

# А ВЫ НОКТЮРН СЫГРАТЬ СМОГЛИ БЫ НА ЭХЕ МАГИСТРАЛЬНЫХ ТРУБ?

Найти достойное применение строящемуся трубопроводу газа – занятие, требующее не только специальных разрешений, но и известного творческого самоотречения. Но такой умелец выискался: немецкий музыкант Армин Кюппер приспособился использовать незаполненный газом трубопровод как резонатор для своего саксофона.

Господин Кюппер, проживающий в городке Лидберг (Северный Рейн-Вестфалия), стал местной знаменитостью. Труба божественным образом вторит его замысловатым соло, превращаясь в значимое событие небогатой культурной жизни постпанэпидемической, как нынче выражаются, поры.

«Иногда я просто не могу наиграться вдоволь, — это признание высокотехнологичного исполнителя приводит ганноверский журнал Pipeline Technology Journal. — А когда вечером становится прохладно, я залезаю в трубу, еще теплую от солнечных лучей, и наслаждаюсь закатом, импровизируя на саксофоне».

Впрочем, свой творческий потенциал Армин использует еще далеко не на полную катушку. Ведь в его творческом потенциале – умение искусно играть еще и на гитаре и даже на диджереиду, духовом



инструменте аборигенов Австралии, считающимся одним из старейших духовых инструментов в мире.

Возможно ли использовать музыкальную инновацию господина Кюппера для виброакустического мониторинга целостности трубопровода, насколько его музыкальный гений способен заменить снаряд внутритрубной очистки и диагностики, пока неясно. Слово за специалистами!

А убедиться в высоком акустическом потенциале изобретения немецкого музыканта можно по ссылке:  
<https://www.youtube.com/watch?v=uKskKxtvbws>

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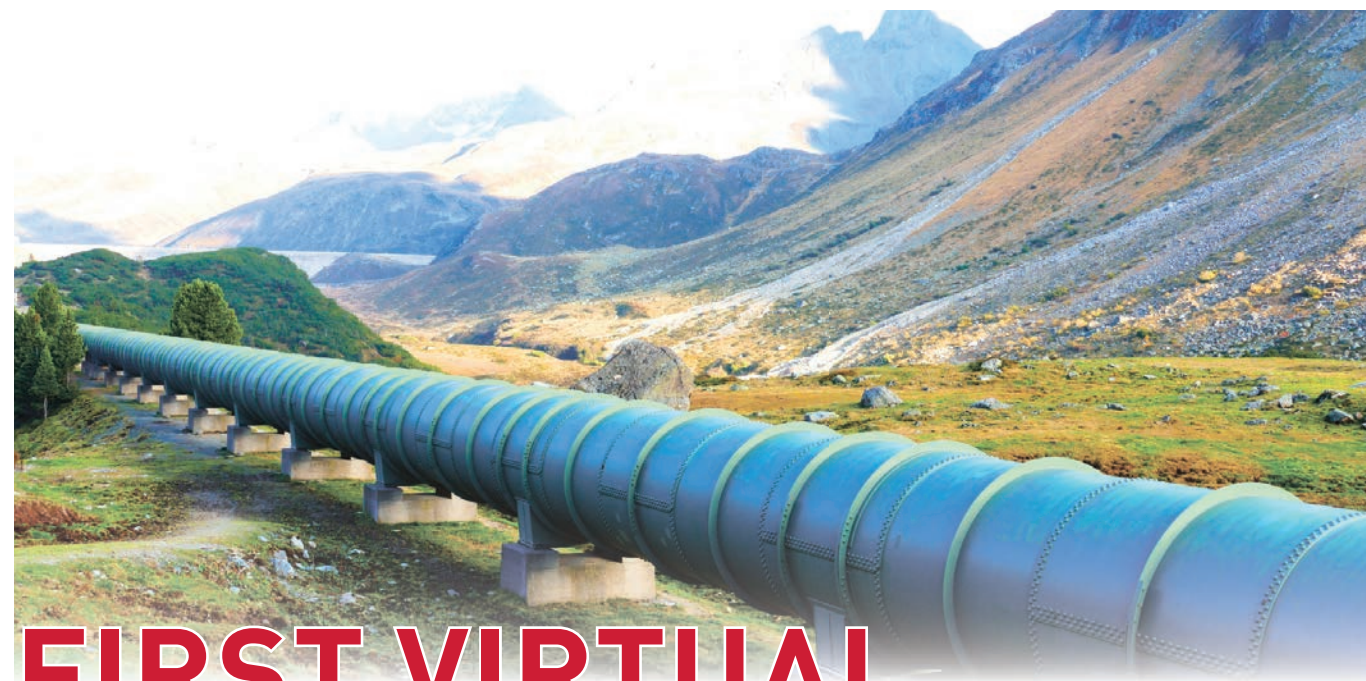
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# FIRST VIRTUAL PIPELINE SUMMIT BREAKS NEW GROUND FOR ONLINE EVENTS IN THE PIPELINE INDUSTRY

Following the lessons learned from the first ever online Pipeline Technology Conference in March 2020 the organizing EITEP Institute developed a new Virtual Pipeline Summit (VPS) series of events.

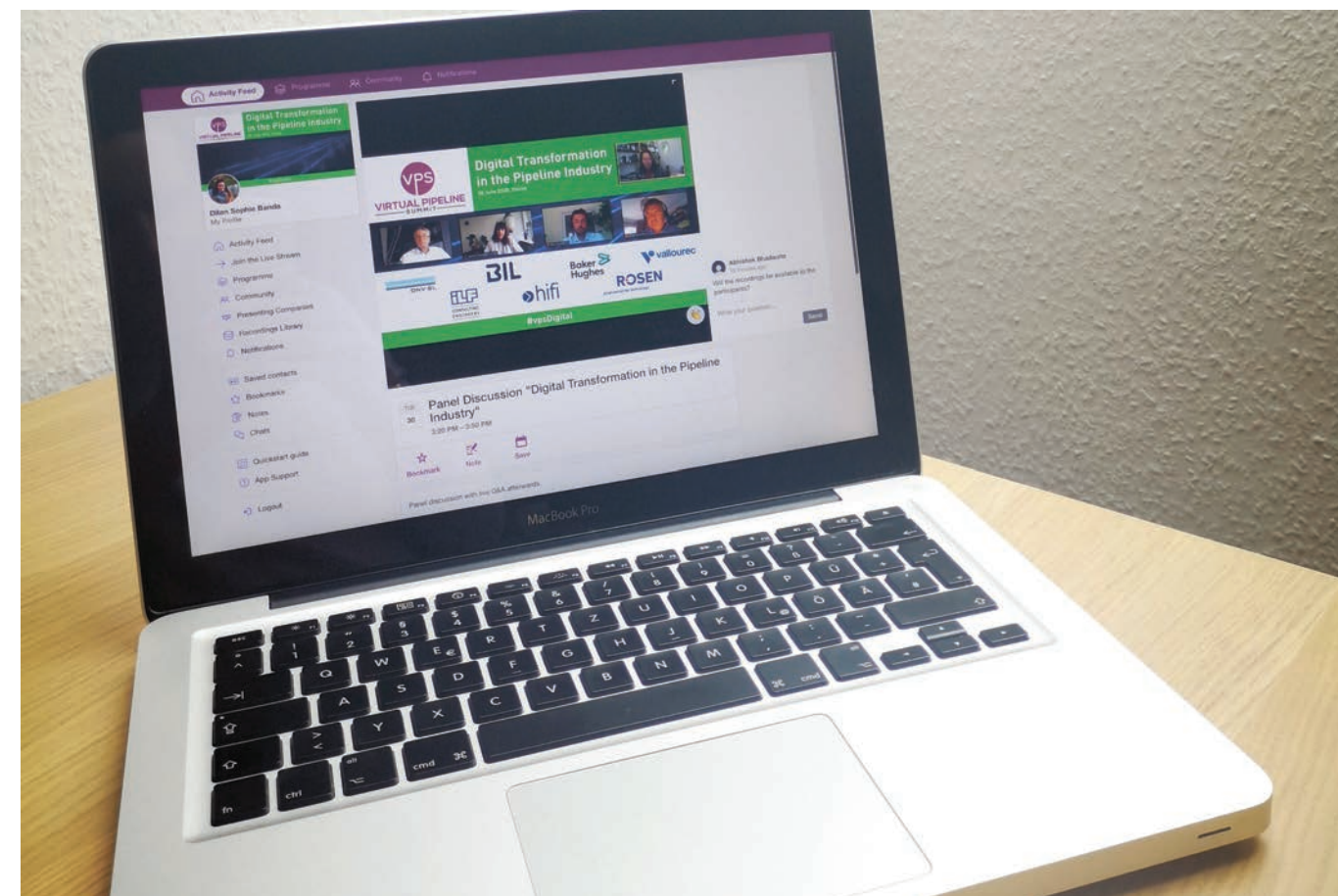
On 30 June 2020 more than 600 participants from 69 different countries joined the first VPS on

“Digital Transformation in the Pipeline Industry” online. Almost 30% of the participants came from pipeline operators the world over.

The goal of the online event was to give back to the pipeline industry the lost opportunities for knowledge transfer and networking, and to provide a comprehensive overview and competitive technology

showcase of a spectrum of problems and solutions in these challenging times.

Amid the global pandemic, pipeline operators in particular must adapt their processes, procedures and staff to more extensive digitalization in order to meet supply and safety responsibilities. Pipeline operators need to shift staff



to crisis management tasks, which leave a large gap in the capacity to perform business-as-usual operations. The ability of pipeline operators to leverage process automation, machine learning and artificial intelligence capabilities has become essential. In addition, pipeline companies around the world are more vulnerable than ever to cyberattacks as a result of the pandemic. As attackers try to take advantage of the situation, the ability of all companies to defend themselves against this threat has become critical.

All these aspects were covered during the 3 hour event in several live presentations from DNV GL, ILF Consulting Engineers, BIL, Hifi Engineering, Baker Hughes, ROSEN and Vallourec, and a live panel discussion with participants from Shell UK, Energinet Denmark, BIL and Baker Hughes. The participants made extensive use of the chance to ask live questions and to talk to each other via a LinkedIn-like activity feed and to exchange virtual

**16<sup>th</sup> Pipeline Technology Conference**  
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business cards with each other.

Even beyond the date of the live event, the participants could follow up with the speakers and the other representatives from the presenting companies in case there are questions that had not been answered during the sessions. Moreover, all live content will stay online as recorded videos for participants who were not been able to join the live video feed.

The organizing EITEP Institute is already working on the announcement of the upcoming 2nd Virtual Pipeline Summit to be held in September and of the 16th Pipeline Technology Conference & Exhibition that will take place as usual in Berlin from 15-18 March 2021.

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## OMEGA Fiber Optic Monitoring System: New Features for Technological Security of Transneft Pipelines



Dr.Aleksey I.Turbin > OMEGA

### Abstract

Since 2009 the OMEGA Company develops and produces multifunctional monitoring systems for extended facilities indicating in online mode oil, oil products and gas leaks as far as third party activity in the protected zone using a fiberoptic cable (FOC) as sensing element. Implementing distributed acoustic and temperature sensors the Leak Detection and Activity Control System (OMEGA LDACS) provides precise detection of location and nature of vibrations and change of temperature characteristics on and around extended facilities. The leaks are detected through analysis of fluctuations both in the temperature and vibroacoustic field.

Having equipped more than 6000 km of pipelines with OMEGA LDACS in Russia and abroad the Company is in permanent search of ways of improvement of the FOC monitoring technologies. The newest LDACS feature is the implication of the artificial neural network for more precise identification of potentially dangerous events registered by the system. Another option in the equipment of LDACS with additional pressure and displacement sensors.



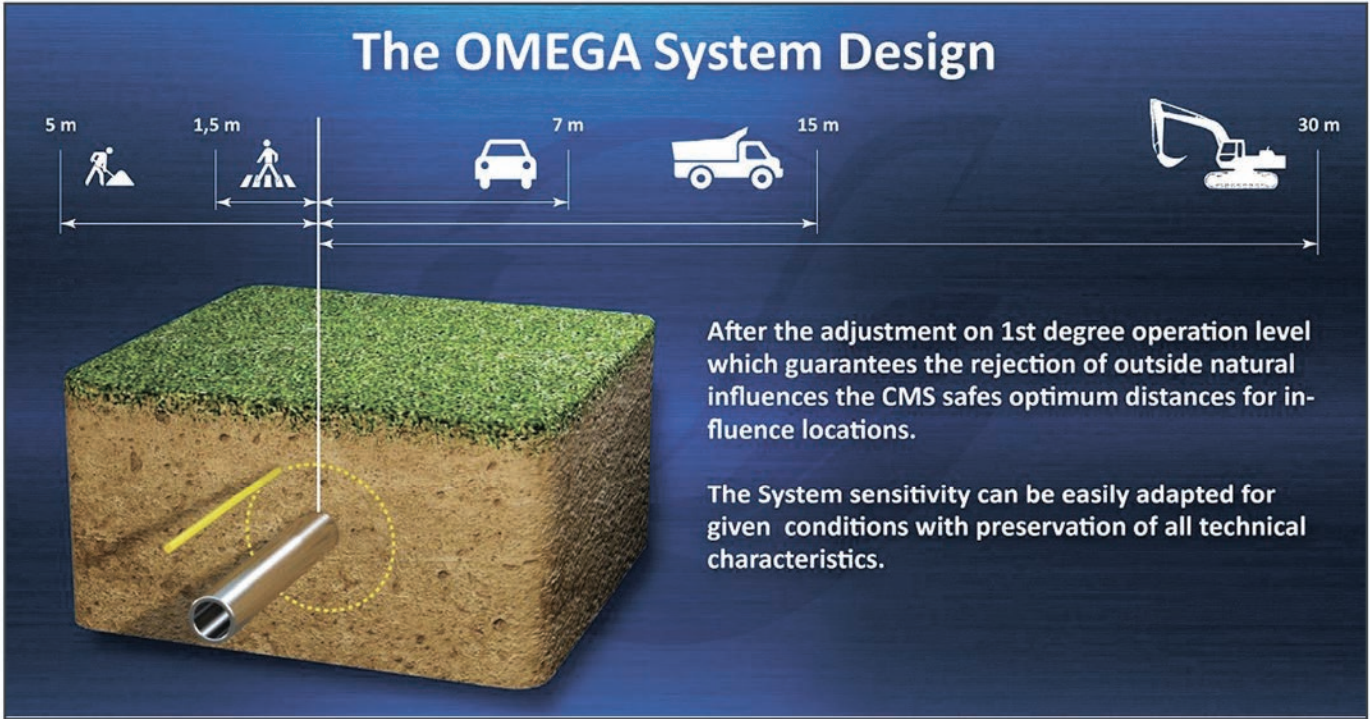


Figure 1: The OMEGA System Design

The main feature to be developed in coming years in the implementation in OMEGA LDACS of artificial neural networks for better recognition of events registered by the system.

Having been founded in 2009 the OMEGA Company celebrated its first anniversary last year being one of the European leaders in total monitoring system equipment length which reached 6000 km last year.

The fifth version of the OMEGA LDACS based on temperature and acoustic field monitoring and implemented now on TRANSNEFT pipelines provides high-precision detection of location and nature of acoustic vibrations and temperature characteristics of pipelines.

The extended object is monitored through the whole length of optic fiber used for the System's sensor and not requiring electric power along the line in real time mode.

In comparison to similar systems the OMEGA LDACS shows high accuracy ( $\leq 3\text{m}$ ) both event detection on extended object. The main achievement of the OMEGA scientific team is the implementation of artificial neural network for more precise recognition of the potentially dangerous event.

The range of parameters that can be measured by fiber optic sensors is quite extensive. These are the temperature and temperature change dynamics, absolute and

gauge pressure, linear-and-angular movements and the rate of speeding up. The use of high-stable materials and application of cutting-edge technologies make it possible to produce ultra-high accuracy sensors. These are main directions of product development for OMEGA scientists – keeping an eye on other implication fields besides oil and gas transportation.

With high sensitivity rate the OMEGA LDACS can be applied for detection of pipeline ruptures or small leakages amounting to hundreds of liters per 5 minutes. The fluid flowing under high pressure generates the acoustic wave detected by optic cable.

With false alarms being the main universally recognized disadvantage of FO technologies the implementation of the mentioned version 5 of OMEGA LDACS on one of the 200 km pipelines in middle Russia allowed the reduce the false alarms rate by 6 times bringing it to the acceptable 2-5% level.

The general ideology of the system of event recognition based on artificial intelligence is the creation of patterns describing the reaction of both DAS and DTS sensors to leaks and other events. The absence of some acoustic and temperature parameters which the system needed some years ago for a concrete event alarm is replenished by the "experience" of OMEGA LDACS – which is in fact the centerpiece of the artificial intelligence.

In general, the OMEGA LDACS is build around two crucial

In general, the OMEGA LDACS is build around two crucial sensors developed and patented by our scientific groups.

The OMEGA DTS based on the of Raman light scattering analyzes changes in the temperature field and detects in real-time mode leaks of gas, oil and other liquids in single- and multiphase pipelines.

Maximum coverage range	25 km
Spatial resolution	Up to 1 m
Thermal resolution	0,2 - 2 °C
Type of fiber used	Singlemode

Table 1: OMEGA DTS parameters

The OMEGA DAS architecture is based on the use of fiber optic cable as a set of virtual microphones and as a means of information transmitting. DAS uses coherent optical reflectometry (COTDR) to analyze backscattered light to record vibrations in several virtual channels, the number of them can reach tens of thousands. This enables the OME-

GA LM to record hundreds of events simultaneously.

Another direction of OMEGA Company research and

Maximum coverage range without an optical amplifier	25 km
Maximum coverage range with optical amplifier	50 km
Virtual Channel Length	2 m
Type of optical fiber used	Singlemode

Table 2: OMEGA DAS parameters

development is the elaboration of compact and cheaper solutions demanded for other branches besides oil and gas transportation. An important step on this way is done this year– in Riga, Latvia, we begin tests of our Heating Systems Monitoring system based on same principles as our LDACS. It seems to be a promising business sector for OMEGA Company – the implementation of pour achievements in this branch can help avoid hot water transportation cuts and both economic and environmental damage.

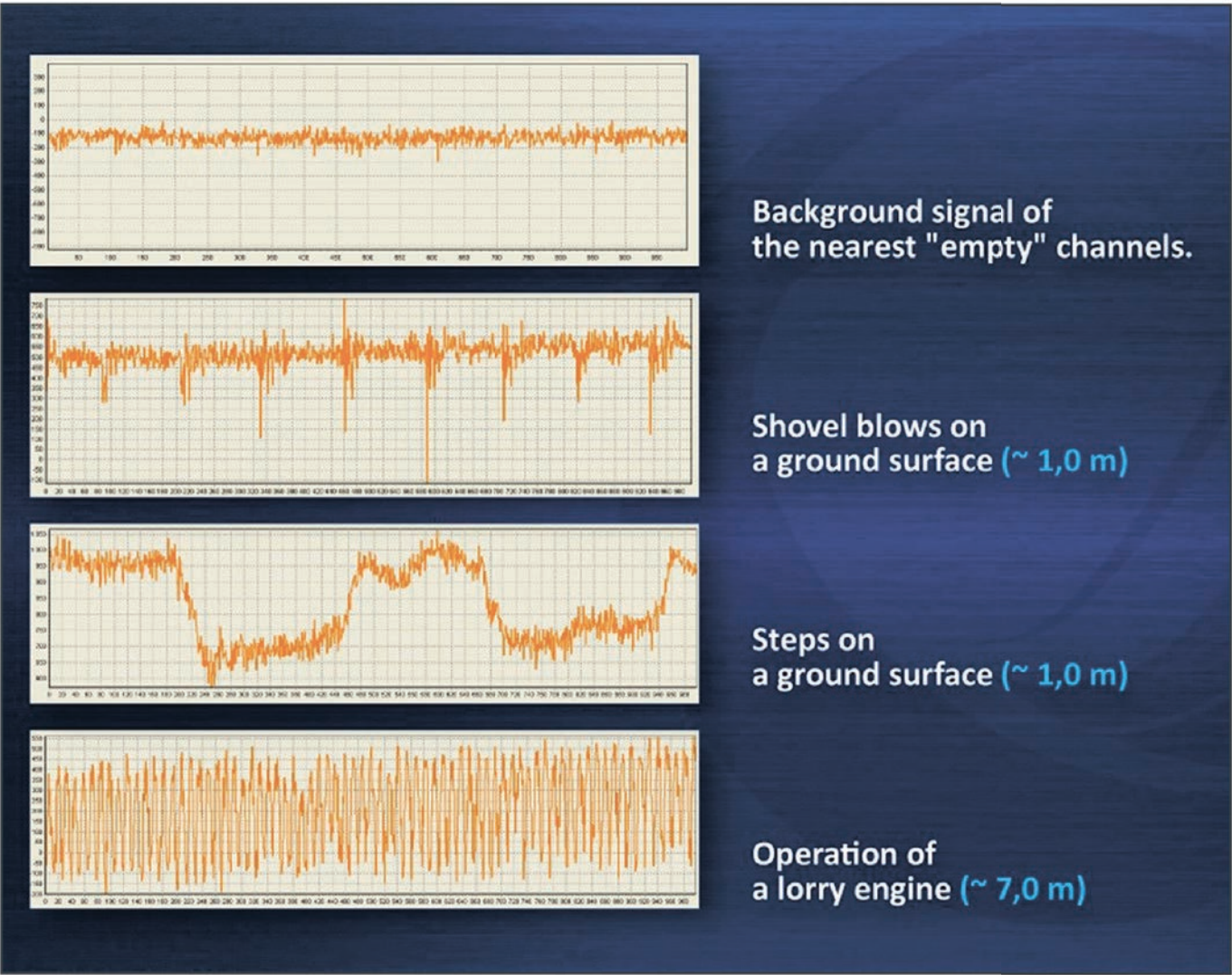


Figure 2: Reflectograms of several impacts registered before recognition



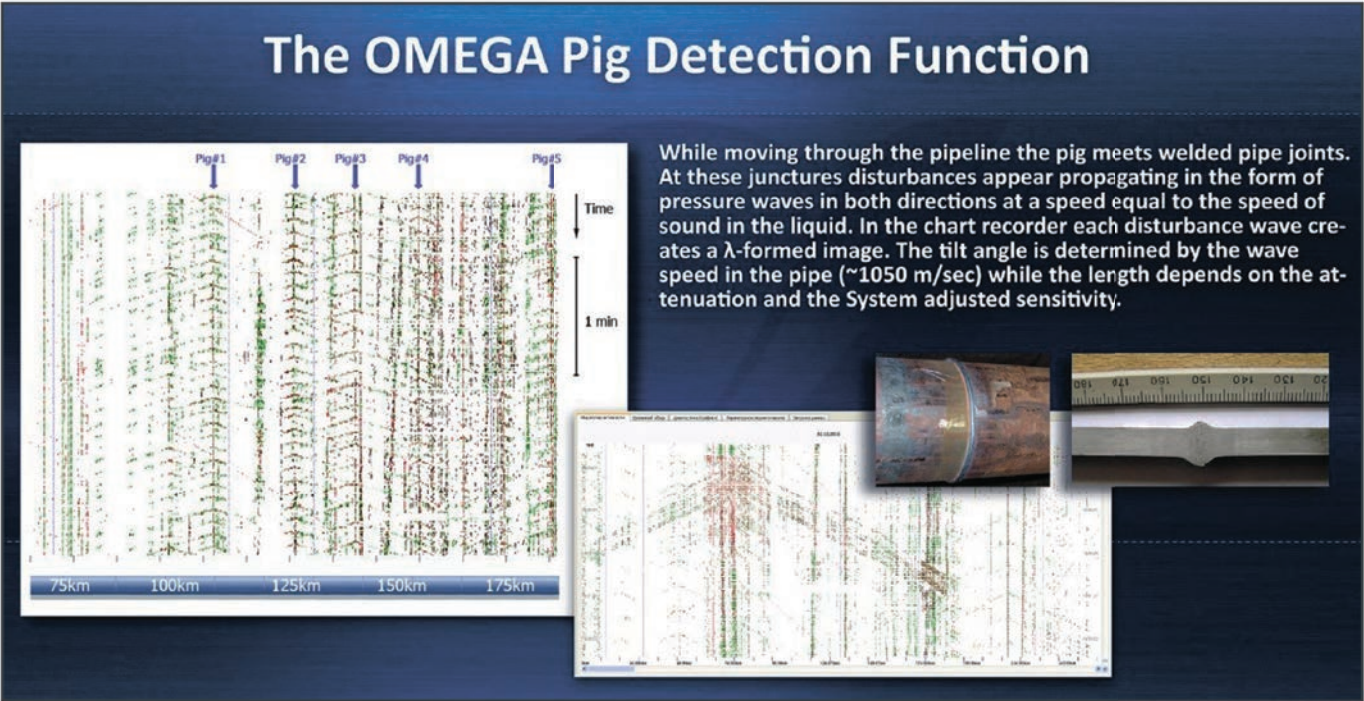


Figure 3: The OMEGA Pig Detection Function

EVENT	Criteria for reliably event determination
Leak	The pressure in oil pipeline $\geq 8 \text{ kg/cm}^2$ . Leak rate - more than $28 \text{ m}^3/\text{h}$ . Leak detection time - $\leq 30 \text{ minutes}$
Manual excavation	Detection time $\leq 10 \text{ minutes}$ with distance from the source of activity to the FO $\leq 3 \text{ meters}$ .
Mechanized excavation	Detection time $\leq 10 \text{ minutes}$ with distance from the source of activity to the FO $\leq 10 \text{ meters}$ .

Table 3: OMEGA LDACS technical parameters

A permanent focus on market requirements will hopefully help the OMEGA Company to diversify its production.

OMEGA LDACS main equipped facilities (state – April 2020):

- “Baltic Pipeline System (BPS-2)”, equipped length - 1000 kilometers”
- “East Siberia – Pacific Ocean” Pipeline System”, “Skov-rodino – Koz’mino” sector, equipped length - 2500 kilometers”
- “Pur-Pe – Samotlor” Pipeline System, equipped length - 429 kilometers
- Adamtash- Dzharkuduk and Dzharkuduk - Shurtan-neftegaz Commodity Park condensate pipeline (LU-KOIL Uzbekistan Operating Company) – 150 km.

With the international market of FO monitoring systems satiated in recent years by both internationally recognized and national producers the OMEGA Company concentrates its efforts of a broader range of business directions contiguous to what we have done in last ten years.

Using competences accumulated by our divisions we offer our services in IT-research & development in oil and gas sector, first of with implementation of artificial neural networks. Our scope comprises Fiber Optic lines design and construction as far as technical and financial consulting in facilities construction in energy and fuel production and transportation.

The latest development is the requisition of the partnership status of Russian divisions of such companies as HUAWEI and LENOVO – we see this as a kind of recognition of the level achieved by OMEGA Company engineers.

### Author

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OMEGA

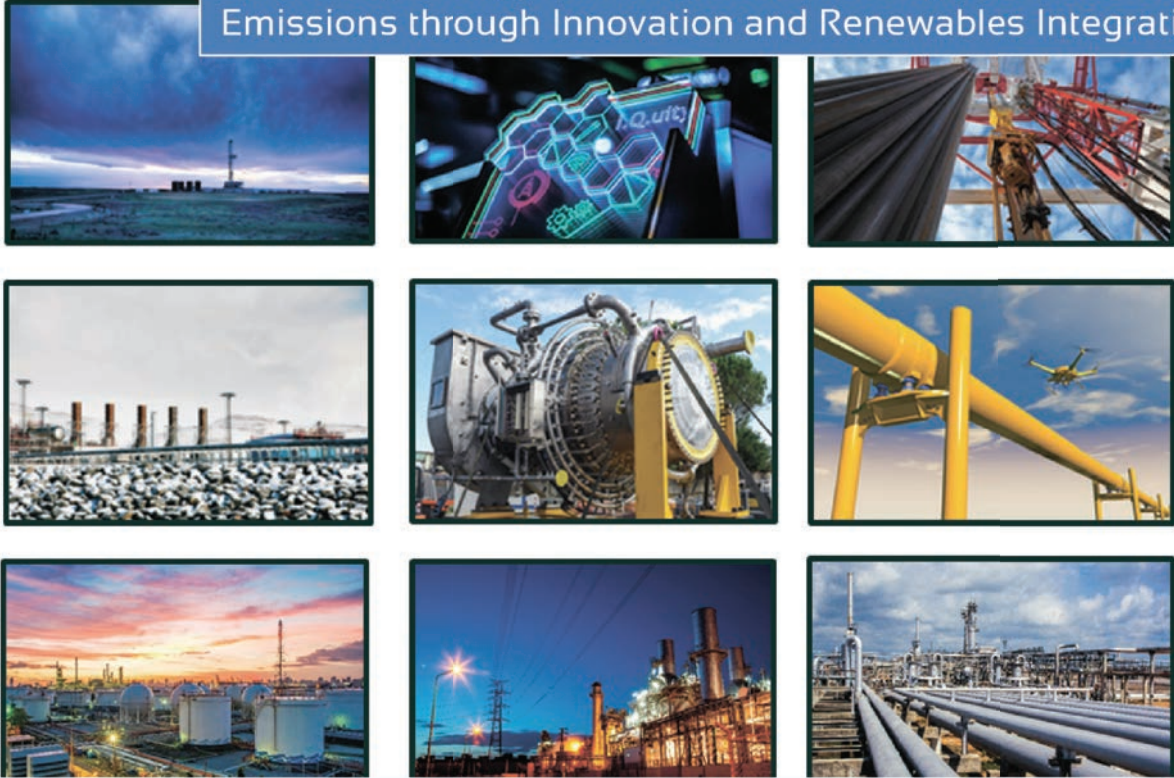
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### Enhancing Energy Efficiency and Reducing Greenhouse Gas Emissions through Innovation and Renewables Integration



Ernesto Nasini, Marco Santini, Marco Baldini, Simone Amidei, Maurizio Vaccaro > Baker Hughes

### Abstract

Consequences of global warming on Earth’s climate are one of the greatest challenges worldwide faced, particularly by industry players. To effectively reduce the amount of greenhouse gas emissions, it is necessary to increase efficiency and exploit renewable energy sources.

Baker Hughes (BH) developed technologies to reduce CO2 emissions and benefit from integration with renewables, such as pipeline compression stations and LNG plants, leading up to 55,000 tons/year of CO2 emission savings and up to 20,000 tons/year of fuel gas savings for a PGT25 turbo-compressor train.

Paper introduces an innovative technology to convert heat into electricity: the system, a Brayton closed-cycle, is suitable for low power applications ranging between 0.5MWe and 1.0MWe.

This patent-pending technology uses CO2 as working fluid and is based on a reciprocating expander-compressor becoming a competitive alternative, in terms of safety and total cost of ownership, to other WHR solutions. As additional benefit, typical application for this small system is for remote areas where electricity grid is either not present or unreliable.

Besides power generation, waste heat can be utilized for refrigeration, down  $-5^{\circ}\text{C} + -18^{\circ}\text{C}$ , using hydrocarbons or CO2 as working fluid. This cold duty can chill process gas saving compression energy or can be used for different chilling purposes. This patent-pending system is composed by an Organic Rankine Cycle combined with a refrigeration cycle utilizing the same working fluid, both services being directly coupled in simplified architecture fully sealed with magnetic bearings.

Additionally, BH patented Hybrid Gas Turbine solution to integrate mechanical drive gas turbines with variable frequency drive electrical machine. A dedicated software optimizes customer needs to minimize CO2 emissions, fuel savings and energy storage, considering the availability of electric energy also from renewable sources. This configuration allows to stabilize the exhaust thermal load for the WHR system independently from the compressor process conditions.



## 1. INTRODUCTION

There are several solutions to reduce emissions of greenhouse gases in the pipeline environment: renewables, efficiency & innovative technologies, including energy storage, developed by BH, can be viably and affordably applied to operator plants.

In the following paragraphs three different solutions are presented, to address different needs.

## 2. CO2 BRAYTON ENGINE

### 2.1 HOW IT WORKS AND MAIN BENEFIT

BH is very deeply experienced with CO2 compression up to supercritical state, as referenced by more than 100 compressors delivered since 1959 with a capacity up to 19000 Nm3/h and a discharge pressure up to 324bara.

As a consequence of this expertise, BH developed a patent-pending system for waste heat conversion into electric power that exploits supercritical CO2 circulating in closed loop in a Brayton cycle through a reciprocating expander/compressor group, connected with the electrical generator by a common crankshaft, and relevant coolers, other than auxiliaries, according to the scheme shown in Figure 1:

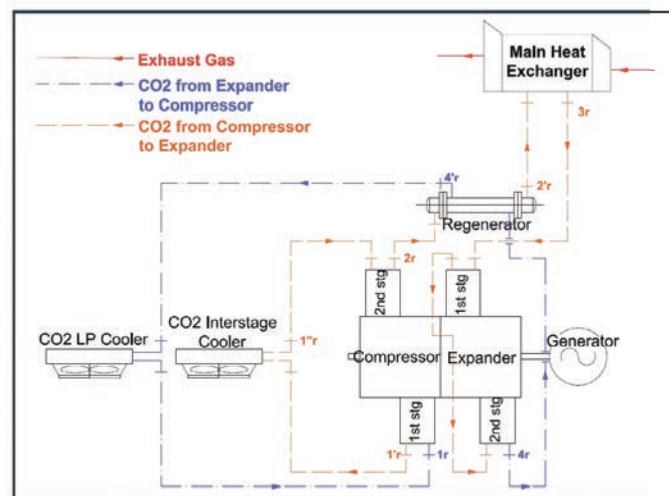


Figure 1: CO2 Brayton Engine

The advantages of use reciprocating machines are linked to their robustness, reliability, wide rangeability with low efficiency decrease at partial loads, affordable price, reduced start-up time, low expertise required for maintenance. Furthermore, considering the high power density related to the supercritical CO2 power plants, for the size of 0.5-1MWe the main advantage of reciprocating machines against solutions with rotating ones is due to the much lower speed (one order of magnitude less, i.e. up to 1000rpm for

the crankshaft vs. 10000rpm and above for rotors) that allows easier coupling (i.e. without gearbox) with generators (or mechanically driven equipment, if required) and a more effective containment of the leakages, since they are fully recovered avoiding the necessity of continuous refilling.

From mechanical point of view, the specific design of the components, such as a proper arrangement of cylinders of the reciprocating expander/compressor group, the selection of suitable piston sealings and materials, the adoption of fully actuated valves, is expected to positively influence the polytropic efficiency.

Therefore, considering its thermodynamic efficiency, the Brayton regenerative cycle reaches an overall efficiency (electrical or mechanical power output to thermal power input ratio) higher than 20% (considering air at 35°C as cooling medium (severe condition) and exhaust gas temperature  $\geq 450^\circ\text{C}$ ) slowly decreasing as the available exhaust gas temperature decreases, at same temperature approach on the hot section of the WHRU (see Figure 2).

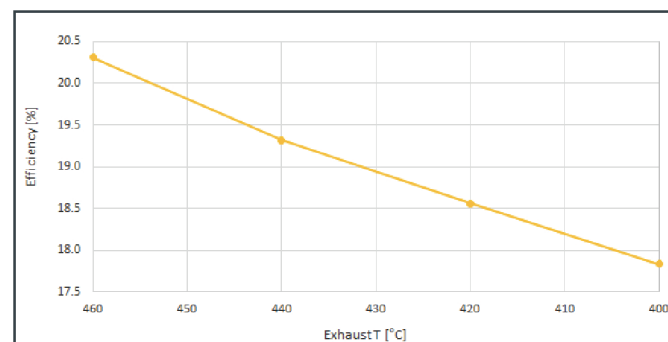


Figure 2: CO2 Bryton Engine efficiency vs. Exh. T (with cooling air @ 35°C).

### 2.2 ENHANCED CYCLE

CO2 exiting from reciprocating expander, although cooled in the regenerator to recover enthalpy by heating compressed CO2, so increasing the cycle efficiency, before entering the final cooler and close the loop is still warm enough to heat a secondary fluid, that can work in a bottom cycle to produce additional power.

BH developed a further patent-pending system for waste heat conversion into electric power that combines the CO2 Brayton cycle shown in the previous paragraph with a bottom Rankine cycle with an organic or a refrigerant fluid, with reciprocating expander group, and eventually the pump, connected with the electrical generator and with CO2 reciprocating expander/compressor group by a common crankshaft, according to the scheme shown in Figure 3. Once more, the low crankshaft speed of reciprocating

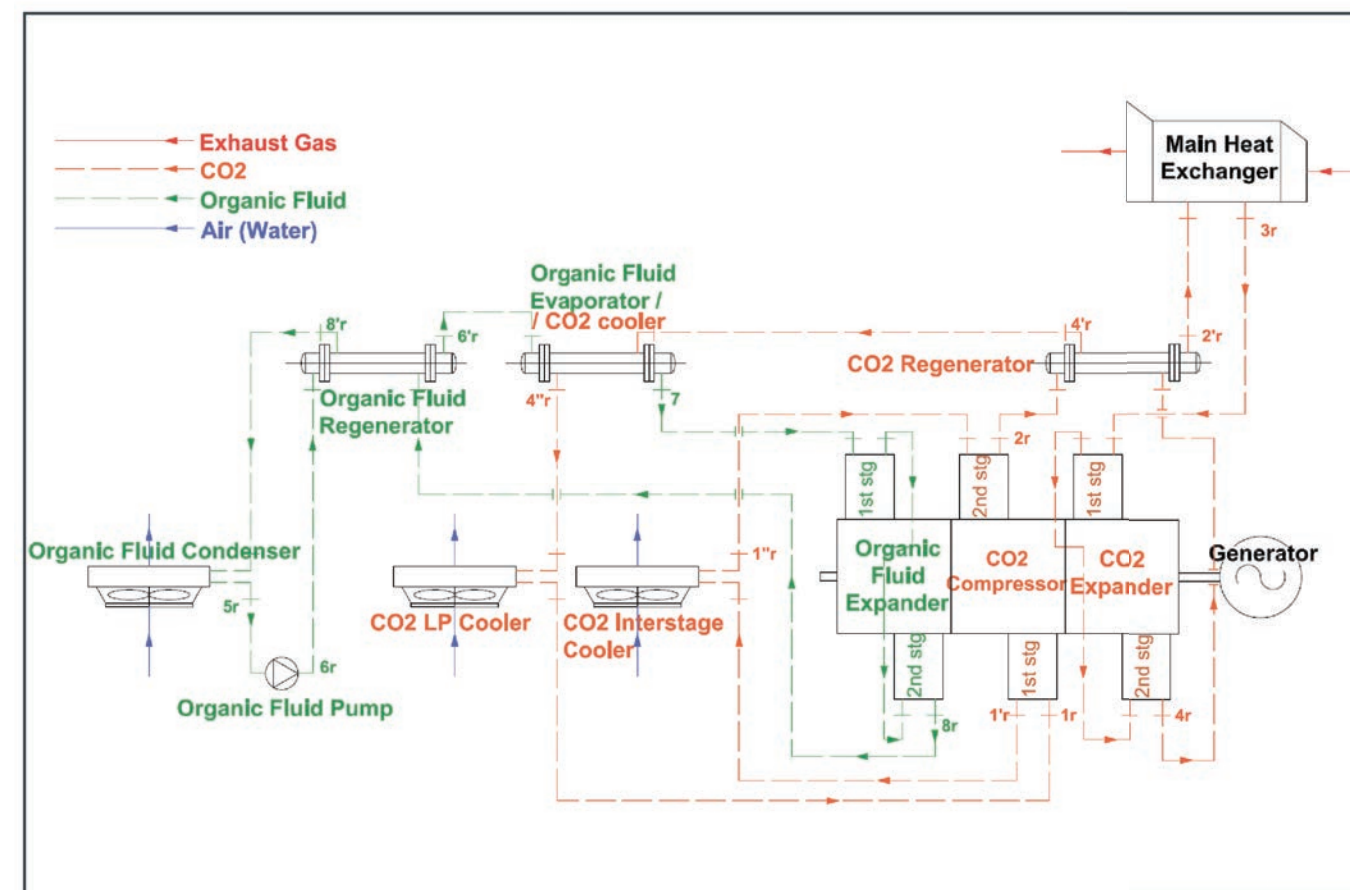


Figure 3: CO2 Brayton cycle combined with a bottom Rankine cycle

system allows the direct coupling of CO2 expander/compressor and bottom cycle expander, as well as acting on cylinders displacement it is possible to elaborate the different volumetric flowrates. To perform the same scenario with rotating machines, it would be necessary an integrally gear machine, significantly decreasing the performances and increasing its complexity.

In the same hypotheses of simple CO2 Brayton cycle, overall efficiency reaches values around 25%.

### 2.3 POTENTIAL APPLICATIONS FOR PIPELINE

Wherever a primary heat source is available, CO2 Brayton Engine contributes to electric and/or mechanical power production with a significant avoidance of fuel consumption and greenhouse gas emissions.

Even where the electric grid is fully available, CO2 Brayton Engine allows to reduce OPEX (electricity cost) and reduce compressor station CO2 emissions.

CO2 Brayton Engine doesn't need water, thermal oil or other utilities, is EHS safe, viable for unmanned operation and it requires minor civil works for a plug and play installation.

## 3. ORCHILLER

### 3.1 CYCLE FEATURES AND TECHNOLOGY

The waste heat conversion into electricity is not always the most viable option (depending on the specific context) for the pipeline operators, so that the direct conversion into another useful effect (refrigeration) could be a better value.

The ORChiller is a patent-pending system by BH for the waste heat conversion into cold energy refrigeration duty, by means of a combination of an Organic Rankine Cycle (ORC) with a mechanical compression refrigeration cycle. It allows to produce chilling service without power generation equipment, by direct mechanical drive of the compression unit, using the same working fluid both for the ORC and for the refrigeration cycle (Figure 4). The two cycles have in common the condenser (that can be air or water cooled). This cycle can also be arranged with double stage compression-expansion, improving so efficiency and reaching lower temperature service.

If compared to the well-known heat-to-cold application, the lithium bromide cooling cycle, the ORChiller can adjust



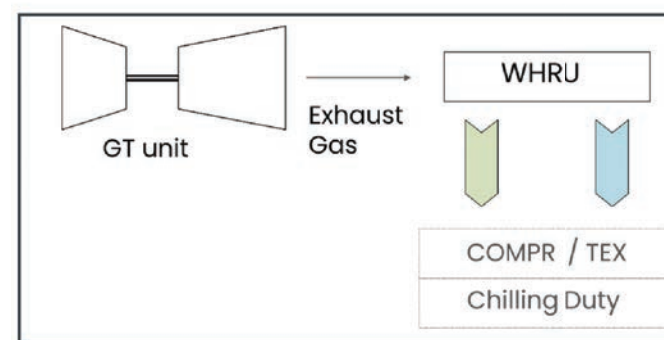


Figure 4: Conceptual ORChiller purpose scheme (GT exhaust application)

the chilling service temperature in a wider range, from 5 °C down to -18 °C (in case of propane as working fluid, single stage machinery).

The cycle configuration is presented in Figure 5. The working fluid proposed is propane, which is pumped and then heated through the exhaust gas waste heat (i.e. from a GT), then it expands producing the necessary mechanical power to drive the compressor, which is part of the refrigeration cycle. Both cycles use the same fluid, and this is one of the main advantages of the ORChiller. The working fluid streams after expansion, and after compression, are sent to the condenser, and the two cycles can start again. The expander-compressor machinery is intended to be integrally connected on the same shaft, by enhancing the ease of the system. Operability and chilling service temperature

are adjustable on the specific application, in a fit-for-purpose way of design.

An intermediate fluid to carry the waste heat must be used, such as thermal oil, as the propane cannot be directly heated through a WHRU by means of direct heating. But in case a non-flammable working fluid like carbon dioxide is used as working fluid, this thermal oil loop can be avoided. OR-Chiller has also been studied to be used with CO<sub>2</sub>, adding also the advantage of reaching lower chilling temperatures (i.e. -18 °C), in case water is available for the condenser cooling, to enhance compactness.

From a turbomachinery point of view, a huge advantage is that the expander-compressor is hermetic type. High reliability service is improved as the hermetic machinery does not use any gas seals system, or lube oil, or gearbox. Magnetic bearings are suggested, so enhancing reliability and keeping the system fully sealed.

Moreover, the air cooler condenser fan motors and circulation pumps motors can be run in Low Voltage, so that no electric conversion or Medium Voltage switchgear is needed, resulting in easy integration with existing electric infrastructure.

The WHRU, when installed on Gas Turbine exhaust, shall be properly selected to minimize backpressure and footprint.

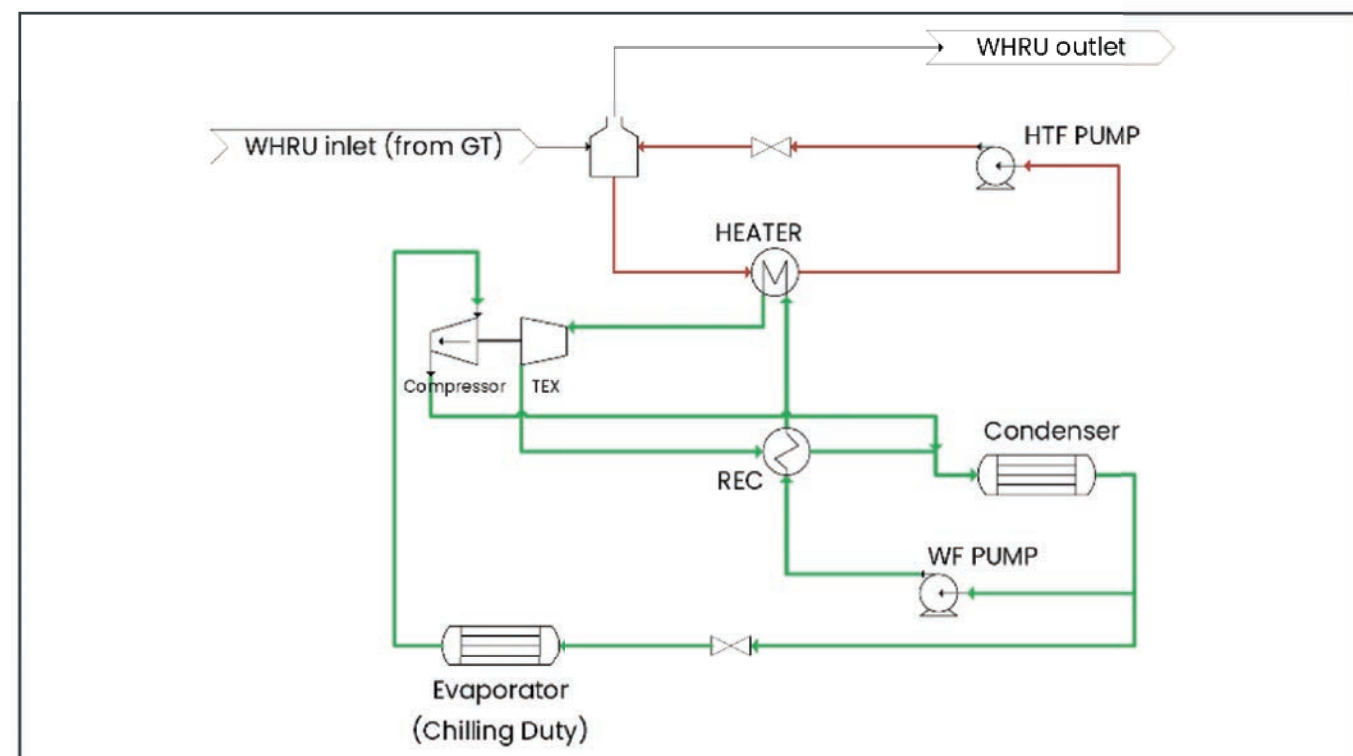


Figure 5: ORChiller configuration with intermediate heat transfer fluid (HTF)

### 3.2 MAIN ADDRESSED USES AND TECHNOLOGY VALUE

The ORChiller can be applied to enhance the efficiency and reduce fuel consumption and CO<sub>2</sub> emission to different industrial and compression plants. The optimal size has been addressed to a 25 MW gas compressor, driven typically by a PGT25/FR5 or similar.

In compression systems operating on gas compositions with low dew point, the suction temperature of the compressor can be reduced with the ORChiller, resulting in reduction of the required power, enhancing the overall compression efficiency. As an alternative, the capacity of the compression station can be increased with the same fuel consumption. Gas turbines (GT) chilling can be included also, increasing the available power in the hot days.

### 3.3 POTENTIAL APPLICATIONS FOR PIPELINE

In case of pipeline application, the ORChiller is estimated to be able to increase efficiency of a significant amount by cooling the inlet process gas and consequently reducing the emissions, when allowed by gas dew point specification, as illustrated in the previous paragraph.

From an operability perspective, the design point can be oriented between two scenarios: in one case the ORChiller is designed to keep the pipeline compressor in its operating envelope, otherwise a re-bundle of the compression train has to be considered, in order to match with the new rated condition. Moreover, in case of ORChiller outage, the pipeline compression train would be not impacted.

Currently heat conversion for refrigeration is done by the well-known lithium bromide absorption units. Differently from lithium bromide technology, the ORChiller can vary the chilling operative temperature, by reaching down to -25 °C, enhancing the flexibility and taking more advantage from the heat

### 3.4 HYBRID SOLUTION: INTEGRATED HIGH-SPEED GENERATOR OVERVIEW

When a small amount of electricity is needed (e.g. self-consumption of the pipeline compression station), a development of the system described above can be also considered; in case of electrical peak load, the balancing between cooling duty and electric production can be directly managed by the control system.

If a proper residual amount of flue gas enthalpy is available, a hybrid integrated solution machine can be developed, by coupling the turboexpander to a permanent magnet generator with magnetic bearings, without seals system issues and using the same process gas to cool the airgap.

Main benefits of this hybrid configuration (which is conceptual only) would be a high level of process integration (piping and equipment reduction) and the supplement of power generation.

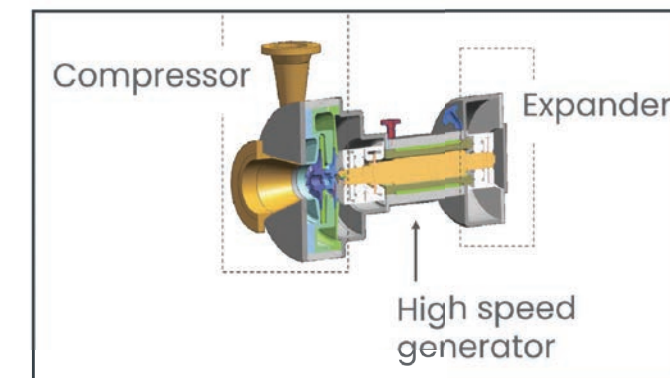


Figure 6: Integrated Turboexpander-Compressor with high speed generator (option for ORChiller base configuration)

## 4. HYBRID GAS TURBINE

### 4.1 OVERVIEW

The synergy between mechanical drive gas turbines (GT) with an electric motor has successfully carried out more than 30 years ago mainly in LNG market. The BH Gas Turbine hybridization concept here described allows to have helper and generator modes on the same shaft, giving to the operator a full flexibility to manage the plant and the resources, developing a turboelectric-compressor train.

As highlighted in the World Energy Outlook 2019 by International Energy Agency, natural gas is accounting today for 23% of global primary energy demand and nearly a quarter of electricity generation. To tackle the energy challenges, it is important to develop smart and integrated networks which function as components of a holistic energy system, including gas, electricity, heat and information technologies (See Figure 7). With the adoption of hybrid GT configuration electricity networks can be actively sustained leveraging on pipeline compressor stations generating additional revenues and providing a positive impact on greenhouse gas emissions.

Furthermore, a strategic partnership can be established with an electric distributor, to properly compensate his load demand, stabilizing the network by importing and exporting energy.

From a strategic gas delivery perspective, the hybrid gas turbine configuration allows to use two different primary energy sources to guarantee availability also in case of any electrical grid issue. This feature is not achievable in case of pure electric compression units.



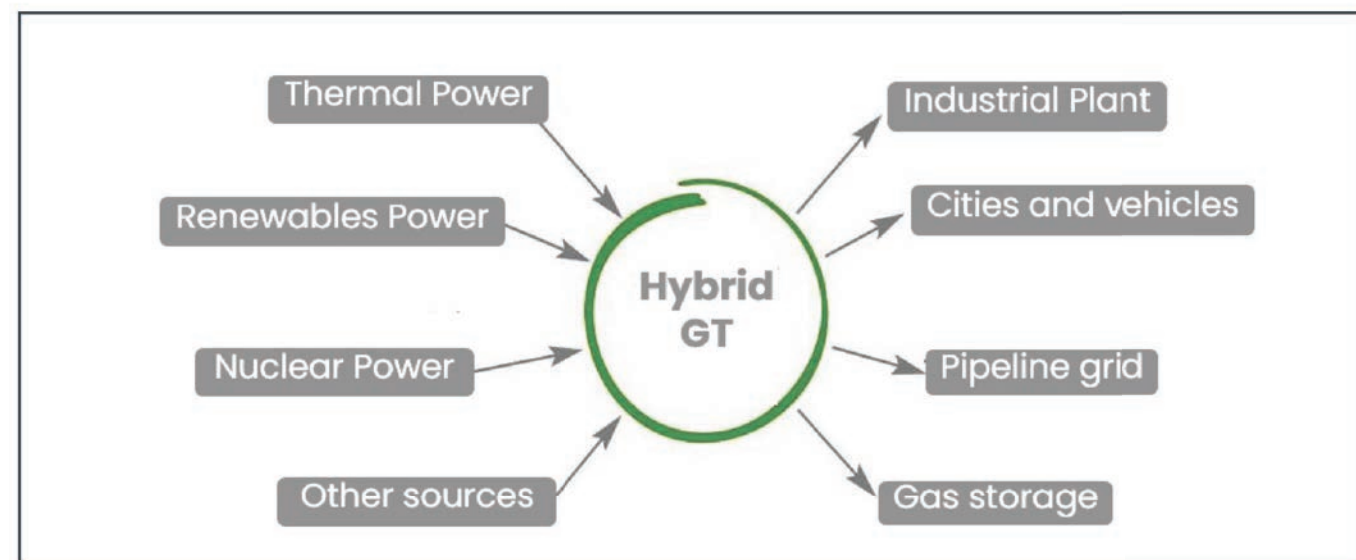


Figure 7: Hybrid GT

## 4.2 HYBRID GT CONFIGURATIONS

## 4.2.1 LP SHAFT HYBRID (PATENT EP3004601 B1)

The main Hybrid GT schematic is composed by an electrical machine coupled on gas turbine low pressure shaft with a self-synchronizing clutch between GT and load compressor (See Figure 8).

This scheme is applicable to all mechanical drive gas turbines (heavy duty and aeroderivative type). Electrical Machine (EM) is connected directly on the compressor shaft using a high-speed motor-generator avoiding the use of a gear box. EM power range could be selected up to 20 MW.

A VFD (Variable Frequency Drive) system and the input transformer are used to adjust the electrical network to the motor and compressor needs. It is able to connect with the network frequency with the EM, spinning it at the desired operating compressor point. This flexibility allows control the train in speed or in torque mode in order to match the

following equation:  $P=c*n$  where  $P$ =power;  $c$ =torque and  $n$ =RPM.

The power of electrical machine will be managed by torque. It will be positive or negative in case the electrical machine works as motor or generator.

A self-synchronizing clutch allows the engagement and disengagement of the gas turbine automatically, based on the speed difference. Such device is largely used in power plant combined cycle, connecting the gas turbine with the steam turbine. The application varies from a range of power from few MW up to 300 MW and a range of speed from 1000 to 12000 rpm.

Hybrid GT concept is applicable to new units or as upgrade on existing turbocompressor units. Of course, to revamp an existing unit, the compressor has to be modified to implement the mechanical shaft connection with the electric motor. The upgrade of compressor shaft allows to adopt the latest stage technology on centrifugal compressor further increasing the overall efficiency.

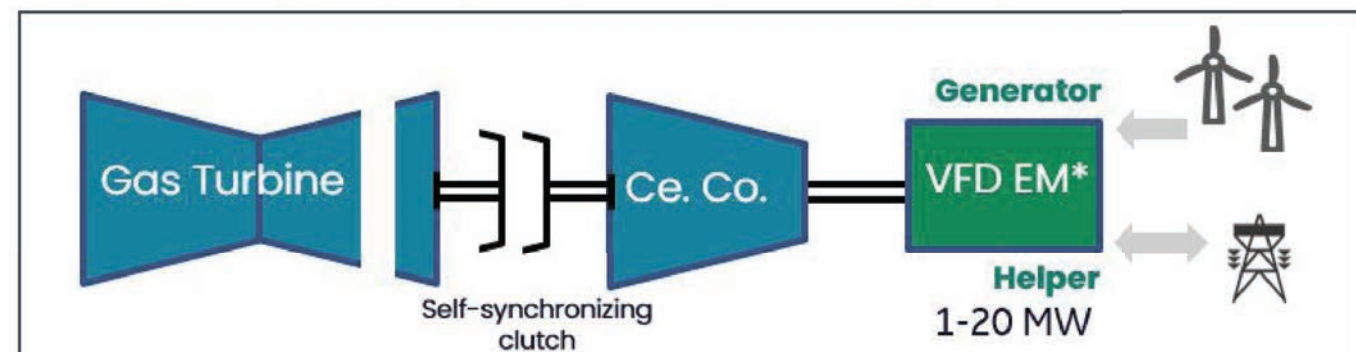


Figure 8: Main Hybrid GT schematic

Proposed configuration can work as helper, generator or full electric modes:

**GENERATOR MODE** - Whenever the gas turbine delivered power is greater than the power required by the centrifugal compressor, this is converted into electrical power available, without any interference with the process.

**HELPER MODE** - The EM can be energized converting electricity into mechanical power either to increase the power of GT at full load when it is not enough for the compressor or to share the absorbed power between GT and EM, so unloading the GT.

**FULL ELECTRIC MODE** - VFD Electric Motor can be dimensioned to deliver the power required by the compressor, allowing to work in Full Electric Mode, producing without emissions (Zero Emissions Configuration). This mode is particularly helpful in case of electricity cheaper cost or excess of it (i.e. renewable sources).

## 4.2.2 HP SHAFT HYBRID (PATENT WO2014102127 A1)

For two shafts gas turbines (heavy duty and NovaLT models) another simpler schematic is available where electrical machine is coupled directly on high pressure gas turbine shaft. The EM power range depends on the GT model: for a Frame 5 up to 3 MW.

This system can operate as Starter and Helper or as Starter and Generator modes and it has the advantage of reduces the impact on brownfield applications (See Figure 9).

**STARTER MODE** - During the starting sequence the VFD modulates the speed/torque to perfectly match the optimum firing conditions and acceleration ramp. At the end of the startup sequence the electrical machine can run in de-energized mode without any limitations or switching in the other operating modes.

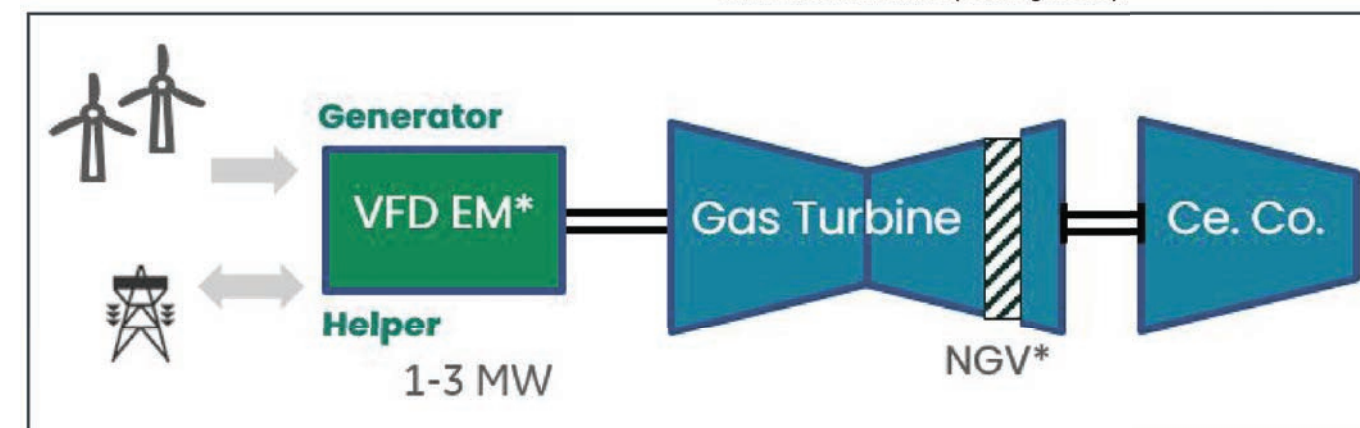


Figure 9: Starter and Helper or as Starter and Generator modes

## 4.3 ENVIRONMENTAL IMPACT

Renewable generation is variable, highly dependent on weather and time of day, and cannot always be turned on at will. The increasing penetration of intermittent generation raises the challenge of how to maintain the balance of supply and demand at all times. The hybrid GT configurations give to the operators the possibility to reach a wide range of benefits especially in case of pipeline application.

In case of green electricity availability or at low cost with the electrical machine working as motor, the abatement of the fuel leads to a CO2 footprint reduction and economic benefits.

On the other side in case of electricity high cost the electrical machine can work in generator mode producing electrical power for additional revenues or cover compressor stations power consumptions. So, it's possible to reduce OPEX putting in shutdown the external electric station generator, reducing emissions too.

In addition, this configuration allows to stabilize the exhaust thermal load, boosting the WHR system independently from the compressor process conditions.

Generator mode helps also gas turbine efficiency and NOx optimization in conjunction with the DLN/DLE technologies.

The full electric mode allows energy storage function by pressure gas accumulation scenario. In fact, the compressor driven by the electric motor will deliver flow and pressure to the pipeline that acts as energy tank storage. Since there are many variables connected each other, for an operator is quite impossible to evaluate how to properly balance the GT fuel and Power controller. For this reason, BH is developing a specific software that manages a tailored dynamic trade off based on real time site process data and economics (See Figure 10).



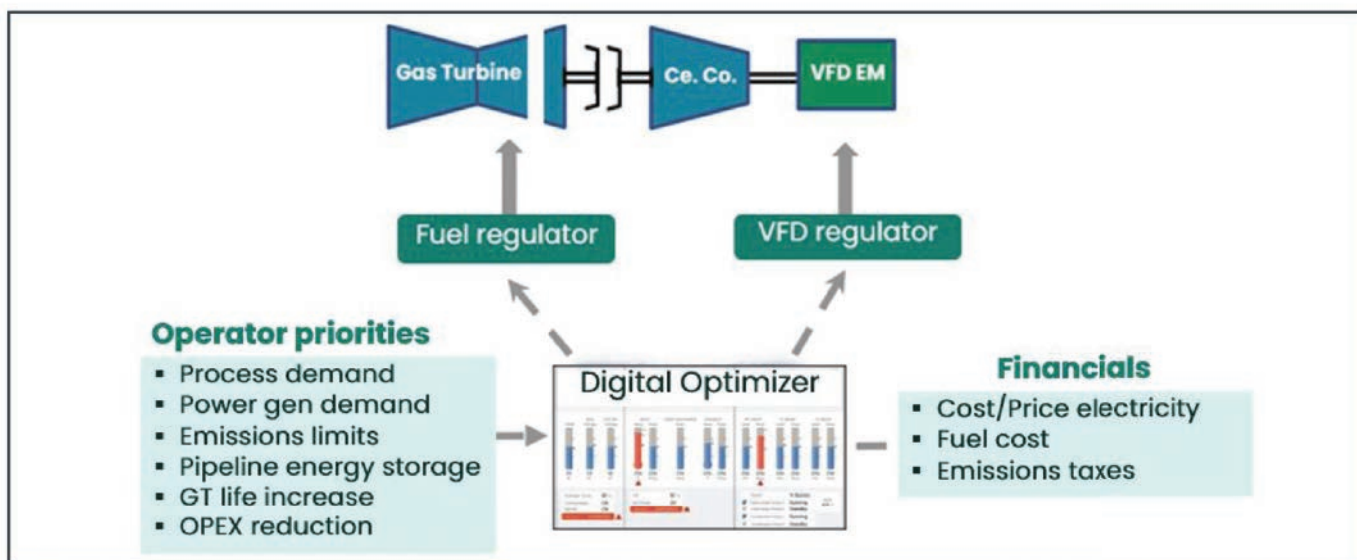


Figure 10: A BH development - Software that manages a tailored dynamic trade off based on real time site process data and economics.

## 5. CONCLUSIONS

The three technologies, above described, are viable solutions to reduce emissions of greenhouse gases in the pipeline environment and allow to strongly integrate the compressor station with electrical grid.

The importance of these technologies, among which is under development in BH, is the message of how BH is intercepting the new market trend of renewable integration in the actual pipeline operator's perspectives, matching the process needs with opex and emissions optimization.

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16th Pipeline Technology Conference	15 - 18 March 2021	Berlin, Germany



ОСНОВАННОЕ В 2009-М ГОДУ КАК ПРЕДПРИЯТИЕ ГРУППЫ КОМПАНИЯ ПАО «ТРАНСНЕФТЬ», АО «ОМЕГА» РАЗРАБАТЫВАЕТ И ПРОИЗВОДИТ УНИВЕРСАЛЬНЫЕ КОНТРОЛЬНО-ИЗМЕРИТЕЛЬНЫЕ КОМПЛЕКСЫ, ОСНОВАННЫЕ НА ПРИМЕНЕНИИ РАСПРЕДЕЛЕННЫХ ОПТОВОЛОКОННЫХ ДАТЧИКОВ. В ЧАСТНОСТИ, СИСТЕМОЙ ОБНАРУЖЕНИЯ УТЕЧЕК И КОНТРОЛЯ АКТИВНОСТИ (СОУИКА «ОМЕГА») ОСНАЩЕНО ОКОЛО ШЕСТИ ТЫСЯЧ КИЛОМЕТРОВ ТРУБОПРОВОДОВ В РОССИИ И ЗА РУБЕЖОМ.



ДИНАМИЧНО РАЗВИВАЮЩАЯ РОССИЙСКАЯ ИННОВАЦИОННАЯ КОМПАНИЯ АО «ОМЕГА» БУДЕТ РАДА ПАРТНЕРСТВУ С РОССИЙСКИМИ И ЗАРУБЕЖНЫМИ ПРЕДПРИЯТИЯМИ ПО СЛЕДУЮЩИМ НАПРАВЛЕНИЯМ:

- ОСНАЩЕНИЕ ОПТОВОЛОКОННОЙ СИСТЕМОЙ МОНИТОРИНГА ТРУБОПРОВОДОВ (ОСМТ): МОНИТОРИНГ ЦЕЛОСТНОСТИ ТРУБОПРОВОДОВ, ОБНАРУЖЕНИЕ ДАЖЕ СВЕРХМАЛЫХ УТЕЧЕК В РЕЖИМЕ РЕАЛЬНОГО ВРЕМЕНИ;
- ПРОКЛАДКА ВОЛОКОННО-ОПТИЧЕСКОГО КАБЕЛЯ СВЯЗИ;
- УСТАНОВКА УСТРОЙСТВА АВТОМАТИЧЕСКОГО ВВОДА РЕЗЕРВА СО СВЕРХБЫСТРОДЕЙСТВУЮЩИМИ ВЫКЛЮЧАТЕЛЯМИ НАПРЯЖЕНИЕМ БОЛЕЕ 1000 В (БАВР): ПРЕДОТВРАЩЕНИЕ ПОТЕРЬ ПРИ НАРУШЕНИЯХ ЭЛЕКТРОСНАБЖЕНИЯ НА ПРЕДПРИЯТИЯХ НЕФТЕДОБЫЧИ, НЕФТЕПЕРЕРАБОТКИ, ХИМИЧЕСКОЙ ПРОМЫШЛЕННОСТИ, А ТАКЖЕ НА НАСОСНЫХ СТАНЦИЯХ СИСТЕМ ТЕПЛО- И ВОДОСНАБЖЕНИЯ;
- МОНТАЖ ИСТОЧНИКОВ БЕСПЕРЕБОЙНОГО ПИТАНИЯ.



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