

Production solutions for deepwater and ultra-deepwater field development

E. Kurt Albaugh, P.E.
Mustang Engineering, Inc.

Operators are racing to find and develop reservoirs in deep- and ultra-deepwater, where reservoir sizes are typically larger and flow rates much higher. Likewise, engineering companies, contractors and fabricators are all competitively racing to have their particular solution selected for deep- and ultra-deepwater field developments.

The wealth of recent discoveries in these water depths has encouraged and accelerated engineering companies, contractors, and fabricators' efforts to develop or improve their deepwater production solutions. This concept development race has resulted in a number of viable solutions that can support dry and/or wet trees in deepwater and hostile environments worldwide.

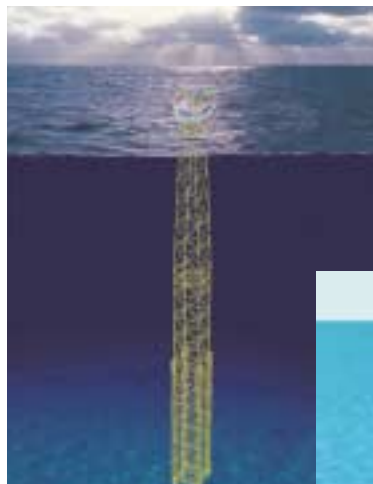
Companies are racing to develop, market, and get their design installed by an operator before a competitor dominates the market and shuts out any new concepts. The solution providers all know that not all of the currently marketed designs are going to be selected. In the next 5-7 years, this long list of solutions will quickly narrow to a select few in each design category. One company will eventually dominate each category.

Solution types

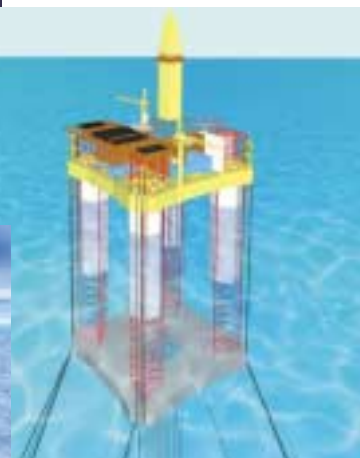
Mustang Engineering recently identified at least nine major deepwater production solution categories or groups for a global survey of deepwater production solutions (see pull-out poster in September *Offshore*). More than 130 production solutions were identified and assigned to a category.

With each group of solutions, there are general advantages and disadvantages that must be understood in order to narrow the list of options related to an offshore field development. The merits of each solution will focus around: water depth rating, dry tree and/or wet tree capability, drilling capability, payload, motion characteristics, CAPEX, OPEX, ABEX, installation method, constructability, fabrication time, among other factors. Each of the production solution types and their acronyms are described below:

- Compliant towers (CT) or compliant piled towers (CPT): To date, there have been three installations – Exxon's Lena guyed compliant tower in 1,018 ft of water, Amerada Hess' Baldpate CP in 1,650 ft, and Texaco's Petronius in 1,754 ft of water. Both J. Ray McDermott and Mustang Engineering are confident that this technology can be taken out to 3,000 ft water depth. ExxonMobil holds the rights to CPT technology and not CT technology in general.
- Deep-draft semis (DDS) or deep-draft semisubmersibles (DDSS): No designs have been installed yet, but numerous studies have been made.
- Floating production systems (FPS), deepwater production semis (DPS), floating production vessels (FPV), floating production/drilling vessels (FPDV): Widely used for hostile environments and where high



(Left) Compliant Piled Tower (CPT)



(Above) Deep Draft Semi (DDS)

(Left) Floating, Production, Drilling, Storage, Offloading (FPDSO)

production rates are required. FPSs have predominantly been used offshore Norway and Brazil. Most of the designs are utilizing the ring pontoon hull configuration.

- Floating production storage offtake vessels (FPSO): There are 75 FPSOs operating or available for work. Petrobras has extended the water depth capability of FPSOs to 6,083 ft offshore Brazil on the Roncador field.
- Floating production, drilling, storage, and offloading systems (FPDSO) or floating drilling, production, storage, and offloading systems (FDPSO): There are many new monohull FPSO concepts with added drilling capability being proposed to industry predominantly by European contractors.
- Mini-tension leg platform (mini-TLP), mini-tension leg wellhead platforms (mini-TLWP): To date, there have been two mini-TLPs installed and two are under construction. The current water depth record for a mini-TLP is 3,300 ft. All of the installed or scheduled to be installed mini-TLPs are the wet tree design with no moon pools. Another milestone for this solution will occur when an operator selects a mini-TLP for a dry tree solution. David Snell of Atlantia

ULTRA DEEP ENGINEERING

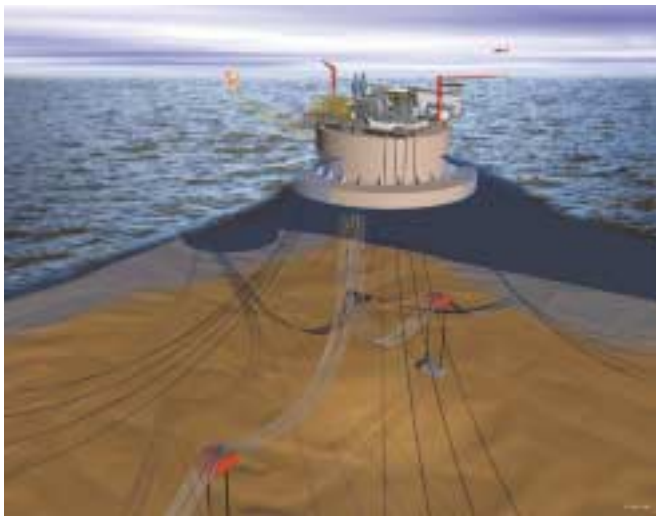
Offshore is confident that they can take the mini-TLP concept deeper from the industry accepted water depth limit of 6,000 ft, to 9,000 ft, using conventional tendon hardware and varying diameter tendons. Both West Africa and the US Gulf of Mexico are the hottest ultra-deepwater areas for mini-TLPs. Seven companies are now marketing mini-TLP designs.

- SPARs, deep draft caisson vessels (DDCV), single column floaters (SCF), deep draft floaters (DDF), cession production units (CPU): Sparers seem to be the preferred deepwater solution when large payloads are required and because they are a proven concept. Twelve companies market their own Spar designs, however the issue of patents and who owns the technology is confusing the industry. To date, three SPARs or DDCVs have been installed. All have been installed in the US Gulf in water depths ranging from 1,930 ft to 4,800 ft.
- Tension leg platforms (TLP), tension leg wellhead platform (TLWP): This technology has progressed to 3,950 ft water depths in the US Gulf with Shell's Ursa TLP installation. There have been 11 full size TLPs installed in the North Sea and US Gulf. Seven companies market TLP designs.
- Wellhead control buoys, production buoy concepts (WHCB or WHPB): This is proven technology, with two installations in South Africa and Australia. This technology is evolving and is best used for subsea tiebacks. Eight companies are now promoting this technology for use in up to 3,000 meters water depth.

Selection process

There is a wealth of deepwater production solutions now available to operators. The list has grown tremendously in the past three years. The process of understanding the advantages and disadvantages of each concept in order to select the best field development approach can be overwhelming and confusing.

Some operators have simplified the selection process by only choosing proven concepts to minimize project risk. Other operators go through a rigorous selection process by identifying the possible solutions, reviewing them, analyzing them, and ranking them based on a set of project and company criteria.



Non-monohull (FPSO)

(Left) Floating Production System (FPS)

During the initial phase of field development planning, most operators don't have the time and/or the staff to adequately survey the industry and to investigate all the alternative solutions for designs that have not built and proven in the field. These constraints have forced companies offering unproven solutions to aggressively market their technology and design by publishing, making presentations, and calling on operators.

Initially, the operator can narrow the long list of solutions to several options based on water depth capability. Another criteria further reducing the list of options is the size of the reservoir. The amount of the recoverable reserves directly affects which solution can achieve an economic target expressed in \$/boe based on a desired internal rate of return (IRR) or financial performance indicators.

The majority of the deepwater solutions are being marketed for the large reserve sizes. It has been only recently that some of the new concepts such as mini-TLPs control buoys, and downsized Spars among others are being focused on marginal deepwater fields.

Not all solutions are equal. They all differ in the maturity of the design. So, how should an operator select a concept? David Snell of Atlantia Offshore has an interesting procedure: "It is paramount that the operator consider the technical merits of the design, historical performance of that design, and most importantly the experience of the people involved."

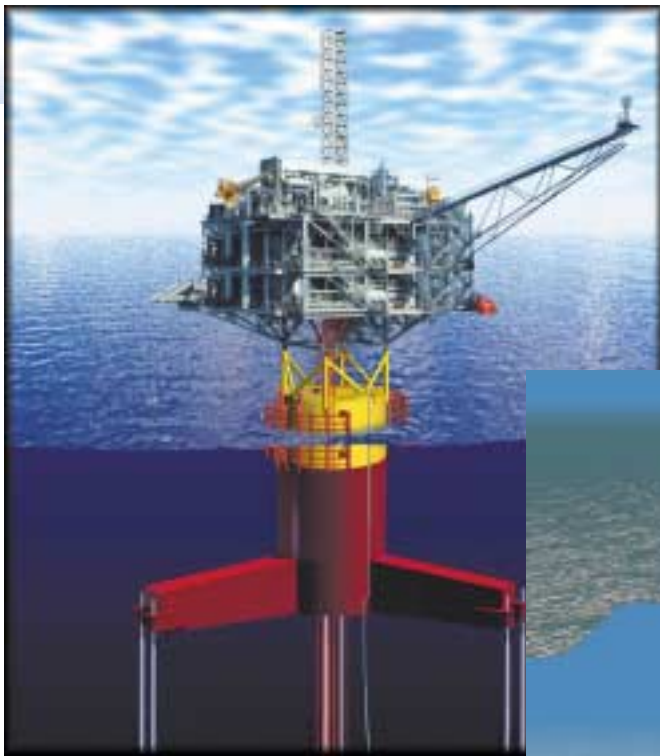
Snell stresses the operator should look at the team that will design and model test, and ultimately execute the construction and installation phases of the contract. "There are many hidden challenges in deepwater, but few companies actually have the experience and historical data to support safety and operability while still being competitive in the market place."

A report card, or benchmark, for determination of the maturity of a particular design is to verify if the solution developer has performed any of the following for various water depths and site locations: vortex induced vibrations (VIV) analysis; global performance analysis; tank tests; wind model tests; fatigue test; and riser analysis.

The more mature production solutions have checked out their designs



Floating Production Storage Offloading (FPSO)



(Above) *Mini-Tension Leg Platform (Mini-TLP)*

(Right) *Spar*

for several operating areas of the world. New concepts are driven by the energy and visions of one or two persons within a company. Without these people, the deepwater production solution will never get accepted.

Wallop the proven

Robin Converse points out that “a new concept has to have an advocate within the operator organization who believes in the concept.” The advocate must also be articulate and respected throughout the company in order to sell the benefits of a particular production solution to management.

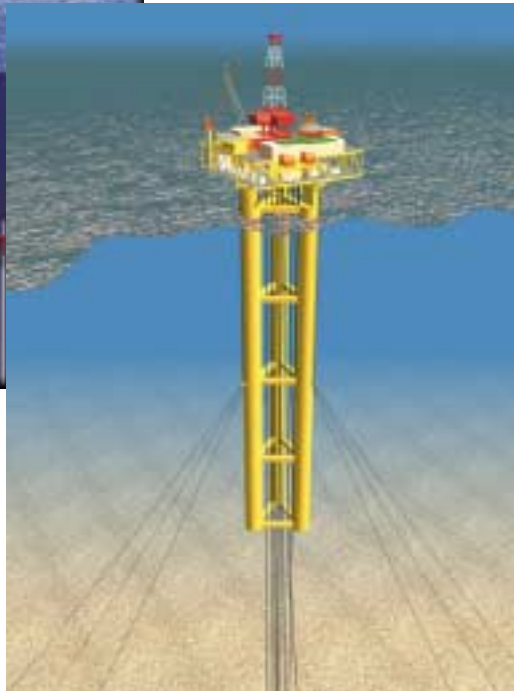
Each unproved concept considered for a field development is competing with proven designs and other new production solutions. An unproved concept is considered risky. Converse says that “oil and gas companies try to minimize their project risks. It is hard for new technology to break in.” When a new solution has to compete with a proven design, it has to produce a 10-20% savings in either CAPEX and/or OPEX in order to economically justify the risk. He adds that “you don’t win in a bid competition by a 1-2% savings; you must wallop the proven design in order to break in with a new design.”

Operator organizations have become thin-



(Above) *TLP*

(Right) *Wellhead Control Buoy (WCB)*



ner as a result of mergers and down-sizing, while deep- and ultra-deepwater technology has grown. Operators are struggling to catch up and to keep up with all of this new technology that is becoming available to the industry. Some of the operators have elected to use a paid design competition approach to determine which solution is technically and economically best for their field development.

Constraints

It is a costly and a lengthy process to bring a deepwater production solution to market. Engineering companies, contractors, fabrication shipyards, and operators have spent millions of dollars to develop or refine their propriety deepwater technology. Not all of the non-operator companies who offer deepwater solutions have the financial resources to finalize their design. Many rely on the operator to select their design, to pay for detail design, and then to install the solution.

In the case of Spars, it took Ed Horton, the inventor of the production/ drilling spar, 10 years from conception to first installation. For Atlantia and their SeaStar^(r) mini-TLP design, the process started in 1990; their first mini-TLP was installed in 1998. This was an 8-year cycle time from conception

to installation.

Independents with small staffs may have to depend on consultants to evaluate the various solutions to determine the viability of competing designs and applicability to a particular field’s development plan.

The necessity of looking for new technology in order to recover reserves at the lowest \$/bbl in deep- and ultra-deepwater is forcing a conservative industry to be more open and receptive to new ideas, basically “necessity is the mother of invention.”

Some of the unproved production solutions will survive and others will quietly fade away, but the wealth of new and proven solutions are providing operators with the enabling technology to produce in deep- and ultra-deepwater safely and economically.

The race to deepwater by operators and the race to provide production solutions by the designer is proceeding at a blistering pace. Only those companies that are flexible, strong, and have the endurance to finish, will be among the winners in the deepwater race. ●

References:

“Worldwide Survey of Deepwater Production Solutions,” Pull-out poster, September 2000 issue, *Offshore Magazine*.

Author

E. Kurt Albaugh, PE, is a Senior Consulting Engineer at Mustang Engineering, Inc., specializing in economic, cost, and feasibility studies for offshore and onshore field developments. He holds a BSCE from Youngstown State University and a MCE from Rice University.

