



# MI 2020 SOLUTIONS

3<sup>RD</sup> MI MINISTERIAL 2018

**MISSION INNOVATION**  
Accelerating the Clean Energy Revolution

Highlighting innovative solutions emerging from  
Mission Innovation member investments that have the  
greatest potential to significantly accelerate the delivery  
of clean and affordable energy by 2020



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# FOREWORD

This is an extraordinary moment for international climate collaboration.

The global community has come together to tackle the challenge of man-made climate change and to safeguard our planet for future generations.

The launch of Mission Innovation at the signing of the Paris Climate Agreement was a critical moment in building this global movement. It acknowledged that to decarbonise successfully we need to unlock a huge wave of innovation to fundamentally transform the way we generate and consume energy.

Delivering this transformation requires global partnerships of governments and the private sector, and Mission Innovation is one of the international community's most important vehicles for driving this forward. The UK is delighted to be part of Mission Innovation and to be collaborating with partners around the world in pursuit of our common goal: accelerating the clean energy revolution.

Mission Innovation is also about coming together to celebrate our successes. I am proud to say that since 1990 the UK has reduced emissions by over forty per cent while growing our economy by over seventy per cent, outperforming the rest of the G7. This shows that a low carbon transition goes hand in hand with economic success, proof that clean growth is not only possible, but the best game in town.

This success is underpinned by innovation and I am delighted that at the 3rd Mission Innovation Ministerial in Malmö, Sweden we can shine a light on some of the most significant breakthroughs emerging from other MI members' investments.



This publication highlights some of these success stories from across the globe: the innovative HYBRIT project from Sweden, which is using hydrogen to reduce CO<sub>2</sub> emissions from ironmaking to zero, and India's unique Micro Solar Dome device are just two of the great examples that should inspire us all.

But there is more work for us to do. We must harness the ingenuity and determination of scientists and engineers in universities and industry across the globe, to continue to drive the phenomenal progress made to date, and to succeed in delivering a clean growth revolution.

A handwritten signature in black ink, appearing to read 'Claire Perry'.

**Rt Hon Claire Perry MP**

Minister of State for Energy and Clean Growth, UK Department for Business, Energy and Industrial Strategy

# INNOVATION CHALLENGES

Many of the solutions highlighted in this booklet are contributing to the MI Innovation Challenges. Innovation Challenges are global calls to action aimed at accelerating research, development and demonstration (RD&D) in technology areas where Mission Innovation members believe increased international attention can make a significant impact in our shared fight against climate change.



## 01

### SMART GRIDS

Enabling future grids that are powered by affordable, reliable, decentralised renewable electricity systems



## 02

### OFF-GRID ACCESS

Developing systems that enable off-grid households and communities to access affordable and reliable renewable electricity



## 05

### CONVERTING SUNLIGHT

Discovering affordable ways to convert sunlight into storable solar fuels



## 06

### CLEAN ENERGY MATERIALS

Accelerating the exploration, discovery, and use of new high-performance, low-cost clean energy materials



## 03

### CARBON CAPTURE

Enabling near-zero CO<sub>2</sub> emissions from power plants and carbon intensive industries



## 04

### SUSTAINABLE BIOFUELS

Developing ways to produce, at scale, widely affordable, advanced biofuels for transportation and industrial applications



## 07

### AFFORDABLE HEATING AND COOLING OF BUILDINGS

Making low-carbon heating and cooling affordable for everyone



## 08

### HYDROGEN

Accelerating development of a global hydrogen market by identifying and overcoming key barriers to the production, distribution, storage, and use of hydrogen at gigawatt scale

## SECTION 1

# SMART GRIDS & ENERGY STORAGE

01 UK

Piclo Peer-to-peer Energy Trading Platform

03 EC

BroadBit

02 Australia

Power Ledger

04 Japan

High-power all-solid-state batteries using sulfide superionic conductors

05 Korea

Development of Organic-Inorganic Hybrid Solid Electrolytes for Medium-Large-Sized Semi-Solid Lithium Rechargeable Batteries

08 Korea

Development and Demonstration of an IoT-Based Campus Microgrid at Seoul National University

06 UK

Upside Energy Cloud Based Smart Grid Platform

09 Germany

Die Stadt als Speicher (City as Storage)

07 Germany

Silicon-air battery reaches a duration of over 1000 hours for the first time

10 India

Establishment of pilot project on Grid scale Battery Energy Storage Systems (BESS) of different technologies



## 01

# PICLO PEER-TO-PEER ENERGY TRADING PLATFORM



UK  
NL, IT



## CHALLENGE

Piclo is a revolutionary online energy marketplace that is democratising access to local energy markets. Piclo is lowering barriers for individuals, communities and businesses with solar panels and batteries to trade peer-to-peer and provide balancing services to the local electricity grid. As a result, Piclo is helping solve one of the biggest barriers facing the global energy system today: how to connect more renewables and electric vehicles to the grid without sacrificing cost, efficiency or resilience.

## INNOVATION

Piclo is a match-making service for local energy markets. Just as Airbnb matches customers with the most relevant short-term rentals, Piclo matches customers with the energy produced by their neighbour's solar panels. Piclo also

enables the distribution network operators (DNOs) to participate by placing bids for “demand flexibility” in congested parts of their network and reward customers accordingly. The electricity system is very complex with multiple different actors and needs; Piclo helps simplify and standardise all local trading opportunities whether they are peer-to-peer or directly with the DNO.

## ACTION

Piclo launched in 2015 and was delivered in partnership with electricity supplier Good Energy. It was supported by a £310,000 Energy Entrepreneurs Fund grant from the UK government's Department of Energy and Climate Change. Following a successful regional trial in Cornwall, the service was commercialised and rolled out across the UK. Further international roll-outs followed



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with Edoardo Raffinerie Garrone (ERG) in Italy and Essent in Netherlands.

The second phase of the project was initiated in 2017 through a further £412,000 UK government grant. It involved engaging with local DNOs to unlock the financial benefits of local trading. Piclo is working with these operators to set up flexible capacity contracts for customers with batteries, demand response technology or electric vehicles, so they can manage grid congestion more effectively.

## POTENTIAL

Peer-to-peer marketplace technology removes barriers to a decarbonised and decentralised energy system. It provides a scalable means to connect everything to the grid without compromising on cost, reward or resilience.

This technology has the potential to disrupt centralised and manual market mechanisms designed for traditional energy companies and traders, and replace it with distributed and algorithmic trading mechanisms that unlock direct participation from customers.

The \$2.2 trillion global electricity system is going through a transformation and peer-to-peer trading will underpin all energy exchange in the future: helping propel us towards a fully renewable and decentralised energy economy.

## USEFUL LINKS:

Peer-to-peer network charging white paper: [bit.ly/local-grid-charging](https://bit.ly/local-grid-charging)

## 02 POWER LEDGER



AUSTRALIA



### CHALLENGE

The challenges of integrating distributed energy production and alignment with demand could be addressed through blockchain technology and data analytics.

### INNOVATION

Power Ledger is trialling the use of blockchain-powered distributed energy and water systems. It is gathering academics, infrastructure, and technology experts to assess how cities can use this technology for the integration of renewables.

The trial will involve highly resilient, low-carbon and low-cost systems installed and connected using blockchain technology. A large solar PV plant, rooftop solar PV panels, a precinct-sized battery, an electric vehicle charging station and a precinct water capture and treatment

system will be managed using this technology and data analytics. This will demonstrate how blockchain works with assets that are either co-located or located in different locations, such as an off-site solar farm planned for South Fremantle.

In April 2018, Power Ledger announced a trial partnership with Japan's second largest energy retailer KEPCO. The trial will help renewable energy customers better monetise their investments, and help KEPCO develop virtual energy power plants to better support the demands of the wider energy market.

In May 2018, Power Ledger struck a deal with Northwestern University in Chicago, USA, for the first commercial deployment of its technology platform. This deployment will enable Northwestern to trade the power generated by solar panels on university buildings between facilities without investing in any technology of its own, with Power Ledger collecting a small percentage of each trade.

### ACTION

Power Ledger will create and maintain a blockchain platform which enables electricity metering, big data acquisition, rapid micro transactions and grid management at an unprecedented granular scale.

The Australian Government will provide 2.57 million AUD in direct funding and another 5.68 million AUD will be provided by project partners including Curtin University, Murdoch University, Curtin Institute of Computation, LandCorp, the Commonwealth Scientific and Industrial Research Organisation (CSIRO)/Data 61 and Cisco.

### POTENTIAL

Trading in embedded networks breaks the nexus between renewables generation ownership and energy consumption, meaning value can be derived from an investment in distributed energy resources even when the investor is absent or doesn't consume all the energy they generate.

### USEFUL LINKS:

[powerledger.io](http://powerledger.io)



## 03 BROADBIT



EC  
FI



### CHALLENGE

Compared to the current lithium-ion technology solutions, BroadBit's sodium batteries are significantly more cost-effective, safer and more environmentally friendly have a wider operating temperature range and allow for the 100x scaling needed to supply coming rechargeable battery market.

### INNOVATION

The technology start-up BroadBit has developed new batteries using novel sodium-based chemistries with the support of the EU Framework Programme. BroadBit's batteries are based on metallic sodium and other widely available and plentiful compounds. The main active material is sodium chloride (NaCl), also known as table salt.

This revolutionary sodium-based battery creates the conditions for long-lasting impact on the electric vehicle and renewables sectors and a range of electronic applications.

### ACTION

The project was awarded the Innovation Radar Prize in 2015. BroadBit is now working with Fraunhofer to develop the manufacturing process for a battery capable of higher energy density and at a lower cost than lithium-ion batteries. High costs, safety, long recharging time and limited storage are the main barriers to uptake of e-vehicles. BroadBit offers an innovative solution making electric vehicles price competitive and enabling longer driving range.

In the short term, BroadBit is planning to have the batteries used in drones and electric bikes. The mid term goal is to have the batteries used in electric cars, passenger planes, buses and trucks, while the long term goal is to have applications in grid storage.

### POTENTIAL

The new generation of sodium-based batteries will allow electronics such as laptop computers, sensors and flashlights to be lighter and last longer between charges. These batteries are also safer as non-flammable electrolyte is used to eliminate the risk of fire due to short circuits.

Decarbonising the transport sector is an urgent need and can be achieved by increasing the deployment of e-vehicles. New generations of batteries and innovative energy storage solutions have a huge potential to accelerate the market adoption of electric vehicles and to progress in transitioning towards a clean and sustainable mobility system.

BroadBit is already at an advanced stage of pre-commercialisation and is currently raising funds and negotiating partnerships to finalise R&D and to produce battery components and assembly battery cells.

### USEFUL LINKS:

BroadBit website: [broadbit.com](https://broadbit.com)



# 04 HIGH-POWER ALL-SOLID-STATE BATTERIES USING SULFIDE SUPERIONIC CONDUCTORS



JAPAN



## CHALLENGE

Conventional lithium-ion batteries, which use liquid electrolytes, are reaching the upper limit of energy density and facing challenges concerning limited operation temperature. All-solid-state batteries are a promising solution to creating a high-capacity and highly-powered battery of the future.

## INNOVATION

Toyota Motor Corporation and the Tokyo Institute of Technology have discovered superionic conductors with the world's highest lithium-ion conductivity. They have been applied to develop an all-solid-state battery that has achieved a power density three times as high as the conventional lithium-ion batteries. This is part of a project with the New Energy and Industrial

Technology Development Organization (NEDO), the Japanese government agency which supports innovation in renewable energies and environmental and industrial technologies.

## ACTION

Testing has revealed that the battery is able to operate efficiently at a wide range of temperatures, between -30 and 100 degrees Celsius while a conventional lithium ion cell showed very low discharge capacity at -30 degrees and couldn't operate at 100 degrees.

## POTENTIAL

All-solid-state batteries can be used as electric vehicle batteries or stationary storage to support intermittent renewables, contributing to the reduction of

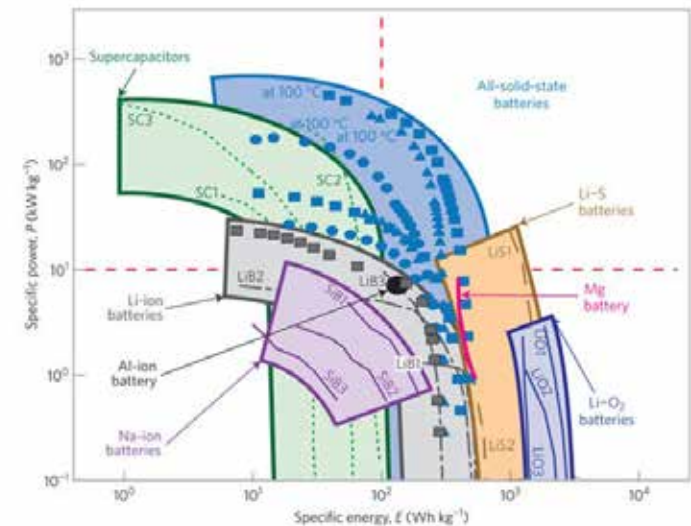
greenhouse gas emissions. They provide an opportunity for a cost-effective means to smoothen the electricity from intermittent renewable energy sources, especially solar. There is still work remaining in order for the technology to become commercially available, but this discovery may pave the way for all-solid-state batteries to become commercialised.

## USEFUL LINKS:

[icef-forum.org/top10/pdf/ICEF2017\\_top10\\_5.pdf](https://icef-forum.org/top10/pdf/ICEF2017_top10_5.pdf)

[nedo.go.jp/english/news/AA5en\\_100060.html](https://nedo.go.jp/english/news/AA5en_100060.html)

[nature.com/articles/nenergy201630?WT.feed\\_name=subjects\\_energy](https://nature.com/articles/nenergy201630?WT.feed_name=subjects_energy)



<ul style="list-style-type: none"> <li>■ <math>\text{Li}_4\text{Ti}_5\text{O}_{12}/\text{LiNbO}_3</math>-coated <math>\text{LiCoO}_2</math></li> <li>● <math>\text{Li}_4\text{Ti}_5\text{O}_{12} + \text{LGPS}/\text{LGPS}/\text{LiNbO}_3</math>-coated <math>\text{LiCoO}_2 + \text{LGPS}</math></li> <li>▲ <math>\text{Li}_4\text{Ti}_5\text{O}_{12} + \text{LSIPSCl}/\text{LSIPSCl}/\text{LiNbO}_3</math>-coated <math>\text{LiCoO}_2 + \text{LSIPSCl}</math></li> <li>■ Graphite + LPS/LPS   LGPS/<math>\text{LiNbO}_3</math>-coated <math>\text{LiCoO}_2 + \text{LGPS}</math></li> <li>SIB1: <math>\text{Na}_3\text{V}_2(\text{PO}_4)_3</math> (NVP) + graphene/NVP + graphene</li> <li>SIB2: NVP + CNT/NVP + CNT</li> <li>SIB3: NVP + activated carbon (AC)/NVP + AC</li> <li>Al-ion battery: Al/graphite</li> <li>Mg battery: <math>\text{Mg}/\text{V}_2\text{O}_5</math></li> </ul>	<ul style="list-style-type: none"> <li>SC1: activated carbon/activated carbon</li> <li>SC2: reduced graphene oxide <math>\text{RuO}_2/\text{RuO}_2</math>-polyaniline</li> <li>SC3: activated carbon/activated carbon</li> <li>LI1: Li/S (graphene + single-walled CNT)</li> <li>LI2: Li/S</li> <li>LI3: Li/S</li> <li>LI4: Li/S</li> <li>LI5: Li/S</li> <li>LI6: Li/S</li> <li>LI7: Li/S</li> <li>LI8: Li/S</li> <li>LI9: Li/S</li> <li>LI10: Li/S</li> <li>LI11: Li/S</li> <li>LI12: Li/S</li> <li>LI13: Li/S</li> <li>LI14: Li/S</li> <li>LI15: Li/S</li> <li>LI16: Li/S</li> <li>LI17: Li/S</li> <li>LI18: Li/S</li> <li>LI19: Li/S</li> <li>LI20: Li/S</li> <li>LI21: Li/S</li> <li>LI22: Li/S</li> <li>LI23: Li/S</li> <li>LI24: Li/S</li> <li>LI25: Li/S</li> <li>LI26: Li/S</li> <li>LI27: Li/S</li> <li>LI28: Li/S</li> <li>LI29: Li/S</li> <li>LI30: Li/S</li> <li>LI31: Li/S</li> <li>LI32: Li/S</li> <li>LI33: Li/S</li> <li>LI34: Li/S</li> <li>LI35: Li/S</li> <li>LI36: Li/S</li> <li>LI37: Li/S</li> <li>LI38: Li/S</li> <li>LI39: Li/S</li> <li>LI40: Li/S</li> <li>LI41: Li/S</li> <li>LI42: Li/S</li> <li>LI43: Li/S</li> <li>LI44: Li/S</li> <li>LI45: Li/S</li> <li>LI46: Li/S</li> <li>LI47: Li/S</li> <li>LI48: Li/S</li> <li>LI49: Li/S</li> <li>LI50: Li/S</li> <li>LI51: Li/S</li> <li>LI52: Li/S</li> <li>LI53: Li/S</li> <li>LI54: Li/S</li> <li>LI55: Li/S</li> <li>LI56: Li/S</li> <li>LI57: Li/S</li> <li>LI58: Li/S</li> <li>LI59: Li/S</li> <li>LI60: Li/S</li> <li>LI61: Li/S</li> <li>LI62: Li/S</li> <li>LI63: Li/S</li> <li>LI64: Li/S</li> <li>LI65: Li/S</li> <li>LI66: Li/S</li> <li>LI67: Li/S</li> <li>LI68: Li/S</li> <li>LI69: Li/S</li> <li>LI70: Li/S</li> <li>LI71: Li/S</li> <li>LI72: Li/S</li> <li>LI73: Li/S</li> <li>LI74: Li/S</li> <li>LI75: Li/S</li> <li>LI76: Li/S</li> <li>LI77: Li/S</li> <li>LI78: Li/S</li> <li>LI79: Li/S</li> <li>LI80: Li/S</li> <li>LI81: Li/S</li> <li>LI82: Li/S</li> <li>LI83: Li/S</li> <li>LI84: Li/S</li> <li>LI85: Li/S</li> <li>LI86: Li/S</li> <li>LI87: Li/S</li> <li>LI88: Li/S</li> <li>LI89: Li/S</li> <li>LI90: Li/S</li> <li>LI91: Li/S</li> <li>LI92: Li/S</li> <li>LI93: Li/S</li> <li>LI94: Li/S</li> <li>LI95: Li/S</li> <li>LI96: Li/S</li> <li>LI97: Li/S</li> <li>LI98: Li/S</li> <li>LI99: Li/S</li> <li>LI100: Li/S</li> </ul>	<ul style="list-style-type: none"> <li>LIB1: graphite/<math>\text{LiCoO}_2</math></li> <li>LIB2: <math>\text{Li}/\text{LiFePO}_4</math></li> <li>LIB3: <math>\text{Li}_4\text{Ti}_5\text{O}_{12}/\text{LiNi}_{0.5}\text{Mn}_{0.5}\text{O}_2</math></li> <li>LI01: <math>\text{Li}/\text{O}_2</math> (graphene)</li> <li>LI02: <math>\text{Li}/\text{O}_2</math> (carbon nanofibres)</li> <li>LI03: <math>\text{Li}/\text{O}_2</math> (carbon nanotubes (CNT))</li> </ul>
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05

## DEVELOPMENT OF ORGANIC-INORGANIC HYBRID SOLID ELECTROLYTES FOR MEDIUM-LARGE-SIZED SEMI-SOLID LITHIUM RECHARGEABLE BATTERIES



KOREA



### CHALLENGE

The lithium-ion batteries (LIBs) that are currently available use flammable organic liquid electrolytes, posing a potential fire and explosion hazard.

### INNOVATION

This project sought to replace liquid electrolytes with safer solid electrolytes in lithium-ion batteries.

This required the team to overcome low ionic conductivity and deterioration of performance characteristics due to high resistance in the degradation of contact with the anode and cathode that occurs during cell manufacturing.

A soft, half solid-state electrolyte material was designed that can be directly coated onto

electrodes by mixing in a fluoropolymer, a ceramic solid electrolyte that features enhanced conductivity, with a small amount of liquid electrolyte, before making the mixture into a film.

The electric energy storage capacity of the new battery is about 95% of the capacity of the conventional LIB but with enhanced safety.

### ACTION

The ionic conductivity of a LLZO ceramic electrolyte was improved to as much as a fifth of the level found in conventional liquid electrolytes and separators. By applying this technology, an organic-inorganic hybrid solid electrolyte with enhanced ionic movement capability was designed and developed that is more than 50% better than the level found in conventional liquid electrolytes and separators.

### POTENTIAL

Developing a lithium secondary battery that features high-safety solid electrolytes, which performs as well as organic liquid electrolytes, will enable LIB use in electric vehicles and energy storage systems, while ensuring public safety.

## 06

## UPSIDE ENERGY CLOUD BASED SMART GRID PLATFORM

UNITED  
KINGDOM

### CHALLENGE

The deployment of renewable energy technologies means that power increasingly comes from multiple, intermittent sources. This makes it challenging for the network operators to balance supply with demand. Inefficiencies in energy supply lead to volatile energy prices for customers and higher greenhouse gas emissions.

### INNOVATION

A UK company, Upside Energy, has developed a cloud based smart-grid technology that eases peak-time pressure by connecting a range of common devices that store energy. Upside Energy's platform aggregates the energy stored in everyday connected devices, such as batteries and hot water tanks, to create a virtual energy store that can be drawn on as needed. Devices in homes and small businesses can then be quickly switched on or off at

the right times, communicating through the Internet of Things.

### ACTION

Upside Energy developed a pilot through a collaborative project, with funding from Innovate UK, and partners including Sharp Laboratories of Europe, Select Innovations (enLight), Tempus Energy and the University of Manchester.

In 2017 the UK government and Innovate UK awarded £2.5m to a consortium led by Upside Energy, with Powervault, Mixergy, Eden Project and Oxford University, for the Pete (Power, energy, technology, efficiency) Project. The project is developing an integrated system using home battery systems, intelligent hot water tanks, and cloud-based Demand Side Response Services to provide a balancing service to the power industry.



© Upside Energy Ltd

When there is too much power, the batteries and hot water tanks will charge/heat; when there is too little, the batteries can provide power to the grid and the hot water tanks will stop heating. The project expects to install 500 intelligent hot water tanks and 100 lithium-ion batteries in households across England.

### POTENTIAL

Through the aggregation of domestic storage devices, Upside Energy estimates that the Pete Project will be able to offer 1MW of power to the grid. This type of integrated, low-cost

system, in a physical and digital network, would provide the flexibility needed to efficiently integrate renewable energy supplies into the grid, helping network operators to balance electricity supply and demand. Customers could also save on their energy costs, avoiding using electricity during peak times.

### USEFUL LINKS:

Pete (Power, energy, technology, efficiency) website: [peteproject.com](http://peteproject.com)

07

## SILICON-AIR BATTERY REACHES A DURATION OF OVER 1000 HOURS FOR THE FIRST TIME



GERMANY



The development of energy storage capabilities is crucial for the integration of renewables into the power grid or in off-grid areas. Silicon-air batteries have the potential to outperform current technology. They have a much higher energy density, are smaller and lighter than today's lithium-ion batteries, as well as being environmentally friendly and insensitive to external influences. Silicon is also relatively low-cost and almost indefinitely available.

On the downside, silicon-air batteries have a relatively short runtime. The AISiBat project is seeking to overcome this. Having discovered this weakness was caused by the consumption of the electrolyte, a pump system was developed to refill the electrolyte fluid as required, achieving a runtime of over 1,100 hours. Ways to keep the battery running without refilling the electrolyte are now being explored.

08

## DEVELOPMENT AND DEMONSTRATION OF AN IOT-BASED CAMPUS MICROGRID AT SEOUL NATIONAL UNIVERSITY

Seoul National University has developed an Internet of Things-based campus microgrid. It uses various resources including renewable energy to optimise power consumption and save energy.

The microgrid analyses the characteristics of each load to develop precise campus models. Supplying surplus power from one microgrid to another microgrid manages the power consumption of the entire grid system, especially during peak demand.

At the same time, technologies for effective load management and economic grid management can be developed.

In the future, demonstration of microgrids needs to be conducted in a wide variety of conditions so that the economics and reliability of the campus microgrids model can be thoroughly verified.



KOREA



## 09 DIE STADT ALS SPEICHER (CITY AS STORAGE)



GERMANY



Virtual energy storage has been successfully demonstrated across two German cities, Herten and Wunsiedel. As part of a project, several small and medium-size prosumers and producers were bundled and participated in the energy markets. Both private and municipal plants formed part of the model, connecting households, electric vehicles and a public swimming pool, as great untapped storage capability lies in existing infrastructure.

The virtual storage was adapted to market demand and participated in the spot market. This system could have a role to play in the rapidly changing energy supply sector with owners of CHP plants, heat pumps, night storage heating or PV-batteries motivated to promote clean energy systems.

## 10 ESTABLISHMENT OF PILOT PROJECT ON GRID SCALE BATTERY ENERGY STORAGE SYSTEMS (BESS) OF DIFFERENT TECHNOLOGIES



Recognising the increasing importance of Battery Energy Storage Systems in India, POWERGRID has established a pioneering pilot project demonstrating two battery storage system technologies (Advanced Lead Acid & Lithium Iron Phosphate) with battery management at Puducherry.

The systems, of 250 kWh and 500 kW in size, are installed in one location and connected with the same feeder to provide identical grid conditions. They can therefore be compared on

various parameters like overall sizing, efficiency, auxiliary power consumption, operational difficulties and maintenance requirements. While the units are relatively small for large grid storage management, this could be advantageous in the future as grids become less centralised, as well as for off-grid locations.

The inclusion of multiple storage technologies along with grid management software will provide valuable data to enable grid balancing and facilitate wider deployment of renewables.



INDIA





## SECTION 2

# RENEWABLE ENERGY

## 01 Canada

Fundy Ocean Research Center  
for Energy (FORCE)

## 02 India

Ocean based floating islands  
capable of generating sustainable  
solar power for remote  
coastal locations

## 03 Korea

Development of fabrication of  
a highly efficient and large-area  
perovskite photovoltaic module  
using a printing process

## 04 India

Micro Solar Dome (MSD)  
- Surya Jyoti

## 05 Norway

Dynatec Reactor -  
Spinning the solar revolution

## 06 Canada

Glencore's Raglan mine:  
A wind turbine success

## 07 China

Qinghai achieves zero emissions  
for 168 hours non-stop

## 08 Sweden

Wave power inspired  
by the heart

## 09 Chile

Atacama Modules,  
Systems & Technology Center  
(AtaMoSTeC)

## 10 Japan

Breakthrough's in solar  
conversion efficiencies

01

## FUNDY OCEAN RESEARCH CENTER FOR ENERGY



CANADA

### CHALLENGE

Most of Nova Scotia's electricity is still generated by burning imported fossil fuels. These emissions contribute to rising sea levels, storm surges, extreme weather events, ocean acidification and population-level shifts in the marine ecosystem on which Atlantic Canada is particularly dependent.

### INNOVATION

Tidal stream energy holds great promise for producing low-carbon electricity and the Fundy Ocean Research Centre for Energy (FORCE) is in an ideal geographic setting to explore this promise. Approximately 160 billion tonnes of water flows through Canada's Bay of Fundy each tide, equal to four times the estimated flow of all the freshwater rivers and streams in the world combined.

Unlike wind and solar, tidal energy offers a significant strategic advantage: it is predictable, allowing electricity utilities to reliably predict tidal resource levels years in advance. For tidal stream technology to move to large-scale development, the public and regulators must be satisfied that any development activity is safe, sustainable and viable. FORCE's environmental effects monitoring program is designed to better understand the natural environment of the Minas Passage and the potential effects of turbines as related to marine life and mammals, marine noise, benthic habitat and other variables.

Used with permission from FORCE



### ACTION

FORCE has successfully fabricated and installed an 11 km subsea power cable network – the largest transmission capacity for tidal stream in the world. It has also welcomed the first 2-megawatt tidal stream turbine connected to the North American grid – Cape Sharp Tidal's OpenHydro turbine.

The Fundy Advanced Sensor Technology programme enhances environmental data capture, site characterization capability and marine operation methodologies in extreme high flow environments. Collecting this data will help address any environmental concerns related to this breakthrough technology.

### POTENTIAL

The world's oceans contain vast amounts of energy, with the potential to meet 10% of global electricity demand. Estimates suggest Canada's total marine renewable energy technology potential is approximately 80,000 MW, with many high-energy sites. To explore these opportunities, the industry must continue to refine tidal stream technology, lowering technical and financial risk, as well as monitoring tidal devices and mitigating any potential effects.

### USEFUL LINKS:

[fundyforce.ca](http://fundyforce.ca)

## 02 OCEAN BASED FLOATING ISLANDS CAPABLE OF GENERATING SUSTAINABLE SOLAR POWER FOR REMOTE COASTAL LOCATIONS



INDIA



### CHALLENGE

There are several coastal and island communities in India and around the world with intermittent or no access to electricity. While solar energy can help electrify these locations, acquiring large tracts of land on which to base a plant in these regions is problematic and expensive, especially considering the growing population. However, these coastal regions do have one resource in abundance – the sea. Floating solar power installations on lakes has been gaining popularity over the last few years, but there has been no system capable of laying a solar power plant over the ocean.

### INNOVATION

PSea6 Energy has created eco-friendly floating islands called Dweeps, which are modular, scalable and designed to survive the harsh marine environment. The Dweeps make use of the plentiful ocean surface to provide a novel way of deploying existing technology to generate solar energy. This power can also be used to generate fresh water through desalination plants, generating the maximum amount of fresh water in the hot summers when the sun is most plentiful and when water is most needed.

The Dweeps are able to withstand poor weather conditions by making use of a concept found ubiquitously in nature – tensegrity – to flex to the changing surface of the ocean rather than resisting it. Using a combination of pre-stressed cables and struts, it is able to mimic the flexibility seen in the human body with bones and tendons. An added advantage of this system is that the flexible nature allows the structure to absorb the wave energy, acting as a natural breakwater to reduce coastal erosion by waves.

### ACTION

A prototype unit has been installed off the coast of Tamil Nadu, where the results have been extremely promising.

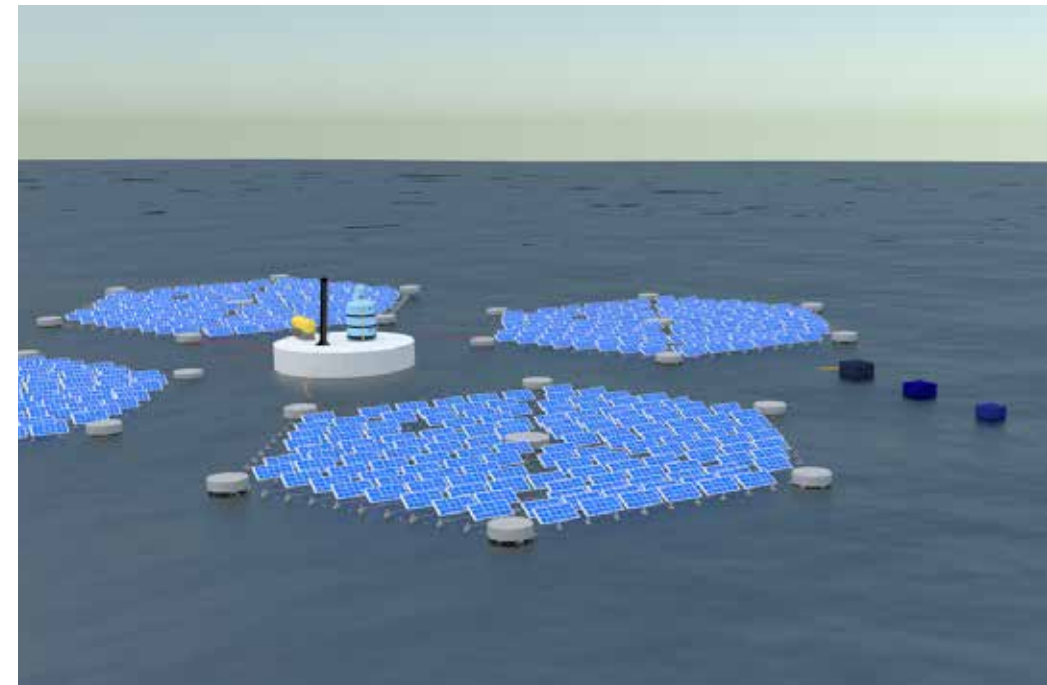
### POTENTIAL

As a next step, there are plans to deploy a system capable of generating at least 100 kW of power to demonstrate the potential of the system. The size of the islands can vary based on their application, ranging from a few square metres to several hectares.

These solar powered islands can also serve as autonomous research stations in the middle of the sea, capable of collecting valuable oceanographic data throughout the year.

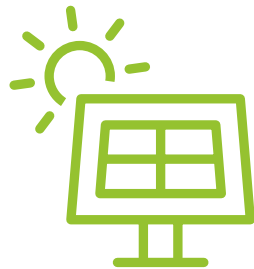
### USEFUL LINKS:

[dweep.in](http://dweep.in)



## 03

## DEVELOPMENT OF FABRICATION OF A HIGHLY EFFICIENT AND LARGE-AREA PEROVSKITE PHOTOVOLTAIC MODULE USING A PRINTING PROCESS



KOREA

### CHALLENGE

The efficiency of perovskite solar cells, which are price-competitive and offer flexibility, translucency, and lightness, needs to be improved so they can compete with silicon solar cells. Unlike conventional silicon solar cells, perovskite solar cells can be used in the emerging window-type and portable solar cell market.



### INNOVATION

A research team at the Korea Research Institute of Chemical Technology has produced large modules through a printing process. It has successfully fabricated high efficiency modules with an efficiency level of over 15% (based on active areas) that exhibit heat stability for 1,000 hours at 85°C, as well as excellent

performance after 50 heat cycles (-45°C – 85°C). This makes these cells longer lasting and more efficient than previous generations.

### ACTION

The project has broken the world record for perovskite solar cell efficiency five times and most recently achieved an efficiency level of 22.7% on a unit cell in October 2017. This efficiency level is on par with those of conventional silicon solar cells and higher than the 22.1% and 22.6% maximum efficiency levels of cadmium telluride (CdTe) in thin film solar cells and copper indium gallium selenide (CIGS) solar cells.

A 20.9% efficiency level was also confirmed on a unit cell created as part of the effort to secure enlargement technology.

The team is currently working on optimising the module production process to minimise areas of loss and make them longer lasting.

### POTENTIAL

The research team applied high-efficiency technologies in producing large modules through a printing process. It is expected that applying roll-to-roll processing, a production method that allows for rapid mass production at low cost, will revolutionise the dissemination of solar cells in the future.

## 04 MICRO SOLAR DOME (MSD) - SURYA JYOTI



INDIA



### CHALLENGE

The Surya Jyoti Micro Solar Dome is a unique device designed to tackle the problem of access to lighting for remote and underdeveloped communities. There are currently millions of off-grid households in rural areas or households in urban areas without reliable electricity.

### INNOVATION

The device is low cost, simple to use and eco-friendly. It can work for up to 17 hours giving an illumination equivalent of a 60 watt incandescent lamp, with a lifespan of up to 20 years for the dome structure.

The device has a transparent semi-spherical upper dome made of acrylic material which captures the sunlight.

The light passes through a sun-tube, which has a thin layer of highly reflective coating on the inner wall of the passage.

The latest model operates in three modes: daylight without any electricity, night time with solar PV and night time with conventional grid after 17 hours of operation.

### ACTION

4,000 Micro Solar Domes have been installed in impoverished parts of Delhi, Mumbai, Kolkata and Bengaluru. They have been tested and developed with support from the Department of Science and Technology's Clean Energy Research Initiative. 54 technicians from 14 states have been trained in the manufacturing process.

### POTENTIAL

The installation of Micro Solar Domes could lead to an emission reduction of 12.5 million tonnes of CO<sub>2</sub>. The Department of Science and Technology is providing training and licenses to start-up and self-help groups to make the lamps. Attempts are also being made to integrate the device for subsidy in rural and urban housing schemes,

MP Local Area Development Schemes, and Corporate Social Responsibility activities of public sector enterprises.

### USEFUL LINKS:

[youtu.be/irpJvLqh6a0](https://youtu.be/irpJvLqh6a0)





## 05

## DYNATEC REACTOR - SPINNING THE SOLAR REVOLUTION



© Dynatec Engineering AS

### CHALLENGE

Producing solar panels requires the purification of silicon, which is a slow and energy intensive process. Currently production of solar grade silicon is primarily carried out using the Siemens reactor. Silicon rods are heated to between 800 and 1,100 degrees Celsius, and a silicon containing gas is injected and thermally decomposed releasing silicon that is deposited onto the rods. To prevent silicon growth on the walls, these are kept at below 200 degrees Celsius.

### INNOVATION

Dynatec has produced a centrifugal reactor which lowers the energy intensity of refining silicon in solar panel production by 90% compared to the decomposition reactors currently in use.

Instead of keeping hot elements inside a cool chamber, with Dynatec's reactor the deposition takes place on the walls. The whole reactor is also set into rotation and built as a centrifuge. By inverting the process, it is possible to grow the silicon without maintaining large temperature differences.

### ACTION

With support from the Research Council of Norway, Dynatec has built two demonstration reactors. The energy consumption of a decomposition reactor is currently about 70 kwh/kg, while the new centrifugal reactor has demonstrated production of first grade silicon at less than 5kwh/kg.

### POTENTIAL

Having already built two successful demonstration reactors the company is now building a full-scale industrial reactor in cooperation with a customer.

Dynatec has also founded two spin off companies where the centrifugal reactor is to be used differently and refitted to make silicon nano-particles of similar shape and size for both battery and medical applications.



NORWAY



### USEFUL LINKS:

[sciencenordic.com/speedy-production-silicon-solar-cells](https://sciencenordic.com/speedy-production-silicon-solar-cells)

## 06

## GLENCORE'S RAGLAN MINE: A WIND TURBINE SUCCESS



CANADA



### CHALLENGE

Wind power in Northern Canada has had limited success. Conditions in the area can be challenging for rotating machines and the variable nature of wind makes it difficult to integrate with diesel power plants. As a result, one of the best wind resource regions is largely unexploited.

### INNOVATION

Glencore's Raglan mine demonstrates that these obstacles can be overcome. With \$7.8 million in funding from the Government of Canada, Tugliq Energy Co is reaching new heights in harvesting wind energy at an industrial scale through its Glencore Raglan Mine Renewable Electricity Smart-Grid Pilot Demonstration project.

Tugliq Energy used a flywheel – a mechanical device that stores energy created by a spinning

wheel – to successfully manage wind power dips and drops without tripping the security mechanisms of the Raglan diesel micro-grid.

The project deployed an Arctic-rated 3 MW ENERCON E-82 E4 wind turbine generator. A spider-like steel foundation was engineered for the turbine in order to alleviate potential problems associated with melting of ice lenses in Raglan's permafrost, should global warming accelerate over the 20-year lifecycle of the turbine. It is also equipped with a cold winter package that includes blade heating by air convection.

A Hatch Microgrid Controller (HμGrid) monitors demand for wind power, and variations in supply, to produce a smooth power output that enables high (50%) wind power penetration in a cost-effective way.



© Tugliq Energy Co.

### ACTION

The wind turbine has successfully operated for three consecutive years, delivering 20.1 GWh of renewable energy to the Glencore RAGLAN Mine, abating 5.1 million litres of diesel and 14,424 tons of CO<sub>2</sub> equivalent in greenhouse gas emissions.

Through 2015 and 2016 the wind turbine achieved a record-setting 97.6% uptime average (among the world's best in 3MW class). The wind and storage system will be monitored for a minimum of five years.

### POTENTIAL

Acting as a flagship site for future industrial-scale wind power development

in the region, Glencore's Raglan mine successfully demonstrates that harvesting wind energy can improve long-term economic stability and energy security, and reduce greenhouse gas emissions and the environmental footprint of Canada's northern mining operations and communities. The company is currently installing another wind turbine, with even more storage.

### USEFUL LINKS:

[tugliq.com/en/wind.html](http://tugliq.com/en/wind.html)

[tugliq.com/press/Tugliq%20Public%20Report%20EN.pdf](http://tugliq.com/press/Tugliq%20Public%20Report%20EN.pdf)

07

## QINGHAI ACHIEVES ZERO EMISSIONS FOR 168 HOURS NON-STOP



CHINA



The State Grid Corporation of China achieved 100% clean energy supply to the Qinghai province for a record-breaking 168 hours non-stop. During this period it relied on the coordinated use of various power sources including wind, hydro and solar and control and rolling closed-loop dispatching to achieve zero emissions moving them closer to achieving towns run on 100% renewable energies.

The Qinghai Yellow River Hydropower Company developed a new model of water and solar complementarity using photovoltaic power generation of plants such as the Gonghe Photovoltaic Industrial Park, and upstream hydroelectric power stations, such as Longyangxia,

08

## WAVE POWER INSPIRED BY THE HEART

CorPower Ocean AB has developed a compact high-efficiency Wave Energy Converter, with a design inspired by the pumping principles of the human heart. The design enables the converter to oscillate in resonance with the incoming waves, strongly amplifying their motion and power capture. This enables a significant reduction in the required buoy size compared to conventional wave energy converters, and improves survivability due to the ability to detune the device in storms.

Public sector support has been provided at several stages including through the EU Horizon 2020 funded project WaveBoost. A half-scale unit is currently being tested on the coast of Scotland.



SWEDEN

USEFUL LINKS:  
[corpowerocean.com](http://corpowerocean.com)

## 09 ATACAMA MODULES, SYSTEMS & TECHNOLOGY CENTER (ATAMOSTEC)



CHILE  
DE,FR



The Atacama Desert, in the north of Chile has the highest levels of solar irradiation in the world. However, this region faces a number of specific challenges which effects the scale-up of the use of photovoltaics. This include high levels of ultra violet radiation, temperature over the solar panels of up to 70°C degrees, dust, water scarcity and a high seismic activity. In 2016 the Chilean Government funded a consortium involving several

Chilean Universities, Fraunhofer (Germany), the National Solar Energy Institute (France) and 19 companies to carry out applied research and development. The consortium aims to adapt and develop appropriate photovoltaic technologies for desert zone conditions and high solar irradiation, in terms of durability and expected yields, with the target to reduce the energy cost level by the year 2025.

## 10 BREAKTHROUGH'S IN SOLAR CONVERSION EFFICIENCIES

Japan aims to reduce the cost of solar power generation to \$0.06 per kWh by 2030 through its innovation programme. As part of the programme, several breakthroughs have been achieved in this technology area.

Sharp Corporation has achieved one of the world's highest conversion efficiency for a solar module (31.17% for 968 cm<sup>2</sup>). A triple-junction compound was used to capture a wider range of the spectrum of sunlight.

Kaneka Corporation has also achieved the world's highest conversion efficiency in a crystalline silicon solar cell of practical size (26.33% for 180 cm<sup>2</sup>). By combining heterojunction technology, low resistance electrode technology, and a back-contact structure achieved capture of more solar energy.



JAPAN



## SECTION 3

# FUELS

01 EC

Itaka

02 Germany

Energiepark Mainz

03 China

Biomass aqueous  
reforming to produce  
alternative aviation fuels

04 India

The DBT-ICT  
2G-Ethanol Technology

05 China

CO<sub>2</sub> Hydrogenation with  
renewable H<sub>2</sub> to produce  
chemical fuels

06 Sweden

C Green - 21st century  
superefficient sludge  
disposal

07 EC

European Innovation  
Council Prize - Fuel from the  
Sun: Artificial photosynthesis

08 Germany

Synlight - The World's  
largest artificial sun



# 01 ITAKA



EC  
ES, FR, RO,  
CH, UK, FI,  
IT, NL, BR



## CHALLENGE

In order to reduce carbon emissions, biofuels are considered the only available option to decarbonise the air transport sector in the near future, due to this sector's dependence on liquid fuels and its rapid rate of growth expecting to exceed 10% of the global GHG emissions in 2050. As an aircraft lifetime is over 30 years, drop-in decarbonised solutions are needed for existing fleets.

## INNOVATION

Project ITAKA has supported the development of aviation biofuels in an economic and sustainable manner, and at the same time improved the readiness of existing technologies and infrastructures. ITAKA is an innovative project funded by the EU's Seventh Framework Programme for Research and Technological Development. The project brought together the main actors along the

value chain, from feedstock and fuel producers to fuel distributors and users such as airports and airport managers and airlines.

The breakthrough project has revealed total compatibility and better energy efficiency for airplane engines, testing biojet fuel in existing airport fuel systems and in a series of long-haul and short-haul flights. At the same time, the project has proved that flying on advanced biofuel is safe, and successfully demonstrated that biojet fuel can be used as a green alternative to fossil fuels in the same aeroplane engine and in the same airport structure.

## ACTION

The environmental impact as an indirect outcome of this project (if the project would be applied to 2.1 million hectares left fallow (no crop) in Europe yearly) is only estimated at around 700,000 tons per year of sustainable biojet fuel (around 1% of EU jet fuel consumption) that could save 1.7 Mt CO<sub>2</sub>eq and create around 100,000 jobs.

The project confirmed very positive environmental impact of GHG savings more than 70% on a life cycle basis of the value chain

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and negligible particle shoot emissions due to the fuel source and handling while engine tests proved more than 30% improvement for the local air quality at airports.

For the market out-reach, the project established supply of biojet fuel through conventional logistics channels and illustrated that the declaration of its use is possible under the Emissions Trading Scheme and the Renewable Energy Directive policies.

## POTENTIAL

Since January 2017, biojet fuel produced in the EU was used for the first time worldwide by more than 6 million passengers in around 60,000 flights.

Recognising that scaling up is critical for bringing innovation to the market, a new project (BIO4A) is supported under Horizon 2020 ensuring industry commitment as part of retrofitting Total's refinery in La Méde France which has renewable fuel capacity of several hundred thousand tonnes per year. The production of 5,000- 10,000 thousand tonnes of biojet fuel within the project is supported also through take off agreements for its purchase by KLM and Air France.

## USEFUL LINKS:

[ec.europa.eu/research/infocentre/article\\_en.cfm?artid=44616](https://ec.europa.eu/research/infocentre/article_en.cfm?artid=44616)

## 02 ENERGIEPARK MAINZ (ENERGY FARM IN MAINZ)



GERMANY



### CHALLENGE

Electricity from renewable sources accounts for approximately one third of the power supplied in Germany. The government aims to raise this to 65% by 2030 and to 80% by 2050. The challenge is that wind and solar radiation are intermittent, so storage capabilities are needed. Further, “sector integration” is vital to also decarbonise other sectors, and energy needs to be transported from the sources to the users.

### INNOVATION

The energy carrier hydrogen is the key element to solving these three challenges.

It can be made by from water and renewable power by “electrolysis”, and it can simply be stored, transported and used – not only as a fuel for vehicles

and to make heat and power, but also as a building block for green industry. E.g. in a fuel cell, hydrogen can be converted directly and highly efficiently into electric power, allowing zero emission mobility on roads, railway and water.

Energiepark Mainz, operated by Stadtwerke Mainz and Linde and co-financed by the Federal Ministry of Economic Affairs and Energy in Germany, was launched to investigate and demonstrate large-scale hydrogen production from renewable energy for a variety of use cases. A 6 MW Proton Exchange Membrane (PEM) electrolysis made by Siemens has been brought to full-scale proof-of-concept at Energiepark. It is connected to a wind farm in the direct vicinity, which is sufficient to compensate for capacity shortages in the distribution grid.

### ACTION

Energiepark Mainz vividly demonstrates the potential of hydrogen as an energy vector. The electrolyzers can be switched on and off or ramped up and down within seconds to take up excess energy and stabilise the grid.

The hydrogen produced can be stored and either converted back to electricity later, or used for other purposes like mobility, heating or as an industrial feedstock.

The Energiepark constitutes the world’s first multi-Megawatt PEM electrolyser installation; previously the technology had been used at much smaller scale, e.g. at hydrogen fuelling stations. In May 2018 it is still the world’s largest system by peak capacity.

### POTENTIAL

In the future similar plants could work in various locations to stabilise the grid and

augment the energy transition by sector integration. To achieve this the concept needs to reach economic viability; for that, energy regulation and political support should be tailored accordingly. In addition, the production, storage and distribution of hydrogen should be standardised, electrolyzers capabilities further improved and extended hydrogen applications actively developed and pushed.

### USEFUL LINKS:

[energiepark-mainz.de](https://energiepark-mainz.de)



By Energiepark Mainz

## 03

## BIOMASS AQUEOUS REFORMING TO PRODUCE ALTERNATIVE AVIATION FUELS



CHINA



### CHALLENGE

The International Air Transport Association has calculated that alternative jet fuel can reduce carbon dioxide emissions by 50 per cent. Sustainable aviation fuel can be created by aqueous phase reforming technology. This is the most viable solution particularly for developing economies that cannot afford to buy newer generation aircraft.

### INNOVATION

To produce sustainable aviation fuel from lignocellulose, an innovative technology had been developed by the Guangzhou Institute of Energy Conversion and Chinese Academy of Science. The alternative aviation fuels is produced from corn or sorghum stalks using a series of catalytic conversion processes.

The key component of the processes is to effectively combine the traditional hydrolysis technology and new hydrothermal depolymerisation technology.

Another advantage of the technology is to simplify the utilisation process of biomass, resolving the problem associated with separation of biomass platform compounds and enrichment of energy intensity.

This new technology is the only method that can convert whole biomass to aviation fuels by an aqueous reforming process. It is more efficient and environmentally friendly than to pathways.

### ACTION

The demonstration project has an anticipated production volume of 1,000 tons of aviation fuel per year. The project will process 12,000 tons of corn stalks per year generating 2.4 million yuan for local farmers, providing value-added utilisation of corn stalks.

### POTENTIAL

Governments could work together to make the most of their resources, for example agriculture and industries like sugar refining could convert their waste or by-products into aviation fuels. The research would also benefit from the support of leading airlines, especially in the areas of emission control and creating a new aviation fuel standard.





# 04

## THE DBT-ICT 2G-ETHANOL TECHNOLOGY



### CHALLENGE

80% of India's 150GW energy requirement is met from imported petro-crude. The country is mandated to blend 5% green biofuels into gasoline and diesel by its National Biofuel Policy (2009). However, India today has no diesel substitute of note while barely managing to achieve circa 3.3% bioethanol blending into gasoline. The use of surplus agricultural residues and other renewable sources of energy could lead to partial or full replacement of petro-derived fuels, ensuring a sustainable energy supply for the country.

### INNOVATION

2G Ethanol technology developed by the DBT-ICT Centre, which produces ethanol from agricultural residue feedstock, has the potential to significantly reduce emissions from the transportation and agricultural sectors in India. It also promises added social, economic and environmental benefit such as revenue for farmers, job creation and less agricultural waste.

The continuous processing technology converts biomass feed to alcohol within 24 hours. Competing technologies from the developed economies can

take anywhere from 3 to 5 days. The plant design also has unique features such as advanced reactor design and separation technologies with rapid reaction regime operations.

### ACTION

The technology was proven at 1 ton/day scale during Phase 1 at the India Glycols site. This was later scaled up to a demonstration scale plant of 750,000 litres annual alcohol capacity.

### POTENTIAL

The DBT-ICT Centre, along with industrial partners, Bharat Petroleum Corporation and Hindustan Petroleum Corporation, are already on the way to design and scale-up the technology to 400 ton/day scale. Larsen & Toubro Hydrocarbon Engineering has signed on as the engineering partner for the commercialisation of the technology.

The aim is to demonstrate that the technology is cost-effective and easy to scale up. The impact of significant usage would be a net reduction in the import of crude oil and of carbon emissions.

The conversion of agri-waste to ethanol would help achieve the proposed 20% target of ethanol blending with biodiesel.

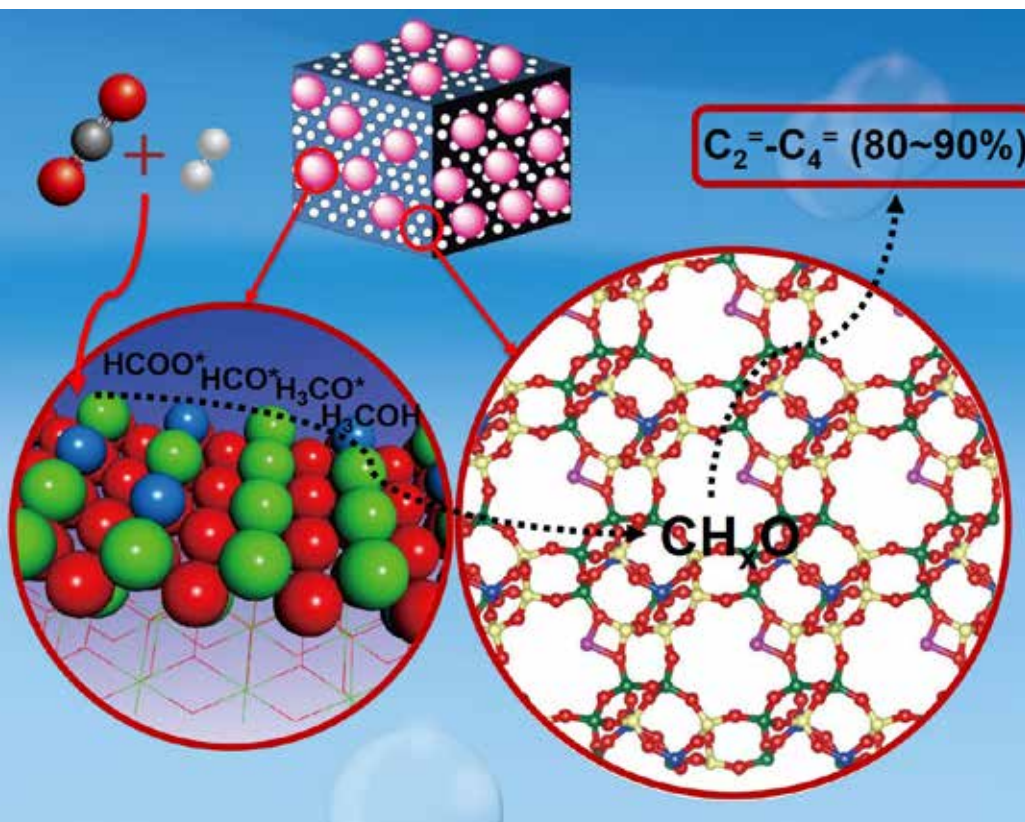


INDIA



# 05

## CO<sub>2</sub> HYDROGENATION WITH RENEWABLE H<sub>2</sub> TO PRODUCE CHEMICAL FUELS



### CHALLENGE

The direct production of liquid fuels from carbon dioxide hydrogenation has attracted enormous interest for its significant role in mitigating emissions and reducing dependence on fossil fuels. That is provided that the hydrogen (H<sub>2</sub>) is from renewable sources, such as photocatalytic or photoelectrochemical splitting of water.

### INNOVATION

In 2017, scientists in China developed a variety of catalysts to convert carbon dioxide (CO<sub>2</sub>) to methanol, gasoline hydrocarbons, and even lower olefins with high selectivity and conversion efficiency under relatively mild experimental conditions.

Development of these CO<sub>2</sub> hydrogenation catalysts makes it possible to reduce CO<sub>2</sub> emissions and convert CO<sub>2</sub> to value added chemicals, such as fuels and chemical feedstocks in large scale.

Dalian Institute of Chemical Physics (DICP) has developed a ZnO-ZrO<sub>2</sub> solid solution catalyst, which can achieve CO<sub>2</sub> to methanol selectivity of 86-91% with conversion efficiency of more than 10% under reaction conditions of 5.0 MPa, 24,000 ml/ (g hour), H<sub>2</sub>/CO<sub>2</sub> = 3:1 to 4:1, 320°

to 315°C. The catalyst showed high stability for at least 500 hours on stream and resistance to sintering at higher temperatures.

The DICP team also achieved selective conversion of CO<sub>2</sub> to lower olefins through CO<sub>2</sub> hydrogenation over a ZnZrO/SAPO tandem catalyst. The selectivity for lower olefins was as high as 80-90%. Furthermore, this catalyst is stable toward the thermal and sulfur treatments.

DICP has also reported a highly efficient, stable and multifunctional Na-Fe<sub>3</sub>O<sub>4</sub>/HZSM-5 catalyst. It can directly convert CO<sub>2</sub> to gasoline-range (C<sub>5</sub>-C<sub>11</sub>) hydrocarbons with selectivity up to 78% of all hydrocarbons, while only 4% methane at a CO<sub>2</sub> conversion of 22% and remarkable stability for 1,000 hours on stream.

### ACTION

The technologies attracted extensive attention from the industrial sector and now the process is going through a pilot phase to scale up the experimental solutions in China.

### POTENTIAL

This breakthrough may rapidly accelerate CO<sub>2</sub> utilisation in industry, thereby reducing global emissions.



CHINA





## 06 C GREEN – 21ST CENTURY SUPEREFFICIENT SLUDGE DISPOSAL



SWEDEN



Sweden-based C Green has created a revolutionary new way to convert wet sludge into biofuel. Increasing amounts of sludge are being produced by sewage treatment plants around the world, containing 270 TWh per year of energy.

To tackle the challenge of water content of the material, C Green patented Zero-Energy HT - an energy-efficient hydrothermal carbonization process.

This can convert 60 tons of wastewater sludge, industrial sludge or wet biomass per day into biofuel.

The resulting biofuel is odourless and free from bacteria, viruses and the most complex pharmaceutical residues, and is suitable for use in biofuel power plants.

## 07 EUROPEAN INNOVATION COUNCIL PRIZE - FUEL FROM THE SUN: ARTIFICIAL PHOTOSYNTHESIS



Artificial photosynthesis can contribute to tackling both energy and climate problems as a sustainable alternative to fossil fuels for a range of applications in industry, housing and transport. It mimics the process of natural photosynthesis by absorbing solar energy to produce fuel that can be stored and transported. It is considered one of the most promising clean energy technology breakthroughs.

The European Commission has launched a €5 million Artificial Photosynthesis Prize for innovators globally to build a fully functioning prototype.

This is one of six Horizon 2020 prizes, setting ambitious goals to solve major challenges facing present-day society.

Meeting the challenge will stimulate innovation, raise public awareness, encourage the industrial participation and creation of start-ups, as well as increase commercial interest. Moreover, this prize will help accelerate the development of new solar energy conversion systems.



EC





©Markus Hauschild

## 08 SYNLIGHT - THE WORLD'S LARGEST ARTIFICIAL SUN

Synlight, located at the German Aerospace Center facility in Jülich, is the world's largest solar simulator. With a 350-kilowatt array, Synlight produces solar radiation 10,000 times more intense than at the Earth's surface. Temperatures at the target point of the lamps can reach up to 3,000 degrees Celsius.

Researchers use these temperatures to manufacture fuels including hydrogen. With three radiation chambers available for experiments in which the required radiation can be directed, Synlight allows intensive research into alternative energy production. Fuels, propellants and combustibles acquired using solar power offer immense potential for long-term storage, the production of chemical raw materials, and the reduction of carbon dioxide emissions.



GERMANY



## SECTION 4

# TRANSPORTATION

## 01 Australia

Reinventing the wheel  
for global markets

## 02 Norway

Future of the Fjords

## 03 Norway

ChargeFlex

## 05 Germany

New fuel membrane beats  
state-of-the-art technology

## 04 Sweden

Enerfy - the future of  
auto insurance

## 06 Canada

AddÉnergie's smart infrastructure  
for charging electric vehicles



# 01

## REINVENTING THE WHEEL FOR GLOBAL MARKETS



AUSTRALIA



### CHALLENGE

Transport is responsible for almost a quarter of energy-related greenhouse gas emissions worldwide, and emissions are increasing at a faster rate than any other sectors in the past decade. Emissions produced by light vehicles account for over half of the total. Without intervention, global transport emissions could grow by 70% to 2050.

### INNOVATION

Australian company Carbon Revolution has developed a world-leading technology to tackle carbon emissions in light vehicles. It has developed the first mass-produced carbon fibre car wheel as an alternative to heavier aluminium wheels, which are used in approximately half of all cars globally.

The one-piece carbon fibre wheels are up to 50% lighter than aluminium wheels for equivalent strength, and can deliver a 6% improvement in fuel efficiency when they are fully integrated into vehicle design. Their use could significantly improve vehicle fuel efficiency and reduce CO<sub>2</sub> emissions intensity by reducing vehicle weight.

### ACTION

Carbon Revolution's carbon fibre wheels are already being used in growing volumes in high performance vehicles manufactured by Ford in the US. Carbon Revolution is aiming to expand its annual wheel production to over 100,000 by 2021.



The Australian Government through the Clean Energy Innovation Fund, committed 10 million AUD to Carbon Revolution's 50 million AUD capital raising in 2016.

### POTENTIAL

Carbon Revolution is looking to capitalise on manufacturer interest to extend the use to more affordable models. The company is planning an initial public offering to raise as much as 100 million AUD in the near future, to expand the plant's capacity to 250,000 wheels a year. After that, it will seek to expand into offshore

production markets, closer to major global automotive markets. The local operation will be used as a test bed and also serve as a production site for larger but small-volume wheels for trucks and aeroplanes.

### USEFUL LINKS:

[carbonrev.com](https://carbonrev.com)

[cefc.com.au/media/files/clean-energy-innovation-fund-helps-australian-manufacturer-reinvent-the-wheel-for-global-markets.aspx](https://cefc.com.au/media/files/clean-energy-innovation-fund-helps-australian-manufacturer-reinvent-the-wheel-for-global-markets.aspx)

## 02 FUTURE OF THE FJORDS



©Brødrene Aa

### CHALLENGE

Hundreds of cruise-vessels visit the famous Norwegian fjords every summer, causing air pollution in the area. Emissions could be considerably reduced if some of the cruise vessels could stop closer to the coastline and use zero emission vessels to show tourists some of the UNESCO world heritage areas.

### INNOVATION

Brødrene Aa built the world's first civilian passenger boat in carbon fibre back in 2001. Now they have taken this a step further by constructing an all-electric passenger vessel called Future of the Fjords. They combined a low weight carbon fibre structure with the lightest lithium battery technology, and an effective propulsion line with controllable pitch propellers, to deliver a zero emission vessel. The vessel also has a unique universal design, giving tourists a special experience of the scenery in the Norwegian Fjords.

The project is part of the Norwegian Research Council's PILOT-E programme, which is focused on emission-free

maritime transport. PILOT-E is a collaboration between different Norwegian support systems to fast-track through the stages of research from idea to market. It was inspired by the American programmes designed to address specific challenges, such as the Advanced Research Projects Agency and Defense Advanced Research Projects Agency.

### ACTION

To increase the range of this type of weight sensitive vessel, the battery technology needs to be improved, and a higher energy density is also needed. It is also important to source a lower price battery.

### POTENTIAL

When Future of the Fjords can operate at 16 knots, with 400 passengers for 2.5 hours, it will be a real eye-opener in the market for zero emission vessels. Brødrene Aa has already received many enquiries from all over the world about the boat.

### USEFUL LINKS:

[braa.no](http://braa.no)



**NORWAY**  
JP, SE, DE, KR





© eSmart Systems

### 03 CHARGEFLEX



NORWAY

ChargeFlex, an R&D project from eSmart Systems, developed software to better exploit the grid and increase the charging capacity for electric vehicles (EVs). It provides analysis and enables the control of energy resources with the help of predictive algorithm to increase capacity by 40%.

By expanding the charging capacity without investing in the current infrastructure, electricity providers can put up more charging points and offer better charging opportunities.

This means that the end-users can charge their EVs at home knowing that the electricity bill will not be higher than necessary. The car charges when the price is at its lowest.

The software has now been commercialised under the brand Connected Prosumer.



### 04 ENERFY – THE FUTURE OF AUTO INSURANCE

Enerfy™ is an auto insurance data platform that saves customers lives, produces fuel savings and reduces claims costs by 40% and CO<sub>2</sub> emissions by 17% through changed behaviours. By generating real-time risk reports on safety and environmental performance for auto insurers, it provides a financial incentive for drivers to be environmentally friendly.

The company is seeking \$15 million to globally scale up sales and marketing to meet the goal of 40 million drivers insured within five years.

The World Wildlife Fund and Swedish Energy Agency has estimated that the Enerfy technology can contribute to a global reduction of CO<sub>2</sub> emissions of over 100 million tons per year.



SWEDEN



# 05 NEW FUEL CELL MEMBRANE BEATS STATE-OF-THE-ART TECHNOLOGY



GERMANY



Fuel cells can efficiently produce electricity with low or no emissions, with applications from zero-emission vehicles, to off-grid power generation and portable power for electronic devices. The project PSUMEA-2 focussed on developing lower cost and more reliable alternative membranes for PEM fuel cells and PEM electrolyzers, compared to the market-established Nafion membrane.

The innovative membrane reduces stack costs by 20%, requires a 30% smaller cooling system, minimises cooling costs by almost 70%, and is more robust at high temperatures. The PSUMEA-3 project will continue this promising research with the ultimate goals of scale-up and the facilitation of market access.

# 06 ADDÉNERGIE'S SMART INFRASTRUCTURE FOR CHARGING ELECTRIC VEHICLES



Used with permission from AddÉnergie Technologies Inc.

Canada's AddÉnergie is developing new and innovative technologies that contribute to the growth of the country's electric vehicle charging infrastructure, such as fast-charging stations, curbside stations for city streets and residential chargers.

This infrastructure relies on AddÉnergie's Charging Station Network Management System, a cloud-based management system that enables the company to provide a highly reliable service across the network.

To date, AddÉnergie has deployed over 4,500 charging stations and 3,500 residential chargers, all connected to the central system.

The project has led to better market awareness, an increased understanding of needs and expectations of drivers and charging station owners, and a clarified business model for operating charging stations.



CANADA



## SECTION 5

# BUILDINGS

01 UK

Q-Bot

02 Japan

Demonstration of positive energy building begins in Lyon

03 EC

Celcius City

05 Sweden

Ectogrid

04 UK

Warming up to hydrogen

06 Australia

Affordable heating and cooling open data platform

# 01

## Q-BOT



UK  
FR, EU



### CHALLENGE

The largest single contributor to the UK's CO<sub>2</sub> emissions is space heating of homes, accounting for 60% of domestic energy use. The vast majority of older, hard-to-heat homes have suspended floors which let cold air, dust and mould in from the void below, creating cold draughts and uneven temperatures. Recent studies demonstrate that uninsulated timber floors can contribute as much as one quarter of the total heat loss and a third of the draughts for the whole building. Without retrofit of existing buildings and the insulation of suspended timber floors, it will be almost impossible to meet targets set by the UK's Climate Change Act 2008.

### INNOVATION

Q-Bot has developed the first affordable solution for retrofitting insulation to suspended timber floors.

It works by using a robotic vehicle to insulate the underside of the floor with a polyurethane foam developed and certified for this application. The robot is inserted under the floor through an access hatch or air vent, surveys the void and condition of the floor, if suitable sprays an expanding insulation foam, and finally records the install to verify the area and depth of insulation applied.

Applying the insulation in situ allows it to expand and fit the shape of the floor, leaving no gaps for draughts to enter the property and reducing the risk of damp and mould – meaning far better results for the building and occupants.

### ACTION

Q-Bot's solution is cheaper, performs better and has none of the hassle and disruption of traditional methods. Independent studies have shown that the insulation resulted in a significant improvement in thermal comfort with less cold draughts and uneven temperatures. The results show on average a 33% improvement in airtightness and an 80% reduction in heat

loss through the floor. Q-Bot has been awarded the highly prized BBA accreditation for the installation process (British Board of Agrément Certificate Number 17/5440i1).

### POTENTIAL

Q-Bot is currently rolling the service out in the UK with social housing providers. By working with local authorities and housing associations, Q-Bot can quickly create a critical mass in each region that underpins the creation of a delivery

channel. This in turn brings jobs and upskills the workforce and can deliver the service to the private market.

Q-Bot is currently working with a number of partners to bring the service to Europe and North America, and is developing a number of new solutions to improve the health of our buildings.

### USEFUL LINKS:

Q-Bot website: [q-bot.co/news](http://q-bot.co/news)



©Q-Bot Ltd

## 02

## DEMONSTRATION OF POSITIVE ENERGY BUILDING BEGINS IN LYON



JAPAN  
FR



### CHALLENGE

Energy demand and greenhouse gas emissions from global buildings will reach 40% of total demand in 2050, according to the International Energy Agency's Energy Technology Perspectives (2016). As zero energy housing technology can greatly cut down carbon dioxide emissions, France has set the goal of making all new public buildings constructed as 'positive energy' buildings.

### INNOVATION

As part of a demonstration conducted in Lyon, France, Toshiba and Bouygues have constructed the positive energy complex HIKARI (meaning 'light'), which generates more energy than it consumes by using a range of cutting edge technology.

This is in partnership with Japanese government agency New Energy and Industrial Technology Development Organization (NEDO) and Grand Lyon, France.

HIKARI is a 12,500-m<sup>2</sup> complex of three mixed-use buildings containing offices, shops and apartments. Three positive energy building features of HIKARI include bioclimatic architectural design, the ability to produce energy on-site and pooled energy resources and data analysis. They use photovoltaic (PV) power generation (including a see-through PV façade on the MINAMI building), storage batteries, and heat storage materials that are controlled by an energy management system.



### ACTION

Energy consumption has been reduced by 15% or more than the calculated amount at the basic design phase. HIKARI has been verified as a positive energy building. The next step is to make it economically feasible.

### POTENTIAL

There is huge potential for this project as buildings remain the most widespread, and also the most overlooked, target for rational energy management. NEDO is aiming to disseminate the results of the demonstration widely in other cities and countries.

### USEFUL LINKS:

[nedo.go.jp/content/100871965.pdf](https://nedo.go.jp/content/100871965.pdf)

[bouygues-immobilier-corporate.com/en/press-release/greater-lyon-inaugurates-hikari-first-positive-energy-mixed-use-development-france](https://bouygues-immobilier-corporate.com/en/press-release/greater-lyon-inaugurates-hikari-first-positive-energy-mixed-use-development-france)

[eu-smartcities.eu/sites/default/files/2017-09/1.%20Positive%20Energy%20Blocks%20for%20Small%20%26%20Medium%20Sized%20Cities\\_0.pdf](https://eu-smartcities.eu/sites/default/files/2017-09/1.%20Positive%20Energy%20Blocks%20for%20Small%20%26%20Medium%20Sized%20Cities_0.pdf)

## 03 CELSIUS CITY



EC  
SE, DE, UK,  
NL, IT



### CHALLENGE

Buildings account for almost a third of total energy consumption globally, with space heating and cooling and the provision of water accounting for approximately half of this consumption. Waste heat produced in the EU could be enough to heat its entire building stock, but heat recovery processes are often challenging, and there is no sufficient distribution network to move the energy from where it is produced to where it is needed.

### INNOVATION

Celsius City is an innovative city-based project making building heating and cooling systems more sustainable and efficient. It has developed a new approach using a network of insulated pipes that distribute heat or cold using hot water, steam or cold water, meaning individual homes do not need to generate their own heat on-site.

Instead, any heat source can be connected to the network by identifying waste heat and devising ways to capture and integrate this heat into a city's local district heating system.

The project is funded by the EU with about €14 million under the EU FP7 programme to provide smarter, more efficient heating and cooling systems to cities across the EU.

### ACTION

Celsius City currently provides new integrated technology solutions to develop smart district heating and cooling systems to 67 European cities.

It creates better heating systems for cities to facilitate a more efficient transfer of heat from point of production to storage and point of use. The project established an intelligent heating system, covering virtually all the households and commercial

buildings in the appropriate high density areas of the city. These systems make use of a range of excess heat sources all created within the city during the course of an average operational day.

### POTENTIAL

Celsius City and its smart district heating technologies promote transfer of information, knowledge and expertise to cities across Europe, creating a model that can be exported,

adopted and adapted to the specific needs of any city.

In terms of reducing harmful emissions, the EU estimated that district heating has the potential of saving an extra 400 million tons of CO<sub>2</sub> each year.

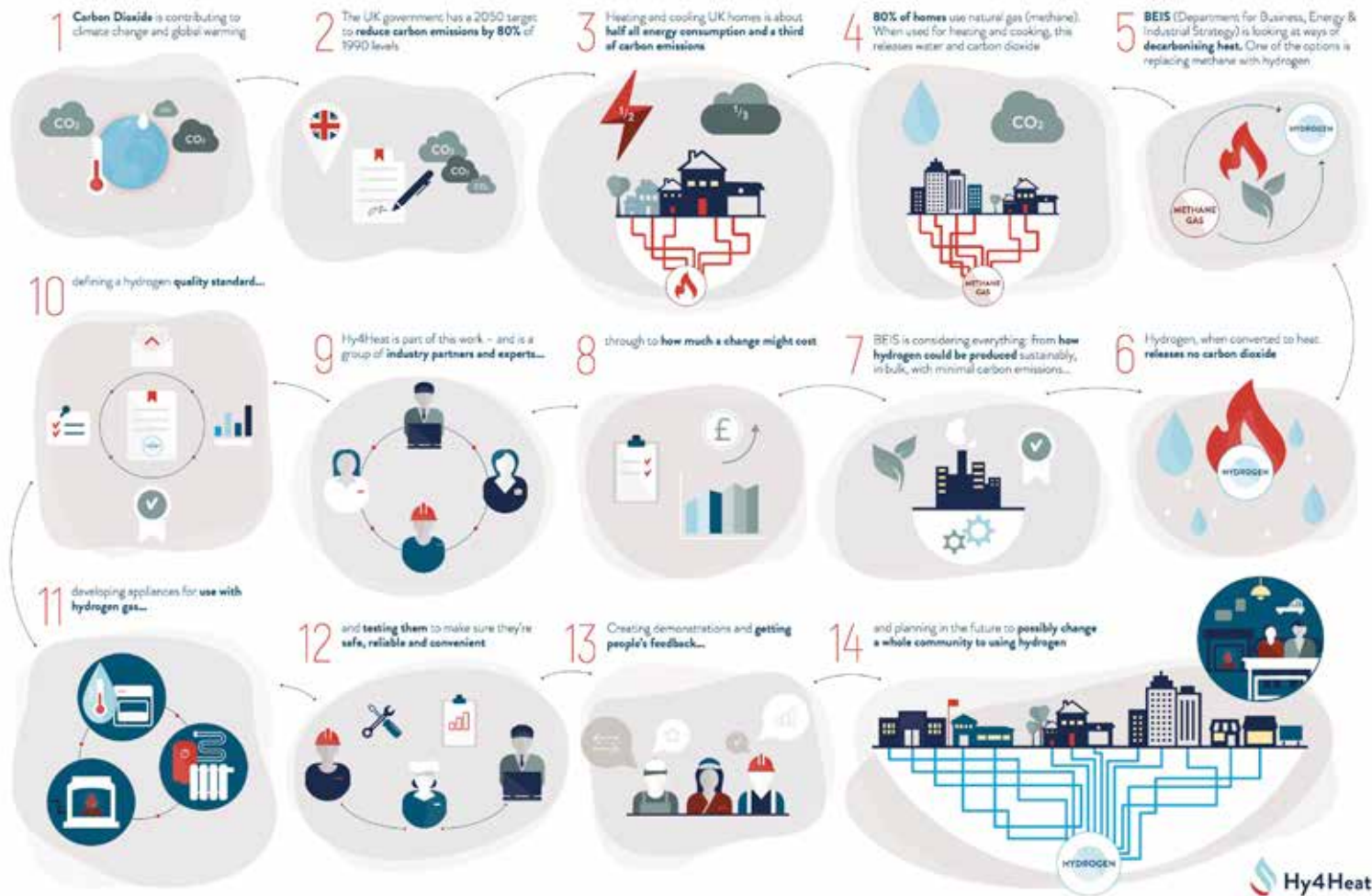
### USEFUL LINKS:

Project website: [celsiuscity.eu](http://celsiuscity.eu)





## The Hy4Heat Programme



## 04 WARMING UP TO HYDROGEN

Over 35% of the UK's carbon dioxide emissions come from the use of natural gas for heating and cooking in homes and businesses. The UK Government is funding a £25 million programme, known as Hy4Heat, to explore whether hydrogen could replace natural gas and enable reuse of the existing gas network to deliver low carbon energy.

This programme will focus on overcoming two of the biggest challenges with hydrogen: safety issues associated with its use in buildings, and development of appliances to burn hydrogen. It will involve creating new gas standards for the safe use of hydrogen. Manufacturers will be appointed to develop hydrogen boilers, cookers and fires for test and demonstration, and preparations will be made for a community trial.





# 05 ECTOGRID



SWEDEN



ectogrid™ is a 5th generation district heating system that enables the efficient use of heating and cooling, integrated with electricity generation. ectogrid™ takes the best characteristics from heat pumps and cooling machines and combines them with the best characteristics from energy distribution grids (electrical, thermal and gas).

By connecting buildings with different needs and balancing the energy between them, only one thermal grid is needed that serves several purposes – thermal distribution for both heating and cooling as well as storage and flexibility. E.on intends to build a demonstration system in cooperation with Medicon Village, Peab and Qvantum and to verify the system together with Lund University of Technology.

USEFUL LINKS:  
[ectogrid.com](http://ectogrid.com)

# 06 AFFORDABLE HEATING AND COOLING OPEN DATA PLATFORM



As a result of the MI IC#7 ‘Affordable Heating and Cooling’ workshop, an international consortium of industry and researchers will develop an open data platform to reduce the energy wastage (up to 30%) from poorly maintained, degraded and improperly controlled air-conditioning equipment.

The platform will provide energy efficiency service providers with access to low-cost, high-quality data from buildings and infrastructure, to enable heating, ventilation, and air conditioning software-as-a-solution services.

It will accelerate industry growth by attracting innovators and start-ups, and used to run hackathons and grand challenges. Where appropriate, data will be accessible to define new global and national benchmarks or indices, and inform jurisdictional policy on codes, standards and ratings.

Rapid implementation will be achieved by adapting a leading building industry controls software platform, provided by Switch Automation, and a business model developed for the platform to become financially self-sustaining.



AUSTRALIA  
CA, NL, US,  
MX, NZ, IL



## SECTION 6

# INDUSTRY

## 01 Canada

Shell Canada's Quest carbon capture and storage facility

## 02 India

Methane carbon capture in everyday value-added products  
- String Bio PVT LTD

## 03 Sweden

Climeon - Dependable.  
renewable, clean electricity

## 04 Australia

Integrating Solar Thermal  
for minerals processing

## 05 EC

H2Future

## 06 Sweden

HYBRIT, hydrogen breakthrough  
for ironmaking technology

## 07 Germany

Carbon2Chem

## 08 Norway

Full scale carbon capture  
at Norcem Brevik

01

## SHELL CANADA'S QUEST CARBON CAPTURE AND STORAGE FACILITY



CANADA



### CHALLENGE

Carbon capture, use and storage (CCUS) is a low-carbon technology necessary to reduce carbon dioxide emissions from fossil-fired power plants, and a key option for deep CO<sub>2</sub> emission reductions from refineries, the chemical sector, and cement and steel production. The International Energy Agency has highlighted the role of CCUS in reducing future temperature increases to 2°C in the period to 2060, in a cost-effective manner. The Intergovernmental Panel on Climate Change's Fifth Assessment Report states that without widespread implementation of CCUS, the world is unlikely to reach its desired 2°C scenario.

### INNOVATION

Shell Canada, on behalf of the Athabasca Oil Sands Project, has developed Quest, a large-

scale, fully integrated CCUS project located near Edmonton, Alberta, Canada. This is the first commercial-scale project of this nature to tackle carbon emissions in the oil sands.

The Quest facility captures and stores up to 1.2 million tonnes of CO<sub>2</sub> per year from a bitumen upgrading unit, the Scotford upgrader. The captured CO<sub>2</sub> is then transported via pipeline and stored in a deep saline aquifer in the Western Sedimentary Basin.

### ACTION

The project began commercial operations in November 2015 and, as of March 2018, has captured and stored 2.7 million tonnes of CO<sub>2</sub> – approximately the equivalent of 22 years of electricity emissions from the City of Vancouver. Direct emissions from the Scotford upgrader are now being reduced by as much as 35%.



Used with permission from Shell

Quest illustrates an effective public-private partnership, with private sector investment by Shell and joint venture owners, and jointly funded by Canada's federal government, with \$120M provided by Natural Resources Canada, and by the provincial government of Alberta, which provided \$745 million.

### POTENTIAL

Given Quest's success, future CCUS opportunities from Shell-operated facilities in Alberta are being investigated, including consideration of utilisation options such as CO<sub>2</sub>-Enhanced

Oil Recovery (EOR), fertiliser production, and concrete curing. Quest's success can help demonstrate that CCUS is feasible and cost-effective, supporting broader uptake globally by serving as a model for advancing and deploying CCUS in a variety of industrial operations.

### USEFUL LINKS:

[energy.alberta.ca/AU/CCS/CCSPA/Pages/default.aspx](https://energy.alberta.ca/AU/CCS/CCSPA/Pages/default.aspx)

Shell Canada: [tinyurl.com/ybnt6v5q](https://tinyurl.com/ybnt6v5q)

02

## METHANE CARBON CAPTURE IN EVERYDAY VALUE ADDED PRODUCTS - STRING BIO PVT LTD



INDIA



### CHALLENGE

Methane is the second most damaging greenhouse gas produced by human activity. Though methane's lifetime in the atmosphere is shorter than that of carbon dioxide, it is more efficient at trapping radiation. Methane has 25 times greater impact on climate change than CO<sub>2</sub> over a 100 year period. An economical and sustainable technology to enable methane conversion to value added products will help harness methane for productive use.

### INNOVATION

The proprietary platform of the String Integrated Methane Platform project exploits advances in synthetic biology, fermentation technology, chemistry and process engineering.

One of the critical components of this platform is the gas conversion technology that this project has developed, with its first product to market being a protein, String Pro, made from methane. Conversion of methane to protein is a process that takes place naturally in lakes and ponds. Using advances in biology and engineering, this conversion has been industrialised. It can be leveraged for the manufacture of chemicals, food and feed ingredients from methane.

Biological conversion of methane can occur at ambient temperature and pressure and has advantages such as no risk of catalyst poisoning, low operating costs and higher specificity.



### ACTION

The technology behind String Pro provides a biological route for conversion of methane to value added products and, as a second step, allows for working with small to medium volumes of natural gas.

### POTENTIAL

The project scope can be further widened when adapted for other geographies as well as alternate sources of methane. Converting methane into protein creates a sustainable protein

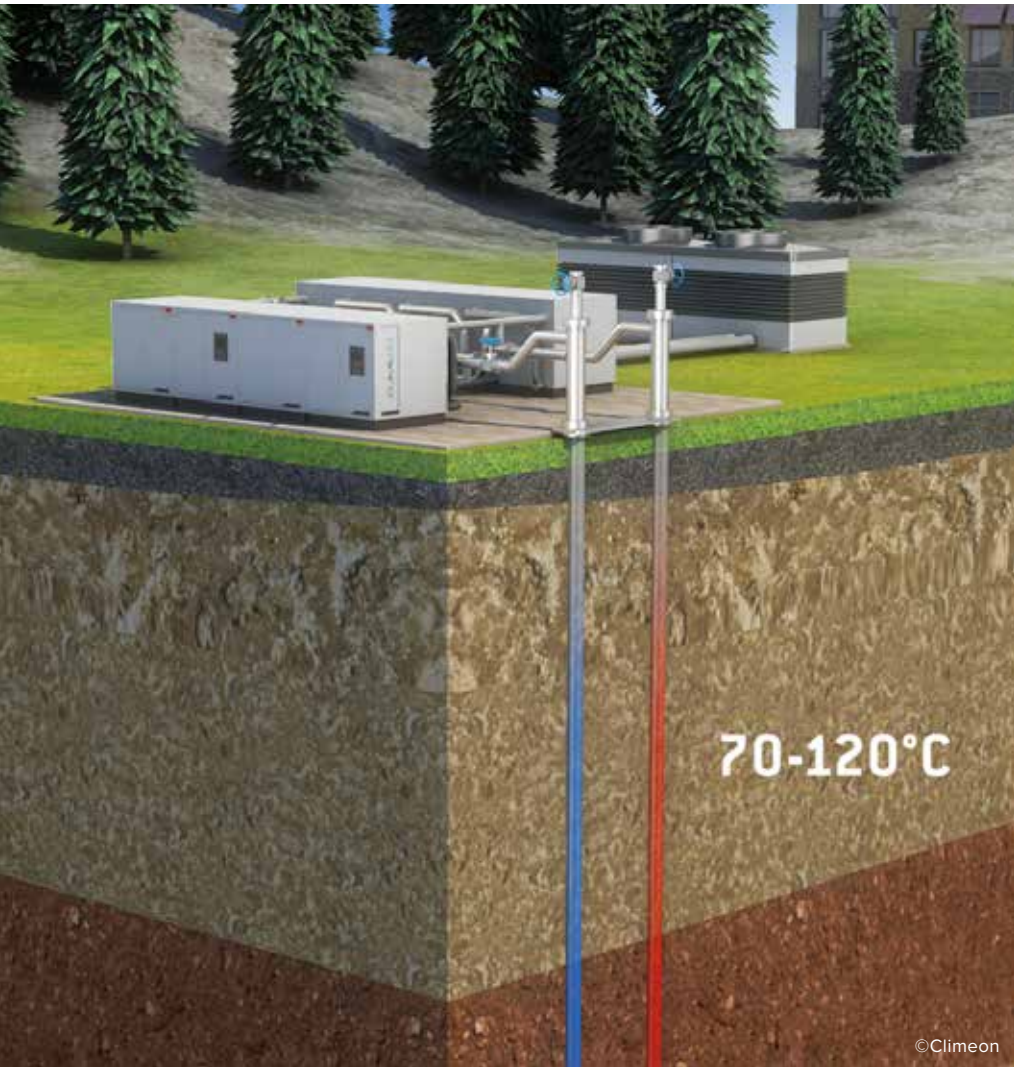
source that is cost effective and can address the growing worldwide protein demand by using a vented or flared resource as the input carbon.

The project is currently being validated at pilot scale and is seeking finance, manufacturing capacity, and land to scale the technology to commercial production.

### USEFUL LINKS:

[youtu.be/NQ7LEROhB0s](https://youtu.be/NQ7LEROhB0s)





# CLIMEON – DEPENDABLE, RENEWABLE, CLEAN ELECTRICITY

## CHALLENGE

Low temperature waste heat is an untapped source of energy that is equal to over half the world’s energy output.

## INNOVATION

Climeon provides a technology that uses the energy in waste heat from industries and low temperature geothermal heat to generate electricity, creating so called heat power.

Heat power is a 100% renewable baseload, meaning it produces an even flow of electricity irrespective of the weather or the time of day.

## ACTION

Climeon’s Heat Power system generates electricity below 250°F and is a physically compact, plug-and-play modular system, which comes with a high return on investment and a short payback time.

## POTENTIAL

The technology makes low temperature geothermal plants economically viable and allows waste heat from ship engines to steel plants to be used to generate renewable energy.



SWEDEN



## USEFUL LINKS:

Project website: [climeon.com](https://climeon.com)

## 04 INTEGRATING SOLAR THERMAL FOR MINERALS PROCESSING



### AUSTRALIA

Alumina refining in Australia is energy-intensive and reliant on natural gas. A project looking at using concentrated solar thermal technologies such as low-temperature digestion, solar reforming of natural gas, and high-temperature calcination could lead to a 50% reduction of the natural gas consumed and may be applicable in other industries. The 15.1 million AUD project, led by the University of Adelaide, includes 4.5 million AUD in funding from

the Australian Government though the Australian Renewable Energy Agency. The University of Adelaide, CSIRO and the University of New South Wales are contributing over 600,000 AUD in cash and 8.7 million AUD of in-kind resources, further supported by 620,000 AUD of in-kind contributions from industry partners including Alcoa of Australia Limited, IT Power, and Hatch.

## 05 H2FUTURE

Steel manufacturing is one of the largest sources of CO<sub>2</sub> emissions. Cutting these is necessary to achieve the goals set at the United Nations Climate Change Conference (COP21) in 2015.

The €18 million H2Future, a Fuel Cell and Hydrogen Joint Undertaking (FCH JU) project, is one of the first to explore harnessing the power of renewable hydrogen to decarbonise steelmaking. An innovative electrolysis pilot plant will be constructed at the Voestalpine production site, currently one of Austria's biggest greenhouse gas emitters. One of the largest and most modern electrolyzers using Proton Exchange Membrane technology will be deployed to produce

green hydrogen for industrial use, which will be fed directly into Voestalpine's internal gas network for testing in various process stages of steel production.

The EU backed project where Voestalpine, Siemens and Austrian utility Verbund join forces, represents the type of unique public private cooperation that is needed to address the complexity of curbing industrial CO<sub>2</sub> emissions. By supporting research, technological development and demonstration in fuel cell and hydrogen technologies, the FCH JU aims to accelerate market introduction in order to realise the technologies' full potential for achieving a carbon-lean energy system across multiple sectors.



### EC





## 06 HYBRIT, HYDROGEN BREAKTHROUGH FOR IRONMAKING TECHNOLOGY



The HYBRIT project, supported by the Swedish Energy Agency, aims to reduce carbon dioxide emissions from ironmaking to zero by using hydrogen produced from “clean” electricity to eliminate the need to use fossil fuels for iron ore reduction. The project, led by Swedish companies SSAB, LKAB and Vattenfall, started in 2016 with a pre-feasibility study. A pilot demonstration plant is planned for 2018.

## 07 CARBON2CHEM



The Carbon2Chem project of the Federal Ministry of Education and Research is exploring the utilisation of smelter gases from steel production and hydrogen produced using surplus electricity from renewable energy sources to create valuable primary products, such as fuels, plastics or fertilisers. The Carbon2Chem approach is expected to make 20 million tons of the German steel industry’s annual CO<sub>2</sub> emissions economically exploitable.

Carbon2Chem will answer central questions of the energy transition concerning the storage of electrical energy and the stabilization of the electrical grid and build a bridge between basic research and the market. BMBF is providing more than €60 million funding for the project with partners involved expected to invest more than €100 million by 2025.

## 08 FULL SCALE CARBON CAPTURE AT NORCEM BREVIK



The cement industry is a major source of industrial CO<sub>2</sub> emissions, contributing 5-6% of global anthropogenic greenhouse gas emissions. Norcem AS, with its parent company Heidelberg Cement Group and the European Cement Research Academy, is exploring various post-combustion CO<sub>2</sub> capture technologies at small-scale to determine their suitability for deployment in modern cement kiln systems.

A full-scale capture at Norcem Brevik would be the first of its kind globally for cement production. It would achieve improved levels of carbon emission from cement installations, along with a new environmental standard for cement production in Europe.



NORWAY



## SECTION 7

# INNOVATIVE FINANCING

## 01 Sweden

India-Sweden  
Innovations Accelerator

## 02 UK

Leveraging crowd investors  
to deliver affordable solar  
energy access for families  
in Sub-Saharan Africa

## 03 Australia

Innovative peer-to-peer  
green lending platform

## 04 Australia

Australian Clean Energy  
Seed Fund

# 01

## INDIA-SWEDEN INNOVATIONS ACCELERATOR



SWEDEN  
IN



### CHALLENGE

There was a desire to introduce innovative technologies and solutions from Sweden to Indian counterparts for joint adaptation in both countries.

### INNOVATION

The Sweden-India Innovations Accelerator (ISIA) is an initiative with the purpose to bridge innovations and entrepreneurship between India and Sweden. ISIA has developed several new clean energy technologies, including solar powered water pumps to bring water and energy to rural India, and the repurposing of the material used to make airbags to create fabric based biogas reactors.

ISIA was initiated in 2012 by the Swedish Energy Agency as a central pillar of the bilateral work in India. Business Sweden and Confederation of Indian

Industries – Green Business Centre are programme partners. The innovation of the project lies in its approach to collaboration between two countries: initiated by the Swedish Energy Agency, in partnership with business associations in both Sweden and India.

### ACTION

Since 2015 the programme has developed as one of the most important tools for collaboration between small, medium and large sized companies from both countries, in the fields of technology for new, renewable, efficient energy.

ISIA consists of several collaborative projects, for example using the material developed for airbags, FOV Biogas has developed cost-effective fabric based biogas reactors.



TVS company based in Chennai using food waste for biogas generation and the gas is used for cooking

In March 2018 Swedish company Aili Innovation collaborated with the Indian company Tata Thrust to develop highly efficient solar driven water pumps for small scale farmers in India, based on a new invention from Sweden. Replacing diesel pumps, the solar pump system provides water for irrigation and power for lighting and the charging of smaller devices like cell phones or fans.

### POTENTIAL

In 2017 more than 330 Swedish companies participated in the programme, and during 2018 another

nine companies will join. During the same time period, tenfold as many Indian counterparts have contributed. Around 50% of the Swedish companies that have gone through the programme are still active in India with various projects spanning from pilot installations to commercial partnerships.

### USEFUL LINKS:

Project website:  
[innovationsaccelerator.com](http://innovationsaccelerator.com)

## 02 LEVERAGING CROWD INVESTORS TO DELIVER AFFORDABLE SOLAR ENERGY ACCESS FOR FAMILIES IN SUB- SAHARAN AFRICA



UK

TZ, KE, UG, MZ



### CHALLENGE

Current levels of investment have put Africa far behind schedule in achieving the United Nations Sustainable Development Goal 7 to deliver universal access to affordable, reliable, sustainable and modern energy by 2030.

Businesses installing solar home systems are in urgent need of low interest rates of working capital, in order to provide rural families with the low-cost financing plans they need to afford these systems.

### INNOVATION

Energise Africa uses fintech to facilitate investments from individual investors, as well as

more experienced investors, in pioneering businesses that install life-changing solar systems in Sub-Saharan Africa homes. This platform allows businesses to extend 'pay-as-you-go' credit to low income households, so they can afford to pay for solar energy systems in small instalments over time.

The innovation lies in applying lessons from the growth of alternative finance in Europe to the needs of early stage businesses in the energy access sector and matching these with the evolving needs of investors who want to generate a social, environmental and financial return with their money. The web-based operation enables Lendahand Ethex (the two partner organisations behind Energise Africa) to contain overheads whilst rapidly scaling, which translates into lower costs to the borrower and attractive rates for lenders.

### ACTION

Since the launch of Energise Africa in August 2017, it has raised £3.4 million from 650 investors, providing investment to enable 25,000 families and 125,000 people to access affordable

clean energy in Kenya, Uganda, Mozambique and Tanzania.

By crowdfunding investments from UK-based retail impact investors at scale, Energise Africa is helping to enable solar companies on the ground in Africa to grow and expand their scope, providing a long-term, sustainable way of improving clean energy access.

### POTENTIAL

Energise Africa is an evolving initiative which would benefit from further match funding, first loss cover and electronic vouchers to continue to lower the

perceived risk to individual investors considering investing in Africa. Energise Africa is also looking to build further awareness amongst a younger and more diverse investor base of the important role impact investing plays in supporting renewable energy access.

### USEFUL LINKS:

Further information: [lendahand.co.uk](https://lendahand.co.uk)

Energise Africa video: [youtu.be/WRXUoUo-Xzk](https://youtu.be/WRXUoUo-Xzk)

©Lendahand Ethex



## 03 INNOVATIVE PEER-TO-PEER GREEN LENDING PLATFORM



AUSTRALIA

### CHALLENGE

Scaling-up investment in renewable electricity is critical for reducing greenhouse gas emissions from the power sector. Despite increasing cost-competitiveness of the technologies, policy and market fragmentation is hampering the financing of such projects.

### INNOVATION

Australia's first peer-to-peer green lending platform, RateSetter's Green Loan marketplace, makes it easier for investors, borrowers and clean energy providers to do business in the clean energy field by reducing market fragmentation.

It is an online platform, which brings together investors, borrowers and clean energy product providers with a shared interest in low emissions, energy efficiency and renewable energy projects, to conclude deals that benefit both parties.

It allows investors to lend directly to creditworthy borrowers looking to buy or install an approved "green" product. Investors can specify the amount they wish to invest and the interest rate they are prepared to accept. Their request can then be matched to approved borrowers who seek finance to invest in eligible clean energy assets such as solar panels and inverters for rooftop installation or energy efficient and low emission equipment such as power factor correction, voltage optimisation or LED lighting.

### ACTION

20 million AUD funding has been provided by the Australian Government, through the Clean Energy Finance Corporation to develop the platform. The platform will increase the flow of finance into the clean energy sector through RateSetter's retail lender base, which will now have access to borrowers via the peer-to-peer loan product.

### POTENTIAL

The facility creates an opportunity for retail investors to have access to a regulated "green" loan product for the first time in the Australian market and may establish a precedent for the rollout of similar investment platforms.

### USEFUL LINKS:

[cefc.com.au/media/files/cefc-commits-20-million-to-australian-first-peer-to-peer-green-lending-platform/](https://cefc.com.au/media/files/cefc-commits-20-million-to-australian-first-peer-to-peer-green-lending-platform/)



# 04

## AUSTRALIAN CLEAN ENERGY SEED FUND



### AUSTRALIA

The Australian Clean Energy Seed Fund launched in 2016 with the aim of increasing the supply of clean energy start-ups in Australia through venture capital support. It seeks to encourage co-investment from a wide range of investors.

The fund gained a 10 million AUD cornerstone commitment from the Australian Government's Clean Energy Innovation Fund in 2016, and a further 16 million AUD from Australian Ethical Investment,

Hostplus and Future Super. Over a four to five-year period the fund will invest at seed, angel and later stages of development in up to 50 start-ups across a range of technologies, such as: energy storage; demand management; biofuels and energy from waste; renewable energy, and technologies that exploit the Internet of Things.



