NORWEGIAN PETROLEUM DIRECTORATE

Leads, Prospects, Plays and

Resource estimation

Why should the government know?

Key questions:

from the President, politicians, media, oil companies, NGOs.....

- How much oil and gas ?
- Where are the resources ?
- When will they be found ?
- When can they be produced?

Can YOU answer?

I need to know the Petroleum Resource volume in order to:

- make national financial strategies and budgeting
- make legislation and tax regulations
- facilitate promotion,
- initiate licensing
- negotiate contract terms
- formulate investment strategies

What resource class do you need to know?

SPE PRMS 2007		NPD 2001	
	Project Maturity sub-classes	Project status category	
Production		S	Sold and delivered
RESERVES	On Production	1	In production
	Approved for Development	2 F/A	Approved PDO
	Justified for Development	3 F/A	Licencees have decided to recover
CONTINGENT RESOURCES	Development Pending	4 F/A	In the planning phase
	Development unclarified or on Hold	5 F/A	Recovery likely but undecided
		7 F/A	Not yet evaluated
	Development not Viable	6	Recovery not very likely
Unrecoverable			
PROSPECTIVE RESOURCES	Prospect	8	Prospect
	Lead	9	Lead and Play
	Play		

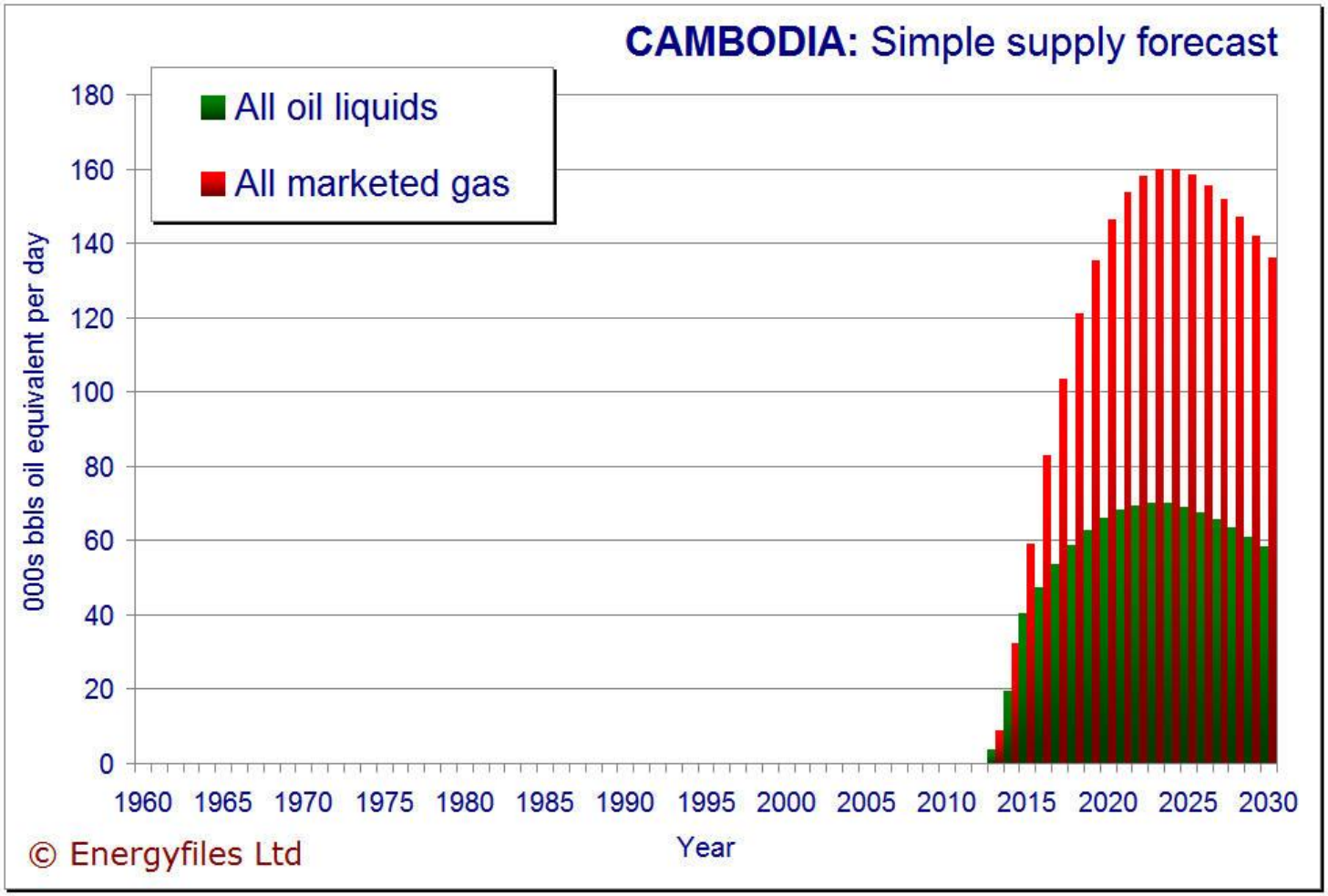
SPE/WPC/AAPG 2000		
PRODUCTION		
RESERVES		
Proved	**P**roved **P**robable	**P**roved **P**robable **P**ossible
CONTINGENT RESOURCES		
Low estimate	Best estimate	High estimate
Unrecoverable		
PROSPECTIVE RESOURCES		

I want to know the Proven oil reserves!

In 2 minutes!!!!!

Proven oil reserves (million barrels)

	OIL (MMbbl)	(GAS BCM)
CAMBODIA	45	
CHINA	?????	
INDONESIA	3500	17 bcf
KOREA		0.4 tcf
MALAYSIA	3000	400 tcf
PHILLIPINES	28	3 tcf
THAILAND	435	11 tcf
TIMOR LESTE	700	14 tcf
VIETNAM	150	

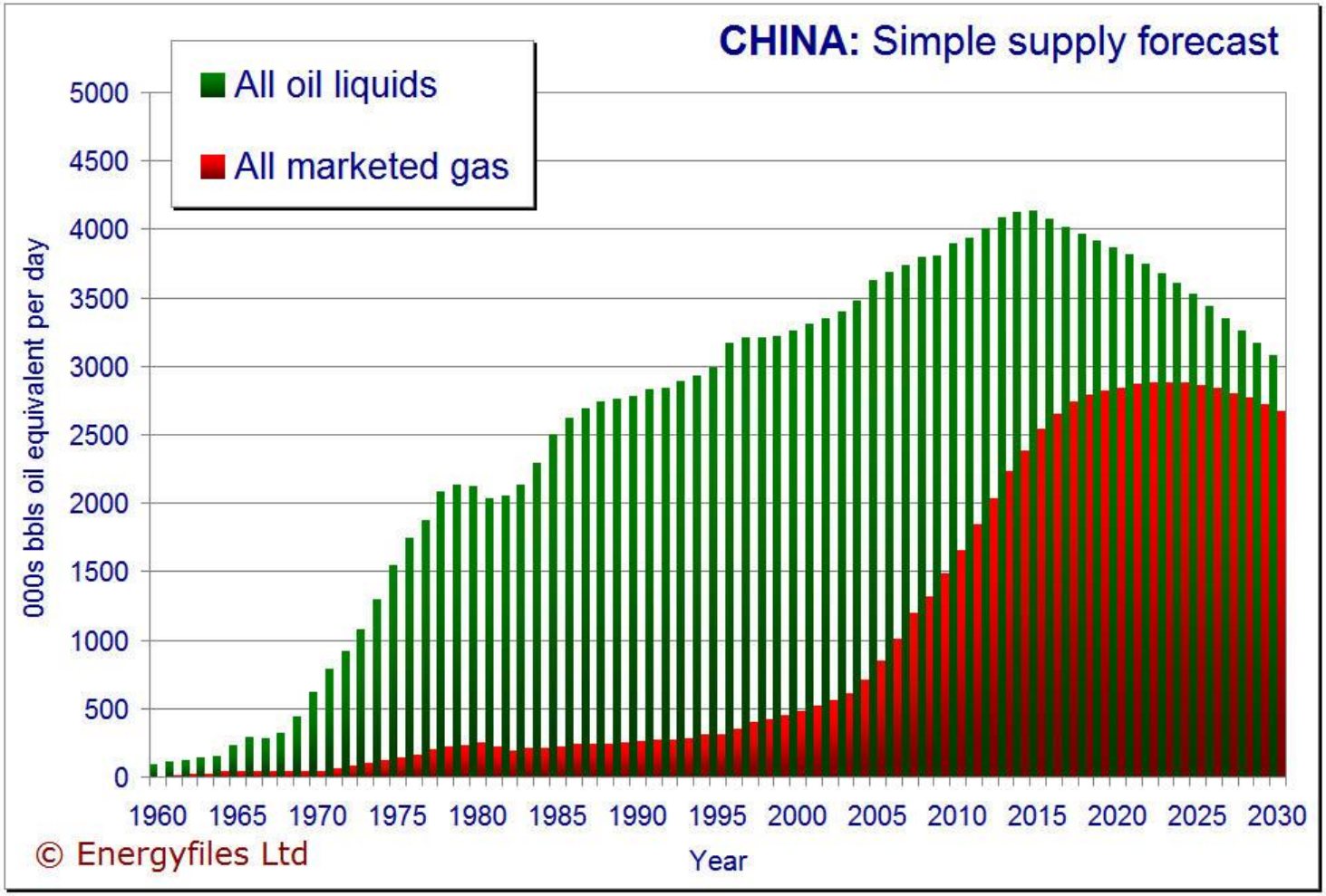


NPD

Proven Reserves:

BP: -

CIA: 0 million barrels oil, 0 billion m^3 gas

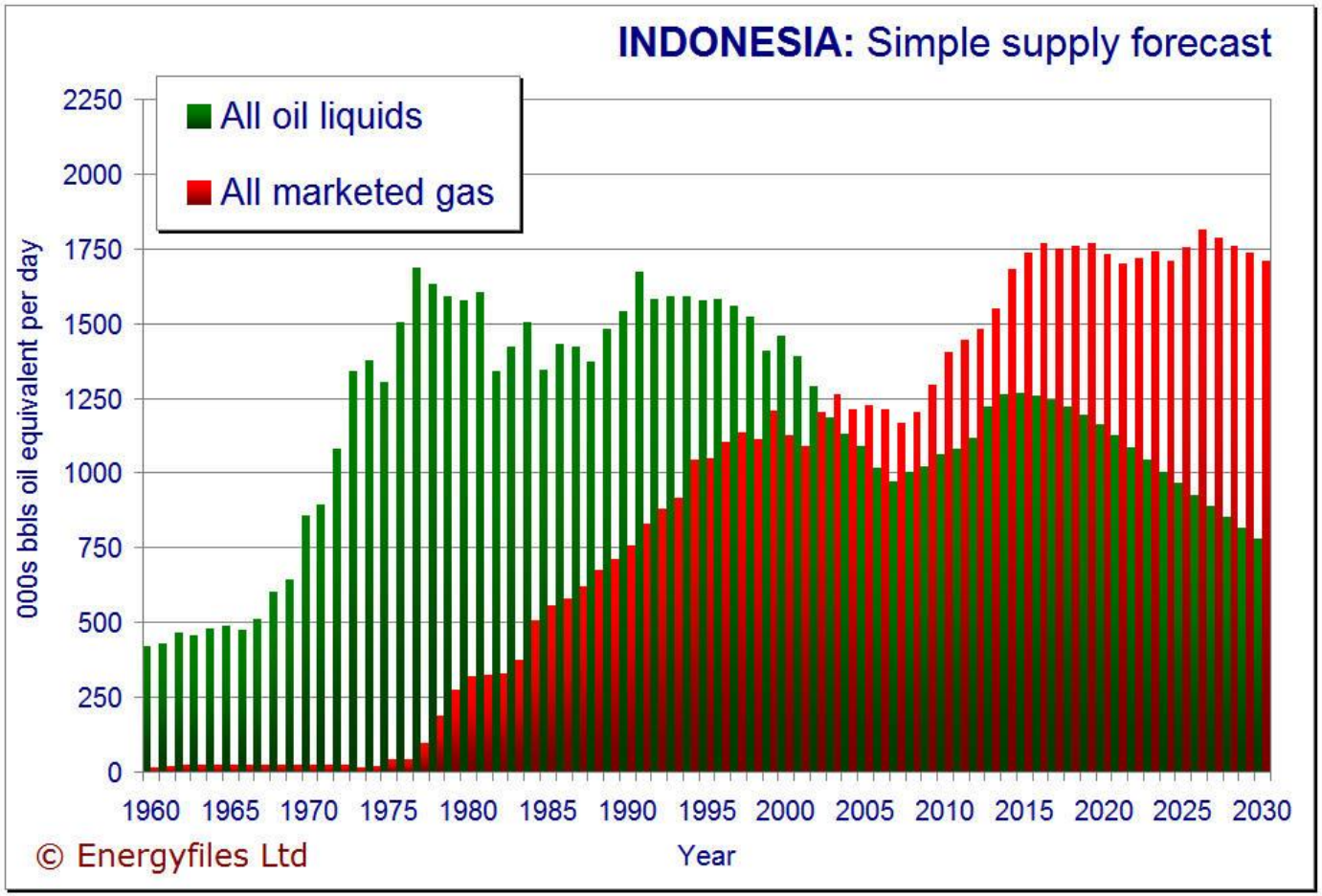


NPD

Proven Reserves:

BP: 14 800 million barrels

CIA: 20 350 million barrels oil, 3030 billion m^3 gas

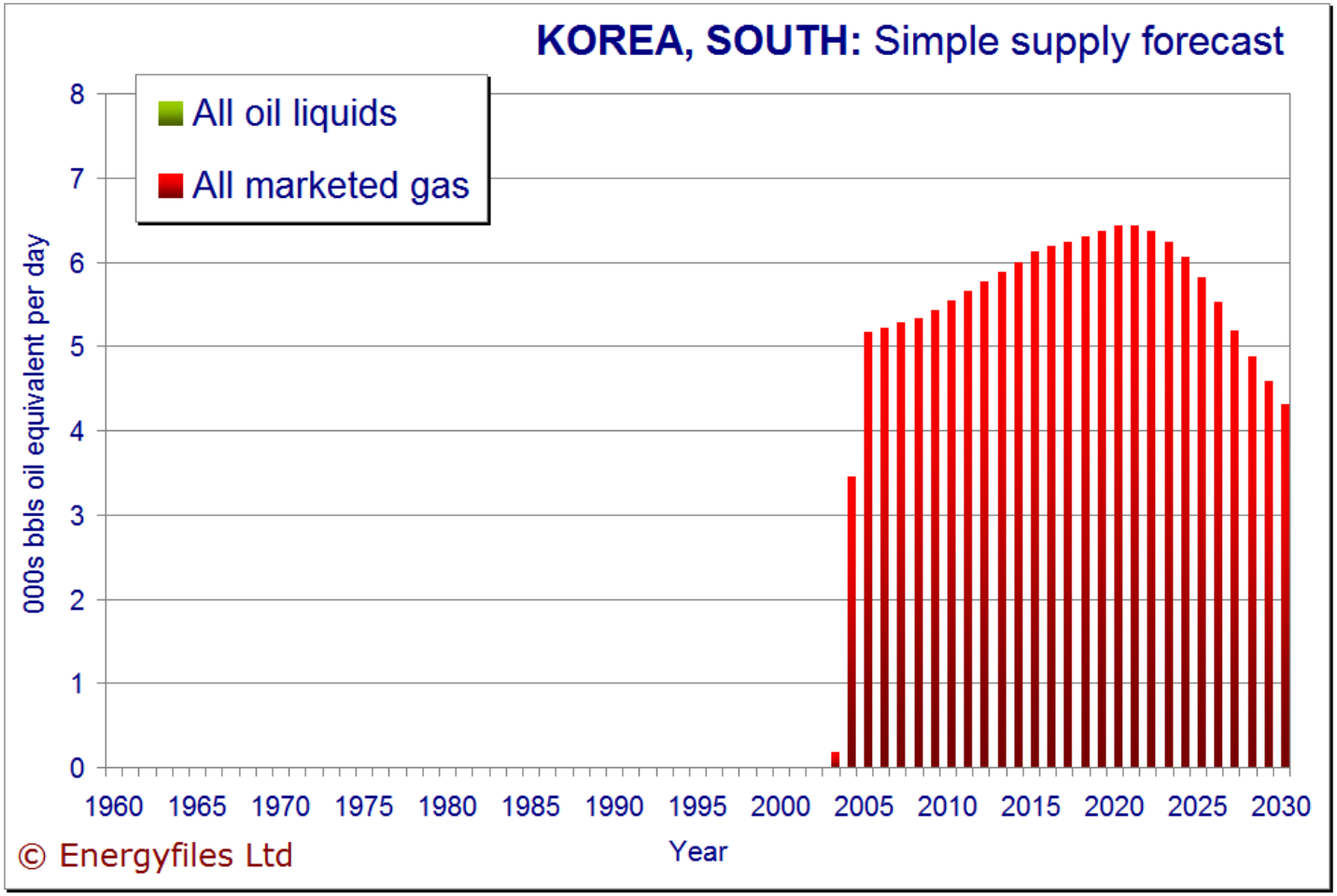


NPD

Proven Reserves:

BP: 4 200 million barrels

CIA: 3 990 million barrels oil, 3000 billion m^3 gas

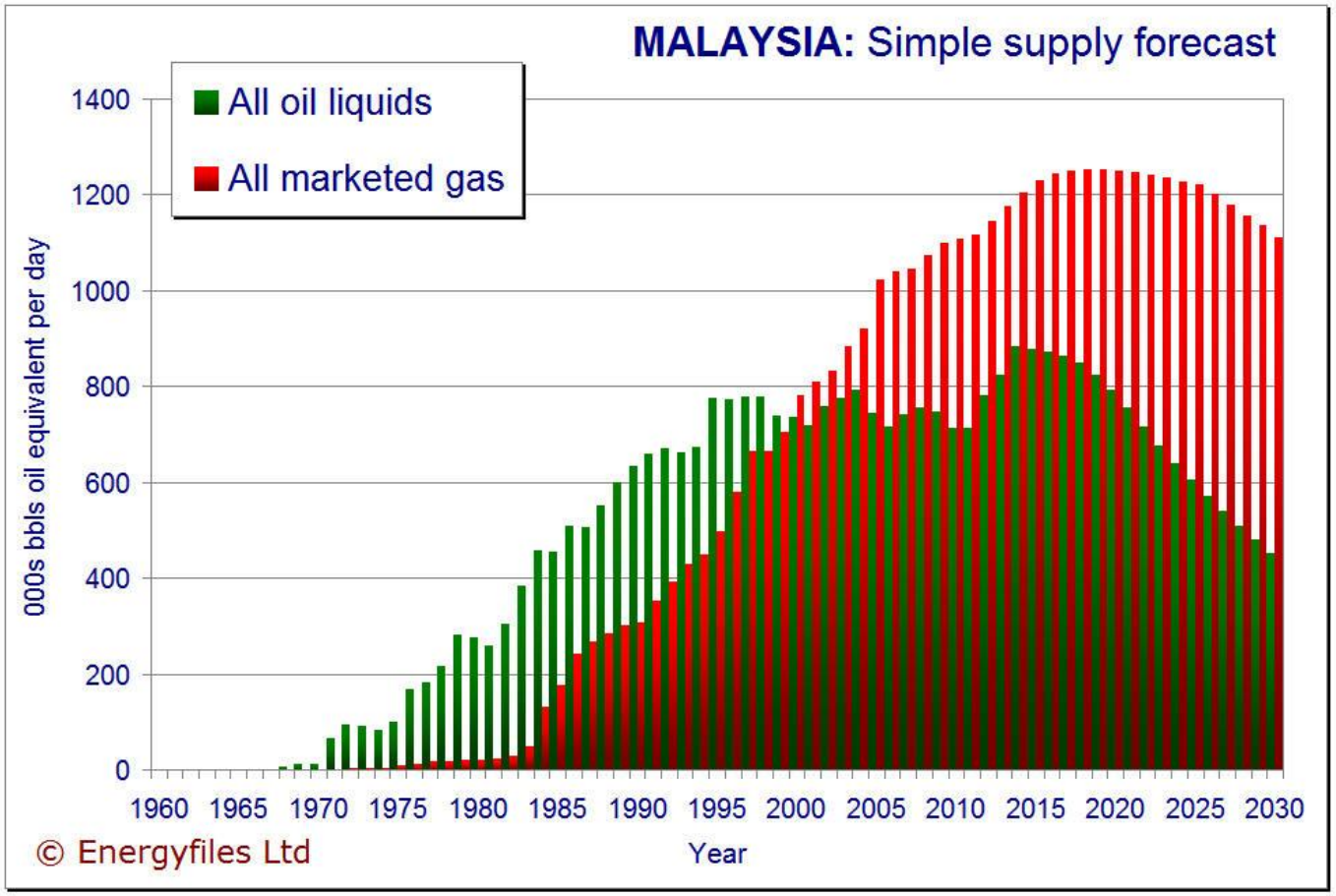


NPD

Proven Reserves:

BP: -

CIA: 0 million barrels oil, 50 billion m^3 gas

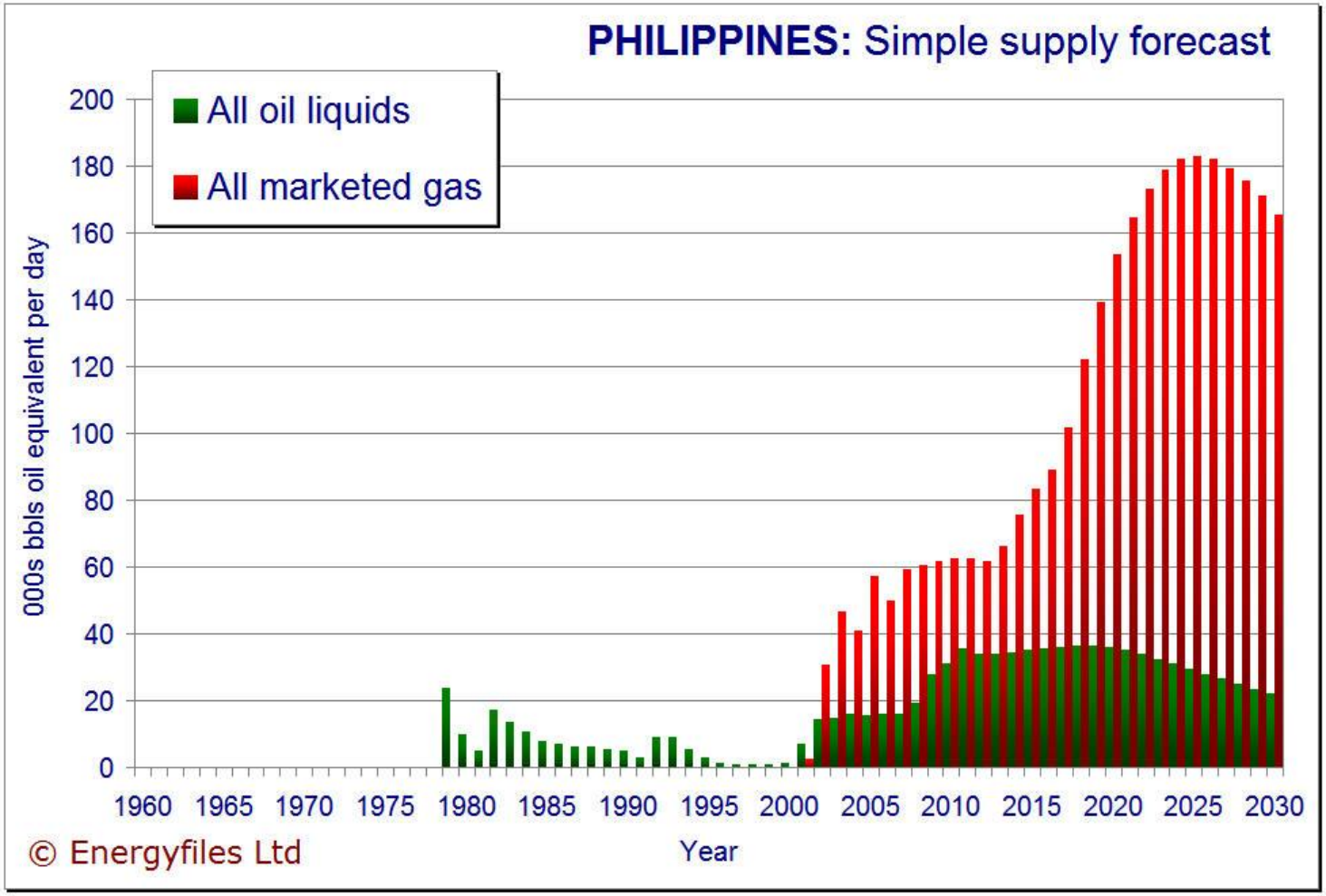


NPD

Proven Reserves:

BP: 5 800 million barrels

CIA: 4 000 million barrels oil, 2 350 billion m^3 gas

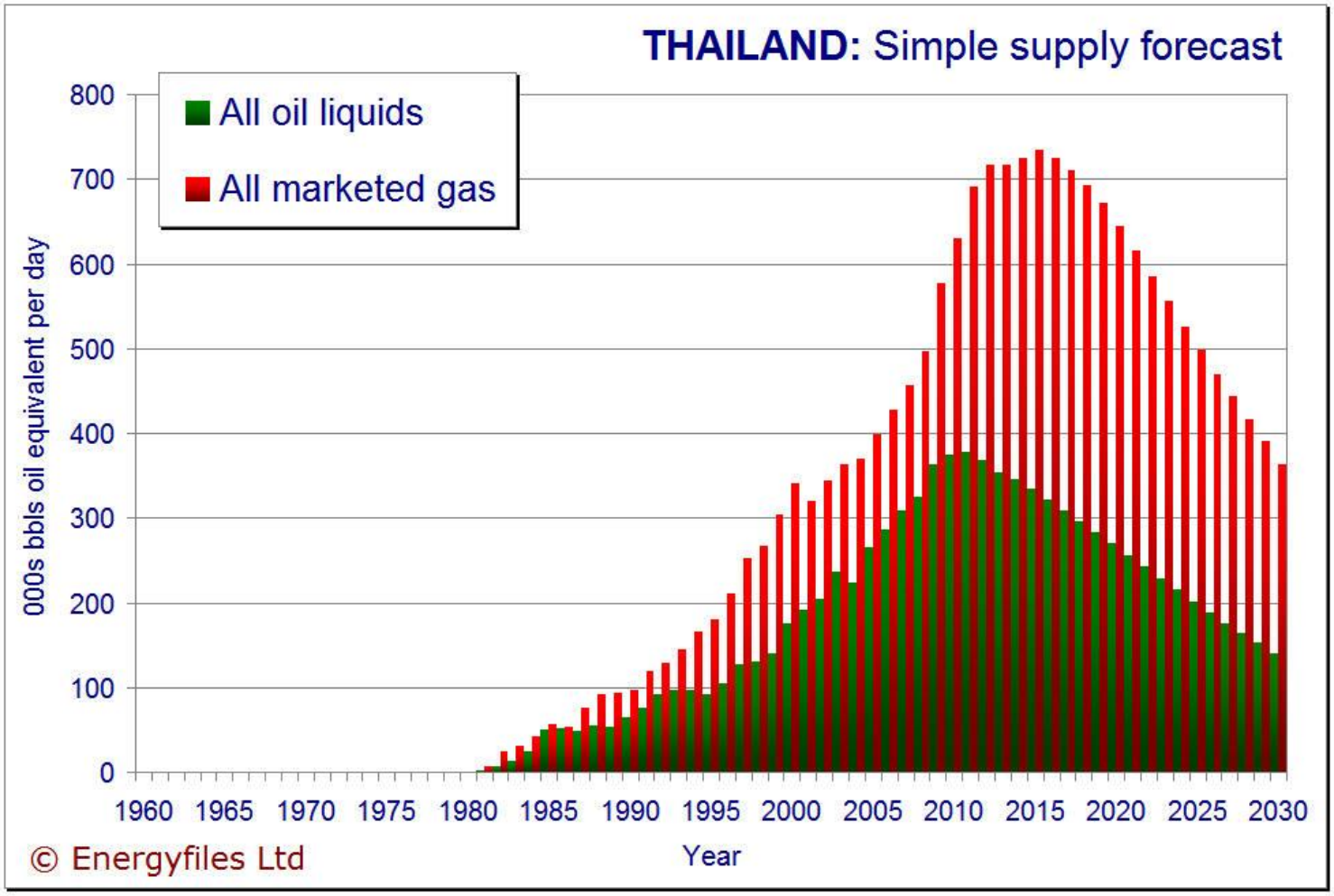


NPD

Proven Reserves:

BP: -

CIA: 138 million barrels oil, 98 billion m^3 gas

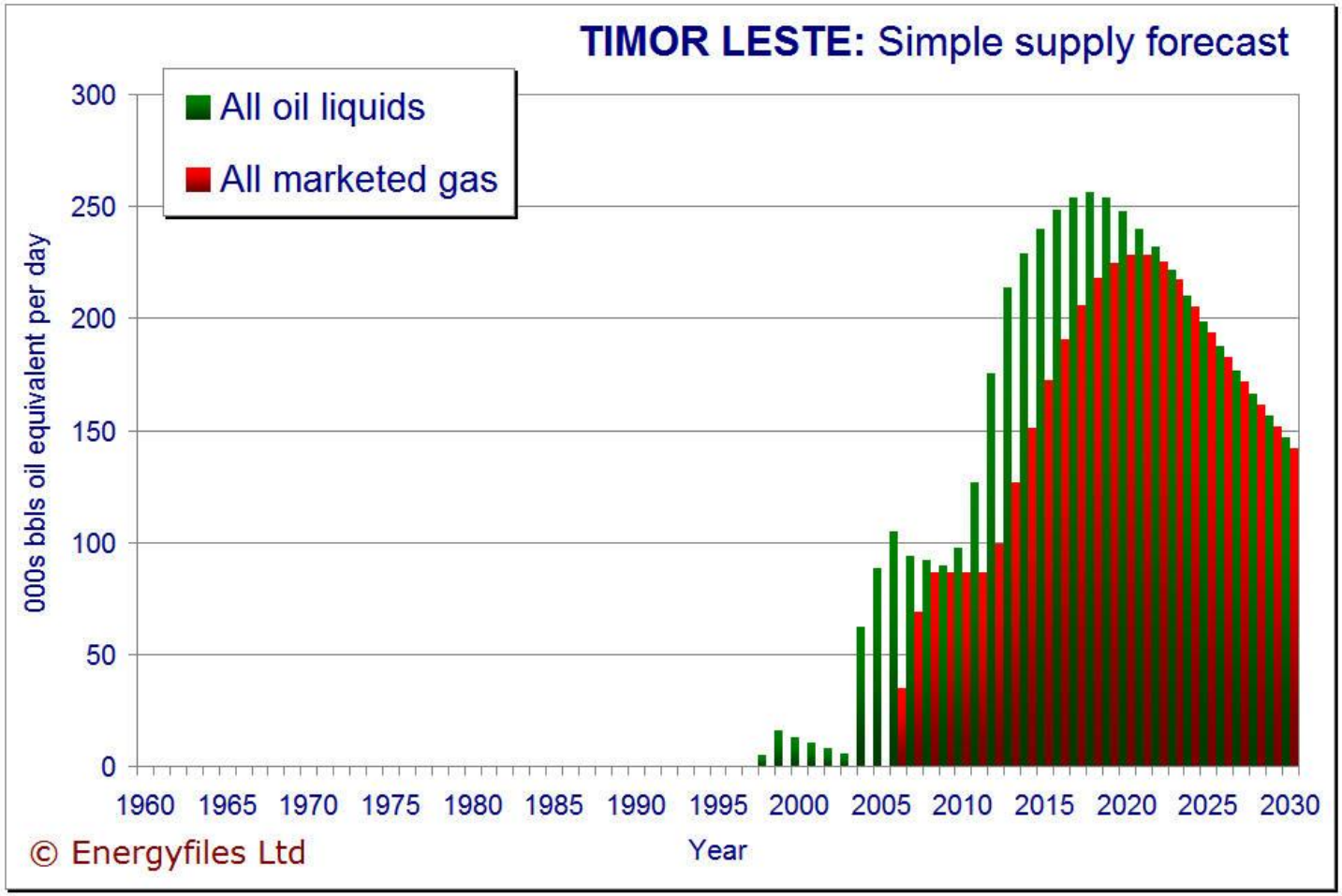


NPD

Proven Reserves:

BP: 400 million barrels oil

CIA: 435 million barrels oil, 312 billion m^3 gas

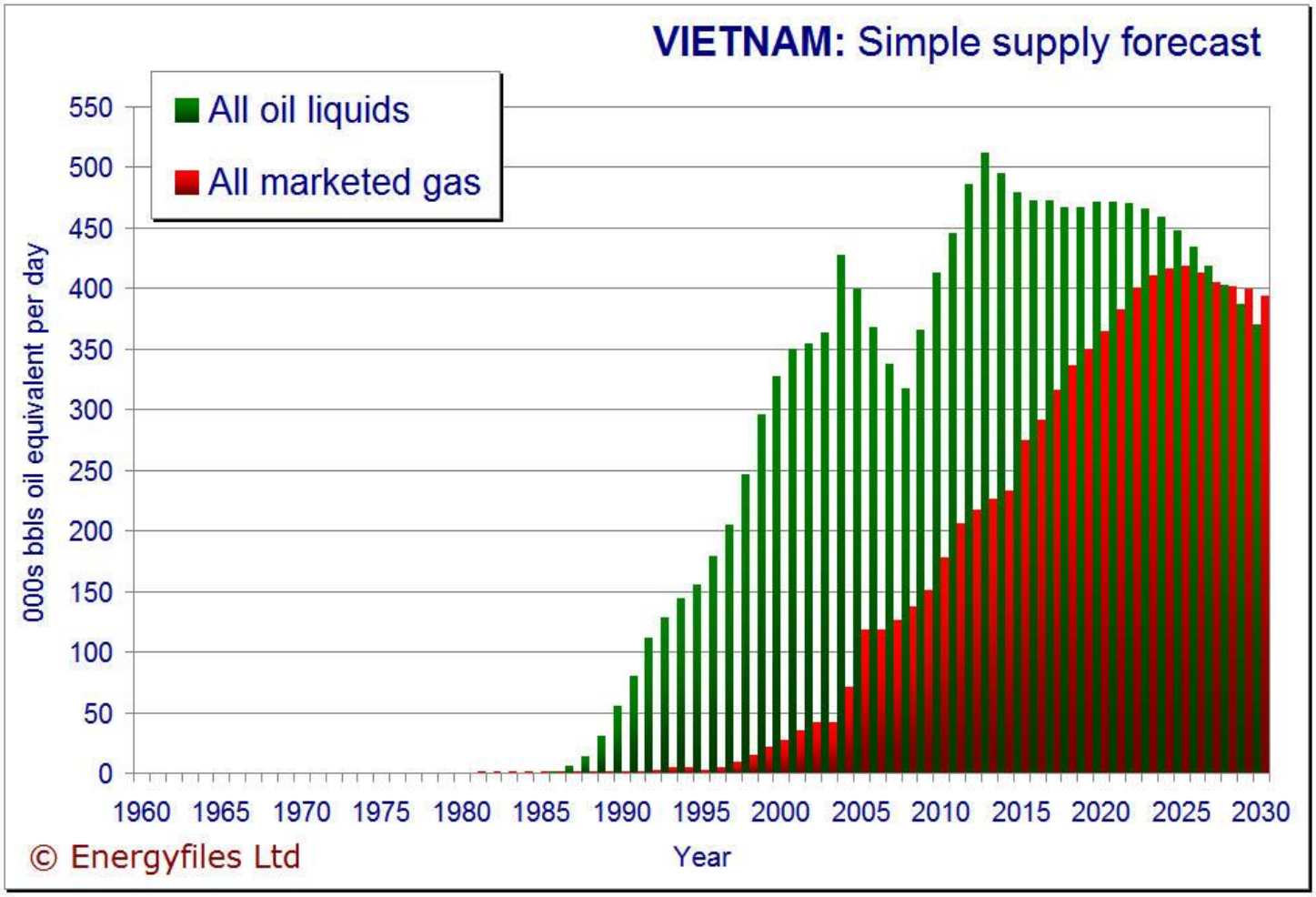


NPD

Proven Reserves:

BP: -

CIA: 553 million barrels oil, 200 billion m^3 gas

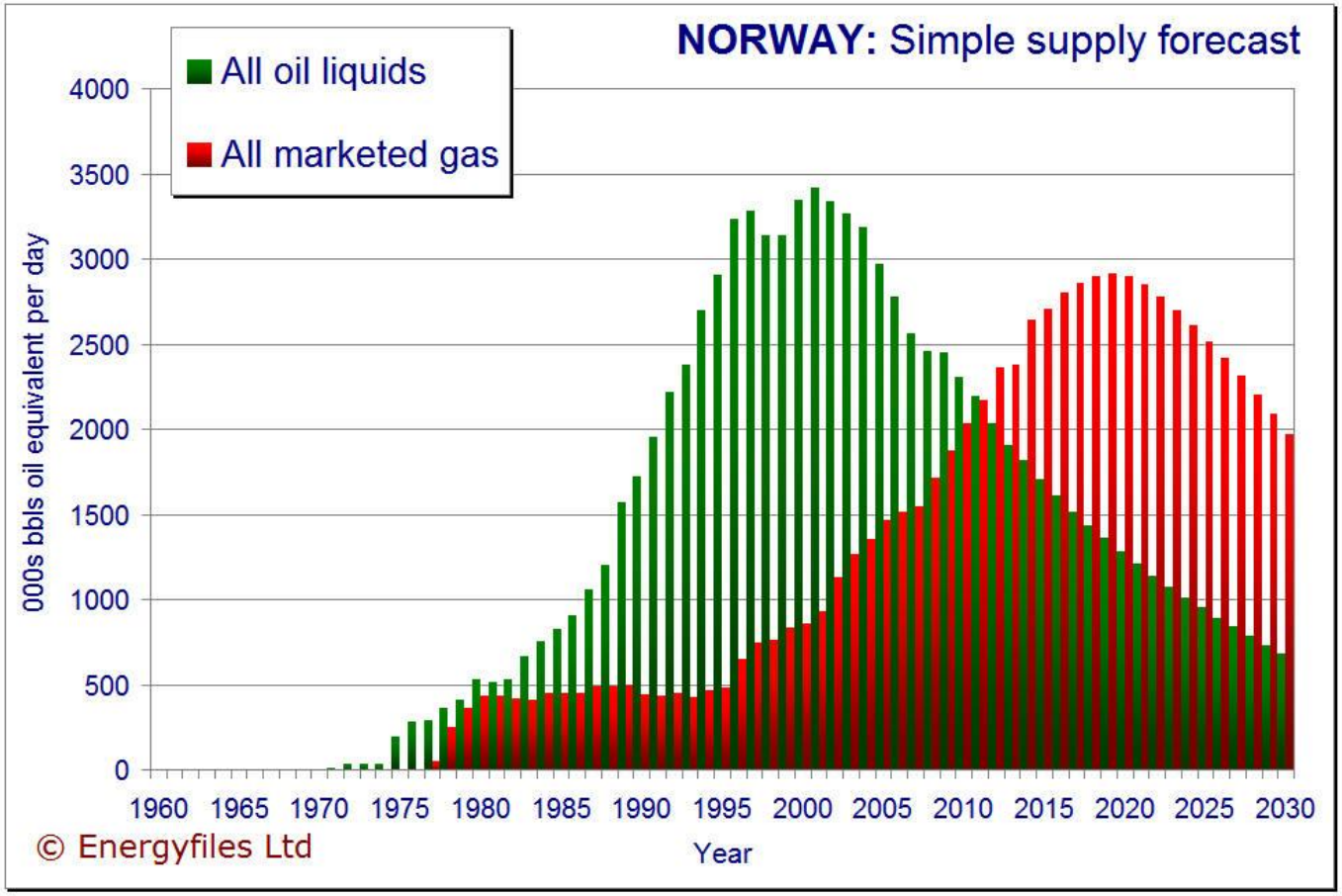


NPD

Proven Reserves:

BP: 4 400 million barrels

CIA: 600 million barrels oil, 192 billion m^3 gas



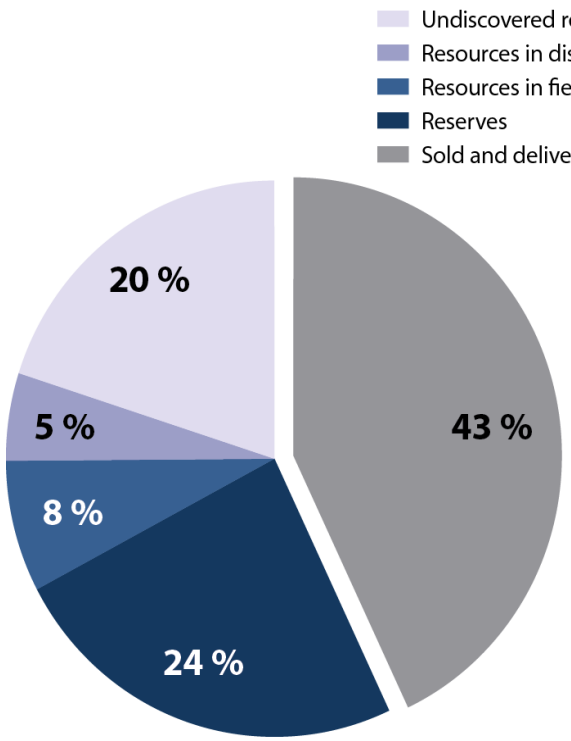
NPD

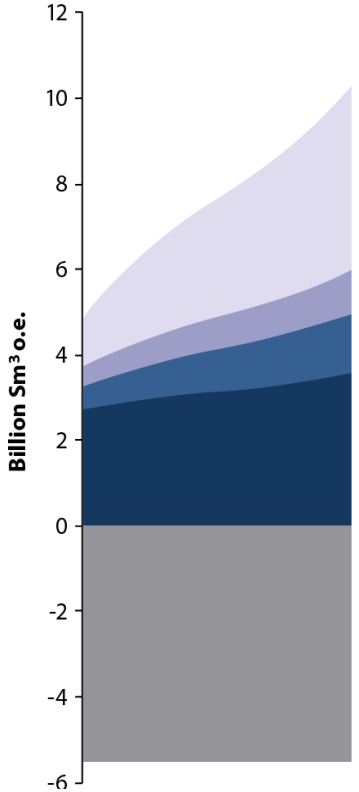
Proven Reserves:

BP: 6 700 million barrels

CIA: 5 670 million barrels oil, 2 039 billion m^3 gas

Norway

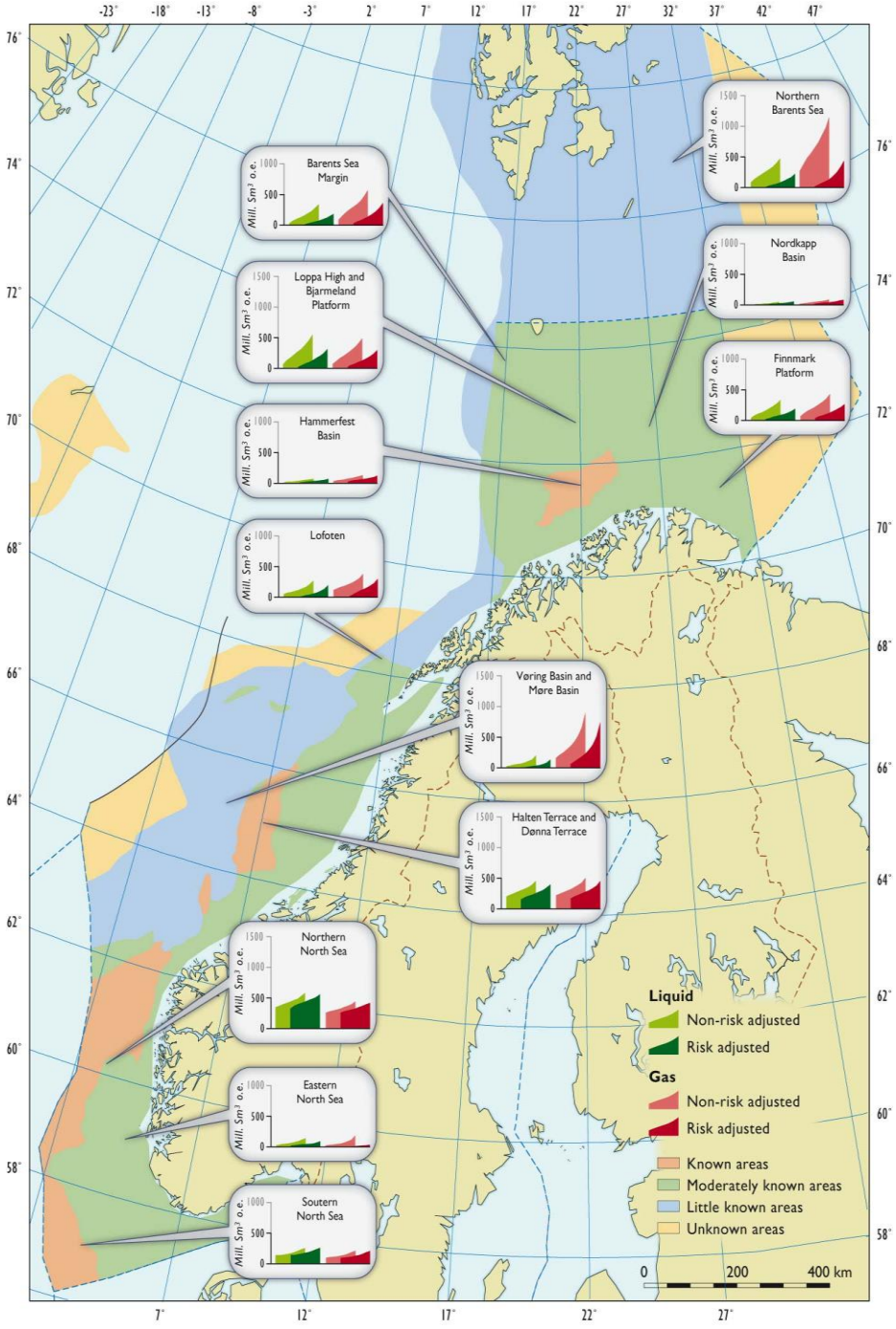




NPD

Total recoverable resources:

- ~ 13 billion Sm^3 o.e.
  - 5.5 billion Sm^3 o.e. Produced
  - **3.1 billion Sm^3 o.e. Reserves**
  - 1.7 million Sm^3 o.e. Contingent resources in fields and discoveries
  - 2.6 billion Sm^3 o.e. Undiscovered resources



NPD

Resource account for Norwegian shelf

Systematic analysis based on all data acquired

Published on paper and internet

We are going to talk about Prospective Resources

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	Project Maturity sub-classes	Project status category	
Production		S	Sold and delivered
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Unrecoverable			
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	Lead	9	Lead and Play
	Play		

Definitions

- Petroleum system.
  - A group of plays within a given geographical area having a common source rock.
- Play.
  - A geographically and stratigraphically delimited area where common geological factors exist in order that petroleum accumulation can occur.
- Prospect.
  - A potential petroleum trap.
  - With a mappable reservoir rock volume.

Prospect Volume

Producable oil volume =

Gross Rock volume x

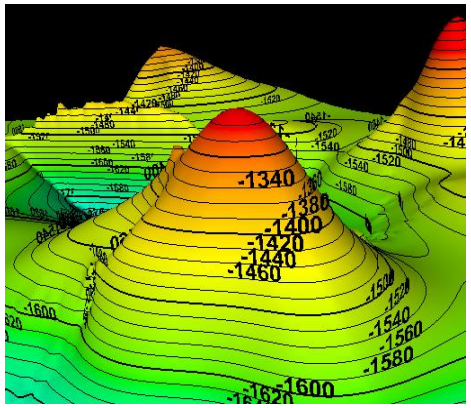
N/G ratio x

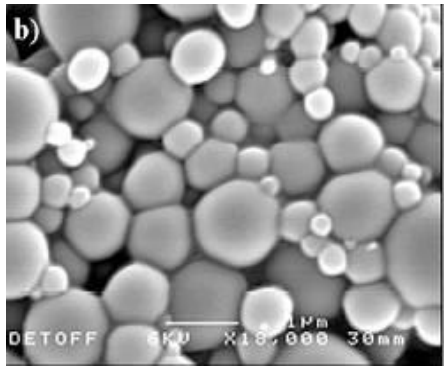
porosity x

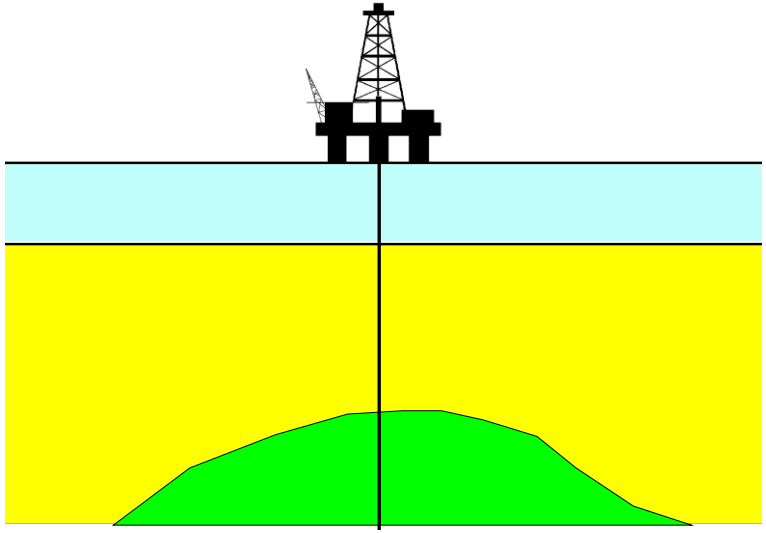
Hydrocarbon saturation x

Formation volume factor x

Recovery factor







Methods for resource assessment

- Analogue
- Petroleum Systems
- Areal yield
- Volumetric yield
- Geochemical material-balance
- Historical methods
- Prospect and play analysis
- Direct or combinations of methods

Level of Knowledge (LOK)

LOK	*Basin Description*	*Methodology*
Very High	The basin is very well explored and has a multitude of discoveries in all plays. Most plays are regarded as mature but some will be regarded as emerging. A large proportion of the basin is covered by 3D seismic. The success rate is on a decreasing trend	**Mature fields** Material balance Decline analysis **New fields and discoveries** Quantitative Reservoir Simulations. Probabilistic volumetric calculations **Play and Prospects** Probabilistic prospect analysis Play analysis level A
High	The basin is well explored and has several discoveries. Most of the plays are confirmed, but some are still unconfirmed. Some 3D seismic surveys exist outside of the discoveries and the 2D grid is dense. The success rate is on an increasing trend	**New fields and discoveries** Probabilistic volumetric calculations **Plays and Prospects** Probabilistic prospect analysis Play analysis level B
Moderate	The basin is moderately explored. At least one play is confirmed, but most plays are unconfirmed. Only 2D seismic data exists outside of the discoveries	**Plays and Prospects** Probabilistic prospect analysis Play analysis level C
Low	Little exploration has taken place. No plays are confirmed. Only a few regional seismic lines or a very coarse grid of 2D seismic exists	**Plays** Play analysis level C
Very Low	None or very little exploration has taken place in the basin. No or little seismic exists.	Delphi and Analogue methods

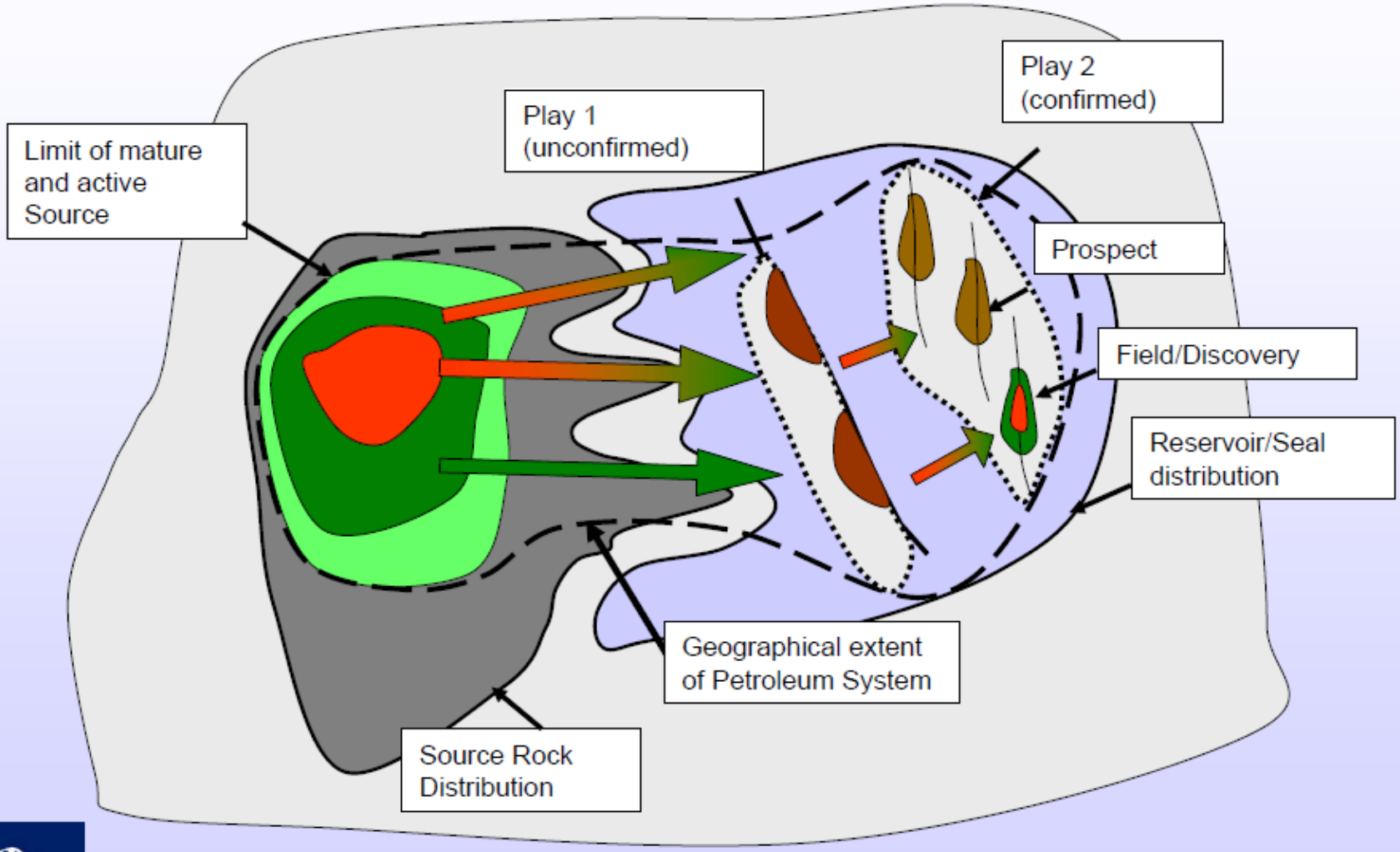
Analogue –
when you know little about the basin

- Sedimentary basins with no or little exploration and with very little data/information about geological evolution and prospectivity.
- Compare the basin with other known explored basins anticipated to be of similar geological evolution where information is available
- Require good analogue database

Petroleum system (PS)

- The petroleum system is the essential elements and processes as well as all genetically related hydrocarbons that occur in petroleum shows, seeps, and accumulations whose provenance is a single pod of active source rock.
- Source rock is basis for PS

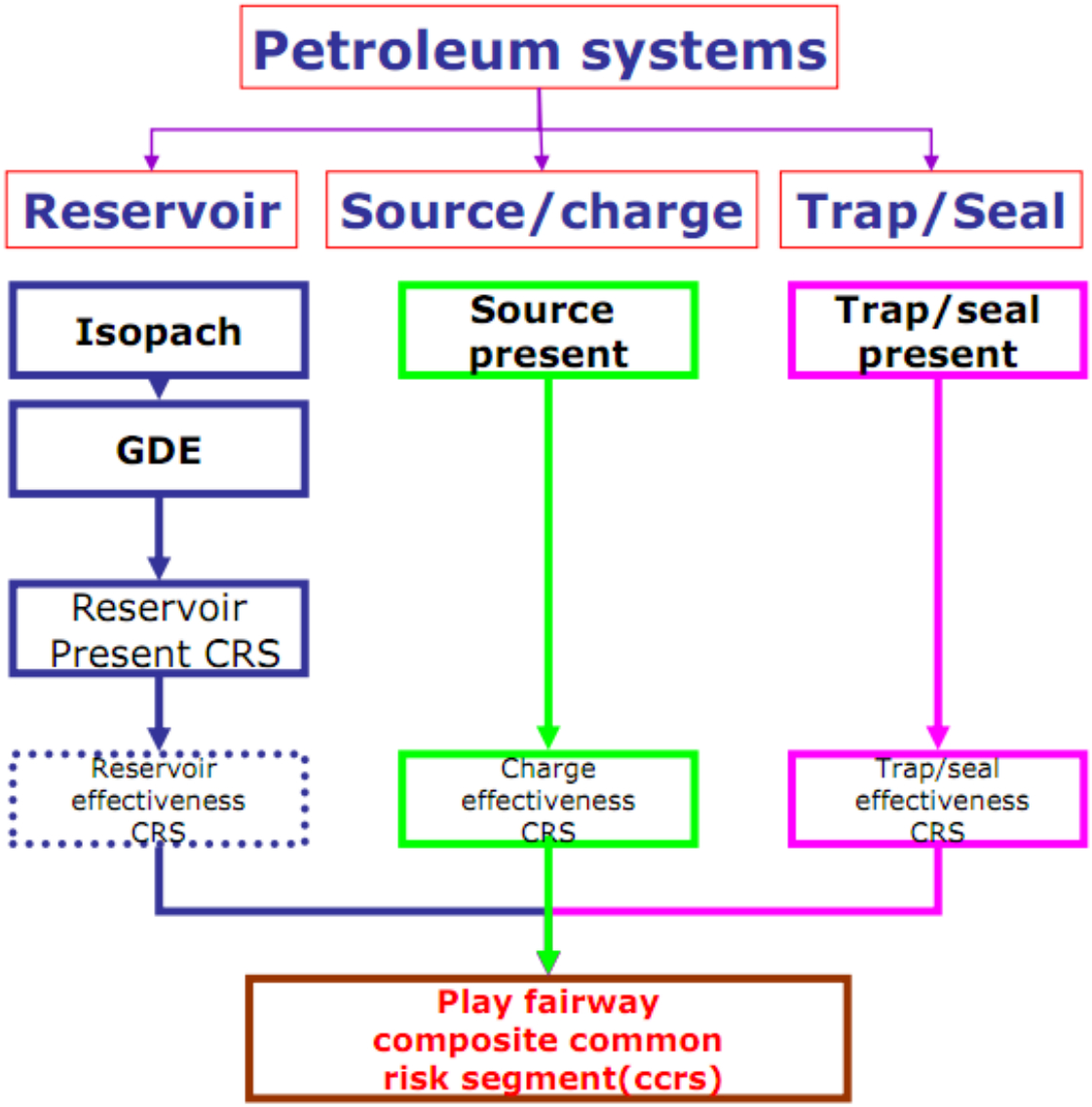
Petroleum system



Dr. Alfred Kjemperud

Modified from R. Birtles, 2000

Play fairway analysis



Total Petroleum System TPS (USGS)

The TPS is a naturally occurring hydrocarbon-fluid system in the lithosphere that can be mapped, and includes the essential elements and processes needed for oil and gas accumulations to exist.

Assessment based on probability for

1. **Charge** (source rock and termal maturity)
2. **Rocks** (Reservoir, trap and seal)
3. **Timing** (relative ages of migration, traps and preservation)

USGS
science for a changing world

Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle

In the Circum-Arctic Resource Appraisal (CARA), 33 provinces were examined, of which 25 were judged to have a 10-percent or greater probability of at least one significant undiscovered petroleum accumulation in any constituent assessment unit (AU) and were therefore quantitatively assessed. Shown in these three maps are the relative probabilities for all assessment units assessed and the estimated relative potentials for undiscovered oil and gas in the assessed provinces.

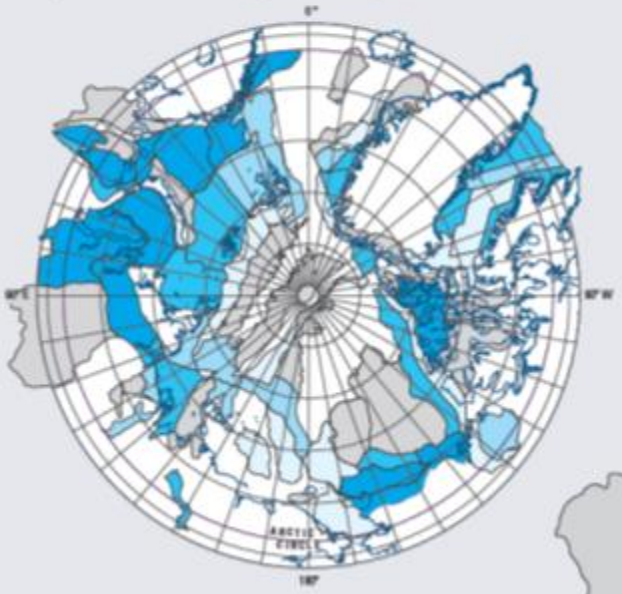


Figure 1. Assessment units (AUs) in the Circum-Arctic Resource Appraisal (CARA) color-coded by assessed probability of the presence of at least one undiscovered oil and/or gas field with recoverable resources greater than 50 million barrels of oil equivalent (MMBOE). Probabilities for AUs are based on the entire area of the AU, including any parts south of the Arctic Circle.

PROBABILITY
(percent)

- 100
- 50–100
- 30–50
- 10–30
- <10
- Area of low petroleum potential

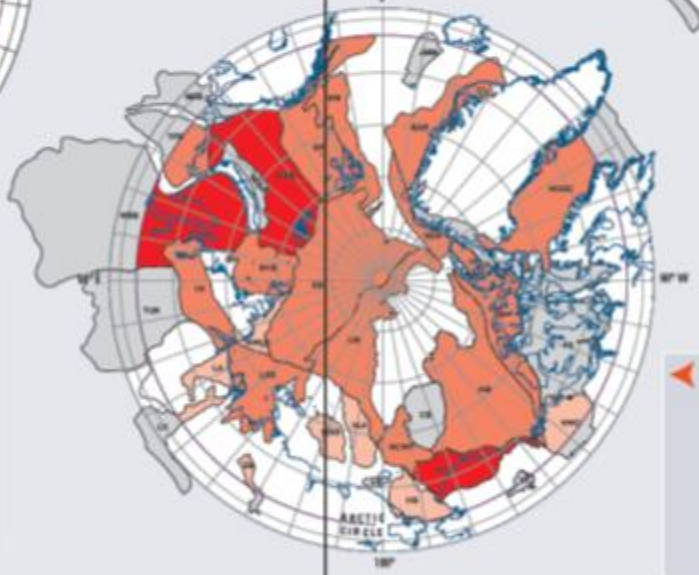


Figure 2. Provinces in the Circum-Arctic Resource Appraisal (CARA) color-coded for mean estimated undiscovered gas. Only areas north of the Arctic Circle are included in the estimates. Province labels are the same as in table 1.

UNDISCOVERED GAS
(trillion cubic feet)

- >100
- 6–100
- <6
- Area not quantitatively assessed
- Area of low petroleum potential

Figure 3. Provinces in the Circum-Arctic Resource Appraisal (CARA) color-coded for mean estimated undiscovered oil in oil fields. Only areas north of the Arctic Circle are included in the estimates. Province labels are the same as in table 1.

UNDISCOVERED OIL
(billion barrels)

- >10
- 1–10
- <1
- Area not quantitatively assessed
- Area of low petroleum potential

Assessment Unit (AU) within the Total Petroleum System (TPS)

- The assessment unit (AU) ***is a volume of rock*** within the TPS that encompasses fields, discovered and undiscovered, sufficiently homogeneous in terms of geology, exploration strategy and risk characteristics to constitute a single population of field characteristics with respect to criteria used for resource assessment.
- TPS may consist of several AU.

Arial yield

Potentially productive area * Yield

A simple, “quick and easy” method

Problem:

Does not take into account variations in depth!

Volumetric yield

Potentially productive area * Average net pay thickness * Yield

BASIN ASSESSMENT BY VOLUMETRIC YIELD

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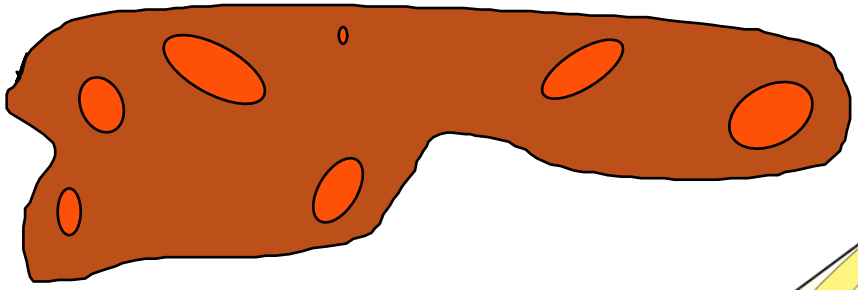
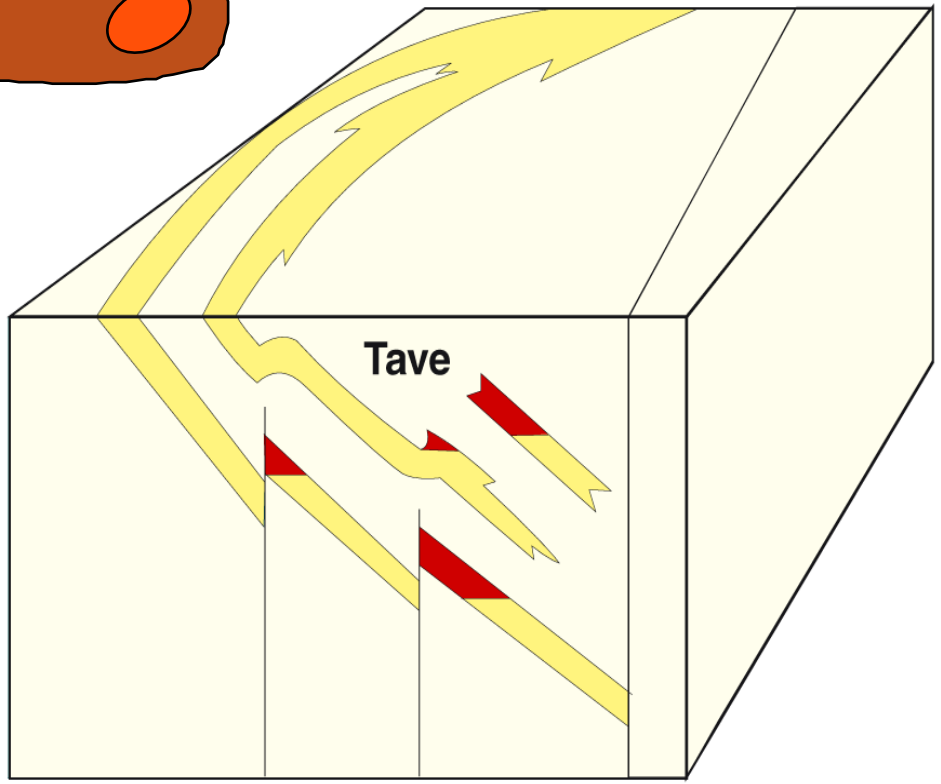


NC VOLUME FACTORS

BASIN AREA, Mi^2 (A)
x
AVERAGE TOTAL-SEDIMENT THICKNESS, Mi (T)
x
POTENTIAL BBL/Mi^3



POTENTIAL FIELDS IN BASIN

CCOP, Rep phase 1. June 1996

OD 0404007

Geochemical material balance

Calculate the amount of hydrocarbons generated from the source rock, migrated and entraped.

Important factors:

- **drainage area**
- **thickness of source rock above and below reservoir bed**
- **generated amount of hydrocarbons**
- **migrated amount of hydrocarbons**
- **entrapped amount of hydrocarbons**

Problem:

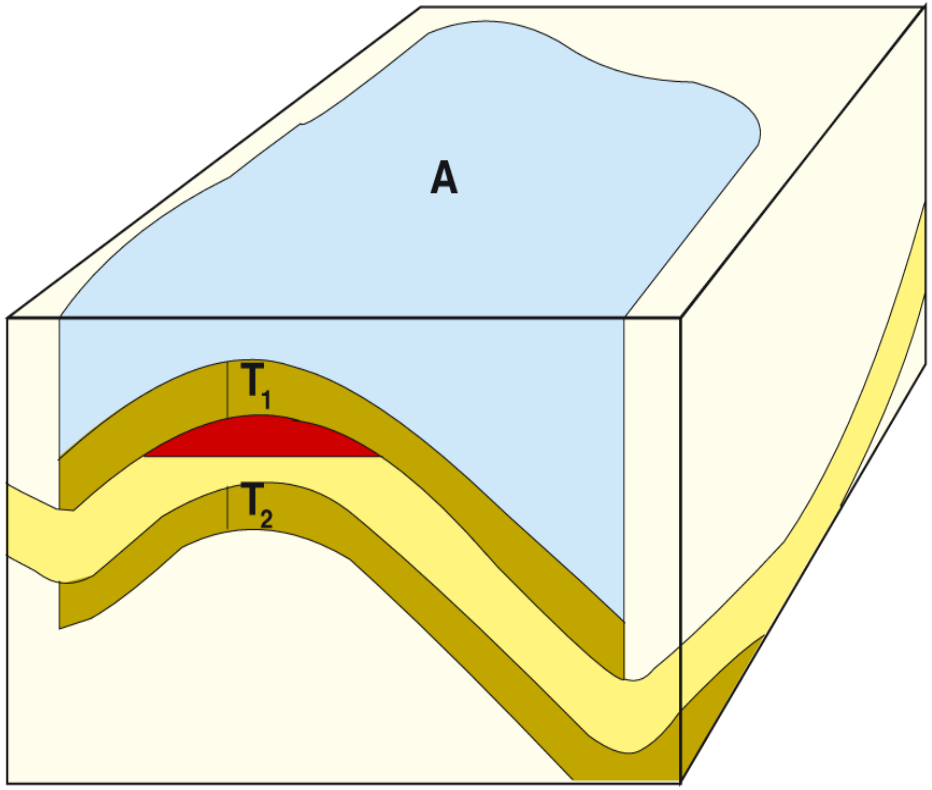
The level of understanding of the basic processes and the ability to reconstruct the geological history.

PROSPECT ASSESSMENT BY GEOCHEMICAL MATERIAL BALANCE

NPD

NC VOLUME FACTORS

DRAINAGE AREA (A)
x
SOURCE THICNESS (T_1 + T_2)
x
% ORGANIC CONTENT
x
% GENERATED INTO HYDROCARBON
x
% MIGRATED
x
% TRAPPED
x
% POTENTIALLY RECOVERABLE



POTENTIAL FIELD IN PROSPECT

CCOP, Rep phase 1. June 1996

OD 0404006

Historical method

- Field number and size

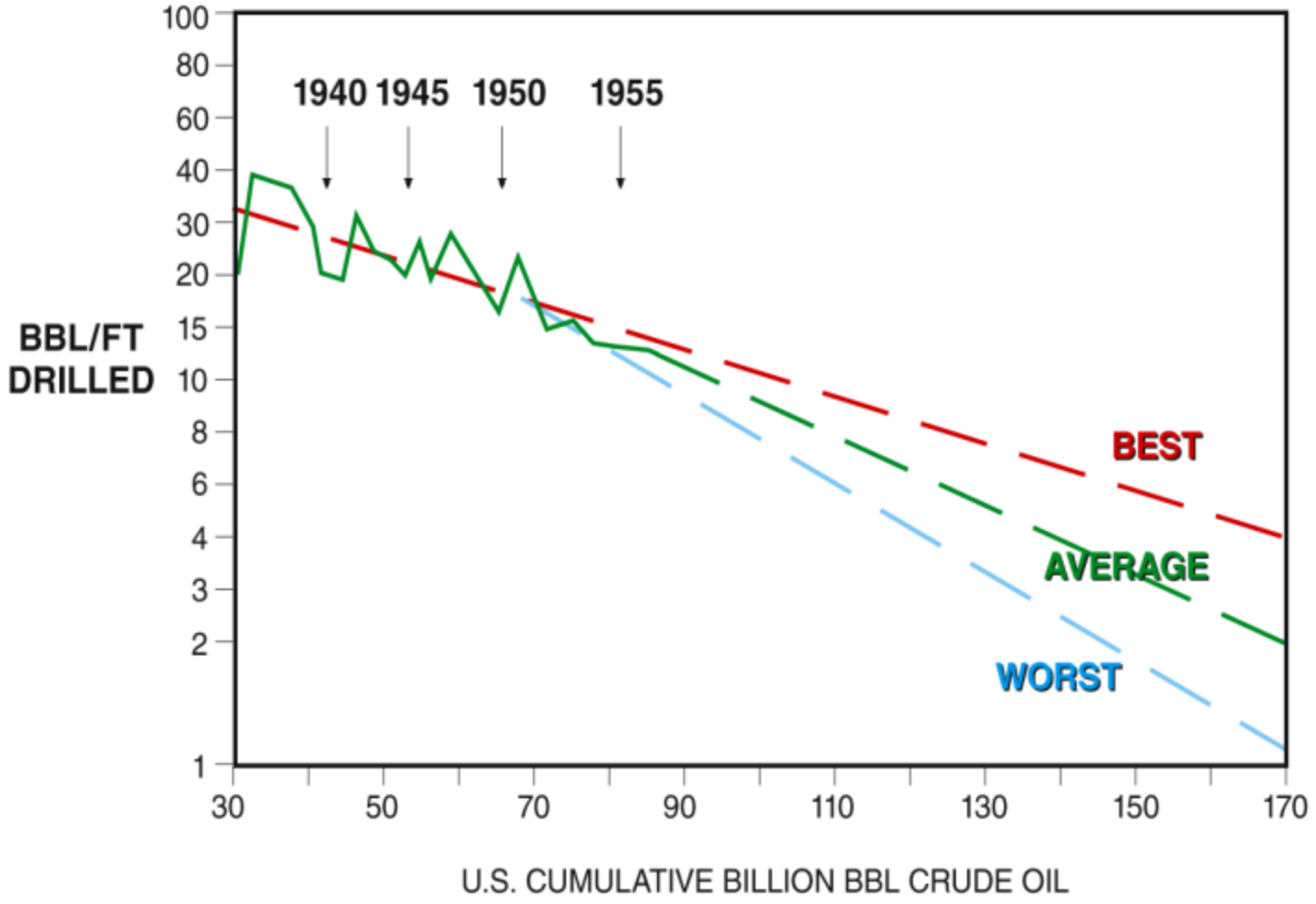
Extrapolate known prospect sizes and discovery rates from drilled prospects to undrilled prospects.

Problem:

Based on areas where all relevant prospects are mapped.

Prospect types which are not easily recognised, as stratigraphic traps are a problem.

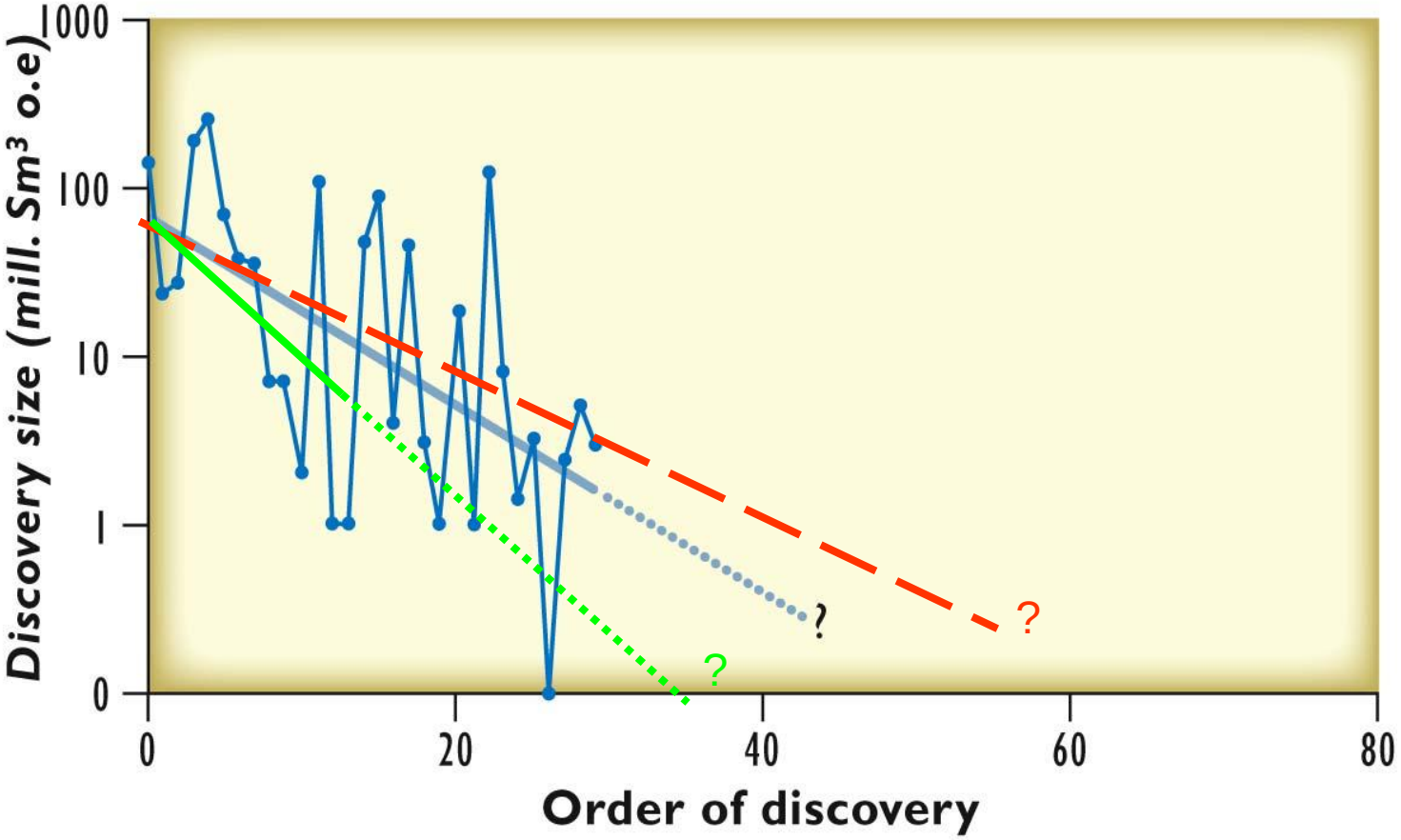
EXTRAPOLATION OF DISCOVERY RATE EXPRESSED AS BARRELS DISCOVERED PER FOOT DRILLED



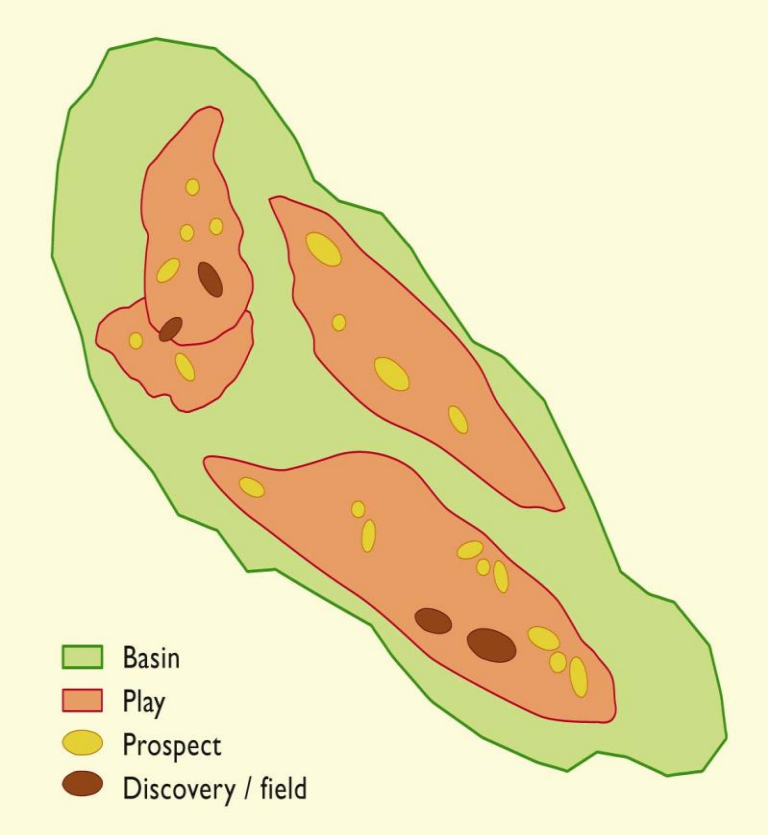
CCOP, Rep phase 1. June 1996

OD 0404005

Discovery Process Modelling



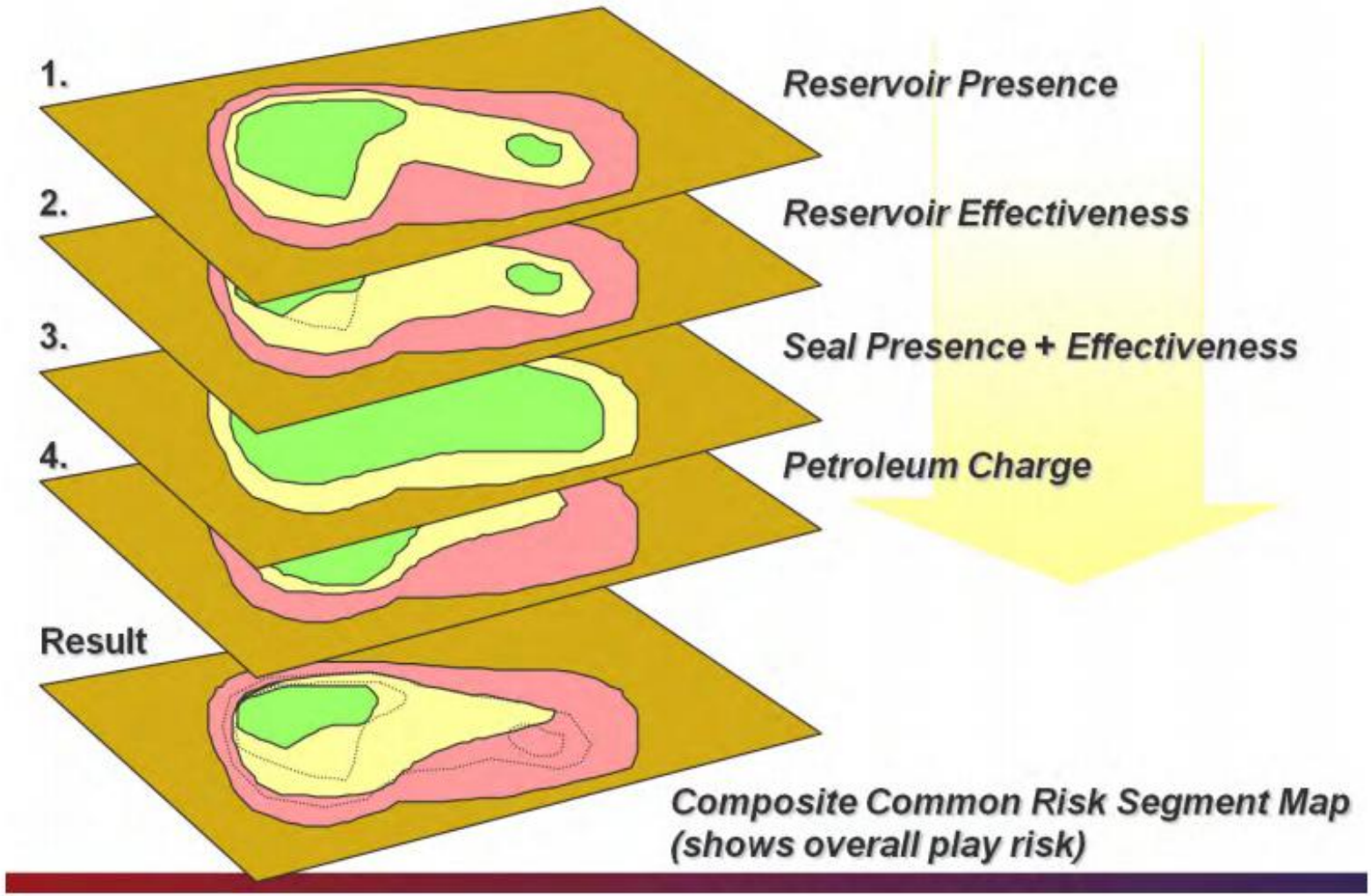
Estimating undiscovered resource volumes by statistical methods – play modelling



A Petroleum play is:

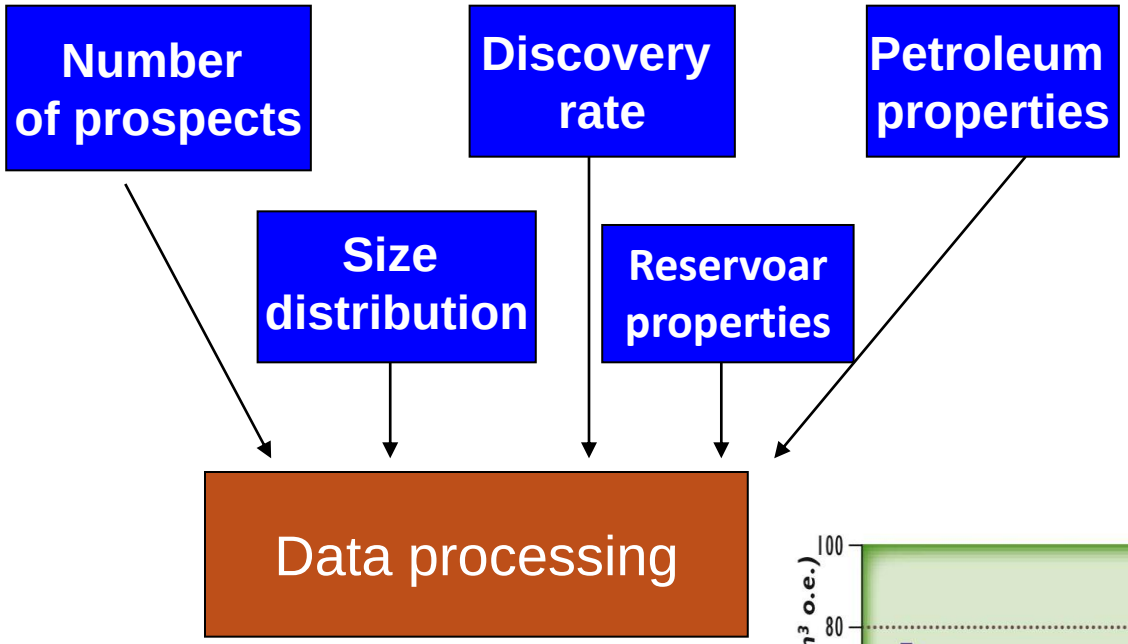
- Geographically and stratigraphically delimeted area.
- Spesific set of geological factors; reservoir, trap, source.
- Confirmed play: discovery.
- Unconfirmed play: no discovery.
  - The play is risked.

Common Risk Segment Overlay Process (to get the Composite Risk)



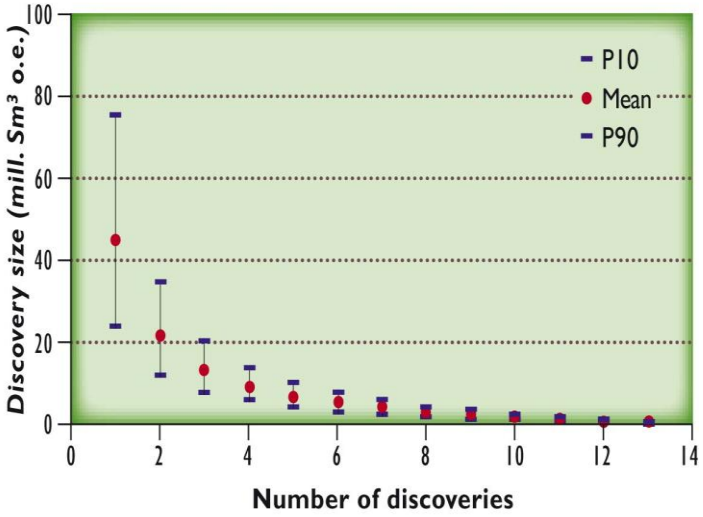
Statistical modeling

Input data:



Assessment software:

Results: Number and size distribution of future discoveries, volume of oil, gas and condensate.



Reliably assessing the resource base takes:

1. **Hard work**
2. **Skilled civil servants**
3. **Functional government institutions**

- **May require assistance from cooperating countries**
- **May require use of independent consultants**