SHELL GAMECHANGER
BUILDING ON THE PAST TO CREATE TECHNOLOGY ALLIANCES AND PARTNERING WITH START-UPS DELIVERING IMPACT AND CHANGE

December 2019, 1st edition
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**External collaboration:**
https://eu001-sp.shell.com/sites/AAFAA3397/default.aspx?e=1%3A2ea8c3a4481fda8a50984778218dde6

**Shell Research Connect (SRC):**
https://eu001-sp.shell.com/sites/AAFAA3397/Pages/SRC.aspx

**Shell GameChanger (GC):**
https://eu001-sp.shell.com/sites/AAAAA8217/default.aspx

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Two of Shell’s four innovation vehicles:

**Shell Research Connect**
Bringing together the brightest minds

**Shell GameChanger**
FOREWORD

This is a time of great challenges and great opportunities for the energy industry: we must provide the energy that society needs to prosper and help in tackling the climate challenges arising from greenhouse gas emissions. This requires bold vision to test new concepts and ideas and to find new solutions.

For more than 20 years, Shell GameChanger has been at the forefront of helping Shell to confront its most challenging issues. From the first floating liquefied natural gas concept to expandable casing designs, Shell GameChanger, one of Shell’s four innovation vehicles, has, in close collaboration with the Shell Ventures vehicle, helped numerous ideas to get the funding and expert support they need to reach their full potential. These ideas have come from within Shell and from external sources. Shell GameChanger is also known in Shell and the industry as a source of support for some of the riskiest ideas. It was one of the very first funding mechanisms in the energy industry to encourage the “failing-fast” philosophy. Believing in testing risky ideas that could have a large reward if they succeeded is also very much part of its success formula.

Over the past few years, Shell GameChanger has pivoted towards supporting mostly external start-ups and focusing on some of the most impactful up-and downstream, new energy and digital technologies. We have also formed strategic alliances with various incubators, academic institutions and national laboratories to increase significantly both the quantity and the quality of the deal flow in close collaboration with Shell Ventures.

To illustrate the progress we have made, we have thoroughly reviewed the past Shell GameChanger portfolio, its impact on technology and Shell businesses, and the lessons learned. We will use this to shape the future plans of Shell GameChanger. Thanks to Shell GameChanger intern Elliott Lee, and with support from present and past team members, this information has been used to compile a booklet where you will find stories about a cross section of the ideas that we have had the honour of nurturing and some of the real people behind them.

We hope you will enjoy reading this booklet. We also invite you to get in touch about the bold ideas you have encountered that have real game-changing potential. We would like to work with you to bring these ideas to the testing stage to help Shell stay at the forefront of energy technologies, digital transformation and energy transition. Let us make the future together.


"We need Shell GameChanger more than ever to help make the future by leading the energy transition to a low-carbon future, leveraging the external environment fully for Shell’s digital transformation, and securing its social licence to operate by inviting the external innovation community to co-create the technology and solutions that society needs to prosper."
THE SHELL GAMECHANGER APPROACH

THE SHELL GAMECHANGER PROGRAMME HAS REINVENTED ITSELF SEVERAL TIMES SINCE 1996. INITIATED FOR INTERNAL IDEA SELECTION, IT NOW WORKS WITH START-UPS AND BUSINESSES ON UNPROVEN EARLY-STAGE IDEAS WITH THE POTENTIAL TO AFFECT THE FUTURE OF ENERGY. WE PROVIDE STARTUPS WITH MENTORING, EXPERTISE AND PRE-SEED FUNDING WHILE THEY MAINTAIN THE INDEPENDENCE TO GROW THEIR COMPANY.

Disruptive ideas that could help to accelerate the energy transition can exist anywhere. We evaluate and mature early-stage technologies that companies are working on to help to de-risk them, to move them towards a proof of concept and to increase their chances of success.

Using an established approach, Shell GameChanger evaluates technologies to check for a match with the programme. **We assess against four key criteria:**

1. **novelty**: Is your technology fundamentally different and unproven?
   - evolutionary or revolutionary

2. **value**: Could your technology create substantial new value if it works?
   - hundreds of millions or billions
   - reputational
   - environmental
   - health, safety and environment

3. “**Why Shell?**”: Is your technology relevant to Shell and the energy future?
   - Why Shell GameChanger?
   - capabilities
   - opportunities
   - competition

4. **testable/doable plan**: Can the concept be proven quickly and affordably? Is the right team in place to deliver this?
   - credible road map
   - proof of concept
   - clear first steps
   - fast and affordable
   - commercially minded.

In 2018, we upgraded the GameChanger process by applying agile ways of working that resulted in projects reaching maturity in six weeks instead of six months.
The process leading up to the graduation of a deal can be a long one, depending on the idea’s level of maturity, the functionality of the team and the due diligence needed to mature and contract a company, idea or project. Once executed, the deal is labelled as “graduated”, and the company, idea or project will be well prepared to change the game.
KEY SHELL GAMECHANGER STATISTICS

**CURRENT**

- **92 OPEN DEALS**
  - 43 (47%) Created
  - 11 (12%) Maturing
  - 5 (5%) Contracting
  - 33 (36%) Executing

**ALL TIME**

- **5,555 DEALS CREATED**
  - 170 (3%) Graduated deals
    - 29 (17%) External
    - 141 (83%) Internal
  - External deals only in 2017

**PAST FIVE YEARS**

- **561 DEALS CREATED**
  - 35 (6%) Graduated deals
    - 19 (54%) External
    - 16 (46%) Internal
  - $44 million spent on projects

**THEMES**

- Oil and gas: 56%
- New energies: 31%
- Other: 13%

**ADDITIONAL NOTES**

- 2 Shell Ventures backed, 3 in Shell Venture’s pipeline
- Among the graduated:
  - 39% oil and gas,
  - 11% new energies,
  - 50% other

- 75% of external graduated deals were created in 2015 to present
- Shell GameChanger shifted to 100% external in 2017

- 3 graduated companies in 2019

- 75% of external graduated deals were created in 2015 to present

- Shell GameChanger shifted to 100% external in 2017
Five graduated companies in 2019:
- Geothermal power, GreenFire Energy, $17 million
- Liquefied gas electrolytes, South 8 Technologies, $17.6 million
- Liquid-assisted gas lift, Petroleum Emerging Technology, $46.6 million
- HiProbe, Sisprobe, $38 million
- OceanIt, Ultra, net present value pending
SHELL GAMECHANGER HIGHLIGHTS

SHELL GAMECHANGER PROJECTS IN THE PIPELINE THAT HAVE BEEN CALLED “STAR” COMPANIES

DATAJUDO (oil and gas)
Autonomous drilling system through data and trend analysis
Datajudo has been working with Shell GameChanger to bring a completely new approach to drilling to the market. Technology from new start-up AI Driller will enable the prediction of geological formation changes and the application of self-learning algorithms to fine-tune drilling parameters while drilling. Datajudo is trying to automate the control of drilling parameters and sliding with drilling motors. Data entry, workflows and visualisation will also be implemented.

OCEANIT (oil and gas)
Laser communications systems in deepwater environments
Oceanit has been working with Shell GameChanger to determine the feasibility of integrating a laser communications network with self-powered sensors for use in deepwater subsea environments. A key part of its ULTRA system is the passive power harvesting intended to extend battery life in sensors and the communication system and to reduce or eliminate the need for remotely operated battery replacement in the sensors connected to the ULTRA network.

SPARKCOGNITION (oil and gas)
Digitalising pore pressure prediction
SparkCognition has worked with Shell GameChanger to develop the digitalisation of predrilling pore pressure prediction during the exploration and appraisal phases using artificial intelligence for correlating logs and machine learning for modelling improvement. SparkCognition is estimating rock properties from drilling data while generating optimised models for data sets.

WFS TECHNOLOGIES (oil, gas and more)
Subsea cloud computing networks
WFS Technologies’ subsea cloud computing is a logical extension of the Subsea Internet of Things. Based on multiparameter sensors designed for retrofitting to subsea flowlines, etc., subsea cloud computing is set to revolutionise a wide range of industries, including oil and gas, subsea mining, environmental monitoring, aquaculture, homeland security and defence. Each smart node incorporates local data processing, analytics and SeaTooth® Hybrid wireless radio, acoustic and optical communications.

DIMENSIONAL ENERGY (new energies)
Solar thermal chemical reactor technology for converting carbon dioxide to hydrocarbons
Cornell University start-up Dimensional Energy has produced a solar thermocatalytic reactor that enables the conversion of carbon dioxide and water to methanol and other hydrocarbons. The unique feature of the reactor is optimised light delivery to ensure that all the catalyst material has enough light to activate the reaction. This is accomplished through a glass honeycomb waveguide structure that delivers light directly to the catalysts and by performing the reaction at elevated temperature using the parts of the solar spectrum that cannot catalyse the reaction to provide heat. The optimised photo reactor is integrated with photocatalysts that are functionalised for enhanced carbon dioxide capture and conversion.

SENSLYTICS (oil and gas)
Predicting time to contamination threshold
Senslytics sets out to predict contamination levels of fluid samples during formation testing operations. Formation testing plays a critical role in the exploration and appraisal of oil and gas. It provides downhole fluid samples as well as pore pressure, mobility, permeability and anisotropy measurements, which are vital to real-time drilling safety, geosteering, hydraulic fracturing and economic analysis. Senslytics sets itself apart from other data-science companies by focusing on understanding the situational and surroundings dynamics influences on core system behaviour. Gaining lead time to any upcoming event is the key to avoid emergency or nonproductive operational experiences. The Intuition Technology framework is designed to do exactly that.
**TERATONIX (new energies)**
Converting ambient radio waves to electricity for a maintenance-free replacement for batteries
The Teratonix energy harvester converts the ambient radio waves ubiquitously available in the urban environment to electricity. By generating power on the spot, the energy harvester cuts maintenance expenses for wireless devices by a factor of 10, eliminates hazardous battery waste and enables multiple new Internet of Things applications that were previously too expensive. Based on a proprietary, patented ultra-high-speed diode, Teratonix’s energy harvester can produce 10 times more energy than competing devices.

**EARTH ENERGY RENEWABLES (new energies)**
Converting waste biomass to oxygenated chemicals
The carboxylate platform from Earth Energy Renewables uses a mixed culture of soil-derived microorganisms to convert biomass to carboxylates ranging from C2 to C8. Negative-value waste materials that would normally damage the environment are used as feedstocks to create positive-value oxygenated chemicals. The carboxylate platform is energy efficient and can generate its own energy by combusting undigested residues.

**TREAU (new energies)**
Climate system for more-efficient, smarter buildings and lower emissions
Treau’s home climate system provides the benefits of mini-split air conditioners at the price of window units. Treau lowers the cost of the key components in air conditioners (heat exchangers) by using commodity materials in patented architectures enabled by advanced manufacturing. The company has prototyped and tested several heat exchangers and demonstrated increased performance per cost compared with traditional devices.

**OPUS 12 (new energies)**
Carbon abatement by recycling carbon dioxide
Opus 12 has developed a device that recycles carbon dioxide into chemicals and fuels such as syngas, ethylene and methane. The company’s technology can reduce the carbon footprint of the world’s biggest emitters by creating a revenue stream from what is normally waste. Opus 12 was one of six clean energy start-ups chosen for the first cohort in the Cyclotron Road programme at Lawrence Berkeley National Laboratory.

**LUX ASSURE (chemicals and plastics)**
Closed-loop chemical management system
LUX Assure seeks to automate the processing of data from its chemical monitoring and management products so that the information is immediately available to clients. Another aspect of the project is a desk-based feasibility study that will generate a road map to develop an online instrument; technical work will be undertaken to de-risk the most challenging aspects identified. The final aspect of the project will review current injection systems and make recommendations for connecting the LUX Assure data with injection pump software.
SHELL GAMECHANGER GRADUATES IN THE NEWS

ALL SHELL GAMECHANGER COMPANIES THAT HAVE GRADUATED AND HAVE BEEN FEATURED IN NEWS ARTICLES, PAPERS OR MAGAZINES

**THE ENGINEER, 12 JUNE 2019**

Removing carbon dioxide from the atmosphere will be critical in reaching climate goals and, to that end, Professor Klaus Lackner, director of Arizona State University’s Center for Negative Carbon Emissions, USA, has developed a filter that binds to carbon dioxide from the atmosphere. The Center for Negative Carbon Emissions graduated from the Shell GameChanger programme in January 2017.

**OILANDGAS.COM, 02 JUNE 2019**

Lift ETC, a venture of Petroleum ETC, aims to enhance the artificial lift process. Its new process drastically decreases the amount of risk involved with the current form of gas lift used for well technology and reduces the cost of development while also increasing recovery. Petroleum ETC/Lift ETC graduated from the Shell GameChanger programme in April 2019.

Shell GameChanger has invested in HyperSciences’ HyperDrill, which can be used for tapping geothermal energy.
With $9.6 million from SeedInvest, an equity crowdfunding platform, HyperSciences has built a hypersonic propulsion system that can fire a projectile at five times the speed of sound. Shell GameChanger has invested in HyperDrill, which can be used for tapping geothermal energy. HyperSciences graduated from the Shell GameChanger programme in March 2017.

Maxterial has developed MaxShield coating technology to replace hard chromium coatings. The goal is to commercialise durable, scalable and nature-inspired anti-fouling coatings with unmatched easy-to-clean performance in high-temperature and highly corrosive environments. Maxterial graduated from the Shell GameChanger programme in January 2018.
SCIENCE DAILY, 13 NOVEMBER 2018
Researchers at Massachusetts Institute of Technology have captured 3D images of kerogen’s internal structure in 50 times greater detail than previous images. This will lead to better estimates of the recoverable reserves of natural gas and thereby help the world to speed up its transition from coal and oil. The kerogen project from Massachusetts Institute of Technology graduated from the Shell GameChanger programme in March 2016.

TRITON MAGAZINE, 07 MAY 2018
South 8 Technologies co-founders Cyrus Rustomji and Yangyuchen Yang are working to make lithium batteries function better and longer in lower, more extreme temperatures. South 8 Technologies graduated from the Shell GameChanger programme in May 2019.
Kaggle is a platform that hosts data science and machine learning competitions, thereby enabling companies to solve many data analytics problems while extracting maximum value from data sets. Since its launch in 2010, Kaggle has raised more than $12.5 million in funding. Kaggle graduated from the Shell GameChanger programme in September 2013.

Kite Power Solutions, a company developing technology for high-altitude wind power generation, received investment from Schlumberger and Shell Ventures after its completion of the Shell GameChanger programme. Kite Power Solutions received more than £5 million in funding in 2016. Kite Power Solutions graduated from the Shell GameChanger programme in September 2014.
PCIP, the company behind the “ice pigging” project, was acquired by Aqualogy back in 2014 and then by SUEZ. Ice pigging was developed as an alternative to pipe cleaning methods that might require disinfectants. PCIP graduated from the Shell GameChanger programme in September 2015.

WellDog has launched its Shale SweetSpotter service after testing with Shell. This is the first commercial reservoir evaluation analysis technology specific to unconventional natural gas. WellDog received funding from Shell Ventures in 2015. WellDog graduated from the Shell GameChanger programme in 2004.

Backed by GameChanger and funded by Shell, GlassPoint has received more than $53 million in outside investment.
GREENTECH MEDIA, 08 SEPTEMBER 2014

GlassPoint, a company backed by Oman’s State General Reserve Fund, Shell and other venture firms, received about $53 million in outside investment in 2014. This was for a Series C round led by the State General Reserve Fund and Shell Ventures. GlassPoint graduated from the Shell GameChanger programme in 2007.

OFFSHORE TECHNOLOGY, 31 MARCH 2008

FieldWare Production Universe improves real-time production surveillance for gas quality monitoring, allocation, etc. Deployed in 2002, it is currently installed on more than 5,000 wells within Shell on more than 65 top assets, notably in Brunei, the Netherlands, Iraq, Sarawak, the USA and Canada. FieldWare Production Universe graduated from the Shell GameChanger programme in 2000.
**SHELL GAMECHANGER GRADUATES AT A GLANCE**

The table of Shell GameChanger graduates is sorted by graduation date, with the most recent graduates first.

- Companies currently being evaluated for Shell Ventures funding
- Companies that have successfully moved from GameChanger to Shell Ventures and received funding

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<tr>
<th>PROJECT</th>
<th>COMPANY</th>
<th>GRADUATED YEAR</th>
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<tr>
<td>Geothermal power</td>
<td>GreenFire Energy</td>
<td>2019</td>
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<td>Liquefied gas electrolytes</td>
<td>South 8 Technologies</td>
<td>2019</td>
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<tr>
<td>Liquid-assisted gas lift (Lift ETC)</td>
<td>Petroleum Emerging Technology</td>
<td>2019</td>
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<td>HiProbe</td>
<td>Sisprobe</td>
<td>2019</td>
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<td>Ultra</td>
<td>OceanIt</td>
<td>2019</td>
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<tr>
<td>Anti-fouling coating</td>
<td>Maxterial</td>
<td>2018</td>
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<td>Slim gas-lift system</td>
<td>Welltec</td>
<td>2018</td>
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<td>Visual probe enhanced oil recovery formation tester</td>
<td>Pietro Fiorentini</td>
<td>2018</td>
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<td>Long-term flow assurance</td>
<td>Tomson Technologies</td>
<td>2017</td>
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<td>Hypersonic percussive drilling (HyperDrill)</td>
<td>HyperSciences</td>
<td>2017</td>
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<td>Ambient air capture of carbon dioxide</td>
<td>Arizona State University, Center for Negative Carbon Emissions</td>
<td>2017</td>
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<td>Zero-emission actuator(s)</td>
<td>Linear Motion Technologies</td>
<td>2016</td>
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<td>PROJECT COMPANY GRADUATED YEAR</td>
<td>DESCRIPTION</td>
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<tr>
<td><strong>Geothermal power</strong></td>
<td>ECO2G™ technology reinvents the geothermal industry model by overcoming the limiting factors. The proprietary ECO2G technology combines the oil industry’s directional drilling capabilities with ultra-high-efficiency carbon dioxide turbines now being developed by multiple vendors.</td>
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<td><strong>GreenFire Energy</strong></td>
<td>South 8 Technologies has developed breakthrough new liquefied gas electrolyte chemistry for electrochemical energy storage devices, including lithium batteries and electrochemical capacitors. The patented technology enables a substantial increase in energy storage, improved safety and an exceptionally wide operating temperature.</td>
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<tr>
<td><strong>2019</strong></td>
<td><strong>Liquid-assisted gas lift</strong> is a disruptive well technology for artificial lift that addresses the key issues that currently limit the wider use of gas lift. It dramatically reduces the ultimate development cost and minimises well intervention while increasing recovery and safety. Liquid assisted gas lift utilises the co-injection of liquid with lift gas to simplify gas lift completions and reduce the surface pressure requirements to kick off gas lift.</td>
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<td><strong>Petroleum Emerging Technology</strong></td>
<td>Sisprobe developed new seismic interpretation based on the use of multiple dense arrays of geophones and the use of anthropogenic noise, as passive seismic, for the monitoring of fluids movement and pressure state in the reservoir.</td>
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<td><strong>2018</strong></td>
<td>OceanIt has developed an ultra-high bandwidth, long-range optical communication system that uses a modulated tight-beam laser link and offers a significantly higher bandwidth/range combination than any available wireless technology to unlock the potential of the digital subsea.</td>
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<td><strong>Maxterial</strong></td>
<td>Maxterial is pursuing a lean business model to commercialise durable, scalable and nature-inspired repellent coatings with unmatched easy-to-clean performance in high-temperature and highly corrosive environments. The company envisions a coating that can be applied on complex geometries such as inside and outside pipes while potentially combining the easy-to-clean performance of Teflon® with the chemical resistance and durability of superalloys.</td>
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<td><strong>Welltec’s slim gas lift system</strong> is a simple slim-bore–full-bore system without conventional side-pocket mandrels. Protected behind a slick sleeve during installation, it remains dormant until gas lift is initiated, perhaps years after installation.</td>
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<td><strong>2017</strong></td>
<td>The visual probe enhanced oil recovery formation tester is a formation testing tool with Minitron/detector sampling and oil measurement capabilities. The tool produces an elemental spectrum of the formation minerals and compares the maximum recovery of alkaline–surfactant–polymer, carbon dioxide, solvent and low-salinity enhanced oil recovery options, all while obtaining conventional pressure data and samples.</td>
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<td><strong>Tomson Technologies</strong></td>
<td>Tomson Technologies is looking to change how chemicals are delivered downhole with its nanoparticle carrier platform. A new class of field application treatments and a carrier platform to deliver the treatment into the reservoir can achieve long-term protection of near-wellbore formations, tubing and surface equipment.</td>
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<td><strong>2016</strong></td>
<td>HyperSciences was founded in October 2014 to develop hypervelocity industrial solutions utilising ram accelerator chemical mass driver jet propulsion technology to propel HyperCore projectiles to hypervelocity speeds (+2 km/s). HyperDrill is an application of that technology that can produce an order of magnitude increase in the rate of penetration compared with rotary drilling in hard rocks for significantly improved conventional resource economics and access to new and unconventional oil, gas and geothermal resources.</td>
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<td><strong>Arizona State University’s Center of Negative Carbon Emissions</strong> is making air an unlimited, cost-effective source of carbon for climate-neutral synthetic hydrocarbons. A carbon dioxide concentration process that uses wind to guide carbon dioxide passively over moisture-sensitive sorbent materials that bind the carbon dioxide when dry and release it when wet at a two orders of magnitude higher concentration has been developed.</td>
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<td><strong>Linear Motion Technologies</strong></td>
<td>Linear Motion Technologies, a Houston-based small business, was established to commercialise patented shape memory alloy, aka “electric muscle”, and SmartRam™ actuator technologies. SmartRam technology uses a shape memory alloy developed for use in extreme land, sea, air and space environments.</td>
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<tr>
<td>PROJECT</td>
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<tr>
<td>Kerogen evolution</td>
<td>Massachusetts Institute of Technology</td>
<td>2016</td>
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<td>New and improved lubricants</td>
<td>Texas A&amp;M University</td>
<td>2016</td>
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<td>Digital twin, low-cost structural analysis</td>
<td>Akselos</td>
<td>2016</td>
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<td>Meadowlark</td>
<td>Shell</td>
<td>2015</td>
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<td>Aneutronic fusion power</td>
<td>NASA</td>
<td>2015</td>
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<td>Atherosclerotic reservoirs</td>
<td>Boston University</td>
<td>2015</td>
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<td>Anhydrase enzyme system for carbon dioxide capture</td>
<td>Akermin</td>
<td>2015</td>
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<tr>
<td>ECOFORM</td>
<td>SRI International</td>
<td>2015</td>
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<td>Ice pigging of pipelines and piping</td>
<td>PCIP</td>
<td>2015</td>
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<td>Kite power generation</td>
<td>Kite Power Solutions</td>
<td>2014</td>
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<td>High-bandwidth, wireless drillpipe (the well communication highway)</td>
<td>Green Gecko Technologies</td>
<td>2014</td>
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<tr>
<td>Fly ash–foam enhanced oil recovery</td>
<td>Shell</td>
<td>2014</td>
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<tr>
<td>PROJECT COMPANY GRADUATED YEAR</td>
<td>DESCRIPTION</td>
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| Massachusetts Institute of Technology | 2016 
A Massachusetts Institute of Technology project aims to build a production-oriented physical phase diagram of kerogen evolution. The project had four stages: (1) prepare kerogen proxies with variable maturity by pyrolysis of medium- or high-molecular weight precursors; (2) prepare oriented shale proxies by co-sedimentation of clays and cells or cell fragments followed by controlled pyrolysis; (3) perform full structural characterisation of those samples; and (4) perform full adsorption-desorption static and kinetic characterisation. Prepare oriented shale proxies by co-sedimentation of clays and cells or cell fragments (for instance, chloroplasts), followed by controlled pyrolysis. |
| Texas A&M University | 2016 
This project from Texas A&M University is aiming to develop one or more novel nano-sheet materials as lubricant additives and/or for restoring corroded areas and then demonstrate a proof of concept. |
| Akselos | 2016 
The Akselos project is looking to use nanoparticles to stabilise asphaltenes and prevent the formation of large aggregates and their subsequent deposition. The plan is to evaluate the impact of wettability changes due to the presence of nanoparticles and their influence on fluid flow properties of the pore network in rock micromodels. Because micromodels offer the ability to control the initial wetting state, pore geometry and visualisation, they can be used to scale up the effects of contact angle on multiphase flow. |
| Texas A&M University | 2016 
This project from Texas A&M University is aiming to develop one or more novel nano-sheet materials as lubricant additives and/or for restoring corroded areas and then demonstrate a proof of concept. |
| Akermin | 2016 
Akermin is developing a novel biocatalyst approach that efficiently removes carbon dioxide from industrial gas streams. The company uses a multidisciplinary approach to integrate enzymes within a proprietary delivery system that can be readily incorporated into conventional processes that remove carbon dioxide using chemical absorption. Targeted industries include liquefied natural gas plants, biogas upgrading and ammonia production. |
| SRI International | 2015 
SRI's engineered charge for optimal fracturing of rock mass (ECOFORM) approach applies an optimal strain rate for fracturing by selecting suitable explosives and tailoring the design of the charge array. ECOFORM uses SRI's patented dilute explosive to tailor the loading pulse with an adjustable detonation pressure and pulse duration to optimise the fracture. Advanced finite element analysis, including LS-DYNA and SRI-developed material models for fracture, damage, and failure, are used for charge design. |
| PCIP | 2015 
With inspiration from glaciers, PCIP has matured the idea of using ice slurry to clean pipelines and has used it in the food industry to clean, for example, butter and yogurt pipelines. |
| Kite Power Solutions | 2014 
Kite Power Solutions has designed a new and highly cost-effective means of producing electricity using pairs of automatically controlled traction kites that run off one base station, which keeps the alternator spinning continuously. It has been deployed globally, specifically through New Energies. |
| Green Gecko | 2014 
Green Gecko's project resulted in a drillpipe communication backbone capable of data rates of megabits per second. Its applications include drilling control, drill string integrity, formation evaluation and looking ahead of the bit. |
<table>
<thead>
<tr>
<th>Project</th>
<th>Company</th>
<th>Graduated Year</th>
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</thead>
<tbody>
<tr>
<td>Kaggle</td>
<td>Kaggle</td>
<td>2013</td>
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<tr>
<td>Data to text</td>
<td>Data2Text</td>
<td>2011</td>
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<tr>
<td>Enhanced sequestration of carbon dioxide and hydrogen sulphide in carbonate reservoirs before production</td>
<td>University of Marseille</td>
<td>2011</td>
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<td>Distributed optical fibre sensor</td>
<td>Silixa</td>
<td>2010</td>
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<td>Synthetic aperture application in electromagnetics</td>
<td>Colorado School of Mines</td>
<td>2010</td>
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<tr>
<td>Solar steam generation for thermal enhanced oil recovery</td>
<td>GlassPoint</td>
<td>2010</td>
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<tr>
<td>Toolbox for mixed-integer nonlinear programming</td>
<td>Bayreuth University</td>
<td>2009</td>
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<tr>
<td>CFEX self-expanding tubular technology</td>
<td>Confluent Filtration Systems</td>
<td>2009</td>
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<tr>
<td>Nuclear magnetic resonance multiphase flowmeter</td>
<td>Shell</td>
<td>2008</td>
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<tr>
<td>Swellfix swellable elastomer</td>
<td>Swellfix</td>
<td>2005</td>
</tr>
<tr>
<td>WellDog Shale SweetSpotter</td>
<td>WellDog</td>
<td>2004</td>
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<tr>
<td>FieldWare Production Universe software</td>
<td>Shell</td>
<td>2000</td>
</tr>
<tr>
<td>PROJECT COMPANY GRADUATED YEAR</td>
<td>DESCRIPTION</td>
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<tr>
<td>Kaggle</td>
<td>Kaggle runs crowdsourced predictive modelling competitions. It takes companies’ high-value data or analytics problems, structures them as a competition and crowdsources them to a community of 70,000 data scientists. Competition among a large and diverse set of scientists extracts maximum value from data sets and has historically achieved a return on investment several times greater than the prize money invested.</td>
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<tr>
<td>Data2Text</td>
<td>Data2Text specialises in building computer software systems that can automatically generate textual (English, French, etc.) summaries of numerical and other complex spatial and temporal data sets. The high-quality narratives are generated using the incoming data streams and knowledge captured from domain experts. The company is based on world-leading technology developed by the data-to-text research group at the University of Aberdeen, which has developed software that automatically summarises complex data.</td>
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<tr>
<td>University of Marseille</td>
<td>The main objective of the project was to develop a methodology for extracting carbon dioxide and hydrogen sulphide from the hydrocarbons within a reservoir and trapping them before production. The idea was to separate these gases from the hydrocarbons using physicochemical and microbial processes, for example, bioremediation at subsurface conditions, without altering the deliverability of the reservoir.</td>
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<tr>
<td>Silixa</td>
<td>Silixa has developed and commercialised a distributed optical fibre sensor that can uniquely measure acoustic signals (sound) at every point along a length of optical fibre. The sensor effectively transforms a length of standard, unmodified optical fibre into 10,000 independent sensors. The system is suitable for applications such as pipeline security and flow assurance monitoring. The idea is to overcome subsurface complexity using synthetic aperture techniques to increase the detectability of deeper and smaller reservoir targets.</td>
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<tr>
<td>GlassPoint Solar</td>
<td>GlassPoint Solar harnesses and concentrates sunlight to produce steam for enhanced oil recovery. GlassPoint has backing from Shell Ventures and its technology has been deployed in upstream sites, including in Oman.</td>
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<td>The project aimed to develop a class of numerical algorithms in Fortran in the form of a general-purpose toolbox for mixed-integer nonlinear programming from where a user could select a suitable combination depending on the structure of the model and the discrete variables. The codes were implemented in a unified manner with a common, easy-to-use interface and were tuned for robustness and high-level efficiency.</td>
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<td>The CFEX self-expanding tubular technology project aimed to develop well casings with significantly larger expansion ratios, for example, 40%, using conventional materials with normal in-place strength parameters and to possibly eliminate the use of cement.</td>
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<td>The project utilised Halbach magnets for modifying the direction and intensity of the external magnetic field in a nuclear magnetic resonance multiphase flowmeter to improve spatially resolved measurements. The flowmeter was trialled in the Nederlandse Aardolie Maatschappij and Rotterdam assets, and has been commercialised with Kriohne GmbH, which developed the industrial version, under a royalties arrangement.</td>
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<tr>
<td>Swellfix</td>
<td>Swellfix developed a downhole swellable elastomer for downhole isolation that includes both water- and oil-swellable elastomers. Swellfix technology has been deployed externally and internally.</td>
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<td>WellDog's sweet-spot technology uses lasers and sophisticated detectors to provide a direct measurement of where the hydrocarbon lies in an unconventional reservoir to help optimise drilling and production.</td>
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<tr>
<td>FieldWare Production Universe software improves real-time production surveillance for gas quality monitoring, allocation, etc. Deployed in 2002, it is currently installed on more than 5,000 wells within Shell on more than 65 top assets, notably in Brunei, the Netherlands, Iraq, Sarawak, the USA and Canada.</td>
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SHELL GAMECHANGER PARTNERSHIPS SINCE JULY 2017

AN OVERVIEW OF CURRENT, ONGOING PARTNERSHIPS AND COLLABORATIONS HELPED BY THE SHELL GAMECHANGER TEAM

GCxN ACCELERATOR OVERVIEW

GCxN is a multimillion dollar and multiyear programme/accelerator developed by Shell GameChanger and powered by the United States Department of Energy’s National Renewable Energy Laboratory (NREL). A member of the Channel Partners network of Cleantech incubators, accelerators and universities must recommend early-stage companies. The companies in each cohort are provided with up to $250,000 in non-dilutive funding along with technical experts and potential future funding opportunities with a strategic partner. Companies in the accelerator also have access to state-of-the-art facilities and resources to run tests to accelerate their path to market.

FEASIBLE (new energies)
Improving the cost and performance of batteries
Feasible is developing a technology platform, EchoStat, that uses sound waves and data analytics to deliver insights about batteries across the value chain. At scale, Feasible’s technology will enable the widespread adoption of clean energy sources by improving the performance and safety of battery packs and decreasing their lifetime cost. Feasible was referred to GCxN by Cyclotron Road.

ANTORA ENERGY (new energies)
Inexpensive, long-duration energy storage
Antora Energy is building large batteries for the grid at remarkably low cost using modified solar panels to change heat to electricity efficiently. This technology will improve grid resiliency and provide long-duration energy storage at about 5% of the cost of conventional batteries. Antora Energy was referred to GCxN by Cyclotron Road.

ELECTRICAL GRID MONITORING LTD (new energies)
Dynamic and adaptive, self-reporting grid
Electrical Grid Monitoring created its Meta-Alert™ system to secure real-time communications and perform self-learning analytics on the whole grid. The collected data produce insights for optimal grid management and operation. Electrical Grid Monitoring was referred to GCxN by NREL.
ENERGYx ACCELERATOR OVERVIEW

The Idea Village, a nonprofit innovation hub in New Orleans, partnered with Shell GameChanger in late 2018 to develop the ENERGYx programme, which starts off with a four-day boot camp at which companies are taken through an intensive validation process to test their commercial potential in the marketplace. From there, suitable teams are chosen to attend a 16-week accelerator programme.

ARIX TECHNOLOGIES (oil and gas)
Pipe crawling inspection robot
ARIX Technologies was chosen from the ENERGYx accelerator to be sent through the Shell GameChanger programme. ARIX’s inspection robots crawl on the outside of above-ground pipes while remotely deploying various sensors. The agile, untethered external pipe crawler can navigate field obstacles such as pipe bends, supports and flanges more nimbly than other inspection robots. ARIX is working with Shell to address problems in design, manufacturing and certification.

“"For early-stage companies like ARIX that are developing new, unproven technologies, the ability to partner with an industry leader like Shell through the Shell GameChanger programme has truly been transformative. Co-developing and testing with Shell not only gives us critically important end-user feedback early and often during the development cycle, but also offers industry validation and support.”

DIANNA LIU
PRESIDENT AND FOUNDER, ARIX TECHNOLOGIES
YES!Delft and Shell GameChanger partnered to find student teams and entrepreneurs who could use data science and/or artificial intelligence to develop algorithm(s) for the energy sector during a five-day hackathon from 25 February to 1 March 2019. Teams use real-life cases during hackathons. This year, the teams were tasked with optimising energy consumption at Shell power plants using provided data. The teams also receive technical support from Shell, the Technical University of Delft and YES!Delft.

MOBIQUITY: AEGIR
(oil and gas)

Deep learning for plant optimisation

Mobiquity won first place at Shell GameChanger’s 2019 Hackweek in partnership with YES!Delft. Mobiquity’s solution, Aegir, is unique in that it understands and captures the complexity of the physical processes at a plant while also providing the user with an estimation of the model’s uncertainty. This solution stems from the issue that there is a lack of trust in the outputs of the black-box models currently in production.
Shell has partnered with YESiDelft, Rockstart and Get in the Ring: companies that support start-up development. The Shell New Energy Challenge will emphasise innovative carbon reduction companies that can aid in the energy transition, specifically in Europe and Israel. For 2019, there will be two tracks. Track one will focus on early-stage start-ups: Shell GameChanger will be working with the winners. Track two will be for scaleups and Shell Ventures will be working with the winners.

**NOSTROMO ENERGY**  
(new energies)  
The most cost-effective, cleanest and safest energy storage system ever  
Nostromo was one of the finalists in the 2017 Shell New Energy Challenge. The IceBrick™ is a building block developed by Nostromo that enables customers to build an ice storage reservoir as a seamless extension to a building. The immediate value will be a reduction in electricity costs (up to 30%) owing to a reduction in the demand charges.

**HYSILABS**  
(new energies)  
Easy-to-deliver hydrogen  
HySiLabs was a runner-up in the 2017 Shell New Energy Challenge and has developed a hydrogen-based liquid carrier that is stable and safe at ambient conditions, thereby enabling logistics similar to those for conventional fuels. HySiLabs is the only hydrogen liquid vector that enables the release of hydrogen on-site on demand and without energy input. The solution enables customers to benefit from all hydrogen’s advantages without its drawbacks.
Shell GameChanger has selected start-ups working on radically different 24/7 monitoring solutions that automatically identify methane sources and report their mass emissions rates. Methane is a greenhouse gas that has a far more potent impact on global warming than carbon dioxide. Its detection and quantification are widespread industry challenges.

SELECTED COMPANIES: NASA’s Goddard Space Flight Center, MultiMechanics and MIRICO

Corrosion under insulation is a widespread challenge in the industry and across Shell’s up-, mid- and downstream assets. Given the significant amount of equipment and piping that is susceptible to corrosion under insulation, assets need the ability to prioritise their inspection and maintenance work and to find ways to improve the effectiveness and efficiency of inspection and mitigation measures significantly. Shell GameChanger has selected companies to prove versatile and non-intrusive technologies that can cover a broad corrosion-under-insulation inspection scope and detect early corrosion under insulation flaw conditions.

SELECTED COMPANIES: Nucsafe and Physical Optics

Our identity · United by technology · Driven by impact and enabled by us
DOWNHOLE POWER HARVESTING TECHNOLOGIES
The pursuit of reliable and cost-effective downhole monitoring solutions for wells has moved from the commonly used tethered downhole completion systems to wireless concepts. Shell GameChanger has selected a novel and disruptive power harvesting technology to work in a subsurface downhole environment while having minimum effect on the current completion designs.

SELECTED COMPANY: Tubel Energy

TOP CODER
Topcoder is a crowdsourcing global community of more than 1.5 million designers, developers, data scientists and programmers. Shell GameChanger proposed a new challenge for them: map the community to identify teams and companies that could help Shell to find innovative approaches and solutions to real problems in oil and gas production.

SELECTED GROUPS: Rice Doctors, Pupa AI and Bayesian Brothers
MOVING FORWARD

In 2017, Shell GameChanger began working with Shell businesses to define those problems that were worth solving and to help them find solutions. Targeted calls with our stakeholders have proven to enable technology by providing companies with coaching, expertise, seed funding and access to markets. Looking to the future, Shell GameChanger will continue to showcase its new ways of working through internal and external partnerships and events. Its goal is to be as flexible as possible to enable technology solutions for Shell business units.

LET US POWER PROGRESS TOGETHER

In October 2019, Shell GameChanger, Shell Production Gulf of Mexico and The Idea Village teamed up for an accelerator programme, ENERGYx in NOLA, to support start-ups and innovators with the potential to affect the future of Louisiana and other coastal areas around the world. They are focusing on companies with emerging innovative technologies for coastal construction and water management that will improve the capital efficiency of real projects and can be launched to provide scalable business opportunities worldwide.

A Shell GameChanger investment in coastal construction technologies will capture multiple benefits for Shell. It will directly benefit our asset protection projects and contribute positively to Louisiana’s ambitious plan to restore and protect its coast. I believe that programmes like Shell GameChanger make a significant, positive contribution to society by helping entrepreneurs and our business at the same time.”

RICHARD TALLANT
VICE PRESIDENT PRODUCTION,
GULF OF MEXICO

ENERGY TRANSITION
China 2019 Challenge

Shell GameChanger has partnered with Shanghai Xinwei Technology Development to look for safe, reliable and cost-competitive technologies to debottleneck the challenging safety, cost and reliability issues that limit the commercially viable delivery of hydrogen from the point of production to the point of use, and dispensing it to fuel cell electric vehicles.

Accelerated growth in fuel cell electric vehicle fleets is likely in the coming decades, so safe and cost-effective solutions that deliver hydrogen to refuelling stations and dispense it into vehicles are becoming increasingly important. This is widely regarded as a prerequisite for the industrial-scale deployment of hydrogen as a fuel option for the transportation sector.

It is exciting to see that the first Shell GameChanger challenge in China aims to accelerate the development of hydrogen delivery and dispensing solutions. It will be beneficial to work with the vibrant innovation ecosystems in China on disruptive but unproven ideas and innovations that have potential impacts on the way Shell, with its partners, will do business in the future.”

TOBIAS CHEN
HYDROGEN COMMERCIAL MANAGER, ASIA PACIFIC

Call for hydrogen delivery and dispensing solutions
PhDsoft’s participation in Shell GameChanger challenge triggered our global expansion, powered our exponential growth and established the technological platform to support the next 10 years of innovations.”

FINALISTS:
- **PhDsoft** – a predictive ageing digital twin on floating production, storage and offloading facility topsides (asset integrity focus)
- **Pix Force** – oil spill detection and alert via automatic satellite monitoring (health, safety and environmental focus)
- **Teia Labs** – predictive analysis platform and data visualisation based on deep learning (subsurface focus)

“Whereas Shell GameChanger supports start-ups in their “seed” phase to a proof of concept, Shell Ventures will consider an investment at a later stage of their maturity curve, primarily from a Series A funding round onwards. In between the proof of concept and the Series A, Shell GameChanger and Shell Ventures work together to devise the right approach to support the entrepreneur. Offering a partnership tailored to the maturity of the start-up we work with is critical to the process of innovation.”
THE SHELL GAMECHANGER TEAM

The Shell GameChanger team spans the globe and specialises in providing business and technical expertise in a wide variety of areas to develop early-stage energy transition, digital and oil and gas solutions. Find out where we are based, what our different focus areas are and how to get in touch with us.

CURRENT GAMECHANGER TEAM MEMBERS

**THE NETHERLANDS**

Lene Hviid, Global Manager Shell Research Connect and GameChanger, PhD

Adrie Huesman, Principal Partnerships Advisor and GameChanger, PhD

Jeroen Smith, GameChanger, MSc and MBA

Catherine Smura, GameChanger, PhD

Frank Wubbolts, Senior Partnership Advisor, PhD

**BRAZIL**

Vacancy

**CHINA**

Qun Deng, Principal Partnerships Advisor and GameChanger, PhD

Lexie Sui, Innovation Analyst, MS

Chang Wang, Senior Partnerships Advisor and GameChanger, PhD

**INDIA**

Arjun Bailey, GameChanger

**UK**

Catherine Price, Principal Partnerships Advisor and GameChanger, PhD

**USA**

Kamran Akbar Zadeh, Senior Partnerships Advisor, PhD

Haiyong Cai, GameChanger, PhD

Carolina Rio, GameChanger, PhD

Dharmal Tokhar, GameChanger, PhD

Alicia (Lee) Williams, GameChanger, PhD

**SELECTED PAST GAMECHANGER TEAM MEMBERS**

Russ Conser

Lorena Cuellar

Subhrarajit Dey

Hani Elshahawi

Hans Haringa

Joep Huismans

Marcelo Mofati

Henk Mooiweer

Sophie Postif

Willem Rensink

Malcolm Ross

Wim Schinkel

Richard Smith

Wouter Spiering

James Unterreiner

Chaco van der Sijp

Dave Austgen

Grahame Buss

Russ Cosner

Gary Hamel

Hans Haringa

Matt Kohnen

Peter Lednor

Joe Machado

Wim Manders

Marian Marino

Dave McCormick

Lex Mollinger

Michel Muylle

Leo Roodhart

Michael Ruggier

Jan van Schijndel

Tom Semple

Bob Tait

Saskia van den Muijzenberg

Alexander van der Made

Garo Vaprociyan
Current GameChanger team members

- Brazil
- Netherlands
- USA
- UK
- China
- India
- Houston
- Beijing
- Shanghai