

Title

# French-German partnership achieves 46% PV conversion efficiency in the lab

Organization

**Soitec, CEA-Leti, Fraunhofer ISE**

Period

**Dec/2014**

France-based semiconductor maker Soitec and technology firm CEA-Leti in partnership with Germany-based Fraunhofer Institute for Solar Energy Systems have tested a **multi-junction photovoltaic cell that converts 46% of solar light into electrical energy.**

The achievement marks a **new world record for PV conversion efficiency.**

The new cell is a four-junction cell, with each of its sub-cells converting one quarter of the incoming photons in the wavelength range between 300 nm and 1,750 nm into electricity. A special challenge that had to be met by this cell was the exact distribution of the photons among the four sub-cells. This has been achieved by precisely tuning the composition and thicknesses of each layer inside the cell structure.

Compared to conventional solar cells, multi-junction solar cells are more expensive to manufacture. However, by using concentrating optics to focus the sunlight onto these cells, it is possible to minimize cell size to only a few square millimeters. This principle enables these modules to be manufactured inexpensively.

## GHG emissions reduction potential

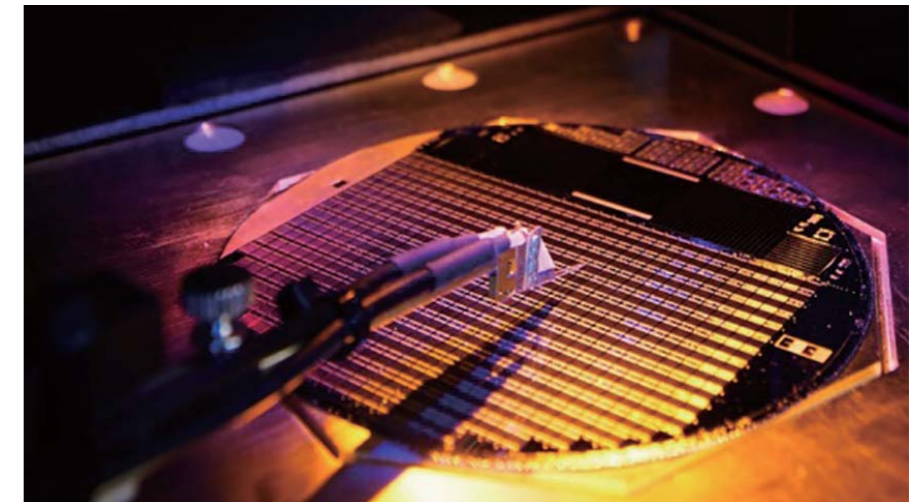
The IEA technology roadmap (2014) envisions PV' s share of global electricity increasing to 16% by 2050. Advances in conversion efficiency will have a strong impact on reducing GHG.

## Innovativeness

The project has achieved the highest PV conversion efficiency by resolving issues that prevented efficiency increase in the past.

## Feasibility

The technology has not reached the commercialization stage. However, a production line has already been installed in France to produce the new cells.



**New record solar cell on a 100mm wafer yielding approximately 500 concentrator solar cell devices.**

**Source** ©Fraunhofer ISE/Photo Alexander Wekkeli  
(<https://www.ise.fraunhofer.de/en/press-and-media/press-releases/press-releases-2014/new-world-record-for-solar-cell-efficiency-at-46-percent>)

## Comments by the Top10 Working Group

A conversion rate of 46% of solar light into electrical energy is indeed an outstanding R&D result.

High impact potential, large market potential and demand.

High marks for taking on construction sector energy savings.

Title

# Researchers develop high-performance ionic-liquid-based membranes to capture CO<sub>2</sub>.

Organization

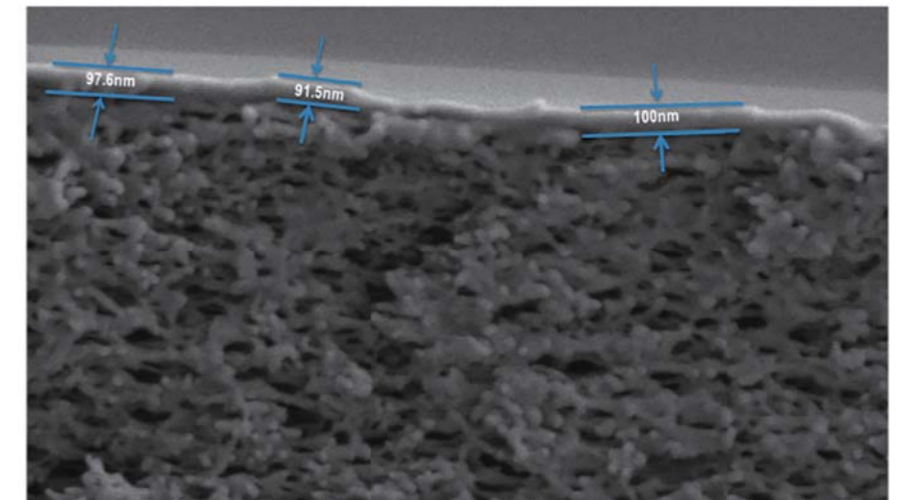
**3M Company (US),  
University of Colorado, Boulder (US)**

Period

**Dec/2014**

The University of Colorado at Boulder and its partner The 3M Company, have developed and fabricated innovative new thin-film composite (TFC) membranes that can capture CO<sub>2</sub> at a cost of less than \$15 per ton—a level that is significantly lower than today's best carbon capture technologies. The research was conducted through ARPA-E's program.

The researchers have demonstrated the first example of TFC gas separation membranes, which are created by coating room-temperature ionic liquid (RITL) - polymer composites as thin layers onto porous support structures in such a way that the membrane has good mechanical strength. This new membrane pulls CO<sub>2</sub> out of coal-derived flue gas at twice the rate of current technologies, while restricting the flow of other materials through it. The higher permeance of the TFC reduces the membrane material required, thereby reducing the capital cost of the process.



**Cross-sectional SEM image of the thin-film composite membrane**

Source <http://pubs.acs.org/doi/abs/10.1021/ie5040682>

## GHG emissions reduction potential

If CCS projects steadily increase and if around 10% of existing coal-fired power generation in the US and Canada is replaced with CCS, CO<sub>2</sub> emission reduction is estimated to be around 150 million t-CO<sub>2</sub>/year. Resources, but use renewable energy are an important measure to reduce GHG emissions.

## Innovativeness

This is the highest CO<sub>2</sub> permeance value reported for a membrane with such high selectivity.

## Feasibility

Even though there remain some research questions such as the effects of coating variations and the durability of membranes, the new membranes can potentially reduce the cost of capturing CO<sub>2</sub> to an economically viable level of <USD15/t-CO<sub>2</sub>. This has been confirmed, so commercialization looks like a good bet.

## Comments by the Top10 Working Group

The new membrane may be a real innovation.

Current technologies increase the cost of electricity and decrease the power output, so they have little commercial viability. With further development of this new membrane technology, there is significant potential to reduce costs and renew interest in capturing CO<sub>2</sub> from coal-derived flue gas.

Title

# CETO 5 Wave Energy Farm commences operations in Australia

Organization

**Carnegie Wave Energy Limited (Australia) Mar/2015**

Period

The Australian company Carnegie Wave Energy Limited has announced that a three-unit array of its CETO 5 wave energy generator has been completed and is operating at the Perth Wave Energy Project, located off Garden Island in Western Australia.

**The CETO system differs from other wave energy systems because it operates under water where it is protected from severe storms and is invisible from the shore. The fully submerged buoys can drive seabed pump units to deliver high-pressure fluid onshore through a subsea pipe to standard hydroelectric turbines, generating zero-emission electricity.** The high-pressure water can also be used to supply a reverse osmosis desalination plant, replacing or reducing reliance on the fossil fuel power driven pumps usually required for such plants. If successful, construction is expected to start of a larger commercial-scale version - 3 MW CETO 6 wave farm - in 2016.

## GHG emissions reduction potential

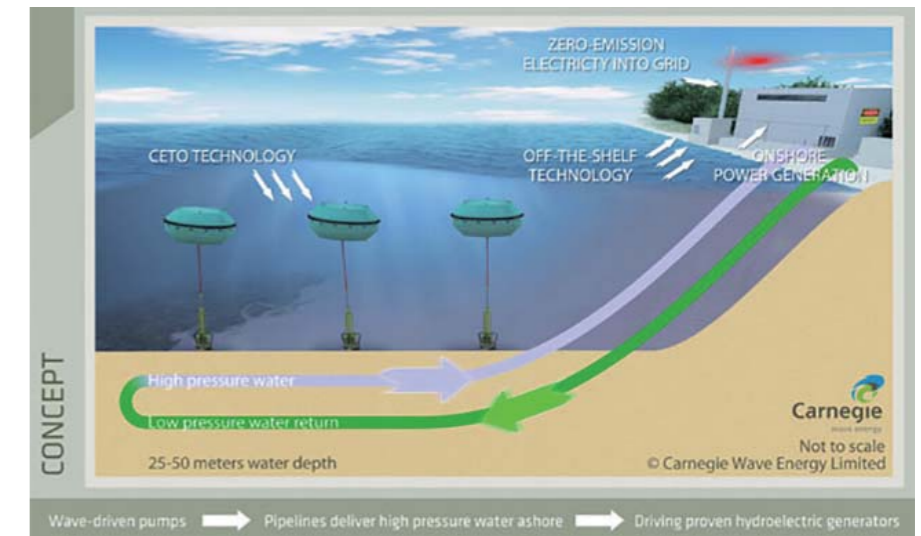
Carnegie Wave Energy hopes to expand commercialization of this technology and is targeting 1,000 MW of capacity installed by 2020. With an assumed CO<sub>2</sub> emission factor (0.823 t-CO<sub>2</sub>/MWh, Australia) and capacity factor of 30%, emissions will be reduced by approximately 2,200,000 t-CO<sub>2</sub> annually.

## Innovativeness

CETO is a novel wave energy generator, whose characteristics include: converting ocean wave energy into zero-emission electricity and desalinated water, being environmentally friendly with minimal visual impact, being fully submerged in deep water, unaffected by storms.

## Feasibility

Feasibility is relatively high because this technology is close to commercialization with the CETO 6 planned for 2016.



Source Carnegie Wave Energy Limited  
(<http://www.carnegiwave.com/ceto-technology/what-is-ceto.html>)

## Comments by the Top10 Working Group

Highly innovative and unique.

In spite of the abundant potential of wave energies, few activities have been undertaken to date.

Interested and would like to know the results.

Title

# World's largest Superconducting Flywheel Energy Storage System test machine is developed

Organization

**Railway Technical Research Institute,  
Kubotek Corporation, Furukawa Electric Co., Ltd.,  
Mirapro Co., Ltd., Public Enterprise Bureau of Yamanashi Prefecture (Japan)**

Period

**April/2015**

The Railway Technical Research Institute (RTRI) has developed a superconducting flywheel energy storage system, as a next-generation power storage system, with support by NEDO. **This is the world's first superconducting magnetic bearing which uses superconducting material both for its rotor and stator, and is capable of supporting heavy weight, although it is a compact-sized system.**

The flywheel energy storage system is capable of storing energy in the form of kinetic energy by rotating a flywheel, and converting the rotating energy again to electricity. RTRI developed a superconducting magnetic bearing composed of a high-temperature superconducting coil and high-temperature superconducting bulk for the developed system. These enable the flywheel to be levitated by the superconducting magnetic bearing without contact.

**It is a very practical system, which enables stable fluctuating power generation such as PV over a long period.** It has been connected to a solar power system and power grid of Tokyo Electric Power Company in Yamanashi Prefecture.

## GHG emissions reduction potential

Compared to hydro pumping, superconducting Flywheel Power Storage System will improve storage efficiency from 70% to 85%. With assumption that 1.2 million kW of flywheels will be deployed by 2040, the improvement by Superconducting Flywheel would bring about a 400 million kWh reduction of electricity consumption (around 200 thousand t-CO<sub>2</sub>) a year.

## Innovativeness

The project is innovative in that it is the first demonstration to use superconducting material both for rotor and bearing.

## Feasibility

The project demonstrates the technological feasibility of applying a superconducting magnetic material for rotor and bearing.



System configuration of demonstrated flywheel

Source Railway Technical Research Institute  
(<http://www.rtri.or.jp/eng/news/pdf/nr20150415e.pdf>)

## Comments by the Top10 Working Group

The first flywheel power storage using a superconducting magnet bearing.

Title

# Toyota launches first commercial FCV, MIRAI

Organization

**Toyota Motor Cooperation (Japan)**

Period

**Nov/2014**

Toyota has launched the MIRAI, **the first commercial hydrogen vehicle poised for mass production.** After introduction to the Japanese market in December 2014, Toyota is launching the MIRAI in US, available from the fall of 2015. More markets will follow. The offer includes complimentary fuel for 3 years, compensating for the high upfront cost of the first model.

The MIRAI is a four-door, mid-size fuel cell sedan with a level of **performance that fully competes with traditional internal combustion engines; it refuels in 3 - 5 minutes, and travels up to 300 miles (482 km) on a full tank, overcoming many of the hurdles that electric vehicles are currently facing in gaining recognition from ordinary consumers.** Furthermore, it accelerates from 0-60 mph (0-97 km/h) in 9 seconds.

The MIRAI uses the Toyota Fuel Cell System (TFCS). The TFCS consists of both fuel cell technology and hybrid technology, including a fuel cell stack, a fuel cell boost converter and high-pressure hydrogen tanks. The TFCS is more energy-efficient than conventional engines and emits no CO<sub>2</sub> or pollutants when burnt in the vehicle. Another important feature is safety. Toyota has designed a fail-safe system that prevents explosions.

## GHG emissions reduction potential

If hydrogen is created emission-free and assuming a conventional car travels around 20,000 km/year releasing 120 g-CO<sub>2</sub>/km, 2,400 kg-CO<sub>2</sub> would be reduced a year for each FCV sold.

## Innovativeness

The first commercially available FCV ever.

## Feasibility

MIRAI is a commercial product. The success of its public uptake depends on creating hydrogen-related infrastructure, and reducing product cost.

**Toyota MIRAI**

Source Toyota Motor Cooperation  
(<http://newsroom.toyota.co.jp/jp/detail/4197769/>)

## Comments by the Top10 Working Group

The move by TOYOTA is an important step in disseminating fuel cell technology and in creating markets for hydrogen produced from renewable sources.

The first commercially available FCV for everybody.

Title

# Hybrid power plant with 600 kW of solar power was commissioned in Berlin

Organization

**GE, Kofler Energies and BELECTRIC**

Period

**May/2015**

The project partners GE, Kofler Energies, and BELECTRIC have commissioned a **hybrid power plant with 600 kW of PV power, a 400kW gas CHP plant, and a battery array with 200 kWh charge capacity** at GE Power Conversion production site in Berlin-Marienfelde.

The conventional energy portion is not drawn from the grid, but is generated by the CHP plant on site. The battery buffers excess energy, and an energy management system controls the output of the hybrid power plant to meet demand. **The plant will not only supply power and heat to the GE Power Conversion production site in Berlin-Marienfelde, Germany, but it will also feed power into the grid. The plant enables primary energy savings of around 30 percent compared to systems that generate heat and power separately through conventional heating and external electricity procurement.**

The project was planned by Kofler Energies and GE's planning office BLS Energieplan. According to the companies, the business model for self-sufficiency and feeding surplus energy into the grid can be transferred to other industrial applications, which can also be larger than the current implementation.

## GHG emissions reduction potential

The plant enables primary energy savings of around 30 percent compared to using conventional heating and external electricity procurement.

## Innovativeness

The project is innovative in the way it takes a collaborative approach to achieving a system that enables a decentralized energy supply.

## Feasibility

The system can be adapted to other larger units.



**Hybrid power plant at GE Power Conversion production site in Berlin**

Source GE

(<http://www.gepowerconversion.com/press-releases/ge-kofler-energies-and-belectric-take-highly-efficient-hybrid-power-plant-operation>)

## Comments by the Top10 Working Group

There are a lot of hybrid power plant projects in the world. The Berlin project is special because of the consortium of companies.

Very unique technology - High impact - Easy to replicate in future energy systems.

Title

# Mazda releases the most fuel efficient diesel car ever - the Demio

Organization

**Mazda (Japan)**

Period

**Oct/2014**

**Mazda has released version 4 of its Demio series**, which won the car of the year Japan award 2014-2015. The compact Demio car comes in both diesel and gasoline versions, and delivers **extremely high fuel efficiency, with the diesel engine topping 30 km/L, which is unrivaled by its non-hybrid brethren. The new car builds on Mazda's original concept of fuel-efficient SKYACTIV technology.**

The Demio features SKYACTIV series technologies. The model is equipped with the newest 1.5 liter diesel engine, the SKYACTIV, a SKYACTIV-DRIVE automatic transmission system or a SKYACTIV-MT manual transmission system, and the SKYACTIV-BODY and CHASSIS for the structure of the vehicle. The SKYACTIV technology series aims at producing a car that emits minimal CO<sub>2</sub>, while ensuring good handling and an excellent driving experience. All of its parts are extremely light, and it is one of the smallest diesel engines in the world.

The Demio will be sold at the relatively low price of ¥1,350,000 to ¥2,192,400 (\$11,250 to \$18,270), ensuring the technology will spread.

## GHG emissions reduction potential

For each liter diesel consumed, 2,640 g-CO<sub>2</sub> is produced. So, the Demio produces 88 g CO<sub>2</sub>/km based on a mileage of 30 km/l of diesel. Assuming that a conventional car travels around 20,000 km/year releasing 120 g-CO<sub>2</sub>/km, 640 (2,400-1,760) kg-CO<sub>2</sub> would be reduced a year for each Demio sold.

## Innovativeness

The result of years of continuous research to improve the diesel engine, the Demio is a showcase for the state of innovation in engine technologies.

## Feasibility

Diesel engines have been on the market for over a century, and the uptake of fuel-efficient cars has been very good lately. Furthermore, the low price of the vehicle will help its diffusion.



**Mazda Demio**

Source Mazda (<http://www.mazda.co.jp/cars/demio/feature/design/>)

## Comments by the Top10 Working Group

Promising market potential; integrates well into the market. Accessible to consumers

Title

# MHI Vestas V164-8.0 MW breaks power production record

Organization

MHI Vestas Offshore Wind A/S (Denmark)

Period

Oct/2014

The MHI Vestas V164-8.0 MW prototype turbine broke the record for power production by a wind turbine during a 24-hour period from 6-7 October 2014 when the turbine produced 192,000 kWh under steady wind conditions at a test site in Østerild, northern Denmark. The power produced by the turbine in one day was enough to supply the energy needs of approximately 13,500 Danish households.

The world's most powerful turbine combines a mix of cutting-edge and innovative solutions in a largely evolutionary design and scaling process. It is driven by MSG-PMG (Medium-Speed Geared Permanent Magnet Generators) drivetrain, which is a very compact, light-weighted, slower speed solution offering the highest efficiency with low maintenance needs.

MHI Vestas Offshore Wind has already signed a stream of contracts for the turbine to be used in a large number of offshore wind projects, such as 450 MW for the "Borkum Riffgrund 2" project in Germany and 630 – 970 MW for the Navitus Bay project in the UK

## GHG emissions reduction potential

The turbine can produce up to 192 MWh in a single day. With an assumed CO<sub>2</sub> emission factor (0.352 t-CO<sub>2</sub>/MWh, EU) emissions are reduced by approximately 25,000 t-CO<sub>2</sub> annually per unit.

## Innovativeness

The innovative V164-8.0 MW wind turbine is the most powerful wind turbine in the world, which is achieved by cutting-edge and innovative solutions in a largely evolutionary design and scaling process.

## Feasibility

Feasibility is very high because the prototype installation showed excellent availability, and MHI Vestas has already signed a large number of contracts for various offshore wind farms.



Source MHI Vestas Offshore Wind A/S  
(<http://www.mhivestasoffshore.com/innovations/>)

## Comments by the Top10 Working Group

The most powerful offshore wind turbine.

There is an urgent need to reduce generation costs, which are still more than twice those of onshore generation. Perhaps the development route Vestas has taken will contribute to solve this



Title

# Researchers at Michigan State University develop transparent solar windows

Organization

**Michigan State University**

Period

**Jan/2015**

Researchers at Michigan State University (MSU) have developed a **technology that uses transparent, uncolored plastic, which can be placed over windows or smartphone screens, to produce electricity from sunlight**. The new technology is called a transparent luminescent solar concentrator and absorbs non-visible wavelengths.

For the new solar harvesting system, the research team developed organic molecules that absorb specific wavelengths, which are not visible to the human eye. Afterwards, those are transported to thin strips of photovoltaic cells at the side of the plastic, which then convert the light into electricity. Because the absorbed wavelengths are not visible to us, the material looks transparent.

If the technology can be scaled up, a whole new spectrum of photovoltaic applications will open up. The current conversion efficiency is around 1%, however **the group is aiming to reach an efficiency of 5 % when the invention is fully optimized**.

## GHG emissions reduction potential

The IEA technology roadmap (2014) envisions PV' s share of global electricity increasing to 16% by 2050. If this technology develops, it could dramatically increase the share of electricity from solar power by 2050.

## Innovativeness

The project is innovative in a way that it opens the first commercial-scale carbon capture and utilization facility.

## Feasibility

The technology has the potential to be scaled up for commercial or industrial applications at an affordable cost.



**A transparent luminescent solar concentrator module.**

Source ©Yimu Zhao/Michigan State University  
(<http://msutoday.msu.edu/news/2014/solar-energy-that-doesnt-block-the-view/>)

## Comments by the Top10 Working Group

Great innovation for a multipurpose solution.

The economic costs may be prohibitive and the impact may not become significant. Still attractive market niches may exist.

Title

# Europe creates a unified gas and electricity market

Organization

## EU transmission companies (EU)

Period

## Apr/2015

The European Union has been aiming for the creation of a **common energy market** (Internal Energy Market, IEM) since the 1990s. **Connections are increasing**, and the latest projects include the Italy-France transmission line (1.2 GW) and the U.K.-Norway transmission line (4 GW).

Apart from ever increasing transmission capacity, most of the western and northern European electricity markets were price coupled in late 2014, with the rest of the markets slated to join in 2015 or 2016. This means that **electricity can be traded between markets using the same rules, and buyers and sellers won't have to take into consideration transmission constraints, maximizing the use of available transmission capacity, and the possibility of sending energy that originates from variable generation between regions.**

IEM increases the ability to send electricity between markets. This, in turn, increases the possibility of sending variable generation between markets, thus reducing the need to stop renewable energy power plants when they produce more than is needed in a local market.

### GHG emissions reduction potential

This increases the possibility of sending variable generation between markets, thus reducing the need to stop renewable energy power plants when they produce more than is needed in a local market.

### Innovativeness

This is the first example of multiple countries harmonizing their rules, so it is considered to be highly innovative.

### Feasibility

Achieving the IEM is seen to be an important building block in creating a seamless European Union, and because most of the reforms are underway, the feasibility of success is deemed to be high.



The European Energy Market

Source © European Union 2015 - EC, Photo : Maout Christophe  
<http://ec.europa.eu/avservices/photo/photoDetails.cfm?ref=P-027638/00-01&sitelang=en#0>

### Comments by the Top10 Working Group

This is an important step towards finalizing the so-called single European electricity market by 2015/2016. The single market improves the substitution of conventional power stations by renewables.

Practical and thinking big.