Final report

1. Project details

Project title	H_2S Management System – Part 2: Full Scale Test (H2SMAN)
File no.	64017-0802
Name of the funding scheme	EUDP, Nordsøpulje
Project managing company / institution	SulfiLogger
CVR number (central business register)	41489359
Project partners	SulfiLogger, Pieter Mouritsen Airtech, LICengineering, TOTAL E&P DK, HESS Denmark, Energy Cluster Denmark
Submission date	31 March 2021

2. Summary

English:

The core of H2SMAN is to further develop, test and demonstrate an alternative to currently applied H_2S management systems in the oil and gas sector, to eliminate overdosing and discharge of excess scavenger to the sea, which constitutes the largest environmental impact from several platforms. This will allow for less environmental impact during hydrocarbon production in the Danish North Sea, along with a significant cost reduction for the operators. It is estimated that implementation of the dosage system can reduce the H_2S scavenger consumption by 10-40%.

Dansk:

Omdrejningspunktet i H2SMAN er at videreudvikle, teste og demonstrere et alternativ til de nuværende H_2S-systemer i olie- og gassektoren. Formålet er at reducere unødig overdosering og udledning af H_2S-scavenger i havet. Dette er i dag den største enkeltudledning fra adskillelige platforme. Dette projekt vil derfor reducere miljøpåvirkningen fra olie- og gasindvindingen i den Danske Nordsø, og samtidigt reducere omkostninger for operatørerne. Det er estimeret at systemet kan reducere det totale forbrug af H_2S-scavenger med 10-40 %.

3. Project objectives

- *What was the objective of the project?*

The objectives of the H2SMAN project were:

1) Design of the H_2S management system; the design will be applicable for integration on existing offshore production facilities.
2) Build the H_2S management system.
3) Preparation, installation and integration of the system on two offshore production facilities operated by two different operators.
4) On-site test to demonstrate and verify optimal measuring point on offshore facilities.
5) Analyze and validate data and confirm full business case for implementation of the H_2S management system.
6) Prepare to commercialize the H_2S management system.

- *Which energy technology has been developed and demonstrated?*

SulfiLogger has develop a novel H_2S-sensor that can provide real-time measurements from the separator gas outlets and thereby enable sensor-controlled scavenger dosing. The sensor technology has been matured to a level, where the sensor can measure directly in the raw natural gas without any pre-treatment of the gas. It was demonstrated that the technical advantages of this novel sensor technology translate into superior sampling resolution with minimal delays. The robustness of the sensor is the key to the design of an ultra-compact sensor system that is competitive to large analyzer cabinets, and the compactness is crucial for placing the sensor directly at the main gas flow.

LICengineering has designed a new chemical injector system for use in process plant flowline applications. The injector achieves injection from a number of nozzles creating a spray haze over the full flowline conduit, which is novel to the present state of art using only one nozzle. The injector has an injection wing which can be inserted and removed through double block and bleed valves into a high-pressure flowline system without interruption of the process flow as the double block isolations are maintained. This last feature is important in order to maintain production during injector maintenance or replacement, which the present type of injector system do not allow for.

A full-scale injector demonstrator has been designed and constructed and the functionality to install, insert, inject, retract wing and remove the injector has been successfully tested at Pieter Mouritsen Airtech Test facilities.

A prototype of the system has been designed based on the results and evaluation of the injector demonstrator. The prototype is shown in Figure 1-1. In this prototype system it is proposed to install two units side-by-side in order to allow maintenance on one system while maintaining the injection capability uninterrupted.

In parallel, the injector has been submitted for patenting as per February 2020. The 2nd technical examination has been received. The examination indicates that the injector can be patented.

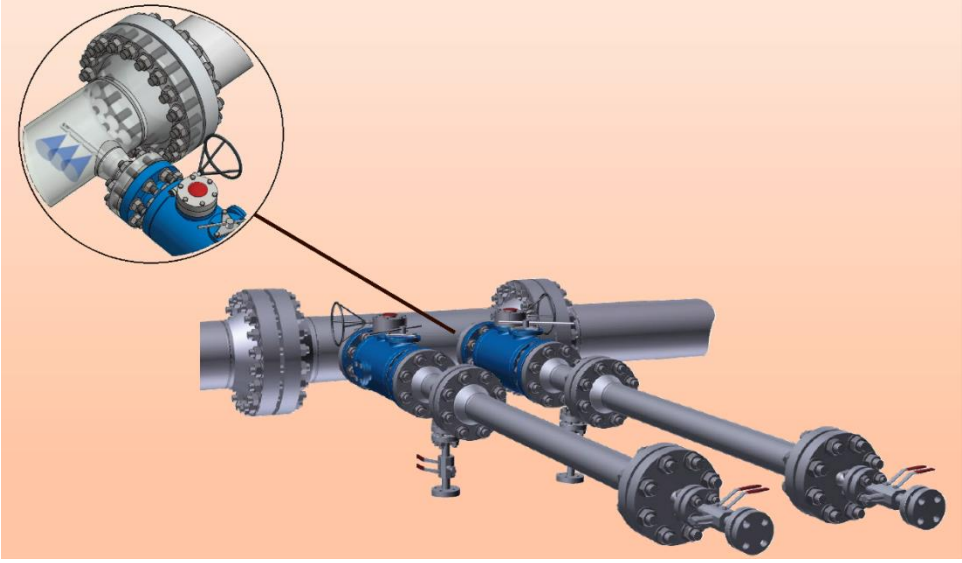


Figure 1-1 Injector prototype with two identical systems for maintenance purpose.

The injector is developed with a focus on H_2S removal by use of direct injection. The development is carried out by LICengineering A/S as part of the EUDP supported H2SMAN project conducted under the Offshore Energy Cluster in Esbjerg.

Based on their deep competencies within fluid handling and offshore processes Pieter Mouritsen Airtech throughout the project has contributed to defining and adjusting project outcome and milestones in order to continuously reflect project findings and increasing understanding of end user needs.

In close cooperation with the project partners Pieter Mouritsen Airtech specified and supplied components – both standard and custom made – for the pilot unit. Besides this Pieter Mouritsen Airtech's role in the project has been to specify in details part of the test setup as well as sourcing specific components. The final verification test of the test setup was conducted in Pieter Mouritsen Airtech's test facilities in Vejle.

4. Project implementation

- *How did the project evolve?*

The project was kick-started by obtaining ATEX approval on the core sensor in record time. This was crucial for the following offshore tests and optimizations. We ended up with a total of 4 offshore trips, and on each trip, there was significant learnings that gave valuable input to the development teams.

During the first measurement campaigns with the new sensor, we obtained continuous H_2S data at the relevant sampling point. The data showed that the changes where on a timescale of a few minutes, which implied that (1) the existing SCADA system and pumps would be sufficiently fast for the scavenger dosing control, and (2) sampling delays of +2 minutes would not be acceptable for proper dosing control.

Therefore, the project focused on optimizing the sensor performance to ensure that it could tolerate the harsh environment of the raw natural gas, and also on optimizing the chemical injection which could be a key to real-time dosing control.

The results are very satisfying with full demonstration of the sensor stability and sampling speed in the offshore environment. The chemical injection solutions have also been developed to a stage where it can be used for offshore trials.

- *Describe the risks associated with conducting the project.*

It was unknown if the real-time temporal H_2S changes would be on a second-scale or minute-scale. If the changes would occur in seconds, then the injection control system should be programmed in a dedicated controller. During the offshore tests it was proven that the typical changes are on a minute scale, so fast sampling is needed but existing pumps can be used, and the SCADA system is sufficiently fast for the control. This simplified the project significantly.

The long-term stability of the sensor was the most immediate risk since the offshore environment is extremely harsh and difficult to simulate in the laboratory. This has been and on-going task to optimize the sensor design to tolerate the environment.

The requirements to the physical process parameters have also been a risk throughout the project. The sensor cannot handle the design temperatures and design pressures in most parts of the gas production process. However, we managed to find sampling points, and later in the project we developed at compact sensor system for handling the temperature and pressure.

- *Did the project implementation develop as foreseen and according to milestones agreed upon?*

Overall, the project was executed according to the plan. There were extensions, but that was mainly to the scheduling of offshore trips and to ensure that learnings from the offshore trips could be implemented before moving further in the projects.

- *Did the project experience problems not expected?*

The main challenge was to get access to offshore trips during the project, but the two operators where very interested in the project and managed to find time in the schedules. Sourcing components (valves, fittings etc.) for the tests also proved challenging, due to extended delivery time from the component suppliers.

5. Project results

- *Was the original objective of the project obtained? If not, explain which obstacles that caused it and which changes that were made to project plan to mitigate the obstacles.*

The project objectives were overall obtained, please find an overview below, and each of these commented below the figure.

#	**Objectives as described in application**	**Obtained/Not obtained**
1	Design of the H_2S management system; the design will be applicable for integration on existing offshore production facilities.	Obtained
2	Build the H_2S management system.	Obtained
3	Preparation, installation and integration of the system on two offshore production facilities operated by two different operators.	Obtained
4	On-site test to demonstrate and verify optimal measuring point on offshore facilities.	Obtained

5	Analyze and validate data and confirm full business case for implementation of the H_2S management system.	Obtained
6	Prepare to commercialize the H_2S management system.	Obtained

1) Design of the H_2S management system; the design will be applicable for integration on existing offshore production facilities.

The Sulfilogger has during the project period been optimized to withstand the harsh offshore environment. From the initial tests and basic process operating conditions it was possible to outline key development areas for the sensor technology. Many of the development tasks have been focused on the sensor durability. The key sensor development tasks are described below:

Clean room chip optimization:
The internal sensing element, which is a wafer-based chip produced under clean room conditions, have been optimized to lower the internal electrical leakages between the bonded elements. Having lowered the internal electrical leakages a more robust sensing system is achieved, and the production output is significantly increased.

Long term stability of sensor components
Since the Sulfilogger sensor is based on a micro-electrochemical sensing principle, the electrode surfaces and the electrolyte are key components. In the project the electrolyte lifetime has been increased by a factor of 5-10 and the tolerances of the sensor assembly components have optimized to achieve better long-term stability of the sensor.

Outer membrane durability
One of the findings from the initial test was that the outer protective membrane displayed low adherence to the stainless-steel substrate under offshore conditions. Through thorough testing of materials and the membrane deposition methods it was found that local surface corrosion causes blister effects that over times causes the membrane to fail. The solution is to enhance the corrosion properties of the substate either by surface treatment or by changing the material. Tests are still ongoing to find the right solution.

Operation at sub-zero temp.
From the start of the project is has been a known issue that operation at sub-zero temperatures is challenging due to the freezing point of the electrolyte used in the sensor. Work has begun on changing the electrolyte concentration to lower the freezing point. This involves changing the materials of the sensor assembly and the sealing methods used to withstand stronger acidic electrolyte.

2) Build the H_2S management system.

During the project period many different process layouts and design of especially the H_2S sampling system were considered. Initially, a very complex system was derived that involved several safety measures and measurement points of temperature and pressure. From cost estimation it was however deemed too expensive a system and the physical size of the system was too large.

From tests it was clear that low response time of the H_2S sampling system is vital for a good H_2S management system, the faster the system can respond to changes in the sulfide concentration, the more chemicals can be saved. Traditional analyzer cabinets are large, and therefore often placed several meters from the sampling point. The general trade-off in sampling systems is that in order to obtain low sampling delays, the system must either be installed close to the measurement point (short piping, low flow) or use a higher flow rate (long piping, high flow). If the pressure is high at the sample point, a local pressure reduction could be beneficial to keep the flow rate high in the sample pipelines. A small footprint is often required to be installed close to the source.

It was decided to focus on a compact installation close to the source, to keep the flow rates low. A key feature of the Sulfilogger sensor is that it can operate with very low flow rates (>200 ml/min). Having low flow rates are in many ways favorable. If a large pressure reduction is required, a low flow rate will result in a lower fluid

temperature drop. Lower flow rates require a smaller filter. Low flow rates are also easier to ventilate and thus the emissions are lowered.

Therefore, a small compact H_2S sampling system that can be installed close to the sample point was designed. The system consists of a filter, a pressure reduction valve, a manometer, a metering valve, a flow cell and mounting plate. The system components are explained below:

- **Filter:** The main purpose of the filter is to avoid particles blocking the pressure reduction valve and metering valve. The Sulfilogger itself can inherent handle even very large particles (> 1 mm). The filter size is thus governed by the system valves.
- **Pressure reduction valve:** The current design of the Sulfilogger only allows for pressures up to 3 barg. Thus, pressure reduction is needed to operate, e.g., at the separator which often operates at 15-30 bars. The inlet pressure rating of the valve should at least be rated to that of the system design pressure and thus also function as a safety valve.
- **Manometer:** The system flow rate is governed by the outlet pressure of the pressure reduction valve and the setting of the metering valve.
- **Metering valve:** A low *Cv* metering valve offers a precise adjustment of the required flow rate needed to acquire the minimum acceptable retention time of the system.
- **Sulfilogger flow cell:** A specially designed flow cell for the Sulfilogger sensor was developed in the project. Using a special adapter, the sensor can easily be unmounted from the flow cell without twisting the cables. The sensor with adapter fits into the calibration cap, thus the system allows for easy calibration of the sensor. The flow cell features a 3 bar pressure rating.
- **Mounting plate:** The system components are installed on a compact stainless steel mounting plate with multiple options for mounting the system close to the sampling point.

3) Preparation, installation and integration of the system on two offshore production facilities operated by two different operators.

During the project period test campaigns were conducted at two different offshore production platform in the North see. Three measurement campaigns were conducted at the Hess platform Syd Arne and one campaign at the Total site Dan FG.

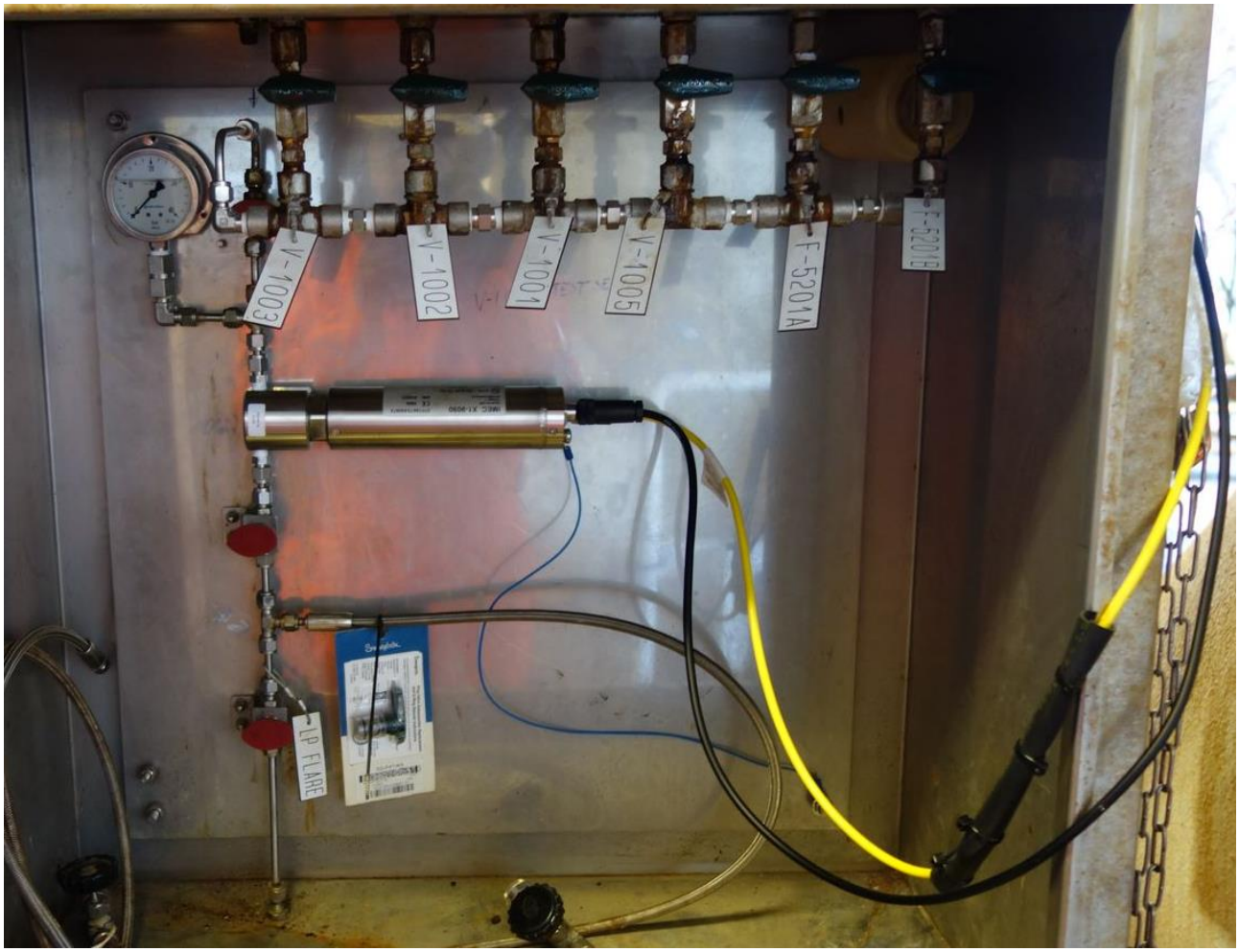
Hess – Syd Arne

October 2018
The first test was conducted at a sample cabinet near the test separator. The cabinet featured several outlets from different sample points of the separator. A sample mock-up setup was designed for the tests, the setup can be seen installed on the picture below. The sample setup consists of two inlets (sample and calibration), a switch valve, manometer, flow cell and shut off valve. The flow through the setup was controlled using the valve on the left-hand side.
Experiences from the test proved it difficult to control the flow rate to the test setup, as the *Cv* of the valve were too large. The pressure expansion from the gas, also caused the valve to freeze. Moreover, the flow path of the piping caused pockets of condensed water to create pressure spikes, disturbing the sensor signal.
The sensor was left on-site to do continuous measurements supported by the Hess lab technicians.

April 2019

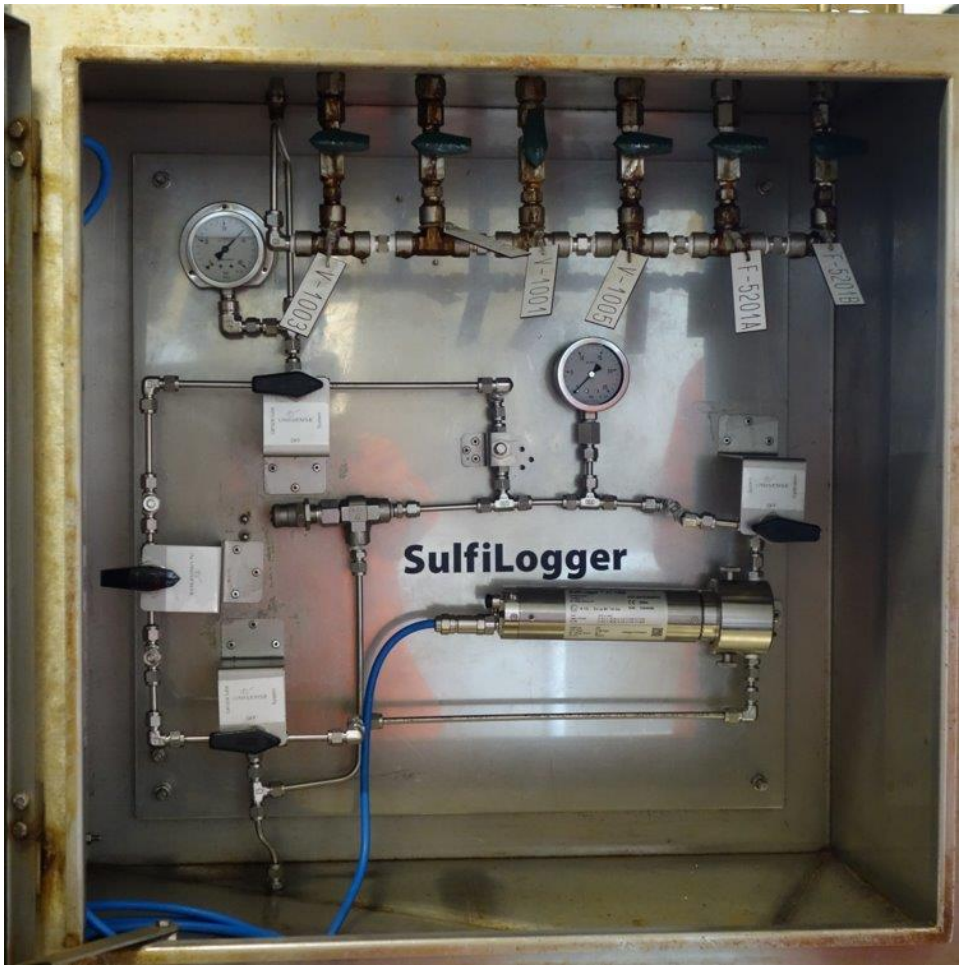
The second test on Syd Arne was done at the same location using the same setup, but with improved sensors. After the first day of testing the sensor severe problems with pressure build up was encountered. Thus, it was decided to install the flow cell and sensor inline in the existing setup, as shown the picture. This significantly improved the pressure build-ups; however, the flow was very difficult to control, due to a missing metering valve.

The results from this test also showed that the sensitivity of the sensor signal damped significantly at temperatures below 5 °C.



June 2020

From the experiences from the last measurement campaign, it was decided to build a permanent setup. The sensor was installed inline and declining tubes all the way to the sensor to avoid pressure build-ups by water accumulation. The setup was built on the actual backplate of the original sampling cabinet. The plate was shipped to the Sulfilogger workshop and the flow cell, valves, piping and manometer were installed on the plate. The plate was then shipped back to Syd Arne prior to the test. The installation is shown on the picture below.



The experiences from the third test in the sample cabinet was overall positive. The sensor system worked well in regard to the stability of the sensitivity and the earlier problems at low temperatures. Data showed that with high sampling flow it was possible to obtain H_2S reading with only 5 minutes delay. It was however also clear that the high flow could cause problems with icing of the water condensate in the needle valve. This was the clear indication on that the sensor system should be placed close to the sampling point to keep a low flow and low sampling delay.

Test were also conducted very close to the 1st stage separator to reduce the retention time of the measurements. The flow cell was simply installed on the outlet of the sampling valve as shown on the picture. The sensor was powered by a new ATEX approved device called the PowerCom Box (black box), which features a battery supply and cellular communication to cloud data management (latter not used in this project).

From the measurement close to the 1st stage separator, it was found that even shorter sampling delays could be realized. This is the ideal installation point, and a future permanent installation is planned for this location. This was an important finding for planning the final test at Total.

Total – Dan FG

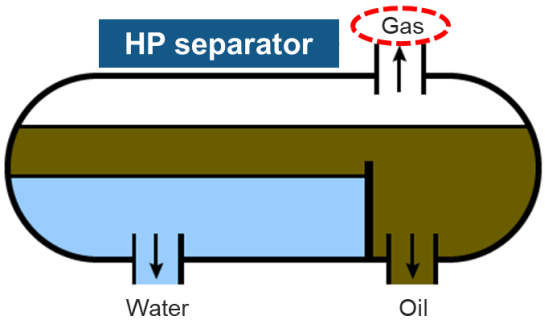
February 2021
Experiences from previous tests indicate that a small compact sampling system is needed to by installed close to the wanted sample point, as seen below. Using a pressure regulator in combination with a fine metering valve very stable flow conditions were delivered to the Sulfilogger sensor. The setup also features a novel quick connect flow cell, so that the sensor can be dismounted easily for calibration without the hazzle of twisted cables.


SulfiLogger
SulfiLogger

Another test was conducted on produced water from the separator. Due to the unique features of the Sulfilogger the sensor can be installed directly in the water phase. As can be seen on the picture below a very simple mock-up was created to enable these measurements.

4) On-site test to demonstrate and verify optimal measuring point on offshore facilities.

All the offshore tests described above had a clear focus on identifying the optimal measuring point, and it was clearly demonstrated that it is ideal to place the sensor system as close to the main pipe as possible. For most applications that is to place the sensor directly after the separators.



5) Analyze and validate data and confirm full business case for implementation of the H_2S management system.

Sensor data from the offshore H_2S sensors confirms the saving potential of 10%-40% on chemicals, which is in line with the expectation in the proposal (up to 30 %). Large variations in the H_2S concentration could be used to adjust the scavenger dosing rate.

6) Prepare to commercialize the H_2S management system.

SulfiLogger A/S has decided that they will begin sell the sensors and the sensor system here after the project.

The initial pilot sales will be followed closely to get all learnings from these installations. SulfiLogger expect that the addition experiences will allow for a full commercial launch in 2022.

From the injector perspective a novel Injector system has been designed. A demonstrator has been constructed and tested. Based on these results a prototype injections system has been designed. The system is not yet ready for commercialization; however, the demonstrator has shown that the system is efficient and works according to the ideas. Next step is a demonstration to the partnering operators, and subsequently a potential cooperation with one or both of these (Total or Hess), for an installation of a prototype, designed and built specifically for one of their offshore process plants. The following step will be a commercialization when proved on site offshore.

- *Describe the obtained technological results. Did the project produce results not expected?*

During the project focusing on the development of the SulfiLogger, it became clear that there was a challenge with efficient dosing of the scavenger and also maintenance of the scavenger injector without interrupting the gas flow and hereby the key operation onboard the platform. Therefore, LICengineering invented a new Scavenger Injection System. This included:

- Design of a prototype,
- Design and construction of a Demonstrator,
- Tests of Demonstrator,
- Re-design on prototype based on Tests,
- Final Tests proving design updates
- Patenting the novel Injection System

- *Describe the obtained commercial results. Did the project produce results not expected?*

In May 2019 the some of the project participants went to the Offshore Technology Conference (OTC) fair in Houston, Texas, with the purpose of promoting the project internationally. Please see the program in the attached Appendix (Appendix_OTC 2019). The result was several leads that could lead to commercial agreements after the project has finalized. A similar trip is being considered post-EUDP funding, in August 2021, where the project group is able to present further results and then commercialize the products from the project. Note, this is outside EUDP scope, as it is after the funding period has ended.

No direct commercial results have been produced, as the products have only been used for test and therefore not been sold. However, there are many learnings about the possible commercialization post-EUDP funding. Please see the following sections.

- *Target group and added value for users: Who should the solutions/technologies be sold to (target group)? Describe for each solutions/technology if several.*

For the global go-to-market strategy, emphasis will be on identifying different strategies for SMEs with novel and innovative solutions to enter the global offshore energy market; a market characterized by high entry barriers and major global players relying on long-term relationships with already established supply chains.

Possible Sales Channels

In a market with high entry barriers direct sales can be difficult. On the basis of the SulfiLogger, the different Sales channels could be the following:

#	Potential customers / Sales channels	Pros	Cons	Example of companies
A	E&P Operators	+No intermediate link between end-user and supplier +No costs for intermediate link +Dialogues directly with end-users for potential upgrades	-Requires strong ties into the company -Requires a significant track-record and display of quality	TOTAL, HESS, INEOS
B	Engineering companies	+Already established relationships with end-users. +Trusted by end-users +Potentially unlocks more volume	-Reduced margin/sales price -No control of feedback from end-users	LICengineering, HYTOR
C	SCADA system providers	+Direct integration from the beginning into SCADA system. +Potential of high-volume sales	-Low margin assumed	N/A

The obvious preferred solution would be A, to maintain product knowledge, high margins etc. However, it can prove difficult to overcome the high entry barriers. However, one method applied in the H2SMAN project is to enter dialogues through thrusted mediators, such as the clusters. This has in the case of the SulfiLogger paved the way for an innovation project in close collaboration with E&P Operators. The tests and proof of technology and concepts provides clear client cases after the execution of the innovation project. Therefore, this allows for an increased level of trust and close connections to the industry throughout this innovation project. Thus, all is in favor of option A in this case.

Collaboration Types

There are different ways of selling/collaborating. At one extreme there is a buyer-suppliers relationship with no strong ties, typically found in commodity products. These are however not the typical products of the O&G industry. At the other extreme there is the option of a merger/acquisition. The different type of collaborations will briefly be described, in combination with the pros/cons of these.

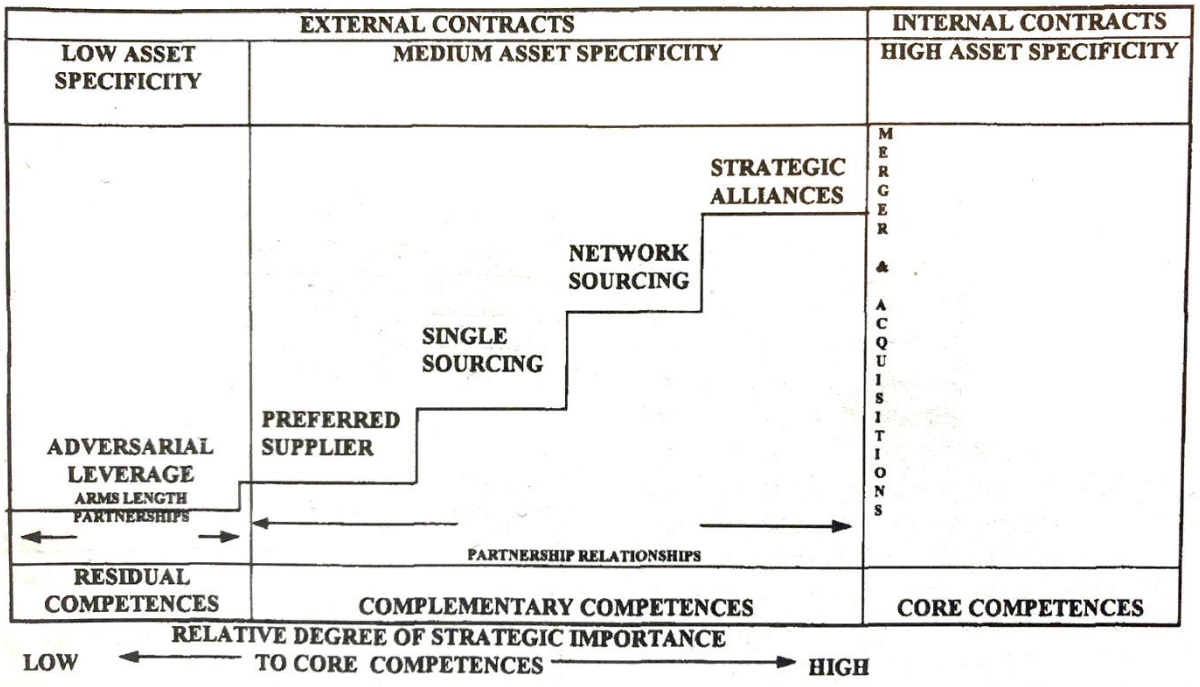


Figure 2: Vertical versus horizontal integration (3).

The figure above illustrates different types of contracts. In the far left there is low asset specificity, meaning that the product/service is a commodity. In such cases it makes most sense for the buyer to purchase on market conditions. In the middle there are different levels of partnerships, where the asset specificity increases towards the right. In the far right, the asset specificity becomes within the range of the buying company's core competences, thus mergers and acquisitions are a typical case. This framework can be used to determine what partnership types could be of best use to the buyer/supplier, also in the O&G business. With regards to the specific case, the SulfiLogger, it is neither in the low asset specificity or in the high asset specificity. Also, both the buyer and supplier would benefit from a flow of feedback in order to improve the product. That being said, it is doubtful that the buyer (E&P Operators) would make an exclusive agreement, as there is a natural interest in keeping costs at a minimum. Therefore, in short, the suggested approach and partnership relationship should be within the preferred supplier to single sourcing range. However, normal practice for O&G companies is to have a few selected suppliers for each product, which again favors these collaboration types. Lastly, the SulfiLogger technology proves to be significantly cheaper than the competitors when comparing total cost of installation and maintenance. This is a unique advantage of the product when ready for commercialization.

- *Where and how have the project results been disseminated? Specify which conferences, journals, etc. where the project has been disseminated.*

Conferences/Seminars:

14th International Conference on Chemical and Process Engineering, 26-29 Maj, 2019, Bologna, Italien (Poster presentation)

Seminars

Energy Innovation Cluster (now Energy Cluster Denmark), has held several seminars regarding Oil and Gas on topics such as emissions, and discharge oil. These were held in 2018, November 5 and December 12. Here new ideas regarding the H2S-scavenging have also initiated, some regarding the scavengers (reacted or unreacted) that are found in the discharge water. Furthermore, a seminar was also held in relation to the OTC event (See Appendix_OTC 2019).

In addition, ECD has also held workshops on solutions for Oil and Gas related challenges, where H_2S-scavenging was in focus. The other focus was to find SMEs that could enter in dialogues with the operators, that were otherwise difficult to reach.

Offshore Technology Conference 2019

The project group was at the Offshore Technology Conference (OTC) in Houston, Texas, USA, in May 2019. Please find the appendix (Appendix_OTC 2019) with a description of the activities.

Journals:

Chemical engineering transactions: *Johansen, L. N., Kloster, L., Andreasen, A., Kucheryavskiy, S., Nielsen, R. P. & Maschietti, M. (2019), Raman spectroscopy for monitoring aqueous phase hydrogen sulphide scavenging reactions with triazine: a feasibility study. 74, p. 541-546. Disseminated as part of several ongoing H_2S-related activities.*

6. Utilization of project results

- *Describe how the obtained technological results will be utilized in the future and by whom.*

See Possible Sales Channels in Section 5.

- *Describe how the obtained commercial results will be utilized in the future and by whom the results will be commercialized.*
  - *Did the project so far lead to increased turnover, exports, employment and additional private investments? Do the project partners expect that the project results in increased turnover, exports, employment and additional private investments?*

As previously described, there are no commercial results yet, under the definition as commercialization will occur upon payment for the product. However, as mentioned several leads for sales have been generated.

- *Describe the competitive situation in the market you expect to enter.*
  - *Are there competing solutions on the market? Specify who the main competitors are and describe their solutions.*

The competitive landscape will be described to answer the above.
Key value propositions are defined (in dialogue with the operators) as:

1) Response time
2) Maximum pressure
3) Maximum temperature
4) Maintenance effort
5) Measurement range
6) Cost effectiveness
7) Accuracy

These are plotted into the table below with an overview of the competitors in the market.

Competitor	**Product**	**Sensor**	**Response time**	**Pressure max**	**Temp max**	**Maintenance effort**	**Range**	**Range (ppm)**	**Cost effectiveness**	**Accuracy**
SpectraSensors	SS2100	TDL	Fast	High	High	Low	Low	N/A	Medium	High
AnalyticalSystemsKECO	H2S Analyser (Tape)	Sulfur Tape Analyzer	Slow	Low	High	High	Low	N/A	High	High
AnalyticalSystemsKECO	Continuous H_2S Trend Analyzer	Electrochemical	Fast	Low	Low	Low	High	0-1000	High	Medium
Hobré Analyzer Solutions	Tisomec	Photo Acoustic	Fast	Low	Low	Low	Medium	0-100	Medium	Medium
SulfiLogger	S1-1220-1000ppm. X1-1220-1000ppm (ATEX)	Microelectrochemical	Fast	High	High	Low	High	0-1000	High	High

Ametek	N/A	UV-spec-troscopy	N/A	Low	Low	High	Me-dium	0-100	High	Medium
Applied Ana-lytics	OMA H_2S Analyzer	UV-spec-troscopy	Fast	Low	Low	Low	Low	0-10	Me-dium	Low
Dräger	Polytron 7000	Electro-chemical	Fast	Low	Low	Low	Low	Low	High	Medium

Figure 3: Competitive overview. Sources: Company websites (1), Industry contacts (2)

On the basis of the value propositions above, a simple score (1-3) would reveal the comparative benchmarks on all the value propositions. However, please note that not all value propositions might be relevant under the specific conditions.

Competitor	**Product**	**SCORE: (24 max)**
SpectraSensors	SS2100	19
AnalyticalSystemsKECO	H_2S Analyser (Tape)	14
AnalyticalSystemsKECO	Continuous H_2S Trend Analyzer	19
Hobré Analyzer Solutions	Tisomec	16
SulfiLogger	S1-1220-1000ppm. X1-1220-1000ppm (ATEX)	24
Ametek	N/A	13
Applied Analytics	OMA H_2S Analyzer	13
Dräger	Polytron 7000	14

Figure 4: Comparative scores

Based on the findings, the SulfiLogger outcompetes the other competitors on an overall basis.

- *Describe entry or sales barriers and how these are expected to be overcome.*

In the previous section entry barriers have been indicated as being high. The reason for this is that the oil and gas sector need reliable and high-quality products. Errors in products can jeopardize safety and will typically result in high costs for repair/exchange as well. Therefore, the industry operated with a select few, as also indicated previously. However, this complicates the entry of new players in the market. The unique approach of this project has been to commit the oil and gas operators in the project from an early stage. This was possible by utilizing the network of Energy Cluster Denmark. Upon commitment, the oil and gas operators have followed the project and has provided input etc. to this project during is development. This has given the project a unique position that has removed the high entry barriers. By having tested and demonstrated the product offshore, at the operators, this has ensured early engagement, more direct contact in relation to commercial efforts and will prove a stamp of quality and reliability to other operators, not involved in the project.

- *How does the project results contribute to realize energy policy objectives?*

The vision of the H2SMAN project is to provide a new and enhanced technology that can help operators lower emissions and to reduce the impact of oil field chemicals to marine environment of the North Sea discharge using new technologies, in this case the sensor and injector technologies. Even though the Danish government have agreed to stop all activities of fossil fuel production in the North Sea by 2050 production will continue the next 30 years. In this period, new technologies that reduce the environmental footprint is needed, this this a clear objective from the Danish state. The purpose of “Nordsøpuljen” was amongst other things to reduce the footprint for Oil and Gas operations, thus the project is fully aligned with this objective.

In addition, the sensor technology can be used in other parts of the energy sector, as biogas production also face H_2S issues.

- *If Ph.D.'s have been part of the project, it must be described how the results from the project are used in teaching and other dissemination activities.*

No Ph.Ds have been part of the project.

7. Project conclusion and perspective

- *State the conclusions made in the project.*

The H2SMAN-project has succeeded in the development of a system for optimizing the H_2S scavenger dosing for offshore applications. The uniquely robust SulfiLogger H_2S sensor is the key enabler for real-time dosing control, and the injection system is crucial for optimizing the reaction time. It has been clearly demonstrated that ultra-fast H_2S measurements are indeed possible, and that the key components are reliable even in the challenging offshore environment.

- *What are the next steps for the developed technology?*

SulfiLogger expects to sell the first systems to offshore operators to get further experience with this application. The operators are keen on getting value from the more reliable H_2S data, so the seeding sale will further underline the business cases.

Next step is a demonstration for the partnering operators, and subsequently a potential cooperation with one or both of these (Total or Hess), for an installation of a prototype, designed and built specifically for one of their offshore process plants. The following step will be a commercialization when proved on site offshore.

- *Put into perspective how the project results may influence future development*

This project has been crucial for developing the SulfiLogger H_2S sensor for offshore applications. The access to offshore testing with the strong project partners has been vital. The sensor technology can still be improved for this application, but know we have important offshore learnings that has identified the issues. The sensors technology has, however, proven to very suited for the application and future development will occur in projects with customers.

This project has initiated and facilitated the development and design of a novel Scavenger Injection System. The system reduces the amount of scavenger significantly, allow for maintenance during operation and provide a safer system. The input from the Operators participating in the project was important in order to understand the context and need for a better injection system. The design, construction and testing could only take place due to the support from the other partners with their technical knowledge and test facilities. Finally, the project was only viable due to the funding from EUDP. The Injection System will now go into the next phase toward offshore implementation and commercialization, which hopefully will lead to new business for LICengineering our other involved key partners and potential local subcontractors for fabrication.

8. Appendices

- Appendix - OTC 2019 O&G Event
- Journals/publications:
  - https://www.aidic.it/cet/19/74/091.pdf
- Websites:
  - https://www.energycluster.dk/projekter/h2sman/
- Articles:
  - https://www.energy-supply.dk/article/view/576279/15_millioner_skal_gore_olie_og_gasproduktionen_gronnere

OTC 2019, May 5th – May 10th, Houston Texas.

Organized by:

Spotlight on innovative Oil & Gas solutions event, organized by Energy Innovation Cluster supported by the trade council of Denmark in Houston.

Meeting with the Greater Houston partnership and meeting between the University of Aalborg and the University of Delaware, organized by Energy Innovation Cluster.

Energy Innovation Cluster participant:

Tim Villadsen, Senior Project Manager International Projects.

Simone La Fontaine, Project Manager.

Indholdsfortegnelse

1. Introduction/Objectives:

The results from the Energy Innovation Cluster facilitated innovation project H2SMAN were to be promoted internationally according to the project description in work package 7 in the H2SMAN project.

The project partner team Unisense, the University of Aalborg, LIC Engineering and Pieter Mouritsen A/S suggested to do the international promotion of the project in connection with OTC 2019 in Houston to get attention and feedback from the big O&G companies attending OTC 2019 in Houston.

Energy Innovation Cluster arranged a side event to the OTC 2019 conference in collaboration with the trade council, at the General Consulate of Denmark in Houston to promote the H2SMAN project internationally and at the same time promote Danish companies with unique innovative solutions relevant to the international Oil and Gas Industry. As part of the event, a B-2-B networking session with US and Danish companies were successfully completed.

As part of the trip EIC also focused on finding a local US cluster partner within the Oil & Gas industry and Onshore wind. Furthermore, EIC arranged a meeting between the University of Aalborg and the University of Delaware in order for the two universities to discuss university-to-university collaborations.

2. Program Innovative Oil & Gas solutions & unique competences.

Wednesday, May 8th, 2019 from 2 PM – 6.00 PM,

Danish Consulate General in Houston, the Williams Tower, 2800 Post Oak Boulevard, Suite 1910, Houston, TX 77056 - United States

Energy innovation Cluster and The Trade Council of Denmark hereby invites to an afternoon of Innovation/collaboration & networking in Houston, during OTC 2019 in Houston.

This event will focus on Innovation projects from Energy Innovation Cluster and partners, presentation of Danish companies with unique innovative solutions to the Oil & Gas industry and networking between U.S and Danish Companies.

Event Program: Innovation/collaboration & networking.

2.00 PM - 2.30 PM: Networking light Lunch (optional)

2.30 PM – 2.40 PM: Welcome, Energy Innovation Cluster & The Trade Council of Denmark

2.40 PM - 3.30 PM: Presentation Innovation Project H2SMAN (Unisense and the University of Aalborg)

3.30 PM - 5.00 PM: Presentation of Danish O&G companies with unique competences

5.00 PM - 6.00 PM: Networking B-2-B meetings U.S and Danish companies/Networking drinks

Presentations by Danish Companies:

Energy Innovation Cluster, U.M Trade Council, the University of Aalborg, Unisense A/S, LIC Engineering, Rambøl, MacArtney, Mati2ilt, SafeEx and CC Jensen.

Participating companies: 34 persons.

Aalborg University, CC Jensen, Consulate General of Denmark, DSV Air & SEA, Energy Innovation Cluster, Force Technology, LIC Engineering, Logstor, MacArtney Inc., Maersk Drilling, Mati2ilt, Petrofac INC., Rambøll, RelyOn Nutec, SafeEx, Schlumberger, Semco Maritime, Shell, Techstar, Texas Automation Systems, Unisense A/S, University of Delaware, Wood PLC, P.E., PMP, Wärtsilä O&G.

The event organized and supported by:

Energy Innovation Cluster and the Trade Council of Denmark, Houston.