The Importance of Production Allocation in Oil & Gas

by Joseph McMullen, Director, SimSci Marketing

Executive summary

Production Allocation allows the allocation of production to each well which is crucial for financial and technical reasons. Depending on the configuration of the field, different techniques can be applied for all these cases. Simulation software from SimSci is able to provide a robust and efficient solution to determine the production at each well.
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In oil or gas fields, the production of different wells is transferred via flow lines to process facilities where oil, gas, and water are separated and treated to defined specifications, such as, the Reid vapor pressure (RVP) of the export oil. These wells could be drawing from different reservoirs with different shareholders (oil companies) for each reservoir. Since there are few or no reliable measurements of the fluid produced by an individual well, there is no straightforward methodology to determine the production coming from a specific well/reservoir. Production Allocation allows the allocation of production to each well which is crucial for financial and technical reasons. Depending on the configuration of the field, different techniques can be applied for all these cases. Simulation software from SimSci is able to provide a robust and efficient solution to determine the production at each well.

Schematically, an upstream process plant (onshore or offshore) collects the production from different wells (sometime hundreds of wells) and produces the following semi-finite products:

- Export oil/condensate
- Gas (exported or reinjected in a reservoir)
- Water often reinjected for preventing the reservoir pressure decline
- Flared gas and fuel gas used as utility of the plant

The process plant can be very simple (few successive separators) or quite complex, such as, a LNG plant. The distance between the wells and the process plant varies greatly, from a hundred meters to 10 or 20 km.
Unfortunately, there are often few reliable flow measurements, except on the export gas and oil/condensate which are measured with a high accuracy for fiscal metering. Fortunately, well head pressure (WHP) is typically measured with a reasonable accuracy which allows the well production to be estimated by the performance index of the well, which is a relationship between the well head pressure or the bottom hole pressure and the oil or gas flow rate.

Production allocation is important to comprehend where the production comes from, for instance, which fraction of the export oil comes from the well A. This is crucial for two reasons:

1. To determine the financial revenue of each partner in the field, which is not always the same for all wells processed at the plant (see table 1 below)
2. To check that the reservoir behaves as expected, and if needed, modify, - the reservoir modeling against history matching and/or adjust the gas/water injection to limit the pressure decline.

For each field, a methodology to determine production is performed on a daily basis to back-calculate allocation of the production to the wells level based on the available information. In developing a solution, the adopted methodology must be as fair as possible and agreed to by all the partners. While the calculations involved by this methodology can be straightforward (i.e., Microsoft Excel application), often a simulator is needed. In these simulations, we must always assume that the system (pipelines and process plant) is operating in steady state conditions (i.e., no severe slugging in the risers). The simulation will be based on measurements in the field—WHP, separators operating conditions, etc.—based on 24-hour average values maintained in a database, along with fluid properties.

Production Allocation presents no universal solution, so its methodology is executed on a case by case basis that depends on the availability of information, the complexity of the process plant and the complexity of the gathering flow lines network. Here are two examples illustrating possible solutions given the specifications of the case.

**Example 1: Oil Allocation Case**

In this very basic oil field, two wells are supposed to produce the same fluid—identical Gas Oil Ratio (GOR), water cut, and oil properties. The process plant consists of a single stage separation, see Figure 1. The wells are producing from different reservoirs with the shareholders as mentioned in Table 1. Each well is connected to the process plant via its flow lines which are roughly 20 km long—a length leading to a pressure drop large enough compared to the accuracy of the sensors.

![Figure 1](image-url)
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This available data varies each day:

- Export oil flow rate (fiscal metering);
- Export gas flow rate (fiscal metering);
- Pressures downstream the choke valves;
- Separator P and T conditions.

The configuration of the system is defined by:

- Fluid properties: GOR, water cut, oil viscosity, …
- Well performance index (relationship between the WHP and the oil volume rate);
- Pipelines parameters: diameter, roughness, length, profile

The model will include two pipelines with a hydrodynamic model suitable for three phases flow (typically, OlgaS of Schlumberger) and a separator; the black oil approach is used for determining fluid properties.

The flow rate in each line is determined based on the inlet and outlet pressures using the well performance index as initial values. The obtained global flow rates will not match the measured export rates due to deviations in the mass balance. A reconciliation of fiscal measurements must be performed. It can be done manually, if we assume the calculated relative flow rates in the lines is suitable (i.e., 60% of the export oil comes from the well A and 40% from well B), and then simply apply these factors (60/40) to the measured values. SimSci PIPEPHASE is a very good candidate for this kind of application, even with a large number of wells.

A more sophisticated reconciliation can be done with SimSci ROMeo by varying the inlet and separator pressures to match the export oil and export gas measured flow rates.

Table 1
Shareholders of the reservoirs

<table>
<thead>
<tr>
<th></th>
<th>Well A</th>
<th>Well B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company 1</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Company 2</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Company 3</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>
Example 2: Gas Field

Consider a gas condensate field where a large number of wells are connected to a process plant via two inlet manifolds (high pressure and medium pressure). The process plant is quite complex with recycle streams, distillation columns, and expanders to meet the specifications on the export gas. The gas composition varies from one well to the other. Figure 2 is an illustration of such configuration.

This case differs completely from the previous one. It has:

- Short flow lines with too limited pressure drop to be used for flow rate determination.
- Different fluids produced by the reservoirs (i.e., different H2S concentrations).
- Complex process plant unit operations and conditions

In this case, a compositional simulation of the process plant is performed, without the pipelines network. One solution to perform the back allocation of the export gas and export condensate is to duplicate the components, using as many methane, ethane, H2S, C20+ components as the number of wells. The simulation is done with a rigorous thermodynamic model (not the simple black oil approach).

The flow rate produced by each well is estimated from the well performance index or with MPFM (multi-phases flow meter). These flow rates and the associated composition are used in a SimSci PRO/II or a ROMeo simulation. Because the calculated export gas and export condensate rates will not match the measured one, a manual reconciliation is done for each component on the measured values of the export gas/condensate.
In addition to the fluids’ compositions and process plant description, the data is measured each day:

- Export gas flow rate, and optionally, its composition;
- Condensate flow rate, and if possible, its composition;
- Water and fuel/flared gas rate;
- Operating conditions of the main equipment

The simulation has to be robust enough to be able to handle partial shutdown of the plant.

The solution selected for the production allocation on a gas/oil field varies greatly depending on the architecture of the field—complexity of the process plant, available measurements, characteristics of the flow lines, etc. The solution adopted by all the partners of the fields can be quite simple or more complex with the use of a simulator. A detailed study has to be done for each case to choose the most suitable approach.

The resulting solution must be robust (suitable for full or partial shut-down of the wells/process plant), flexible (easy to connect new wells to the installations), fast (ability to rerun a full month) and connected to a database containing field and fluid data.

The two application cases prove SimSci products are excellent candidates for performing simulations included in the production allocation work flow. The simulations could be based on SimSci PIPEPHASE (pipelines network with a very simple process), SimSci ROMeo (data reconciliation on the fiscal measurements) or SimSci PRO/II (gas condensate fields with sophisticated process plant).

In addition to the properties typically expected from a simulator (accuracy, flexibility, user friendliness, etc.), SimSci software contains the properties required for this type of application where the simulator is automatically run without any control by the user and where robustness is crucial: error detection, reliable convergence (mass balance never violated) without any initialization, clear message on the status (reached/not reached), duplication of the components, dialog with another software (via OLE or keyword file). And finally note that some operating companies are currently using SimSci products in their production allocation system.

About the author

Joseph McMullen is the Director of Marketing at SimSci by Schneider Electric. He is responsible for expanding SimSci brand awareness and marketing of its design, simulation, training, advanced control, and optimization software. He has over 15 years of experience in the technical support, product management, and marketing of SimSci solutions. Joe earned his Bachelor’s degree in Chemical Engineering and his MBA from Villanova University.