

Final Outcomes Report: DarkVision Technologies Inc.

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1. Executive Summary

The project demonstrated DarkVision's downhole imaging technology in Alberta well sites with oil and gas producer partners, with co-funding from ERA Trusted Partners Evok Innovations, Business Development Bank of Canada, and Sustainable Development Technology Canada.

DarkVision has developed an ultrasound-based downhole imaging technology that allows operators to see inside their wells and image critical components. The technology is packaged in a downhole imaging tool that performs a high-resolution 3D scan of an oil and gas well as the tool traverses the inside of the well. The imaging technology can find a number of small yet critical problems that are not detectable with existing technologies. Many of these problems can create well integrity issues that produce methane gas leaks by providing a path for gas to migrate to the surface, commonly known in the industry as a Surface Casing Vent Flow (SCVF).

With a visual picture of the downhole problems causing SCVFs, oil and gas operators can use established intervention techniques to stop these methane leaks in their oil and gas wells. The technology solves a well-known and critical problem for the industry and has widespread use across the various well types found in Alberta in both producing and abandoned wells.

Over the course of the 3-year project, DarkVision imaged numerous wells in Alberta. The technology identified erosion, corrosion, leaks, plug damage and other features of interest to its customers. At the start of the project DarkVision did not have a single well imaged in the field, but over the course of the project the team successfully developed, commercialized, and deployed its technology direct to customers. As project completion, DarkVision has expanded its organizational presence in Alberta with a permanent office.

2. Project Description

2.1. Introduction

DarkVision has developed a new ultrasound-based downhole imaging technology that allows operators to see inside their wells and image critical components. The technology is packaged in a downhole imaging tool that performs a high-resolution 3D scan of an oil and gas well as the tool traverses the inside of the well. The high-resolution imaging technology can find a number of very small, yet critical problems that are not detectable with existing technologies.

DarkVision's technology addresses the need that oil and gas operators have for higher quality, higher resolution, intuitive visual information of well conditions and problems. DarkVision's tool can identify root-cause mechanical problems that are causing the methane leaks and allowing the leaks to come to surface, providing a clear 3D visual representation of the problem and all the wellbore components (casing, tubing, connections, liners, slots, sand screens and other downhole components through various fluids and tubing) involved. This high-resolution imaging capability is particularly valuable on SCVF problems where physically small mechanical problems in casing, connections and cement can be very challenging to diagnose, yet have big consequences in terms of leakage. The detailed information of the root cause allows operators to directly perform remedial efforts to fix the problem using standard perforating and cement squeezing or patching techniques.

2.2. Background

DarkVision has developed a high-resolution ultrasound imaging technology. The technology is a high-resolution system that uses a solid-state array of ultrasound transducers to complete a 360-degree 3D scan of an oil/gas well and its inner components. The basic principles of operation are sending, receiving, and processing high frequency ultrasound pulses that both reflect off and transmit through steel and other surface interfaces. Using various imaging techniques, the technology creates a 3D map of the entire well and detects a number of potential problems and defects. These problems include casing connection problems, cracks, erosion, corrosion, cement channeling and other downhole defects

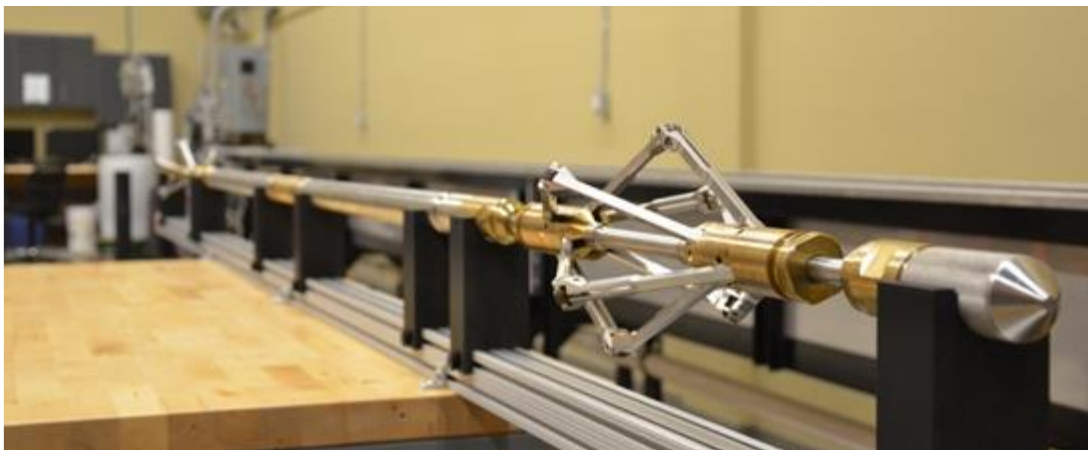


Figure 1 DarkVision's first generation imaging tool in the lab

The imaging technology has been designed into a standard downhole tool form-factor that can be deployed using any number of conventional deployment systems including wireline, tractor, and coil tubing. Above is a picture of DarkVision's prototype MkI tool (Figure 1).

Prior to the ERA work scope, DarkVision completed a significant amount of design work and development of background IP. Some key milestones and work achieved prior to the are summarized as follows:

- Core technology had been invented, various patents filed to protect innovations. Multiple prototypes had been created and lab tested.
- Technology had been packaged into field tools.
- Tools have seen initial field deployments in test wells and customer wells in Alberta.
- Core technical team had been assembled, with key operations hire in Alberta.

2.3. Project Objectives

The key project objectives were:

Demonstrate, develop, and field test DarkVision's ultrasound-based downhole imaging tool in Alberta oil and gas wells (Figure 2), of increasing pressure, temperature, and complexity.



Figure 2 Imaging tool during a field deployment

Validate tool's ability to:

- Identify very small types casing and liner damage that contribute to well problems, poor well performance and well failures;
- Identify very small types of connection damage and cracks that contribute to problems, well integrity concerns, and well failures;
- Identify cement problems and channeling in high resolution that can contribute to SCVF
- Identify and quantify problems with flow control devices, sand ingress, plugging and scale build-up that contributes to poor well performance;
- Validate value proposition of technology and generate case studies and co-author white papers on the technology's performance; and

- Begin early-stage commercialization activities before the end of the project to setup larger scale commercialization rollout post-project.

2.4. Performance Metrics

The Project performance metrics as defined in DarkVision's contribution agreement with ERA are confidential to ERA, DarkVision, and the project consortium partners; as such, they have been redacted here. DarkVision's continued technology development efforts also mean that many of the performance metrics specified in the ERA project have already been improved since the completion of the project work. DarkVision should be consulted directly on all inquiries related to current capabilities and performance of the tool.

2.5. Project Changes

No major project changes or alterations to the work scope were experienced over the course of the project. The tool functioned as expected, and DarkVision were able to complete more than the target number of deployments of its technology.

2.6. Technology Risks

The technology has been sufficiently de-risked for commercial purposes, but the company continues to work on improvements to:

- Radial depth penetration
- Operating envelope
- Different form factors
- Software and firmware improvements

Perhaps the greatest remaining risk is the lifetime of the components and the tool. As the technology is still relatively new, the long-term costs of maintenance and repair are still not fully understood. This risk will be mitigated through more deployments and the collection of field data.

Early in the project, the most significant risk to DarkVision and its technology development plans Under new ownership this is no longer the case. While there are undoubted risks in the geographic expansion, and new product development, the financial resources available to the company mitigate many of them. With strengthening of the team, and increased field validation other key risk are also receding.

There will certainly be challenges and risks, both known and unknown in the years ahead, but the technology is robust, the team is settled, and the company is well capitalized to succeed.

3. Project Work Scope

3.1. Methodology

Over the course of the project, DarkVision deployed its imaging tool at multiple oil and gas well sites across Alberta. Specifics of the deployments of DarkVision's technology at each project well site are confidential to ERA, DarkVision and its respective consortium partners.

In general terms, the project was split into three milestones from 2018 to 2020. Each milestone involved several trial runs of DarkVision's tool in oil and gas wells with varying operations characteristics, completions, and types features to be imaged (though the types of features were project learnings, as they were not known prior to deployment).

Care was taken to select wells that would test the entire operating range of DarkVision's tool, and each milestone contained dedicated tasks to further refine the design of the tool and the 3D data visualization software.

3.2. Overall Project Achievements

DarkVision successfully completed its ERA project work scope, and

- DarkVision trialed and developed several iterations of its ultrasound imaging tool with oil and gas producer partners in wells across Alberta.
- The technology was successfully commercialized, progressing from TRL 6 (initial field demonstration) at the project outset to TRL 9 (commercial implementation) at the conclusion.
- Commercial viability and future uptake/use of the tool in Alberta will be further supported by Koch, DarkVision's new parent company.
- DarkVision also published several technical papers and made various conference presentations as a means of further marketing and commercializing its technology. At the time of writing, further journal publications were also pending. In addition, DarkVision received technical awards from various industry associations over the course of the project; a summary of some of these achievements is contained herein in Section 8, while full details can be found on DarkVision's website.

3.3. Results

Detailed results, including well data, and tool data on imaged features are confidential to ERA, DarkVision, and DarkVision's consortium partners and clients. Production data and greenhouse gas/leakage data remain confidential to DarkVision and its producer partners.

4. Commercialization

DarkVision started the project with a very limited commercial presence in Alberta. Over the course of the project, and due to the success of the technology, DarkVision successfully built and expanded a broad client base of oil and gas producers as end users of the technology. Many of the producer partners that trialed early iterations of DarkVision's tool are now repeat clients.

The performance of the technology funded by the project has been excellent. Operating envelope (pressure and temperature) has exceeded expectations, and the resolution of the tool met pre-project commercial targets (future development likely to decrease this further). While cement and axial penetration was not commercialized to the same degree, DarkVision believes strongly in the market opportunity, and is continuing to develop this, and other downhole products, as well as expanding into other market verticals.

In May of 2020 DarkVision was acquired the Koch Engineered Solutions¹. As part of the acquisition the company was capitalized with a significant investment which will enable the geographic scaling of the downhole service and further development of the technology, with new applications and markets to be unlocked. At time of writing DarkVision has doubled its Canadian headcount post acquisition, is increasing its Alberta headcount, and has many other Canadian positions in the hiring phase and planned. The existing Canadian founders of DarkVision remain in their pre-acquisition roles as CEO, CFO and CTO.

Consistent with the contribution agreement, DarkVision estimates that the project was at TRL 6 upon commencement. DarkVision estimates that the technology was at TRL 8 upon completion of the project and transitioning to TRL 9.

¹ <https://www.prnewswire.com/news-releases/koch-engineered-solutions-acquires-darkvision-in-move-to-develop-integrated-asset-integrity-platform-301060391.html>

5. Lessons Learned

As was previously discussed, DarkVision did not encounter any significant delays, challenges, or technical obstacles over the course of the project that resulted in significant 'pivots' in terms of DarkVision's technological offering.

Longer term, as the technology progresses and its results become accepted by the industry, DarkVision's inspection technology may have the potential to become mandated as an additional source of well integrity information by the Alberta Energy Regulator and other regulatory bodies. The trends around regulation for well integrity in Alberta are becoming more stringent with regulators wanting well integrity issues to be well understood and addressed proactively. These trends are in-line with DarkVision's product offerings. However, there is no need for DarkVision's technology to be mandated as the value proposition itself is already driving strong market adoption.

6. Environmental Benefits

6.1. Emissions Reduction Impact

As a GHG reduction enabling technology, it is difficult to accurately quantify the reduction in GHGs from the deployment of DarkVision's technology. Moreover, customers do not report GHGs to vendors, and often DarkVision is involved in the specific imaging of a feature only. The implications, actions, and mitigations are never relayed to DarkVision before, during or after an imaging operation, and the contextual customer data remains proprietary to the customer.

However, it is clear that DarkVision is finding defects, and that customers are taking action on those defects. As a result, the technology is improving the environmental performance of the oil and gas industry in Alberta.

DarkVision's technology enables GHG reductions by allowing oil and gas producers to accurately identify and repair defects in their wells that are the result of thermal stresses (expansion/contraction cracks or connection failures due to steam cycling and other thermal swings), sand screen/liner failures, or scale buildup. More-severe instances of well integrity failure can lead to depressurization of the steam chamber entirely, requiring intervention, redrill, and reestablishment of the steam chamber. DarkVision's technology enables the avoidance of these situations and their associated greenhouse gas emissions.

Gas migration and emissions from SCVFs can also be identified and avoided. Furthermore, the technology can go one step further by identifying potential problem areas that may not be leaking at the time but pose a high probability of leaking in the future. This critical information allows operators to clearly understand the problems and plan specific remedial efforts.

The Spring 2017 Alberta Oil Sands Industry Quarterly Update states SAGD production in the province to be 1,028,528 bbl/day, with an average single well pair producing approx. 450 bbl/day. Assuming: (i) a 15% baseline SAGD well failure rate (based on presentation by C-FER on June 15, 2015 in Calgary at the Heavy Oil Conference), (ii) operational improvement/workover avoidance enabled by general health, casing, and liner checks by DarkVision, (iii) improvement of steam-oil ratio, and (iv) reduction of drilling activities, DarkVision estimates that greenhouse gas reductions on the order of approx. 494 tCO₂e per well may be achieved by its technology.

DarkVision also estimates that by 2030 its technology may be deployed in as many as 1,550 wells across Canada, with the vast majority being wells with oil and gas producers in Alberta. This number of deployments would result in annual enabled GHG reductions of 765,071 tCO₂e, with 2030 cumulative reductions totaling approx. 4.9 MtCO₂e by 2030.

6.2. Other Environmental Impacts

DarkVision's technology has the following non-GHG environmental impacts:

- Wastewater reduction: DarkVision's technology, when applied to in-situ oil sands assets, can be used to improve the steam-oil ratios of well pairs by enabling operators to troubleshoot performance of inflow control devices and optimize wellbores. Water use reductions can also be achieved via avoided workovers and re-drills. In non-oil sands cases, the water impact from the technology would be limited.
- Land-use related to well abandonments: DarkVision's technology is an enabler for reducing the cost and accelerating the pace of well abandonments. While this will have an impact on methane reductions in cases

where the well is leaking while awaiting abandonment, as additional environmental benefit is that the land can be reclaimed earlier, at less cost and with less impact.

- Chemical use reduction: Well workovers and drilling activities require the use of chemicals which, if not contained in the well as intended, are harmful to the environment. By reducing the need for interventions and redrills, DarkVision's technology reduces the chance of these chemical spills.

7. Economic and Social Impacts

Project-specific economic benefits on a per-deployment basis are confidential to DarkVision's project consortium partners. In most cases, DarkVision's technology is deployed to image a single feature in the well, and any subsequent remediation activities are outside of DarkVision's purview.

However, in general, economic benefits of DarkVision's technology were and will be realized by DarkVision's end users. DarkVision provides oil and gas operators clear visual 3D information of well integrity problems that could be creating production issues or methane leaks in their wells. With this information, operators can plan and execute efficient and effective repairs using industry standard plugging and patching techniques.

Currently, the root cause of many leaking wells is unknown. Attempts to determine the cause of the problem and repair of these wells is often unsuccessful, resulting in multiple failed attempts to detect and repair the problem. Reducing the uncertainty associated with an abandonment or troubleshooting operation would create value for the customer. If these kinds of problems could be fixed in a single decisive operation, the dollar savings would be significant as would be the reduction in methane emissions.

In cases where active wells are leaking, the economics are the primary driver for the business case in fixing and repairing leaks quickly and efficiently. Accelerating repairs enables production to get back online sooner, plus fixes the methane leaks. In these cases, the DarkVision value proposition is strong as a short imaging operation can enable restored production. These leaking active wells represent a significant opportunity, and are also responsible for a large share of methane leakage problem in Alberta.

DarkVision's technology also has the potential for both social and economic benefits for Alberta oil and gas producers in terms of enabling the reduction of environmental liability associated with well abandonment. In the abandonment case, DarkVision's target market are those wells which are difficult or problematic to abandon. There are many out of compliance wells that have been inactive but not abandoned in Alberta. Discussions with operators have indicated that many of these wells will be out of compliance due to difficulty, risk and potential for high abandonment costs. This is a smaller market opportunity and abandonment decisions will be driven in part by regulation and in-part by perceived risk, costs, and the price of oil. DarkVision helps reduce the potential for high abandonment costs in this market.

In terms of direct employment: at the end of the project DarkVision had 5 Alberta based FTE's and plans to increase headcount. Even during the pandemic, no staff were terminated, and DarkVision has had zero Alberta resignations. Headcount will increase in 2021 and likely 2022 as well. The rate at which DarkVision expands its Alberta team in the future will be heavily dependant on the commercial success of the technology and the subsequent adoption by customers, although given DarkVision's success to date it is expected that permanent employment positions in the province will remain for quite some time.

In addition, deployment of DarkVision's tools in Alberta basins uses Alberta service personnel. DarkVision estimates that for a single 1-day imaging operation, there are 6-8 man-days of non-DarkVision well preparation and deployment activities conducted within Alberta and contributing to the economy.

8. Scientific Achievements

Prior to, and over the course of the project, DarkVision has remained committed to protecting its intellectual property via patents that form a robust IP portfolio. Technology IP was developed over the course of the ERA project; where DarkVision has developed and will continue to develop IP associated with the technology.

DarkVision has remained committed to publicizing the results of their technology development through conference attendance and journal publications and have received several recent technical awards. Some highlights over the course of the project are as follows:

- DarkVision's technology was showcased in the May 2020 issue of Hart Energy's industry leading E&P magazine. The article investigates DarkVision's high-resolution acoustic-based imaging technology and its evolution for applications in perforation erosion imaging and measurement (Figure 3).



Figure 3 Hart Energy Publication May 2020

- DarkVision's high resolution images were featured on the front cover of the oil and gas industry's most widely read publication, the Journal of Petroleum Technology (JPT). The January 2020 issue addresses how DarkVision is helping operators diagnose casing failures, providing images of damage within operators' wells (Figure 4).



Figure 4 JPT Cover Article January 2020

- DarkVision was honoured to receive the 2020 Spotlight on New Technology Award from the Offshore Technology Conference (OTC) in Houston, Texas. The award recognizes DarkVision's highly innovative acoustic imaging technology for making a significant impact in the oil and gas industry (Figure 5).



Figure 6 OTC New Technology Award April 2020

- DarkVision was awarded the Intervention and Coiled Tubing Association (ICoTA) Canada Innovation Award for their outstanding technological advancements in oil and gas downhole imaging in 2019 (Figure 5).



Figure 5 ICoTA Innovator of the Year Award October 2019

9. Overall Conclusions

DarkVision has successfully completed their ERA project scope of work, noting the following general conclusions:

- DarkVision trialed and developed several iterations of its ultrasound imaging tool with oil and gas producer partners in wells across Alberta.
- The technology was successfully commercialized, progressing from TRL 6 (initial field demonstration) at the project outset to TRL 9 (commercial implementation) at the conclusion.
- Commercial viability and future uptake/use of the tool in Alberta will be further supported by Koch, DarkVision's new parent company.
- As an indirect technology, it is difficult to quantify the reduction in GHG's from the deployment of DarkVision's technology. Customers do not report GHGs to vendors, and often DarkVision is involved in the specific imaging of a feature only.
- DarkVision is finding defects, and that customers are acting on those defects. As a result, the technology is improving the efficiency of the oil and gas industry in Alberta and helping to facilitate a low-carbon economy and secure Alberta's success in a GHG-constrained future.

10. Next Steps

DarkVision will continue to sell its imaging services to the North American Downhole services market. Early in the project the company focused on Canadian customers, who were geographically close. For much of the project DarkVision sold on an opportunistic basis, with almost no dedicated sales presence until later in the project, a limited sales and marketing spend, the company very much ‘answered the phone’ to generate revenue.

In addition to servicing DarkVision’s Canadian customers, DarkVision’s Alberta office remains the office that supports the field deployment of new technologies, as well as the team that supports global expansion. The Alberta field team are currently preparing to deploy overseas in 2022 and are now a valued and indispensable part of DarkVision’s commercialization and global expansion efforts.

DarkVision will continue to deploy its tool, with a focus on onshore North America. The company hired its first US employee in August 2020 and continues to target the US onshore market. Expansion to other geographies and offshore remain in the DarkVision’s plans and the company also intends to broaden the applications and markets that the technology can be applied. However, no timeline has been set.

Of note is that DarkVision has leased a 52,000 ft² facility in North Vancouver, which is currently undergoing a substantial renovation. DarkVision expects to move the team to this new facility in mid-2021, and for this to be the R&D hub, data processing center and head office going forward.

11. Communications Plan

With increased capital and sophistication DarkVision is now expanding its sales and marketing efforts. In the upcoming year, DarkVision plans to:

- Increase sales and business development personnel;
- Increase attendance at tradeshow;
- Update and improve the DarkVision website; and
- Increase sales and marketing activities.

At the time of writing this report, DarkVision already have several potential journal papers under review for various publications and conferences of the Society of Petroleum Engineers. These publications and conference presentations are slated for late 2020 and early 2021.

Recipient Organization

DarkVision Technologies Inc.

Title

Downhole imaging system for identifying wellbore leakage

GHG Emission Reductions (ERs): 2011–2050

2011	0
2012	0
2013	0
2014	0
2015	0
2016	0
2017	0
2018	8,735
2019	0
2020	0
2021	0
2022	0
2023	0
2024	0
2025	0
2026	0
2027	0
2028	0
2029	0
2030	0
2031	0
2032	0
2033	0
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2041	0
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2046	0
2047	0
2048	0
2049	0
2050	0

Please Refer to ERA's Website For the Quantification Methodologies
<https://www.eralberta.ca/calculating-ghg-emissions-reduction/>