1. Production System Model

The production system model is based on the case of study for production units, production gathering system and well systems for the UNISIM-I-D study case detailed by Gaspar *et al.* (2015) and Victorino *et al.* (2016), and is then applied to the UNISIM-I&II benchmark case.

The production system consists of the following systems:

1) Well system, perforations to access the reservoir in various locations.
2) Gathering system, composed of the pipe network that transports and controls fluid flow from wells to the platform.
3) Surface facilities, production units responsible for the separation, processing and storage of fluids.

The authors created the model of gathering and well systems to represent a typical satellite well with some real characteristics and information necessary for modeling. This satellite well consists of the following parts: riser, flowline (subsea production/injection line), well production/injection column and gas lift valve for producers.

The calculation of the distances of each element follows the format shown in Figure S1. The main variables for satellite well assembly are: internal diameters of the lines for riser (RI) and flowline (LM) and production/injection column diameter (CP); positioning of the gas lift valve (Zgl); injection gas flowrate for gas lift (Qgi); wellhead pressure (Pj); temperature of the lines; and correlations of multiphase and fluid flow. This information has been standardized and will be described throughout the work.

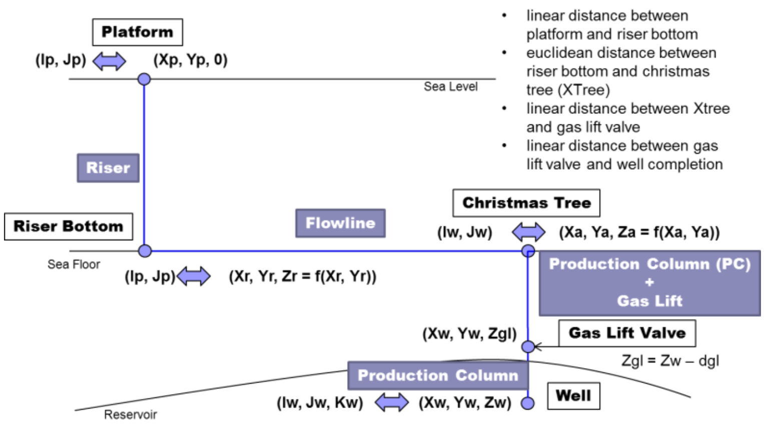

Figure S1 – Satellite well layout, composed of riser, flowline, production column and gas lift valve.

The production unit (platform) in the Black-Oil version of the benchmark is simplified, being represented by the nominal capabilities of production, separation, treatment and injection of fluids. More information can be obtained at Victorino *et al.* (2016), and Gaspar *et al.* (2015).

2. Reservoir Simulation Models

The simulation model of the Sandstone reservoir is defined by the UNISIM-I-D study case, described in detail by Avansi and Schiozer (2015) and Gaspar *et al.* (2015). UNISIM-I-D was built to represent a sandstone field of a design project in the initial planning phase of field development considering a small initial production history of four initial wells.

The simulation model of the Carbonate reservoir is defined by the case of UNISIM-II-D study, described in detail by Correa *et al.* (2015) and Santos *et al.* (2018). UNISIM-II-D was built to represent a carbonate field of a design project in the initial phase of field development, including a 1.5-year period of production data from a Long-Term Test (TLD), and considering the information of a wildcat well and two exploration wells. Additional information on the models is found in Avansi and Schiozer (2015), Gaspar *et al.* (2015), Correa et al. (2015) and Santos *et al.* (2018).

3. Integrate Simulation Model

The production of reservoirs is collected through a platform designed to produce both satellite wells of the Sandstone reservoir and the Carbonate reservoir. This platform has a maximum capacity of 32 slots for connecting wells. Table S1 presents the maximum capacity for each platform installed in the field, based on the UNISIM-II-D study case (Santos *et al.* 2018).

Table S1 – Maximum processing capacity of platform.

Platform	Oil rate (m³/d)	Liquid rate (m³/d)	Water rate (m³/d)	Water injection rate (m³/d)	Natural gas rate (mil m³/d)
FPSO	28,617	28,617	19,078	38,156	4,000

Artificial gas lift lifting method is employed for field production maintenance purposes. The volume of gas lift is not computed in the total processing and reinjection capacity of the platform gas.

The total time for drilling and completing wells in the Sandstone reservoir consumes 30 days and in Carbonate reservoir 60 days. The interconnection and opening time of the wells consumes 30 days for both reservoirs. Overlapping events of different wells is not allowed. There is availability of 2 ships for drilling and completion, plus 2 ships for interconnection.

4. Dates/Mandatory Times

Some mandatory dates should be followed:

- t-3 - 0 day - 31/05/2013:
  - initial time of integrated simulation;
  - starting time of history production of Sandstone reservoir.
- t-2 - 1218 days - 30/09/2016:
  - starting time for TLD of Carbonate reservoir.

- t-1 - 1461 days – 31/05/2017:
    - end of history production of Sandstone reservoir.
- t0 - 1734 days - 28/02/2018 (REFERENCE - present date):
    - end for TLD of Carbonate reservoir;
    - analysis date for updating the cash flow.
- Between 1461 and 1857 days: Sandstone reservoir wells are drilled and completed.
- From 1735 days: carbonate reservoir wells are drilled and completed.
    - incidence of investments in drilling and completion of Carbonate reservoir on the respective dates;
    - Minimum interval for drilling and completion of each well: 60 days.
- t1 – 1857 days - 01/07/2018:
    - date of incidence of investments in drilling, completion and platform/facilities of Sandstone reservoir;
    - start date of production of the platform;
    - interconnection of reservoir wells;
    - (t) opening date of each well;
    - incidence of investments in interconnections (well-platform) on the respective dates (t);
    - minimum interconnection interval (well-platform) of each well: 30 days.
- t2 - 2465 days - 29/02/2020:
    - beginning of the interconnection of the wells of Carbonate reservoir;
    - installation of new platforms, if applicable;
    - (t) opening date of the well;
    - incidence of investments in interconnections (well-platform) and new platforms on their dates (t);
    - minimum interconnection interval (well-platform) of each well: 30 days.
- tf – 12175 days – 30/09/2046:
    - maximum final simulation time (simulation can be closed before but not after this time);
    - maximum date of abandonment of the field, which must be equal to the final date of production of the field.

5. Premises

The well data considered are: 0.156 m well radius for vertical wells and 0.0762 m for horizontal wells, geometric factor of 0.37, angular fraction of the well of 1.0 and skin damage factor of well equal to 0.

Table S2 presents the data for assembly of the production system of satellite producing wells. Table S3 presents the operational conditions of wells for the production period, considering the modeling of the production system.

Table S2 – Data for assembly of production systems.

Type	Sandstone	Carbonate	Unit
Reservoir depth	3,000	4,850	(m)
Sea level	166	166	(m)
Oil gravity	0.87	0.86	-
Gas gravity	0.74	1.06	-
Water density	1.01	1.03	-
Reservoir temperature	80	58	(°C)
Christmas tree temperature	50	38	(°C)
Riser bottom temperature	30	30	(°C)
Separator temperature	20	20	(°C)
Relative roughness	0.0006	0.0006	-
Production water salinity	150,000	250,000	(ppm)

Table S3 – Operating conditions of wells.

Operate conditions type	Sandstone		Carbonate		Unit
	Producer	Injector	Producer	Injector	
Minimum oil rate	20	-	20	-	(std m^3/day)
Maximum water rate	-	5,000	-	5,000	(std m^3/day)
Maximum BHP	-	350	-	480	(kgf/cm^2)
Minimum WHP	15	-	15	-	(kgf/cm^2)
Maximum GOR	200	-	500	-	(std m^3/std m^3)
Maximum water-cut	95	-	95	-	(%)
Maximum gas lift rate	2,000	-	2,000	-	(10^3 std m^3/day)

The economic model needs to consider the calculation of the values of reservoir fluids independently, as well as assume their respective costs independently, being added at the end, according to a methodology proposed by Gaspar *et al.* (2015) and Santos *et al.* (2018). Table S4 presents economic parameters used in study.

Table S4 – Economic parameters

Variable/Parameter	Unit	UNISIM-I	UNISIM-II
Oil price	(USD per m3)	235.5	344.4
Gas price	(USD per m3)	-	-
Oil production cost	(USD per m3)	50.21	68.80
Gas production cost	(USD per m3)	-	-
Water production cost	(USD per m3)	5.02	6.88
Water injection cost	(USD per m3)	5.02	6.88
Gas injection cost	(USD per m3)	-	-
Abandonment cost (% : drilling and completion)	--	8.2%	8.2%
Annual discount rate	--	9%	9%

Table S5 presents complementary information of economic parameters to be used in the production system integration.

Table S5 - Additional economic parameters for production system

Economic parameter	Technical parameter / decision variable	Option	Value	Unit
Investment on connection (well-platform) of vertical / horizontal well	Production / injection flowline	4” 6” 8”	411 768 1976	(USD/m)
	Riser	4” 6” 8”	879 1513 2597	(USD/m)
	Riser and flowline installation	-	11.70	USD millions
Investment on drilling and completion of vertical well	Production column	3” 4” 5”	234 250 270	(USD/m)
	Drilling and completion	-	20.90	USD millions
Investment on drilling and completion of horizontal well	Production column	3” 4” 5”	234 250 270	(USD/m)
	Drilling and completion	-	21185	(USD/m horiz)
		-	25.66	USD millions
Investment on recompletion of vertical well	Production column	3” 4” 5”	29 45 65	(USD/m)
	Workover	-	7.86	USD millions
Investment on recompletion of horizontal well	Production column	3” 4” 5”	29 45 65	(USD/m)
	Workover	-	9.83	USD millions
Investment on well conversion	Production column	3” 4” 5”	29 45 65	(USD/m)
	Workover	-	9.83	USD millions
Additional investment on connection for Artificial-Lift	Injection flowline 4”	-	411	(USD/m)
	Riser 4”	-	879	(USD/m)

Note:

- 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.

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