Abstract

The Smart Fields programme has been active in Shell over the last decade and has given large benefits. In order to understand the value and to underpin strategies for the future implementation programme, a study was carried out to quantify the benefits to date. This focused on actually achieved value, through increased production or lower costs. This provided an estimate of the total value achieved to date. Future benefits such as increased reserves or continued production gain were recorded separately.

The paper describes the process followed in the benefits quantification. It identifies the key solutions and technologies and describes the mechanism used to understand the relation between solutions and value. Examples have been given of value from various assets around the world, in both existing fields and in green fields. Finally, the study provided the methodology for tracking of value. This helps Shell to estimate and track the benefits of the Smart Fields programme at company scale.

Introduction

The Smart Fields programme in Shell has been ongoing since 2002. The programme has expanded and built upon experience and insights from specific solutions in a number of assets – in particular smart wells. Since then, more solutions both large and small have been implemented under the ‘flag’ of Smart Fields – retrofits in existing fields and smartness by design in new projects (ref. 1,2,3). Value is generated by closing the Value Loops, through the cycle of data acquisition, modeling, decision making and execution in the field.

In the energy industry, other oil and gas companies have embarked on programmes with similar goals, under names such as e-field, i-field, Field of the Future (ref. 4-7). Joint industry programmes have been set up, for example Digital Oil Field of the Future (DOFF) led by IHS CERA, Integrated Operations in Norway (ref. 8) and the ISAPP research group (ref. 9,10). A number of vendors market equipment, software or complete solutions to support these programmes. Consultancy is available, ranging from advice for specific solutions in projects to the lead role in an asset improvement programme.

In production and operations in Shell, Smart Fields covers a spectrum of solutions. A standard solution is available in the form of the “Smart Fields Foundation” for real time well monitoring and optimisation, data acquisition and security, and model-based production optimisation and forecasting (ref. 11). This includes Shell’s proprietary Production Universe software for real time well monitoring and optimisation and virtual metering (ref. 12, 13), integrated production system modeling (IPSM), production allocation and the Data Acquisition and Control Architecture (DACA) standard for secure link between office and field. Standard workflows have been defined, that guide staff to execute the right process steps and help asset teams to achieve the full value (ref. 14).

Integrated operations are supported by Collaborative Work Environments, in production (ref. 15) and in drilling operations (ref. 16). On the facilities side, advanced rotating equipment monitoring is available on an increasing number of compressors, pumps and generators (ref. 17). Also, pipeline systems are monitored in real time, in some cases linked to an integrated model of a
pipeline system fed by fields from different operators (ref. 18). More recently, exception based surveillance solutions with guided workflows for problem resolution have been added to the suite of capabilities (ref. 19).

Smart wells have made a big impact on the development of some fields. The smart wells have unlocked oil by combining multiple compartments in one well (ref. 20). During field life, production is optimised and as a consequence, additional oil recovered (ref. 21, 22). In other fields, smart wells enable commingling of production in a well, with reliable allocation of production to the different reservoirs.

In reservoir management, surveillance has been carried out by seismic and other techniques (ref. 23). The results have been used for field development planning (eg. to re-locate wells away from encroaching water) and for reservoir management in ongoing water floods.

**Quantifying business value**

During 2008, a value assessment was carried out to quantify and describe the value achieved from the Smart Fields programme. The value was quantified per capability and for each of Shell EP’s six regions. In total, data was collected from around 50 assets. The data was gathered via project team members in the operating units and by visits of the global Smart Fields programme manager, who interviewed asset managers and worked with the relevant asset staff to obtain the key figures and to gain asset endorsement.

Four major benefit categories were used: Production Increase, Ultimate Recovery Increase, Capex Reduction and Opex Reduction. Smart Fields projects also led to HSE benefits (eg. from reduced logistics exposure), but these have not been quantified.

The value was quantified for the period up to beginning of 2008 and tracked further through 2009. To ensure a defendable figure was reached, value was counted only if from production achieved or costs saved up to that date. Expected future benefits from projects already implemented or from planned projects, such as through recurring production gain and opex reductions or through ultimate recovery increases, were excluded. This meant, for example, that many benefits from smart wells or time lapse seismic were not counted, as they will occur in the future.

The approach used was built on four pillars:

- Maximum leverage of existing insights from Shell’s own project reviews and approaches in industry reviews (the cross-operator review of Integrated Operations by Petoro in Norway, and results from CERA’s DOFF studies).
- A structured approach to linking solutions to value. A Benefits Logic was constructed that shows how solutions yield improvements and generate value. A simplified example is shown in Fig. 1.
- Evidence based analysis, geared at a realistic assessment of the value generated.
- Strong involvement of regional management to ensure endorsement of the benefits quoted.

The objective was to produce a value assessment as solid and traceable as possible, and based on conservative estimates and calculation rules. Conservative estimates were achieved by:

- The use of a relatively low $30/b oil price; this reflects the fact that part of the production gain was new oil, part was acceleration of existing production.
- Only production increase or cost savings achieved in the period to end 2009 were included.
- Value was included only if asset managers confirmed (in some cases, asset managers quoted to expect large benefits but preferred not to treat them as firm; these were not included).
- Where no hard numbers were given, the estimates from local managers were reduced.

In a number of assets, the implementation of Smart Fields solutions formed part of a wider asset improvement programme. In such cases, benefits like increased oil production could not be attributed to one single solution or to Smart Fields alone. Judgement has been made by the asset managers and asset staff to assign the right proportions of observed benefits.

The approach described above has provided the majority but not a fully comprehensive overview of all benefits achieved from the Smart Fields programme. Besides the quantified value, further benefits will have been achieved in different assets or from un-quantified projects in the same assets.
The benefits were categorised by the Smart Fields solution that delivered them and by the type of improvement generated. These were connected to the five main types of benefit (production, recovery, capex, opex and HSE) in the Benefits Logic. Fig. 1 shows a simplified representation of this Benefits Logic. In many cases, solutions contribute to more than one type of improvement. In the figure, this is shown only for Smart Wells, 4D seismic and Collaborative Work Environments. The full Benefits Logic also has more layers in between the Solutions and the Benefits, which may be used in the tracking of value. The structure is indicated in Fig. 2. The categorisation of the benefits as developed in this study also will provide the basis for further benefits tracking.

Fig. 1  Benefits Logic – showing how capabilities and solutions are linked to business value (simplified)

Fig. 2  Structure of the Benefits Logic

**Business Value results**

As a result of this study, we now have a firm quantification of the value of Smart Fields to Shell. Figure 3 illustrates the overall benefits delivered to the business through the implementation of the Smart Fields programme through end 2009.
The overall quantified benefits were $5 bln for the period up to end 2009. The main contributor to that value was Production Increase, with some 70,000 b/d additional production attributed to use of the Smart Fields solutions. The total Capex Reduction achieved was calculated as around $800 mln. Production Increase and Opex Reduction were generally of a recurring nature, whilst Capex Reductions were once-off benefits.

The capability that has delivered the most value to date, has been unlocking the full value of some new fields through smart wells. The prime example is the Champion-West project in Brunei, where smart “snake” wells connect several reservoirs in each well (ref. 20, 22). The platform is un-manned and the wells are fully remote controlled, both downhole and at surface. The snake wells enabled cost effective development at the start of the project and in addition the intelligent completions allow optimising the production during the production phase. This enables pro-active reservoir management and maximising of recovery (ref. 21). In a recent subsequent development in the Seria North Flank field, the concept has been taken further, with so-called “fish-hook wells” drilled from the coast, and curved upwards into the offshore field (ref. 24).

A second example of business value delivered in production optimisation is real time monitoring and virtual metering of wells. The Shell proprietary Production Universe software (ref. 12, 13, 21) has been installed in a number of Operating Units around the world, with a coverage of about 60% of Shell’s total oil production. Its capabilities include exception based surveillance and alerting, real time optimisation of well settings and virtual metering. Business benefit is gained in Production optimisation (eg. ref. 25) from faster identification and remediation of well events, fewer trips due to early warning, real time gas lift distribution optimisation (ref. 26) and improved field management through better production allocation over time.
Integrated production system modelling (IPSM) is now widely spread in Shell assets. It has been used and has delivered value in field development and in the production phase. In field development planning, the integrated model was used to optimise the design of the facilities to meet the requirements over the field life and to cater for the uncertainties of the reservoir. Scenario modeling has been used to support decision making around scope and timing of further investments. In the production phase, IPSM modeling has been used extensively for production optimisation. Regular surveillance is carried out and opportunities for well interventions and well and reservoir performance optimisation are screened and optimised against the integrated model (ref. 27, 28). Examples include debottlenecking, re-routing of wells and changing of separator pressure settings.

Facilities monitoring and optimisation has delivered value in two main areas. Firstly, real time monitoring of the many compressors around the world. Compressor down time is a significant contributor to deferment of production and is the focus of both maintenance and surveillance activities. Basic monitoring of the real time data has become standard. Recent developments have built an advanced monitoring capability for rotating equipment with early warnings of potential problems and advice for potential remediation or optimisation actions (ref. 17). In addition, a global support centre provides expert advice for rotating equipment to assets around the world. Secondly, flow assurance monitoring has been implemented in a number of fields and pipelines (ref. 18). Business benefits have been quantified through production reliability and avoidance of major pipeline mishaps (sand, hydrates, liquid loading).

Collaborative Work Environments (CWEs) have been implemented in Shell with several different objectives. In a number of countries, collaboration centres are in place for production operations. These provide improved office to field communication and support the daily decision making around operations, maintenance and emergency response. Quantified benefits include reduced need for field surveillance staff and avoidance of weather down time (3rd party experts not having to wait for flying weather to provide advice). Increasingly, assets have implemented a CWE for production optimisation (ref. 15). Such a centre focuses on the daily production surveillance and opportunities for production optimisation. Strong video communication and data sharing facilities enable joint interpretation and decision making and improve the team spirit between office and field staff. In the CWE in the Fahud asset in Oman, four different locations have been linked together, between the asset team, the on-site office, the field control room and the well services office. Extensive attention has been paid to engaging, training and coaching the staff members to embed of the new ways of working within the teams in a sustainable way (ref. 29).

A third type of collaborative work environment has delivered value by remote monitoring of drilling operations, through Real Time Operations Centres (ref. 16). Drilling and completion of complex wells is monitored from central locations in selected countries. The centres are linked and provide backup capabilities to each other. As an example, drilling of an exploration well in Brazil has been monitored from a centre in New Orleans and a well in Africa from Norway. Business benefit has been tracked and includes avoidance of drilling mishaps and optimisation of the drilling process.

In reservoir management, business value has been achieved through reservoir surveillance and its impact on development projects, changes in off-take and injection strategies and production optimisation. Time-lapse seismic has delivered the majority of the quantifiable benefits (ref. 23). In some cases, locations of planned wells have been moved away from water fronts, or wells in infill drilling have been concluded unnecessary. The benefits that were counted in this study were mostly capex reductions; benefits in terms of additional recovery will be larger, but have not been counted as in great majority they will fall in the future.

The work processes in field development planning are streamlined through guided workflows that keep track of project progress and provide an overview of the uncertainty elements (ref. 30).

In addition, remote monitoring and control of wells and facilities and the use of collaborative work environments led to a different way of working, with a lower requirement for on-site staff. The resulting reduced logistics has had positive effects on HSE and operating costs. Similarly, benefits have been quantified that result from automation of well test execution. The opex impact is often of a re-curring nature. The HSE impact may be more important to the asset and staff, and has been considered in the decision making for implementation of these capabilities.

Different capabilities have been developed in different operating units in Shell, to meet the different business needs and operating environments, indeed the capability contribution and impact have varied from region to region. A critical requirement is to identify the relevant solutions from the outset. Retrofitting is far more complex and costly, and is only possible for some of the solutions.

A cost – benefit analysis was made for some of the smart fields implementations and solutions mentioned. In some cases it was not possible to separate out the costs and benefits of smart fields items from overall improvement programmes. Hence, a rough overall
cost estimate has been made for the entire programme corresponding to the quantified benefits. This cost–benefit analysis showed clearly that the achieved value of the Smart Fields programme already far outweighs the investment, with the total benefits several times higher than the total costs.

Conclusions

Large benefits of US$ 5 bln have been quantified from implementation of Smart Fields programme in some 50 Shell assets over the period of 2002 to 2009. The benefits have been achieved by fit for purpose retrofitting in existing fields, and by designing in the appropriate elements from the start in new fields. Assets have achieved benefits through application of different Smart Fields solutions, in many cases as a part of a wider improvement programme in the asset. The benefits from some solutions or technologies can be quantified separately. In many other cases, separating the benefits from each individual solution element or technology is not possible and not desired when delivered by a combination of different delivery groups within the organisation.

To achieve the maximum value from investments in Smart Fields technology, it is critical that the opportunities for implementation are identified early in the development process or early in field life, and tracked through to execution. A structured approach has been developed that has enabled quantification and categorisation of the benefits, and will support tracking of the benefits in the future. The Benefits Logic provides a useful methodology to develop such a structure.

References

3. L. de Best and F. van den Berg, Smart Fields – Making the most of our Assets, paper SPE 103575, presented at the SPE Russian Oil&Gas Technical Conference and Exhibition, 3-6 October 2006, Moscow, Russia.
22. Peter Bakker, Lee Watts, Ravil Salakhetdinov, Yee-Yung Liew, and Brigitte Dale, Appraisal and Development of Thin Oil Rims Using the Smart Field Approach, An Example from Champion West, Brunei, paper SPE 122600, presented at the Asia Pacific Oil and Gas Conference & Exhibition, Jakarta, Indonesia, 4-6 August 2009.
28. Bruce James, Kevin A. Kerr, Stephanie Lim, Ed Lewandowski, Craig Knight and Richard Bell, Intelligent Fields Management at Woodside: A Low-Cost Step Improvement in Field Management Using Off the Shelf Technology, paper SPE 116519, presented at the SPE Asia Pacific Oil and Gas Conference and Exhibition, Perth, Australia, 20-22 October 2008.