



# ГУБКИНСКИЙ УНИВЕРСИТЕТ

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ПРИРОДНЫЙ ГАЗ

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## О нас

Губкинский университет предлагает новый сервис – ежеквартальный обзор актуальных научных публикаций, патентов, мероприятий по актуальным направлениям топливно-энергетического комплекса (ТЭК). Дайджест готовится преимущественно силами студенческих активов Губкинского университета при поддержке управления стратегического развития.

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## Параметры составления дайджестов

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4. International Journal of Hydrogen Energy;
5. Applied Energy;
6. Process Safety and Environmental Protection;
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1. SPE Annual Technical Conference and Exhibition, UAE, September 2021;
2. Offshore Technology Conference, Virtual and Houston, Texas, August 2021;

# I. Производство / Production

## 1.1. Технологии сжижения / Liquefaction Technology

### 1.1.1 Статьи / Articles

#### 1. CONCEPTUAL DESIGN OF LNG REGASIFICATION PROCESS USING LIQUID AIR ENERGY STORAGE (LAES) AND LNG PRODUCTION PROCESS USING MAGNETIC REFRIGERATION SYSTEM



**Authors:** Ansarinasab H., Hajabdollahi H., Fatimah M

**Journal:** Sustainable energy technologies and assessments, volume: 46

**DOI:** 10.1016/j.seta.2021.101239

**Abstract:**

This paper presents a theoretical study (conceptual design) aimed at improving the performance of both LNG production and regasification processes. First, a newly process configuration of liquefying natural gas using magnetic refrigerator is developed for a small scale liquefaction process for energy saving purpose. Magnetic refrigeration system has not been utilized for liquefying natural gas up to now. The results show that the new process configuration results in similar to 74.4% energy savings (SEC 0.0752 kWh/kg) as compared to the SMR-APCI process which has been reported to have the lowest SEC among other small scale LNG processes. The COP of the proposed process has a high value of 6.69. Moreover, a novel process configuration of LNG regasification integrated with Stirling engine and liquid air energy storage (LAES) system is developed for enhanced power production and flexible energy storage options. Stirling engine has not been used for such a system up to now. The results indicate that the proposed LNG-LAES-ST process gives maximum round trip efficiency (192%), exergy efficiency (70.88%) and energy storage capacity (0.4785 kW/kgLNG) when compared to six of the best processes which were recently reported in literature. Two novel processes are modelled by Aspen Hysys and Peng Robinson thermodynamic model.

#### 2. THE EFFECT OF MODIFIERS ON THE PERFORMANCE OF NI/CEO<sub>2</sub> AND NI/LA<sub>2</sub>O<sub>3</sub> CATALYSTS IN THE OXY-STEAM REFORMING OF LNG



**Authors:** Mosinska M., Maniukiewicz W., Szykowska-Jozwik M.I., Mierczynski P.

**Journal:** International journal of molecular sciences, volume: 22, number: 16

**DOI:** 10.3390/ijms22169076

**Abstract:**

This work interrogates for the first time the catalytic properties of various monometallic Ni catalysts in the oxy-steam reforming of LNG. Various research techniques, including X-ray diffraction (XRD), specific surface area and porosity analysis (BET method), scanning electron microscopy with X-ray microanalysis (SEM-EDS), temperature-programmed desorption of ammonia (TPD-NH<sub>3</sub>), temperature-programmed reduction (TPR-H-2) and the FTIR method, were used to study their physicochemical properties. The mechanism of the oxy-steam reforming of LNG is also discussed in this paper. The high activity of monometallic catalysts supported on 5% La<sub>2</sub>O<sub>3</sub>-CeO<sub>2</sub> and 5% ZrO<sub>2</sub>-CeO<sub>2</sub> oxides in the studied process have been proven and explained on the basis of their acidity, specific surface area, sorption properties in relation to the reaction products, the crystallite size of the metallic nickel and their phase composition.

### 3. RESEARCH ON SYSTEMS FOR PRODUCING LIQUID HYDROGEN AND LNG FROM HYDROGEN-METHANE MIXTURES WITH HYDROGEN EXPANSION REFRIGERATION



**Authors:** Xu JX, Lin WS

**Journal:** International journal of hydrogen energy, volume: 46, number: 57, pp.: 29243-29260

**DOI:** 10.1016/j.ijhydene.2020.10.251

**Abstract:**

In industrial production processes, gas mixtures with hydrogen and methane as main useful components are often obtained as by-products, which are often not well utilized. In this paper, an innovative approach is proposed to produce both liquid hydrogen and LNG from industrial by-products with H<sub>2</sub> and CH<sub>4</sub> as main components. Taking the purified hydrogen-methane mixtures as the research object, four different separation-liquefaction processes (namely Open Loop-N-2, Open Loop-H-2, Closed Loop-N-2, Closed Loop-H-2) are constructed and optimized, with refrigeration supplied with hydrogen expansion at the cryogenic section and nitrogen or hydrogen expansion at the precooling section. A distillation column is set up before the mixture enters the cryogenic section to facilitate the production of high purity methane and hydrogen products. Every system achieves excellent energy integration, and the load of condenser and reboiler in the column is borne by the hydrogen expansion cycle in the cryogenic section. For each process, the influence of hydrogen mole proportion in feed gas between 10% and 90% on the process performance is analyzed. The results show that the purities of LNG and liquid hydrogen products obtained by the system are higher than 99.99%, and the specific energy consumption of the systems is within 18.01-41.72 kWh.kmol<sup>(-1)</sup> for different situations. At the same time, an open loop and a closed loop are constructed, respectively, to investigate the necessity of recovering cold energy of boil-off gas. The results suggest recommendation of open loop system with nitrogen precooling. (C) 2020 Hydrogen Energy Publications LLC. Published by Elsevier Ltd. All rights reserved.

### 4. INTEGRATED HYDROGEN LIQUEFACTION PROCESSES WITH LNG PRODUCTION BY TWO-STAGE HELIUM REVERSE BRAYTON CYCLES TAKING INDUSTRIAL BY-PRODUCTS AS FEEDSTOCK GAS



**Authors:** Xu JX, Lin WS

**Journal:** Energy, volume: 227

**DOI:** 10.1016/j.energy.2021.120443

**Abstract:**

Hydrogen-rich industrial by-products, such as coke oven gas (COG) and synthetic ammonia exhaust tail gas, are often simply utilized as fuel gas, or even not utilized at all in many cases. An innovative and efficient utilization method is proposed and investigated in this paper. Aiming to coproduce liquid hydrogen and liquefied natural gas (LNG), three helium reverse Brayton cycles are constructed, optimized, analyzed and compared. The LN-He-1 process is constructed with reference to conventional industrial hydrogen liquefaction processes, but with different feedstock gas. The LN-He-2 and N-He processes, which are an improvement on the basis of LN-He-1. A combination of distillation and flash is utilized to reduce the separation load. Analysis of load variation, power consumption, exergy, heat transfer and turbomachinery efficiencies are carried out. For different feedstock gas compositions, the specific power consumptions of LN-He-1, LN-He-2 and N-He processes are within 26.45-54.78 kWh/kmol (feedstock gas), 26.32-53.78 kWh/kmol (feedstock gas) and 21.94-50.42 kWh/kmol (feedstock gas), respectively. The exergy efficiencies are between 13.0% and 66.5%.

## 1.1.2. Патенты / Patents.

### 5. LNG (LIQUEFIED NATURAL GAS) RECOVERY SYSTEM FOR SHALLOW COOLING PROCESS



**Authors:** Wang Yong, Yang Guang, Dou Feng, Zhang Xinyou, Liao Xuanhua, Li Guoming, Zhang Yuxi, Wang Hao, Zheng Jing, Zhang Huiping

**Publication number:** 213930387

**Publication date:** 10.08.2021

**Abstract:**

The utility model relates to an LNG (Liquefied Natural Gas) recovery system for a shallow cooling process. The shallow cooling process LNG recovery system comprises a raw material gas pressurization cooling unit, an ammonia cooling raw material gas unit, a raw material gas separation LPG and NGL unit, a nitrogen refrigeration cycle unit and a raw material gas conversion LNG unit. Ammonia is adopted as a refrigerant, natural gas circularly enters the four-flow plate-fin heat exchanger after being pressurized by the nitrogen pressurizer, raw material natural gas is continuously cooled in cooling capacity generated by expansion of the expansion machine, cost is low, the LNG recovery rate is high, meanwhile, circulating nitrogen continuously absorbs the natural gas to generate cooling capacity released by LNG, and the natural gas is continuously cooled by the four-flow plate-fin heat exchanger. And the utilization efficiency of system energy is improved, and the system can be widely applied to LNG recovery.

## II. Хранение / Storage

### 2.1. Резервуары / Containment Systems

#### 2.1.1 Патенты / Patents

##### 1. LNG STORAGE TANK AUTOMATIC PRE-COOLING SYSTEM BASED ON EFFICIENT COMMUNICATION AND PRE-COOLING METHOD



**Authors:** Xu Qingjiang, Wang Dan, Fan Yunbo, Yan Wenrong, Song Zhihong, Xu Yanhong, Wang Chuan

**Publication number:** 113339695

**Publication date:** 03.09.2021

**Abstract:**

The invention provides an LNG storage tank automatic pre-cooling system based on efficient communication and a pre-cooling method. A CFD numerical simulation module is used for conducting pre-cooling process simulation, and initial flow parameters are provided for the pre-cooling process; and the point positions are installed on a storage tank in a modularized manner, and signal transmission between all sensors in the pre-cooling system and an integrated operation platform is achieved through 5G technology. According to the LNG storage tank automatic pre-cooling system and the pre-cooling method, limit values of parameters such as temperature drop rate, thermal stress, temperature difference between two adjacent points, inner tank pressure and the like are set on the basis of the integrated operation platform, monitoring results and the limit values are compared and analyzed, and then an electric control valve module and a variable frequency pump module are automatically adjusted, so that the conveying flow of a pre-cooling medium is adjusted, and it is guaranteed that the pre-cooling process is stably and safely carried out. According to the LNG storage tank automatic pre-cooling system and method, automatic, integrated and integrated control over the pre-cooling process can be achieved, monitoring personnel do not need to be arranged at monitoring points for a long time, potential safety hazards are avoided, manpower and material resources are saved, pre-cooling control is more accurate, and the pre-cooling efficiency is high.



## 2. LNG STORAGE TANK WITH GOOD HEAT PRESERVATION EFFECT



**Authors:** Liu Yanan

**Publication number:** 213982969

**Publication date:** 17.08.2021

**Abstract:**

The utility model relates to the technical field of fuel gas storage, and discloses an LNG storage tank with a good heat preservation effect, which comprises a shell, a heat preservation layer is arranged on the inner wall of the shell, an LNG storage tank is arranged in the heat preservation layer, the heat preservation layer comprises a heat insulation layer, the heat insulation layer is adhered to the inner wall of the shell, a first heat preservation layer is adhered to the inner wall of the heat insulation layer, and a second heat preservation layer is adhered to the inner wall of the first heat preservation layer. According to the LNG storage tank with the good heat preservation effect, the heat preservation layers are arranged on the inner surface of the shell, the heat preservation layers comprise the heat insulation layer, the first heat preservation layer and the second heat preservation layer, the heat insulation layer is a glass fiber plate, the heat preservation layer is a glass fiber plate, the heat preservation layer is a glass fiber plate, and the heat preservation effect is good. The LNG storage tank in the shell can be prevented from being influenced by external heat, the LNG storage tank can be subjected to heat preservation through the first heat preservation layer and the second heat preservation layer, the first heat preservation layer is a centrifugal heat insulation cotton heat preservation plate and prevents the temperature of the LNG storage tank from dissipating outwards, and the second heat preservation layer is an XPE foam plate and further prevents the temperature of the LNG storage tank from dissipating outwards.

## 3. HPB PRESSURIZATION SYSTEM OF LNG STORAGE CONTAINER



**Author:** Jiang Chunhui

**Publication number:** 113266762

**Publication date:** 17.08.2021

**Abstract:**

The invention relates to the field of LNG supply, in particular to an a HPB pressurization system of an LNG storage container, wherein the LNG storage container is used for storing LNG, and a secondary refrigerant heat release unit is arranged in the container; an LNG heat exchange unit and a secondary refrigerant heating unit are arranged in a water bath type heat exchanger; a secondary refrigerant tank shell communicates with a secondary refrigerant tank inlet pipeline and a secondary refrigerant tank outlet pipeline, and a secondary refrigerant is stored in the shell; a secondary refrigerant is pressurized and conveyed into the water bath type heat exchanger through a circulating pump and vaporized through a heating unit; and the control unit is in control connection with the secondary refrigerant circulating pump. According to the scheme that the secondary refrigerant is adopted to directly heat and vaporize LNG locally and then pressurize the gas phase of the storage container, the problems that the LNG storage container is low in pressurization speed and cannot pressurize the LNG storage container at a low liquid level are solved, and the active rapid pressurization function of the LNG storage container is achieved.

#### 4. LNG (LIQUEFIED NATURAL GAS) SINGLE-CAPACITY STORAGE TANK WITH VACUUM INSULATED PANEL STRUCTURE



**Authors:** Fan Jie, Luo Kaiyan, Wang Qiang, Liu Li, Yang Bo

**Publication number:** 213900706

**Publication date:** 06.08.2021

**Abstract:**

The utility model discloses an LNG (Liquefied Natural Gas) single-capacity storage tank with a vacuum insulated panel structure, which comprises a cuboid box-shaped tank body, the wall of the tank body sequentially comprises a galvanized iron sheet protective layer, a cold insulation layer, an elastic sticker and an inner tank wall from outside to inside, the inner cavity of the tank body is hollow to form a cylindrical LNG container, and the LNG container is arranged in the tank body. The cold insulation layer is composed of one or more cold insulation layers formed by arranging a plurality of vacuum heat insulation plates, the structure of each vacuum heat insulation plate comprises an inner core layer composed of fumed silica, and the outer side of the inner core layer is wrapped with a high-barrier film. The vacuum heat insulation plate is adopted as the cold insulation layer, fumed silica serves as a main core material component of the vacuum heat insulation plate, the heat insulation performance of the vacuum heat insulation plate can be kept stable for a long time, the LNG storage and transportation efficiency is greatly improved, the storage and transportation cost is greatly reduced, and great significance is achieved for energy conservation and consumption reduction of the LNG storage and transportation industry. The vacuum heat insulation plate is adopted as the tank wall cold insulation layer of the LNG single-containing tank, and the LNG single-containing tank has great technical and economic advantages.

#### 5. LNG STORAGE TANK AND SHIP



**Authors:** Xue Lin, Chen Jun, Zhou Jing

**Publication number:** 113212644

**Publication date:** 06.08.2021

**Abstract:**

The invention relates to the technical field of ships, and discloses an LNG storage tank and a ship. The LNG storage tank comprises a tank body, and the tank body is arranged on a deck of the ship body. The LNG storage tank further comprises a partition plate, a liquid pumping assembly and an inflation assembly. The partition plate is arranged in the cavity of the tank body and divides the cavity into a first cavity and a second cavity in a sealed mode, the first cavity is used for storing LNG, and the partition plate can slide along the cavity so that the volume of the first cavity and the volume of the second cavity can be changed. The liquid extraction assembly comprises a liquid extraction pipe and a liquid extraction pump, one end of the liquid extraction pipe communicates with the interior of the first cavity, and the other end of the liquid extraction pipe is connected to the liquid inlet end of the liquid extraction pump. The inflation assembly comprises an inflation pipe and an inflation pump, one end of the inflation pipe communicates with the interior of the second cavity, and the other end of the inflation pipe is connected to the air outlet end of the inflation pump. The gas pressure in the first cavity is adjusted, evaporation of LNG is reduced, safety is improved, reliquefaction operation on the LNG is avoided, cost is reduced, and the utilization rate of the LNG is also improved.

## 6. REGULATING DEVICE FOR PRESSURE OF LNG (LIQUEFIED NATURAL GAS) STORAGE TANK OF LIQUID TANK OF FILLING SHIP



**Authors:** Yuan Hao, Zhu Faxin, Lyu Baicheng, Lin Jiabin, Deng Qiwen, Xu Jingtao, Shi Jingyuan, Zhang Xiao

**Publication number:** 213840473

**Publication date:** 30.07.2021

**Abstract:**

The utility model discloses a filling ship liquid tank LNG storage tank pressure adjusting device which comprises a tank body, a water tank is arranged on the right side of the tank body, a motor is fixedly connected to the top of the water tank, the output end of the motor extends into the water tank to be fixedly connected with a rotating disc, and the lower surface of the rotating disc is fixedly connected with a stirring rod. A plurality of heating plates are fixedly connected to the inner top of the water tank, a buffer pressure reducer is fixedly connected to the inner bottom of the tank body, a gas conveying pipe is fixedly connected to the output end of the buffer pressure reducer, and the output end, away from the buffer pressure reducer, of the gas conveying pipe extends into the water tank and is fixedly connected with a buffer pipe; fixing rings are fixedly connected to the positions, close to the left side edge and the right side edge, of the surface of the tank body, and supporting columns are fixedly connected to the bottoms of the fixing rings. The device is simple and reasonable in structure, the defects in the prior art can be well overcome, and the operation convenience is effectively improved.

## 2.2. Отгрузочные операции / Discharge Operations

### 2.2.1 Патенты / Patents

#### 1. LNG UNLOADING PRY

**Authors:** : Liu Guosheng, Dong Yuanyuan, Liu Zhaoxue

**Publication number:** 214119184

**Publication date:** 03.09.2021

**Abstract:**

The utility model provides an LNG (liquefied natural gas) unloading pry. The LNG unloading pry comprises a clamping frame for clamping an unloading pipeline and an angle adjusting disc, the first clamping assembly comprises a first support opposite to the second clamping assembly, a first screw is horizontally arranged on the first support, a first clamping block is arranged at the end of the first screw, and a first clamping groove is formed in the first clamping block. The second clamping assembly comprises a second support, a second screw rod is horizontally arranged on the second support, a second clamping block is arranged at the end of the second screw rod, a second clamping groove is formed in the second clamping block, and the first clamping block and the second clamping block are oppositely arranged in a matched mode. The first support and the second support are arranged on a rotatable angle adjusting disc through a bearing table. The unloading pipeline clamping device has the advantages that the unloading pipeline connected with a tank car hose can be clamped and fixed through the clamping frame, the position of the unloading pipeline can be conveniently adjusted, the clamping frame is integrally arranged on the rotatable angle adjusting disc, and the angle adjusting disc is rotated to drive the unloading pipeline to conduct angle adjustment.

#### 2. LNG (LIQUEFIED NATURAL GAS) SATURATION ADJUSTING AND FILLING DEVICE

**Authors:** Jiang Chunhui, Xu Lei

**Publication number:** 214093988

**Publication date:** 31.08.2021

**Abstract:**

The utility model relates to the technical field of LNG (Liquefied Natural Gas) filling, and particularly provides an LNG saturation regulating filling device which comprises an LNG storage tank, an LNG saturation regulating skid-mounted device, an LNG filling machine and a control unit, the LNG storage tank is used for storing LNG; the LNG filling machine is used for metering and filling LNG; the LNG saturation regulation skid-mounted device is used for LNG saturation regulation and loading and unloading. The LNG is circulated in the saturation vaporizer once to complete the open-loop saturation adjustment process, or the LNG is circulated and returned to the pre-adjustment tank through the saturation vaporizer to complete the closed-loop compensation saturation adjustment process under the high-load working condition, and after saturation adjustment is completed, the LNG does not need to flow back to an LNG storage tank and directly enters a gas dispenser to fill a vehicle, so that the LNG filling efficiency is remarkably improved, and BOG can be reduced.

### 3. PORTABLE LNG SAMPLER



**Authors:** Gao Yanwei, Wang Lijin

**Publication number:** 113295465

**Publication date:** 24.08.2021

**Abstract:**

A portable LNG sampler comprises a box body (1), and is characterized by further comprising a cold insulation pipeline (2) arranged in the box body (1); a liquid inlet (4), a cryogenic stop valve (5), a density measuring device (6), a first one-way valve (7) and a first needle valve (9) and an electric heating pressure regulating valve (10) connected to a pipeline between the first one-way valve (7) and the first needle valve (9) through a tee joint (8), which are sequentially arranged on the cold insulation pipeline (2); a heat preservation pipeline (3) arranged in the box body (1) and connected with an outlet of the electric heating pressure regulating valve (10); and a thermometer (11), a pressure gauge (12), a buffer tank (13), a second one-way valve (14) and a second needle valve (15) which are sequentially arranged on the heat preservation pipeline (3). According to the invention, LNG can be rapidly sampled, external temperature interference is eliminated, and the portable LNG sampler is small in size, convenient to carry and high in safety coefficient.

## 2.3. Эффекты хранения / Storage Phenomena

### 2.3.1. Патенты / Patents

#### 1. RECONDENSATION SYSTEM



**Authors:** Jia Baoyin, Song Yuanling, Liu Yirong, Wang Hong, Zhao Jiadi, Zhou Yinuo

**Publication number:** 214094026

**Publication date:** 31.08.2021

**Abstract:**

The utility model provides a recondensation system, and belongs to the technical field of natural gas storage. The recondensation system comprises a main output pipe, and a first pressure sensor is arranged on the main output pipe. The bottom end of the re-condenser is communicated with the main output pipe; a first temperature sensor and a standard volume flow detection device are arranged on the evaporation gas input pipe; a second temperature sensor, a first flow sensor and a flow regulating valve are arranged on the liquefied natural gas input pipe, and a density detection device is further arranged to measure the density of the LNG in the liquefied natural gas storage tank so as to reflect the components of the LNG. Therefore, the controller can conveniently adjust the flow of the LNG injected into the recondenser through the flow adjusting valve based on the temperature and the standard volume flow of the BOG and the temperature and the flow of the LNG, cold energy input into the recondenser by the LNG can be matched with heat brought into the recondenser by the BOG, and the recondensation effect is improved.

#### 2. LNG FLASH STEAM RECOVERY SYSTEM



**Authors:** Xiong Lianyou, Xu Peng, Tang Jiancheng

**Publication number:** 214009705

**Publication date:** 20.08.2021

**Abstract:**

The utility model provides an LNG flash steam recovery system. The LNG flash steam recovery system comprises an LNG storage tank, a refrigeration cycle flow path and a recovery flow path, the refrigeration cycle flow path comprises a first compressor, a first heat exchanger, a second heat exchanger, a third heat exchanger, a fourth heat exchanger, a fifth heat exchanger, a sixth heat exchanger, a first-stage expansion machine, a second-stage expansion machine, a control valve, a low-pressure pipeline and a high-pressure pipeline; the recovery flow path comprises a CH<sub>4</sub> rectifying tower, an N<sub>2</sub> condensing tower, an H<sub>2</sub> condensing tower, a first-stage low-temperature adsorber, a second-stage low-temperature adsorber, a He collecting pipe, a first gas guide pipeline, a second gas guide pipeline, a third gas guide pipeline and a fourth gas guide pipeline. According to the device disclosed by the utility model, LNG flash steam generated in the LNG storage tank enters the recovery flow path and then is cooled step by step through the refrigeration circulation flow path, so that high-purity CH<sub>4</sub>, N<sub>2</sub> and H<sub>2</sub> can be separated from the CH<sub>4</sub> rectifying tower, the N<sub>2</sub> condensing tower and the H<sub>2</sub> condensing tower in sequence, and finally, high-recovery-rate and high-purity He is obtained.

## III. Регазификация / Regasification

### 3.1. Статьи / Articles

#### 1. CONCEPTUAL DESIGN OF LNG REGASIFICATION PROCESS USING LIQUID AIR ENERGY STORAGE (LAES) AND LNG PRODUCTION PROCESS USING MAGNETIC REFRIGERATION SYSTEM



**Authors:** Ansarinasab H., Hajabdollahi H., Fatimah M.

**Journal:** Sustainable energy technologies and assessments, volume: 46

**DOI:** 10.1016/j.seta.2021.101239

**Abstract:**

This paper presents a theoretical study (conceptual design) aimed at improving the performance of both LNG production and regasification processes. First, a newly process configuration of liquefying natural gas using magnetic refrigerator is developed for a small scale liquefaction process for energy saving purpose. Magnetic refrigeration system has not been utilized for liquefying natural gas up to now. The results show that the new process configuration results in similar to 74.4% energy savings (SEC 0.0752 kWh/kg) as compared to the SMR-APCI process which has been reported to have the lowest SEC among other small scale LNG processes. The COP of the proposed process has a high value of 6.69. Moreover, a novel process configuration of LNG regasification integrated with Stirling engine and liquid air energy storage (LAES) system is developed for enhanced power production and flexible energy storage options. Stirling engine has not been used for such a system up to now. The results indicate that the proposed LNG-LAES-ST process gives maximum round trip efficiency (192%), exergy efficiency (70.88%) and energy storage capacity 4785 (0. kW/kgLNG) when compared to six of the best processes which were recently reported in literature. Two novel processes are modelled by Aspen Hysys and Peng Robinson thermodynamic model.

## 3.2. Патенты / Patents

### 1. LIQUEFIED NATURAL GAS (LNG) GASIFICATION STATION PROTECTION DEVICE



**Authors:** Yang Bao, Pei Mingyuan, Liu Jie

**Publication number:** 214093260

**Publication date:** 31.08.2021

**Abstract:**

The utility model provides an LNG gasification station protection device, and relates to the technical field of natural gas valves. The LNG gasification station protection device comprises a natural gas pipeline and a valve, the valve is arranged on the outer side of the natural gas pipeline, a protection assembly is arranged on the outer side of the natural gas pipeline, and the protection assembly comprises a protection cover, a first gear, a second gear, a rack, a first sealing gasket, a second sealing gasket, a first supporting rod and a second supporting rod. The protective cover is arranged on the outer side of the natural gas pipeline, and the first gear is arranged on the outer side of the natural gas pipeline. According to the protection device for the LNG gasification station, a first sealing gasket slides into an annular groove, one end of a second supporting rod is inserted into a circular hole, the structure is beneficial for protecting a valve, the valve is prevented from being corroded and damaged due to liquid erosion, natural gas leakage is avoided, a first gear rotates to drive the valve to rotate, and the safety of the valve is improved. By means of the structure, the size of the valve can be adjusted without disassembling the protective cover, convenience and rapidness are achieved, and time and labor are saved.

### 2. LIQUEFIED NATURAL GAS (LNG) GASIFICATION STATION LOW-TEMPERATURE STORAGE TANK INTERFACE VALVE GROUP SYSTEM



**Authors:** Song Pengfei, Pang Lu, Liu Zhihan, Wang Zhenyu

**Publication number:** 213746145

**Publication date:** 20.07.2021

**Abstract:**

A low-temperature storage tank interface valve group system of an LNG gasification station is characterized by comprising a liquid inlet header pipe part and a liquid outlet header pipe part, the liquid inlet header pipe part comprises two branches, one branch is connected with an LNG storage tank pressurizing liquid inlet pipe, a valve (4) is arranged on a storage tank pressurizer liquid inlet header pipe and connected to an interface (B), the other branch is provided with a starting emergency cut-off valve (3), a ZSOV and a VIC are arranged at the position of the valve (3), and the ZSOV and the VIC are connected with the interface (B). A valve (1) and a valve (2) are arranged at the downstream of the valve (3), respectively lead to an upper liquid inlet header pipe and a lower liquid inlet header pipe of the storage tank and are connected to a connector (C) and a connector (D), the connector (C) is connected with an upper liquid inlet of the storage tank, and the connector (D) is connected with a lower liquid inlet of the storage tank; the gas phase pipe is connected with a gas phase opening of the storage tank through a connector (E), the gas phase pipe is a two-way breather pipe, and the gas inlet pipe in the gas inlet direction passes through a connector (I) connected with a storage tank supercharger, a valve (7) is arranged on the downstream of the connector (I), and then the gas inlet pipe is connected to the connector (E) and connected with the storage tank.



### 3. LNG (LIQUEFIED NATURAL GAS) PRESSURE REGULATING AND ODORIZING PRY



**Authors:** Yang Bao, Pei Mingyuan, Liu Jie

**Publication number:** 214094027

**Publication date:** 31.08.2021

**Abstract:**

The utility model provides an LNG (Liquefied Natural Gas) pressure regulating and odorizing pry and relates to the field of gas supply control. An adjusting assembly of the LNG pressure adjusting and odorizing pry comprises a rotating plate, the rotating plate is rotationally connected with one end of a liquid inlet pipe, a supporting rod is fixedly connected to the top end of the interior of a gas tank, a pushing rod is arranged at the bottom of the rotating plate, the pushing rod is rotationally connected with the rotating plate, and the pushing rod penetrates through the supporting rod and is in sliding connection with the supporting rod. The bottom of the push rod is fixedly connected with a floating ball, and one side of the rotating plate is fixedly connected with a second pull rope. The LNG pressure-regulating odorizing pry pushes a rotating plate to rotate, the top of the rotating plate touches a reset switch, the reset switch controls a control valve fixedly connected with the outer side of a liquid inlet pipe to be closed at the moment, meanwhile, a magnetic sheet fixedly connected with the top of the rotating plate is fixedly connected with a magnetic block, the rotating plate keeps the reset switch closed all the time, odorous liquid adding can be automatically closed, and the operation is convenient. Odor liquid adding is more accurate, and the device is in a working state all the time.

## IV. Инфраструктурные решения / Infrastructure Solutions

### 4.1. Статьи / Articles

#### 1. THE EMERGING HYDROGEN ECONOMY AND ITS IMPACT ON LNG



**Authors:** Omran Al-Kuwaria, Max Schönfischb

**Journal:** International Journal of Hydrogen Energy, November 2021

**Abstract:**

Hydrogen is gaining prominence as a critical tool for countries to meet decarbonisation targets. The main production pathways are based on natural gas or renewable electricity. LNG represents an increasingly important component of the global natural gas market. This paper examines synergies and linkages between the hydrogen and LNG value chains and quantifies the impact of increased low-carbon hydrogen production on global LNG flows. The analysis is conducted through interviews with LNG industry stakeholders, a review of secondary literature and a scenario-based assessment of the potential development of global low-carbon hydrogen production and LNG trade until 2050 using a novel, integrated natural gas and hydrogen market model. The model-based analysis shows that low-carbon hydrogen production could become a significant user of natural gas and thus stabilise global LNG demand. Furthermore, commercial and operational synergies could assist the LNG industry in developing a value chain around natural gas-based low-carbon hydrogen.

#### 2. PERFORMANCE IMPROVEMENT POTENTIAL OF HARNESSING LNG REGASIFICATION FOR HYDROGEN LIQUEFACTION PROCESS: ENERGY AND EXERGY PERSPECTIVES



**Authors:** Amjad Riaza, Muhammad Abdul, Qyyuma, Seongwoong Mina, Sanggyu Leeb, Moonyong Leea

**Journal:** Applied Energy, volume: 301

**Abstract:**

Hydrogen serves as an energy vector; however, its storage and bulk transport are challenging because of its low energy content per unit volume. Similar to liquefied natural gas (LNG), pure hydrogen is liquefied prior to transportation—particularly for transportation over long distances. Liquid nitrogen is widely used as a refrigerant in the precooling phase of the liquefaction; however, considering the scale of the predicted hydrogen energy network, alternative sources must be considered. LNG is a promising candidate because the cold energy obtained during the regasification process of LNG is conventionally released in seawater. In the present study, a simple integrated scheme is proposed, wherein LNG cold energy is used to facilitate hydrogen liquefaction by eliminating the precooling refrigeration cycle. The proposed integrated process was designed and analyzed using the well-known commercial simulator Aspen Hysys® v10. The design of the proposed process was optimized via the modified coordinate descent methodology. The results indicated that the overall refrigerant quantity was reduced by approximately 50%, which resulted in a reduction of approximately 40% in the specific energy consumption, i.e., it was reduced to 7.64 . The exergy efficiency of the proposed process was 42.25%, which is significantly higher than that reported for commercial plants (21%). The coefficient of performance of the proposed process was 40.2% higher than those of previously reported processes. The figure of merit of the proposed process was 0.422. The proposed process is expected to change the value chain dynamics of LNG and hydrogen liquefaction, promoting a shift toward a hydrogen economy.

### 3. AN ADAPTIVE DEFECT DETECTION METHOD FOR LNG STORAGE TANK INSULATION LAYER BASED ON VISUAL SALIENCY



**Authors:** Huizhou Liu, Jinqiu Hu

**Journal:** Process Safety and Environmental Protection, volume: 156, pp.: 465-481

**Abstract:**

As the core equipment of the industrial chain, the LNG storage tank is developing in the direction of large-scale and increasing attention has been paid to its economy and safety. The defects of the insulation layer not only affect the insulation performance of the tank but also easily induce safety accidents. To automatically detect these defects, considering the large temperature difference between the defect area and other areas, an adaptive detection method based on infrared thermal imaging technology and a saliency detection algorithm is proposed. Firstly, the median filtering and the Contrast Limited Adaptive Histogram (CLAHE) are introduced to reduce noise and smooth the image. Then, the Adaptive Simple Linear Iterative Clustering algorithm (A-SLIC) based on the entropy of the image is purposed for super-pixel segmentation. After super-pixel segmentation, the saliency map is obtained by manifold ranking, and the salient areas that contain defects of the insulation layer will be segmented automatically. The proposed method is compared with other traditional algorithms on the MSRA1000 dataset and the infrared thermal imaging dataset of LNG storage tanks. The results of the experiments illustrate the effectiveness of the method proposed.

### 4. REDUCING POWER USE IN THE COLD SECTION OF LNG PLANTS



**Authors:** Pal A., Al-musleh E.I., Karimi I.A.

**Journal:** ACS sustainable chemistry & engineering, volume: 9, number: 38, pp.: 13056-13067

**DOI:** 10.1021/acssuschemeng.1c04866

**Abstract:**

Liquefied natural gas (LNG) has garnered global attention as a relatively cleaner, environmentally more friendly, and more efficient energy source than other fossil fuels. Upgrading and liquefying natural gas to LNG is highly energy-intensive, and the most energy-consuming section of a typical LNG plant is its cold section. While much existing research has focused on heat integration and efficient refrigeration cycles to reduce power use in the cold section, energy sourcing for the cold section has received limited attention. Furthermore, several processes and product/fuel quality constraints such as high heating value are not addressed adequately. In this study, we first develop a realistic, energy selfsustaining model of the cold section of a conventional LNG plant. Boil-off gas and end flash gas are hydrocarbon-rich waste streams that are used to power gas turbines that meet the plant's power needs. Then, we propose various structural changes to the conventional plant design, identifying opportunities to reduce energy requirements while increasing LNG production with the same feed flow rate. We develop the process models using a commercial simulator and deploy a simulation-based optimization paradigm to determine optimal design parameters and minimize specific power consumption (SPC) while ensuring that various process and product/fuel constraints are met. The findings reveal those structural improvements to a conventional LNG plant's cold section lower total power usage by 4.83% while increasing LNG output by 16 kt/a (0.48%). The SPC is further reduced by 5.52% due to lower total power usage and increased LNG output.

## 4.2. Патенты / Patents

### 5. CRYO-THERMAL DESALINATOR



**Author:** Garold Paul Hines

**Publication number:** 20210261438

**Publication date:** 26.08.2021

**Abstract:**

The Cryo-Thermo Desalinator (CTD) is a “fire and ice” approach to potability and water reuse using liquid natural gas (LNG) for systemic fuel and cooling. The upstream key heat exchanger (HX) uses LNG to differentiate raw water into pretreated ice melt and cryo-brine blowdown. Ice melt-diluted raw water is primarily sent to the mid-stream key HX condenser where it and LNG tube bundles collapse water vapor into potable water. The downstream key HX uses LNG to separate cryo-brine and thermo-brine into heavy brine and skimmed saline ice which is reinjected into pretreated raw water for maximum corrosion and scaling dilution and extra potability. Heavy brine discharge is more easily dewatered for mining salts, mineral and elements. Pressurized LNG, becoming high pressure natural gas, adds desirable latent heat of vaporization to downstream gas users, including the integrated CCGT/HRSG and is roughly-proportional to thirsty residential/industrial gas users which the CTD serves.

### 6. LNG-L-CNG REMOTE DIAGNOSIS SYSTEM



**Authors:** Yuan Hongtao, Du Guoning, Guo Xiaomin, Zhai Gangbian, Zhu Ronglei, Liang Ding

**Publication number:** 213954990

**Publication date:** 13.08.2021

**Abstract:**

The utility model provides an LNG-L-CNG remote diagnosis system which comprises an LNG filling device and a CNG filling device, and the CNG filling device is communicated with the LNG filling device through a liquid supply control assembly. An LNG equipment running state monitoring assembly and an LNG valve assembly are arranged in the LNG filling equipment, a CNG equipment running state monitoring assembly and a CNG valve assembly are arranged in the CNG filling equipment, and the liquid supply control assembly, the LNG equipment running state monitoring assembly, the LNG valve assembly, the CNG equipment running state monitoring assembly and the CNG valve assembly are all connected with the field master control PLC. The field master control PLC is respectively connected with the field alarm assembly and the data transmission assembly, the field master control PLC is connected with the data processing PLC through the data transmission assembly, and the data processing PLC is connected with the upper computer. According to the utility model, each data and state of the LNG/L-CNG gas filling system are remotely transmitted to the upper computer through the wireless network module, so that the operation data and the operation state of the LNG/L-CNG gas filling equipment are remotely monitored and diagnosed in real time, and intelligent monitoring and diagnosis are realized.

## 7. BURIED LNG (LIQUEFIED NATURAL GAS) FILLING STATION



**Authors:** Wang Wei, Li Yugang, Kang Shujuan, Cui Zhenyang

**Publication number:** 213930422

**Publication date:** : 10.08.2021

**Abstract:**

The utility model discloses a buried LNG (Liquefied Natural Gas) filling station and relates to the technical field of clean energy transmission. A buried LNG filling station comprises a sealing bin, a plurality of gas storage tanks are fixedly connected to the inner wall of the bottom of the sealing bin, gas injection pipes are fixedly connected to one sides of the tops of the gas storage tanks, gas injection valves are installed between every two gas storage tanks and between the gas storage tanks and a gas injection control room, and gas outlet pipes are fixedly connected to the other sides of the tops of the gas storage tanks. A gas outlet valve is installed on the outer wall of the gas outlet pipe, a base is arranged at the bottom of the gas dispenser, and a static electricity removing device is fixedly connected to the top of the base. According to the static electricity removing device, the grounding metal bar is arranged, the connecting wire at the bottom of the grounding metal bar is connected with the contact panel, and the rotating motor and the connecting rod controller are attached to the surface of the automobile to remove static electricity on the surface of the automobile, so that static electricity contained in the automobile body is eliminated, and the probability of accidents caused by static electricity is reduced.

## 8. LNG LOW-TEMPERATURE TRANSPORTATION TANK VEHICLE



**Authors:** Cui Wentian, Tang Zhicai, Liu Kefan, Yu Miao, Li Jia, Zhu Jiandou, Song Chunming

**Publication number:** 113188033

**Publication date:** 30.07.2021

**Abstract:**

The invention discloses an LNG low-temperature transportation tank vehicle. The LNG low-temperature transportation tank vehicle comprises a semitrailer chassis traveling mechanism and a low-temperature liquefied natural gas movable storage tank; the storage tank is composed of a storage tank body and an operation box, and the storage tank body is of a horizontal double-cylinder high-vacuum multi-layer heat insulation low-temperature container structure; an inner container is made of austenitic stainless steel plates, and a wave-proof device is arranged in the inner container; and an anti-wave device comprises a center pipe and a supporting plate, the axis of the center pipe coincides with the axis of the inner container, the supporting plate is in a horn shape, the small-end opening of the supporting plate is welded to the outer surface of the center pipe, and the large-end opening of the supporting plate is welded to the inner surface of the inner container. The wave-proof device effectively reduces the impact and vibration of the liquid in the tank body in all directions in the running process of the vehicle, dozens of aluminum-foil paper with high heat insulation performance is wound on the outer wall of the inner container, glass fiber paper is padded between the aluminum-foil paper, and high-vacuum technical treatment is carried out between interlayers, so that the storage tank can achieve the super heat insulation performance, and the outer container is made of a low-alloy steel plate.

## 9. TANK PRYING TYPE LNG GENERATOR SET BASED ON SEPARATED WATER TANK HEAT DISSIPATION SYSTEM



**Authors:** Heng Chenggu, Cao Shusheng

**Publication number:** 113137305

**Publication date:** 20.07.2021

**Abstract**

The invention discloses a tank prying type LNG generator set based on a separated water tank heat dissipation system. The tank prying type LNG generator set comprises a generator set tank body, the generator set tank body comprises a gasification area, a power area and a heat dissipation area, the gasification area and the power area are separated through a partition plate, and an LNG storage tank is installed in an inner cavity of the gasification area. The outer end of the LNG storage tank is connected with a gasifier through a first connecting pipe, a motor and an engine are installed in an inner cavity of the power area, a partition plate is arranged between the power area and the heat dissipation area, a radiator and a water tank are installed on the side wall of an inner cavity of the heat dissipation area, and a large exhaust fan is installed at the top of the heat dissipation area. The heat dissipation efficiency in the generator set tank body can be improved through separation of the heat dissipation area and the power area, in other words, on the premise that the use safety of the generator set is guaranteed, the gasification area is added into the generator set tank body, the integrity of the generator set tank body is guaranteed, and great convenience is provided for transportation of the LNG generator set.

## 10. SAFETY TYPE PNEUMATIC SUBSECTION CONTROL LNG LIQUID ADDING GUN



**Authors:** Wei Benjian, Li Zhimei, Zhang Hairong

**Publication number:** 113236964

**Publication date:** 10.08.2021

**Abstract:**

The invention discloses a safety type pneumatic subsection control liquid adding gun. The gun comprises a gun head, a gun body, a liquid adding valve body movably arranged in the gun body, a locking sleeve and a driving air cylinder assembly connected with the rear end of the liquid adding valve body and used for driving the liquid adding valve body to move in the gun body. The liquid adding valve body is hollow to form a liquid adding channel. An outlet of the liquid adding channel is located at the front end of the liquid adding valve body, a valve element assembly is arranged at the outlet of the liquid adding channel, and a liquid inlet connector is arranged on the side face of the liquid adding channel and communicated with the liquid adding channel. Through the manner, the design manner that the liquid adding channel is separated from the driving air cylinder assembly is adopted, so that the driving air cylinder assembly is not affected by the low temperature of an LNG medium, and it can be guaranteed that the LNG liquid adding gun does not freeze after long-time continuous filling operation; and the stroke position of a driving air cylinder is controlled through a pneumatic subsection control valve, the actions of gun locking, liquid adding, gun withdrawing and safe gun pulling can be achieved step by step, and the safety of operators is guaranteed.

## 11. LNG (LIQUEFIED NATURAL GAS) FILLING DEVICE CAPABLE OF IMPROVING USE EFFICIENCY OF LNG PLUNGER PUMP



**Authors:** Pei Jingming, Qiu Shi, Qi Zhirong, Yang Mo

**Publication number:** 113236967

**Publication date:** 10.08.2021

**Abstract:**

The invention discloses an LNG filling device capable of improving the use efficiency of an LNG plunger pump. The LNG filling device comprises an LNG tank body, the LNG plunger pump, an LNG liquid adding machine and an LNG immersed pump, wherein the LNG tank body is connected with the LNG immersed pump through a liquid inlet tube, a three-way valve is installed at the outlet end of the LNG immersed pump, a first connecting pipe connected with the LNG liquid adding machine is installed at one end of the three-way valve; the LNG tank body is connected with the LNG plunger pump through an LNG liquid phase pipeline, a third connecting tube connected with the LNG liquid phase pipeline is installed at the other end of the three-way valve. The LNG liquid phase pipeline precooling device has the beneficial effects that losses generated by precooling of the LNG liquid phase pipeline can be reasonably reduced, the precooling time of the LNG plunger pump is shortened, and the use efficiency of a traditional LNG plunger pump device is improved.

## 12. HYDROGEN PREPARATION AND LIQUEFACTION DEVICE SYSTEM AND METHOD BASED ON LNG RECEIVING STATION



**Authors:** Wang Jiangtao, Lu Xiaobin, Guo Lei, Qu Shunli, Wang Fang, Zhang Jingzhou, Yang Lu

**Publication number:** 113061905

**Publication date:** 02.07.2021

**Abstract:**

The invention provides a hydrogen preparation and liquefaction device system and method based on an LNG receiving station. The hydrogen preparation and liquefaction device system comprises a hydrogen liquefaction and cold energy utilization section, a natural gas cold energy power generation and water electrolysis hydrogen production section, a natural gas hydrogen production section, a liquid hydrogen storage unit and an LNG supply unit. The hydrogen preparation and liquefaction method comprises hydrogen preparation and hydrogen liquefaction which are independently carried out. The hydrogen production comprises the following steps: LNG is subjected to cold energy utilization and then is subjected to reforming hydrogen production; the energy generated by cold energy is used for electrolyzing water to produce hydrogen; and the hydrogen liquefaction comprises H<sub>2</sub>-NG pre-cooling, LNG pre-cooling, liquid nitrogen pre-cooling and ultralow temperature pre-cooling which are carried out in sequence. According to the system and the method, liquefaction and preparation of hydrogen are realized by fully relying on a large amount of LNG cold energy in the LNG receiving station, optimized matching of LNG and a hydrogen energy industry chain is realized, the hydrogen preparation cost and liquefaction cost are reduced, and meanwhile, no carbon dioxide is generated, so that environmental protection is facilitated.

### 13. LNG INDUSTRIAL CHAIN COMPREHENSIVE MANAGEMENT SYSTEM BASED ON BIG DATA



**Authors:** Li Yaxian, He Wenbo, Ge Yongwei, Yu Yifan, Zhou Yazhou, He Junyu

**Publication number:** 113065854

**Publication date:** 02.07.2021

**Abstract:**

The invention discloses an LNG industrial chain integrated management system based on big data, and relates to the technical field of LNG management. The system comprises an LNG energy server which is used for carrying out LNG energy data collection, data storage, data access and data analysis; a data monitoring management end which is used for accessing the LNG energy service end to extract data information, predicting the gas consumption trend of the LNG energy, providing networked transport capacity scheduling for transportation, and predicting stock information at the same time; a distribution management end which is used for accessing the data monitoring management end to carry out tank car dispatching management; and an operation and maintenance server which is used for carrying out operation and maintenance service support. On the basis of big data, gas consumption monitoring, plan prediction, transportation and distribution and the like are carried out, the plan prediction accuracy is expected to be improved, the integration degree of informatization data is enhanced, the accuracy of a logistics distribution link is improved, intelligent and real-time monitoring and allocation of an LNG industry chain city are achieved, and manpower and time are saved.



### 4.3. Материалы конференций / Conference Papers

#### 14. INTEGRATED FIELD MANAGEMENT SYSTEM FOR LNG ASSETS: MAXIMIZING ASSET VALUE THROUGH REPRESENTATIVE END-TO-END MODELING



**Authors:** Osama Hasan Khan; Samad Ali; Mohamed Ahmed Elfeel; Shripad Biniwale; Rashmin Dandekar

**Conference:** SPE Annual Technical Conference and Exhibition, UAE, September 2021

**Abstract:**

Effective asset-level decision-making relies on a sound understanding of the complex sub-components of the hydrocarbon production system, their interactions, along with an overarching evaluation of the asset's economic performance under different operational strategies. This is especially true for the LNG upstream production system, from the reservoir to the LNG export facility, due to the complex constraints imposed by the gas processing and liquefaction plant. The evolution of the production characteristics over the asset lifetime poses a challenge to the continued and efficient operation of the LNG facility. To ensure a competitive landed LNG cost for the customer, the economics of the production system must be optimized, particularly the liquefaction costs which form the bulk of the operating expenditure of the LNG supply chain. Forecasting and optimizing the production of natural gas liquids helps improve the asset economics. The risks due to demand uncertainty must also be assessed when comparing development alternatives.

This paper describes the application of a comprehensive field management framework that can create an integrated virtual asset by coupling reservoir, wells, network, facilities, and economics models and provides an advisory system for efficient asset management. In continuation of previously published work (Khan, Ali, Elfeel, Biniwale, & Dandekar, 2020), this paper focuses on the integration of a steady-state process simulation model that provides high-fidelity thermo-physical property prediction to represent the gas treatment and LNG plant operation. This is accomplished through the Python-enabled extensibility and generic capability of the field management system. This is demonstrated on a complex LNG asset that is fed by sour gas of varying compositions from multiple reservoirs. An asset wide economics model is also incorporated in the integrated model to assess the economic performance and viability of competing strategies.

The impact of changes to the wells and production network system on LNG plant operation is analyzed along with the long-term evolution of the inlet stream specifications. The end-to-end integration enables component tracking throughout the flowing system over time which is useful for contractual and environmental compliance. Integrated economics captures costs at all levels and enables the comparison of development alternatives.

Flexible integration of the dedicated domain models reveals interactions that can be otherwise overlooked. The ability of the integrated field management system to allow the modeling of the subsystems at the 'right' level of fidelity makes the solution versatile and adaptable. In addition, the integration of economics enables the maximization of total asset value by improving decision making.

## 15. MAKING LNG AFFORDABLE AS A MEANS TO MONETIZE ASSOCIATED GAS OFFSHORE

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**Authors:** Jean-Philippe Dimbour; Dominique Gadelle; Benoit Laflotte; Lorenzo Disaro

**Conference:** Offshore Technology Conference, Virtual and Houston, Texas, August 2021

**Abstract:**

Today, the gas associated with oil production is becoming an environmental concern for existing fields when it is flared. There are substantial quantities of associated gas still burnt at fields every year. When offshore, the reinjection of such associated gas into the reservoir is not always technically feasible, it is expensive, and may become a blocker for new offshore oil developments.

Associated gases can be monetized in the form of LNG produced directly offshore, it can become an enabler of new oil projects, and a means to reduce CO2 emissions and meet commitments.

LNG production at sea can be achieved at a competitive CAPEX, by using an innovative mega-module concept.

Furthermore, when treating rich associated gases, the production and export of high-value liquid by-products - LPG and condensates and even possibility ethane - can greatly improve the economics of LNG production itself by creating additional revenues, at a marginal increment cost thanks to the integrated process and utilities functionalities, while keeping the possibility to adjust to several LNG market specifications.

## 16. OFFSHORE LNG AND GAS MONETIZATION



**Author:** Femi Adeoye Alabi

**Conference:** Offshore Technology Conference, Virtual and Houston, Texas, August 2021

**Abstract:**

### Objectives/Scope

In recent years, there has been exceptional expansion of the liquefied natural gas industry (LNG), which is largely attributed to rising demands in various parts of the world and triggered the emergence of Floating LNG (FLNG) as a faster and more cost-effective strategy for exploitation of gas resources with a huge competitive advantage in the business activities. However, the introduction of new technologies comes with new requirements for tax related issues.

### Methods, Procedures, Process

It is a testament to the resilience and adaptability of the LNG business to check the hypothesis that FLNG provides a method by that stranded gas discoveries will be monetized and essentially within a shorter time, lower fabrication execution risk and the entrepreneurial vibrancy that comes from competitive suppliers and approaches on FLNG. On FLNG plant cost, Brian Songhurst gives a review of the state of the performance of FLNG after commissioning. The need for the FLNG industry to address both cost base and contractual price formation mechanisms as a viable channel for the delivery of gas is key.

### Results, Observations, Conclusions

The impact of Independent Power Projects (IPP) in the third World nations act as game-changer in the monetization, new gas markets discoveries and increasing impact on the global gas economy. FLNG has potentials to transform the phase transition business from technical and business stand points within the economic development of remote offshore oil fields. The opportunity provided by the contractors to lease the FLNG vessel enables the smaller independent energy companies to avoid arranging project finance and carrying the asset on their balance sheet. However, it could also assist the major energy companies where current low oil prices are restricting capital investment to lease their FLNGs. Given the high level of interest in the researcher's two previous papers, this update will prove equally interesting and useful to analysts and participants in the gas sector, as floating technology continues to open new opportunities. Cost Comparison of the FLNG offerings are following a more industry standard design approach based on functional specifications and vendor standard equipment rather than client standards and design methods as used by the energy companies. The reason for the quality style approach is to position the FLNG facilities to be hired and reused by energy company.

### Novel/Additive Information

The price of producing LNG from offshore gas reserves through the FLNG ought to be less than from onshore plants thanks to the lower CAPEX, albeit this will be somewhat offset by higher OPEX. This paper provides an update on the floating LNG sector (both floating liquefaction and re-gas terminals) over the past few years looking into some of the publication of the floating liquefaction (FLNG) contribution from the Oxford Institute for Energy Studies.

## V. Морские технологии / Offshore Technology

### 5.1. Статьи / Articles

#### 1. DYNAMIC MODELING AND ANALYSIS OF LNG FUEL TANK PRESSURIZATION UNDER MARINE CONDITIONS



**Authors:** Cheng Wanga, Yonglin Jua, Yunzhun Fub

**Journal:** Energy, volume: 232

**Abstract:**

In this paper, a fast and effective dynamic model was developed to predict and investigate the performance of liquefied natural gas (LNG) fuel tank pressurization under marine conditions. An extended sloshing Nusselt number was defined to quantitatively evaluate the heat transfer enhancement in horizontal tanks under resonant sloshing. The validity of the model was confirmed by the corresponding experimental data. The pre-pressurization process, the fuel gas supply process, and the cryogenic liquid sloshing were investigated for two types of LNG fueled ships. Parametric studies, including the tank size, the filling level, the rated power, the engine load, and the sloshing intensity were conducted. The results showed that the heat transfer between the vapor and tank wall dominates the pressurization process, while the vapor condensation at the liquid-vapor interface dominates the holding period and the sloshing process. Moreover, the sloshing has a severe impact on the tank pressure, especially when the resonance condition of the tank is met, which can cause the shut-down of gas engines in extreme situations.

#### 2. DEVELOPING A CFD HEAT TRANSFER MODEL FOR APPLYING HIGH EXPANSION FOAM IN AN LNG SPILL



**Authors:** Zhang Z.R., Krishnan P., Jiao Z.R., Mannan M.S., Wang Q.S.

**Journal:** Journal of loss prevention in the process industries, volume: 71

**DOI:** 10.1016/j.jlp.2021.104456

**Abstract:**

Liquefied natural gas (LNG) is widely used to cost-effectively store and transport natural gas. However, a spill of LNG can create a vapor cloud, which can potentially cause fire and explosion. High expansion (HEX) foam is recommended by the NFPA 11 to mitigate the vapor hazard and control LNG pool fire. In this study, the parameters that affect HEX foam performance were examined using lab-scale testing of foam temperature profile and computational fluid dynamics (CFD) modeling of heat transfer in vapor channels. A heat transfer model using ANSYS Fluent (R) was developed to estimate the minimum HEX foam height that allows the vapors from LNG spillage to disperse rapidly. We also performed a sensitivity analysis on the effect of the vaporization rate, the diameter of the vapor channel, and the heat transfer coefficient on the required minimum height of the HEX foam. It can be observed that at least 1.2 m of HEX foam in height are needed to achieve risk mitigation in a typical situation. The simulation results can be used not only for understanding the heat transfer mechanisms when applying HEX foam but also for suggesting to the LNG facility operator how much HEX foam they need for effective risk mitigation under different conditions.

### 3. BACKTRACKING AND PROSPECT ON LNG SUPPLY CHAIN SAFETY



**Authors:** Jiao Y., Wang Z.Y., Liu J.H., Li X., Chen R., Chen WJ

**Journal:** Journal of loss prevention in the process industries, volume: 71

**DOI:** 10.1016/j.jlp.2021.104433

**Abstract:**

The safety issues of Liquefied Natural Gas (LNG) in production, storage, loading/unloading, transportation/ shipping, and re-gasification have become a major concern, since an accident in the LNG industry would be very costly. Understanding the threat of LNG not only contributes to the process safety and reliability in the research and development (R&D) system, but improves the efficiency of loss prevention, fire protection and emergency responses. As of April 2019, in order to obtain the present status and trend of LNG safety research, basing 1122 documents of the Web of Science database about safety research of LNG as a data source, CiteSpace and VOS viewer were used for network knowledge map analysis. A comprehensive knowledge map of LNG safety field was obtained from several research aspects including scientific research power, research hot spots and trends, research knowledge base and frontier. According to the study results, the development of LNG safety research was divided into four stages from 1970s to 2019, China and South Korea made a lot of contributions, and the United States is the most influential. Among them, the research from 2005 to 2019 was the most representative. Current research results indicate that a combination of Formal Safety Assessment (FSA) methodology and Dynamic Procedure for Atypical Scenarios Identification (DyPASI) will fully identify risks; The PHAST and TerEx programs quickly define safety zones. Computational Fluid Dynamics (CFD) software package can provide accurate quantitative data for the study of LNG safety. Research on quantitative risk assessment (QRA) and LNG evaporated gas (BOG) has been a hot topic and trend in this field. The application of expansion foam in LNG accident mitigation covers most of the research content in this field, and the optimization of LNG liquefaction process has a great influence on this industry. As the international demand for LNG energy output increases, floating liquefied natural gas (FLNG) will have considerable development, and increasingly researchers attach vital importance to the safety of LNG offshore production integrated unit.

## 5.2. Патенты / Patents

### 4. ONLINE MONITORING AND DETECTING SYSTEM OF LNG CLOSED STORAGE DEVICE



**Authors:** : Fu Zihang, Yang Yuxia, Yang Hongwei, Hou Hailong, Wang Xiulin, Han Yinshan, Wu Jianhong, Feng Liang, An Dongyu, Liu Fang, Huang Jiexin

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**Publication date:** 16.07.2021

**Abstract:**

The utility model relates to an on-line monitoring and detecting system of an LNG (Liquefied Natural Gas) closed storage device, which comprises a low-temperature detector, the low-temperature detector is arranged in the upper gas phase or liquid phase space of the LNG closed storage device through a connecting structure, and the low-temperature detector is used for detecting the state in the LNG closed storage device; the low-temperature detector is connected with the external power supply system through the power line, and the power line is arranged in the connecting structure; one end of the connecting structure is connected with the low-temperature detector, and the other end of the connecting structure is connected with the low-temperature sealing flange located outside the LNG closed storage device. According to the utility model, in the operation state of the LNG closed storage device, the internal scene including the integrity information of the inner wall, the equipment and the pipe fitting is visually restored, the problems of on-line detection of the defects of shrinkage deformation, cracks and the like after the LNG closed storage device is filled with liquid and accurate measurement of the geometric volume are solved, and the detection precision is improved. And the problem of wall surface temperature on-line monitoring is solved.

### 5. TEMPERATURE MONITORING AND LEAKAGE PREVENTING DEVICE SUITABLE FOR LNG STORAGE TANK



**Authors:** : Wang Hailiang, Huo Fengguo

**Publication number:** 213932627

**Publication date:** 10.08.2021

**Abstract:**

The utility model discloses a temperature monitoring and leakproof device suitable for an LNG (Liquefied Natural Gas) storage tank, which comprises a temperature measuring optical fiber which is wound on the outer wall of an inner storage tank and is annularly laid in a thermal insulation layer at a bottom plate of an annular space between the inner storage tank and an outer storage tank, and a thermal insulation material is filled between the inner storage tank and the outer storage tank. The head end and the tail end of the temperature measuring optical fiber are connected with one end of a data acquisition template in the junction box, the other end of the data acquisition template is connected with a temperature measuring host, and the temperature measuring host is connected with a control system. A gas one-way valve and an alarm are installed on the outer storage tank, the gas one-way valve is connected with a vacuum pump, and the vacuum pump is connected with a collecting pipe. The device has the functions of monitoring temperature in real time and accurately positioning leakage points, and is long in service life and good in system stability.