Investigation on the Impact of EPW-A Audit Initiatives on HSSE and Well Engineering Performance

Thesis

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Abstract

Across the global oil and gas industry, considerable effort has been focused on the prevention of major incidents. Because of very complex operations, heavy tools, high pressures and hazardous substances, drilling operations are creating a high potential for such incidents. The challenge does not only lie in identifying the risks leading to incidents, but in creating a common risk and safety awareness within a company as well as between a company and its contractors. Controlling the level of risk a company is willing to accept on its drilling operations is one of the reasons for implementing management systems. These management systems build the framework for standards, processes and regulations that operations have to follow. To ensure compliance to the management systems across the board, audit initiatives have to be implemented.

Since 2008 OMV E&P has been applying a rigorous audit initiative on its contracted drilling and workover rigs. While the audits are focused on safety issues and review the three major aspects, the equipment, the crew competence and the management system, the benefits of the initiative go beyond safety only. Adequate contractors work safely but also and more efficiently, resulting in less non-productive time, lost time incidents and ultimately in less costs. Additionally OMV is also auditing subsidiary offices on their compliance level with E&P standards. Both audit initiatives generate a vast amount of data along the way.

The intention of this thesis is to use the available data revealing the influence of the audit initiative on safety and economics. Therefore, the data is analysed with statistical methods, like trend or correlation analysis, and the results are then combined with some quality background information to reveal deeper insights. In the first part of the thesis the key performance indicators are analysed for possible cross-correlations, while in the second part the key performance indicators of each subsidiary are analysed separately.

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List of Acronyms

ACC	Acceptance Audits
AFE	Authorization for Expenditure
ALARP	As Low As Reasonably Practical
API	American Petroleum Institute
BOE	Barrel of Oil Equivalent
E&P	Exploration and Production
HSSE	Health, Safety, Security, Environment
HSSE MS	Health, Safety, Security and Environmental Management System
HSEQ	Health, Safety, Security and Quality
DPR	Drilling Performance Reports
DWOP	Drilling the Well on Paper
DWP	Detailed Work Program
ESIA	Environmental and Safety Impact Assessment
FU	Follow-Up Audits
HAZID	Hazard Identification Study
IDS	Independent Drilling Software
KPI	Key Performance Indicator
LL	Lessons Learnt
LLI	Long Lead Items
LOPC	Loss of Primary Containment
LTIF	Lost Time Incident Frequency
ProjM	Project Manager in Subsidiary
ProcM	Procurement Manager in Subsidiary
MD	Measured Depth
MS	Management System
NPT	Non Productive Time
OM	Operations Manager in Subsidiary
OHSAS	Occupational Health- and Safety Assessment

PDCA	Plan Do Check Act
PWP	Preliminary Work Program
RA	Regular Audits
RP	Recommended Practice
TD	Total Depth
TRIF	Total Recordable Incident Frequency
WDC	Well Design Criteria
WE	Well Engineering
WEMS	Well Engineering Management System
WEP	Well Engineering Process
WETP	Well Engineering Technical Policy

1 Introduction

Across the global oil and gas industry, considerable effort has been focused on the prevention of major incidents. Because of very complex operations, heavy tools, high pressures and hazardous substances, drilling operations are creating a high potential for such incidents. In recent years the industry has recognized the importance of collecting, sharing and reporting occupational accident statistics. Collecting illness data makes it possible to identify, assess and finally control the initial risks responsible for the incident.

The challenge does not only lie in identifying the risks, as for drilling operations they are more or less the same around the globe, but in creating a common risk and safety awareness within a company as well as between a company and its contractors. This common awareness should not be taken as a matter of course, because different cultures and educational systems, the risk and safety culture and experience are relevant factors that influence risk and safety awareness.

A further challenge lies in optimized processes and cost efficiency. As drilling operations represent a considerable share of expenses, the focus lies in the improvement of well engineering performance. To manage these two challenges the implementation of an adequate management system is essential. Management systems provide a basis on what a company or a company division does, how it is organized, how it manages its business and who is responsible for what. It is a structured hierarchical framework of processes which enable the company to fulfil all tasks required to achieve its objectives. It includes standards, regulations and guidelines, as well as processes that have to be followed and key performance indicators used for measuring performance and results. These key performance indicators are stored and can be used for rolling analysis on how performance is developing.

An important part of each management system concerns audits. Audits are conducted in order to ensure the effectiveness of a company's management system. In light of tougher environmental regulations and increasing safety awareness, a comprehensive safety auditing process is essential to provide management compliance assurance. However, also regarding the costs, arising from the strive of complying to international standards and regulations, audits are an important tool. The costs of non-compliance do not stop at high fines and penalties. Lapses caused by non-compliant operations can also result in catastrophic losses from spill, releases or fire and can result in personnel injury or death. There is no doubt that the bottom line of a company can be impacted by a serious safety incident.

Therefore, an effective audit process should start at the local level with the operator in the field taking responsibility to know and understand the standards, policies and regulations that apply to his own processes and operations. Periodic facility compliance as well as operations compliance inspections should be conducted by independent, special trained employees. After documenting and reporting the compliance results actions for closing-out the non-compliance findings should be taken.

1.1 Research Question

Since 2008 OMV Exploration and Production (E&P) has been applying a rigorous audit initiative on its contracted drilling and workover rigs. While the audits are focused on safety and review three major components: equipment, crew competence and management system, the benefits of the initiative lie beyond pure safety. Adequate contractors will work safe but also more efficient, resulting in less non-productive time (NPT), lost time incidents (LTI) and ultimately in less costs for OMV. Additionally EPW-A is also auditing subsidiary offices on their compliance level with well engineering standards. A vast amount of data has been generated along the way.

The intention of this thesis is to analyse if the implemented audit initiative in OMV has an impact on safety, performance and costs. Therefore the following research question was defined:

"Is it possible to prove the effect of the audit initiative on HSSE, performance and costs with hard facts?"

1.2 Approach

The approach for answering this question will be the following. First, three different databases will be set up. One database will import all safety, performance and cost key performance indicators per well collected in drilling operations since 2010. The second database will include all non-compliance findings per rig which occurred during the rig and equipment audits conducted since 2010. Finally, the third database will contain all non-compliance findings per subsidiary occurred during operations audits conducted since 2010. After collecting all available data, the data will be analysed with the help of statistical methods like trend or correlation analysis and the results will be combined with some quality background information. The analysis will be split in two different parts. The first part will focus on the development of key performance indicators and compliance data for all wells. In this part the key performance indicators (KPIs) will be analysed for possible cross correlations. In the second part, each subsidiary will be analysed separately. There the development of compliance performance metrics will be interpreted and if an influence of the audit initiative on safety and performance can be derived will be discussed.

2 Basic Concepts and Systems

The following chapter shows the basic concept on integrated management systems. Additionally to that, information on drilling performance KPIs and Health, Safety, Security, Environment (HSSE) KPIs, which are an important element of each management system, is given. In the last chapter the basic concept of audit systems, those ensure compliance to and continuous improvement of management systems, is presented.

2.1 Integrated Management Systems

These days, companies are becoming more and more aware of quality, environment, process, risk and safety management. One point that many companies do not consider refers to matching the contents between the different management systems in a company. Therefore, trade-offs between the different systems and departments are the result. These trade-offs can be avoided by integration, the basic idea of integrated management systems. *The purpose of an integrated management system is to help provide a clear representation of all the features of your respective management system pieces, to show how they impact and complement one other, and to demonstrate how their relationship assists in managing the respective management systems risks of the organization.*[1] In other words, an integrated management system concentrates on interdependencies of management systems and on their optimization. For that purpose different international standards are used. These standards are providing a common basis for defining goals, deciding on KPIs, implementing processes and forcing continuous improvement.[2] [3] [4]

[1] Reference: Pardy (2010), p. xi

[2] Reference: Pfeifer (2001), p. 114-126

[3] Reference: Ranieri et al. (2013), p. 1-9

[4] Reference: Rezaei, Abbas (2013), p. 1-10

By implementing an integrated management system the list of benefits can be very long. Realized benefits can be:[5]

- Alignment of business and Health, Safety, Environment and Quality (HSEQ) goals and maximization of KPIs
- Creation of an integrated team approach focusing on mutual goals and benefits
- Establishment of common objectives, processes and procedures
- Creation of synergies, reducing redundancy and increasing effectiveness and efficiency
- Reduced risk through management based on factual data and overall analysis of performance metrics
- Increased understanding of all customers' and stakeholders' needs and wants
- Saving of time, money and effort
- Improved internal processes and communications

Before going into detail with integrated management systems, the question, what a management system is, should be answered. A management system describes the set of procedures an organization needs to follow in order to meet its objectives. In order to accomplish that, a management system provides a framework of policies, systems, processes and procedures to ensure that the organization can fulfil all business objectives. In general, the larger the organization, the more likely it is that there are written instructions how things are done. This makes sure that nothing is left out and additionally it clarifies who needs to do what, when and how. Depending on which management systems are used in a company, standards that might be included are:[6]

- ISO 9001 (Quality Management Systems)
- ISO 14001 (Environmental Management Systems)
- OHSAS 18001 (Occupational Health- and Safety Assessment)
- CSA Z1000 (OHS Management System/Canada)
- ANSI/AIHA Z10-2005 (OHS Management System/United States)
- ILO-OSH 2001 (OHS Management System/International)

Typically more than one system is implanted in an organization. It is not uncommon to have separate management systems controlling quality, occupational health and safety or for example environmental issues. The difficulty of managing several systems is that they can become dysfunctional if the systems do not consider or complement each other. Different standards to which they comply may result in administrative burdens, duplication of paperwork and confusion between demands of different standards.

[5] Reference: Pardy (2010), p. 3

[6] Reference: Pardy (2010), p. 2

Therefore the ISO Guide 72 provides a framework of common managements system requirements. The common characteristics of some of the well-known management systems models include:[7][8]

- Policies, and the objectives and targets associated with them
- Planning that reflects the strategic and management system objectives
- Organizational structure defining roles, responsibilities and authorities for personnel performing work that can impact upon the management system objectives
- Processes, procedures and resources to carry out organizational and management system activities
- Methods for measuring and evaluating performance
- Correction of problems and identification and implementation of opportunities for continuous improvement
- Management of review of system performance

Due to the different standards to comply with, the amount of additional problems can be reduced by making cross references among the individual parallel management systems in an organization. The following figure gives an example of cross references between different systems.

[7] Reference: Pardy (2010), p. 3

[8] Reference: Wilkinson, Dale (2001), p. 318-329

ISO Guide 72	ISO 9001	ISO 14001	OHSAS 18000
2.1 Identification of needs, requirements and analysis of critical issues	5.2 Customer focus 7.2.1 Determination of requirement related to the product	4.3.1 Environmental aspects 4.3.2 Legal and other requirements	4.3.1 Planning for hazard identification, risk assessment and risk control 4.3.2 Legal and other requirements
3.2 Management of human resources	6.2.1 General 6.2.2 Competence, awareness and training	4.4.2 Competence, training and awareness	4.4.2 Training, awareness and competence
5.2 Preventive action	8.5.3 Preventive action	4.5.3 Nonconformity, corrective action and preventive action	4.5.2 Accidents, incidents, nonconformity and corrective action

Figure 1: Cross references between ISO Guide 72, ISO 9001, ISO 14001 and OHSAS 18001[9]

Finding out similarities and increasing the compatibility of each standard is a common foundation towards an integrated management system. The next step is to get a common understanding of the processes of coordination and the tasks involved. This means that the integrated management system has to be based on the generic aspects of management: policy, planning, implementation, corrective action and management review. This refers to the so called Plan-Do-Check-Act Cycle (PDCA Cycle).

Because this thesis refers to the processes of well engineering (WE) and OMV implemented a well engineering management system, an example how a well integrity management system is designed in literature is given.

[9] Reference: Jørgensen et al. (2006), p. 716

In general the well integrity management system should provide directions regarding the manner in which wells are designed, constructed and abandoned. *The well integrity management system is defined as the continuous management, assessment and verification process used to ensure the integrity of wells is designed, achieved, monitored and maintained throughout the life cycle of the well.*[10] The purpose of the well integrity management system is to develop a clear statement of objectives with the main aspect that the risk to personnel, environment and assets due to failure are as low as reasonably practical (ALARP) throughout the well life-cycle. To ensure this, performance management and continuous improvement are important elements of the management system and are supported by the already mentioned PDCA cycle.[11]

The following nine key elements are essential activities to be controlled by the well integrity management system:[12]

- Activity Program & Procedures: practices and procedures to reduce the potential for failures.
- Critical and Simultaneous Activities: means to identify and control activities critical to integrity at all stages of the life-cycle.
- Risk Assessment Activities: to consider all the criticality of well assets in well integrity reviews at different life-cycle stages.
- Contingency Planning Activities: includes emergency recovery plans for recovery from high risk events.
- Management of Change Activities: the management system will implement management of change processes to evaluate and control risks from changes to well assets, design and operating conditions.
- Experience Transfer and Reporting: deals with information and knowledge management.
- People: ensures the involvement and commitment of the right people to perform their roles effectively.
- Quality Assurance & Quality Control: to provide a systematic approach to review documents.
- Integrity Implementation Stage: ensures that well integrity becomes part of the practices of the relevant engineering disciplines and business units.

These nine key elements represent the elements of the well engineering management system of OMV as shown in chapter 3.2.1 and 3.2.2.

[10] Reference: Daghmouni et al. (2010), p. 2

[11] Reference: Daghmouni et al. (2010), p. 2

[12] Reference: Daghmouni et al. (2010), p. 3

An important and essential part of the well integrity management system, as well as of the OMV well engineering system, refers to performance monitoring and improvement. Performance management is intended to achieve compliance with the existing standards and improvement of well integrity management. Therefore, the management system defines the steps necessary to achieve a basic level of performance. One step is the definition of appropriate KPIs for measuring well performance. KPIs related to well integrity are established at lower levels of the business as well as corporate-level KPIs may include elements relevant to well integrity. . The second step refers to integrity audits and reviews. These audits shall be conducted annually to provide the management with a clear statement of the compliance status.[13] [14]

Chapter 3.2.2 shows the design of the well integrity management system, as defined in literature, is reflected in the well engineering management system of OMV. The above mentioned nine key elements are elements of OMV well engineering management system and the idea of performance management is as well very similar to this theory model.

2.2 Key Performance Indicators

Nowadays KPIs are an essential tool to measure and control business activities. They build the core for a company's controlling concept and nearly each business unit measures and reports its own KPIs. In general, KPIs simplify the complex reality in quantitative values that inform about economical actual situations. In other words, KPIs focus on the aspects and/or areas of an organization's performance that are essential for the ongoing and future success. Further they measure a company's success in key areas and processes that affect customers, employees, shareholders and stakeholders.[15] [16]

[13] Reference: Daghmouni et al. (2010), p. 3-6

[14] Reference: Rahil (2007), p. 1-6

[15] Reference: Meyer (2008), p. 17-18

[16] Reference: Dujmovich (1998), p. 1-9

By using KPIs the following advantages and disadvantages have to be mentioned[17]:

Advantages:

- Continuous KPI reporting ensures early identification of weaknesses and deviations
- Simplifies controlling
- Defining critical measures as target values for individual business units
- Defining of objectives as quantitative values

Disadvantages:

- Operators may only use KPIs and interpret them in a way that is useful to support their objectives
- By designing a process on the basis of KPIs, long term profits may be neglected
- KPIs might represent only a one-way view, for example environmental issues or employee’s satisfaction are not considered

Regarding the title of this thesis the focus lies on two groups of KPIs that are very common in the oil and gas industry. The first group of KPIs covers drilling performance, the second one HSSE. Traditional economical KPIs, like the Return on Investment, Economic Value Added etc., are as well used in the oil and gas industry, but are disregarded in this thesis.[18]

Drilling Performance KPIs

The importance of improving the efficiency of drilling operations in the E&P industry cannot be overemphasized, since it directly impacts the overall well costs. With economic downturns, increased competition and variations in oil and gas prices the industry has become far more cost and efficiency sensitive. Literature research reveals that two KPIs are representative for measuring drilling performance, non-productive time (NPT) and feet per day (ft/d) or equivalent. The KPI ft/d is the metric for measuring drilling performance efficiency and may directly impact the rig level and consequently the budget approved by management for a well in the operating plan. Non-productive time refers to the time spent on unplanned or unscheduled events. After excluding waiting on weather, the NPT can be classified in several categories like NPT due to rig contractor or service company, NPT due to operator or external problems or NPT due to downhole problems. While the available academic literature on this topic is very rare it is noted that besides several other drilling performance

[17] Reference: Meyer (2008), p. 17-25

[18] Reference: Olds (2012), p. 1-7

KPIs used by oil and gas companies the previously mentioned two can be considered the most important.[19] [20] [21] [22]

HSSE KPIs

The situation is different for HSSE KPIs. As the whole oil and gas industry is focused on preventing major incident, a lot of effort has been made to define KPIs that aid in the prevention of such incidents. In researching related literature it becomes apparent that every organization has its own safety KPIs that are integrated with its HSSE business model with the objective of achieving world class performance. By measuring and reporting safety KPIs an organization can profit from the following:[23]

- **Preventing major incidents:** failures in process safety and asset integrity can result in serious harm to people, the environment, property, reputation and financial stability of an organization. Recording of major incidents and analysis of the root causes can provide lessons to prevent reoccurrence.
- **Improving reliability:** preventing major incidents goes hand in hand with making operations more reliable.
- **Avoiding complacency:** safety KPIs provide a constant reminder of asset integrity, the attention needed on process safety management systems and the warnings from near misses and less severe incidents.
- **Communication performance:** KPIs provide reassuring evidence of management focus and can therefore support safety culture and behaviours.

In general, safety KPIs can be divided in two categories, reactive or lagging indicators and active or leading indicators. Leading indicators monitor the achievement of plans and how well standards were complied with. They provide feedback to the organization and measure the reinforcement progress by rewarding the workforce, which can increase motivation to continuous improvement. Contrary, lagging indicators are triggered after an event including injuries and cases of ill health, losses to asset and/or the environment.[24] The objective of these indicators is to learn and to identify measures to prevent reoccurrence of similar events. [25] [26]

[19] Reference: www.rushmorereviews.com
[20] Reference: Saeverhagen et al (2013), p 1-6
[21] Reference: Weekse et al. (2013), p 1-6
[22] Reference: Paulsen et al. (2001), p. 1-5
[23] Reference: OGP (2011), p. 3
[24] Reference: McClaine et al. (2008), p. 1-8
[25] Reference: Smith (2002), p. 1-2
[26] Reference: Rozendal, Hale (2000), p. 1-2

Some examples for leading indicators are:[27]

- No. of HSSE visits completed by senior/top management and no. of observations closed
- No. of near miss incidents reported and no. of incidents closed
- Risk management – no. of risk reduction control measures implemented
- Actions from safety risk studies – no. of recommendations implemented raised in various technical studies
- No. of safety audits conducted
- Compliance status of recommendations
- Behavioural tools

Examples for lagging indicators are:[28]

- Number of fatalities
- Fatal accident rate
- Lost workday case
- Lost time injury frequency
- Severity rate
- Totals recordable injury frequency
- Work related motor vehicle accidents and frequency rate
- Prohibition notices/improvement notices by statutory authorities

Oil and gas companies strive to implement barriers to prevent major incidents. As shown in the swiss cheese model, hazards are contained by several of these protective barriers. These barriers, represented in the following figure by slices of cheese, are in general management systems, physical engineered containment or other protection to prevent incidents. In E&P industry the main focus lies on Loss of Primary Containment (LOPC) of hazardous material which is the main cause of major incidents. LOPC events occurred because of weaknesses, depicted as holes in the model, in several barriers. The challenge is to implement control systems which detect an LOPC event and mitigate its consequences.[29]

Because the topic of safety KPIs is of very high importance, the International Association of Oil & Gas Producers published a recommended practice on key performance indicators to ensure proper functioning of these barriers. The

[27] Reference: Al Abdul Salam, Adivi (2012), p. 4

[28] Reference: Al Abdul Salam, Adivi (2012), p. 4

[29] Reference: OGP (2011), p. 2-3

aforementioned leading indicators monitor the barrier strength to avoid hazards while lagging indicators measure the barrier defects[30].

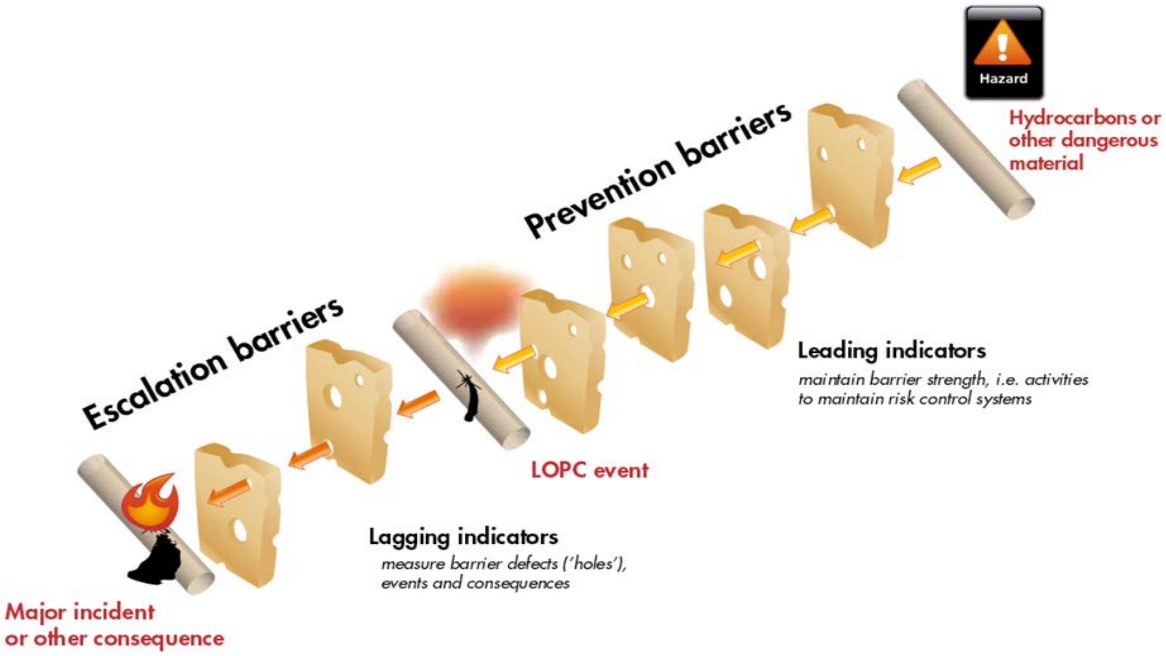


Figure 2: Swiss Cheese Model[31]

The swiss cheese model is also supported by Recommended Practice (RP) 754 published by the American Petroleum Institute (API). As the process safety indicator pyramid shows, major incidents are the result of a combination of failures of the barriers that are designed to control risks. Therefore it is a fatal mistake that many oil and gas companies are only measuring and reporting lagging KPIs as they are occurring rather infrequently. To get a set of significant statistically data it is recommended by API RP 754 to monitor leading KPIs as well.

[30] Reference: Cooke (2012), p. 1-8

[31] Reference: OGP (2011), p. 2

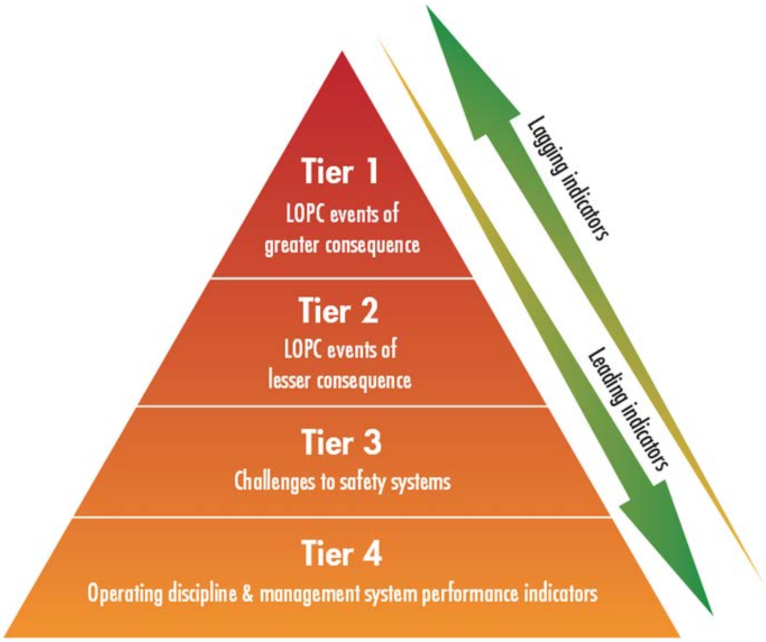


Figure 3: Process Safety Indicator Pyramid[32]

According to API RP 754, definitions and consequences for the indicator tiers are described as:

A Tier 1 process safety event is a loss of primary containment with the greatest consequence. It is an unplanned or uncontrolled release of any material, including non-toxic and non-flammable material from a process that results in one or more of the following consequences:[33]

- *An employee, contractor or subcontractor 'days away from work' injury and/or fatality*
- *A hospital admission and/or fatality of a third party*
- *An officially declared community evacuation or community shelter in place*
- *A fire or explosion resulting in greater than or equal to $ 25,000 of direct cost*
- *A pressure relief device discharge to atmosphere whether directly or via a downstream destructive device*

A Tier 2 process safety event is a LOPC with lesser consequence. It is an unplanned or uncontrolled release of any material, including non-toxic and non-flammable materials from a process that results in one or more of the consequences listed below:[34]

- *An employee, contractor or subcontractor recordable injury*

[32] Reference: American Petroleum Institute, Recommended Practice 754 (2010)

[33] Reference: American Petroleum Institute, Recommended Practice 754 (2010)

[34] Reference: American Petroleum Institute, Recommended Practice 754 (2010)

- *A fire or explosion resulting in greater than or equal to $2,500 of direct cost*
- *A pressure relief device discharge to atmosphere whether directly or via a downstream destructive device*

A Tier 3 indicator records an operational situation, typically considered a near miss, which has challenged the safety system by progressing through one or more barrier weaknesses to result in an event or condition with:[35]

- *Consequences that do not meet the criteria for a reportable Tier 1 or Tier 2 event*
- *No actual consequences, but the recognition that, in other circumstances further barriers could have been breached and a Tier 1 or Tier 2 event could have happened*

Because Tier 3 KPIs are primary intended for internal company use and these indicators are specific to particular facilities or company management systems, they are not generally suitable for benchmarking.[36]

A Tier 4 KPI represents performance of the individual risk control barriers, or its components, within a facility's management system, and operating discipline.[37] These KPIs reflect a company's activities associated with maintaining and improving its risk control barriers. They are intended for use by operators, first-line supervisors, engineers and managers at the facility of business level where awareness of specific hazards is critical.

2.3 Audit

After implementing any kind of management system, especially for implementing safety systems to a highly hazardous process, it is essential to get constructive feedback to ensure that continuous improvement of the management system do occur and that the desired results are achieved. One feasible feedback method is the use of KPIs as described in the previous chapter. A second valuable and much more detailed feedback is the periodic auditing.[38] In general, *auditing is a sampling technique where verification*

[35] Reference: OGP (2011), p. 18

[36] Reference: OGP (2011), p. 18

[37] Reference: OGP (2011), p. 19

[38] Reference: Ebel (2001), p. 152-164

is checked against prescribed and agreed policies, practices and standards.[39] The objectives of audits are therefore apparent:[40]

- Determine the extent of conformity with the management systems
- Evaluate the capability of management to ensure compliance with legal requirements
- Evaluate the effectiveness of the management system in meeting objectives
- Identify areas for potential improvement of the management system

Although audit initiatives often have to face resistance, especially by the auditee, the benefits for the auditing organization are obvious:[41] [42]

- Assurance that standards and procedures are applied and effective
- Provision of independent, objective, expert feedback
- Identification of previously unrecognized problems
- Enhanced safety awareness
- Shared safety management and operating experience
- Demonstration to third parties of effective safety management

Before discussing the different audit types and the way of how to conduct an audit, worldwide audit initiatives are dealing with the following challenges:

Comparability

A big challenge lies in the comparability of audits. Regardless of which auditor is conducting the audit, the result should be repeatable in the same subsidiary as well as any other subsidiary. To ensure repeatability of the audit same preconditions should be specified, independent of subsidiary or auditor. For sure this will never be possible because of two simple reasons. The first reason refers to the different individual backgrounds and experiences of auditors. Although the auditors are following strict checklists and standards an audit is in some respects always subjective. Therefore two different auditors will usually not come to the same results. Second, the status of the audited units will not always be the same, hence the type of audit necessary may vary for example when auditing a unit for a tender. Therefore it is important to classify the audits and to compare only audits of the same type.[43]

[39] Reference: Sexton, Visser (1991), p. 3

[40] Reference: Mahfouz, Rashwan (2007), p. 3

[41] Reference: Sexton, Visser (1991), p. 2

[42] Reference: Hubbard et al. (2010), p. 1-6

[43] Reference: Wirth et al. (2011), p. 3

Costs

When implementing audit initiatives in a company one of the main challenges lies in convincing the organization of the value of audits and to show that arising expenses will pay off. Cost arise from the required travel and auditor costs and even more from delays in the drilling or workover process due to the time required for the audits. However, comparing the audit costs with non-compliance costs it becomes clear that audit costs is money well spent. In the past, the cost to companies that incur serious incidents of non-compliance has risen dramatically. They result from fines and penalties, damage to company or third party property, downtime and lost production, clean up and restitution, personal injury or death and litigation. Additionally to that a company's market share can also suffer from the negative publicity often associated with a high profile incident.[44] [45]

Scheduling

Facility categories, audit frequency and schedule should be considered by a company when preparing an audit program. The audit frequency is dictated by a facility categorization in combination with any environmental difficulties which may be encountered. Keeping the costs in mind, it is important to have auditors on location timely. This can become a logistic problem because due to required flexibility in E&P business the definite audit start is sometimes only known a few days before.[46] [47]

Literature research shows that in general there are three different distinguished audit types.[48]

- **First Party Auditing:** the focus of this audit type could concentrate either on one employee auditing the other employees performing work and then providing feedback, on geographical regions or on single aspects of a management system.
- **Second Party Auditing:** the primary purpose is to determine whether appropriate management systems and controls are in place to effect compliance with corporate policies and standards, laws and regulations. The auditors are from outside the organization which should bring a higher degree of objectivity to the audit findings.
- **Third Party Auditing:** a third party audit is conducted when a company pays an outside firm who specializes in auditing facilities or when the outside

[44] Reference: Wirth et al. (2011), p. 3

[45] Reference: Brommelsiek, Tinsley (1996), p. 2

[46] Reference: Wirth et al. (2011), p. 4

[47] Reference: Haffner (1992), p. 2

[48] Reference: Rains (2009) p. 1

firm performs a system audit on the company's internal second party audit program. But it is also a third party audit when a community group orchestrates a review of a company facility of a governmental regulatory body conducts an on-site facility audit.

The benefits and weaknesses of the three audit types are summarized in the following table:

First Party Audit	**Second Party Audit**	**Third Party Audit**
+ Flexible scheduling + Direct leader involvement + Less formal + Immediate response	+ Common corporate culture + Results easily comparable + Develops internal auditors + Reasonable costs	+ Balance between standards and regulations + Totally objective and unbiased + Highest quality audit + Receiving organizations is highly motivated to respond and act
- Limited learnings - Biased reporting - Easily procrastinated	- Weaker on local requirements - Part time auditors; lower quality - Too internally focused	- Expensive - Detailed citations may miss big picture - Progress difficult to track

Table 1: Pros and Cons of First, Second, Third Party Audits[49]

The following nine keys are essential to perform safety audits that will make a dramatic and positive contribution to improved safety:[50]

1. **Understanding audit objectives:** by answering the question what should be achieved by the audit initiative, will assure that the audit aligns with the overall company strategy and business needs.
2. **Deciding what to audit:** the audit subject should be defined and it should be assured that the right things are audited.

[49] Reference: Rains (2009) p. 11

[50] Reference: Kolts, Petersen (2005), p. 2-9

3. **Steps to perform a successful audit:** audits should conform to professional standards and procedures. The steps an audit should follow are: planning, conducting, reporting, documentation and corrective actions.
4. **The power of audit performance measures:** an assessment of audit results can provide organizational performance measures that gauge the health or safety systems. KPIs let management know if things are getting better or worse and help management to identify and manage areas of potential risk.
5. **Auditor skills:** auditors require a special skill set and that includes knowledge, being objective, diplomatic professional and inquisitive, and being an effective communicator.
6. **Corrective action:** an audit could be the most thorough, professional audit ever done, but unless deficiencies are corrected it was no substance. This is where improvement takes place, change happens, root causes are removed and controls are put in-place to prevent recurrence.
7. **Audit ownership enhancing collaboration and positive audit outcomes:** it is essential that the auditee is involved in the process from the beginning. Only then the audit becomes a synergistic and collaborative effort without fear or retribution.
8. **Due care:** well managed companies are taking proactive steps to monitor and enhance safety. Therefore audit reports should accurately present the facts and audit findings. In no case they should overstate, understate or misstate the facts.
9. **Caution auditing traps:** things that should be avoided are the wrong depth of the audit, reactive rather than proactive audits or failing to look beyond compliance.

3 OMV

The following chapter gives in the first part some general information on OMVs business background. In the second part the organization of the Well Engineering department is presented in detail. This includes a description of the Well Engineering Management System (WEMS) and its elements and standards.

3.1 General

OMV was founded in Austria more than half a century ago and since then there have been continuous domestic E&P activities in Austria. The internationalization of OMV E&P began in 1970 with exploration in Africa and in 1985 the first production in an international venture, which was Libya, started. In 1999 the acquisition of the Australian E&P company Cultus Petroleum NL took place followed by the acquisition of Preussag Energie's international E&P portfolio in 2003. The greatest acquisition in the company's history happened in 2004 where OMV acquired 51% of the Romanian Petrom Group. The next milestone in OMVs history was in 2011 when OMV acquired Petronas' assets in Pakistan and Pioneer's assets in Tunisia. Moreover OMV's portfolio includes shares of Petrol Ofisi and Borealis.[51]

In 2012 OMV produced 111,1 million barrel of oil equivalent (mn boe), which is an average of 303 kboe/d and its proven reserves amounted to 1.117 mn boe. After the Arab Spring in 2011, OMV re-started operations in North Africa and Middle East and increased total production by approximately 5% vs. 2011 and approximately 70% of total production is aggregated to Austria and Romania.[52]

[51] Reference: Reference: OMV Exploration & Production Overview (2013)

[52] Reference: OMV Exploration & Production Overview (2013), p. 2

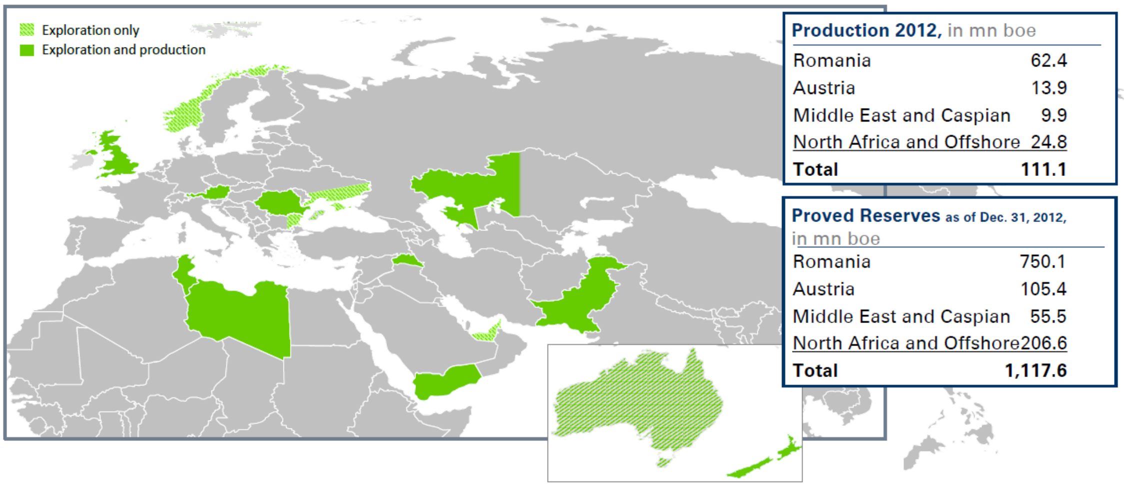


Figure 4: OMV E&P footprint[53]

OMV's strategy is defined by the objective to be a focused, integrated oil and gas company with improved overall profitability and strong growth in upstream. To reach this, OMV shifts capital from the division Refining & Marketing (R&M) to E&P as well as Gas & Power (G&P). That means that more than two thirds of the investment funds of the group will be invested in E&P. The framework of the E&P strategy includes the following three goals:[54]

- **"Exploit the core":** the first goal is to raise short-term performance until 2014 by stabilizing production in the core Romania and Austria.
- **"Grow to and beyond critical mass":** the second goal concerns the current portfolio by reaching a production grow by 2% per anno organically and up to 4% per anno via acquisitions. This will bring up the Reserves Replacement Rate to 100% by 2016.
- **"Find new growth areas":** the third goal is positioned for a long-term growth until 2021 by increasing exploration effort.

To achieve the three goals of strategy 2021 but also to increase focus in the complex E&P business five E&P targets have been set up in a simple scorecard and are monitored permanently:[55]

- **HSSE:** KPIs are developed with focus on process safety and improving contract management. HSSE is the first priority in E&P.

[53] Reference: OMV Exploration & Production Overview (2013), p. 2

[54] Reference: OMV Exploration & Production Management System (2011), p. 7-8

[55] Reference: OMV Exploration & Production Management System (2011), p. 9

- **Production:** the second priority in E&P is to increase the daily production rate in that year and to reach or exceed the production target.
- **Costs:** Capital expenditure, production cost and EBIT (Earnings before Interest and Tax) are measured and should be optimized. This is the third priority target in E&P.
- **Growth:** development, exploration and acquisition are three different areas defined for growth.
- **People:** growing local talent, enhancing the graduate academy program, building up competencies and strategic workforce planning provide the basis for future success.

From these overall E&P targets, the drilling KPIs have been derived.

Figure 5 shows that, OMV E&P is organized in a matrix structure consisting of regional and country based operating entities executing the business and functional departments supporting the business. The E&P board member is reporting directly to the OMV Chief Executive Officer and is member of the OMV Executive Board. The role of operating entities is to execute the business and deliver its objectives. While the role of the other departments is to provide functional leadership and expertise to the operating entities in order to achieve technical excellence and build competitive advantage. Additionally the functional departments also assure that the business is being conducted in accordance with the appropriate standards and procedures.[56]

[56] Reference: OMV Exploration & Production Management System (2011), p. 11

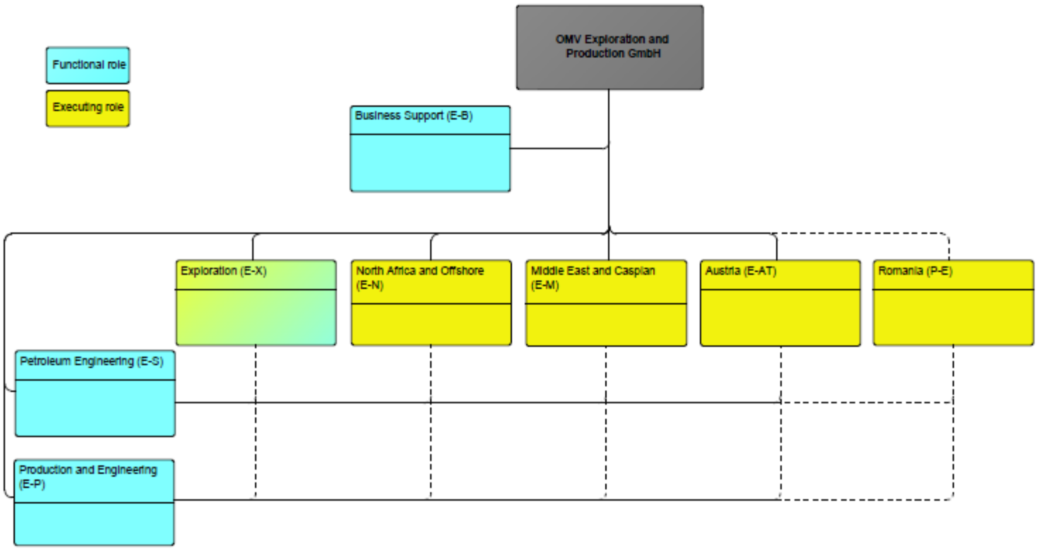


Figure 5: OMV E&P Organisation[57]

3.2 Well Engineering

The following chapter describes the scope of work of the Well Engineering Department and in detail the work of Well Engineering Operational Assurance. Additionally all standards that are used by the Well Engineering Department are described in detail, since all operations are based on them.

3.2.1 E&P Management System

OMVs E&P Management System (E&P MS) provides the framework for how OMV Group manages all aspects of its operations to ensure the safety and protection of people and the environment as well as of its assets and reputation and to ensure compliance with the Code of Conduct and the Sustainability HSSE Policy.[58]

In common with other companies' MS, the OMV E&P MS documentation is organized in a hierarchical manner in the form of a pyramid used to ensure that OMV E&P can fulfil all tasks required to achieve its objectives at all levels in the business.

[57] Reference: OMV Exploration & Production Management System (2011), p. 11

[58] Reference: OMV Health, Safety, Security, Environment Management System (2011), p. 3

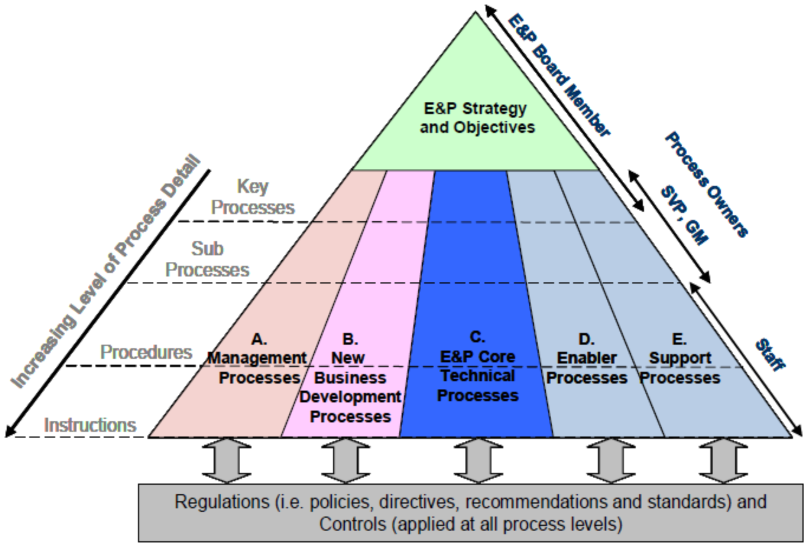


Figure 6: Structure of OMV Management System[59]

Inside this pyramid the WEMS is located in section C, "E&P Core Technical Processes". Inside the section C, Figure 7 shows that the WEMS covered with the red box, belongs to the process Development.

[59] Reference: OMV E&P Management System (2011), p. 2

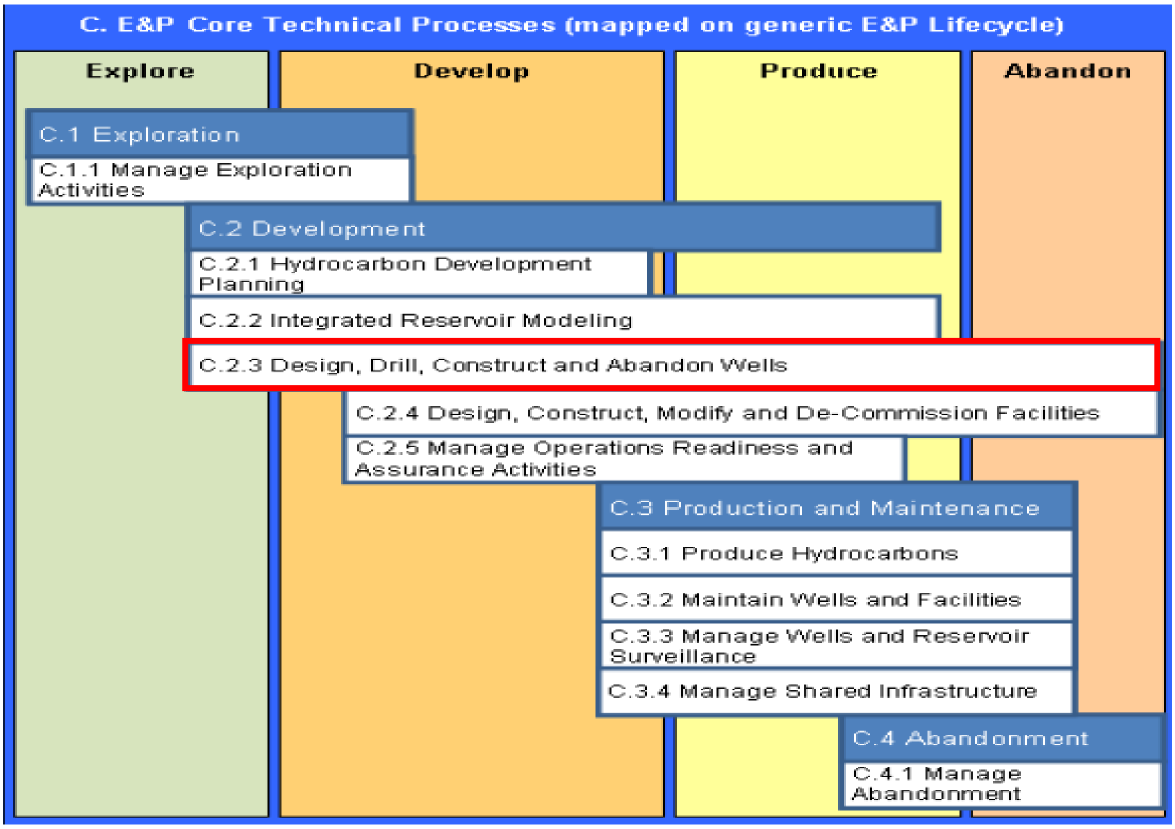


Figure 7: E&P Core Technical Processes[60]

The process C.2.3 "Design, Drill, Construct and Abandon Wells" is defined as a key process and includes all activities required to construct a new well and either complete or abandon it. The process applies to appraisal, development and exploration wells and a key goal is to ensure effective and auditable planning, execution and close-out of well operations with the over-riding objective of ensuring process safety. The process owner is the Senior Vice President of Production and Engineering. A detailed explanation of the individual process steps as well as the process objectives and process documentation is found in the WEMS Manual that contains among other references the Well Engineering Process (WEP) Reference Manual and the Well Engineering Technical Policy (WETP).[61]

3.2.2 Well Engineering Management System

The WEMS Manual shows how the Well Engineering Group within a subsidiary can meet the requirements of the E&P business principles and provides a guide on how

[60] Reference: OMV E&P Management System (2011), p. 4

[61] Reference: OMV E&P Management System (2011), p. 58

subsidiaries should carry out their activities. To assure that all activities of a subsidiary are carried out in accordance with the requirements in the WEMS, the subsidiary shall assess their activities in a Bridging Document. This Bridging Document demonstrates how the requirements and the philosophy of the WEMS are applied in the subsidiary.As Figure 8 shows the WEMS contains a set of standards and guidelines including the WEP and WETP. The compliance of a subsidiary to the WE standards is mandatory while the WE guidelines provide a further guidance on WE activities.

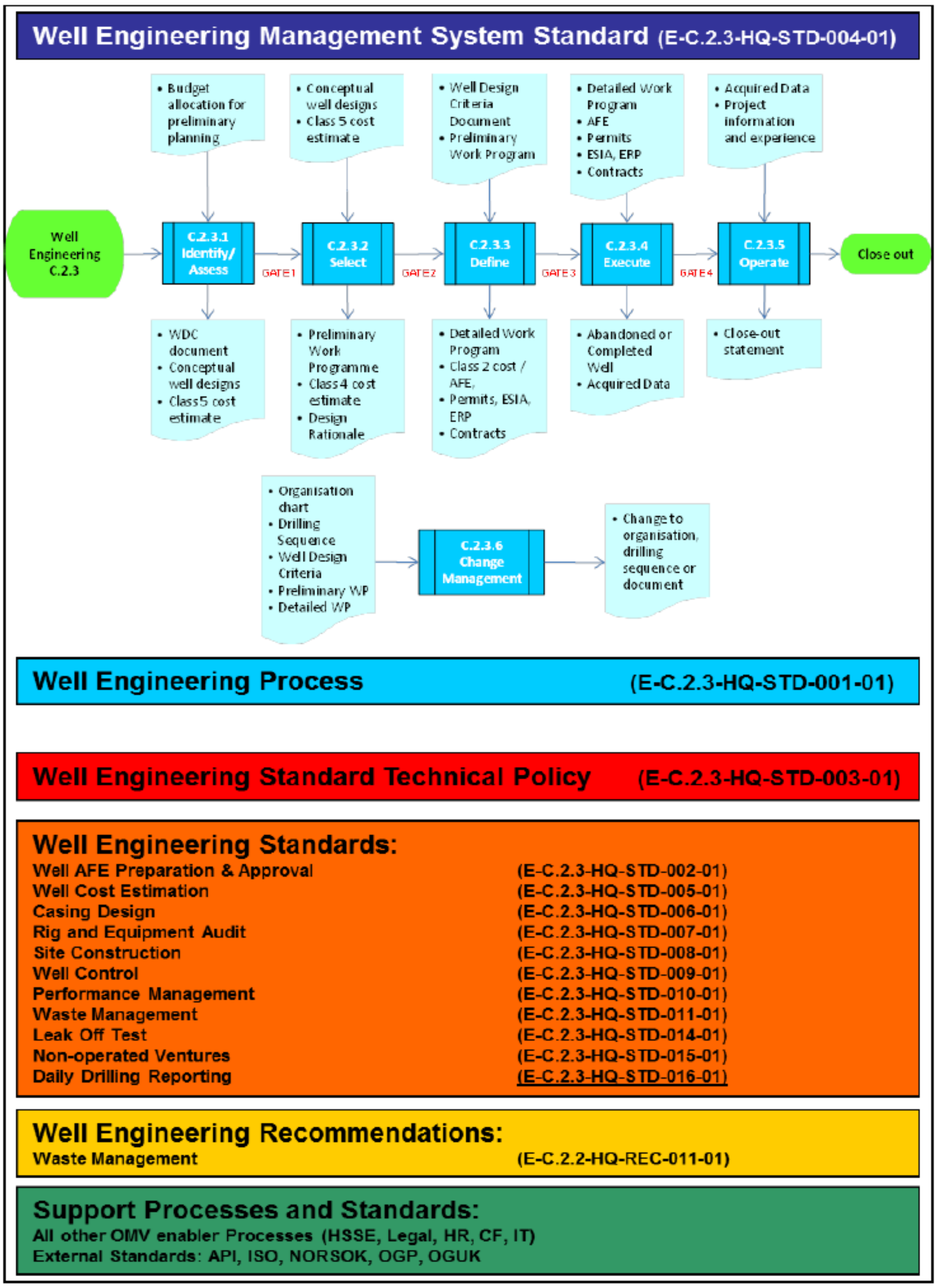


Figure 8: E&P Well Engineering Management System Manual[62]

[62] Reference: OMV Well Engineering Management System Manual (2013), p. 8

The WEMS covers the following elements to be compliant with the E&P MS:

Well Engineering Objectives

The principal aim of WE in a subsidiary is to provide support in all aspects of WE and Drilling Operations so that Asset Owners may maximize return and minimize total costs over the life cycle of the company assets whilst meeting the agreed safety and environmental performance.

Each subsidiary derives the planning of its assets from the E&P strategy, the E&P work program and the general budget planning. The subsidiaries business plan provides input to the Corporate Mid-Term Plan and contains the planning for the next four years. The venture General Manager annually sets targets, which provide the basis for the subsidiary's balanced scorecard.[63]

Well Engineering Organization

The organisations aim is to provide support execution of the WE activities, its structure as well as the staffs roles and responsibilities. Individual financial authorities of all relevant WE personnel should be specified. Another area of responsibility covers the technical authorities that are defined in the WETP where all technical boundaries within the subsidiary are specified. For each venture compliance with the WETP is mandatory, therefore a detailed description of the WETP will be given in chapter 3.1.4. The WE Organisation also ensures that sufficient fully trained and competent personnel are available but also that staff performance is assessed by the WE manager periodically. It is also ensured, that all WE positions have next to their discipline specific competence profile HSEQ competences and non-technical skills. Another point that is regulated in the WE Organisation, refers to the competence of contractor personnel. Service Companies shall demonstrate the competence of their personnel and the competence of the personnel from their subcontractors.[64]

Well Engineering Process

The WEP describes the activities necessary to sustain process performance, the assessment of risks and the application of process controls to guide process execution to the desired schedule, technical and cost objectives. Because operational audits evaluate

[63] Reference: OMV Well Engineering Management System, p. 10

[64] Reference: OMV Well Engineering Management System, p. 11-13

the subsidiary's compliance to the WEP, the following chapter will give a detailed presentation of the WEP steps.[65]

Health, Safety and Environment Planning & Control

This section describes the implementation of the E&P HSEQ policy, HSEQ management system and standards within the WEP. As a general principle local and national laws, regulations and OMV standards shall be complied with and it is the responsibility of each subsidiary to assure compliance. The HSEQ policy requires that all WE activities are carried out in a manner that minimizes risks to the health and safety of its work force, contractors and the public. To ensure this

- Technical Safety
- Deviation Standard
- Technical Integrity Standard
- Environmental Management System and Drilling Waste Management
- Occupational Health and Workplace Safety Management
- Incident and Accident Investigation, Recording & Reporting
- Crisis Management/Emergency Response
- Competence related to Safety and Environmental awareness
- Travel, Transportation and Security
- Management of Contractors
- HSSE Management Review

are precisely defined in the WEMS.[66]

Performance Management

The WE Performance Management Standard specifies how performance is defined, measured and reviewed. Because all relevant KPIs that are used for the analysis of the audit initiative are defined in the Performance Management System a detailed description is given in chapter 3.1.5.[67]

[65] Reference: OMV Well Engineering Management System, p. 14-21

[66] Reference: OMV Well Engineering Management System, p. 29-34

[67] Reference: OMV Well Engineering Management System, p. 34-36

Business Improvement

This section outlines how improvement opportunities and business improvement tools are used to direct improvement efforts. The business improvement plan is produced annually and contains upon other terms the WE targets and results, processes and technologies and ways of working. Business Improvement also refers to lateral learning, the process of capturing knowledge in one area and shift it to another area.[68]

Data and Records Management

Information and Knowledge Management describes how information systems support is enabled, detailing responsibilities, locations for records management and provisions for document control. This area will be subject to further revision once a new daily drilling reporting system has been implemented.[69]

Audit

The last point covered by the WEMS belongs to audits. Chapter 3.1.6 shows how audits are conducted and what typed of audits are operated.

3.2.3 Well Engineering Process

Into the E&P MS the WEP has been developed as a core process and it provides the framework and outline of the process. Under the control of the WEMS the process is applicable for all planned and executed well operations within a subsidiary and compliance with the process specifications shall be demonstrated. To ensure a high level of process compliance operational audits for evaluation are conducted periodically. The WEP is based on a Plan-Do-Check-Act cycle and therefore provides the basis for a continuous improvement philosophy. To avoid misinterpretation and misunderstanding all functions and responsibilities, documents and activities within each process step are defined in an exact way.[70]

Figure 9 shows all steps that are defined in the WEP for well design and planning. It includes all activities required to construct a new well and either complete or abandon

[68] Reference: OMV Well Engineering Management System, p. 36-38
[69] Reference: OMV Well Engineering Management System, p. 38-40
[70] Reference: OMW Well Engineering Process, p. 4

it. The main purposes of the process are to ensure safe and cost-efficient operations through application of process and best practices.

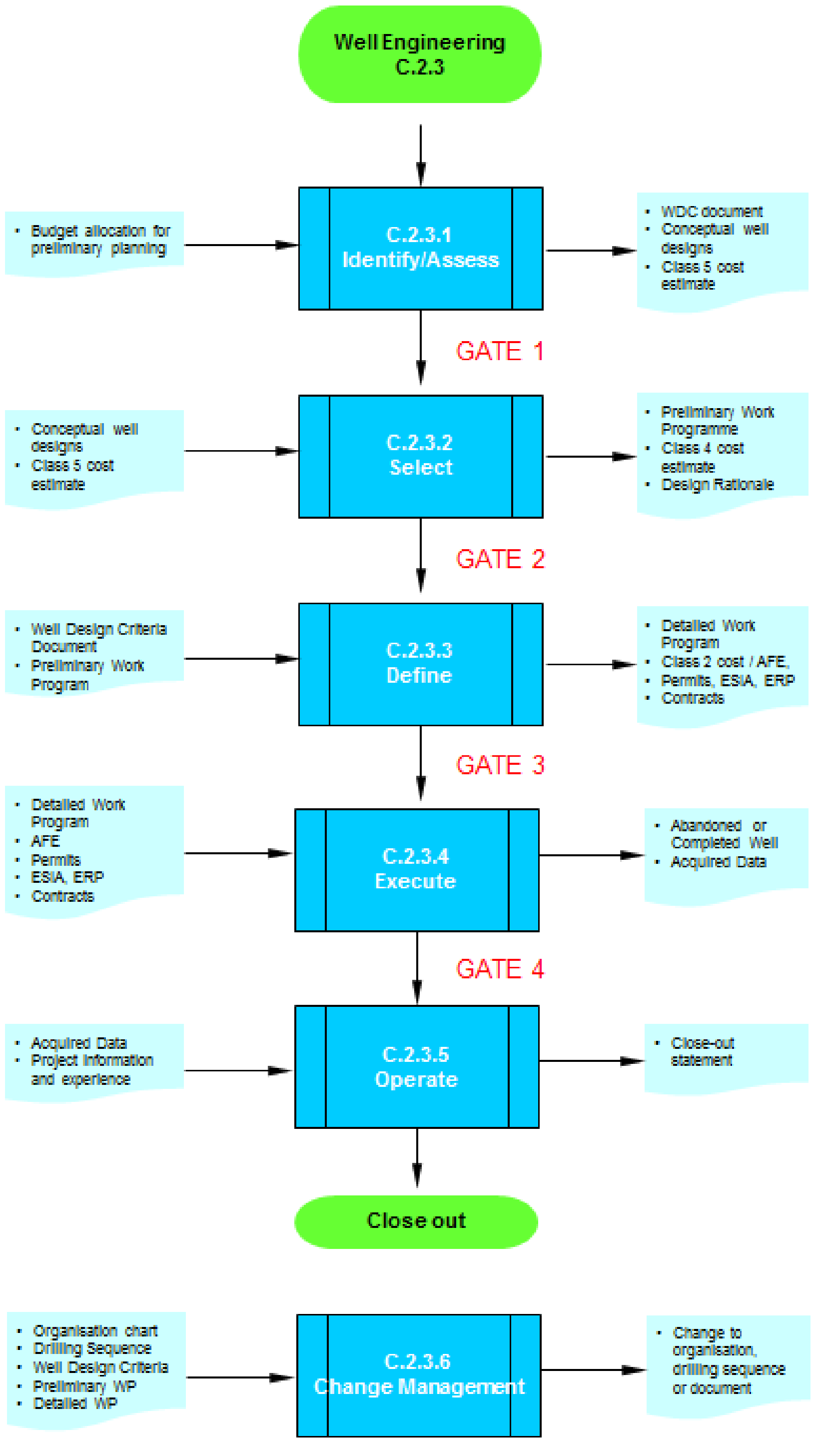


Figure 9: Well Engineering Process[71]

[71] OMV Well Engineering Process, p. 5

C.2.3.1: Identify/Assess

The trigger process released by the Exploration Manager (EM), the Asset Manager (AM) and the Project Manager (ProjM) is the first step of the WEP. In this step budget allocation is provided and commencement of work on the well project is authorized by the responsible manager. Furthermore a project definition document is approved and during the kick-off meeting all well objectives are finalized. The key deliverable from this step is the Well Design Criteria (WDC) Document which includes the required subsurface data. After passing the Gate 1 review, where next to the WDC Document the Conceptual well designs and Class 5 cost estimate are proven and frozen, this process step is completed.

C.2.3.2: Select

The responsible function in this stage is Well Engineering which carries out an offset well review and examines the range of design options for the well. The key deliverable from this phase is the Preliminary Work Program (PWP) which contains a preliminary design that meets the well objectives and compiles with the OMV technical policies and standards. Gate 2 is reached by proving and freezing the PWP as well as Class 4 cost estimate and the Design Rationale.

C.2.3.3: Define

In step three, Well Engineering develops the Detailed Work Program (DWP) together with contingency scenarios and risk ranking. Afterwards it is peer reviewed and subjected to independent well examination. Additionally the project is approved according to E&P Financial guidelines and Authorization for Expenditure (AFE) for Long Lead Items (LLI) is approved. Next to the WE activities, four other critical planning tasks which are essential for the further process are carried out by other departments. HSSE prepares the Environmental and Safety Impact Assessment (ESIA) and reviews and aligns emergency response plans with project specific requirements. Furthermore Procurement executes the tender process. The fourth task is the audit of shortlisted rigs in compliance with the OMV Drilling, Workover and Well Service Unit Audit Standards. For passing Gate 3 the DWP has to be submitted.

C.2.3.4: Execute

In this step WE is responsible for a safe and efficient execution of the DWP. This means that the location is designed and constructed, the rig is mobilized to construction, rigged up and an acceptance audit is carried out by WE and HSSE. A pre-spud meeting together with all contractors is arranged and well operations are carried out in compliance to the DWP. In case of a dry hole project, the well is abandoned after reaching the measured depth (MD). If it is a discovery project, the well is evaluated and either abandoned or suspended for future completion or production. If unforeseen events occur or necessary changes have to be made, the sub-process Change Management has to be triggered. The key deliverables to pass Gate 4 are the abandoned or complete well with a documentation of the acquired data as well as to reach the well objectives without accidents and incidents of harm to the environment.

C.2.3.5: Operate

The objective of the last process step is to ensure that all relevant data and knowledge gained during the project is captured and archived. For that a Lessons Learned (LL) workshop is conducted and operational performance is evaluated in accordance to the OMV Performance Management Standard. Key deliverables from this stage are Post Well Review Reports and consolidation of LL and Closed-out Well Costs.

C.2.3.6: Management of Change

The Management of Change sub-process ensures that any changes to the approved project scope are planned, documented and auditable. This process refers to major changes with a more than 10% AFE deviation and which are affecting well objectives. In this case a draft program that is then peer reviewed is prepared followed by a revised and approved DWP and AFE. The key deliverables from this process are an Approved Change Management Documentation, Approved Amendments to the DWP and a revised AFE.

3.2.4 Well Engineering Technical Policy

The WETP is a standard designed with the objective to set a common level of technical risk for major accidental events across the organization with respect to well engineering, drilling operations, completions, well testing and workovers. Regulations for well intervention operations involving wireline, slickline, coiled tubing or snubbing units are also involved. This policy applies to all OMV exploration and production activities where OMV E&P has an asset equity share 50% or greater, or where OMV is the designated operator acting on behalf of a consortium. Furthermore the compliance with this policy is mandatory but there is the option to permit a deviation to the WETP.[72]

Deviations are specified in the “Deviation from the Requirements of Technical Standards” and the idea of this standard is to stem from regulatory operational or even environmental constraints. However, it has to be clear that this standard shall not be considered a way of avoiding the compliance with the requirements of technical standards. Following the deviation process is obligatory to manage variations in operational risk resulting from deviations from technical or other standards so that:[73]

- Risk to people, assets and the environment are controlled when there is the potential for having to operate below defined standard practices.
- Risks that are either intentionally or unintentionally created by deviating from accepted standards are adequately managed by following the steps defined in the Guidelines for Risk Assessment Criteria.

Deviations shall be written in such a way that they apply to the specific activity requiring the deviation from a standard requirement. Additionally their use must be limited to the operational unit and the validity kept to the minimum period needed to achieve compliance with the relevant standard. No requests will be approved that will lead to non-compliance with applicable laws and regulations.[74]

The WETP defines the minimum requirements for well engineering operations carried out in the ventures and these requirements are summarized in three chapters. The first refers to “Well Design and Project Planning” where guidelines for all associated activities and applications are specified. These guidelines cover a detailed description of the software to be used, the handling with pore pressure, casing seat selection and design criteria, zonal isolation, drilling fluids, directional drilling and surveying as well as project mapping and well location control, abandonment and a blowout contingency plan. The section “Equipment” contains all regulations necessary to assure that no major accidental events occur because of defective equipment. This includes standards for rig and equipment selection and audit, equipment certification, well control equipment safety-critical rig equipment, integrity of procured equipment and services, safety systems, instrumentation and recording systems, temporary pipework, safety-critical software and systems requirements. The third chapter deals with “Operations

[72] Reference: OMV Technical Policy, p. 4

[73] Reference: OMV Deviation from the Requirements of Technical Standards, p. 4

[74] Reference: OMV Deviation from the Requirements of Technical Standards, p. 4

Integrity" and assures that all well operations meet the requirements. Operations, that are defined, in that chapter belong to location hazards, shallow gas, offshore drilling units, rig moving and positioning, well control, barrier philosophy, coring operations, casing operations, on-site verification of operations, pressure testing as well as well testing and simultaneous operations offshore. The compliance with the WETP is evaluated during the operational audits as described in the chapter concerning operations audits.[75]

3.2.5 Performance Management Standard

Next to the WEP, WETP and WEMS the "Performance Management Standard" is the important document needed to understand on one hand how the audit initiative is connected to the WEP, WETP and WEMS and on the other hand how the WEP, WETP and WEMS interact with each other. The objective of this standard is to set out the minimum requirements for the well engineering performance management process used across OMV. This process permits a consistent performance comparison between subsidiaries and allows also external benchmarking.

The process cycle covers a full well life cycle and runs through the following steps:[76]

1. **Set the Baseline:** first of all a performance baseline for cost and time estimates is established
2. **Drill the Well:** after the baseline is fixed the well is drilled in accordance of with local regulations and OMV policies. During the drilling operation operational and performance data is captured and entered in IDS, the system described in chapter 4.1. As well as drilling data also lessons learned from executing the plan are captured and documented by the wellside team.
3. **Identify the Gaps:** after finishing the drilling operation a performance analysis is conducted with the purpose to identify the gaps between planned and actual data. This step ends with deriving drilling performance and HSSE KPIs.
4. **Implement the Improvement Plan:** to ensure an improvement of drilling performance and HSSE KPI each subsidiary establishes and implement an improvement plan. Additionally they should observe trends in terms of improvement or regression and ensure that all systems are updated with the latest performance.

[75] Reference: OMV Technical Policy, p. 4

[76] Reference: OMV Performance Management Standard, p. 5-6

5. **Communicate Performance:** performance indicators should be communicated to the employees to increase the general awareness concerning KPIs.

The standard defines a minimum set of KPIs for use across the organization, but for sure each subsidiary can define additional indicators. This KPI set is defined in the following sections:[77]

1. **HSEQ Measures include:**
    a. Lost Time Incident Frequency (LTIF) per million man-hours worked
    b. Total Recordable Incident Frequency (TRIF) per million man-hours worked
    c. Average number of STOP cards per rig per day in the subsidiary
2. **Complete Well Performance Measures:**
    a. Days per 1000 meters: the number of days from commencement of rig move to release from the well per 1000 meters of usable hole drilled.
    b. Cost per meter: the total cost of costs written to the well AFE per meter of usable hole drilled.
    c. %NPT: amount of Non Productive Time (NPT) as a percentage of the time from commencement of rig move from the well.
    d. Actual cost of the well as % of the original pro-drill approved AFE excluding any supplementary approvals.
3. **Dry Hole Performance:**
    a. Days per 1000 meters
    b. Cost per meter
    c. %NPT
4. **Functional Excellence:**
    a. % compliance with Well Engineering Process: the number of relevant steps completed in the well construction process
    b. Conformance to Policy: a self-assessment grade between 1 (least) and 5 (most complete)

[77] Reference: OMV Performance Management Standard, p. 9-10

c. % Gap to best in class, where % gap to best in class is defined as:

$$Gap = \frac{Actual\ Days\ per\ 1000m - BIC\ Days\ per\ 1000m}{Actual\ Days\ per\ 1000m} \times 100$$

The level of conformity of a subsidiary to WEP, WETP and WEMS is evaluated with a predefined mark between 1 and 5:

- **Level 1 – wholly unacceptable:** this means that there is no evidence of any documentation and team members are unaware of the existence or content of standards and policies.
- **Level 2 – immediate improvement required:** means that rudimentary documentation exists and a few team members are aware of the existence and content of standards and policies, but there is no systematic review of operations against policies.
- **Level 3 – marginally acceptable:** at this level some evidence of documentation and notes to the means of compliance exists. Nevertheless there is no evidence of a periodic review.
- **Level 4 – satisfactory:** evidence exists of a systematic documentation and gap analysis of the activity against the requirements of policy. All team members are aware of the policies and standards and they also understand them.
- **Level 5 – excellent:** all requirements to achieve compliance are fully documented and all team members are fully familiar with the requirements of the policies and they also know in detail how the requirements impact their work and their responsibilities for compliance.

3.2.6 OMVs Audit Initiative

The general objective of the audit procedure is to identify and reduce potential risks of operated or contracted units. This means to precipitate a major accident through defective equipment, incompetent personnel or flawed management systems. In this context reducing the risk refers to a reduction to a risk level that is as low as reasonably practical (ALARP).

In general it can be distinguished between technical audits and operational audits. Technical audits are conducted separately for each drilling or workover rig used in the subsidiaries while operations audits evaluate a subsidiary's compliance level with the WEP, WETP and WEMS. In the following paragraphs a brief description on how technical and operations audits are conducted is given.

Rig and Equipment Audit

Rig and equipment audits are as spot-checks of the rig equipment. During these inspections, the focus lies especially on risk critical equipment. In general every rig is inspected once a year at which OMV is supported by ModuSpec, a company that has great experience in auditing rigs.

During a technical audit the auditor checks the rig's compliance in regard to equipment, crew competence and management systems with applicable standards. The auditor evaluates in the first step if the condition of the rig equipment, like for example lifting equipment, well control equipment, drilling equipment and so on, fulfil all required OMV standards, API standards as well as other industry standards. After checking the equipment the auditor writes a report where all findings, either they are critical, major or minor, are documented. Critical findings are systems or processes that do not comply with OMV policy and standards and are in a condition which presents a risk of major accident. Such findings are show stoppers and lead immediately to a close of operations. However major or minor findings concern systems that generally comply with OMV standards and policy and they present no risk of major accident at the moment.

After checking the equipment, the second part of the technical audit is characterized by an evaluation of the crew competence. During this process the auditor checks the validity of all the personnel's certificates. A missing or expired certificate, that is asked for in his or her job description, of staff members is evaluated as a critical finding and the only possibility to keep operations running is to seek for a deviation. Next to certificates the auditor also verifies if the crew is proper trained by checking the trainings matrix. This audit step is completed by summarizing all findings in a report.

The third cluster the auditor monitors, concerns the compliance with management systems. In this part for example it is checked if and how the contractor is aware of equipment maintenance. So, if the equipment is maintained according to OMV standards and if a preventive maintenance system is used.

In general several types of technical audits could be distinguished. During the period a tender for a new operation is executed, the pre-hire audit assesses how high is the contractors compliance level to OMV standards. The compliance is documented in the pre-hire report. During the acceptance audit it is reviewed if the findings of the pre-hire audit are solved in an adequate way. Once again this is documented in an acceptance report which is the basis for the following decision if operations start or not. After operations kick-off, yearly regular audits, with proper reports, are conducted. Follow-up audits are the last type of rig audits, they are conducted whenever more clarity on unit is needed.

The following two examples show how the three clusters, equipment, crew competence, management systems, interact with each other:

- **Critical finding EX equipment:**
    - Equipment: does the equipment fulfil all specifications?
    - Crew competence: is the electrician proper trained and does he know how EX equipment is specified and how it is monitored?
    - Management system: are all specifications documented, is there an appropriate maintenance system, is it obeyed?
- **Change of Maximum Allowable Static Hook Load of rig:**
    - Equipment: contact Original Equipment Manufacturer if the change is possible
    - Crew competence: are the people aware of the change and the potential risk?
    - Management system: is the change process guided by a Management of Change Standard?

Operations Audit

In operations audits the auditor evaluates compliance of a subsidiary with WEP, WETP and WEMS on the basis of predefined marks described in chapter 3.1.5, these audits shall be carried out prior to commencement of a new operation or project and shall be repeated at regular intervals thereafter. The scope of these audits is to verify compliance of the subsidiary with the requirements of all aspects of the WEMS. Therefore the auditor visits the subsidiary and reviews if all process steps of an on-going drilling or workover operation strictly adhere to the WEP standard. This means he checks if all documents are available, set up and approved in a proper way. In the next step the auditor checks the subsidiaries compliance with WETP followed by an evaluation of the WEMS compliance. All deviations from approved standards are assessed and recorded in an audit report. The WE manager reviews afterwards the findings listed in the audit report and agrees an action plan to resolve any findings identified. The first priority is rectification of non-compliance, alternatively the WE manager may seek a deviation for an alternative solution to reduce the risk. Under no circumstances shall the WE manager commence or continue operations as long as a critical finding remains or no deviation is granted as such a finding poses a risk of major accident, losing the license to operate or damage the reputation of the company.

4 Data Sources and Databases

This chapter shows the different data sources that were used to gain the data for the databases. The three databases summarize all relevant data and information and are the basis for the analysis. A detailed description of the databases is given as well.

4.1 Data Sources

Two points attracted attention concerning data quality. The first one concerns data discrepancies, because in some cases one data source has a different value for the same KPI than another source. The second one was that for some wells no data was available. After aligning the data the three databases have been set up.

Drilling KPIs Standard Form

The Drilling KPIs Standard Form is an OMV internal template that is defined in compliance with the WEMS and it is based on Rushmore Review definitions. This template summarizes all the KPIs which are defined in the Performance Management Standard for each well. The drilling managers are responsible for filling out the template and therefore are responsible for the data quality. Because the Drilling KPIs Standard Form was set up by EPW-A and is quality checked by them it was the main data source for the three databases. Rushmore Reviews and Independent Data Services were only used in a few cases where additional well data like the TD, AFE, actual costs and so on were missing.

Rushmore Reviews

The Rushmore Reviews serves the oil and gas industry since the early 1990s with well data from different operators that is set up on a standard set of metrics and definitions. From the beginning the Reviews have been growing to encompass drilling, completions, interventions and abandonment data from 100 countries contributed by hundreds of operating companies from conventional hydrocarbon, shale and coal seam gas wells. To ensure the data was sufficiently reliable a layer of quality was added. The Rushmore Reviews are now the only source of global offset well data provided directly by the operator and then independently quality controlled. So, operators use this data for better planning and budgeting their well operations as well as it provides a driver for, and a measure of, performance improvement.[78]

OMV joined Rushmore in the year 2000 by providing drilling data and using the Rushmore Drilling Performance Reports (DPR). The standard DPR dataset comprises around 120 fields covering the wells identity and location, drilling contractor, rig name, well characteristics, casings, muds, logging, timings, NPT and costs. Also time vs. depth charts and well path diagrams for complex geometry wells are shared by the operators.[79]

Independent Data Services

Independent Data Services (IDS) is a web based platform providing customised web-delivered software solutions for analysing and reporting on operational performance by measuring efficiencies related to human capital and equipment. The platform focuses on drilling contractors, service companies and operators and ensures that all applications are scaleable and completely tailored to meet the unique requirements of the client's operating environment. ISD offers solutions for operational planning, monitoring, regulatory reporting, drilling, completions, workovers, fracturing, geology, lessons learned, cost tracking and asset management.[80]

OMV uses the DrillNet Solution of IDS, a centralised database for the management of all drilling data. DrillNet supports the instantaneous generations of Daily Drilling Report, Final Well Report, KPIs and Visualisations. Because of its web based character the Drilling Manager can enter the drilling data and get access to valuable information anytime and anywhere.

4.2 Key Performance Indicator Database

The KPI Database was set up as an MS Excel file and it provides the source for all following data and trend analysis. The idea behind preparing the database is to display

[78] Reference: www.rushmorereviews.com

[79] Reference: www.rushmorereview.com

[80] Reference: www.idsdatanet.com

all relevant KPIs, which are stored in different systems and files, on one common platform. The input data in the database is a snapshot of the data valid and available from January 2010 until September 2013. Data before 2010 was not considered because there was no quality check on data before the audit initiative started. Therefore the data was not included in the analysis although it would be interesting to see on one hand the KPI development before the audit initiative started and on the other hand the influence of the initiative on the KPI trend.

The database includes all relevant HSSE, performance and cost KPIs as well as information about the contractor, rig and crew. Performance KPIs were calculated for the complete well and dry hole performance separately and are already defined in chapter 3.1.5. So, the database allows to distinguish between complete well and dry hole performance at which the following analysis are based on dry hole performance. The reason for that is that dry hole performance can be related to pure drilling performance because due to the Rushmore definition the term dry hole does not refer to the explorational success of the well. The dry hole case refers to the time from the spud of the well until:

- the logging tolls from the TD logging are back on surface
- the reaming tools are back on surface
- the bit is back on surface after drilling to TD

For that reason dry hole performance can be influenced by the audit initiative because it is under the full and exclusive responsibility of Well Engineering. The following trend analysis is therefore based on dry hole data. Next to the performance and HSSE KPIs, information about the well type was included as well. Thus allowed clustering the wells in appraisal, development or exploration wells with a total depth (TD) under or over 3000m. The clusters allowed a more detailed analysis of diverse wells in different subsidiaries. For sure, it can be considered to cluster the well types in more detail, for example to add data about the hole type or the drilling method. But due to the size of available data this was not reasonable because the sample for the analysis was too small. The information about the contractor, rig and crew allows analysing the well against contractor quality and crew competence.

A second sheet in the database displays data about the compliance level of the subsidiaries. The subsidiaries compliance level was determined in the subsidiary's operational audit for drilling or workover operations and evaluated with a mark between one and five. The database displays now all operational audit marks for each sub-process as well as yearly average marks for each subsidiary. The averages were calculated as ordinary arithmetic means. So, the sum of all values was divided by the number of items.

4.3 Operations Audit Database

The OP Audit Database is as well as the KPI Database a MS Excel file. It contains all findings from operations audits, with the corresponding sub-process where they occurred and the related process document. The conformance level of the sub-process was also added. Additionally the effect of one sub-process on HSSE, Performance and Costs is presented. The quality database allows analysis concerning the occurrence and frequency of findings across all subsidiaries or in detail of one subsidiary. As showed in Table 2, a findings matrix was set up with the aim to get a quick overview which findings occurred more than once. The left side of the matrix shows the process step with the appropriate document. The middle column displays the years when the finding occurred and on the right side the impact of the finding on HSSE, performance and/or costs is shown. For example, the finding on "Project Definition Document" occurred each year from 2010 to 2013. The red coloured box means that in the years 2010 and 2011 the finding was a critical one and no documentation was available, it was wholly unacceptable. Contrary to that the orange box means that the finding still occurred but not as a critical one. The "x" in the column performance and costs shows that the finding has a primary influence on these two parameters. A full table with the findings impact on HSSE, performance and costs and as well the whole OP finding matrix is shown in the appendix.

Step	Document	2010	2011	2012	2013	HSSE	Performance	Costs
1.1	Project Definition Document	x	x	x	x		x	x
1.10	Risk scenarios, DWOP			x	x	x	x	
1.11	Final Approved AFE	x	x	x				x
1.3	Preliminary Work Program	x	x	x	x		x	x

Table 2: Abstract of OP Findings Matrix

4.4 Rig Audit Database

Equally to the two other databases the rig audit database is a MS Excel file. The Database contains all the critical, major and minor findings of the rig audits and makes it possible to filter the findings per country, rig, contractor, audit type and year. The audit type can be distinguished in acceptance audits (ACC) and regular audits (RA). Pre-hire audits were not considered in the database because, as already mentioned in the subchapter Rig and Equipment Audit, the findings of the pre-hire audit are closed anyway before an acceptance audit is conducted. The intention of the rig audit database is to display the development of audit findings per year and to link the findings with the metrics of the KPI Database. The outcome should show if the number of findings have an impact on KPIs. The idea behind that is to see if a high quality contractor, who is maybe more expensive, shows less findings over the years. Fewer findings could be an indicator for a better performance because of lower downtimes due to maintenance or repair work and therefore the overall costs should be reduced.

5 Data Analysis

The following chapter is viewed as the core chapter of the whole thesis. It shows the results of the KPI and quality information analysis and answers the question if the different factors affect each other. Additionally to that the impact of the audit initiative on the KPIs is proven.

The chapter is subdivided in two parts. Chapter 5.1 shows an overall analysis of all KPIs and available quality information and the effect of the audit initiative on them. In contrary to that the chapters 5.2 to 5.8 analyse the different subsidiaries in detail. Therefore the wells were split in different well clusters, separated in appraisal, development and exploration wells with a TD over and under 3000m. The development of HSSE, performance and cost KPIs were described. Afterwards the trends were interpreted and factors which were influencing the trends were presented.

5.1 Overall

As already mentioned this chapter shows an overall data analysis, afterwards the outcome will be feed with quality information. Additionally, it will be tried to link the audit initiative with the outcome of the data analysis and it will be figured out if there are some facts that show the influence of the audit initiative on the KPIs. It will also present some hard evidence, expressed in values, which shall prove the impact of the audit initiative on HSSE, performance and cost KPIs. Contrary to the approach in the second sub-chapter, where the HSSE, performance and cost KPI trends were analysed for each well cluster separately, in this chapter the analysis was based on all wells in common. It was not reasonable to analyse for example the KPI development of a well cluster which includes wells drilled in Austria and Kurdistan Region of Iraq because of different geological, regional, political or cultural situations.

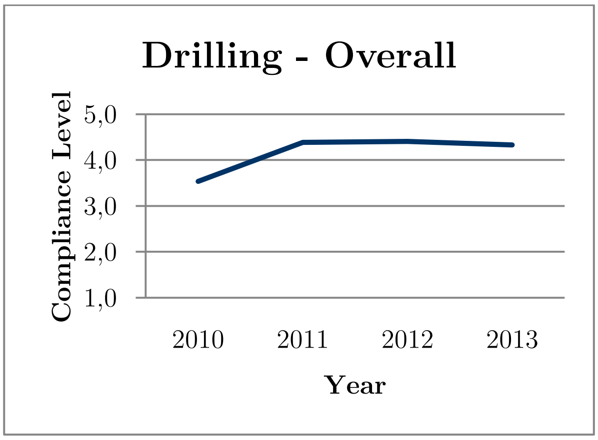
To present the data analysis in a clear way this chapter was structured as follows. In the first part the observations and analysis of the operational audits are presented and they are connected to the HSSE, performance and cost KPIs via a correlation analysis.

In the second part the outcome of the rig and equipment audits are displayed and afterwards they are linked to the HSSE, performance and cost KPIs.

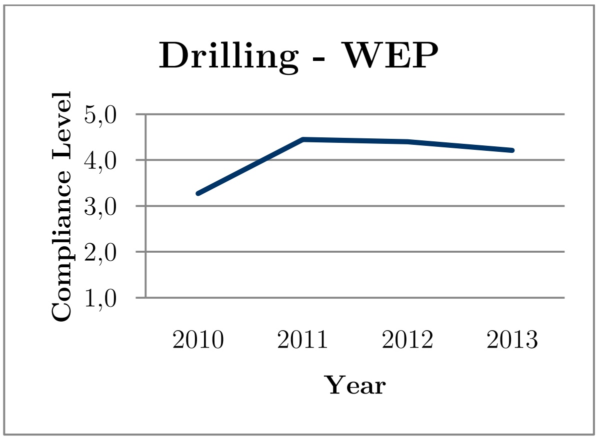
5.1.1 Influence of Operations Audits on Key Performance Indicators

Since 2010 in nearly each subsidiary an annual operational audit regarding drilling and workover operations has been conducted. Thereby a numerous amount of data was collected which was the source for the following analysis. This data represents on the one hand the compliance level marks and on the other hand the different process documents which were not compliant with the specifications in the WEMS. To avoid confusions it should be noted that in the following non-compliant process documents are referred to as findings.

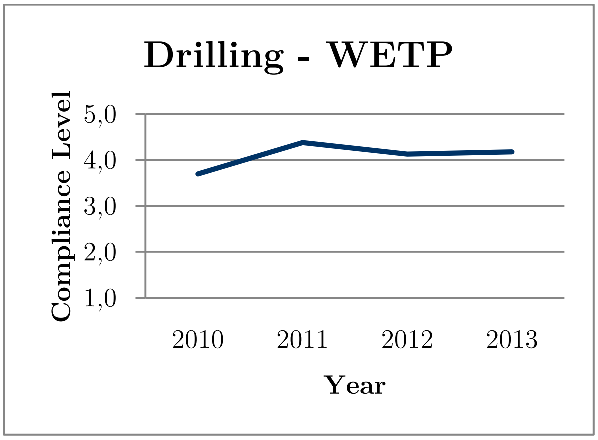
To start with the subsidiary's compliance level marks the following graphs should be regarded. The compliance levels are mean values of all evaluated sub-processes of all subsidiaries per year. The development of the compliance per subsidiary is presented in the particular chapters concerning the individual subsidiary.



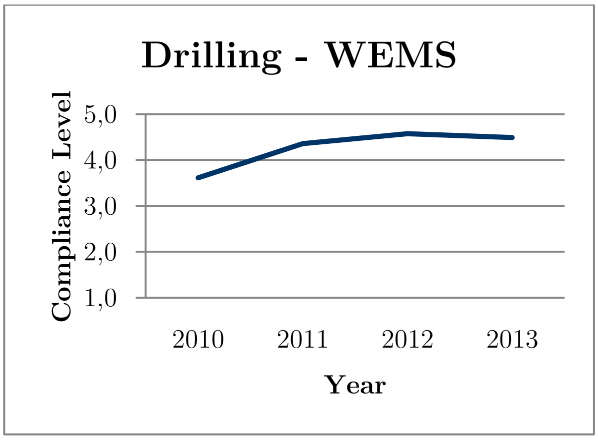
Graph 1: Total Compliance Drilling



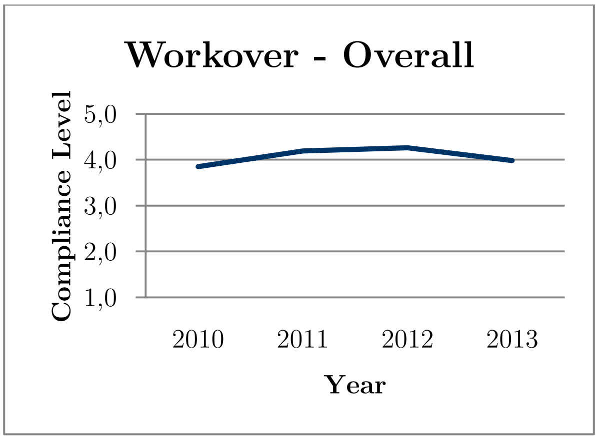
Graph 2: Total WEP Compliance Drilling



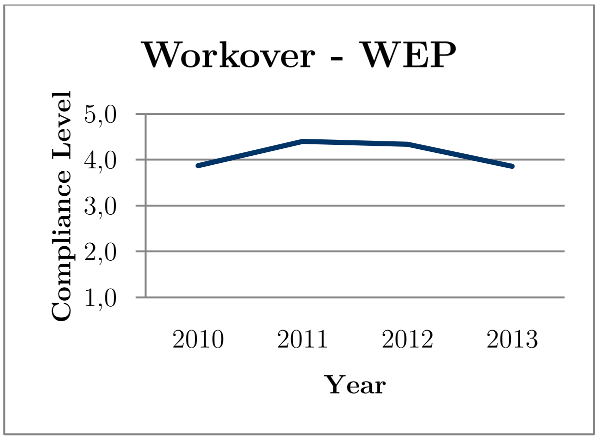
Graph 3: Total WETP Compliance Drilling



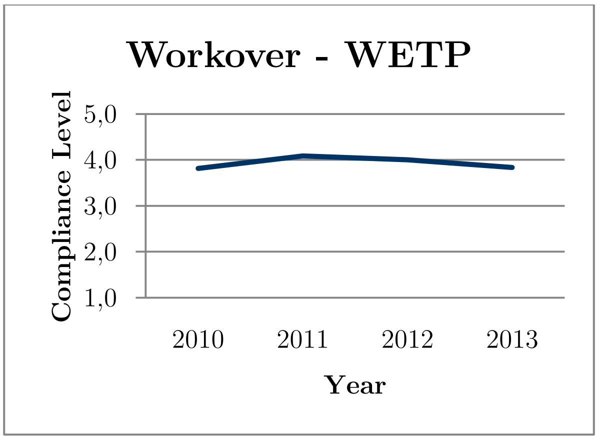
Graph 4: Total WEMS Compliance Drilling



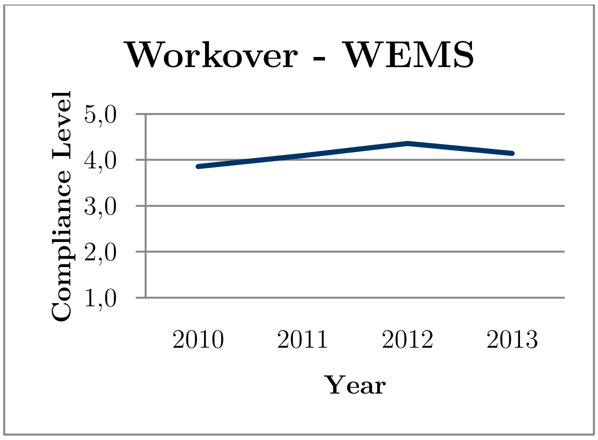
Graph 5: Total Compliance Workover



Graph 6: Total WEP Compliance Workover



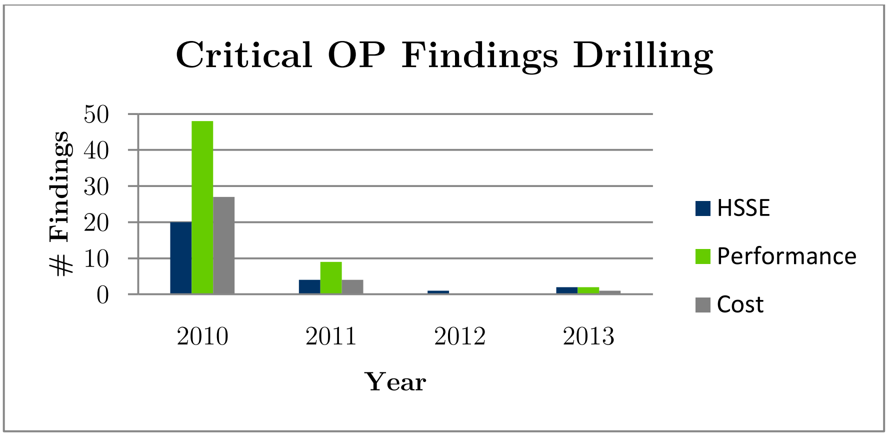
Graph 7: Total WETP Compliance Workover



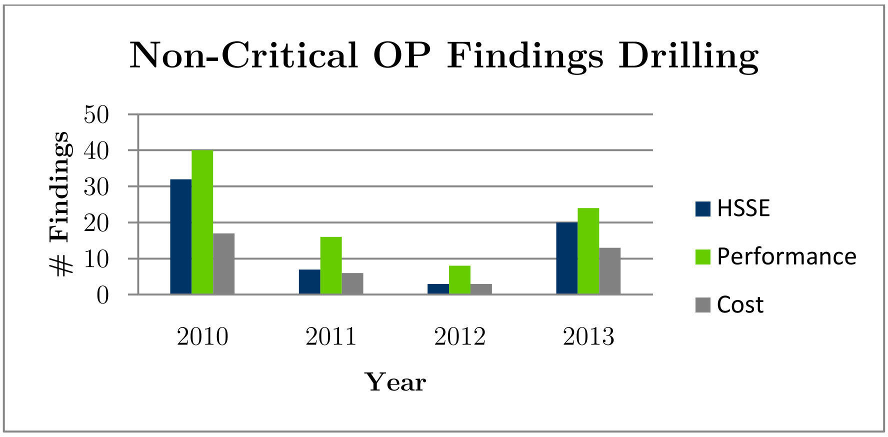
Graph 8: Total WEMS Compliance Workover

The graph concerning drilling operations compliance shows that the compliance awareness increased from 3.5 in 2010 to 4.4 in 2011, remained steady in 2012 and decreased very slightly to 4.3 in 2013. The development of the workover compliance is represented by 3.8 points in 2010 and an increase to 4.2 in 2011. In 2012 the compliance level rose along to 4.3 before it decreased to 4.0 in 2013. The descent of both marks in 2013 can be explained by two facts. The first one considers that the new venture New Zealand was audited the first time and evaluated poorly. The second one takes into account that referring to the Arabic spring drilling operations in Yemen were suspended for two years and respuded in 2013, therefore compliance marks were poor as well. These two weak evaluation results are reflected in the decreasing compliance level in 2013. Despite the weaker compliance level in 2013 the general development of compliance is following a positive trend.

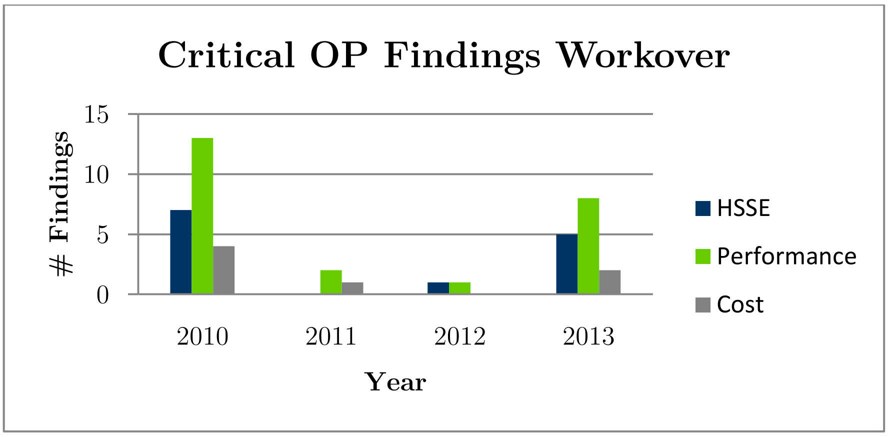
A subsidiary's level of compliance develops in the same way as the development of critical and non-critical findings concerning HSSE, performance and costs. Before showing the findings development, a short reminder of how critical and non-critical findings in OP audits were defined. A finding is critical if the process document of the sub-process or the whole process is wholly unacceptable, in such case the audited document or process is not available, and marked with one. Contrary, a finding is non-critical if the document of the sub-process or the process itself is not wholly unacceptable, but still not excellent and therefore evaluated with a mark between two and four. The following graphs show that the number of critical and non-critical findings for drilling and workover operations was decreasing from 2010 to 2011. It decreased slightly in 2012 before increasing in 2013. This development is directly reflected in the compliance level trend. Generally the number of findings was reduced enormously and from that point of view it can be said that there has been a positive effect of the operational audit initiative on HSSE, performance and costs.



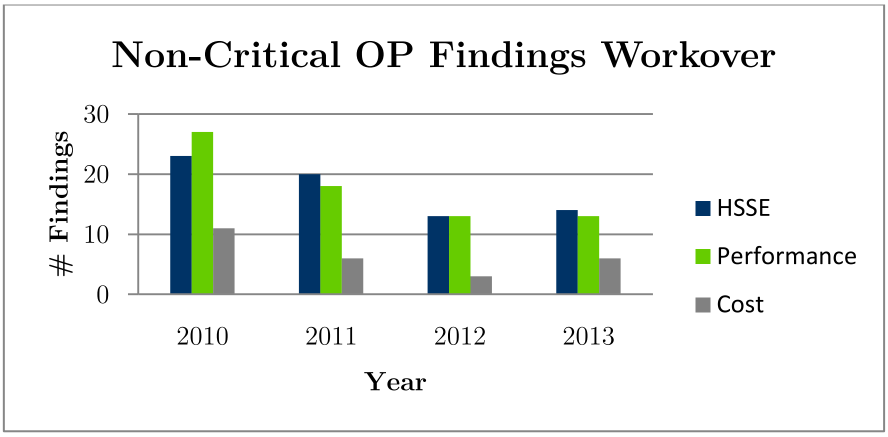
Graph 9: Number of Critical OP Findings Drilling



Graph 10: Number of Non-Critical OP Findings Drilling



Graph 11: Number of Critical OP Findings Workover



Graph 12: Number of Non-Critical Findings Workover

The interesting question is now, if there is some evidence expressed in values showing the positive influence of OP audits on HSSE, performance and cost issues. A correlation analysis, where HSSE, performance and cost KPIs for each well were opposed to the annual compliance level of the subsidiary in which the well was drilled, revealed if there is some beneficial effect. The model of hypotheses for the correlation is:

$$H_0: \rho_{(X,Y)} < 0$$

$$H_1: \rho_{(X,Y)} \geq 0$$

H_0 expresses the null hypothesis, which defines a negative correlation between the two variables, and H_1 the alternative hypothesis, which defines a positive correlation between the two variables. There is one limitation to the correlation analysis which concerns the wells. The wells Bina Bawi 3, Bina Bawi 4, Bina Bawi 5, Mala Omar 1, which were drilled in Kurdistan Region of Iraq, the well Chamonix, drilled in Norway, and the well Habban 28, drilled in Yemen, were not included in the analysis. The reason why the wells drilled in Kurdistan Region of Iraq were not included is that the field is characterized by special geological formation with caves a few hundred meters below the ground. These caves were responsible for mud losses and for extreme difficult drilling conditions. Therefore the KPIs generated in these drilling operations are not representative and not included in the analysis. The Norwegian well was not included because it is an offshore well while all the others are onshore. In case of Yemen the reason why Habban 28 was not included is that due to the Arabic spring, drilling operations for Habban 28 were shut down in 2011 and resumed in 2013. Therefore the KPIs for well Habban 28 show extreme spike values which are not representative for the general drilling performance.

Excursion: Correlation Analysis

In general, correlation shows a statistical relationship between two random variables or two sets of data. The most familiar measure is the Pearson's correlation coefficient and it is obtained by dividing the covariance of the two variables by the product of their standard deviations.

$$\rho_{X,Y} = corr(X,Y) = \frac{cov(X,Y)}{\sigma_X \sigma_Y}$$

Formula 1: Pearson's Correlation Coefficient

$\rho_{X,Y}$ expresses the correlation coefficient between the two variables X and Y with standard deviations σ_X and σ_Y. The Pearson correlation is +1 in the case of a perfect positive linear relationship, -1 in the case of a perfect negative linear relationship, and some value between -1 and +1 in all other cases, indicating the degree of linear dependence between the variables. As it approaches zero this means that there is no correlation. The closer the coefficient is either to -1 or +1, the stronger the correlation between the variables. In literature a correlation coefficient lower than -0.3 and higher than +0.3 means that the correlation is significant. A positive correlation means that the variables increase together while a negative relationship is defined by one decreasing variable and one increasing variable.[81]

Coming back, the result of the correlation shows the following:

	Days/1000m	*Compliance Level*
Days/1000m	1	
Compliance Level	-0,443837038	1

	Cost/m[EUR]	*Compliance Level*
Cost/m[EUR]	1	
Compliance Level	-0,492569162	1

	%NPT	*Compliance Level*
%NPT	1	
Compliance Level	-0,199125526	1

	LTIF	*Compliance Level*
LTIF	1	
Compliance Level	-0,001192411	1

	TRIF	*Compliance Level*
TRIF	1	
Compliance Level	-0,077671217	1

	STOP cards	*Compliance Level*
STOP cards	1	
Compliance Level	0,105760144	1

Table 3: Result of Correlation Analysis

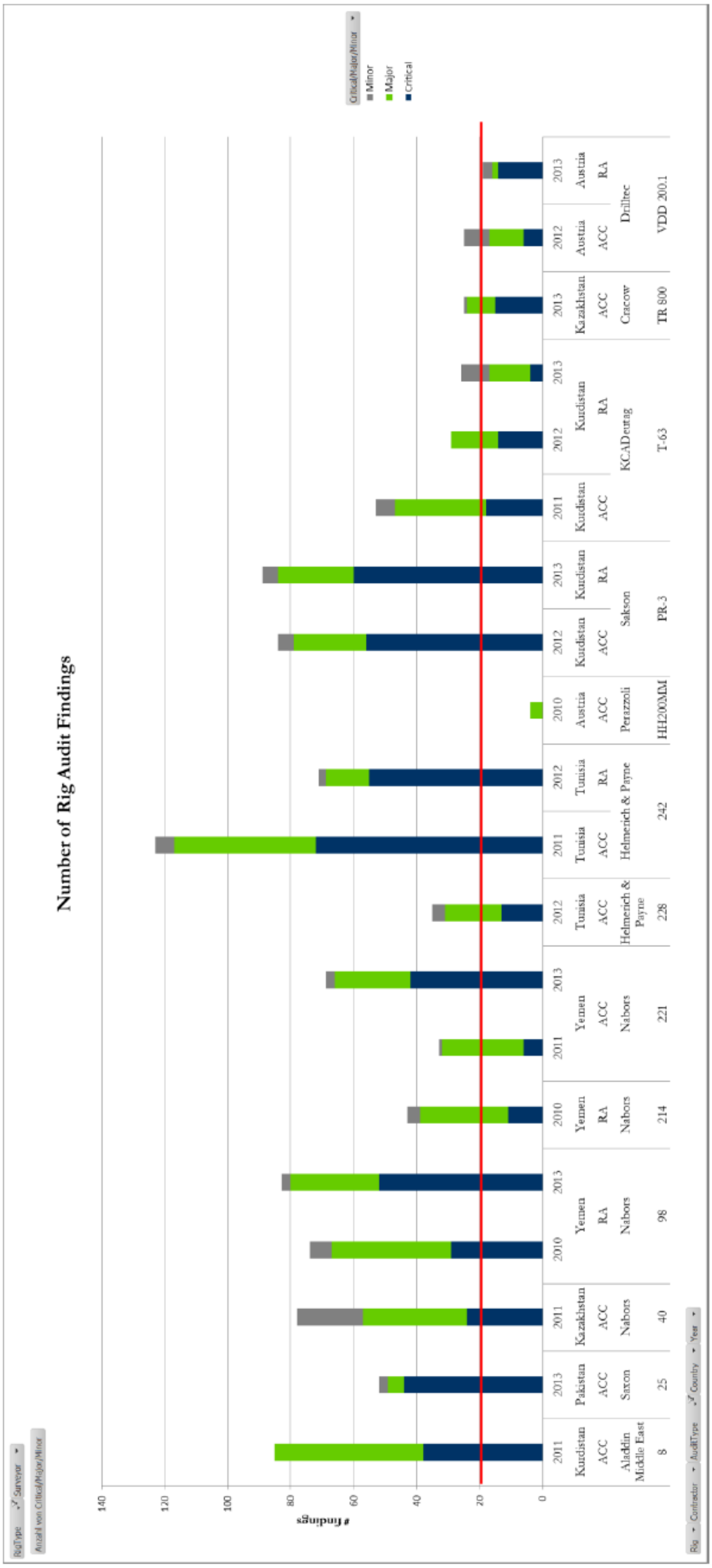
The correlation coefficient of -0.44 for the variables days/1000m and compliance level shows that the two variables correlate negative and therefore validates H_0. This means

[81] Reference: Riedwyl, Ambühl (2000), p: 8-22

that if the compliance level increases the KPI days/1000m decreases and vice versa. The same applies for the correlation coefficient of -0.49 for the variable cost/m [EUR] and compliance level. If the compliance level increases the KPI cost/m [EUR] decreases. Because both correlation coefficients are lower than -0.3 it can be said that the correlation is significant. Contrary to that, the correlation coefficient, with a value of -0.19, for the variables NPT and compliance level is statistically not significant. The same applies to the correlation coefficient of the HSSE KPIs and compliance level. In general the negative correlation between the variables shows the right trend but a coefficient of -0.0011 for the variables LTIF and compliance level and a coefficient of -0.077 for the variables TRIF and compliance level are absolutely not significant. The positive correlation for the number of issued STOP cards and the compliance level shows basically the right development. As a higher compliance level indicates a higher safety awareness this ultimately leads to an increasing number of issued STOP cards to prevent safety incidents. However, a correlation coefficient of 0.10 is too low to say that the correlation is significant.

5.1.2 Influence of Rig and Equipment Audits on Key Performance Indicators

Since 2010 EPW-A and ModuSpec has been conducting Rig and Equipment Audits which can be separated in acceptance and regular audits. As already mentioned in chapter 3.1.6 the findings are classified in critical, major and minor findings, at which critical findings are show stoppers and therefore treated seriously. To get an overview how many findings occurred during the individual audits, the following graph should be considered.



Graph 13: Number of Rig Audit Finding

The red line represents a number of findings, above which a direct connection between the quantity of findings and a weak performance can be measured. This line defines the threshold above which, rigs with more than twenty critical and major findings in sum, are analysed in more detail. This threshold was defined by empirical values and it will be demonstrated in the following graphs and abstracts that this approximate value is valid to use. Because OMV is following a zero critical findings policy the questions:

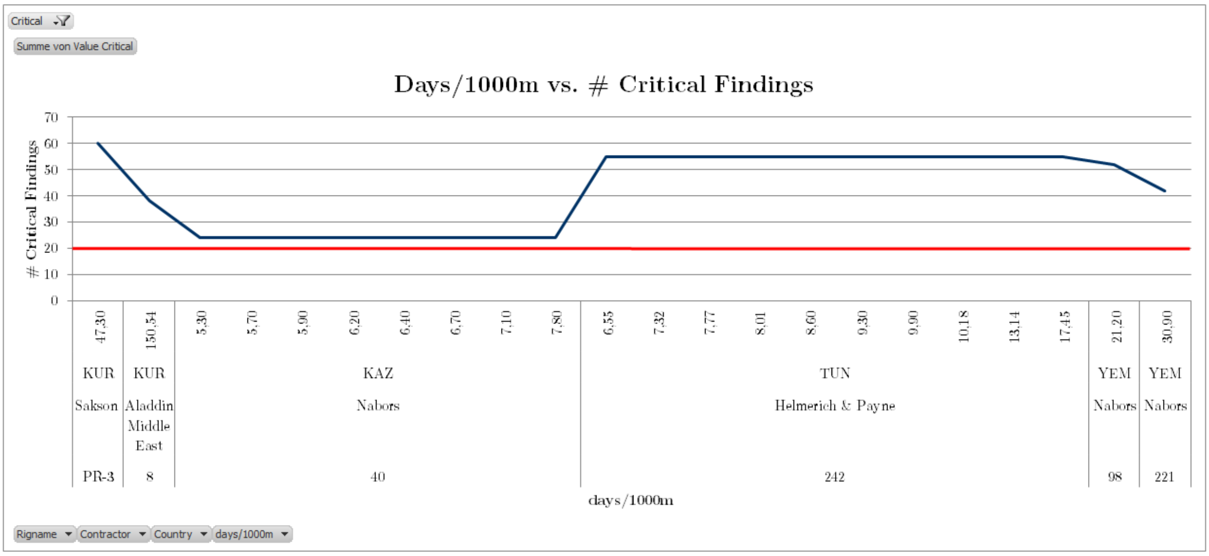
- "How should critical findings be treated?"
- "How should EPW-A react on a continuous critical findings sequence?"

should be answered within the department.

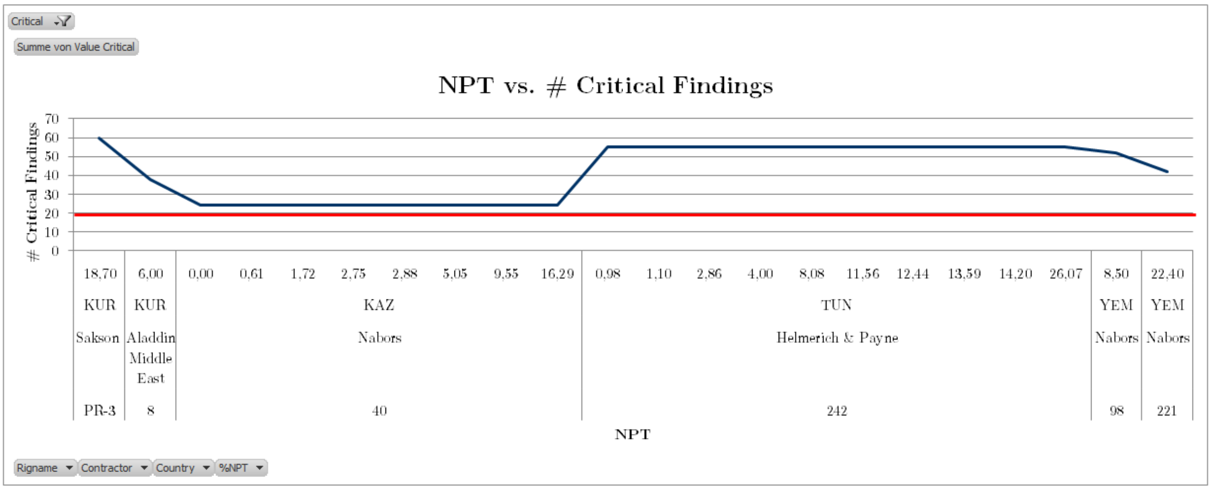
The graph shows, that for almost all rigs more than twenty critical and major findings were identified during the rig and equipment audit. The most critical ones are now analysed in more detail to find out if there are some feasible reasons for the high number findings and to show that the number of findings has an impact on drilling performance.

Due to Arabic spring riots in 2011 drilling operations were shut down and both rigs were secured and suspended. This reason explains the high number of findings for the Nabors rig 98 and 221 in 2013. Because there were no maintenance operations during the last two years the overall rig condition was not good and therefore the high number of findings occurred. The reason for rig 25, operated by Saxon, is similar. Due to the security situation in Pakistan EPW-A conducted for several years no rig inspection. For that reason the high number of findings is the conclusion. For rig 25, where Helmerich & Payne is the contractor, the situation is different. In this case the contractor can be blamed for the extreme high number of critical findings due to mismanagement and localisation problems. Nabors with rig 40 should be remembered for the future, because there is at the moment no feasible reason why they exceeded the threshold. The contractor Aladdin Middle East with rig 8 is already released because of a bad drilling performance. The last rig with an excessive number of findings concerns the Sakson rig PR-3. Because there is no feasible reason for the high number of findings and for the fact that this number increased from the audit in 2012 to the audit in 2013 it should be considered to release the contractor. Additionally to that during drilling operations several problems occurred, which are described in detail in chapter 5.4, what is a further argue for a release.

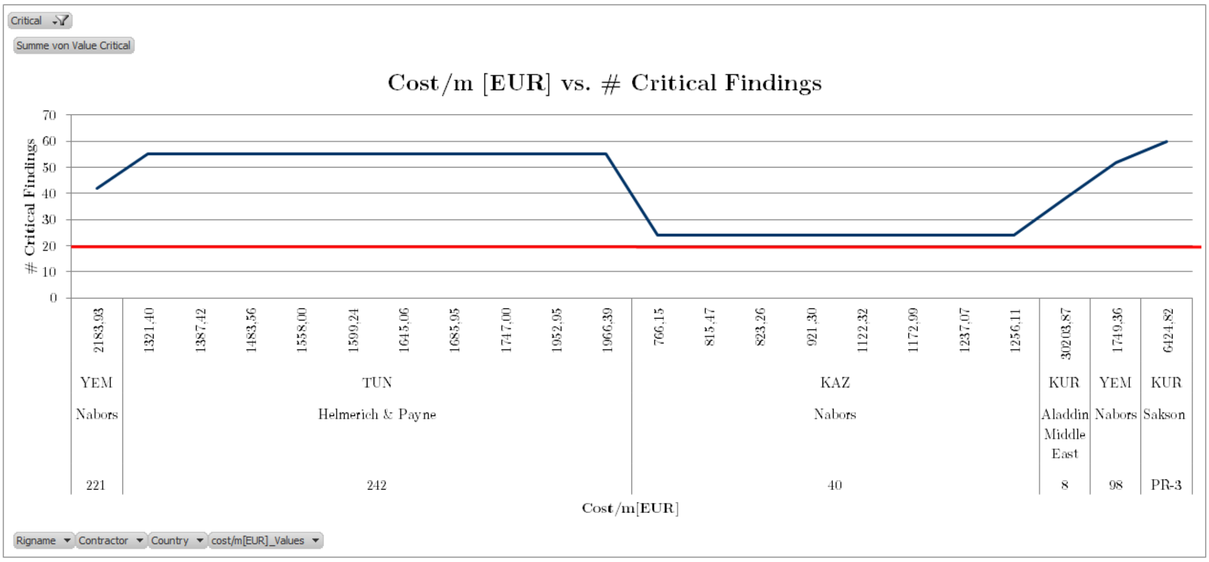
The following graphs should now prove the impact of the amount of critical findings on drilling KPIs. Based on the fact that the overall mean value for days/1000m for all wells drilled is 12.96 days/1000m, Graph 14 shows explicit that in the case of the Sakson rig PR-3, the Aladdin Middle East rig 8, Helmerich & Payne rig 242 and the Nabors rigs 98 and 221 the KPI is above the mean value. This is definitely an argument that a high number of critical findings have a negative effect on drilling performance. The same is valid for the second performance KPI, the NPT with an overall mean of 9.02%. As revealed in Graph 15, rigs with a high number of findings are characterized by an above-average NPT. The cost/m KPI shows the same picture than the performance KPIs as presented in Graph 16. Finally, the same negative influence of a high number of critical findings on HSSE KPIs is valid as well. Graph 17and Graph 18 show that rigs where LTIFs or TRIFs occurred are marked by a high number of critical findings.



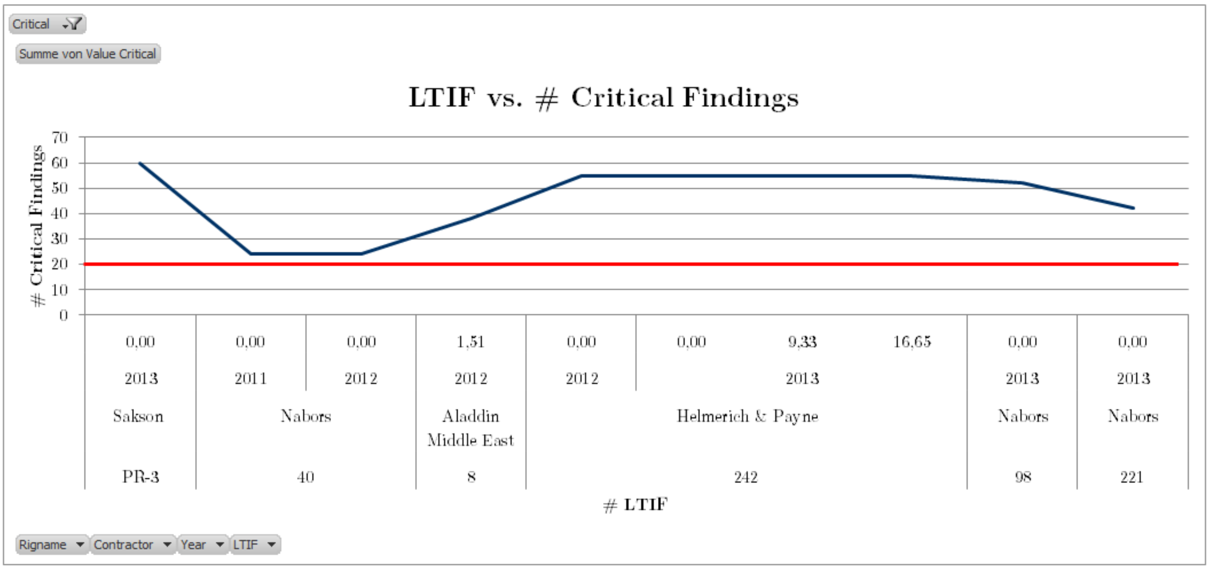
Graph 14: Days/1000m vs. # Critical Findings



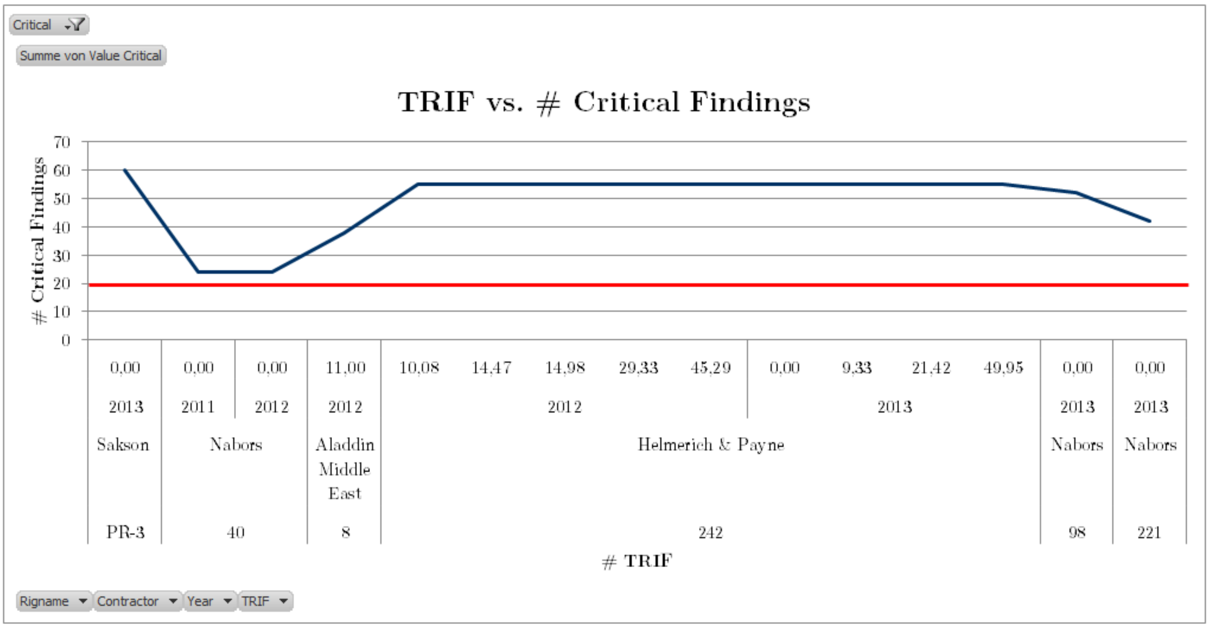
Graph 15: %NPT vs. # Critical Findings



Graph 16: Cost/m [EUR] vs. # Critical Findings

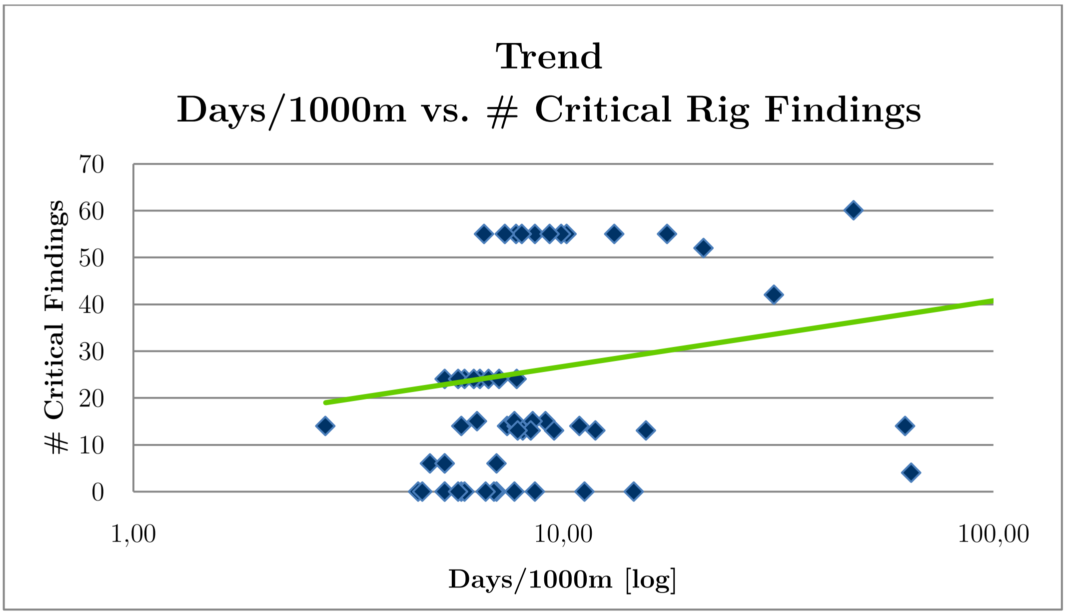


Graph 17: LTIF vs. # Critical Findings

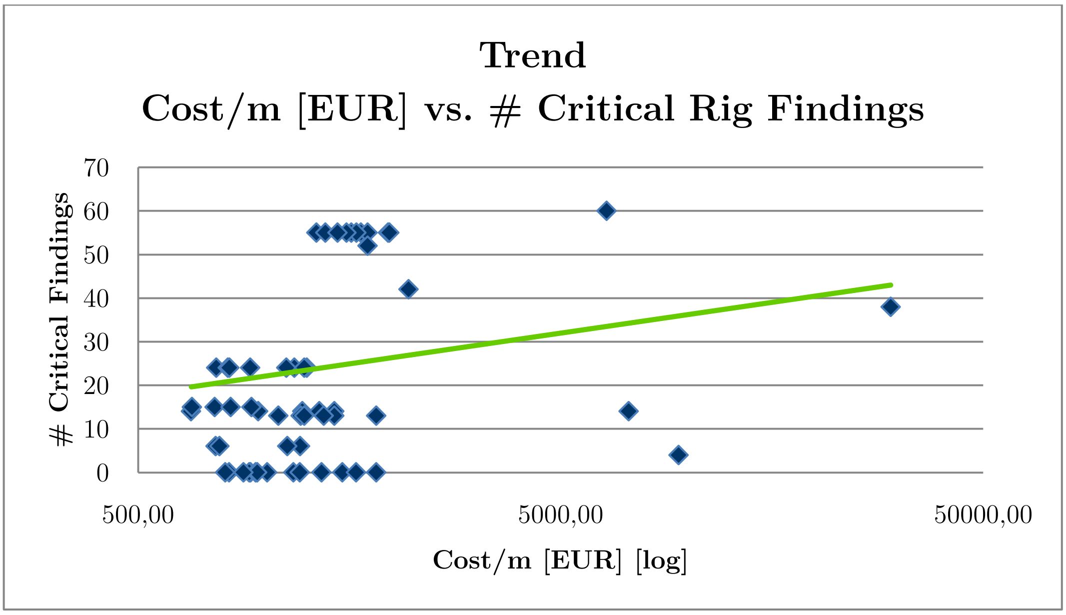


Graph 18: TRIF vs. # Critical Findings

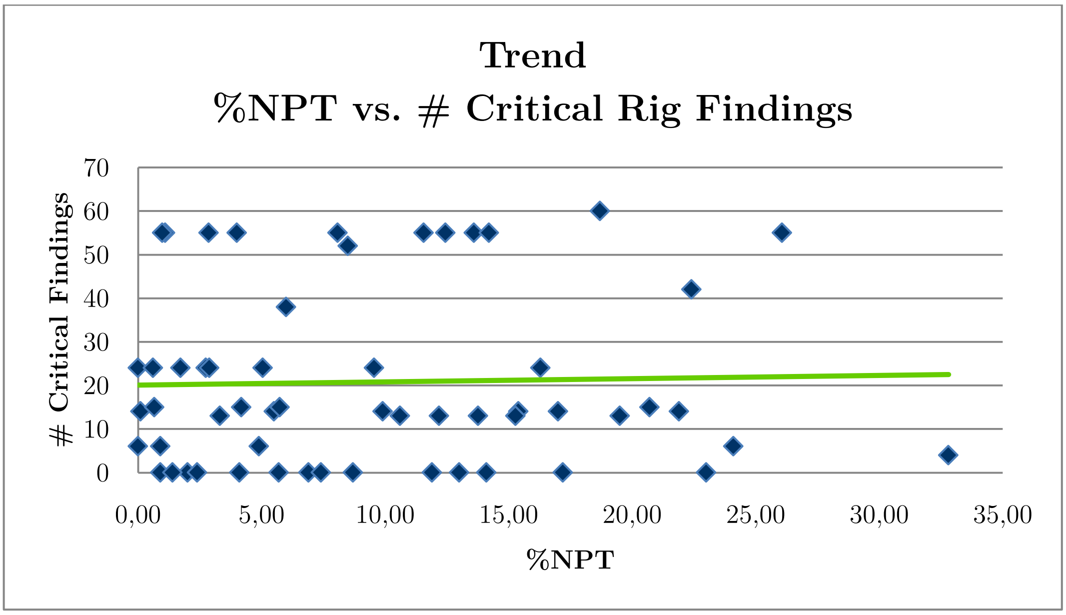
Finally, the interaction between the number of critical findings and HSSE, performance and cost KPIs and the trend that a higher number of critical findings results in more HSSE incidents and in a weaker performance is proven in the next figures. To show this interaction, the KPIs were opposed to the number of critical findings. Generally, all figures show the trend that the more critical findings occurred during a rig inspection the weaker the performance is. And in the case of HSSE issues, a higher number of critical findings lead to a higher number HSSE incidents. By having a view on the next graphs this relation should be obvious because the majority of points are below or on the trend line. Each point represents the corresponding KPI of one well and the number of critical findings of the rig, which drilled the well. Graph 19 and Graph 20 are semi-log plots because of a better illustration.



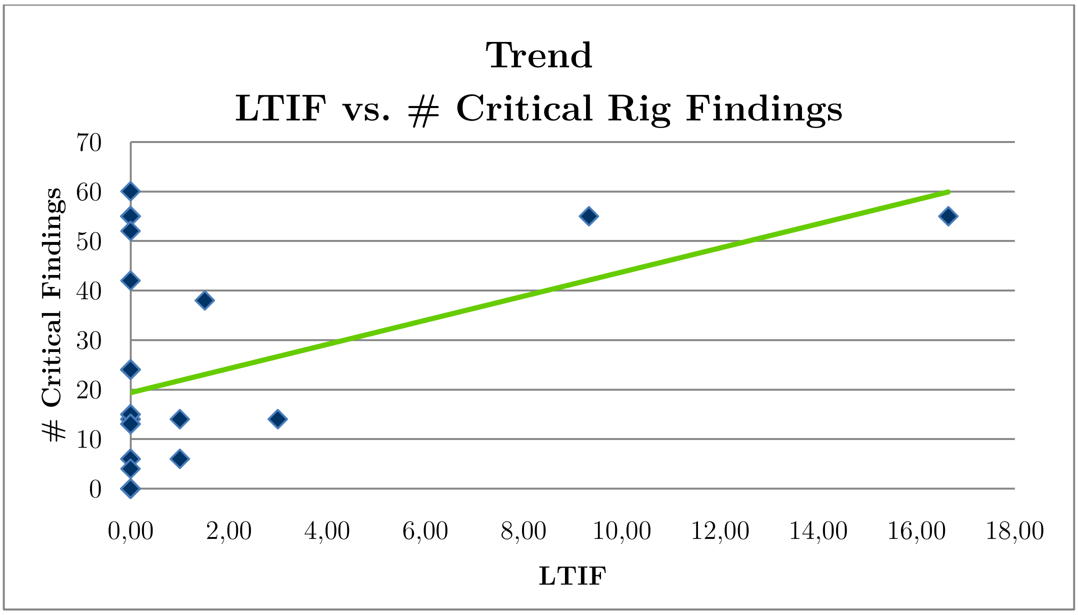
Graph 19: Trend - Days/1000m vs. Critical Rig Findings



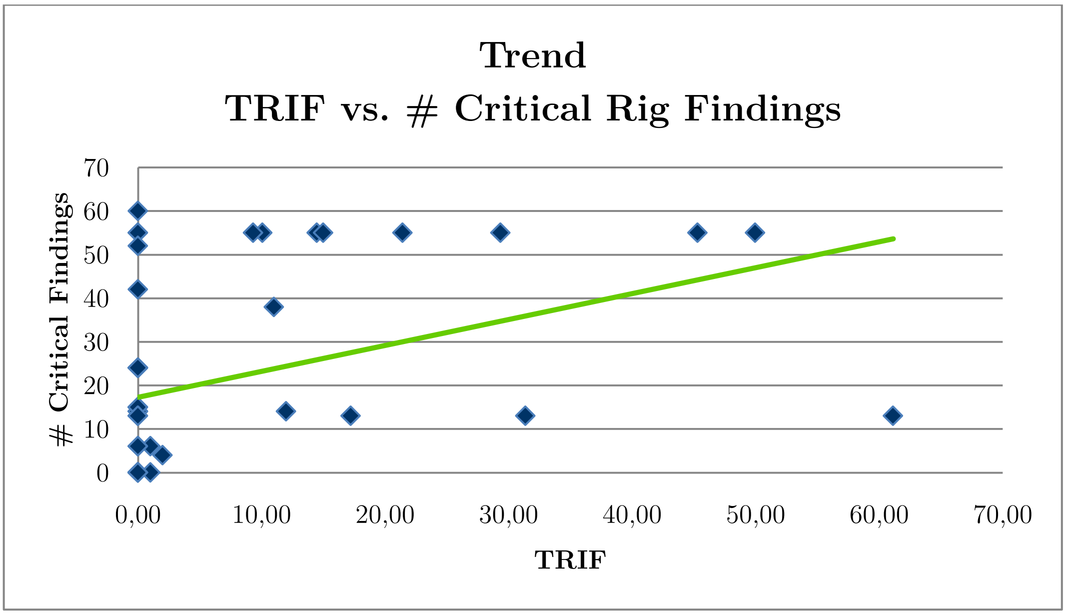
Graph 20: Trend - Cost/m [EUR] vs. # Critical Rig Findings



Graph 21: Trend - %NPT vs. # Critical Rig Findings



Graph 22: Trend - LTIF vs. # Critical Rig Findings



Graph 23: Trend - TRIF vs. # Critical Rig Findings

The next chapters give a detailed analysis of all subsidiaries. All of them are structured in the same way. First the data and quality information of the three databases is described. Afterwards the KPI development of the different well clusters are illustrated and interpreted.

5.2 Austria

Key Performance Indicator Database

For the subsidiary Austria the KPI Database shows the following. The total number of wells drilled between 2010 and 2013 is counted with twenty-four, all with a TD under 3000m. In 2010 two exploration wells and three development wells were drilled while in 2011 one appraisal, seven development and two exploration wells were drilled. For 2012 one appraisal and three exploration wells and for 2013 one appraisal and four development wells can be counted. The rig history shows that two contractors were responsible for drilling operations during that period. Perazzoli was operating in 2010 and in 2011. After Perazzoli's release in 2011 Drilltec was contracted in 2012 and has been operating the drilling campaigns since that date.

	Perazzoli		Drilltec	
	2010	2011	2012	2013
DrakeHH200MM				
VDD 200.1				

Table 4: AUT Rig History

Operations Audit Database

EPW-A conducted OPs audits with focus on drilling and workover operations in 2010, 2011 and 2012. The quality analysis of the OP audit reports shows the following. For drilling operations the number of findings decreased from eighteen in 2010 to only two in 2012 tremendously. Approximately one third of the findings were critical ones where no documentation was available. Most of the findings concerned performance issues followed by HSSE and cost issues. Table 5 shows that four findings occurred more often than once, at which two of them were closed in 2011.

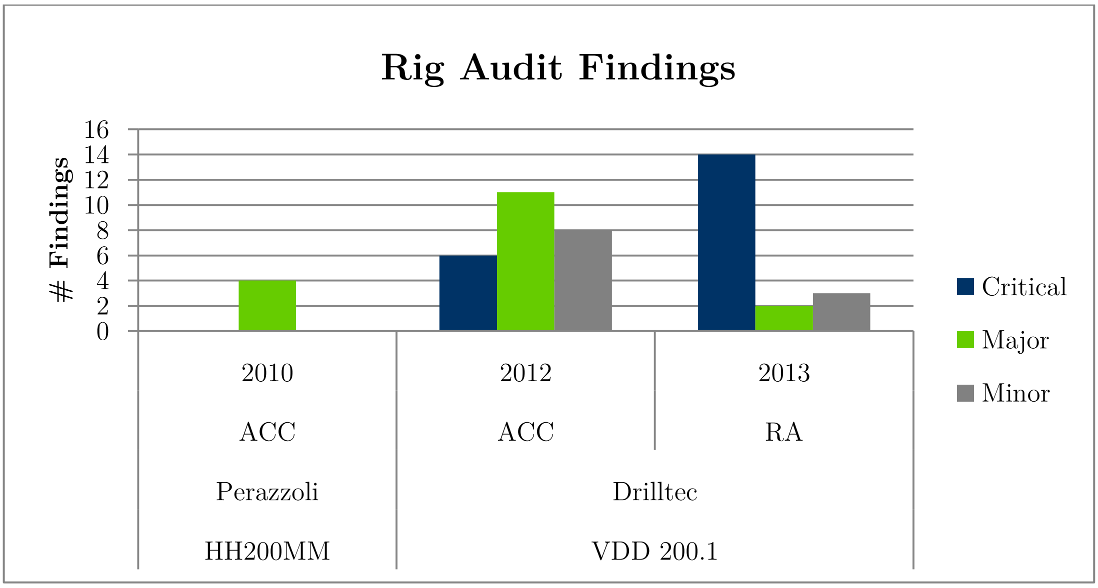
For workover operations the number of findings decreased by more than half from twenty-eight to twelve. In the case of workover operations most findings concerned performance and HSSE issues followed by cost issues. The findings matrix shows that there are plenty of findings which occurred frequently.

Step	Document	Drilling_1/ WO_2	2010	2011	2012	2013	HSSE	Performance	Costs
7.3	Balanced Scorecard	1	x	x			x	x	
10.3	Dispensation procedure	1	x	x			x	x	
7.9	Blowout Contingency Plan	1	x	x	x		x		
8.1	Organization Structure	1		x	x			x	
1.8	Long Lead Item AFE	2	x	x	x				x
1.8a	ESIA	2	x	x			x		
1.9	Risk Scenarios, DWOP	2		x			x	x	
1.11	Final Approved AFE	2	x	x	x				x
1.11b	ERP	2	x		x		x		
10.3	Dispensation procedure	2	x	x	x		x	x	
10.10	Travel and Security	2	x	x	x		x		
10.11	Contractor Management	2	x	x			x	x	x
13.4.4	Close-out well records	2	x	x				x	
2.5	Audit Document	2	x	x	x		x	x	
2.6	Pre-Spud Meeting	2	x	x	x			x	
3.1	Lessons Learnt MOM	2		x	x			x	
3.1a	Debris / Contamination Survey	2	x	x			x		
8.1	Organization Structure	2	x	x				x	
8.3	Financial Authorities	2		x	x				x
8.4	Technical Authorities	2	x					x	
8.5	Training and Development	2	x		x			x	
8.5.4	Contractor Personnel Competence	2	x	x			x	x	x
9.5	Well Control	2		x	x		x		
9.6	Barrier Philosophy	2		x	x		x	x	

Table 5: AUT OP Findings Matrix

Rig Audit Database

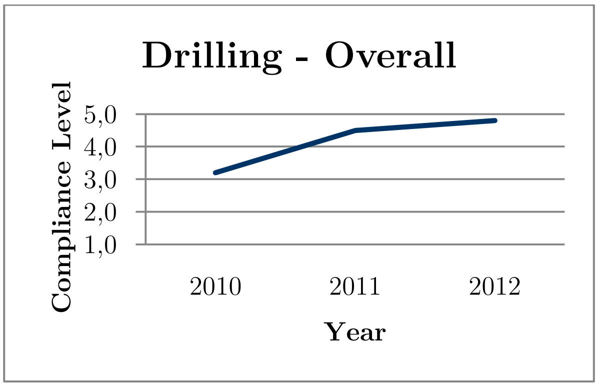
The rig audit database reveals the following observations. ModuSpec conducted an acceptance audit for rig HH200MM in 2010 and displayed four major findings. Due to the fact that the contractor Perazzoli was released in 2011 no regular rig audit was executed. The history for the Drilltec rig VDD 200.1 is a little bit different. The acceptance audit conducted by EPW-A in 2012 recorded six critical, eleven major and eight minor findings. The outcome of the 2013 rig audit, conducted as well by EPW-A, shows a very negative development because the number of critical findings increased to fourteen. This dramatic increase can be explained by the fact that, due to organisational problems and understaffed personnel most major findings of 2012 were not closed and became critical findings in 2013. The personnel situation and the consequences will be described in more detail in the interpretation part.



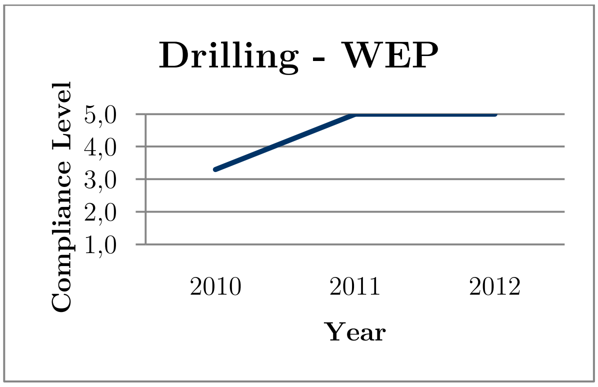
Graph 24: AUT Rig Audit Findings

Compliance Level

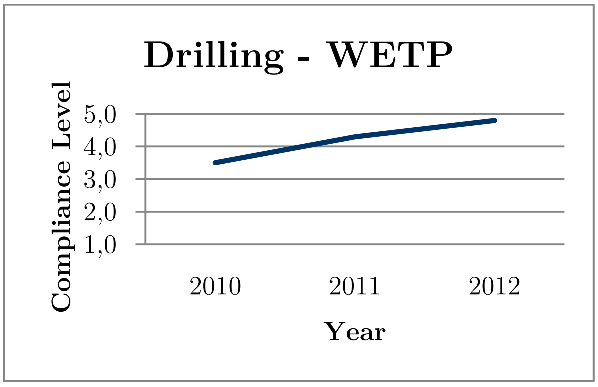
By analysing the following graphs the conclusion is that in general the compliance awareness development shows a positive trend, although there is especially for workover operations plenty of room for improvement. The WEP compliance level for drilling operations improved in 2011 to a level of 5.0 and remained steady in 2012. The compliance with WETP and WEMS has been improving over the period of review as well. In 2012 for the WETP a level of 4.8 and for the WEMS a level of 4.7 was achieved. Contrary to the drilling compliance the compliance level for workover operations shows more room for improvement. The WEP compliance reached a level of 4.2 in 2012 while the WETP and the WEMS reached 4.3.



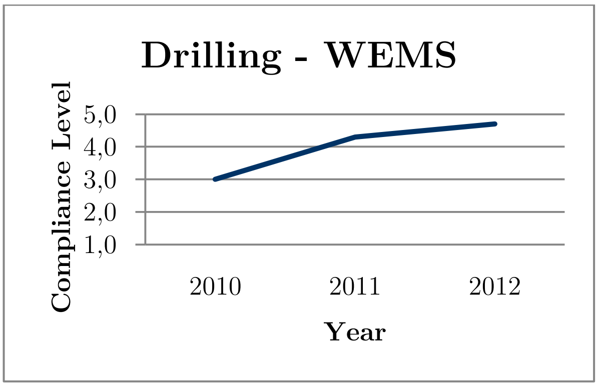
Graph 25: AUT Overall Compliance Drilling



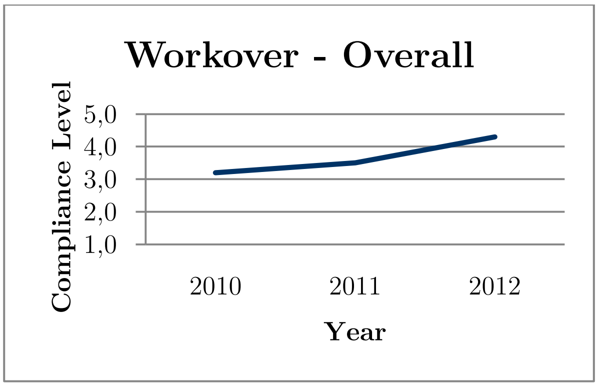
Graph 26: AUT WEP Compliance Drilling



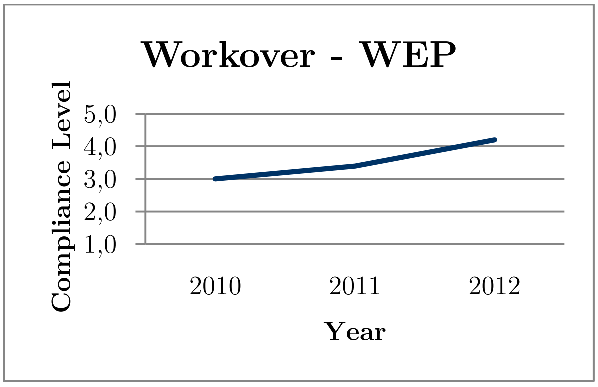
Graph 27: AUT WETP Compliance Drilling



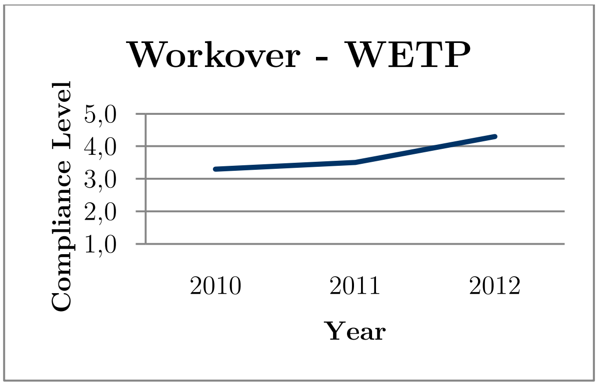
Graph 28: AUT WEMS Compliance Drilling



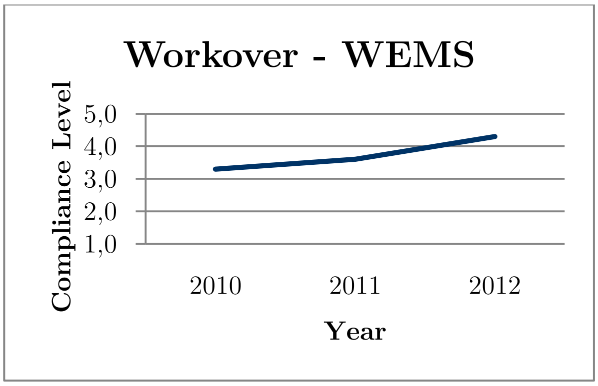
Graph 29: AUT Overall Compliance Workover



Graph 30: AUT WEP Compliance Workover



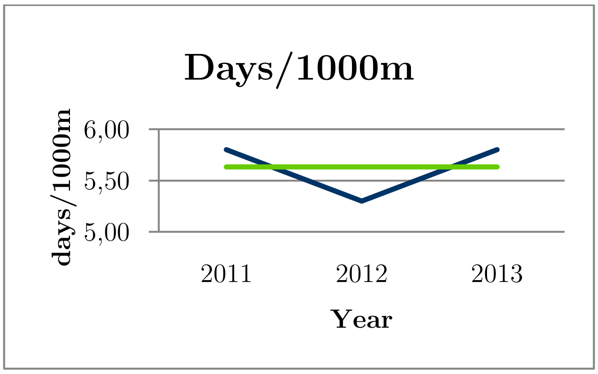
Graph 31: AUT WETP Compliance Workover



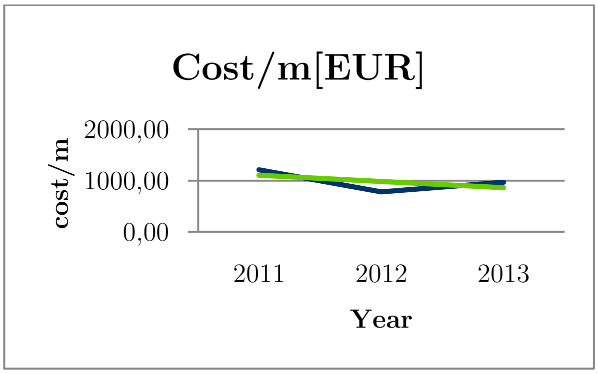
Graph 32: AUT WEMS Compliance Workover

5.2.1 Cluster: Appraisal well, Total Depth under 3000m

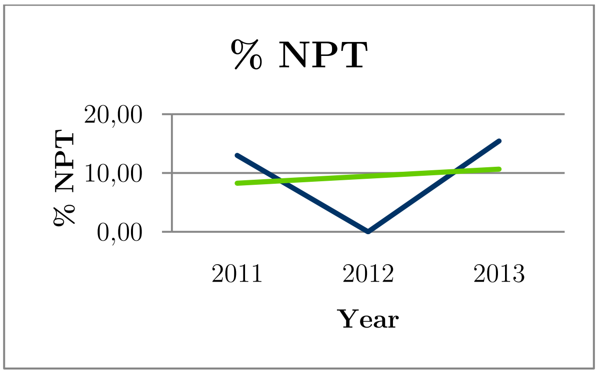
The graphs show that, the development of the KPIs days/1000m, cost/m and NPT follow the same trend. All of them decreased in 2012, in the case of the NPT to the perfect level of zero, and increased again in 2013. In the case for days/1000m the KPI reached the same level as in 2011 while cost/m increased only slightly. The NPT jumped after reaching the zero level in 2012 to a peak value of 15.4. By taking a look on the HSSE graphs the LTIF rate stayed on a steady level of zero in 2011 and 2012. In 2013 one incident occurred and therefore the level increased. The TRIF rate remained on a zero level over the period of review. The number of issued STOP cards fluctuated between 1.1 and 0.34.



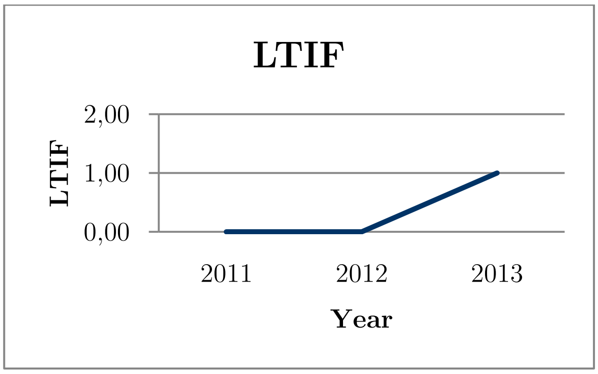
Graph 33: AUT (A, <3000), Days/1000m



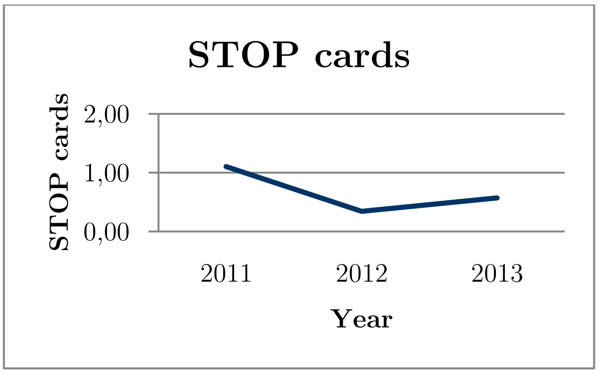
Graph 34: AUT (A, < 3000), Cost/m [EUR]



Graph 35: AUT (A, < 3000), % NPT



Graph 36: AUT (A, <3000), LTIF



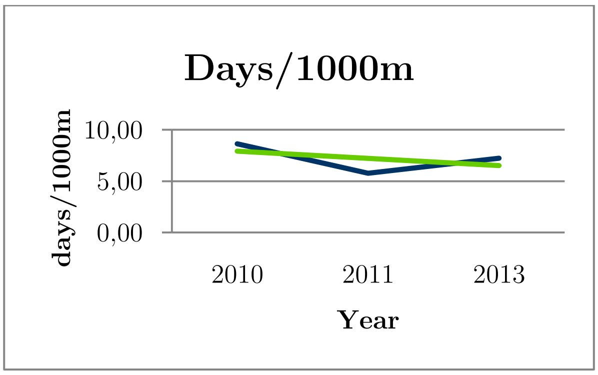
Graph 37: AUT (A, <3000), STOP cards

Interpretation

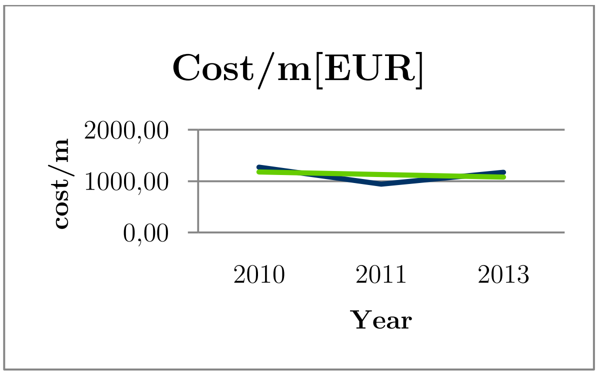
Summarizing all the information mentioned above the KPI development can be interpreted in the following way. The performance increase in 2012, displayed by the decreasing KPI trend lines, can be linked to the good performance concerning WEP, WETP and WEMS compliance. As the number of OP audit findings decreased to a number of two, processes became more standardized and therefore more efficient. A higher compliance level is influencing not only planning and operation processes but also sufficient equipment maintenance as well as staff training and therefore crew competence. It has to be recognized that in 2012 Drilltec was under new contract as a drilling operator. In spite of the new contractor and the new rig crew the drilling performance improved what can be assessed as very positive. The increase of the KPI trends and therefore the performance loss in 2013 is easily explained. The main factor that is responsible for this development can be referred to an absolute understaffed drilling department in the subsidiary. This year only one junior drilling engineer was left. All the other drilling engineers, even the drilling manager, changed to other companies or resigned. Because of that it is not possible to keep operations running at an efficient level.

5.2.2 Cluster: Development well, Total Depth under 3000m

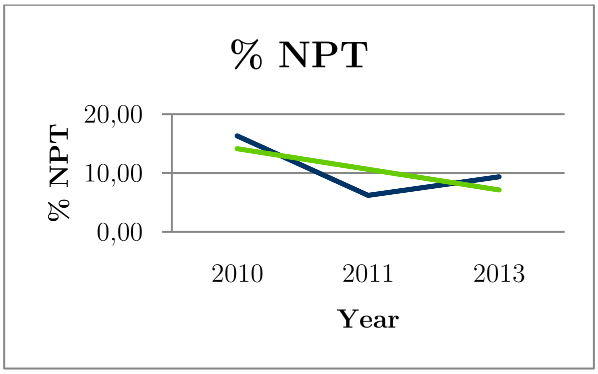
The HSSE and performance trends for this well cluster show the same development as the ones in the previous cluster although the wells were drilled in 2010, 2011 and 2013. The KPI days/1000m shows a positive development as it follows a decreasing trend line. After decreasing from 8.63 days/1000m in 2011 to 5.77 days/1000m in 2012 it increased slightly in 2013 to 7.23 days/1000m. Cost/m fluctuated in the same way as the KPI days/1000m and the NPT shows the same development as the performance KPI, decreasing from 2010 to 2011 and raising in 2013. The HSSE KPIs show a very positive trend as there was no LTIF since 2010 and the TRIF rate follows as well a zero level. Over the period of time, the number of issued STOP cards remains on a relative low level of 1.5 cards.



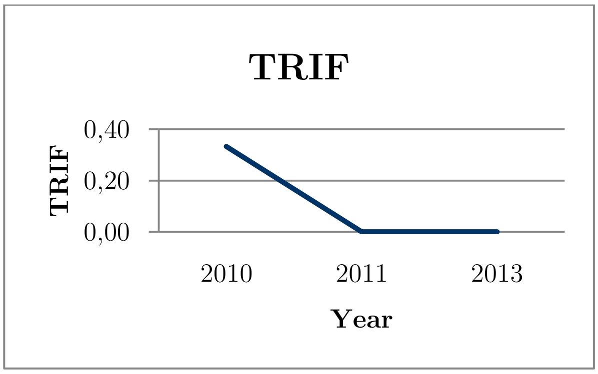
Graph 38: AUT (D, <3000), Days/1000m



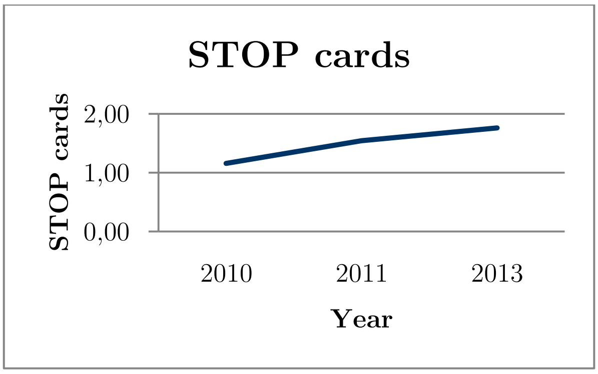
Graph 39: AUT (D, <3000), Cost/m [EUR]



Graph 40: AUT (D, <3000), %NPT



Graph 41: AUT (D, <3000), TRIF



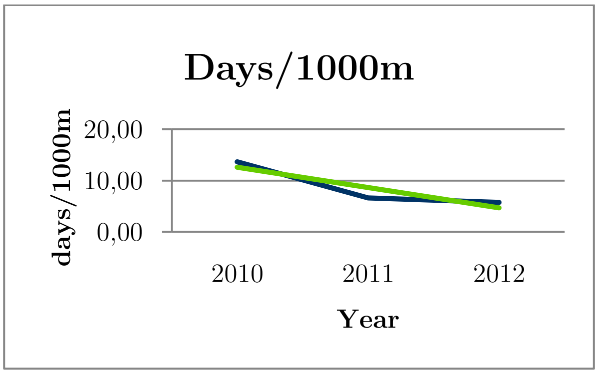
Graph 42: AUT (D, <3000), STOP cards

Interpretation

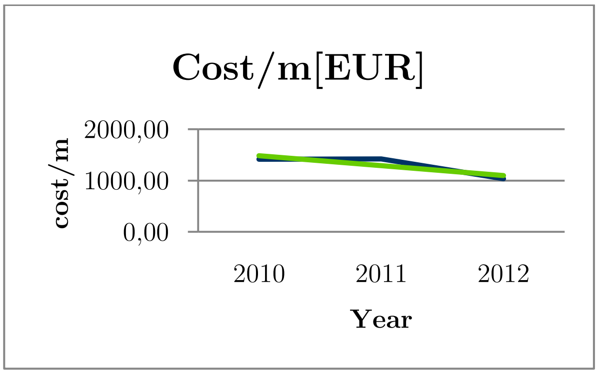
The interpretation of the KPI development shows the following conclusion. The increasing performance between the first two years was definitely influenced by the tremendous decrease of OP audit findings as they dropped for drilling operations from a number of eighteen in 2010 to four in 2012. Furthermore the positive development might also be linked to the fact that Perazzoli was on contract the second year and therefore familiar with all OMV standards. The increase in the KPI values can be explained by the same reason mentioned in the conclusion of the previous well cluster. Because of the understaffed situation drilling personnel is under pressure and do not put much effort on optimizing issues.

5.2.3 Cluster: Exploration Well, Total Depth under 3000m

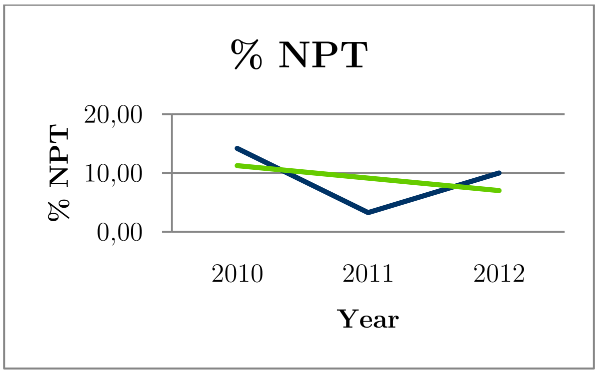
The last well cluster for the subsidiary Austria concerns wells drilled for exploration issues with a TD under 3000m. In the case of this cluster wells were drilled in 2010, 2011 and 2012. The trends are displayed in the next graphs and have the following values. Days/1000m decreased from 13.7 in 2010 to 5.7 in 2012. The KPI cost/m dropped by approximately € 400.00 per meter between 2010 and 2012 and the NPT fluctuated, but shows in general a decreasing linear trend. The HSSE KPIs are pretty clear as there was no incident in 2010 and 2011 while in 2012 the LTIF and TRIF rate rose to 0.33.



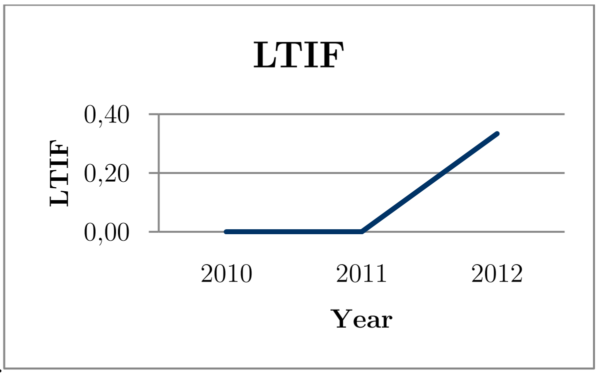
Graph 43: AUT (E, <3000), Days/1000m



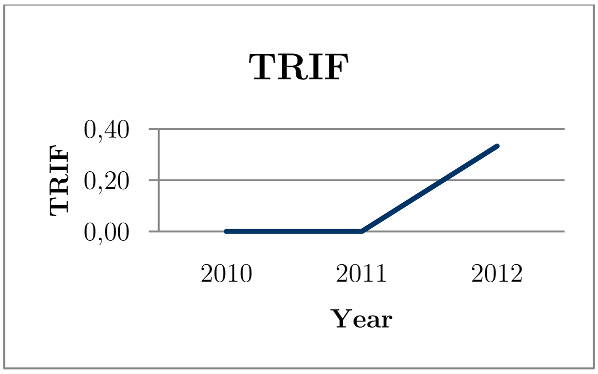
Graph 44: AUT (E, <3000), Cost/m [EUR]



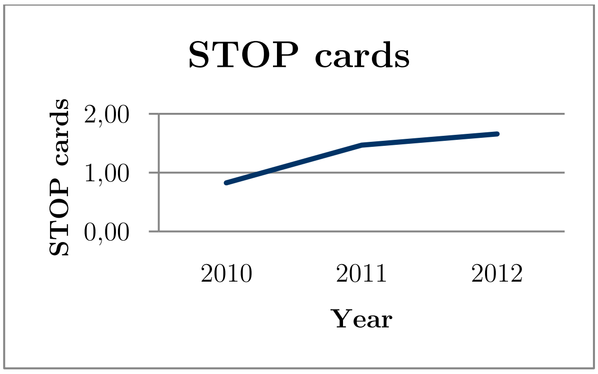
Graph 45: AUT (E, <3000), %NPT



Graph 46: AUT (E, <3000), LTIF



Graph 47: AUT (E, <3000), TRIF



Graph 48: AUT (E, <3000), STOP cards

Interpretation

For this well cluster the improved performance from 2010 to 2011 is a result of the strong decrease of OP audit findings. Further, Perazzoli was the second year under contract and familiar with OMV operations and processes. This is as well a reason for the positive KPI development in 2011. Considering that in 2012 Drilltec was under new contract and not familiar with operations and processes, the KPI development can be assessed as a positive one.

5.3 Kazakhstan

Key Performance Indicator Database

Between 2011 and 2013 twelve wells were drilled in Kazakhstan. Four of them were classified as development wells with a TD over 3000m and the eight were classified as development wells with a TD under 3000m. The rig history shows two operators were responsible for the drilling operations. Nabors drilled with rig forty four wells in 2011 and subsequent four wells in 2012. Between the two years of operation Nabors was under a constant contract and the rig crew remained steady with no changes. After Nabors was released in 2012 Cracow was hired in 2013 and responsible for drilling four further wells in 2012. When analysing the KPIs this contractor change should be considered.

		Nabors		Cracow
	2010	**2011**	**2012**	**2013**
40				
TR 800				

Table 6: KAZ Rig History

Operation Audit Database

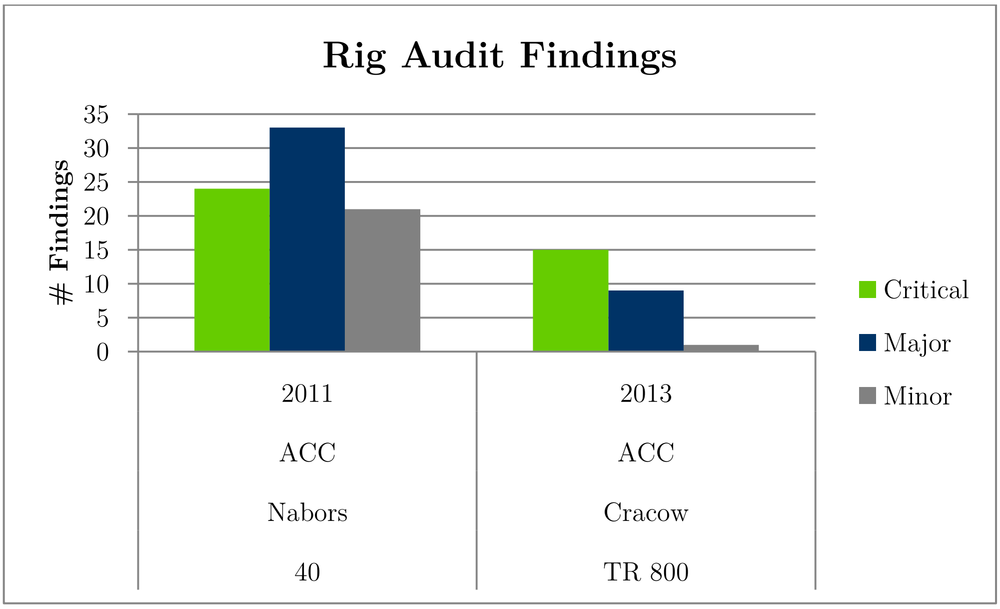
In Kazakhstan OP audits were conducted in 2010, 2011 and 2013. The missing audit in 2012 refers to the fact that the evaluation in 2010 and 2011 was good and therefore executing an audit was not required. The audits referred to drilling and workover operations and the out-come was the following. In total, for drilling operations five findings occurred while only one finding appeared more often than once. During the workover audits, in total six findings were found over the reviewed period and the following table shows frequently occurring findings.

Step	Document	Drilling_1/ WO_2	2010	2012	2011	2013	HSSE	Performance	Costs
1.3	Preliminary Work Program	1			x	x		x	x
2.4	Ready to Spud	2	x		x				x
9.6	Barrier Philosophy	2	x			x	x	x	
10.11	Contractor Management	2	x		x		x	x	x

Table 7: KAZ OP Findings Matrix

Rig Audit Database

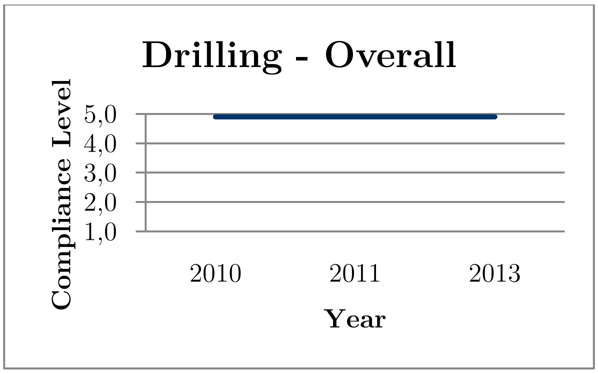
The rig audit database shows the following observations: for both rigs only acceptance audits were executed. Because Nabors was released in 2012, no regular audit was conducted in that year. The Nabors acceptance audit showed twenty-four critical, thirty-three major and twenty-one minor findings. In contrast, for the new hired contractor Cracow fifteen critical, nine major and one minor findings were found. The reason why Nabors was released in 2012 was that the drilling campaign, for which they were hired, was finished and their contract was not extended.



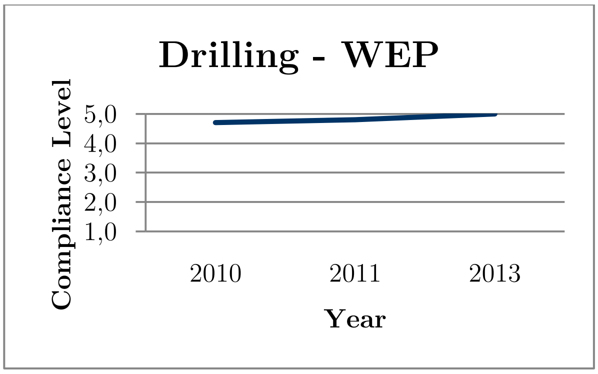
Graph 49: KAZ Rig Audit Findings

Compliance Level

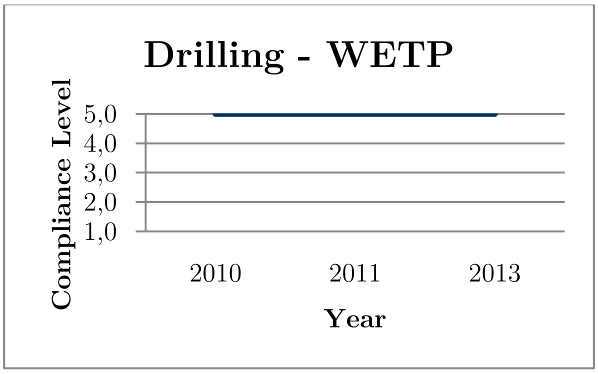
As already mentioned in 2010, 2011 and 2013 OP audits for drilling and workover operations were executed. In general for both operation types the overall compliance level is high and the subsidiary should definitely make an effort to follow this trend. For drilling operations the WEP compliance increased steadily from 4.7 in 2010 to 5.0 in 2013. The WETP compliance remained steady at a level of 5.0 over the period of review while the WEMS compliance decreased very slightly in 2013 to 4.9. For workover operations, the compliance level trends show the same positive development. The WEP compliance increased from a level of 4.8 in 2010 and 2011 to 5.0 in 2013. The WETP decreased from a steady 4.8 level in 2010 and 2011 to 4.5 and the WEMS compliance remained steady at a level of 4.9.



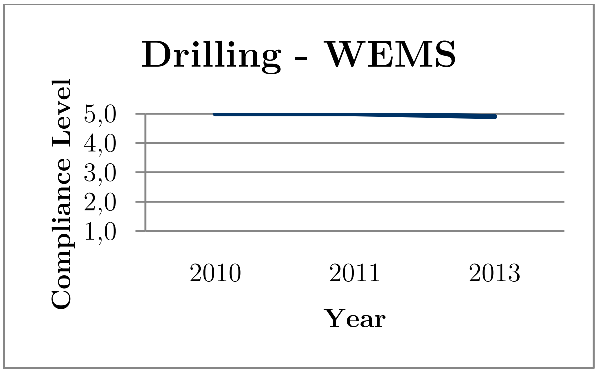
Graph 50: KAZ Overall Compliance Drilling



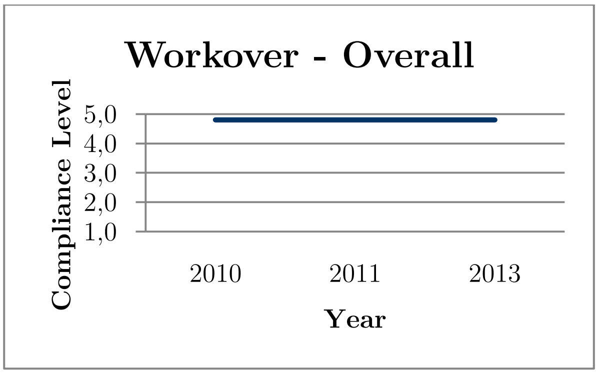
Graph 51: KAZ WEP Compliance Drilling



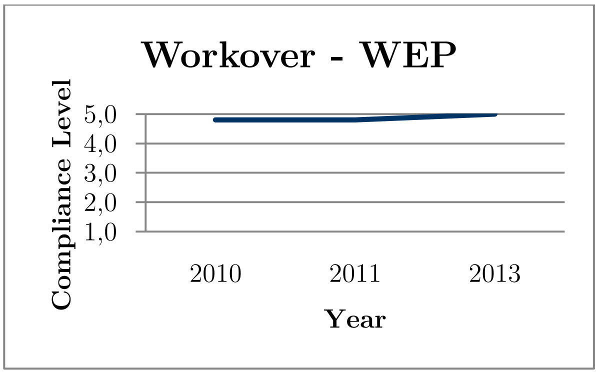
Graph 52: KAZ WETP Compliance Drilling



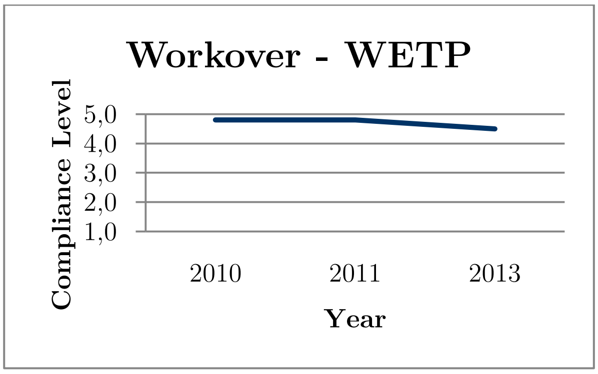
Graph 53: KAZ WEMS Compliance Drilling



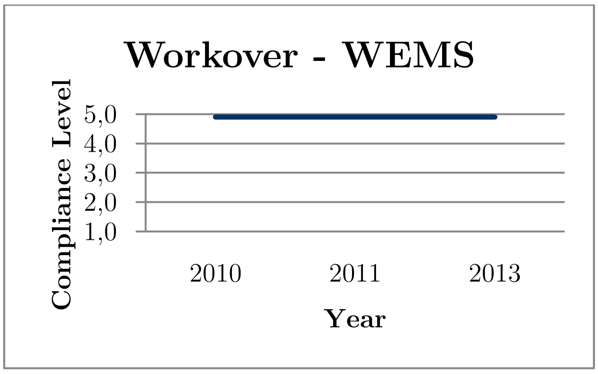
Graph 54: KAZ Overall Compliance Workover



Graph 55: KAZ WEP Compliance Workover



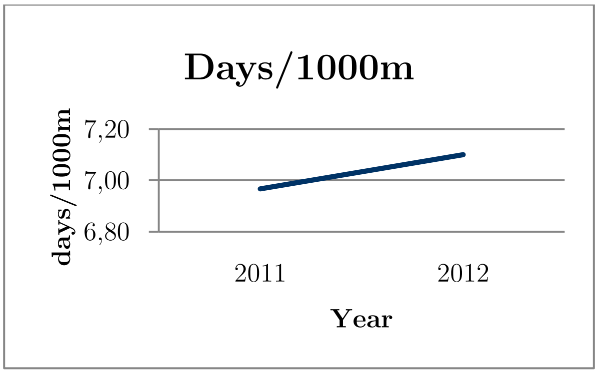
Graph 56: KAZ WETP Compliance Workover



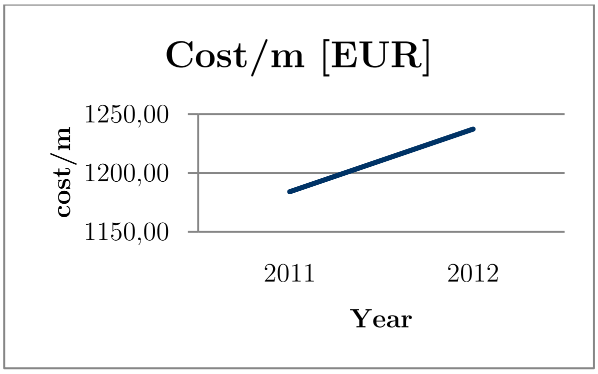
Graph 57: KAZ WEMS Compliance Workover

5.3.1 Cluster: Development well, Total Depth over 3000m

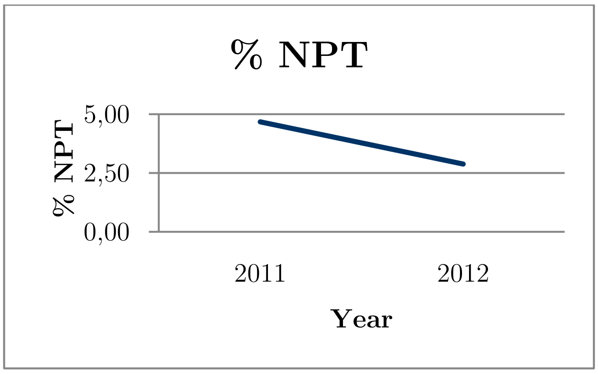
The performance and HSSE trends show the following development. The days/1000m KPI increased by 0.1 day/1000m which is negligible and therefore remained on a steady level during the two years of operations. An equal trend shows the KPI cost/m as the cost increased by less than € 100.00, this is insignificant. Contrary to these two KPIs the NPT dropped from 4.7% to 2.9% which is a quite good development as it decreased by almost half. The development of HSSE KPIs is straight forward as the LTIF and TRIF rates remained on a steady zero level and the number of STOP cards increased from 6.3 cards in 2011 to 7.7 cards in 2012.



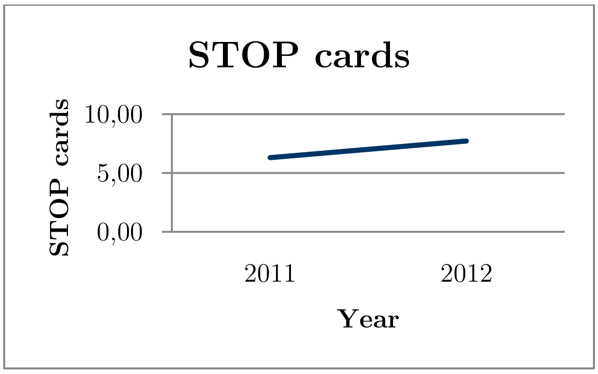
Graph 58: KAZ (D, >3000), Days/1000m



Graph 59: KAZ (D, >3000), Cost/m [EUR]



Graph 60: KAZ (D, >3000), % NPT



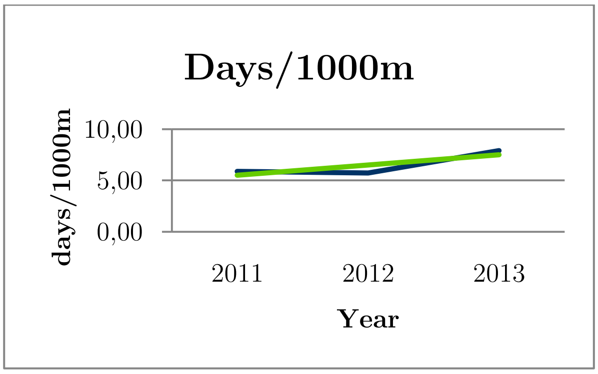
Graph 61: KAZ (D, >3000), STOP cards

Interpretation

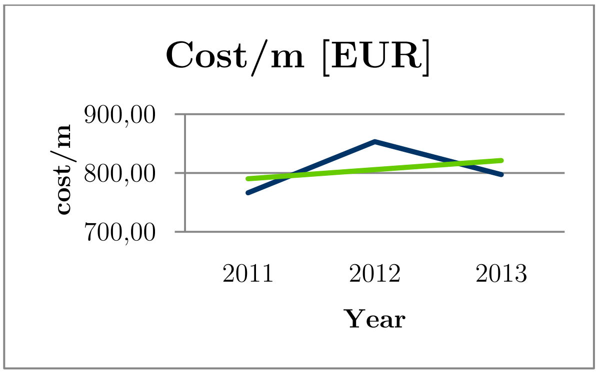
The interpretation for this well cluster is easy because the trends show an upward development. The steady increase of performance and cost KPIs can be referred to the fact that between 2011 and 2012 operations were under the same contractor and there was no rig crew change. A second factor that might have influenced the positive KPI development belongs to the high rated compliance levels of the OPs audits. A high compliance level means that operations follow a predefined process and therefore inefficiencies like time lagging or cost increase are avoided. Additionally the high compliance level is reflected in the HSSE KPIs as they stay on a steady zero level since 2011.

5.3.2 Cluster: Development well, Total Depth under 3000m

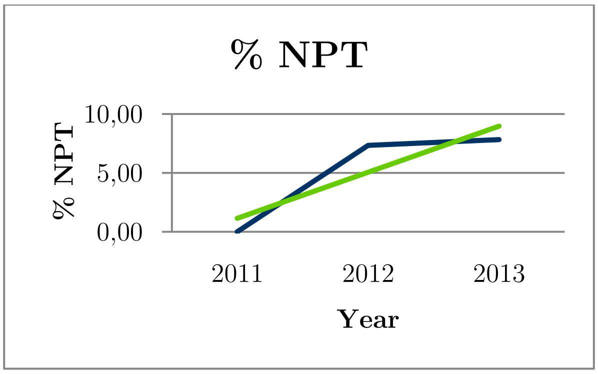
For development wells with a TD under 3000m the KPI value increases by two days/1000m from 2011 to 2013. The cost/m KPI also shows an increasing total linear trend although the trend incline is slight. In Graph 63 the trend was fluctuating within approximately € 100.00 with a peak in 2012. The NPT increased from zero in 2011 to 7.3 in 2012 and remained steady afterwards. The HSSE KPIs trend is self-explanatory. During the period of review the LTIF and TRIF remained on a zero level while the number of STOP cards followed a decreasing trend from 8.8 in 2011 to 7.2 in 2012 and to 6.3 in 2013.



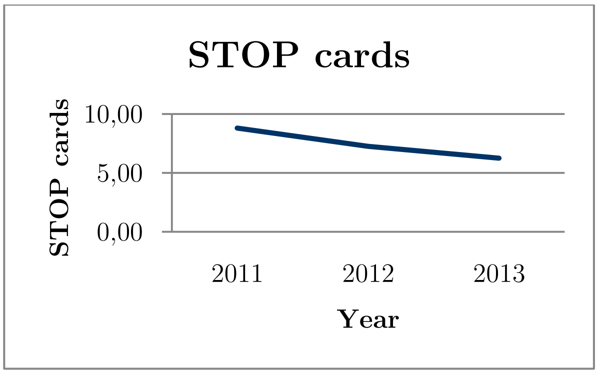
Graph 62: KAZ (D, <3000), Days/1000m



Graph 63: KAZ (D, <3000), Cost/m [EUR]



Graph 64: KAZ (D, <3000), % NPT



Graph 65: KAZ (D, <3000), STOP cards

Interpretation

The increase in days/1000m in 2013 can be explained by the new contracted operator with a new rig crew. Because the new contractor Cracow has been operating the first time for OMV, and therefore has less experience with OMV systems, the increase in days/1000m can be explained by that. In general, Cracow is operating efficient because the cost/m KPI is within the Nabors range and the NPT is nearly the same like the one for Nabors in 2012.

5.4 Kurdistan Region of Iraq

Before starting with a detailed analysis of the subsidiary, one important fact has to be mentioned. Due to special geological conditions in the Bina Bawi Field the KPI trends should not be handled as reference values for drilling performance or costs. The Bina Bawi Field is characterized by caves which are responsible for tremendous mud losses and therefore for extreme drilling conditions.

Key Performance Indicator Database

The KPI Database lists five wells, drilled between 2010 and 2013. All of them were drilled as exploration wells, three of them with a TD over 3000m and two with a TD under 3000m. During the period of review four different contractors were operating. The following rig history shows that Aladdin Middle East was contracted in 2011 and responsible for drilling the well Bina Bawi 3. Weatherford operated in 2010 while Sakson was from October 2012 until July 2013 responsible for Bina Bawi 5 operations. KCA Deutag was hired in 2011 and operated from November 2011 to February 2012 and June 2012 to July 2013. The last well KCA Deutag drilled was Bina Bawi 4. The rig history points out that the time horizon for drilling operations for Bina Bawi wells were disproportional.

	2010	2011	2012	2013
Aladdin Middle East - Rig 8				
Weatherford - WF 319				
Sakson - PR3				
KCA Deutag -T63				

Table 8: KRI Rig History

Operation Audit Database

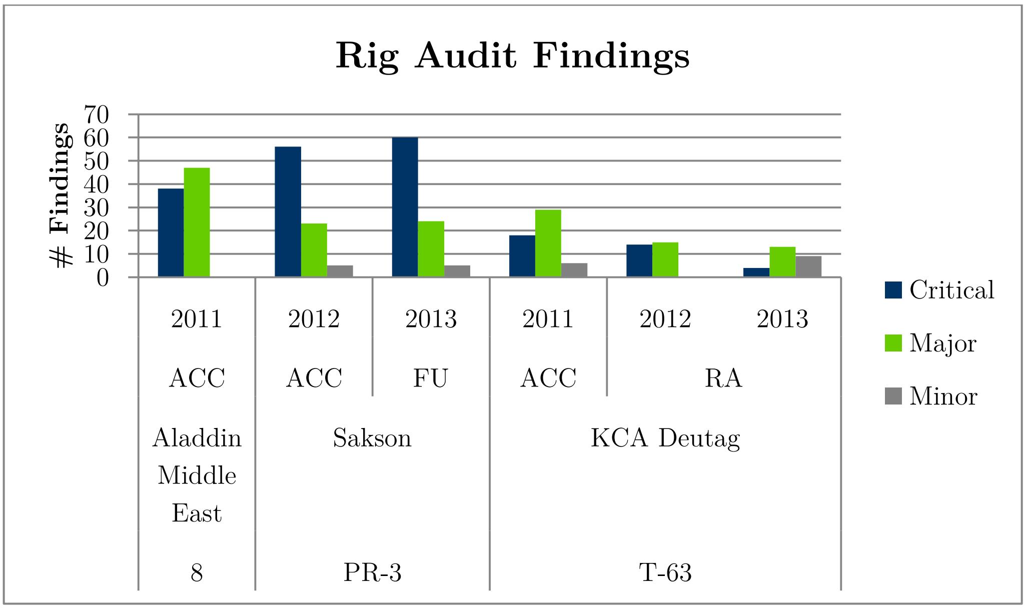
OP audits by EPW-A were conducted in 2010, 2011 and 2013 for drilling operations and in 2013 for workover operations. The number of findings decreased from thirty-nine in 2010 to eighteen in 2011, which is a reduction by half. Although the frequency of findings occurrence reduced in 2013, the total number of findings increased slightly between 2011 and 2013. This increase might be the result of a missing audit initiative in 2012 and therefore of a declining compliance awareness. Nevertheless, the linear findings trend is decreasing what means that the count of findings is decreasing. The majority of the audit findings had an impact on performance parameters followed by the impact on HSSE and costs. The audit concerning workover operations shows a total number of twenty findings, where ten were related to HSSE and/or performance KPIs and six to cost KPIs.

Step	Document	Drilling_1/ WO_2	2010	2011	2012	2013	HSSE	Performance	Costs
1.10	Peer Review	1	x	x				x	x
1.3	Preliminary Work Program	1	x	x		x		x	x
1.8	Organization Structure	1	x	x					x
10.10	Peer Review	1		x		x	x		
10.11	Final Approved AFE	1		x		x	x	x	x
10.3	Dispensation procedure	1	x	x		x	x	x	
10.9	Safety and Environmental Awareness	1	x	x		x	x		
13.4.3	Well Files	1	x	x				x	
7.2	Pore Pressure	1	x	x				x	
7.3	Casing Seat Selection	1	x	x				x	x
8.1	Rig Selection and Audit	1	x			x	x	x	
8.2	Equipment Certification	1	x	x		x	x	x	
8.4	Safety Critical Rig Equipment	1	x	x			x	x	
8.5	Integrity of procured Equipment and Service	1	x	x			x	x	
8.5.4	Contractor Personnel Competence	1	x	x			x	x	x

Table 9: KRI OP Findings

Rig Audit Database

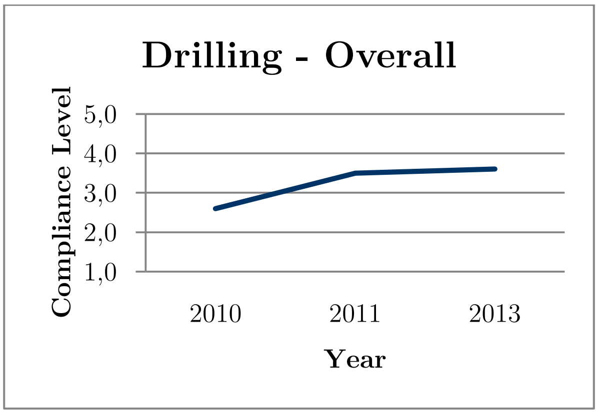
Because four different contractors were operating and a significant number of rig audits were conducted, it is interesting to analyse the development of rig audit findings in more detail. Additionally the impact of different contractors on HSSE, performance and cost KPIs can be displayed. Graph 66 shows, the number of rig audit findings for Sakson increased from 2012 to 2013. In general this trend is not acceptable, especially due to HSSE issues it is essential that the number of critical findings is decreasing over the time horizon. Contrary to this, findings of KCA Deutag show a positive trend as their number decreased steadily from one audit to another. As already mentioned this development can also be directly linked to the performance KPIs, more information on that is given in the interpretation.



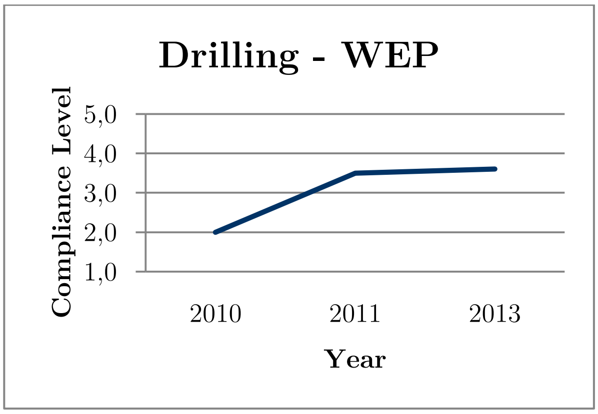
Graph 66:: KRI Rig Audit Findings

Compliance Level

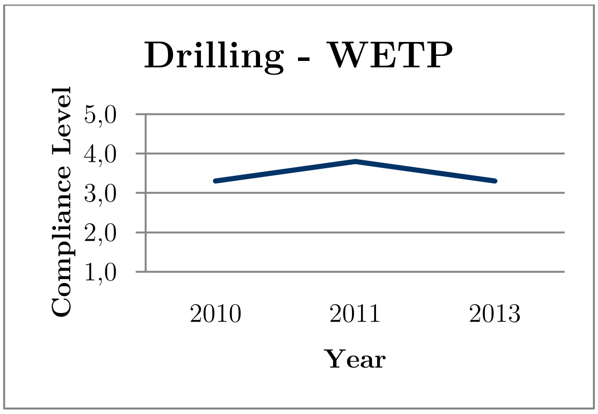
As the compliance level graphs show, the linear trend for drilling operations is rising in the case of the WEP and WEMS. Although the WEP compliance level rose by 1.6 points and by 1 point in the case of WEMS over the period of review, there is still plenty of room for improvement. The linear trend for the WETP is a flat line which equalizes compliance level fluctuations on a 3.5 points level. For workover operations the compliance level for the WEP, WETP and WEMS stays between 3.0 and 3.5. Because only one workover audit was conducted in 2013, it is not possible to see a trend. Nevertheless, there is as well plenty of room for improvement concerning workover compliance.



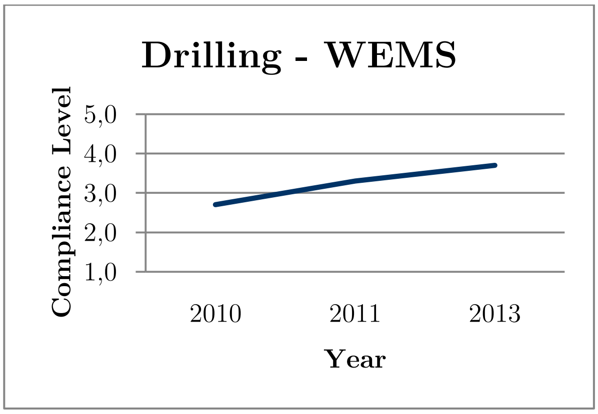
Graph 67: KRI Overall Compliance Drilling



Graph 68: KRI WEP Compliance Drilling



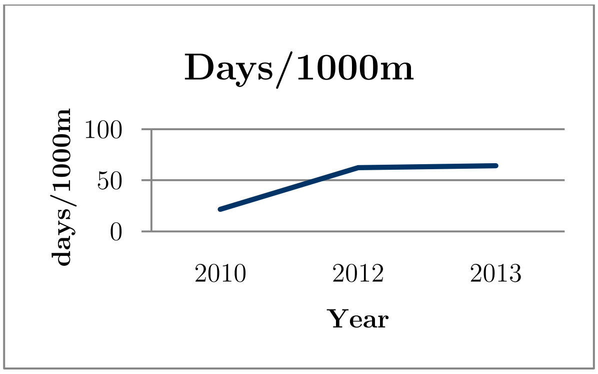
Graph 69: KRI WETP Compliance Drilling



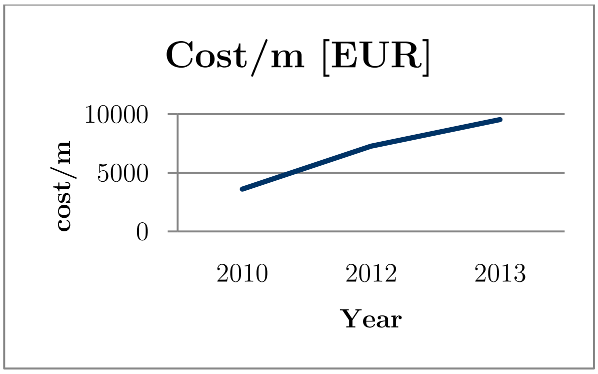
Graph 70: KRI WEMS Compliance Drilling

5.4.1 Cluster: Exploration Well, Total Depth over 3000m

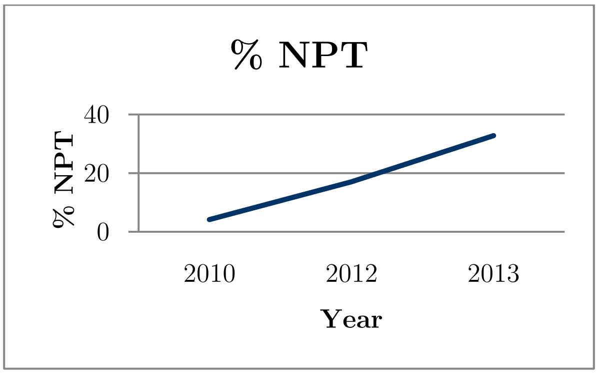
The performance and cost graphs show a negative KPI development. The metric for days/1000m increased from 21.68 up to 64.40 days/1000m. Cost/m rose by almost 65% over the period of review and the NPT ascent as well to an alarming level of 32.80%. The only good fact with these trends is, that the reason for this development and that the responsible factors are known and therefore initiatives for preventing them in future can be carried out.



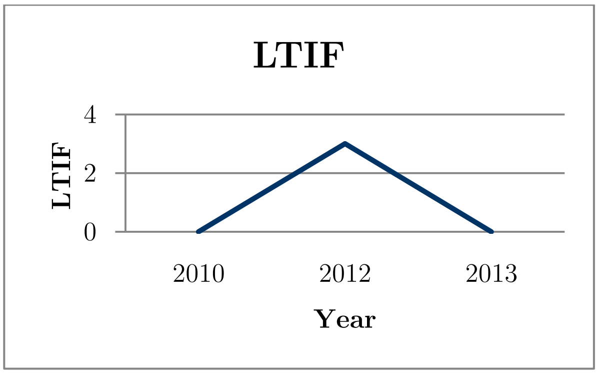
Graph 71: KRI (E, >3000), Days/1000m



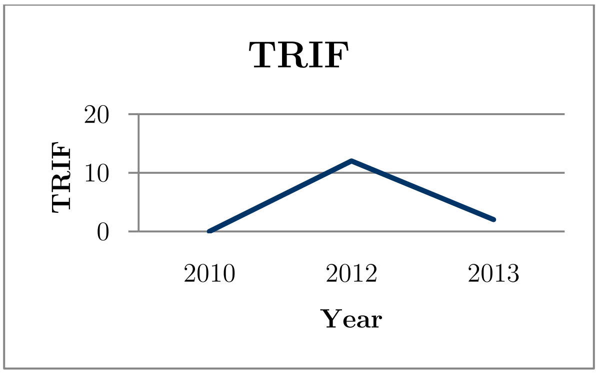
Graph 72: KRI (E, >3000), Cost/m [EUR]



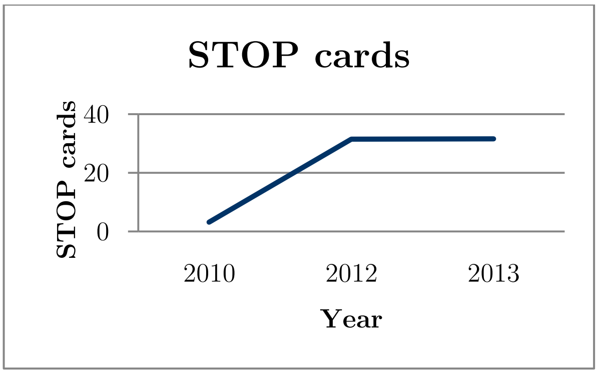
Graph 73: KRI (E, >3000), %NPT



Graph 74: KRI (E, >3000), LTIF



Graph 75: KRI (E, >3000), TRIF



Graph 76: KRI (E, >3000), STOP cards

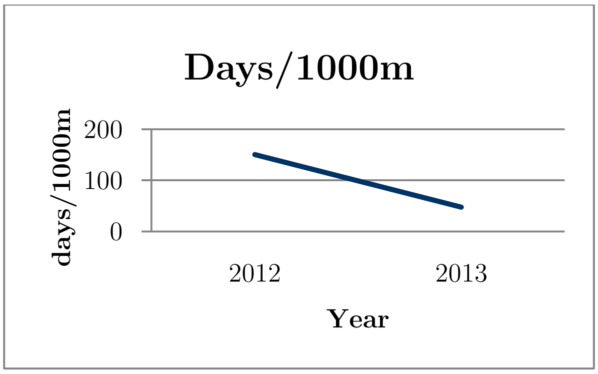
Interpretation

Further background information on the well Mala Omar 1 drilled in 2012 has to be considered. In November 2011 KCA Deutag started with drilling operations for Mala Omar 1. After one- hundred-eighty-six days of drilling the well was plugged and the rig was released and moved to Bina Bawi 4. The reason was, that the commitment for Bina Bawi drilling operations expired in 2013 and therefore it was urgently to start operations before expiring. Because of that KCA Deutag moved to Bina Bawi 4 to start drilling operations. Sakson rigged up at Mala Omar 1 and continued drilling operations there. One problem Sakson had to face referred to a stuck pipe for which reason a sidetrack was drilled. The second big problem was that due to insufficient maintenance the break system collapsed which led to a dropped travel block. These two problems caused massive time lagging and increasing costs.

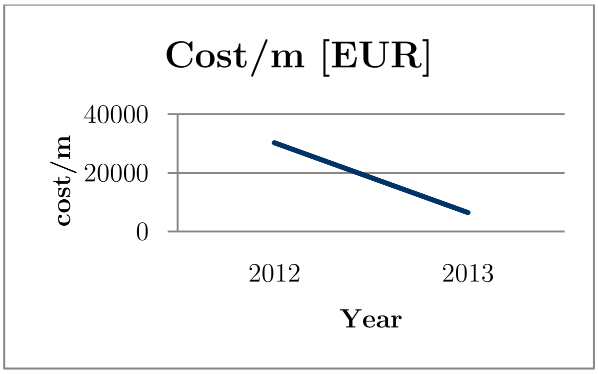
These two problems are directly reflected by the peak in the days/1000m and cost/m KPI graphs. In 2013 the KPI days/1000m remained on a steady level, but due to a TD of 4163m and therefore an exponential increase in performance and cost KPIs, this can be seen as a positive trend. Another fact that influenced the flat trend line between 2012 and 2013 might be, that KCA Deutag was the responsible drilling operator for this cluster in 2013 and as the above rig audit findings graph reveals the number of critical findings was less in 2013. The ascending cost/m trend line from 2010 to 2013 can be explained by the same facts which influenced the days/1000m KPI. Time lagging, caused by the contractor change and the already mentioned drilling problems can be directly connected to the cost increase in 2012. The continuing cost ascent in 2013 can be explained again by the TD and the exponential cost rise for deep bottom holes. The same explanation can also be referred to the ascending NPT. The spike in the HSSE KPIs, LTIF and TRIF, refers to the dropped travel block during Mala Omar 1 drilling operations. The increasing number of STOP cards in 2012 and 2013 can be interpreted as an increased compliance and safety awareness for preventing incidents by using STOP cards. This goes along with a decreased number of OP audit and Rig audit findings. Therefore the improved HSSE KPIs can be directly linked to the new hired operator KCA Deutag in 2012.

5.4.2 Cluster: Exploration well, Total Depth under 3000

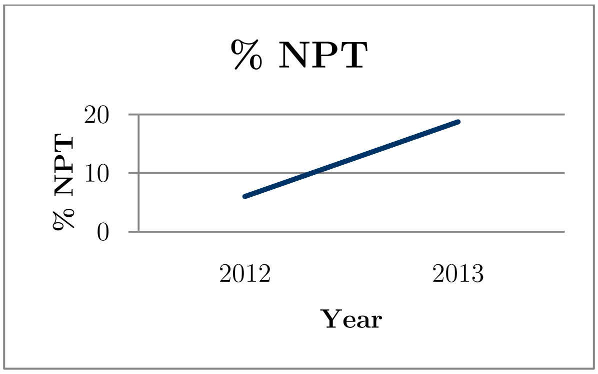
The graphs for exploration wells with a TD under 3000m, KPI values are decreasing which means that in general performance is improving. Days/1000m and cost/m decreased as well as the LTIF and TRIF rates. In 2013 LTIF and TRIF rates reached a zero incident level which is a very positive development. The number of STOP cards is rising what might be reflected in an increased safety awareness.



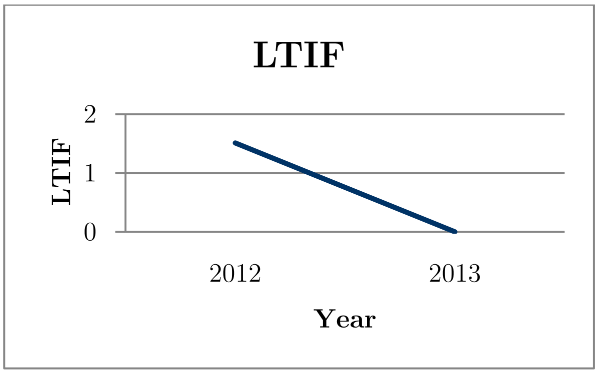
Graph 77: KRI (E, <3000), Days/1000m



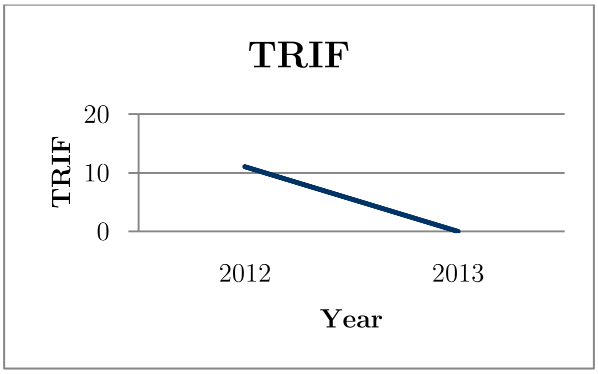
Graph 78: KRI (E, <3000), Cost/m [EUR]



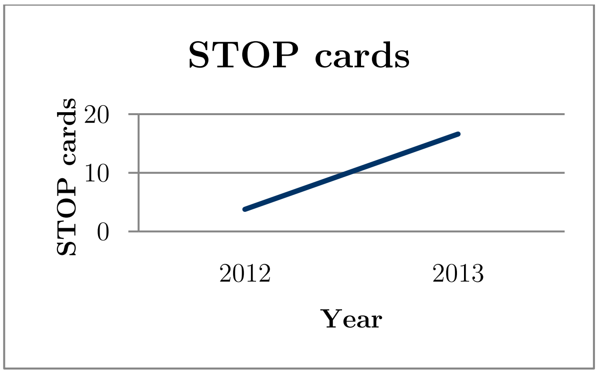
Graph 79: KRI (E, <3000), % NPT



Graph 80: KRI (E, <3000), LTIF



Graph 81: KRI (E, <3000), TRIF



Graph 82: KRI (E, <3000), STOP cards

Interpretation

In 2012 Aladdin Middle East was as the operating drilling contractor responsible for drilling Bina Bawi 3 while in 2013 Sakson was acting as the operator because Aladdin Middle East was released. Although Saksons performance looks compared to the one of Aladdin Middle East much better, it has to be recognized that Sakson is marked by an extreme high number of critical rig audit findings. The number of criticals increased from fifty-six in the acceptance audit to sixty in the follow-up audit which is absolute inacceptable. This is also reflected in the NPT rise because in general a higher number of critical findings lead to higher downtimes and therefore to a higher NPT.

5.5 Norway

Key Performance Indicator Database

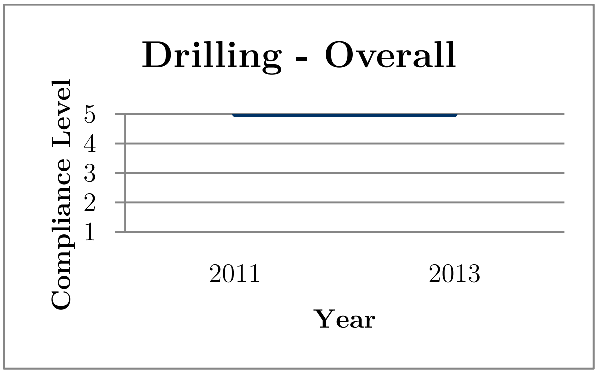
In Norway only one well was drilled in 2011, which was an offshore one. Therefore the KPIs are non-competitive. Because it's useless to show and analyse graphs with only one data point the HSSE, performance and cost KPIs are summarized in Table 10.

Well	Chamonix
Year	2011
Well Type	E
TD	3545
Contractor	Dolphin
Rig	Borgland Dolphin
days/1000m	10.05
cost/m [EUR]	0.00
%NPT	2.60
LTIF	2.00
TRIF	0.00
STOP cards	22.30

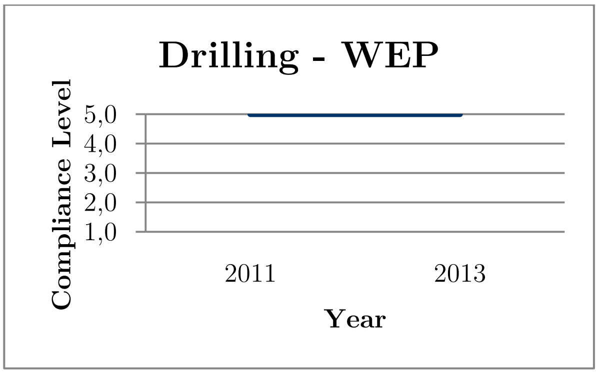
Table 10: Chamonix Data

Compliance Level

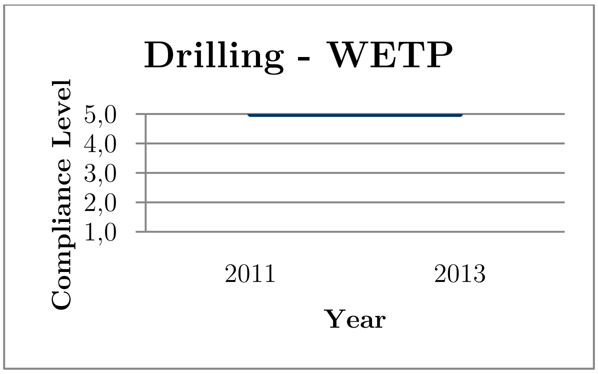
The outcome of Norway's OPs audits is self-explanatory. The WEP and WETP trend stays at a top level rating of five. Only the WEMS compliance shows little room for improvement because there the compliance level is marked with 4.9 points.



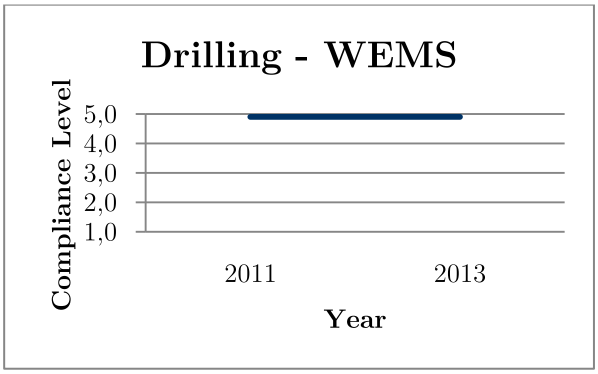
Graph 83: NOR Overall Compliance Drilling



Graph 84: NOR WEP Compliance Drilling



Graph 85: NOR WETP Compliance Drilling



Graph 86: NOR WEMS Compliance Drilling

5.6 Pakistan

Key Performance Indicator Database

The KPI Database lists KPIs of seventeen wells, drilled in Pakistan between January 2010 and September 2013. All wells have a TD over 3000m at which ten of them were classified as development wells and the remaining seven as exploration wells. Between 2010 and 2013 two rigs were used for drilling operations. From 2010 to 2012 the rig owner was Schlumberger SLDC and changed to Saxon in 2013 which is a privately owned company held by Schlumberger Ltd. During the time while rig 15 was operating fluctuation of the rig crew was there, however most of the key personnel retained. The same applies for rig 25 where most of the key personnel remained with the rig while it was with another operator.

	Schlumberger SLDC			Saxon
	2010	2011	2012	2013
Rig 15				
Rig 25				

Table 11: PAK Rig History

Operation Audit Database

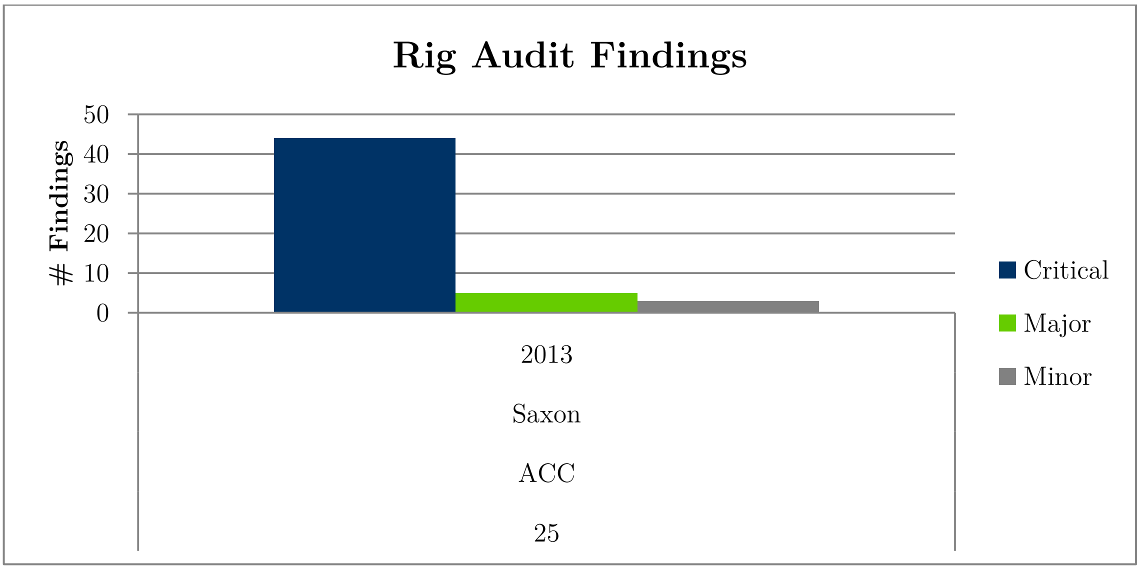
Operations Audits by EPW-A were conducted in 2010, 2011 and 2013. Due to the security situation in 2012 an audit was conducted by the subsidiary itself and is therefore not representative and included in the analysis. In general, the operational audits conducted in Pakistan refer all to drilling operations. The quality analysis of the operational audit reports produced the following. The total number of findings decreased from 2010 to 2011 tremendous, whereas there was a slight increase from 2011 to 2013. Expressed in numbers this means that in 2010 thirty- two findings were accounted in which fourteen were critical. In 2011 one finding occurred and in 2013 six findings were counted. Five findings occurred more than once, at which only the finding “Organization Structure” was marked red throughout. In general, the strongest effect of the findings is first on performance, followed by the influence on HSSE and costs.

Step	Document	Drilling_1/ WO_2	2010	2011	2012	2013	HSSE	Performance	Costs
1.5	Well Economics	1	x			x			x
10.9	Safety and Environmental Awareness	1	x			x	x		
8.1	Organization Structure	1	x	x		x	x	x	
8.2	Equipment Certification	1	x			x	x	x	
8.4	Safety Critical Rig Equipment	1	x			x	x	x	

Table 12: PAK OP Findings Matrix

Rig Audit Database

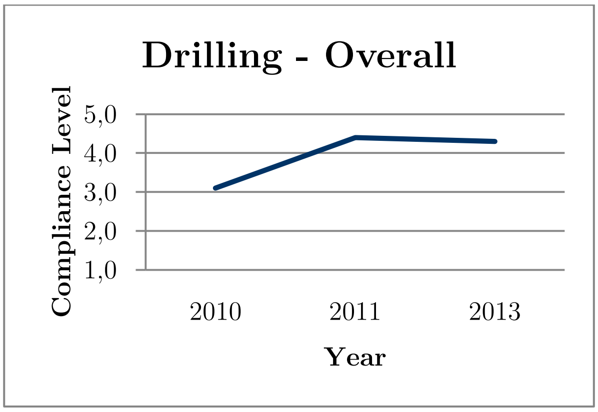
In 2011 ModuSpec conducted a pre-hire audit for rig 15. After a positive acceptance audit, a regular audit by EPW-A in 2012 was planned, but due to security reasons is was conducted by a Pakistani supervisor and therefore cannot be counted as a regular one. For rig 25 in 2013 once more an acceptance audit was executed because of the rig owner change. The regular audit in 2012 was refused for the same reason mentioned for rig 15. As the following graph reveals during the acceptance audit of rig 25 in 2013 forty four critical, five major and three minor findings occurred.



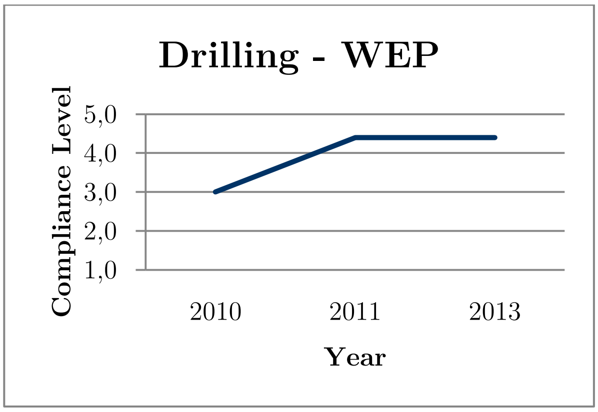
Graph 87: PAK Rig Audit Findings

Compliance Level

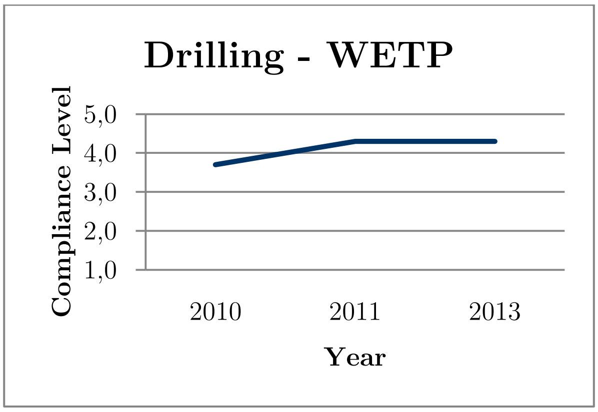
The following graphs point out the trend of the overall compliance level in the subsidiary increased from 2010 to 2013. In 2010 a level of 3.1 was reached which jumped in 2011 up to 4.4. In 2013 there was just a very slight decline of 0.1 points to 4.3. A similar trend is displayed by the WEP, WETP and WEMS compliance. The WEP compliance level increased by 1.4 points from 3.0 in 2010 up to 4.4 in 2011 and remained steady until 2013. WETP compliance rose from 3.7 in 2010 up to 4.3 in 2013. In 2010 the WEMS compliance level was marked with 3.3 points, increased up to 4.4 points in 2011 and slightly decreased to 4.3 in 2013.



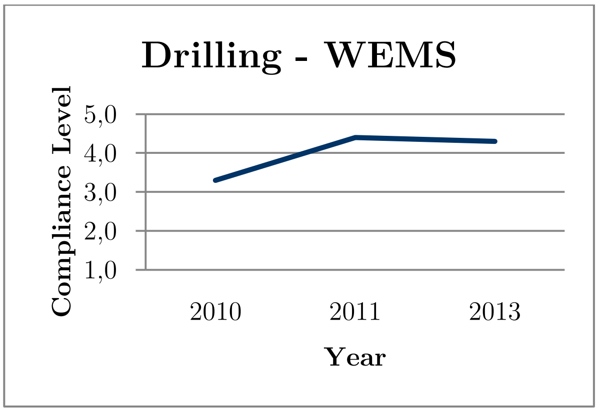
Graph 88: PAK Overall Compliance Drilling



Graph 89: PAK WEP Compliance Drilling



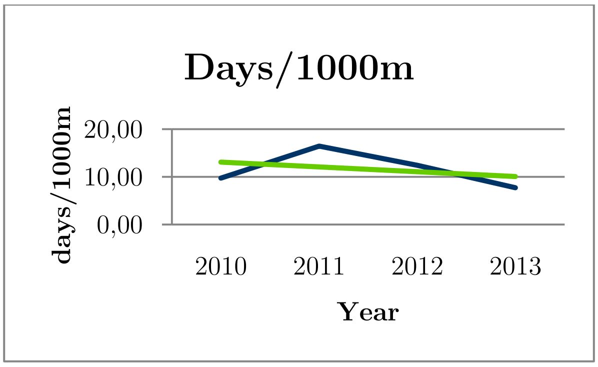
Graph 90: PAK WETP Compliance Drilling



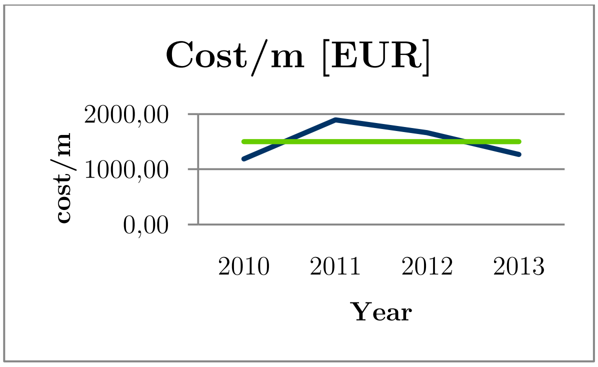
Graph 91: PAK WEMS Compliance Drilling

5.6.1 Cluster: Development Well, Total Depth over 3000m

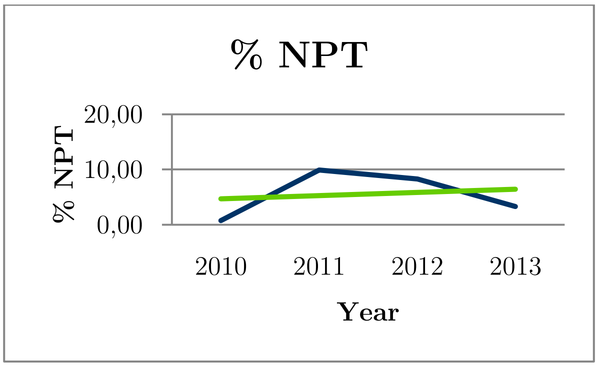
In this well cluster the linear trends in the KPI graphs show different developments. While the linear trend for the KPI days/1000m was decreasing from 2010 to 2013 the trend for cost/m stay at a constant level over the period of review. Contrary to that the NPT follows an increasing linear trend. The HSSE KPIs show in Pakistan a very positive development as they LTIF and TRIF rates were at a constant level of zero. The number of STOP cards was increasing from a five in 2010 up to twenty-four in 2013 and that is a positive development, showing increase of awareness.



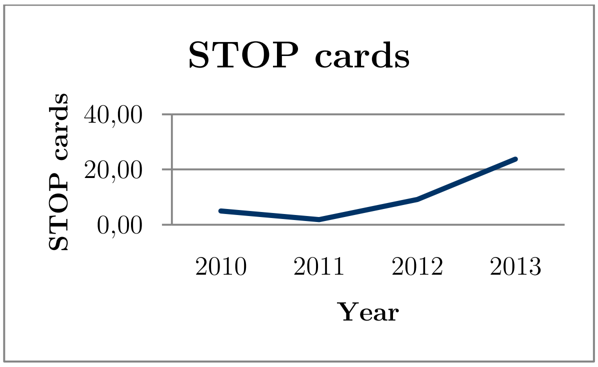
Graph 92: PAK (D, >3000), Days/1000m



Graph 93: PAK (D, >3000), Cost/m [EUR]



Graph 94: PAK (D, >3000), % NPT



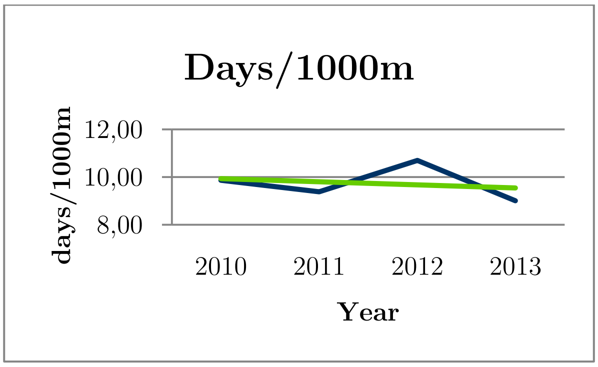
Graph 95: PAK (D, >3000), STOP cards

Interpretation

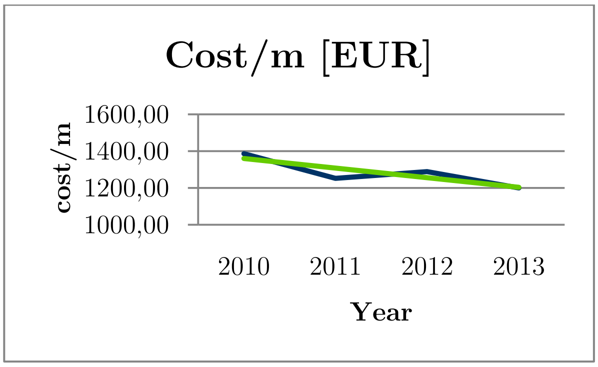
In general, the drilling performance trend correlates with the development of the compliance level. This means that over the period of review the compliance level is increasing steadily while the values for cost/m and days/1000m are decreasing, so the performance is increasing. Giving an interpretation on the trend development the following background information should be considered. For drilling operations in 2010 rig 25 was operating while in 2011 rig 15 was on operation. This rig change may be a reason for the increase in days/1000m, cost/m and NPT. The impact of the rig change on performance KPIs can be explained by the fact that warm-up time for a new rig always takes longer than for one that was already in operation. Additionally between September 2010 and March 2011 no drilling operations were ongoing and the first wells drilled in 2011 were development wells followed by two exploration drilling operations. That also may support the theory why the trend for development wells had a spike in 2011.

5.6.2 Cluster: Exploration Well, Total Depth over 3000m

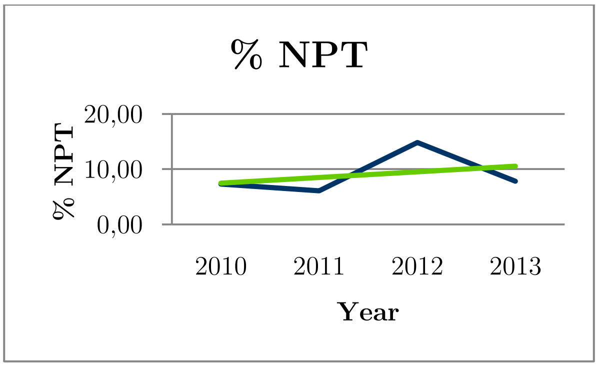
The KPI graphs show, that the linear trend for days/1000m and cost/m have been decreasing since 2010 steadily while the NPT has been following a slightly increasing linear trend. The trends for the three HSSE KPIs show a very positive development at which the LTIF and TRIF trend has been remaining steady at a zero level since 2010 and the number of STOP cards has been increasing over the reviewed period. The benefit of an increasing number of STOP cards is, that the subsidiary staff and rig crew becomes more and more aware of the importance of HSSE issues, therefore treat them more seriously and try to avoid incidents by issuing STOP cards.



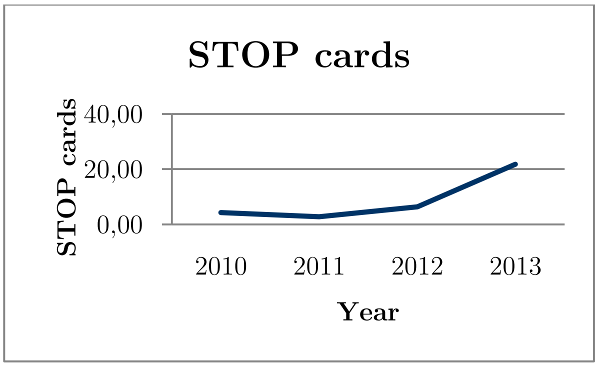
Graph 96: PAK (E, >3000), Days/1000m



Graph 97: PAK (E, >3000), Cost/m [EUR]



Graph 98: PAK (E, >3000), % NPT



Graph 99: PAK (E, >3000), STOP cards

Interpretation

As already mentioned in the interpretation of development wells with a TD over 3000m, the performance trend interacts with the compliance level. Feeding now the development of performance trends with some quality information, the positive development of the performance trend could be referred to the fact that the audit compliance level was improving between 2010 and 2011 greatly and stayed almost steady until 2013. Another fact that influences the performance trend might be that between 2010 and 2013 the key personnel retained although there was some fluctuation in the rig crew. Fluctuations in the rig crew could influence the drilling performance since the crew is not accustomed to each other or the crew competence is on a lower level when new personnel joined. Such personnel fluctuations for example could be a reason for the spike in the performance trends in 2012. Because of a lower crew competence operations might take longer what influences performance KPIs. Another issue responsible for the spike is that there were no ongoing operations for six month in 2012. This break also influences performance KPIs because the warm-up time for new operations after a break is in general longer as if a new operation starts immediately after an old one is finished. Furthermore the peak value in 2012 was influenced by realized adjustments on the operating rig. As the compliance level analysis shows, there was no operational audit conducted in 2012 and that might be as well a reason for the spike. Regarding this fact it is hard to sustain the overall compliance without pushing compliance attitude via audit initiatives each year.

5.7 Tunisia

Key Performance Indicator Database

During the period of review twenty-one wells were drilled in Tunisia. Fifteen of them were exploration wells with a TD over 3000m, while two had a TD below 3000m. Additionally four development wells with a TD over 3000m were drilled. During that time horizon, two rigs were operating in Tunisia. The contractor Helmerich & Payne stayed over the years the same as well as the contract in 2012 and 2013. In 2011 operations were shut down according to the Arabic spring riots. In 2012 a new rig crew continued operations.

	Helmerich & Payne			
	2010	2011	2012	2013
Rig 242				
Rig 228				

Table 13: TUN Rig History

Operation Audit Database

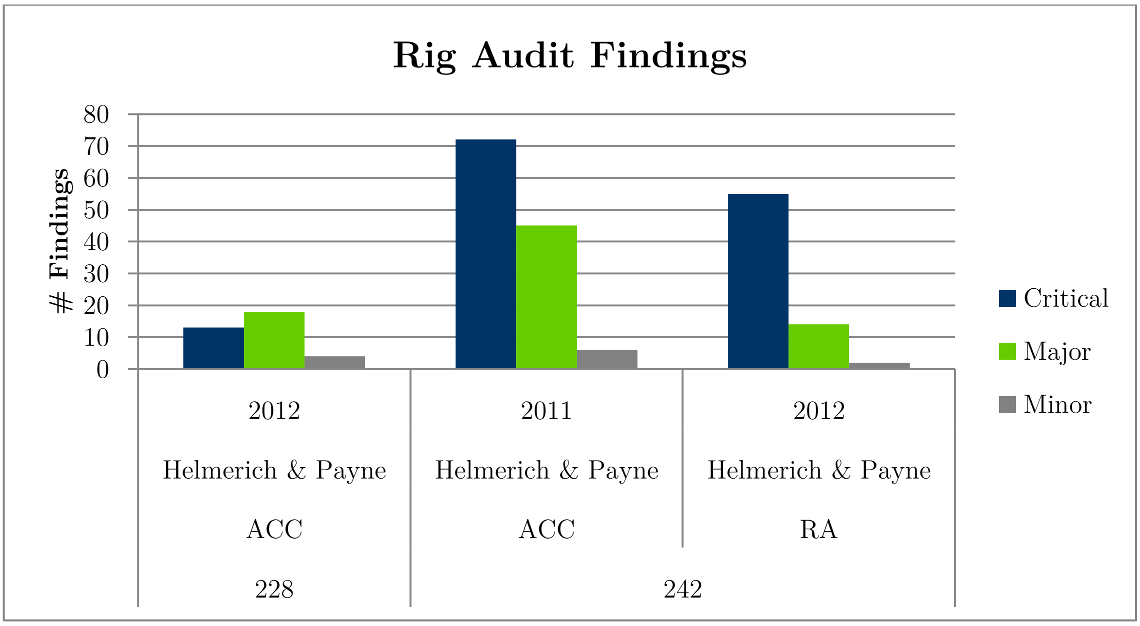
Between 2010 to 2013 EPW-A conducted operations audits with regard on drilling operations. Over the period of review the number of findings decreased from nineteen findings in 2010 to twelve findings in 2013. The OP findings matrix shows, that the steps “Long Lead Item AFE”, “External Benchmarking” and “Statements of Facts” show a weak development over the years and therefore their documentation and realization should be improved. Summarizing all the findings twelve of them had an impact on HSSE, thirty-four on performance KPIs and twenty-three on cost measures.

Step	Document	Drilling_1/ WO_2	2010	2011	2012	2013	HSSE	Performance	Costs
1.3	Preliminary Work Program	1	x	x	x			x	x
1.8	Long Lead Item AFE	1	x	x	x	x			x
11.2	External Benchmarking	1	x	x				x	
2.12	Statement of Facts	1	x		x	x		x	x
3.1a	Debris / Contamination Survey	1	x		x	x	x		
7.2	Pore Pressure	1	x		x	x		x	
7.9	Blowout Contingency Plan	1			x	x	x		
9.7	Coring Operations	1	x		x			x	

Table 14: TUN OP Findings Matrix

Rig Audit Database

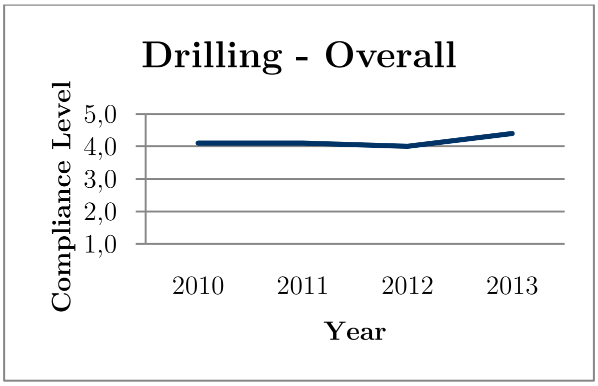
As in the rig findings graph displayed, for rig 228 only an acceptance audit was conducted. The rig was released a year after it was hired and therefore no regular audit was executed. For rig 242 the situation was different. There, in 2011 an acceptance audit was executed followed by a follow-up audit in 2012. In this regard the follow-up audit can be treated like a regular audit. The development of the findings numbers from the acceptance audit to the follow-up audit shows a positive trend, as the number of critical findings dropped by nearly twenty-five percent. It has to be mentioned that the number of fifty-five critical findings is too high because every critical generally acts as a show stopper.



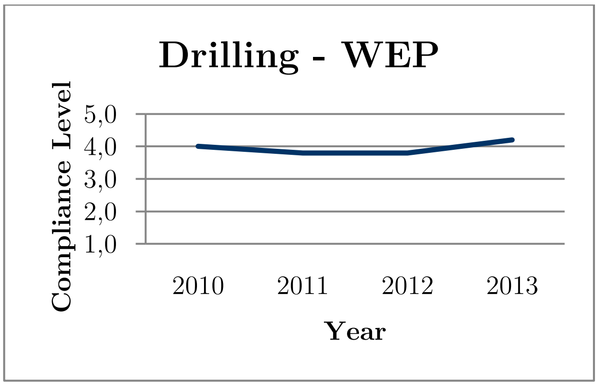
Graph 100: TUN Rig Audit Findings

Compliance Level

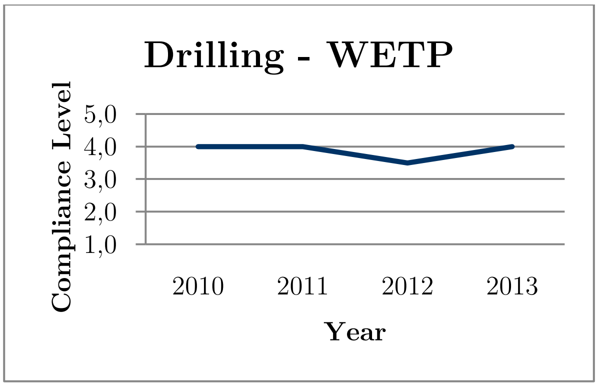
In general, the compliance level development shows a positive trend, although there are some trend fluctuations. The overall compliance level trend increased over the period of review, just with a very slight drop in 2012. This drop was the result from a decrease in the WEP compliance. Nevertheless, the overall compliance level improved again up to a level of 4.4 in 2013. The graphs show, that there is room for improving the compliance level for all sub-processes as the WEP reached a level of 4.2, the WETP of 4.0 and the WEMS of 4.7 in 2013.



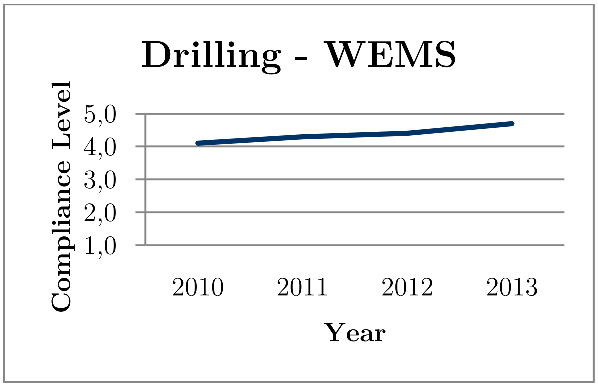
Graph 101: TUN Overall Compliance Drilling



Graph 102: TUN Overall Compliance Drilling



Graph 103: TUN Overall Compliance Drilling

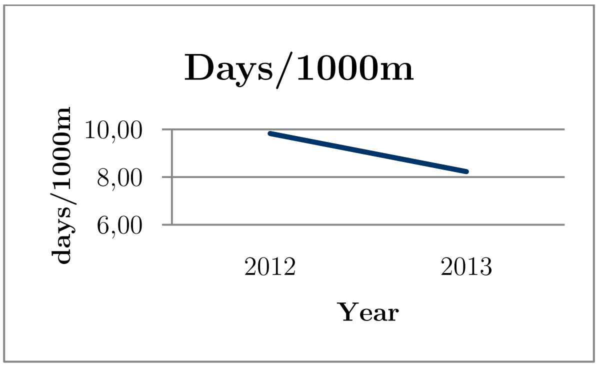


Graph 104: TUN Overall Compliance Drilling

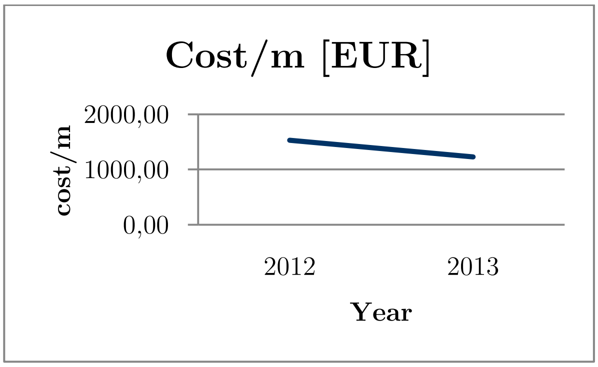
5.7.1 Cluster: Development Well, Total Depth over 3000m

As displayed in the following graphs, development wells with a TD over 3000m were drilled in 2012 and 2013. The performance development is good as the days/1000m KPI decreases by more than one and a half day from 9.8 to 8.2. The cost KPI cost/m decreased as well by approximately 20% from € 1528.00 to € 1225.00. Contrariwise to the two decreasing KPI measures the NPT was increasing by 4% from 9% to 13%. The

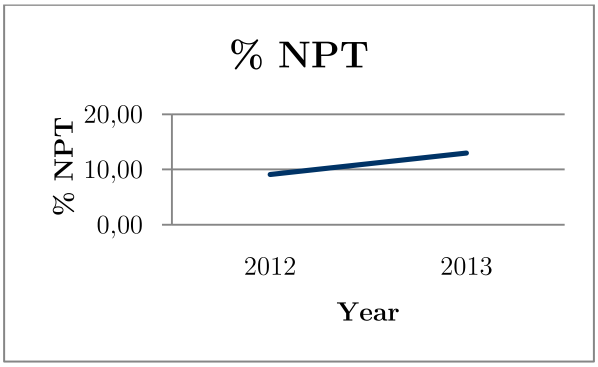
HSSE KPIs show the following changes. Between 2012 and 2013 the LTIF rate remained constant at a zero level whiles the TRIF rate increased by one TRIF. The number of STOP cards increased by an average of two and again this can be seen as a positive trend.



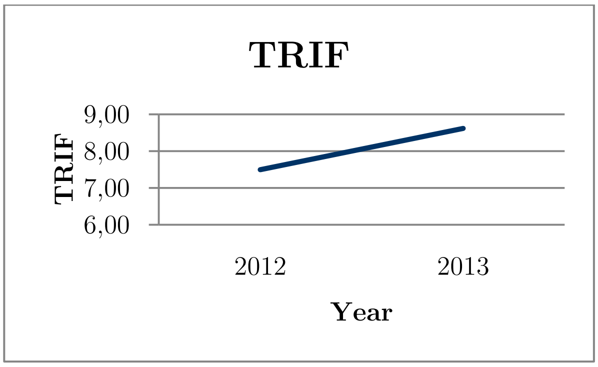
Graph 105: TUN (D, >3000), Days/1000m



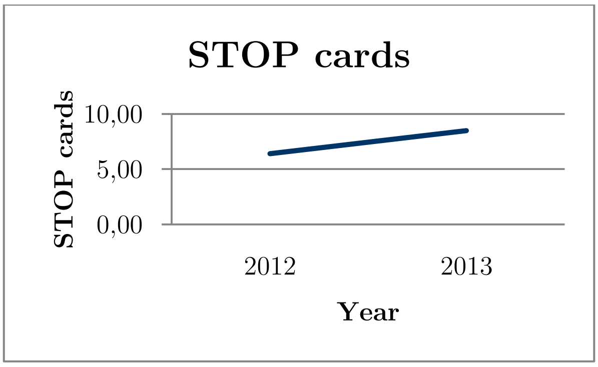
Graph 106: TUN (D, >3000), Cost/m [EUR]



Graph 107: TUN (D, >3000), % NPT



Graph 108: TUN (D, >3000), TRIF



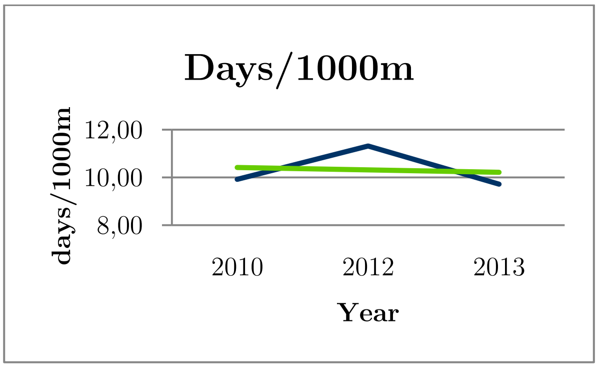
Graph 109: TUN (D, >3000), STOP cards

Interpretation

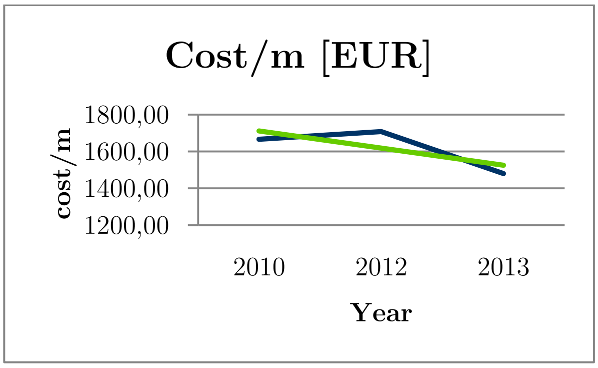
To give a valuable explanation on the trend development in this case is impossible, therefore a conclusion will be relieved. The decline for the KPIs days/1000m and cost/m may be based on the same influencing factors like for the next well cluster.

5.7.2 Cluster: Exploration Well, Total Depth over 3000m

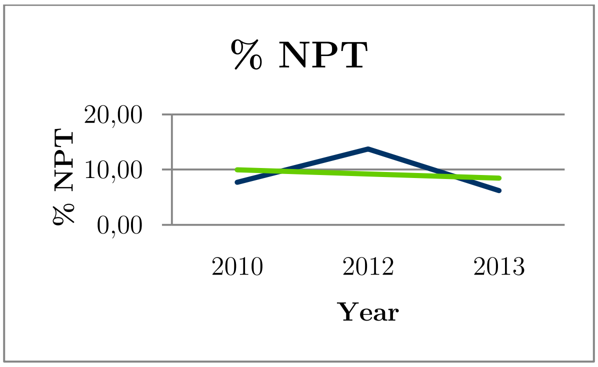
The linear KPI trends for this well cluster show a collective good development as all HSSE, performance and cost trends are improving. For the performance KPI days/1000m and NPT the linear trend is improving slightly. In the case of cost/m, the linear trend dropped by a reduction of € 200.00 per meter. Although the HSSE KPI development is fluctuating over the period of review the linear trend for LTIF and TRIF rates goes down. The number of STOP card increased from four STOP cards in 2010 to almost eight cards in 2013.



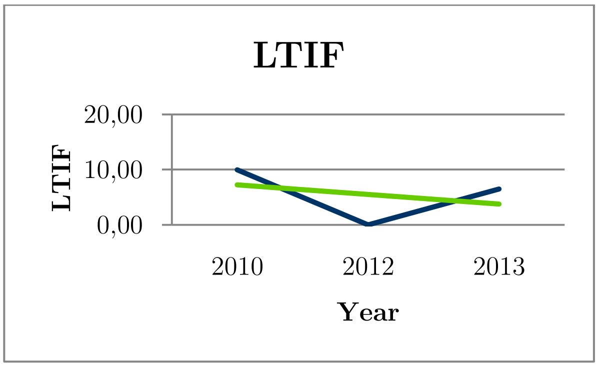
Graph 110: TUN (E, >3000), Days/1000m



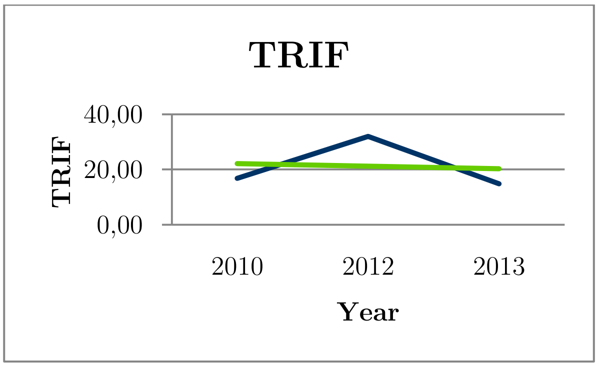
Graph 111: TUN (E, >3000), Cost/m [EUR]



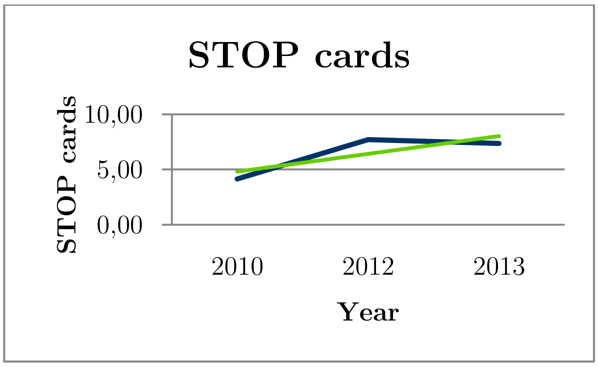
Graph 112: TUN (E, >3000m), % NPT



Graph 113: TUN (E, >3000m), LTIF



Graph 114: TUN (E, >3000m), TRIF



Graph 115: TUN (E, >3000m) STOP cards

Interpretation

This well cluster shows clearly that there is a correlation between the audit initiative and the KPI development. As the compliance level was increasing steadily from 2010 to 2013 and the overall number of findings during the rig and equipment audits were decreasing, the HSSE, performance and cost trends were improving. To make an attempt to explain the spike in the KPIs in 2012 several factors have to be considered. First of all the Arabic spring riots in 2011 caused a shutdown of operations. This one year break could be one of the responsible factors for a weaker performance because after such a long break the warm-up time for a new drilling operations is much longer than after no or just a short break. Additional to that the rig crew changed between 2010 and 2012 and this might directly result in a lower of crew competence. However, new crews are not that familiar with operations and systems than ones operating for some time. Another fact is, that the number of OP audit findings increased in 2012 compared to the number in 2011 what directly influences performance and cost KPIs because of time lagging and additional costs. The high number of findings in the rig and equipment audit is also an important factor with influence on performance and cost parameters. Due to a poor maintained rig, insufficient trained personnel and a low compliance, designing and executing operations are not optimized and therefore generate higher costs and time delays. One more factor that influenced the peak in 2012 refers to a new hired rig. Since 2012 a second rig with a new crew has been operating and again, a new crew is never that familiar with operations than an old one what is reflected in longer operating times and higher costs.

5.7.3 Cluster: Exploration Well, Total Depth under 3000m

The last well cluster in Tunisia refers to exploration wells with a TD under 3000m. In this cluster only two wells were drilled in 2013 and therefore the analysis is brief. The analysis shows an average mark of 8.31 days/1000m and approximately € 1435.00/m. The NPT is 9.10%. During the drilling operations no LTIFs, but 10.71 TRIFs occurred and 6.3 STOP cards were displayed. Because there is only one data point in the graphs, they are not plotted.

Interpretation

Due to fact that in this cluster only in 2013 wells were drilled it's impossible to analyse a trend. But it could be said that in relation to the well cluster exploration well with a TD over 3000m this cluster shows no abnormalities.

5.8 Yemen

Key Performance Indicator Database

Between 2010 and 2013 three wells in the Habban field were drilled in Yemen. One was drilled in 2011 and the other two in 2013. All three wells were drilled as exploration wells with a TD over 3000m where Nabors is the only contractor who has been responsible for drilling operations since 2010. Rig 98 was in operation from end of October 2010 to mid of January 2011 and after more than a two year break it operated from May 2013 until August 2013. The second one, rig 221, was operating from end of January 2011 to mid of March 2011 and from end of April to end of June 2013. Due to security reasons rig 221 and all the rig equipment were secured and operations were suspended until 2013.

	Nabors			
	2010	2011	2012	2013
Rig 98				
Rig 221				

Table 15: YEM Rig History

Operation Audit Database

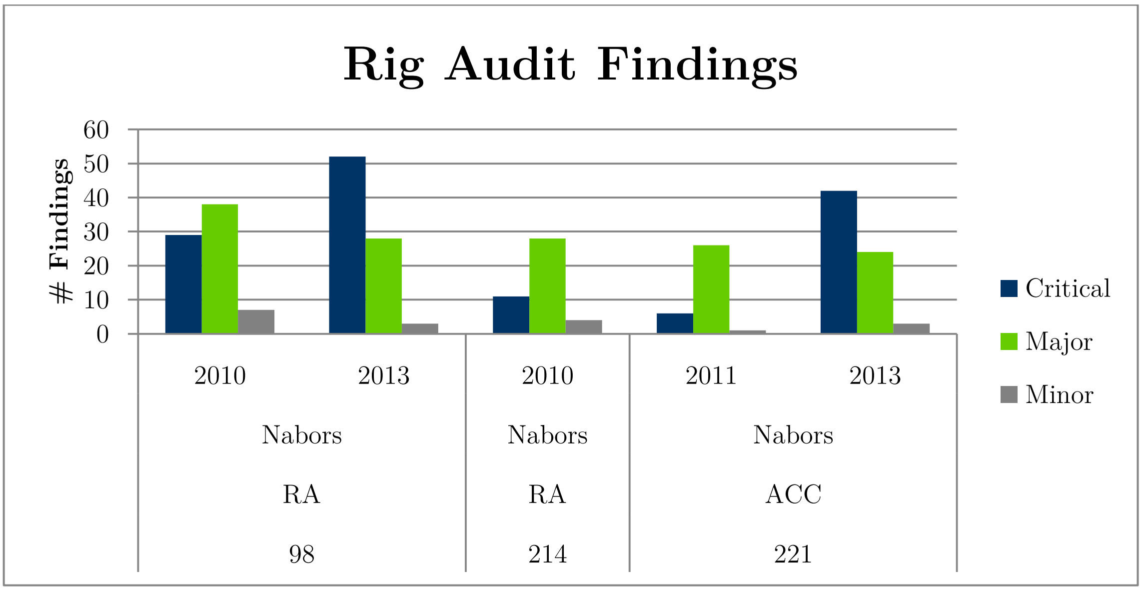
EPW-A conducted OP audits for drilling operations in 2010 and 2013. Additionally one audit regarding workover operations was executed in 2013. The total number of audit findings for drilling operations deceased by almost one third from thirty to twenty-three. The number of findings influencing HSSE and performance parameters decreased as well, while in 2013 there was one more finding concerning cost issues. The following table shows that six findings occurred in each audit year. The findings 10.5 and 7.2 improved from a wholly unacceptable documentation to an acceptable one.

Step	Document	Drilling_1/ WO_2	2010	2011	2012	2013	HSSE	Performance	Costs
1.2	Well Design Creteria Document	1	x			x		x	x
1.9	Risk scenarios DWOP	1	x			x	x	x	
10.5	Environmental Management System and Drilling Waste Management	1	x			x	x		
2.2	Location Built	1	x			x			x
7.2	Pore Pressure	1	x			x		x	
9.5	Well Control	1	x			x	x		

Table 16: YEM OP Finding Matrix

Rig Audit Database

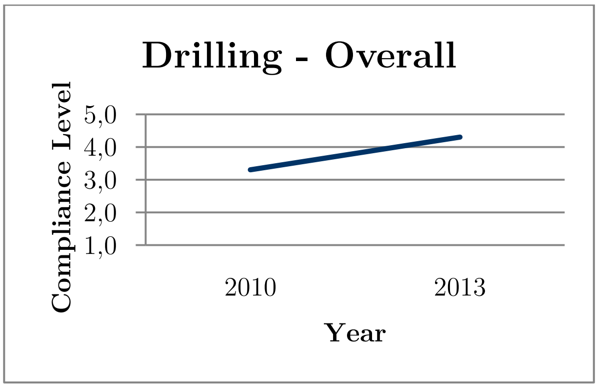
From the rig audit database the following information can be revealed. All rig audits, carried out in the period of review, were conducted by ModuSpec. Rig 98 was already under contract before 2010 and therefore the audit in 2010 was a regular one. Rig 221 was new contracted after a positive acceptance audit in 2011. The reason why in 2013 the audits were dealt as acceptance audits and not as regular audits is that, after the break of almost two years the contract changed and therefore the rigs had to be accepted again. The reason why the number of critical findings increased between 2010 and 2013 so tremendously is that, due to the former security situation operations were suspended and the rig was only secured and left on the well site. The rig was not maintained what results for sure in a pretty high number of critical findings.



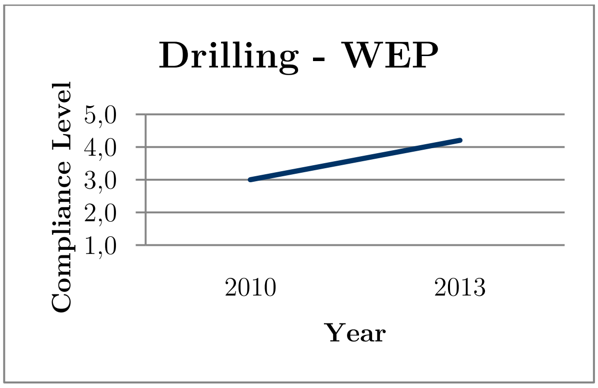
Graph 116: YEM Rig Audit Findings

Compliance Level

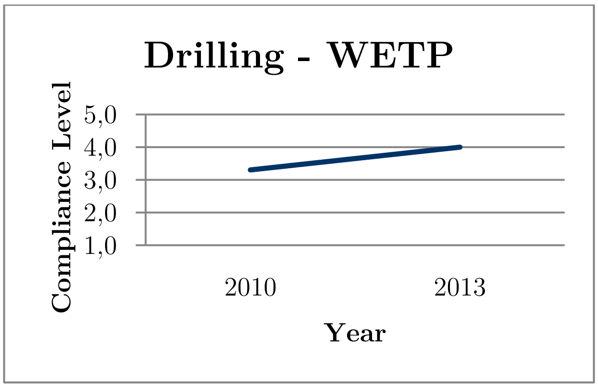
As already mentioned in 2010 and 2013 an OP audit concerning drilling operations was conducted. Additionally to that an OP audit with regard on workover operations was executed as well. Although there is plenty of room for improvement the trends shown in the following graphs follow the right direction. The WEPs compliance increased from 3.0 to 4.2 while the WETP compliance level rose by 0.7 points from 3.3 up to 4. And the WEMS compliance improved by 1.2 points to 4.6. Because there is only one reference point for the workover compliance level it is shown in the following table instead of a graph.



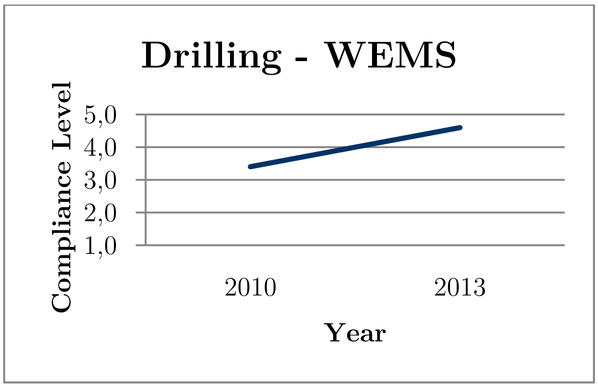
Graph 117: YEM Overall Compliance Drilling



Graph 118: YEM WEP Compliance Drilling



Graph 119: YEM WETP Compliance Drilling



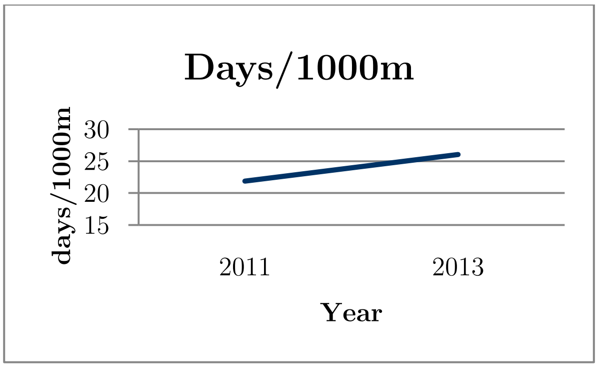
Graph 120: YEM WEMS Compliance Drilling

Year	Overall	WEP	WETP	WEMS
2013	3.8	3.4	3.8	4.1

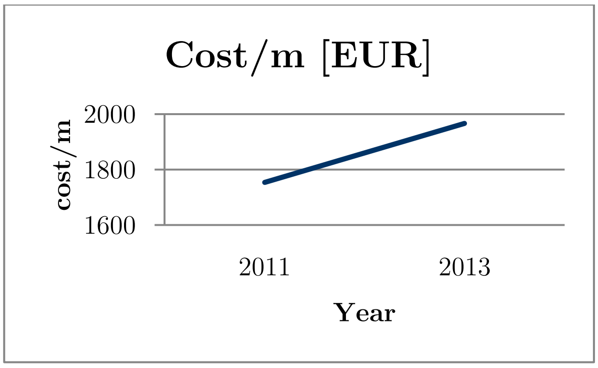
Table 17: Workover Compliance Level Yemen

5.8.1 Cluster: Development Well, Total Depth over 3000m

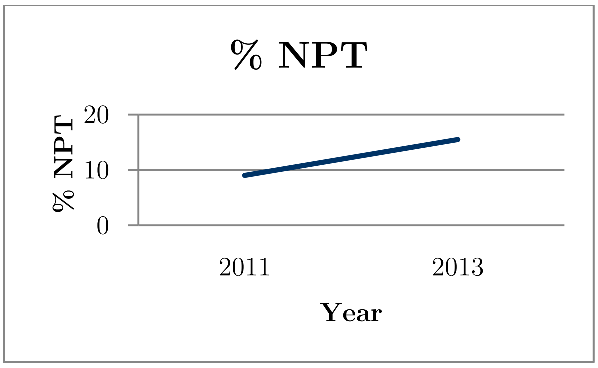
In this well cluster the graphs is following an ascendant line. The performance KPI days/1000m increased from almost twenty-two days up to twenty-six days/1000m while cost/m rose by approximately € 200.00 over the period of review. The NPT displays the tightest increase by almost two-third from 9.0% to 15.45%. A different picture is shown by HSSE KPIs. The LTIF and TRIF rate remain at a steady zero level since 2011 while the number of STOP cards is increasing slightly by an average of 0.5 cards.



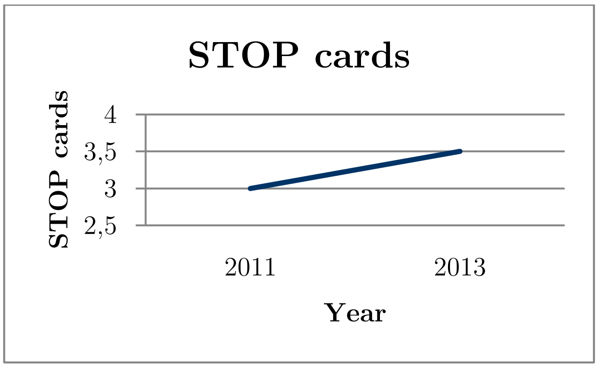
Graph 121: YEM (D, >3000), Days/1000m



Graph 122: YEM (D, >3000), Cost/m [EUR]



Graph 123: YEM (D, >3000), % NPT



Graph 124: YEM (D, >3000), STOP cards

Interpretation

A trend analysis for Yemen is not representative due to the two years shut down of drilling operations. There was a new contract set up in 2013 and the rig crew changed. Therefore a loss of crew competence was recorded. Additionally, rig 221 was new hired. The loss in crew competence and the new hired rig are the main reasons which were responsible for the negative development of performance and cost KPIs. While the two wells which were drilled with rig 98 in 2011 and 2013 show nearly the same KPI values, the KPI values for drilling operation on rig 221 are much higher and therefore the main responsible factor for the trend increase.

6 Résumé

The last chapter concludes the thesis, in which the first part answers the research question and summarizes the results of the analysis. In the second part a recommendation on further activities is given.

6.1 Conclusion

At the beginning of the thesis the research question was: *"Is it possible to prove the effect of the audit initiative on HSSE, performance and costs with hard facts?"*

The approach to answer the question was to analyse all available data which referred to HSSE, performance and cost KPIs gathered out during drilling operations. To structure the data in a clear way, three databases were set up. One contains all mentioned KPIs with additional information concerning the well type, the operator, the used rig and so on. The second database includes information generated during operational audits. This means that all findings which occurred during each operational audit, as well as their impact on HSSE, performance and cost issues, are listed in this database. The third database contains all findings which occurred during each rig and equipment inspection and shows as well the status of the findings. These three databases built the source for all analysis conducted. The conclusion of the outcome of the analysis is the following.

Finally the research question can be answered with: *"Yes, it is possible to prove the effect of the audit initiative on HSSE, performance and costs by hard facts."* Additionally to that the analysis outcome shows that the effect of the audit initiative on HSSE, performance and costs can be observed as a positive one. The following list now shows in a summarized way which facts prove this positive influence.

- The positive effect of the operations audit initiative on performance and cost KPIs is proven by a statistical correlation analysis. The analysis showed that the compliance level correlates with the KPIs days/1000m and cost/m negative, which means that an increasing compliance level trend corresponds with a decreasing days/1000m or cost/m developments. To simplify, an increasing compliance level leads to a better performance.

- The influence of the compliance level concerning standards and processes, which is defined in the WEMS, on HSSE KPIs cannot be proven by a statistical correlation analysis. Although the compliance level correlates with HSSE KPIs negative, the result is not significant because of an insignificant correlation coefficient value.

- Since the audit initiative started the number of non-compliant documents and processes, which are evaluated in operations audits, is continuous decreasing and therefore the compliance level is steadily increasing. This means that the subsidiaries become more and more compliant with the processes and standards defined in the WEMS. Because the WEMS is compliant to the E&P management system, a higher compliance to the WEMS implies a higher compliant with E&P processes and standards in general.

- The positive effect of the rig and equipment audit initiative is proven by the scatter plots where the number of critical rig findings are plotted against the HSSE, performance and cost KPIs. The linear trend lines show for each KPI that a lower number of critical findings interact with a better performance, lower costs and less HSSE incidents.

- A further observation is, that the number of critical findings of contractors with a high reputation is in general lower and therefore they are operating safer and more efficient.

- The individual subsidiary analysis showed that in general the compliance is increasing and the linear trends concerning HSSE, performance and cost KPIs are improving over the period of review. Therefore a relation between the two factors can be made and the interdependent influence can be derived.

To summarize, it can be said that:

An academic analysis of the available data proves the positive effect of the operations audit initiative on performance and cost KPIs and of the rig and equipment audit initiative on HSSE, performance and cost KPIs. Additionally, the positive influence of contractors with a high reputation on safety and operations efficiency and of the audit initiatives on a subsidiary's compliance level is observed. There is potential for additional positive effects, but on the basis of current data they are not verifiable at the moment.

6.2 Recommendation

Finally, I want to share a few ideas for the continuation of the audit initiative. Concerning the operations audit initiative, it should definitely be extended in a way that allows conducting annual operational audits for each subsidiary to maintain the compliance. Additionally to that, controlling measures referring to the close-out of findings should be implemented. That means supporting and controlling the subsidiaries in closing their findings. Concerning the rig and equipment audits implementing a deviation and findings close-out tracking is recommended. This means that an engineer of EPW-A controls if deviations and findings are closed adequately. Referring to the number and defined threshold of critical rig findings the department should define how to treat critical findings and how to react on a continuous sequence of critical findings.

In general, the benefits of the audit initiative should be shared with all involved parties to convince them of the advantages. Therefore it would be useful to use tactics and strategies of the classic Change Management. Further data collection should definitely be continued and similar investigation of the effect of the audit initiative on HSSE, performance and costs should be conducted in a few years. Moreover the improvement of data quality and availability should be ensured.

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Appendix

Step	Document	HSSE	Performance	Cost
1.1	Project Definition Document		x	x
1.2	Well Design Creteria Document		x	x
1.2	UWI Code			
1.3	Preliminary Work Program		x	x
1.4	Optimization Workshop	x	x	x
1.5	Well Economics			x
1.7	Operations Organization Chart		x	
1.8	Long Lead Item AFE			x
1.9	Detailed Work Program	x	x	x
1.9	Risk scenarios DWOP	x	x	
1.10	Peer Review		x	x
1.11	Final Approved AFE			x
1.8a	ESIA	x		
1.8b	Rig & LLI Contracts	x	x	
1.8b	Rig and Service Audit	x	x	
1.9b	Permits & Land Contracts			x
1.11b	ERP	x		
1.11b	Tender Process			x
2.1	Site Survey Report		x	
2.2	Location Design Drawing		x	
2.2	Location Built			x
2.3	Acceptance Statement / Call-off			x
2.4	Ready to Sup Declaration			x
2.5	Audit Document	x	x	
2.6	Pre-Spud Meeting		x	
2.7	Regular Job Reports Drilling		x	
2.9	Dryhole - Discovery Decision		x	
2.11	Regular Job Reports Completion		x	
2.12	Statement of Facts		x	x
2.1p	Mobilization Call-off		x	x
3.1	Lessons Learnt MOM		x	
3.1	Performance / Plan Review		x	
3.2	Final Well Report		x	
3.3	Close Out Statement		x	

Step	Document	HSSE	Performance	Cost
3.1a	Debris / Contamination Survey	x		
3.1b	Acceptance Statement Asset		x	
3.2	Site Restoration Acceptance State	x		
7.1	Software		x	
7.2	Pore Pressure		x	
7.3	Casing Seat Selection		x	x
7.4	Zonal Isolation	x	x	x
7.5	Drilling Fluids		x	
7.6	Directional Drilling and Surveying	x	x	
7.7	Project mapping		x	
7.8	Abandonment	x		
7.9	Blowout Contingency Plan	x		
8.1	Rig Selection and Audit	x	x	
8.2	Equipment Certification	x	x	
8.3	Well Control Equipment	x	x	
8.4	Safety Critical Rig Equipment	x	x	
8.5	Integrity of procured Equipment and Service	x	x	
8.6	Safety systems	x	x	
8.7	Instrumentation and Recording Systems		x	
8.8	Temporary Pipework	x	x	
8.9	Safety Critical Software	x	x	
8.10	Systems Requirements	x		
9.1	Location Hazards	x		
9.2	Shallow Gas	x		
9.3	Offshore Drilling Units	x		
9.4	Rig Moving & Positioning	x	x	
9.5	Well Control	x		
9.6	Barrier Philosophy	x	x	
9.7	Coring Operations		x	
9.8	Casing Operations		x	
9.9	On-site Verification of Operations		x	
9.10	Pressure Testing	x		
9.11	Offshore Well testing	x		
9.12	Simultaneous Operations Offshore	x	x	
7.2	Goals and Stategies		x	
7.3	BO Balanced Scorecard		x	

Step	Document	HSSE	Performance	Cost
8.1	Organization Structure		x	
8.2	Roles and Responsibilities		x	
8.3	Financial Authorities			x
8.4	Technical Authorities		x	
8.5	Training and Development		x	
8.5.2	Staff Performance Review		x	
8.5.4	Contractor Personnel Competence	x	x	x
10.3	Dispensation procedure	x	x	
10.4	Technical Integrity Standard	x	x	
10.5	Environmental Management System and Drilling Waste Management	x		
10.6	Occupational Health and Workplace Safety Management	x		
10.7	Incident and Accident investigation, Recording and Reporting	x		
10.8	Crisis Management / Emergency Response	x		
10.9	Safety and Environmental Awareness	x		
10.10	Travel and Security	x		
10.11	Contractor Management	x	x	x
10.12	HSE Management Review	x	x	
11.1	Minimum Performance Indicator		x	
11.2	External Benchmarking		x	
11.3	Performance review Meeting		x	
12.2	Lateral Learning		x	
12.3	New Technology Applications		x	
13.1	Document/Data Retention Policy		x	
13.4	Specific Well Engineering Systems		x	
13.4.3	Well Files		x	
13.4.4	Close-out well records		x	