

## Annex-B: Additional Information about Production System Integration

### B1. Production System Integration

UNISIM-I-D.pdf original files provide information regarding just the reservoir conditions. For users who want to consider production systems in their studies, the fixed operational constraints for wells and groups in UNISIM-I-D project should be included in the production system. Users interested in working and contributing to the production system integration project are welcome and should send their contacts to [unisim-adm@dep.fem.unicamp.br](mailto:unisim-adm@dep.fem.unicamp.br). We require the information about boundary conditions of constraints and their costs compatible with UNISIM-I-D in order to set up the same problem for all the research groups.

Table B1 presents reservoir data to be used as reference in the production system integration project. The location conditions as well as water depth are the same as the Namorado oil field<sup>1</sup>.

Table B1: Reservoir Data

Reservoir data	Value	Unit
Depth	2900-3400	(m)
Water depth	166	(m)
Coastline distance	80	(Km)
Geothermal gradient	0.020; < 200m and 0.023; >200m	(°C/m)
Water Temperature	20 to 16 linear (downhill)	(°C)
Sea current	0.5	(m/s)

Table B2 presents new wells operating conditions for the production forecast period.

Table B2: Well operation conditions

Type	Producer	Injector
Water rate (m <sup>3</sup> /day)	-	Max 5000
Oil rate (m <sup>3</sup> /day)	Min 20	-
Liquid rate (m <sup>3</sup> /day)	Max 2000	-
BHP (kgf/cm <sup>2</sup> )	-	Max 350
WHP (kgf/cm <sup>2</sup> )	Min 15	
GOR (m <sup>3</sup> /m <sup>3</sup> )	Max 200	-

Table B3 presents preliminary and complementary information of economic parameters to be used in the production system integration.

Table B3: Additional Economic Parameters for Production System

Economic parameter	Technical parameter / decision variable	Value	Most likely	Optim.	Pessim.	Unit	
Investment on connection (well-platform) of vertical / horizontal well	Production / injection flowline	4"	411	514	360	(USD/m)	
		6"	768	960	672		
		8"	1976	2470	1729		
	Riser	4"	879	1098	769	(USD/m)	
		6"	1513	1892	1324		
		8"	2597	3247	2273		
	Riser and flowline installation	-	11.70	14.63	10.24	USD millions	
	Investment on drilling and completion of vertical well	Production column	2 7/8"	221	276	193	(USD/m)
			3 1/2"	234	292	205	
4 1/2"			250	313	219		
5 1/2"			270	337	236		
Drilling and completion		-	20.90	26.38	18.28	USD millions	
Investment on drilling and completion of horizontal well	Production column	2 7/8"	221	276	193	(USD/m)	
		3 1/2"	234	292	205		
		4 1/2"	250	313	219		
		5 1/2"	270	337	236		
	Drilling and completion	-	21185	26481	18537	(USD/m horiz)	
		-	25.66	32.07	22.77	USD millions	
Investment on recompletion of vertical well	Production column	2 7/8"	16	20	14	(USD/m)	
		3 1/2"	29	36	25		
		4 1/2"	45	56	40		
		5 1/2"	65	81	57		
	Workover	-	7.86	9.83	6.88	USD millions	
Investment on recompletion of horizontal well	Production column	2 7/8"	16	20	14	(USD/m)	
		3 1/2"	29	36	25		
		4 1/2"	45	56	40		
		5 1/2"	65	81	57		
	Workover	-	9.83	12.29	8.65	USD millions	
Investment on well conversion	Production column	2 7/8"	16	20	14	(USD/m)	
		3 1/2"	29	36	25		
		4 1/2"	45	56	40		
	5 1/2"	65	81	57			
Workover	-	9.83	12.29	8.65	USD millions		
Additional investment on connection for Artificial-Lift	Injection flowline 4"	-	411	514	360	(USD/m)	
	Riser 4"	-	879	1098	769	(USD/m)	

Note:

- The platform costs provided in *UNISIM-I-D.pdf* file considers water depth of 166m. This is considered in the first term (fixed cost) of the equation.
- Sum vertical and horizontal lengths to obtain total length to evaluate economic parameters above.
- In Drilling and Completion variable cost for horizontal well, consider only horizontal length.

**Examples:**

- 1) Connection of a typical new vertical well with vertical measure of 3085m, distance 1792m from platform, with production column of 4 1/2", production flowline of 6" and riser of 6":

Investment on drilling and completion of vertical well:  $0.000250 * 3085 + 20.899 = 21.67$  MMUSD.

Investment on connection (well platform) of vertical well:  $0.001513 * 166 + 0.000768 * 1792 + 11.703 = 13.33$  MMUSD.

Additional investment on connection for Artificial Lift:  $0.000879 * 166 + 0.000411 * 1792 = 0.88$  MMUSD.

- 2) Drilling of a typical horizontal well with vertical measure of 3062m, 665m horizontal length, with production column of 4 1/2", injection flowline of 6" and riser of 6":

Investment on drilling and completion of horizontal well:  $0.000250 * (3062 + 665) + 0.021185 * 665 + 25.659 = 40.68$ MMUSD.

- 3) Recompletion of vertical well (3085m vertical length) with production column of 4 1/2":

Investment on recompletion of vertical well:  $0.000045 * 3085 + 7.860 = 8.0$  MMUSD.

- 4) Conversion of producer horizontal well (3727m total measure) to injector with production column of 4 1/2":

Investment on well conversion:  $0.000045 * 3727 + 9.831 = 10.0$  MMUSD.

**B2. Reference**

1. *Barbosa, E.G., Tomazelli, L.J., Ayup-Zouain, R.N., Rosa, M.L.C.C., "Análise Faciológica e Modelo Depositional do Arenito de Namorado, Bacia de Campos, RJ" (in portuguese). 3º Congresso Brasileiro de P&D em Petróleo e Gás, IBP, October, 2004, Brazil.*