CBM
The forgotten Factor
Areal Desorption Efficiency

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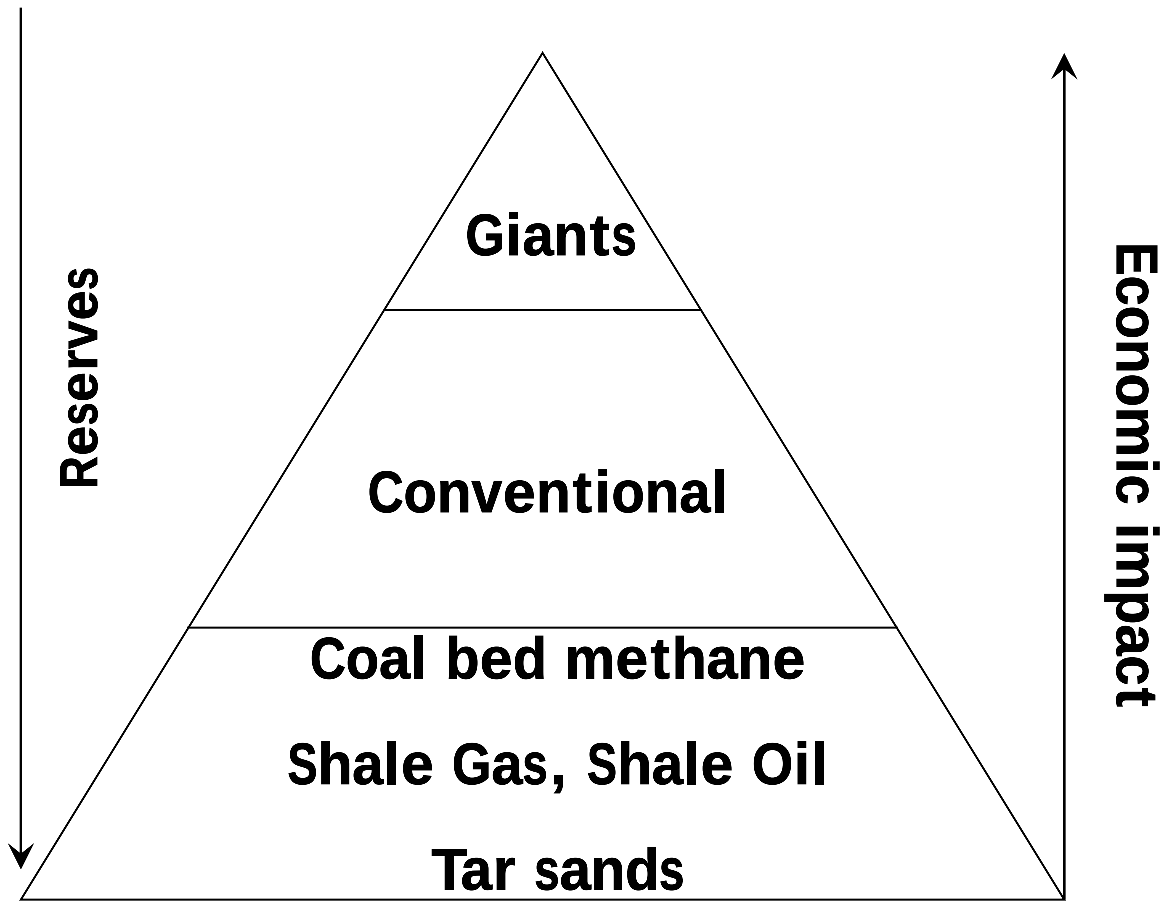
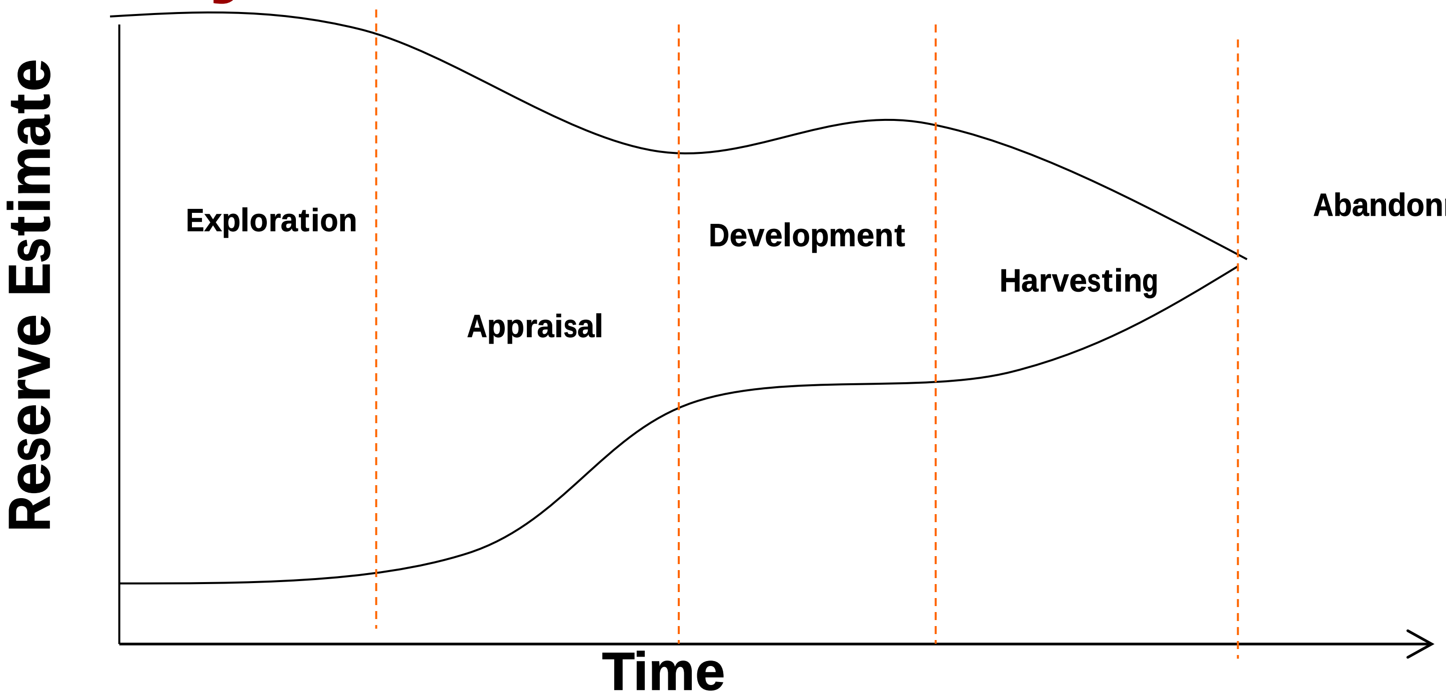
Where Does CBM fit in the resource Triangle



Accuracy of reserves



- Reserves should be expressed as a Range.
- The only time reserves can be 100% accurate is at abandonment of the field.
- Conventional fields: To firm up reserves position usually requires production of 2/3 reserve. (That is why range is important)

What makes up a Reserve.

- **Reserve = Recovery Factor X Gas in Place Number**

- **Recovery factor**
  - Extractable Quantity = GIP X RF $0 < t < t_{(\text{abandonment})}$
    - $t_{(\text{abandonment})}$ Determined by mechanical constraints

- **Economic Factor**
  - Reserves = $\Sigma\, EF_{\text{Year } i}$(Extractable Quantity)
    - Sum while $EF_{\text{Year } i}$(Extractable Quantity) is economic

Reserve Estimate is an estimate of economic deliverability over a period of time.

RESERVES

- **Reserve definitions are open to interpretation and this is unavoidable.**
- **Common mistakes**
  - Based on isotherms which ignore areal desorption scaling factor
  - Ignore deliverability
    - Reserves incorporate a time period
  - Ignore economics
    - Many reserve certifications have a clause that economics not included in the analysis – Beware only half the job is done.

Origin energy

Recover Factor – Critical issues

Conventional Gas

- **Drive Mechanism**
- **Areal Sweep Efficiency**
- **Abandonment Pressure**

CBM

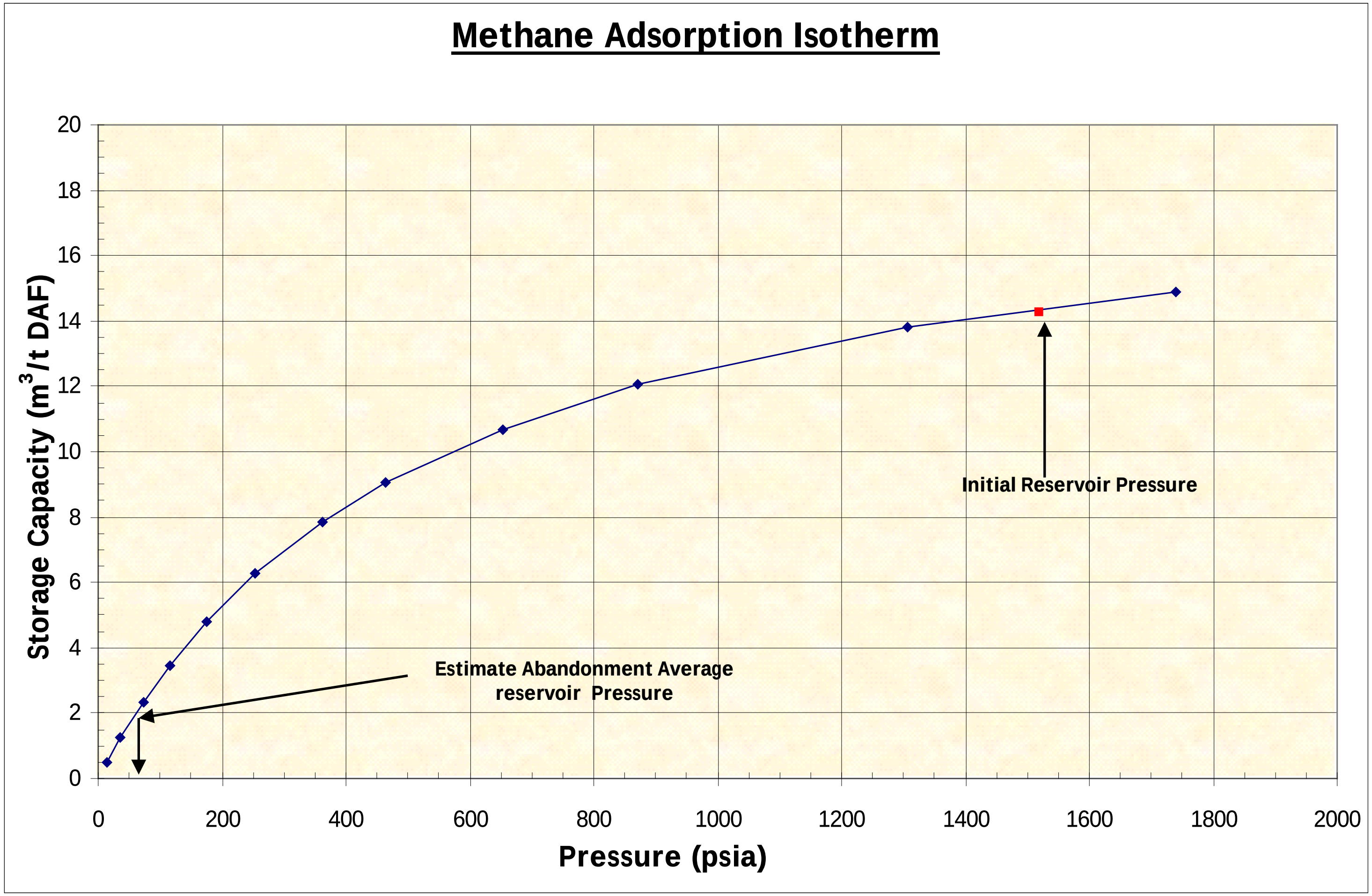
- **Saturation Status**
- **Areal Desorption Efficiency**
  - Permeability (Scale up)
  - Well spacing
  - Cleat spacing
  - Porosity/permeability distribution

Origin energy

Methods of Recovery Factor Determination

- Isotherm (Upper limit).
- Analogy : similar CBM fields
- Simulation
- Decline Curves

Adsorption Isotherm



RF'= (Initial Sorb gas conc. - Abandonment Sorb gas)/ Initial Sorb gas conc.

RF' = 86%

RF from Isotherm

- **Independent of permeability and time**
  - Reserves increase with depth
    - So as perm decreases the reserves increase.
- **Extremely optimistic as it does not take in to account areal sweep efficiency.**
- **RECOVER FACTOR**
- **RF = RF(Isotherm) X Areal Desorption Efficiency**

How do you calculate Areal Desorption Efficiency?

Areal desorption efficiency =

$$\frac{\text{Reserves}}{\text{RF(Isotherm) * Gas in Place}}$$

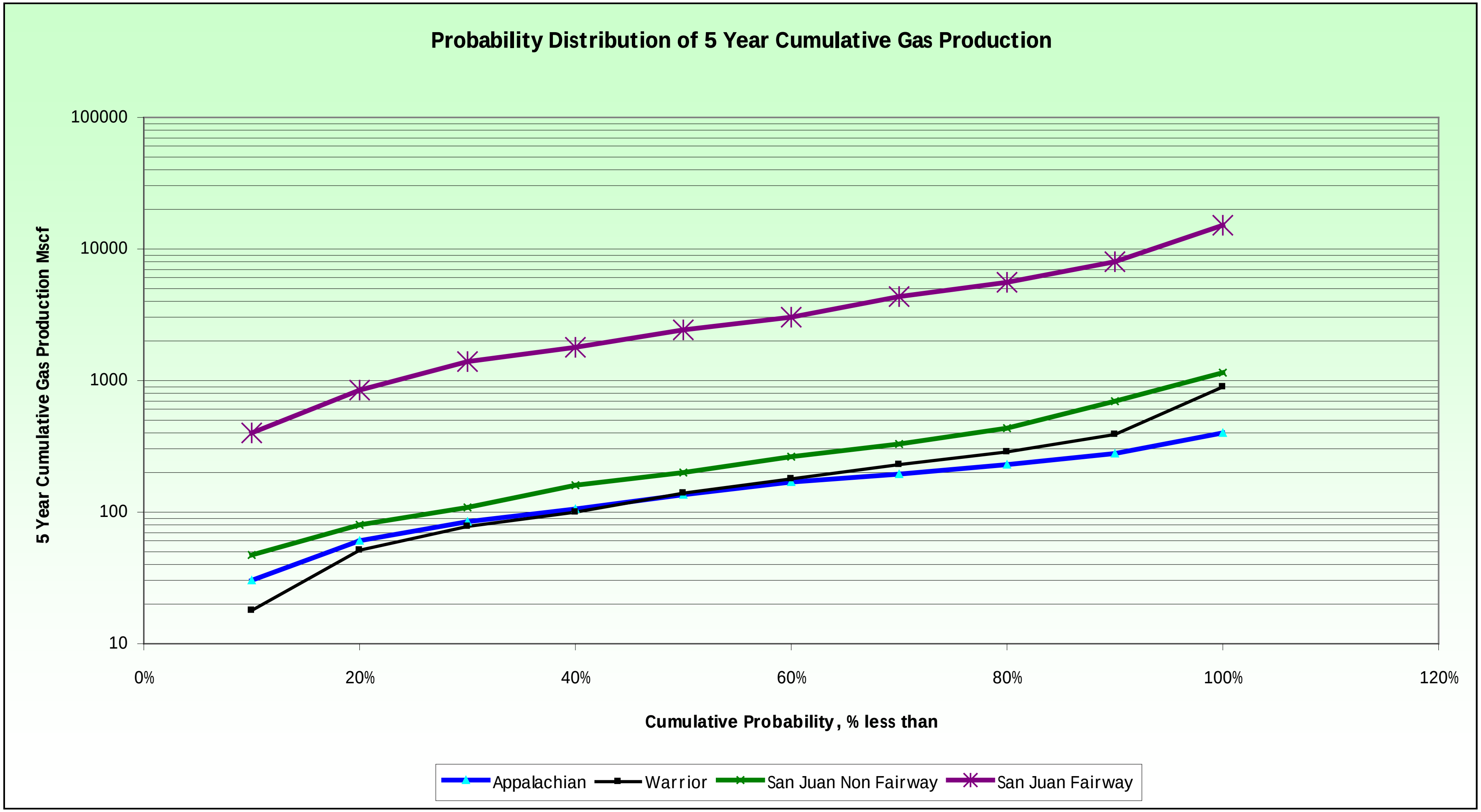
- **But we have two unknowns one equation.**
- **This is why RF from isotherms fall apart because we require to calculate reserves**

Origin energy

By Analogy

- Profiles from similar basins.
- Supporting simulation outcomes

US Basins

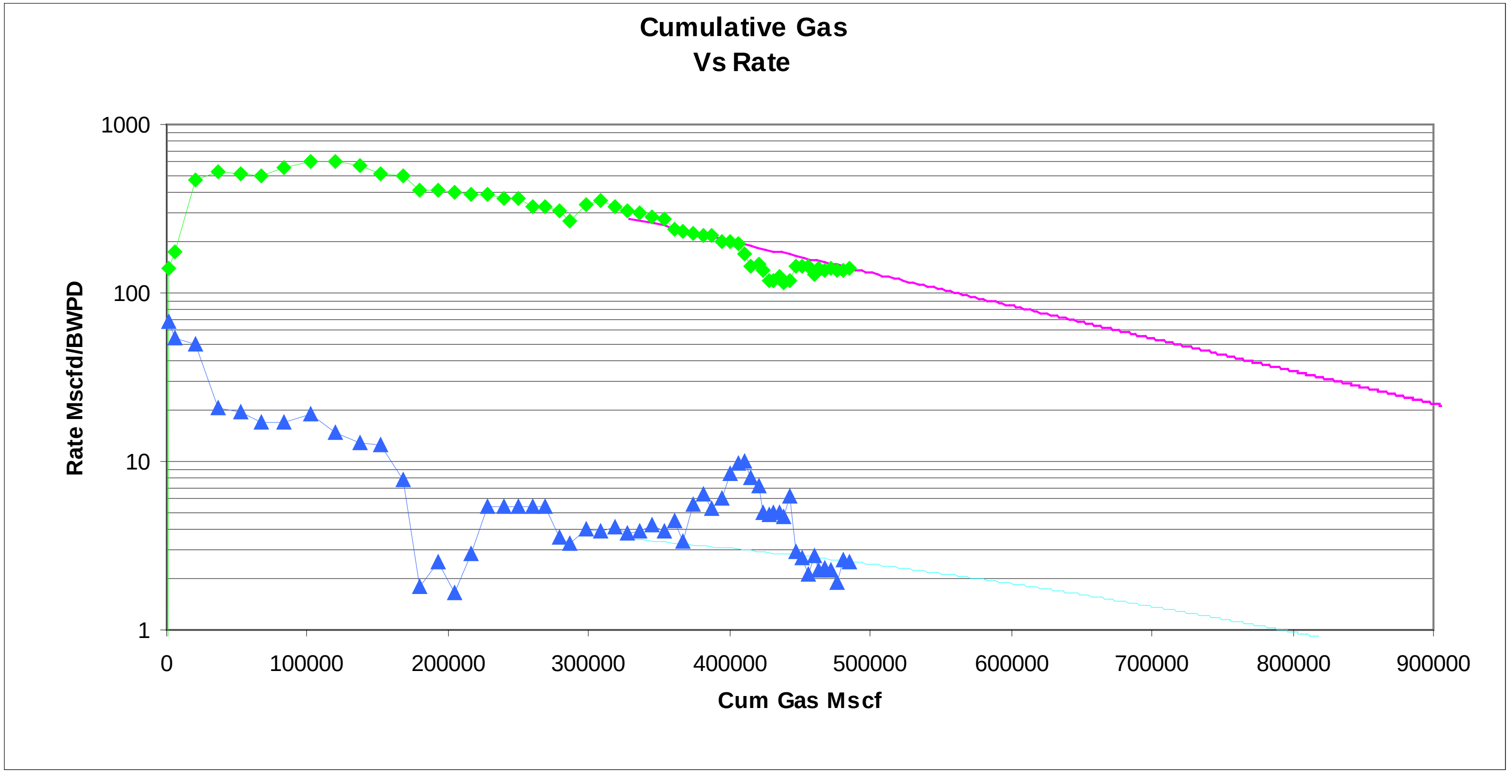

Probability Distribution of 5 Year Cumulative Gas Production
100000
10000
1000
100
10
5 Year Cumulative Gas Production Mscf
0%
20%
40%
60%
80%
100%
120%
Cumulative Probability, % less than
Appalachian
Warrior
San Juan Non Fairway
San Juan Fairway

Simulation

- Requires production tests to calibrate – Non unique solution!
- The assumptions used to calibrate the model should never be changed (Up-scaling) i.e Skin.
- Even with many years of production the solution can vary ±50% - Non Unique
- Used as a Planning Tool: (Best development Strategy)

Decline Curve analysis

- **Applicable only when production is pseudo-steady state, that is, Development stage**
- **Assumes production environment remains unchanged during the forecast period.**



Recovery Factors

- **Example of US low permeable coal fields show recovery factors calculated from decline curves have recovery factor of the order of 20% (Note highly variable)**
- **RF (Isotherm) = 86%**
- **Areal Desorption Efficiency = 23%**

Reserves

- **Reserve estimates should be presented as a range NOT a single Number.**
- **Recovery Factor calculated from Isotherm will deliver an optimistic Reserve Estimate.**
  - Requires Scaling Factor
    - » Areal Desorption Efficiency

Origin energy