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Equation Aids Early Estimation of Gas Field Production Potential

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Natural gas is the world's fastest growing fossil energy source contributing 287 bcfd or roughly 50 million b/d of equivalent oil. NGLs and condensates contribute another 10.5 million b/d of liquids to the oil supply stream. Global supply/demand of natural gas has grown a sizzling 30 percent in the last ten years and according to the latest IEA outlook is expected to further increase 50 percent, to reach 425 bcfd by 2030. Over the last decade new discoveries of natural gas have averaged 103 tcf per year; in contrast, production/depletion of existing reserves averaged 79 tcf per year.

Since 2000, 521 gas and condensate fields have been discovered worldwide with reserves totaling 897 tcf. The top 29 fields, with reserves varying from 265 tcf – the supergiant Osman-South Yolotan field in Turkmenistan – to 3.5 tcf, account for three-quarters of the total discoveries. Thirteen of these giant fields are located offshore and contain 119 tcf of reserves (Table 2). This select list also includes five unconventional shale gas plays with combined reserves of 185 tcf. Although they were not technically discovered during the 2000s, field-scale development did begin during this period.

Globally, there is a vast potential of unconventionals – tight sands gas, coalbed methane and shale gas – waiting to be tapped. Together they represent an estimated in-place volume of nearly 12 qcf worldwide versus 18.4 qcf of conventional resources discovered so far[1]. Unconventionals have always been considered second-rate targets because current production technologies permit only modest recoveries – on the order of 1 to 10%. Conventionals on the other hand have recoveries of 75% and higher. The US is the only country that has implemented large-scale production of unconventionals which currently (2006) provide 24 bcfd or 47% its total gas supply, and 43% of its ultimate reserves. Production of unconventionals in the US has grown 71 percent in the last decade. Worldwide, unconventionals presently account for barely 9% of the total natural gas output but their contribution is expected to grow significantly in the future.

New discoveries always require a comprehensive production evaluation before a development plan for the field can be made. The evaluation period can take 2 to 5 years or more from the time of discovery. Just 20% of the 521 new fields discovered during

[1] Sandrea, R., " Future Global Oil & Gas Supply – A Quantitative Analysis", Oil & Gas Journal Online Research Center, Jan. 2009.
http://www.pennenergy.com/index/resourcecenter/reports/new_future_global.html.

the 2000s are now on stream. They contain 27% or 243 tcf of the total reserves discovered. Consequently, it is of paramount interest to have available an early estimate of the production capacity a new field discovery can put forward. This threshold is vital to supply analysts and for the design of production facilities. The objective of this paper is to develop an algorithm that would provide an early estimate of the production potential of new undeveloped gas fields. Due to the growing importance of unconventionals, the analysis looks into the feasibility of application of the algorithm-model to estimate their production capacity also.

The Production Potential Model

Reserves are the foundation for determining the production capacity of any oil or gas field. In a previous paper[2] it was established for oil fields that the correlation between production potential and ultimate recoverable reserves is one of a power relationship

$$q_{max} = a.K^{b} \qquad (1)$$

where q_{max} is the production capacity, K the ultimate recoverable reserves (EUR), a and b are constants. This basic model was applied to a suite of seven mature giant gas fields and two countries – the US and UK – for which we have reliable data on their field peak production and ultimate reserves (Table 1). Specifically, their ultimate reserves were determined by decline analysis of their historic production data[1]. The fields were chosen to cover a wide spectrum of K-values, ranging from 9 to 920 tcf. The resulting algorithm for gas fields is

$$q_{max} = 0.21\ K^{0.8536} \qquad (2)$$

This has a correlation coefficient (r^2) of 0.980. The units for q and K are bcfd and tcf, respectively. The correlation is shown in Fig. 1. The K-value used to determine the production capacity of a new field would normally be a volumetric estimate of its reserves.

Additionally, we analyzed the validity of the algorithm for unconventionals which are a special case. As a new unconventional field is being developed, determination of its in-place volumes and reserves is complex because classical volumetric formulas are not applicable. For example, current estimates[3] of the reserves of the Barnett shale – the first of six major shale gas plays in the US to go on large scale development – range from 35 to 50 tcf. Based on these estimates, Equation 2 establishes that the Barnett's production potential would be between 4.4 and 5.9 bcfd. Recent published production forecasts for the Barnett assume peak values of 4.5 or 6.5 bcfd. The Barnett currently produces 3.8 bcfd.

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[2] Sandrea, R., "Estimating new field production potential could assist in quantifying supply trends", Oil & Gas Journal, May 22, 2006.

[3] "Study analyzes nine US, Canada gas plays, Oil & Gas Journal, Nov. 10, 2008.

The production potential model was applied to the 29 giant gas fields discovered during the 2000s. Almost all of these fields are in the planning stage of their development. The exceptions are Sulige, Homa and the five shale gas plays which are currently under development. Table 2 summarizes the published estimates of reserves for the 29 giants and their corresponding production capacities as determined by the model. Overall, the combined production potential of the 29 fields is 81 bcfd.

Final Comments

- A production potential model was developed to provide an early estimate of the production capacity of newly discovered gas fields. It is intended to be applied as soon as a wildcat is confirmed to be a gas discovery. Establishing the real potential of a gas field may take several years after discovery, following a costly appraisal drilling program.

- The predictive algorithm, Equation 2, is simple and only requires a geologic approximation of the recoverable reserves of the target field at the time of discovery. It covers a wide range of field sizes and is applicable to unconventional gas fields as well.

Table 1: Selected Mature Gas Fields
Field Peak Production & Ultimate Reserves

Field	Country	Production (q_{max}) bcfd	Reserves (K) tcf
Urengoy	Russia	28	222
Yamburg	Russia	17	138
Groningen	Netherlands	8.6	73
Medvezhye	Russia	7.1	68
Orenburg	Russia	4.6	45
Shatlyk	Turkmenistan	3.3	29
Samotlor	Russia	1.5	9
All fields (Conventional)	US	60	920
All fields	UK	10.4	95

Source: Sandrea, R., " Future Global Oil & Gas Supply – A Quantitative Analysis", Oil & Gas Journal Online Research Center, May 2008.

Table 2: Largest Gas Discoveries, 2000-2008
Reserves and Production Potential
(Reserves exceeding 3.5 tcf)

Field	Country	Discovery Year	Reserves, tcf	Production*** Potential, bcfd
Osman-South Yolotan	Turkmenistan	2006	265	25
Haynesville shale	US	2005**	70	7.9
Marcellus shale	US	2007**	55	6.4
Fayetteville shale	US	2004**	35	4.4
Kish*	Iran	2006	30	3.8
Levoberezhnoye	Russia	2004	26	3.4
Jansz *	Australia	2000	20	2.7
Sulige	China	2000**	19	2.6
Longgang	China	2006	17.5	2.4
Woodford shale	US	2004**	15	2.1
Abadi *	Indonesia	2000	14	2.0
Puguang	China	2005	12	1.8
Jupiter*	Brazil	2008	11	1.6
Kamennomyskoye *	Russia	2000	10	1.5
Deep Bossier shale	US	2003**	10	1.5
Lavan	Iran	2003	8	1.2
Clio*	Australia	2006	6.5	1.0
North Alexandria*	Egypt	2000	5.9	0.96
Incahuasi	Bolivia	2004	5	0.83
Chuandongbei	China	2004	5	0.83
PlutoXena*	Australia	2005	5	0.83
Liwan*	China	2006	5	0.83
Shwe *	Myanmar	2004	4.8	0.80
Homa	Iran	2000**	4.7	0.79
Dina-2	China	2001	4	0.69
Wheatstone*	Australia	2004	4	0.69
Chandon*	Australia	2006	4	0.69
Caliance *	Australia	2000	3.9	0.67
Dey	Iran	2000	3.5	0.61
TOTAL			**679**	**81**

Notes: * Offshore fields. **Fields on stream. ***Estimated using Equation 2.

Fig. 1 Production Potential & Recoverable Reserves
Gas Fields