



Economic and Social Council

Distr.: General
10 February 2020

Original: English

Economic Commission for Europe

Committee on Sustainable Energy

Expert Group on Resource Management

Eleventh session

Geneva, 20-24 April 2020

Item 9 of the provisional agenda

Development, maintenance and implementation of the United Nations Framework Classification for Resources and the United Nations Resource Management System

Case Study on Bridging from the National Standard of the People's Republic of China Classification for Petroleum Resources/Reserves (GB/T 19492-2004) to the United Nations Framework Classification for Resources (UNFC): Gas Field A

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Summary

This case study is intended to provide application guidelines and typical examples for the global application of the Bridging Document between the China National Standard of Classification for Petroleum Resources/Reserves (GB/T 19492-2004) and the United Nations Framework Classification for Resources (UNFC). Through this case study, the GB/T 19492-2004 to UNFC Bridging Document has been applied to a gas field owned by a Chinese national oil company. The resources estimates have been successfully mapped to UNFC throughout the whole life cycle, including the exploration and appraisal stage, initial development stage and late production stage.

I. Introduction

1. This case study was prepared by China National Oil and Gas Exploration and Development Company Ltd. and the Mineral Resources and Reserves Evaluation Centre of the Ministry of Natural Resources of the People's Republic of China, in cooperation with the Technical Advisory Group of the Expert Group on Resource Management. The key contributors are YANG Hua, YUAN Ruie, XIA Mingjun, YI Yanjing, SHAO Xinjun, Alistair Jones, Satinder Purewal and Jan Bygdevoll.
2. This case study is based on the supporting information provided by a Chinese national oil company. Through the Bridging Document between the National Standard of the People's Republic of China Classification for Petroleum Resources/Reserves (GB/T 19492-2004) and the United Nations Framework Classification for Resources (UNFC), (hereinafter referred to as the Bridging Document¹), the resource estimates for the main exploration and development (E&D) stages in the life cycle of Gas Field A per GB/T 19492-2004 and its evaluation guidelines are mapped to UNFC with its numerical codes.
3. This case study is intended to provide application guidelines and typical examples for the global application of the aforementioned UNFC Bridging Document.

II. Basic Information

A. Introduction

4. The rationale for resources classification and evaluation in this case study is as follows: the China National Standard of Classification for Petroleum Resources/Reserves (GB/T 19492-2004); the Industrial Standards of Regulation of Petroleum Reserves Estimation (DZ/T 0217-2005); the Estimation Methods of Natural Gas Recoverable Reserves (SY/T 6098-2000); UNFC; and, the Bridging Document between the National Standard of the People's Republic of China Classification for Petroleum Resources/Reserves (GB/T 19492-2004) and UNFC.
5. Through a look-back process, this case study illustrates the mapping scenarios in three major exploration and development stages of Gas Field A, including the Exploration and Appraisal Stage, the Initial Development Stage, and the Late Production Stage.

B. Overview of Estimates under GB/T 19492-2004

1. Background of Gas Field A

6. Gas Field A is a fractured-vuggy type stratified carbonate gas reservoir, located in a mature petroliferous basin. It was discovered by Wildcat E1 based on 2D seismic data. After being acidized, well E1 achieved commercial production of $736 \times 10^3 \text{ m}^3/\text{d}$. Subsequently, 3D seismic acquisition and interpretation were performed in this area and two appraisal wells, A2 and A3, were drilled. The 3D seismic defined a structural spill point at 4,810 metres true vertical depth sub-sea (mTVDSS) with a trap acreage of 35.95 km². By logging interpretation, the net pay in wells A2 and A3 are estimated as 21.3 m and 35.8 m respectively. After being acidized, the productivity of well A3 was tested as $872.2 \times 10^3 \text{ m}^3/\text{d}$ and well A2 failed due to a casing fish. So far, no gas-water contact has been penetrated. According to the approved field development plan, Gas Field A was put into progressive development in two phases. After 18 years of depletion, this field is now in its late production stage with declined production close to the economic limit.
7. The example field has experienced almost a full life cycle from discovery to abandonment. According to the applicable Chinese standards for resource classification and

¹ http://www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/UNFC-China-Bridging-Document-Public-Comment/Chinese_Petroleum_BD_Final.pdf.

evaluation, the estimates in the main E&D stages of the example field were derived based on its maturity, the certainty on geological knowledge, productivity verification with the geological and engineering data available, and the company's technical and economic conditions.

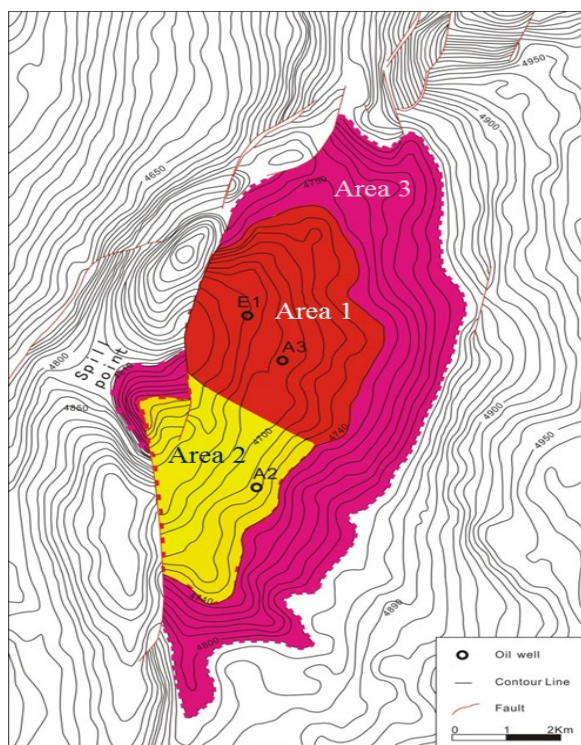
2. Exploration and Appraisal Stage

8. Status description: In the Exploration and Appraisal Stage of Gas Field A, after the wells E1, A2 and A3 were drilled, data available for resource estimation included structural maps demonstrated by 3D seismic data, rock and fluid properties based on lab analysis, the lowest known gas of 4,740 mTVDSS identified by well A3, and recovery factor by depletion of 68.2% from analogous reservoirs. The economic analysis was conducted in the feasibility study.

9. Resource classification: As shown in Figure I, according to the lowest known gas and the identified spill point of 4,740 mTVDSS, the whole gas-bearing area was divided into three parts: **Area 1** with an acreage of 9.96 km² above the lowest known gas, classified as Measured considering that there is a high level of confidence in gas bearing volumes for Area 1 and a final investment decision is expected; **Area 2** with an acreage of 6.94 km² above the lowest known gas, classified as Indicated considering that there is a moderate level of confidence in gas bearing volumes for Area 2; and **Area 3**, delineated by contour lines of 4,740 mTVDSS and 4,810 mTVDSS, classified as Inferred considering that there is a low level of confidence in gas bearing volumes and more data needs to be acquired.

Figure I

Resource Classification in the Exploration and Appraisal Stage: Gas Field A



10. Resource estimation outcomes: According to Chinese standards for resource classification and evaluation,² using volumetric and analogy methods, the resource estimates of three areas of Gas Field A are derived and summarized in Table 1.

² Refer to Figure 1 and Figure 2 from the Bridging Document.

Table 1

Summary of Estimates in the Exploration and Appraisal Stage: Gas Field A

Categories	Acreage (km ²)	Discovered PIIP (10 ⁹ m ³)	Technically Ultimate Recovery (10 ⁹ m ³)	Economic Ultimate Recovery (10 ⁹ m ³)	Sub-Economic Recovery (10 ⁹ m ³)	Unrecoverable Quantity (10 ⁹ m ³)
Measured	9.96	3.12	2.13	1.28	0.85	0.99
Indicated	6.94	2.17	1.48	1.15	0.33	0.69
Inferred	19.05	5.96	4.07	not defined	not defined	1.89
Total	35.95	11.25	7.68	2.43	1.18	3.57

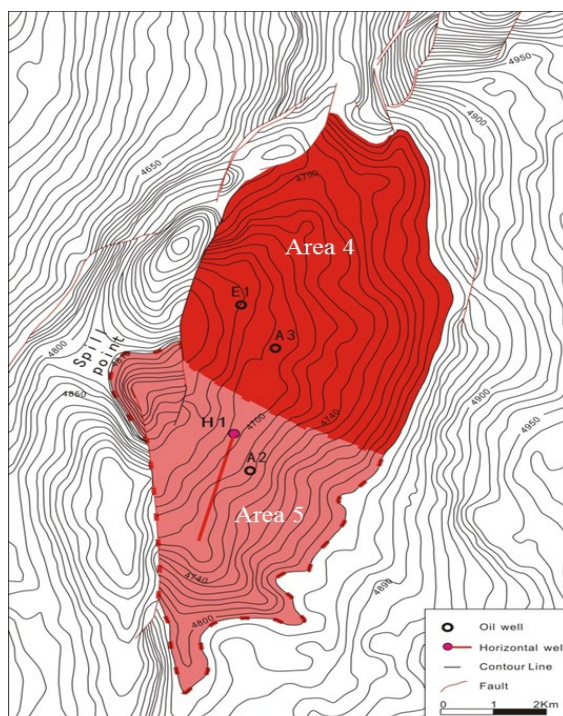
Note: Discovered PIIP refers to Discovered Petroleum Initially-In-Place (i.e. Geological Reserves, as defined in the Bridging Document).

3. Initial Development Stage

11. Status description: In the Initial Development Stage of Gas Field A, based on in-depth regional geological research, 3D seismic inversion data, geological modelling and reservoir numerical simulation, a two-phase progressive field development plan (FDP) of Gas Field A was adopted. In Phase I, the field was planned to be depleted by wells E1 and A3 using the existing facilities and infrastructure; and in Phase II, one more horizontal well H1 was to be drilled with production start-up through new facilities in the third year. According to this FDP, the recovery factor of Gas Field A was increased to 70.5%.

12. Resource classification: According to data available and integrated studies, the whole acreage of the structure trap was demonstrated to be gas-bearing, and classified as Measured (see Figure II), in which, as wells E1 and A3 were put into production in the first year. Area 4 is categorized as Proved Developed Economic Ultimate Recovery (EUR). Area 5, with the planned well H1 still in the process of construction, was categorized as Proved Undeveloped EUR.

Figure II

Resource Classification in the Initial Development Stage: Gas Field A

13. Resource estimation outcomes: Entering the development period, Gas Field A has measured categories in its inventory. With more data, integrated studies, a committed FDP

available, and after the first year of production, the associated resource estimates of Gas Field A in the Initial Development Stage are updated and summarized in Table 2.

Table 2

Summary of Estimates in the Initial Development Stage: Gas Field A

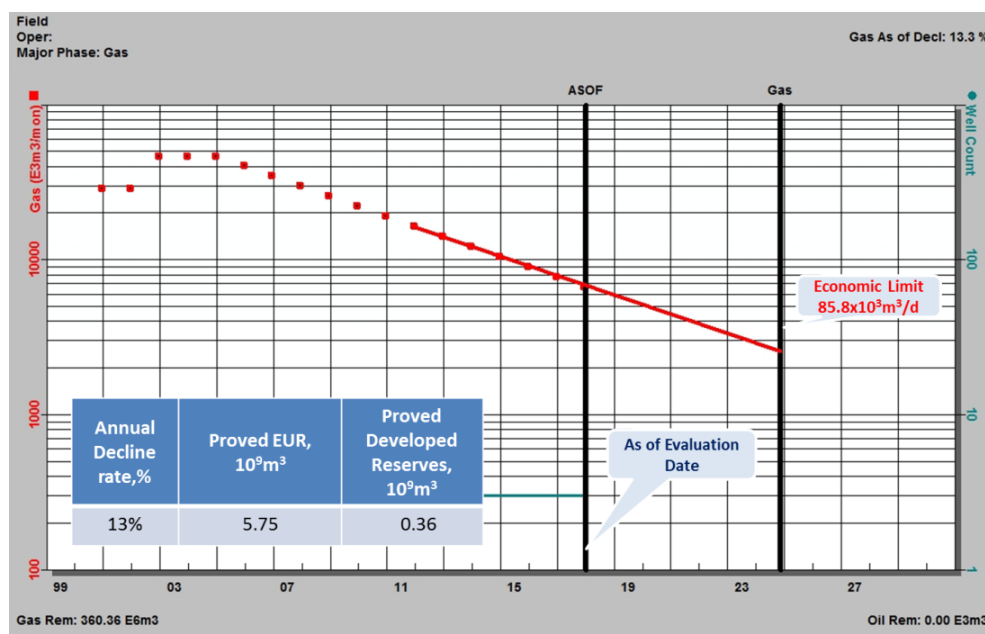
Category	Acreage (km ²)	Discovered PIIP (10 ⁹ m ³)	Technically Ultimate Recovery (10 ⁹ m ³)	Economic Ultimate Recovery (10 ⁹ m ³)		Proved Developed Reserves (10 ⁹ m ³)	Sub- Economic Recovery (10 ⁹ m ³)	Unrecoverable Quantity (10 ⁹ m ³)
				Developed	Undeveloped			
Measured	36.2	9.16	6.46	3.56	1.81	3.22	1.09	2.7

4. Late Production Stage

14. Status Description: After being in operation for 18 years, the cumulative gas production of the example field reached 5.39×10^9 m³. The field is in the period of late stage of decline. See Figure III.

Figure III

Production Performance Analysis in the Late Production Stage: Gas Field A



15. Resource classification: The whole gas-bearing area of the structural trap is classified as Measured, with Proved Developed Reserves, Proved Sub-Economic Recovery (SER), and Measured Unrecoverable Quantity in the gas inventory.

16. Resource estimation outcomes: According to the dynamic performance Decline Curve Analysis, the Proved Developed Technically Ultimate Recovery (TUR) of the field was estimated as 6.64×10^9 m³. Under current economic conditions, the economic limit was 85.8×10^3 m³/d, which resulted in Proved Developed Economic Ultimate Recovery (EUR) of 5.75×10^9 m³ and Proved Developed Reserves of 0.36×10^9 m³ with a recovery factor accounting for 72.5%. Estimation outcomes are summarized in Table 3.

Table 3

Summary of Estimates in the Late Production Stage: Gas Field A

Category	Acreage (km ²)	Discovered PIIP (10 ⁹ m ³)	Technically Ultimate Recovery (10 ⁹ m ³)	Developed EUR (10 ⁹ m ³)	Developed Reserves (10 ⁹ m ³)	Sub-Economic Recovery (10 ⁹ m ³)	Unrecoverable Quantity (10 ⁹ m ³)
Measured	36.2	9.16	6.64	5.75	0.36	0.89	2.52

III. Key highlights in the Bridging Document

17. The National Standard of the People's Republic of China Classification for Petroleum Resources/Reserves (GB/T 19492-2004) is as an Aligned System i.e. it has been aligned with UNFC as demonstrated by the existence of a bridging document that has been endorsed by the Expert Group on Resource Management. The Bridging Document explains the mapping between the reserves and resources by categories of the China Classification (GB/T 19492-2004) and UNFC's Classes and Categories and is intended to guide stakeholders who are reporting petroleum resource estimates under the Chinese standards system with the UNFC codes.

18. The correspondence of the E and F Axes of UNFC is shown in Figure IV.

Figure IV

Mapping of UNFC E-F Matrix to GB/T 19492-2004³

	F1.1	F1.2	F1.3	F2.1	F2.2	F2.3	F3.1	F3.2	F3.3	F4
E1.1	1	2	3	4						
E1.2	1	2	3							
E2	4	4	4	4	5					
E3.1	12	12	12	12	12	12				
E3.2			6	6	6		8	9	10	
E3.3			7	7	7	7				11

Class	Sub-class	Code	GB/T 19492-2004 Class and Category
Commercial Projects	On Production	1	Proved Developed Reserves
	Approved for Development	2	Proved Undeveloped EUR
	Justified for Development	3	Proved Undeveloped EUR
Potentially Commercial Projects	Development Pending	4	Proved SER, Probable EUR, Probable SER, Possible TUR
	Development on Hold	5	Proved SER, Probable EUR, Probable SER, Possible TUR
Non-Commercial Projects	Development Unclassified	6	Proved SER, Probable SER, Possible TUR
	Development Not Viable	7	Proved SER, Probable SER, Possible TUR
Additional Quantities in Place		11	Measured, Indicated and Inferred Unrecoverable Quantities (UQs)
Exploration Projects	Prospect	8	Prospective Recoverable Resources (RR)
	Lead	9	
	Play	10	Unmapped RR
Additional Quantities in Place		11	Prospective and Unmapped UQs
Produced Not Sold		12	

³ Source from Figures 4 and Figure 5 in the Bridging Document.

19. The correspondence of the G Axis is shown in Table 4.

Table 4
Mapping GB/T 19492-2004 categories to UNFC G Axis⁴

GB/T 19492-2004 Class / Category							UNFC Category
Discovered	Measured	PIIP	Proved TUR	Proved EUR	Proved Developed EUR	Cumulative Production	Extracted Production
					Proved Undeveloped EUR	Proved Developed Reserves	G1
						Proved SER	
				Unrecoverable Quantities (UQ)			
				Indicated	PIIP	Proved TUR	
	Probable SER						
	UQ						
	Inferred	PIIP	Possible TUR			G1+G2+G3	
			UQ				
	Undiscovered	Prospective	PIIP	Recoverable Resources (RR)			G4
UQ							
Unmapped		PIIP	RR				
			UQ				

IV. Correspondence of Axes for the Example Case

A. Mapping Summary

20. According to the Bridging Document, the resource estimates in the Exploration and Appraisal Stage, Initial Development Stage, and Late Production Stage of Gas Field A are mapped to the UNFC numerical codes as summarized in Table 5.

⁴ Source from Figure 3 in the Bridging Document.

Table 5
Mapping Estimates Summary per GB/T 19492-2004 to UNFC: Gas Field A

GB/T 19492-2004 Categories						Estimates (10 ⁹ m ³)	UNFC Codes
Exploration and Appraisal Stage	Measured PIIP	Proved TUR	Proved Undeveloped EUR			1.28	E1.1F1.3G1
			Proved SER			0.85	E2F1.3G1
		Measured UQ			0.99	E3.3F4G1	
	Indicated PIIP	Probable TUR	Probable EUR			1.15	E1.1F2.1(G1+G2)
			Probable SER			0.33	E2F2.1(G1+G2)
		Indicated UQ			0.69	E3.3F4(G1+G2)	
	Inferred PIIP	Possible TUR			4.07	E2F2.1(G1+G2+G3)	
Inferred UQ			1.89	E3.3F4(G1+G2+G3)			
Initial Development Stage	Measured PIIP	Proved TUR	Proved EUR	Proved Developed EUR	Cum. Production	0.34	
				Proved Developed Reserves		3.22	E1.1F1.1G1
			Proved Undeveloped EUR			1.81	E1.1F1.2G1
			Proved SER	Proved Developed SER			0.72
		Proved Undeveloped SER			0.37	E2F1.2G1	
		Measured UQ			2.70	E3.3F4G1	
Late Production Stage	Measured PIIP	Proved TUR	Proved EUR	Proved Developed EUR	Cum. Production	5.39	
				Proved Developed Reserves		0.36	E1.1F1.1G1
			Proved SER			0.89	E3.3F2.3G1
		Measured UQ			2.52	E3.3F4G1	

B. Mapping Description

21. In the **Exploration and Appraisal Stage**, under the Chinese standards system, Gas Field A was booked with Proved Undeveloped EUR, Proved SER, Probable EUR, Probable SER, Possible TUR, and Measured, Indicated and Inferred UQs. According to the Bridging Document, the mapping correspondence can be identified, and then further verified by matching the status of Gas Field A with UNFC definitions.

1. E Axis

(a) Proved Undeveloped EUR: Based on the production test and the feasibility study in the Exploration and Appraisal Stage, it was economic to produce both wells E1 and A3, hence the estimates for Area 1 should be assigned as E1.1.

(b) Proved SER: According to the mapping scheme of the Bridging Document, potential digital codes are 4, 5, 6 and 7, corresponding to E1.1, E2, E3.2 and E3.3 respectively. The additional production is sub-economic under current conditions, however there is a reasonable expectation of socio-economic viability in the foreseeable future. As verified with UNFC definitions, it should be mapped to E2.

(c) Probable EUR: According to the pre-feasibility study for Area 2, its future development is economic and should be assigned as E1.1.

(d) Probable SER: Similar to the Proved SER, potential codes are 4, 5, 6 and 7, corresponding to E1.1, E2, E3.2 and E3.3 respectively. Under current conditions, the additional production is sub-economic, however there is a reasonable expectation of socio-economic viability in the foreseeable future. As verified with UNFC definitions, the most appropriate code is E2.

(e) Possible TUR: Similarly, according to the Bridging Document, possible codes are 4, 5, 6 and 7, corresponding to E1.1, E2, E3.2 and E3.3 respectively. Through analogy, it is expected to be socio-economically viable in the foreseeable future. As verified with UNFC definitions, the appropriate code is E2.

(f) Measured, Indicated and Inferred Unrecoverable Quantities (UQs): According to the Bridging Document, this should be assigned as E3.3.

2. F Axis

(a) Proved Undeveloped EUR and Proved SER: For Area 1 with wells E1 and A3, as it is located in a mature region with facilities available, 3D seismic interpretation, production tests and the development feasibility study for depletion have been achieved, there are reasonable expectations of a final investment decision. At this stage, the project has been demonstrated to be technically feasible and corresponds to Code F1.3.⁵ There is a reasonable expectation that all the necessary approvals/contracts for the project to proceed to development will be forthcoming.

(b) Probable EUR and Probable SER: For Area 2, well A2 failed in the production test. By analogy, it is expected to be potentially economic in the foreseeable future. In this stage, project activities are ongoing to further justify its development, and the most appropriate F axis code is F2.1.

(c) Possible TUR: Area 3 in the gas field is actively being appraised to promote full delineation and development, and thus should be classified as F2.1.

(d) Measured, Indicated and Inferred UQs: According to the mapping scheme of the Bridging Document, this should be classified as F4 since no development has been identified to produce these volumes.

3. G Axis

(a) Measured and Proved categories, corresponding to G1.

(b) Indicated and Probable categories, corresponding to G1+G2.

(c) Inferred and possible categories, corresponding to G1+G2+G3.

22. In the Initial Development Stage, under the Chinese standards system, Gas Field A was booked with Proved Developed EUR, Proved Undeveloped EUR, Proved SER, and Measured UQ. According to the Bridging Document, the mapping correspondence can be identified, and then further verified by matching Gas Field A's status with UNFC definitions.

4. E Axis

(a) Proved Developed Reserves: Per the Bridging Document, it should be classified as E1.1.

(b) Proved Undeveloped EUR: According to the mapping scheme of the Bridging Document, corresponds to code 3. As its feasibility study is economic, it should be classified as E1.1.

(c) Proved SER: Mapping check with the E-F matrix of the Bridging Document, shows that potential corresponding codes are 4, 5, 6 and 7, associated with E1.1, E2, E3.2 and E3.3 respectively. Under the conditions of the evaluation date, the estimate is sub-economic, however there is a reasonable expectation of socio-economic viability in the foreseeable future. As verified with UNFC definitions, the most appropriate code is E2.

(d) Measured UQ: In the E-F matrix of the Bridging Document, it is mapped to E3.3.

5. F Axis

(a) Proved Developed Reserves: Field development is under way and this category should be classified as F1.1.

(b) Proved Undeveloped EUR: In the initial development stage, the two-phase FDP has been approved and the capital funds have been committed. According to UNFC definitions, the corresponding code is F1.2.

⁵ Refer to Paragraph 43 of the Bridging Document.

(c) Proved SER: As the FDP of Gas Field A has been approved and implemented, for the volume associated with the Proved Developed part, it should be mapped to F1.1 while for the other volume associated with the Proved Undeveloped part, it should be mapped to F1.2.

(d) Measured UQ: According to the Bridging Document, it should be assigned as F4.

6. G Axis

(a) In the initial development stage, the whole gas field was classified as Measured, related categories correspond to G1 in UNFC per the Bridging Document.

23. In the **Late Production Stage**, under the Chinese standards system, Gas Field A was booked with Proved Developed EUR, Proved SER, and Measured UQ. According to the Bridging Document, the mapping correspondence can be identified, and then further verified by matching the status of Gas Field A with UNFC definitions.

7. E Axis

(a) Proved Developed Reserves are economic, as the production rate exceeds the economic limit under current economic conditions. It should be mapped to E1.1 in UNFC.

(b) Proved SER: According to the Bridging Document, the optional codes are 4, 5, 6 and 7, associated with E1.1, E2, E3.2 and E3.3 respectively. As this field is close to abandonment and it is currently considered that there are not reasonable prospects for economic development and sale in the foreseeable future, its corresponding code is E3.3.

(c) Measured UQ: In the E-F matrix of the Bridging Document, it is mapped to E3.3.

8. F Axis

(a) Proved Developed Reserves: should be assigned to F1.1 in UNFC per the Bridging Document.

(b) Proved SER: due to E3.3 being identified, the possible code is 7. As there is no additional plan available for this volume in the foreseeable future, it should be mapped to F2.3.

(c) Measured UQ: According to the Bridging Document, it should be assigned as F4.

9. G Axis

(a) In the Late Production Stage, the Measured and Proved categories in GB/T 19492-2004 should be mapped to G1 in UNFC.

V. Discussion

24. A Bridging Document is a document that explains the relationship between UNFC and another classification system, including instructions and guidelines on how to classify estimates generated by application of that system using the UNFC Numerical Codes. to explain the mapping correspondence between an aligned resource classification system and UNFC. Bridging Documents are hence of significance to promote global communication in both resource evaluation and administrative management.

25. China has developed an integrated petroleum resource classification and evaluation standard system to support the full life cycle of petroleum resources/reserves management and estimation, serving the demands of both the sovereign and company's business.

26. According to the Bridging Document, it was found that the mapping between GB/T 19492-2004 and UNFC categories does not always give a one-to-one correspondence. It

would be helpful to further verify the corresponding relationship by cross checking with UNFC definitions or direct categorization per UNFC.⁶

27. UNFC is a classification framework system, whose code-characterized estimates cannot yet be directly mapped to China's classification and evaluation system. Further checks are needed using the underlying resources management system and rules.

VI. Conclusion

28. Through this case study, the GB/T 19492-2004 to UNFC Bridging Document has been applied to a gas field owned by a Chinese national oil company. The resource estimates have been successfully mapped to UNFC and its numerical codes for the whole life cycle of the field, including the exploration and appraisal stage, initial development stage and late production stage.

⁶ This exercise will be addressed in a subsequent case study.