dynardo
dynamic software & engineering

# OPTIMIZATION OF HYDRO CARBON PRODUCTION IN UNCONVENTIONAL OIL AND GAS RESERVOIRS

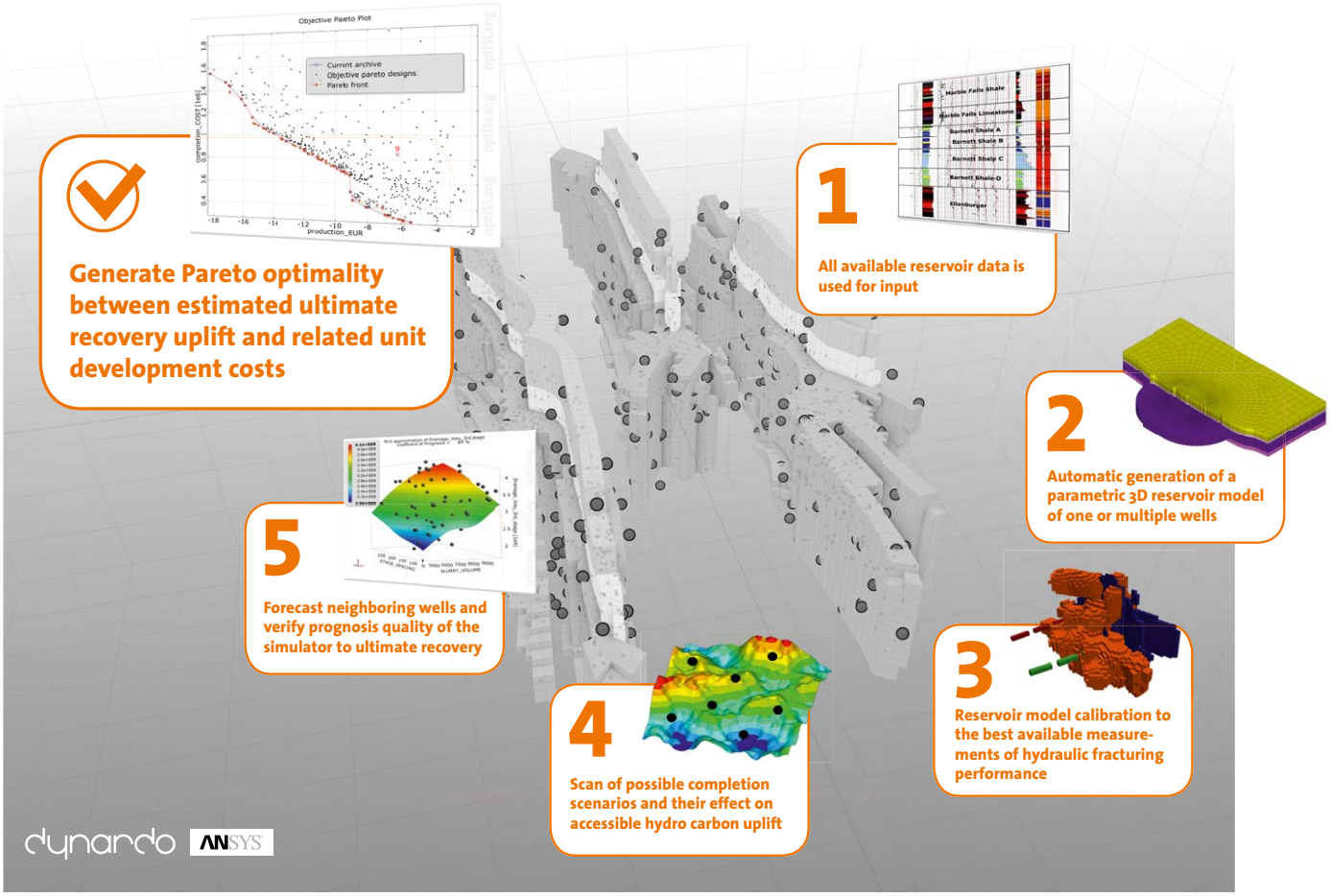
**With an effective 3D hydraulic fracturing simulator, Dynardo provides the software base for the optimization of hydro carbon production with minimal related completion costs.**

## Optimization Task

Unconventional gas and oil reservoirs are often located in layered naturally jointed rock formations with low permeability. Hydraulic fracturing is used routinely in gas and oil industry to create networks of permeable fractures to drain the reservoirs. This network connects the production well with the greatest possible volume of reservoir rock. Today, available fracturing simulators of the oil and gas industry simplify the fracture growth to single planar fractures in the direction of maximum horizontal stresses. In reality, the created fracture networks are much more complex and dominated by reopening of the in-situ natural fracture system. Therefore, so far, only post processing pictures have been generated in combination with available measurement technologies like seismic mapping. These methods also cannot answer the question how a fracture network and the related hydro carbon production at the reservoir location would have grown with a different design of hydraulic fracturing.

## Solution Methodology

Dynardo has established a workflow for optimization of hydro carbon production using the best available numerical simulation and measurement techniques. It starts with the data collection of all available reservoir information. Among them, the best measurements of hydraulic fracturing performance for one well of the reservoir are then used for generating the parametric model. Afterwards, as a consequence, the model can be calibrated to all available information which creates the base to optimize the hydraulic fracturing design. After having established a reservoir



model with proven prognosis quality, a sensitivity analysis of possible operational parameter variation is conducted. This analysis reveals the potentials of the reservoir for optimization and quantifies the connecting Accessible Hydro Carbon Initially In Place (AHCIIP). Thus, key questions like "Can we economically improve the hydro carbon production under the reservoir conditions?" or "Which well, stage and hydraulic fracturing stimulation design is optimal for the reservoir conditions?" will be answered.

**The hydraulic fracturing simulator**

A very important part of the workflow is the effective 3D fracturing simulator which can consider all important anisotropies of unconventional reservoirs including in-situ natural fractures, anisotropy in stress, as well as fracture barriers. Based on ANSYS, one of the world leading FEM simulators used for parametric modeling and FEM analysis, Dynardo developed a fracturing simulator that includes material models for jointed rock, manages the coupling with hydro mechanical simulation of fracture growth and connects powerful post processing capabilities. The nonlinear load history analysis starts with the initial in-situ stress and pore pressure initialization followed by a transient coupled fluid flow mechanical analysis. With this homogenization approach by conducting coupled fluid flow and mechanical analysis of multiple stages and wells for jointed rock, Dynardo provides the first effective 3D numerical reservoir simulator available for industrial use.

**The Workflow includes calibration, sensitivity analysis and optimization**

Another key component of the workflow is Dynardo's optimization tool optiSLang which can be used for calibration of the reservoir model, for investigating the sensitivities towards variations of operational parameter and, finally, for optimizing the hydro carbon production.

During the calibration process, important input values of the parametric reservoir will be fitted to direct diagnostic measurements in order to assign the correct understanding and knowledge about the level of importance regarding the mechanisms of hydraulic fracturing. Only with this degree of diagnostic characterization of the hydraulic fracturing process, it is possible to really understand what affects the evolution of the fracture network geometry. As a consequence, a predictive model of the hydraulic fracture design is generated that is capable of optimizing the hydro carbon production.

After a sensitivity analysis regarding the variation of operational parameters, optiSLang extracts the Metamodels of Optimal Prognosis (MOP) representing the resultant effects on AHCIIP. With the consideration of AHCIIP towards Estimated Ultimate Recovery (EUR), the prognosis quality of hydro carbon production for neighboring wells is verified. This final proof quantifies, first, how much hydro carbon production differences between wells can be explained by different completion scenarios and, second, how much production differences between wells comes from the well location in the reservoir .

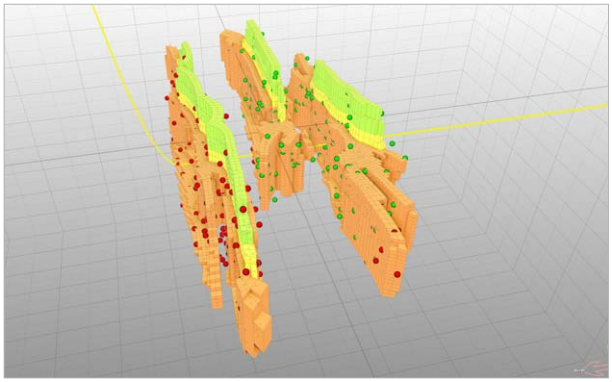
Because of the conflicting goals between maximizing production and minimizing completion costs, the workflow incorporates finally the function for Unit Development Costs (UDC) and creates a Pareto optimality of completion designs which defines the most efficient options. This best possible balance between EUR uplift and related UDC is the basis for competitive business decisions.

**Applications**

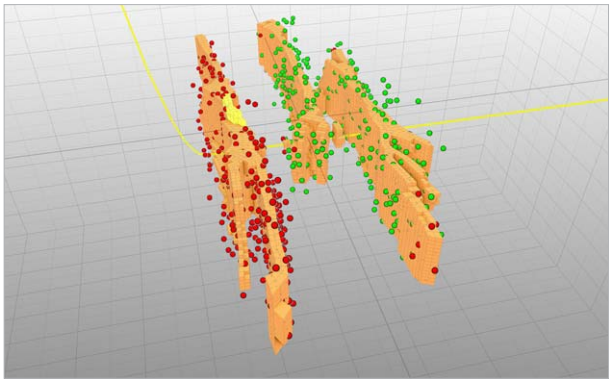
The first application was at the Barnett Shale reservoir in 2008. Since then, the workflow has been very successfully established for multiple other unconventional oil and gas reservoirs in North Amerika.

## Customer Benefits

With the described workflow, a quantification of reservoir potentials regarding optimal operational conditions becomes possible. Well, stage and hydraulic fracturing treatment design will be optimized for maximum hydro carbon production with minimal related completion costs.



Connected water accepting elements



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