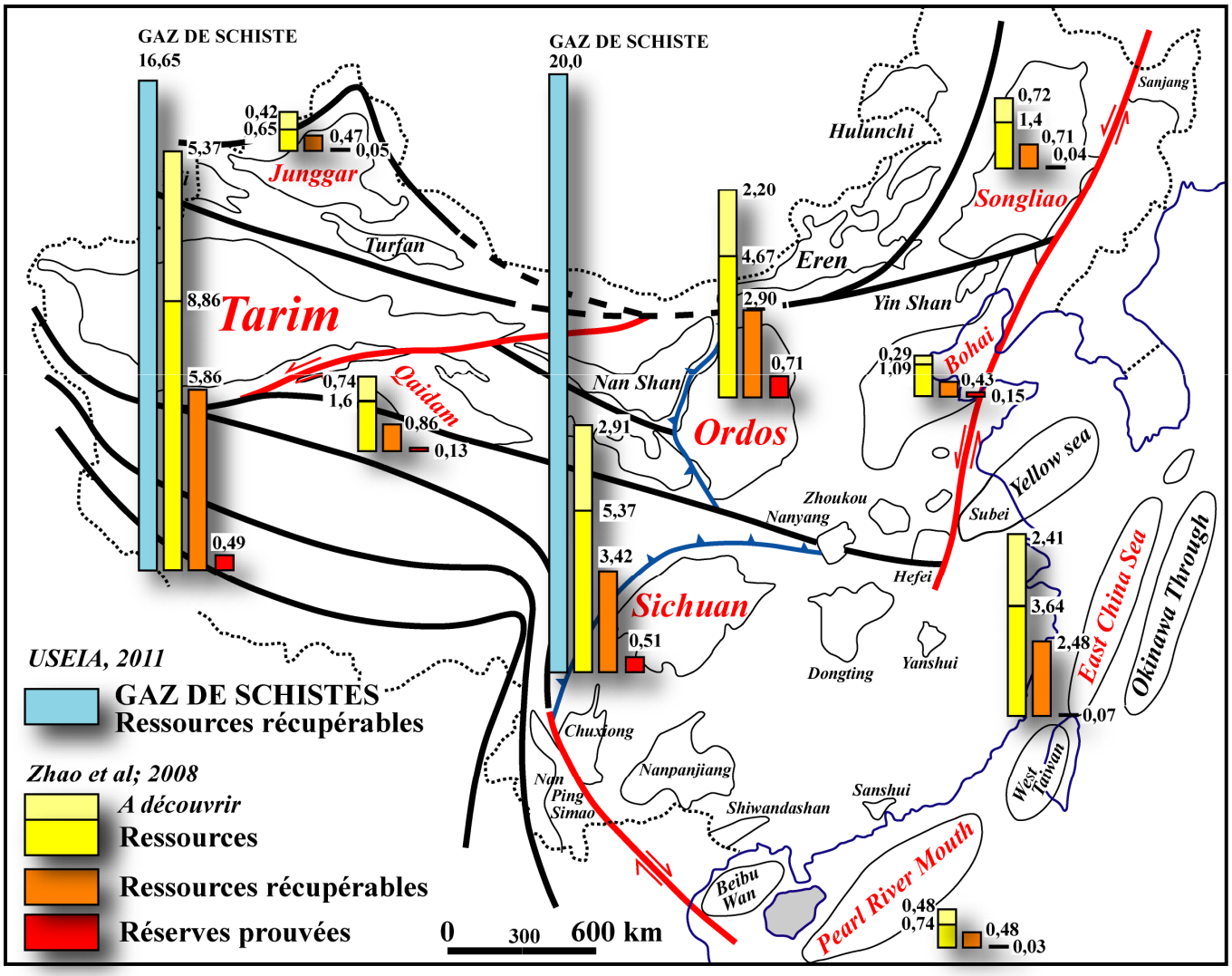


Le plus long gazoduc mondial

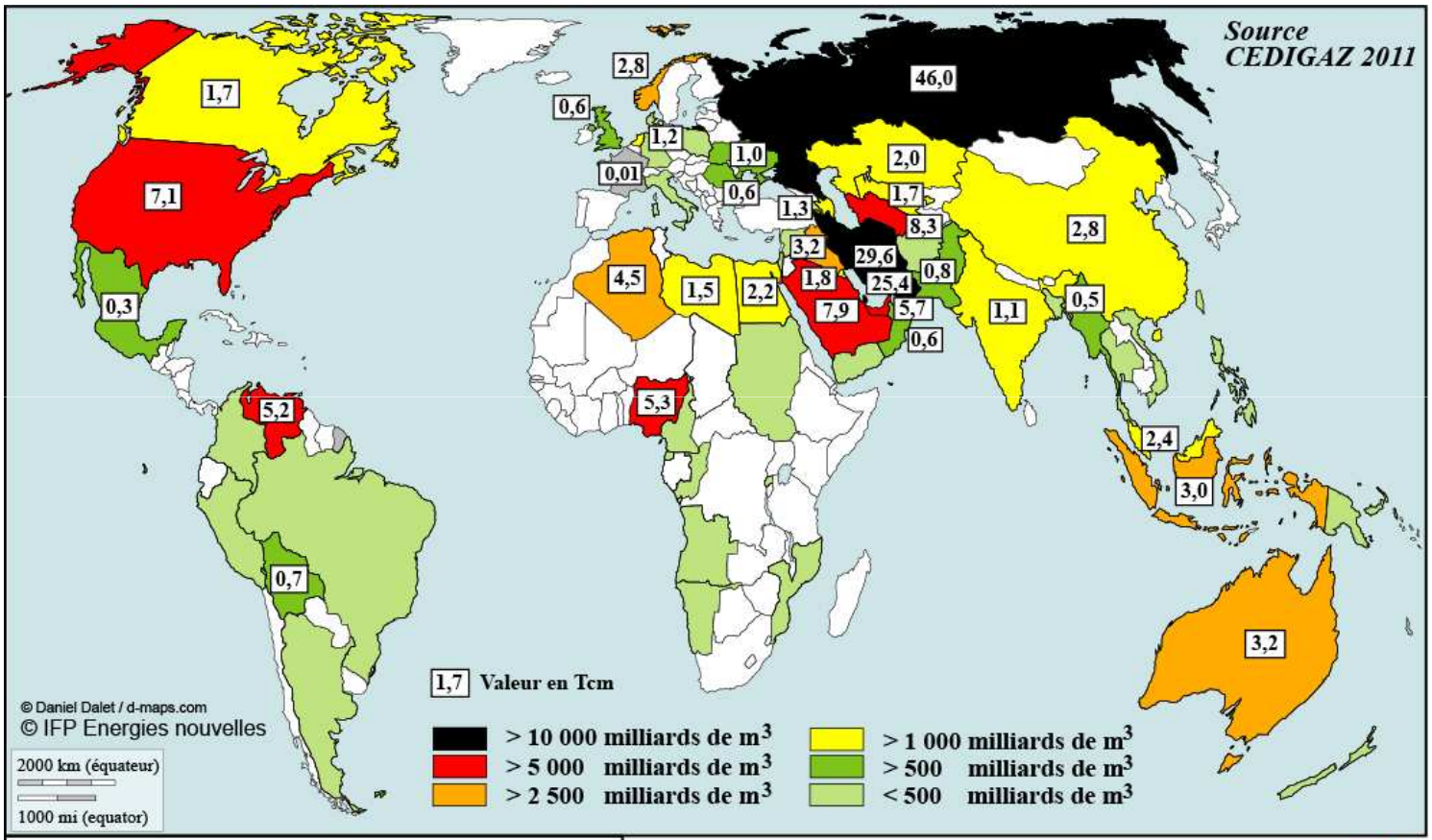
8700 km

Construction du terminal GNL de Dalian (Chine)

Gaz de schistes : Les bassins sédimentaires chinois



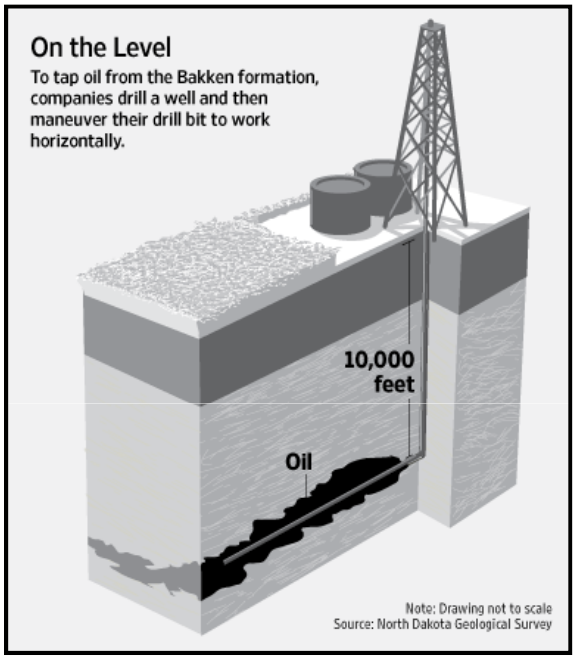
Gaz de schistes : Un paradoxe...

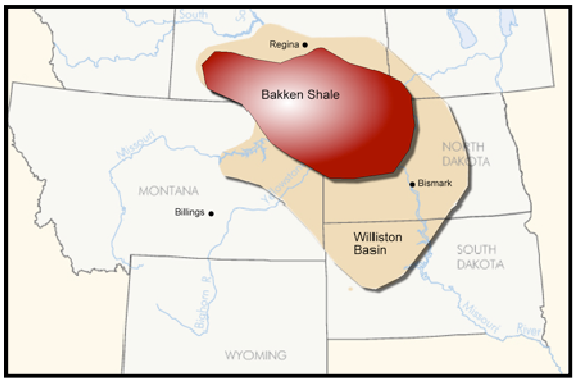


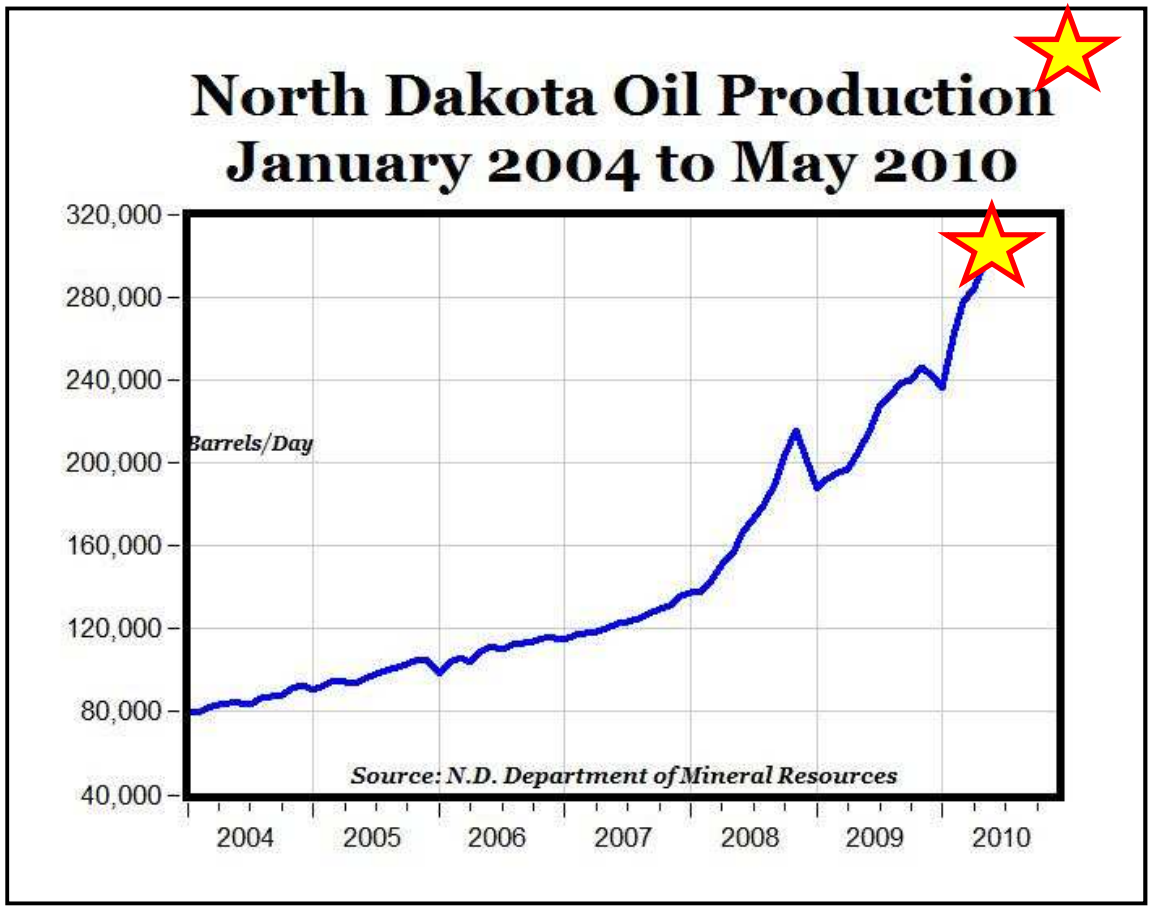
GAZ : Réserves prouvées (2010) — **RESERVES MONDIALES : 188 969 milliards de m^3**

Russie	: 46 000 milliards de m^3	Arabie Saoudite	: 7 920 milliards de m^3	Vénézuela	: 5 241 milliards de m^3
Iran	: 29 610 milliards de m^3	USA	: 7 075 milliards de m^3	Algérie	: 4 504 milliards de m^3
Qatar	: 25 366 milliards de m^3	Abu-Dhabi	: 5 715 milliards de m^3		
Turkmenistan	: 8 340 milliards de m^3	Nigeria	: 5 292 milliards de m^3		

Pétrole de schistes : La nouvelle révolution ?

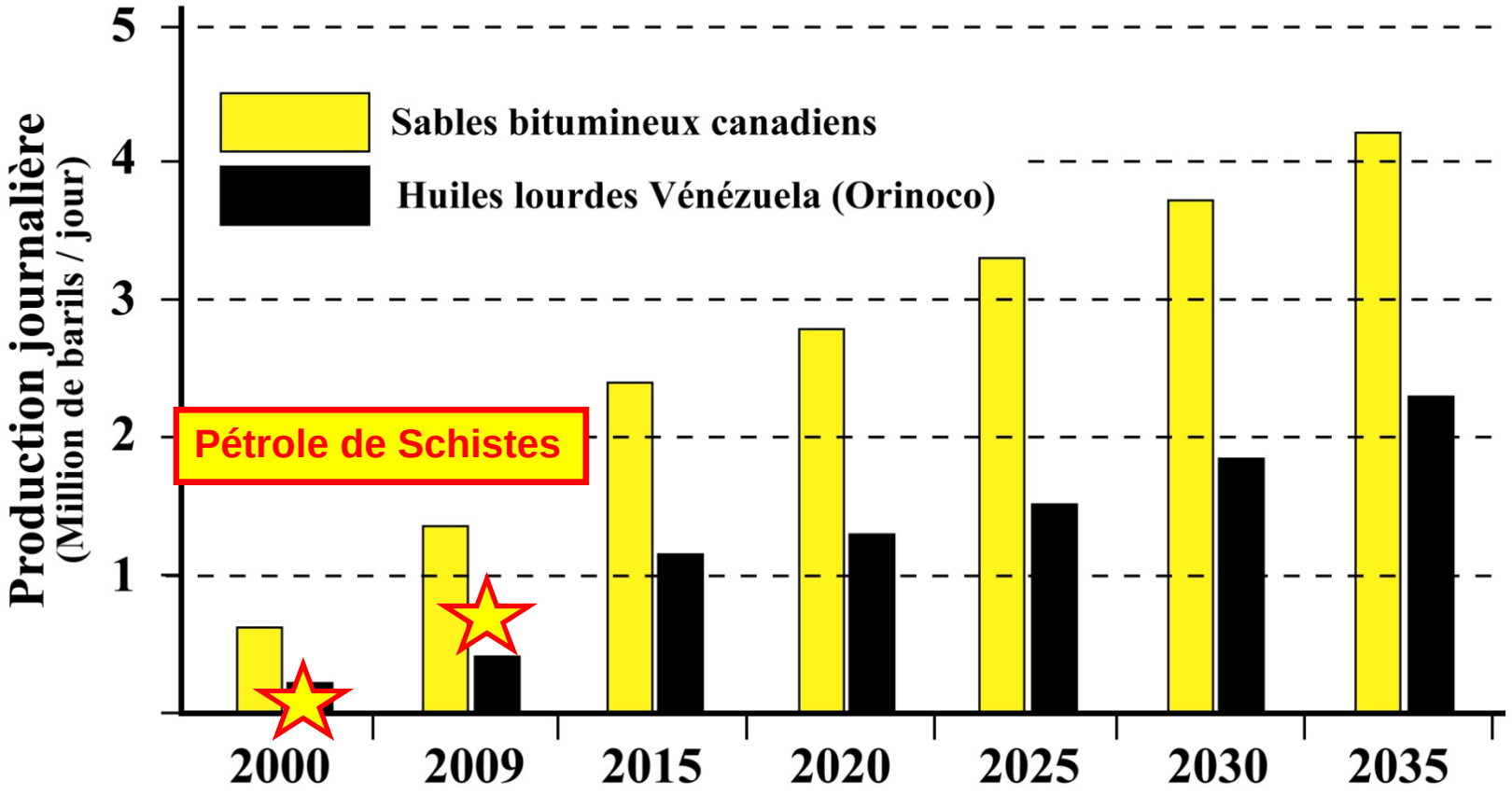






Bakken Formation, bassin de Williston

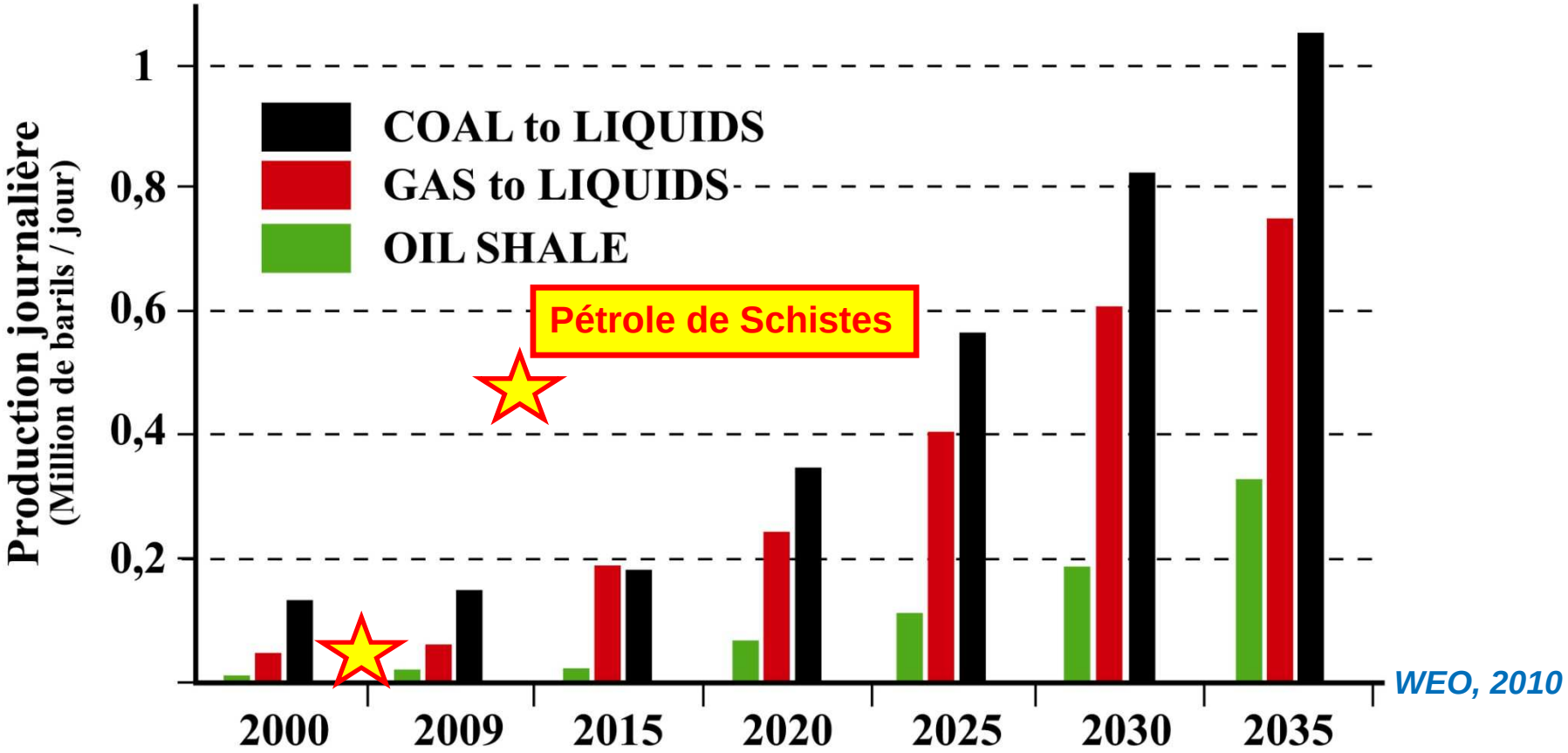
Pétrole de schistes : La nouvelle révolution ?



WEO, 2010

Un développement rapide....

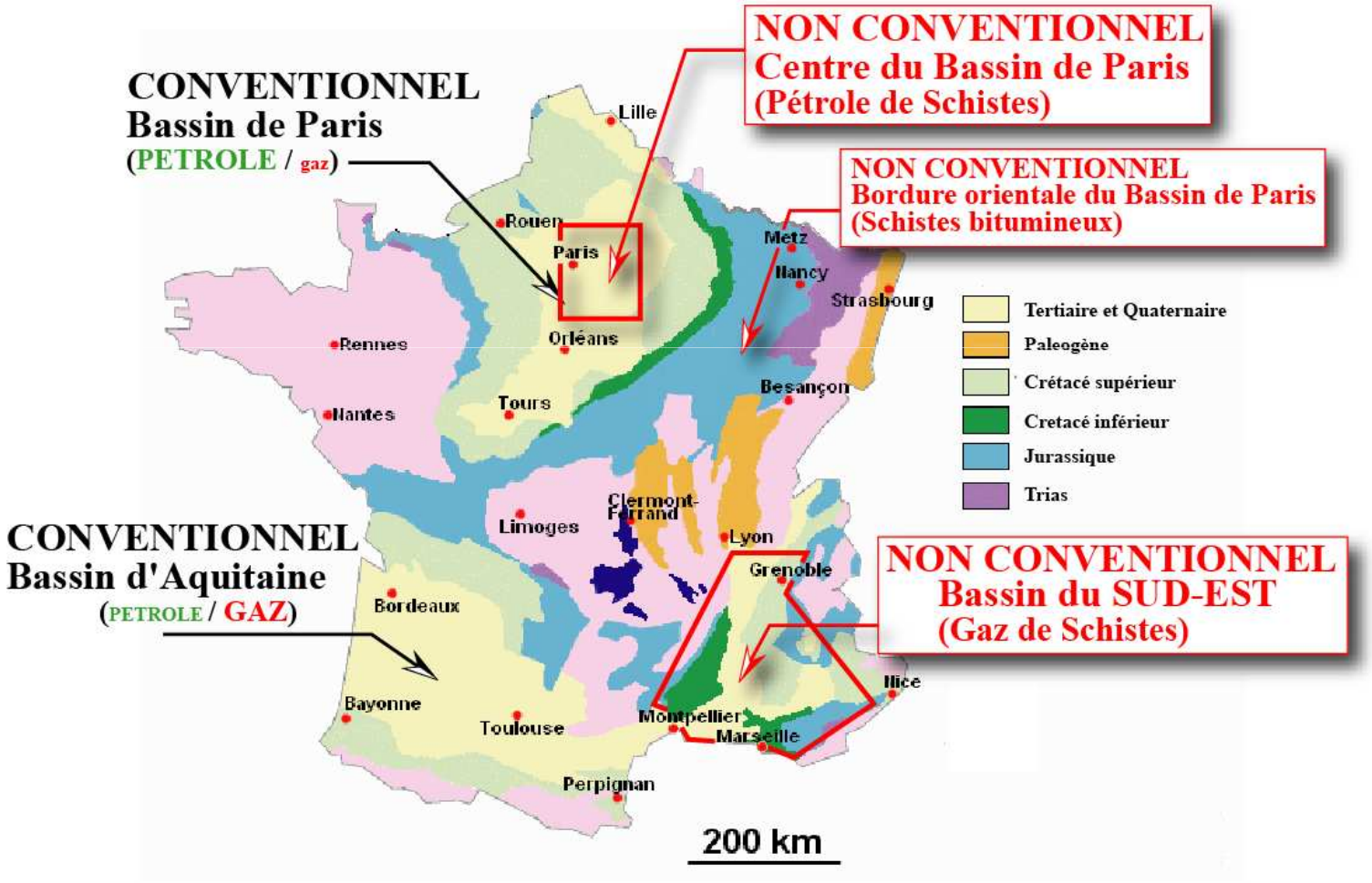
Pétrole de schistes : La nouvelle révolution ?



WEO, 2010

Un développement rapide....

En France



Une excellente roche-mère , les *Schistes Cartons*....

Conclusions

Les hydrocarbures de roche-mère sont amenés à prendre une importance grandissante dans l'approvisionnement mondial.

- L'exploitation des gaz non conventionnels (et particulièrement les gaz de schistes) a déjà profondément modifié le paysage gazier nord américain.
Qu'en sera t'il à l'échelle du monde ?

- L'exploitation naissante mais prometteuse des pétroles de schistes si elle se confirme dans de nombreux bassins sédimentaires ouvre la voie à une véritable révolution dans l'exploration et l'exploitation pétrolière.

Roche-mère
Elément indispensable du système pétrolier

Roche-mère
Objectif d'exploration et de production

Conclusions

Merci de votre attention...

Innover les énergies

www.ifpenergiesnouvelles.fr

Shale Gas

Sylvie Duflot– Total Gas Shale Europe

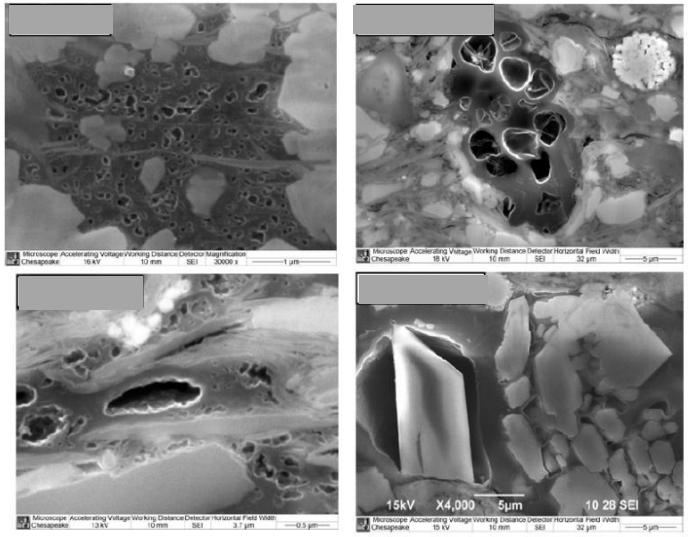
TOTAL

Les différentes phases d'un projet (conventionnel)

Du gaz naturel dans une roche peu perméable

- Shale gas is generated through burial of argillaceous sediments, rich in organic matter, where it remained trapped.
- It is mostly made of methane.

Le gaz de schiste et le gaz naturel ont la même origine et la même composition



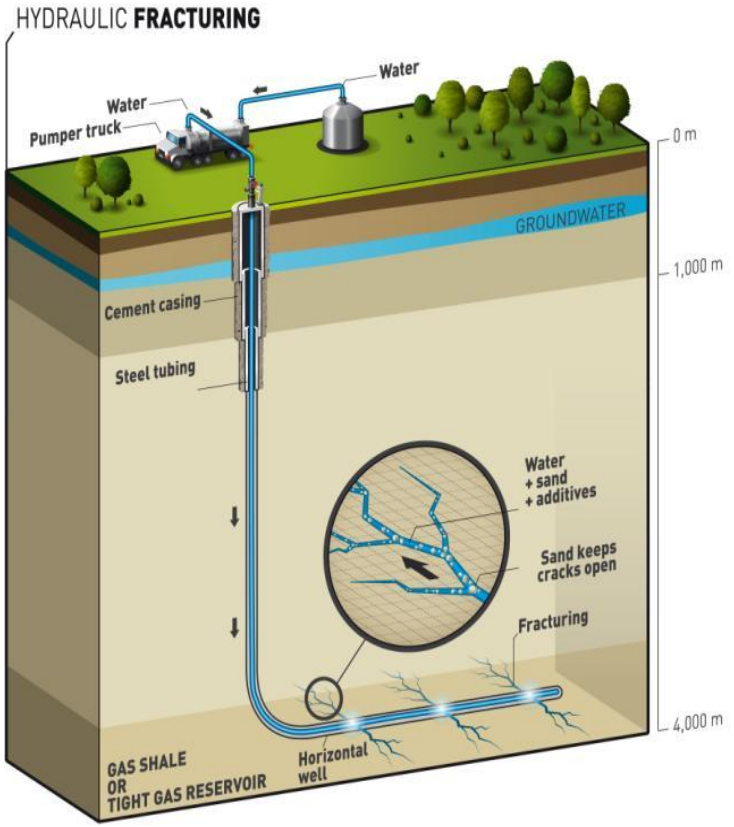
- **Permeability of these rocks is extremely low.**

Les caractéristiques de la roche nécessitent l'usage de techniques spécifiques pour assurer un niveau de productivité économique

TOTAL

Specific production techniques

- **Two types of technology required to enable sustainable production :**
  - Horizontal drilling, which increases the productive section of each well
  - Controlled hydraulic fracturing, which artificially improves rock permeability.
- **The amount of gas retrieved from each well remains low**
  - This implies a large number of wells to reach a significant level of production



These techniques are known to the industry and also used for conventional hydrocarbon production and deep geothermal energy.

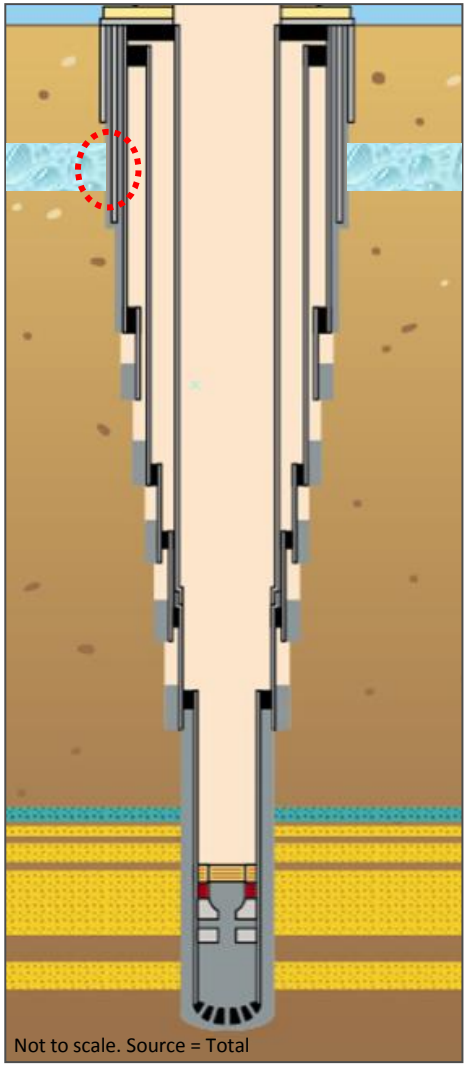
TOTAL

Well architecture – a reminder

Shale gas wells are governed by the same principles as other types of wells. (conventional O&G, water, geothermal energy)

- **Well drilling operations are completed through a succession of phases.**
  - A drilling fluid is always present within the borehole.
  - A drilling phase is followed by running-in with a casing and its cementation.
  - Quality control for casing and cement integrity is compulsory.
- **Well design is aimed at isolation from the surrounding geological formations**
  - Pressure barrier (drilling fluid, mudcake)
  - Mechanical barrier (casing, cement)
- **Surface phases are designed to protect ground waters.**
  - Water based drilling fluids
  - One to two fully cemented casing strings

O&G vertical well architecture

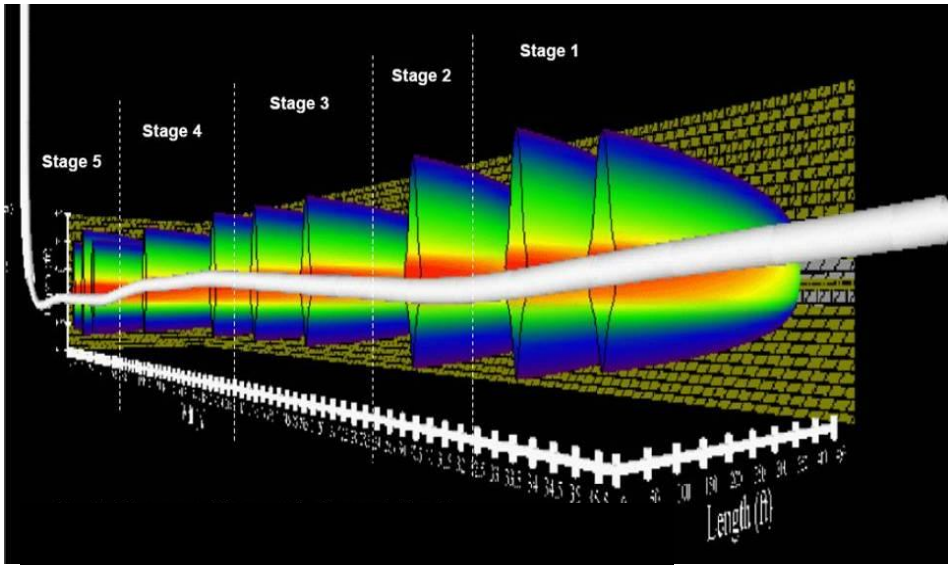


Not to scale. Source = Total

Drilling a well is a state-regulated process, following industry best practices and company internal procedures, using fit-for-purpose materials

Hydraulic fracturing

- **Objective = re-open or artificially create a network of small fractures / cracks**
  - In the targeted interval
  - Around the wellbore
- **Operational procedure :**
  - Performed by successive stages
  - Perforate production tubing and cement
  - Pump fluid, propping agent (sand) and additives
  - Let network develop
  - Stop pumping, retrieve flow back fluids
- **Network characteristics**
  - Develops perpendicular to minimum constraint direction
  - Extend about 100m laterally, a few tens of meters vertically



- **Average figures**
  - Horizontal drain length = 1500 to 2000m
  - 5 to 10 fracturation stages
  - 1500 - 2000 tons of sand for a 5-stage well
  - 10 to 20,000 m3 water
  - 90% water, 9.5% sand, 0.5% additives (volumes)

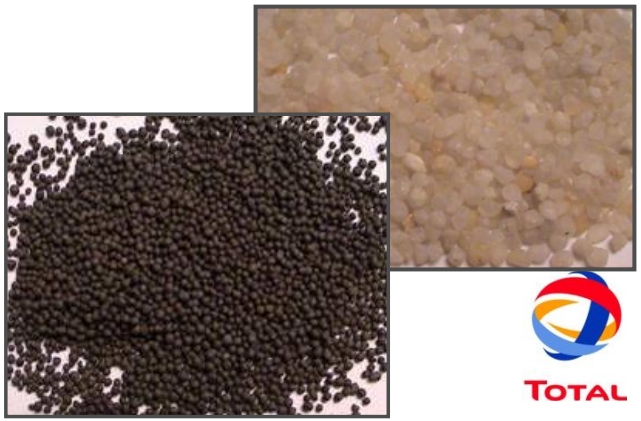
Frac design is variable : adapted to reservoir and well characteristics

TOTAL

Frac fluids

- **Several stimulation fluid systems are available**
  - Gel, Visco Elastic Fluids or Slick Water
  - Depends on the permeability of the formation
  - Shale gas is mainly stimulated using slick water
- **Additives role**
  - Reduce frictions
  - Improve proppant carrying capacity (gel)
  - Allow water removal while leaving proppant downhole after frac (gel breaker)
  - Remove bacteria
  - Prevent corrosion and scale deposits
  - Inhibit shale if needed
- **Way forward**
  - Shift toward the use of low or non-toxic products (food industry)
  - Transparency: http://fracfocus.org/

Concentration	Unit	Component in System	Purpose	MSDS
917	Liter	Water		
81	Liter	22% Liquid KCl		KCl
0.6 to 0.84	Kg	CleanWG1	Friction reducer	FDP-S951-09
0.12 to 0.36	Kg	CleanBreakE	Breaker	FDP-S981-10
1	Liter	CleanSurf	Non-emulsifying Surfactant	FDP-S962-09



The exact fluid composition depends on reservoir properties and well conditions

TOTAL

Make acceptability first priority

Aquifers

Protection of aquifers during drilling, fracing and production

Security and reliability of wells and installations

Reduction in quantity and impact of additives

Use of seismic data for localization and control of intervals to be fracced

Water

Minimize water usage

Reduce water usage in fraccing operations

Search for solutions avoiding uses of public domain water domain and fresh water

Maximize water re-usage after adequate treatment

Ground

Minimize impact of industrial activities

Reduce number of industrial sites by drilling more production horizontal wells in each clusters

Install clusters close to existing infrastructures.

Transport fluids by pipelines.

Site restoration

Local communities

Impact of operations

Consult and exchange with local communities

Take due care of local biodiversity, land view, heritage, dwelling and traffic issues in installations planning

Monitoring and respect of commitments

Legitimate questions requiring adequate answers and actions

TOTAL

Water management

Flowback water

Produced water

Transportation

Treatment

Frac water

Flowback water

Produced water

Recycling

Quantity

Flowback water

Produced water

Frac water

Flowback water

Produced water

Disposal

Flowback water

Produced water

Origin

Risk of contamination

Frac water

Groundwater

Water management is well know to the O&G industry

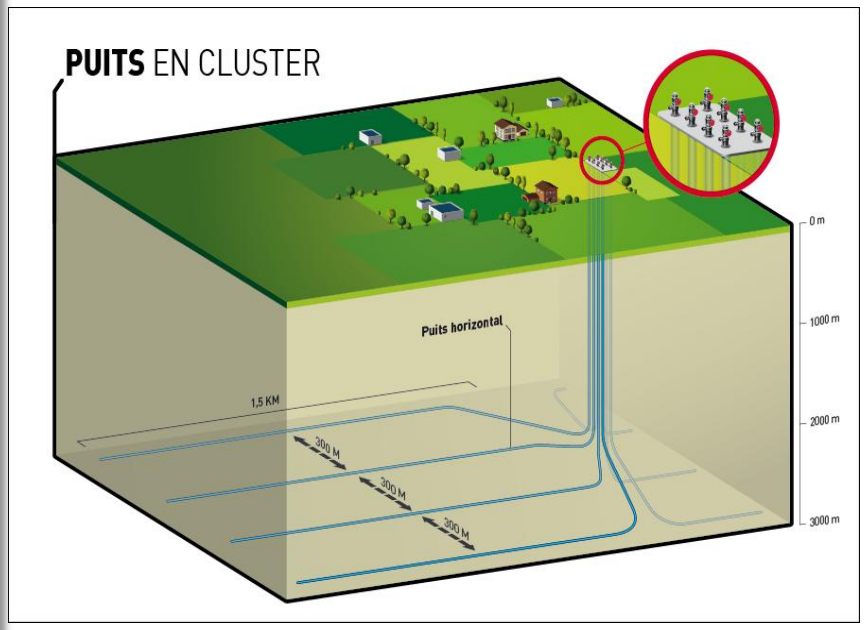
TOTAL

Surface footprint

- **A "cluster" based development**
  - Reduction of the number of surface locations
  - Optimized surface footprint (input and output of material, fluids etc…)
  - Optimized location of well horizontal section in the objective

A solution adapted to the European context

- **Site rehabilitation**



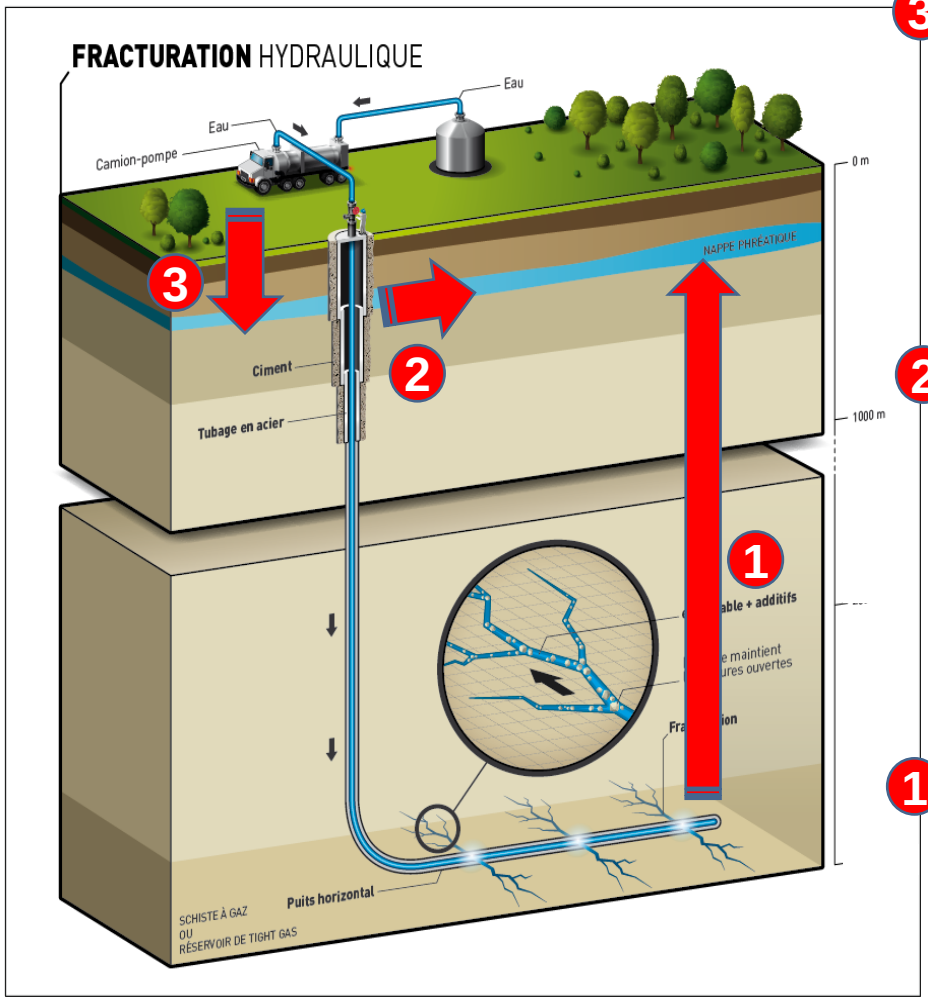
Drilling phase

Fracturation phase

Production phase

TOTAL

Groundwater : risk perception



3 Contamination related to spill or containment failure.

Risk known to the O&G industry and more widely to a large number of industries

2 Contamination due to well integrity issues.

Risk known to the O&G industry (and others), requires respect of regulation and good industry practices

1 Contamination due to hydraulic fracturing.

Risk considered as extremely unlikely given safe distances from aquifers are respected

TOTAL

In a nutshell

- Shale gas exploration still in its infancy in Europe;
- There are associated challenges;
  - … which are well-identified
  - … which can be addressed in a safe way
- Shale gas will only be developed if industry, governments and the civil society are convinced it is worthwhile.

TOTAL

Disclaimer and Copyright reservation

The TOTAL GROUP is defined as TOTAL S.A. and its affiliates and shall include the party making the presentation.

Disclaimer

This presentation may include forward-looking statements within the meaning of the Private Securities Litigation Reform Act of 1995 with respect to the financial condition, results of operations, business, strategy and plans of Total that are subject to risk factors and uncertainties caused by changes in, without limitation, technological development and innovation, supply sources, legal framework, market conditions, political or economic events.

Total does not assume any obligation to update publicly any forward-looking statement, whether as a result of new information, future events or otherwise. Further information on factors which could affect the company's financial results is provided in documents filed by the Group with the French *Autorité des Marchés Financiers* and the US Securities and Exchange Commission.

Accordingly, no reliance may be placed on the accuracy or correctness of any such statements.

TOTAL