

Title

31.17% solar sunroof triple-junction module efficiency

Organization

Sharp

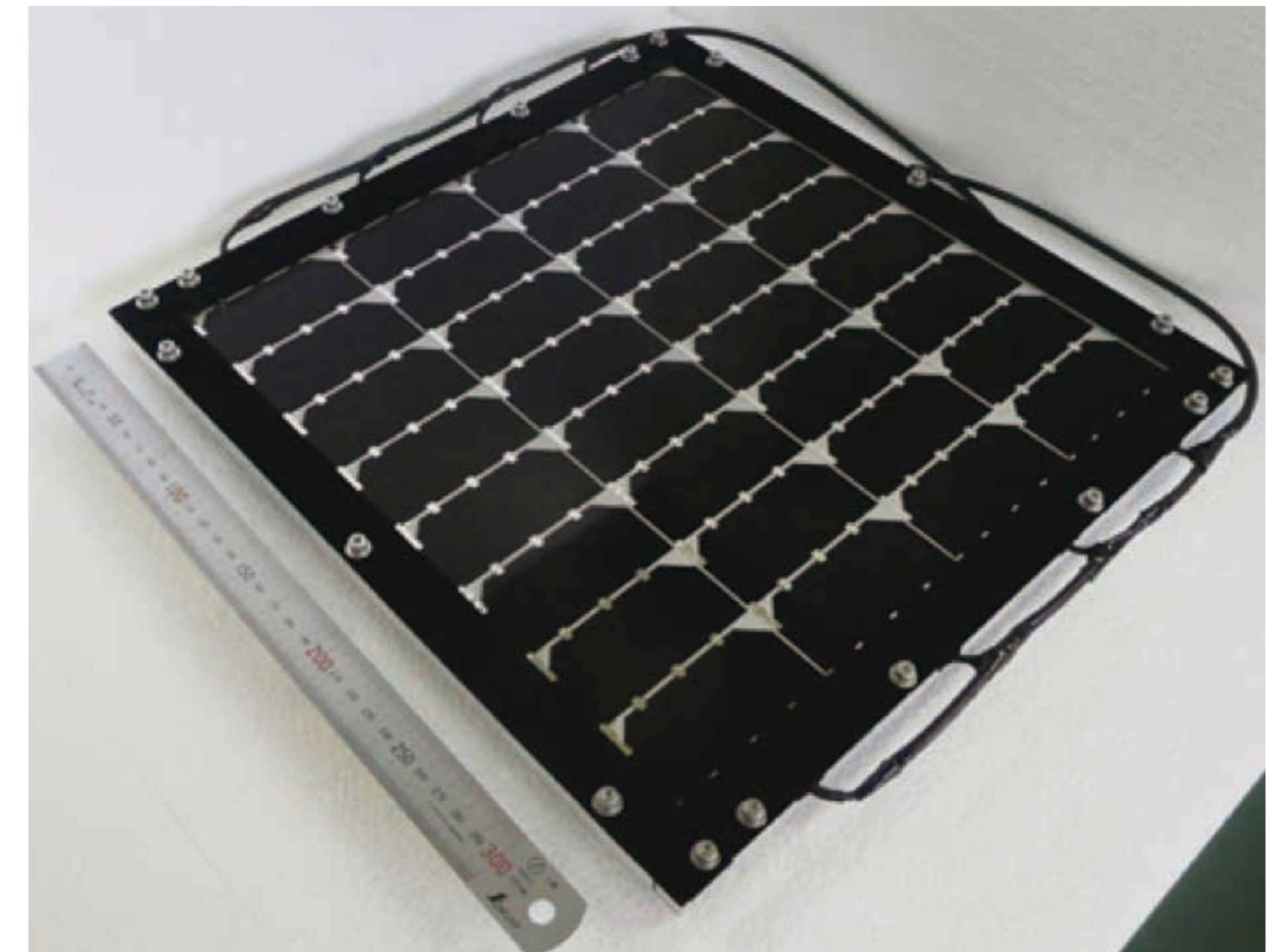
Period

May/2016

Sharp has created a triple-junction compound solar module with a conversion efficiency of 31.17% in NEDO' s project.

While Sharp has previously achieved an efficiency of 37.9% for an individual PV cell using similar technology, that device had an area of just 1.047cm². This time, Sharp succeeded in the development and modularization of a larger size solar cell. It achieved **the world's highest conversion efficiency even as a module (area: 968 cm²)**.

Using a triple junction cell means that the photovoltaic properties of the compounds indium gallium-phosphide (InGaP), gallium arsenide (GaAs) and indium gallium arsenide (InGaAs) can be used to capture a wider range of the spectrum of sunlight. NEDO said Sharp had been able to improve “uniformity in the surface of the substrate” by optimizing manufacturing conditions.



A triple-junction compound solar module with a conversion efficiency of 31.17%.

Source ©SHARP CORPORATION
(<http://www.sharp.co.jp/corporate/news/160519-a.html>)

GHG emissions reduction potential

IEA Energy Technology Perspectives (2016) envisions PV's share of global electricity increasing to 17% by 2050. Advances in conversion efficiency will have a strong impact on reducing GHG.

Innovativeness

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

Feasibility

The technology has not reached the commercialization stage. However, the project has already achieved a practical size of PV module and will continue to chase high conversion efficiencies at a lower cost.

Comments by the Top10 Working Group

This technology provides an opportunity to accelerate the shift to non-fossil fuel electricity.

Title

New world record for thin-film solar cells

Organization

ZSW(Centre for Solar Energy and Hydrogen Research Baden-Württemberg)

Period

Jun/2016

The Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) has slightly pushed up the performance bar for thin-film solar cells. **The Stuttgart-based scientists achieved the highest efficiency in a thin-film solar cell, 22.6 %**, with their latest advance, topping the performance of a Japanese-made cell by 0.3 percentage points and bringing the world record back to ZSW for the fifth time.

The institute's researchers accomplished this latest performance improvement by improving the manufacturing process at several points. For example, one is the post-deposition treatment of the CIGS surface with alkaline metal compounds being incorporated into this layer.

Prof. Michael Powalla, Director and Head of the Photovoltaics division of ZSW, said he expected that ZSW can achieve up to 25% efficiency in the years ahead.



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GHG emissions reduction potential

IEA Energy Technology Perspectives (2016) envisions PV's share of global electricity increasing to 17% by 2050. Advances in conversion efficiency will have a strong impact on reducing GHG.

Innovativeness

The project has achieved the highest PV conversion efficiency in a thin-film solar cell by resolving issues that prevented efficiency increase in the past.

Feasibility

The technology has not reached the commercialization stage. However, when efficiency of 25% and above is achieved in the coming years, it will have various uses.

Comments by the Top10 Working Group

PV generation has the highest power density of all renewable conversions and thin films have the advantage of being low cost. This combination means that this progress is highly sought after.

Title

World's highest conversion efficiency of 26.33% achieved in a crystalline silicon solar cell

Organization

Kaneka Corporation

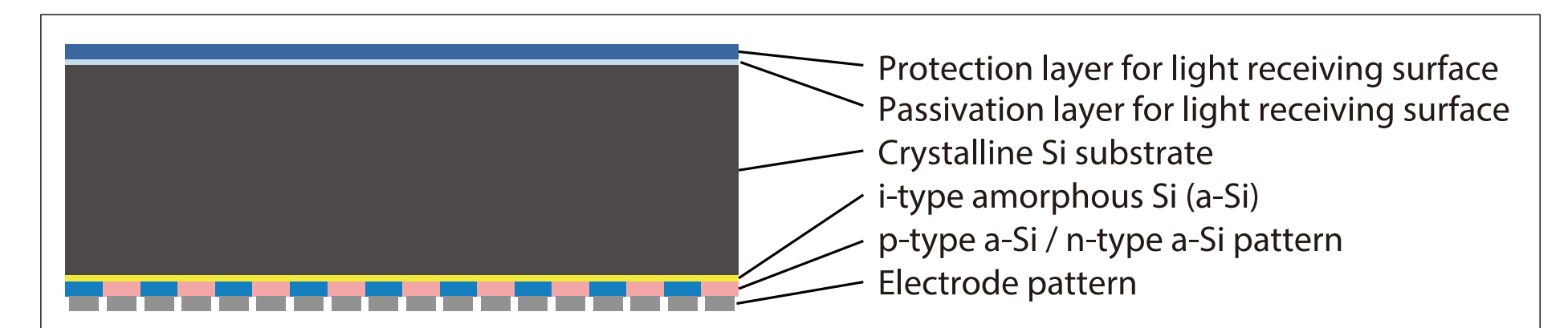
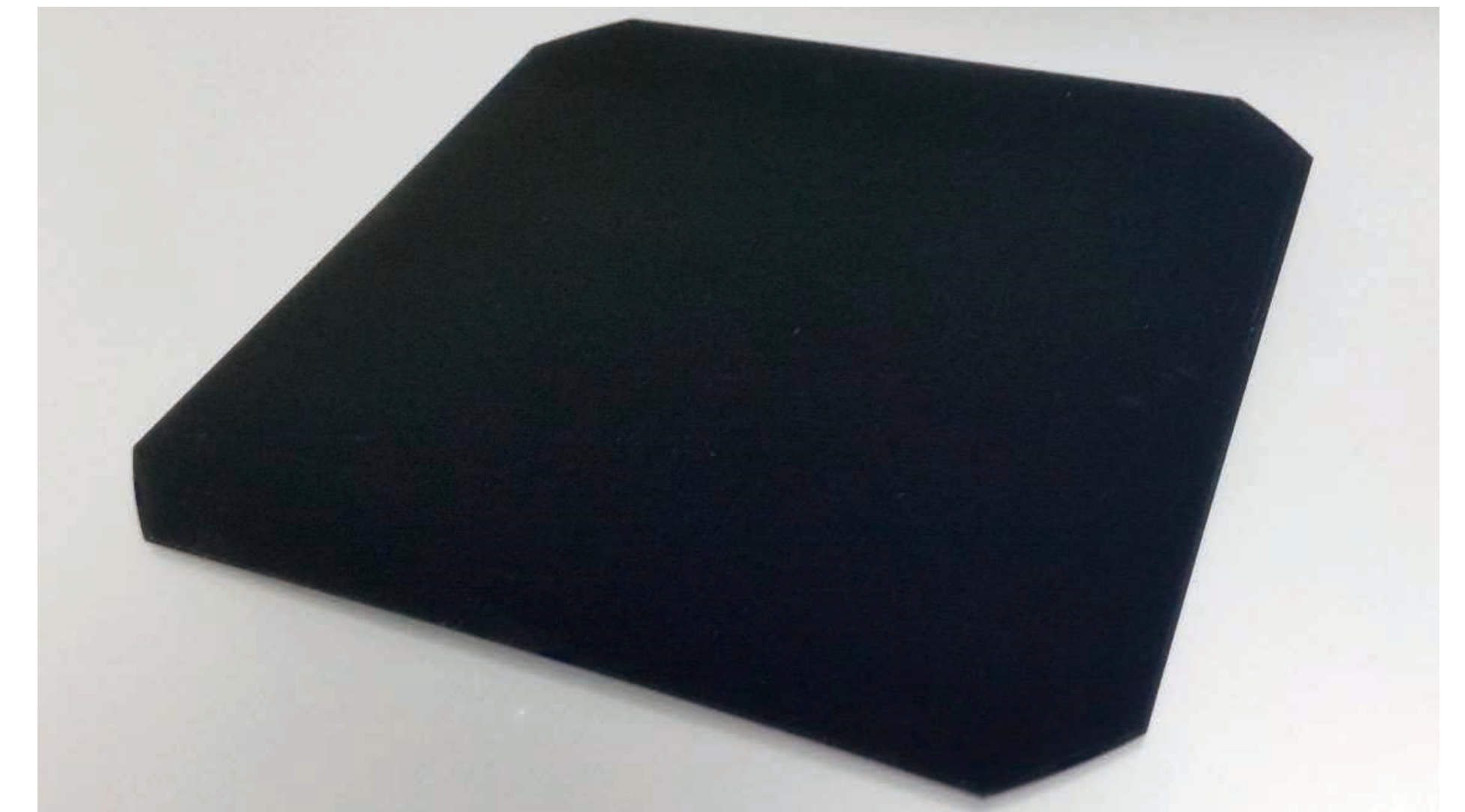
Period

Sep/2016

Kaneka Corporation developed a high conversion-efficiency crystalline silicon solar cell (heterojunction back-contact type) in NEDO's Development of High-Performance and Reliable PV Modules to Reduce LCOE (levelized cost of electricity) project, and has achieved **the world's highest conversion efficiency of 26.33% in a crystalline silicon solar cell having a practical size (180 cm²)**. This achievement breaks the world record of 25.6% by approximately 0.7%, exceeding 26% for the first time in the world.

The result was achieved by means of a combination of heterojunction technology using high-quality amorphous silicon, low resistance electrode technology, and a back-contact structure that captures more solar energy, all of which were developed by Kaneka Corporation.

Achieving a conversion efficiency of over 26% in crystalline silicon solar cells, which are the most widely used solar cells, will make a great contribution to LCOE reduction and is expected to lead to even more widespread use of photovoltaic power generation in residences which have limited installation space.



Schematic device structure of record-breaking crystalline silicon solar cell (heterojunction back-contact type)

Source Kaneka Corporation/NEDO

GHG emissions reduction potential

IEA Energy Technology Perspectives (2016) envisions PV's share of global electricity increasing to 17% by 2050. Advances in conversion efficiency will have a strong impact on reducing GHG.

Innovativeness

The project has achieved the highest PV conversion efficiency in a crystalline silicon solar cell by resolving issues that prevented efficiency increase in the past.

Feasibility

The technology has not reached the commercialization stage. However, crystalline silicon solar cells are the most widely used solar cells, so it will widely spread once commercialized.

Comments by the Top10 Working Group

PV generation has the highest power density of all renewable conversions and crystalline Si cells can achieve the highest efficiencies in this class.

Title

Water splitting–biosynthetic system with CO₂ reduction efficiencies exceeding photosynthesis

Organization

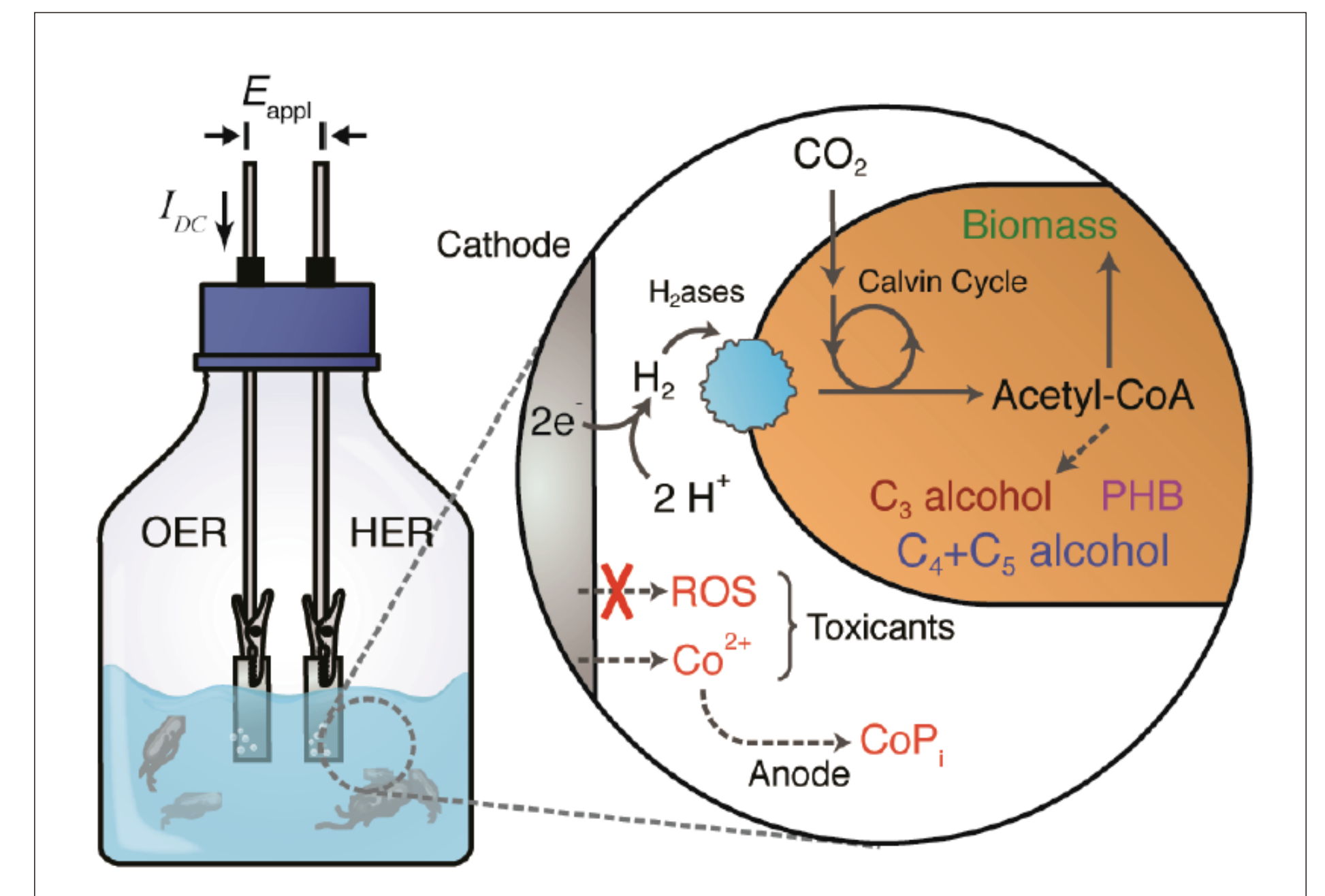
Harvard University

Period

Jun/2016

Prof. Daniel Nocera and his colleague Prof. Pamela Silver have devised a system that completes the process of making liquid fuel from sunlight, carbon dioxide, and water. **Their system works at an efficiency of 10 percent, using pure carbon dioxide, which is one-tenth of the energy of the sunlight captured and turned into fuel.** That is much higher than natural photosynthesis, which converts about 1 percent of solar energy into the carbohydrates used by plants, and it could be a milestone in the shift away from fossil fuels.

In nature, plants use sunlight to make carbohydrates from carbon dioxide and water. Artificial photosynthesis seeks to use the same inputs—solar energy, water, and carbon dioxide—to produce energy-dense liquid fuels. Nocera and Silver's system uses a cobalt-phosphorus catalyst to split water into oxygen and hydrogen, and feeds the hydrogen to bacteria along with carbon dioxide. The bacteria, *Ralstonia eutropha*, a microorganism that has been bioengineered to specific characteristics, converts the carbon dioxide and hydrogen into liquid fuels.



Schematic of hybrid bioelectrochemical system for CO₂ fixation

Source Liu, C., B. C. Colon, M. Ziesack, P. A. Silver, and D. G. Nocera. 2016. "Water Splitting-Biosynthetic System with CO₂ Reduction Efficiencies Exceeding Photosynthesis." *Science* 352 (6290) (June 2): 1210–1213. doi:10.1126/science.aaf5039. <https://dash.harvard.edu/handle/1/27304973> (<https://dash.harvard.edu/bitstream/handle/1/27304973/aaf5039%20Manuscript%20rev%20complete.pdf?sequence=1>)

GHG emissions reduction potential

Innovative fuel production technologies that do not depend upon fossil fuel resources but use renewable energy are an important measure to reduce GHG emissions.

Innovativeness

Achieved solar energy conversion efficiency of 10%, which is much higher than natural photosynthesis.

Feasibility

The technology has not reached the commercialization stage. However, feasibility of this system has already been proven on a laboratory scale.

Comments by the Top10 Working Group

This idea has huge potential if it is commercialized in the future. It is worthy of receiving an ICEF Top 10 Innovations award.

Title

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

Organization

Tokyo Institute of Technology,
Toyota Motor Corporation

Period

Mar/2016

Toyota Motor Corporation and the Tokyo Institute of Technology, as part of a NEDO project, have discovered the **superionic conductors with the world's highest lithium-ion conductivity**.

The superionic conductors 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**. The all-solid-state 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.

Conventional lithium-ion batteries, which use liquid electrolytes, are reaching 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-power battery of the future. **The results of the research team showed the solid superionic conductor reconcile energy and power density at higher level than conventional lithium-ion batteries.**

GHG emissions reduction potential

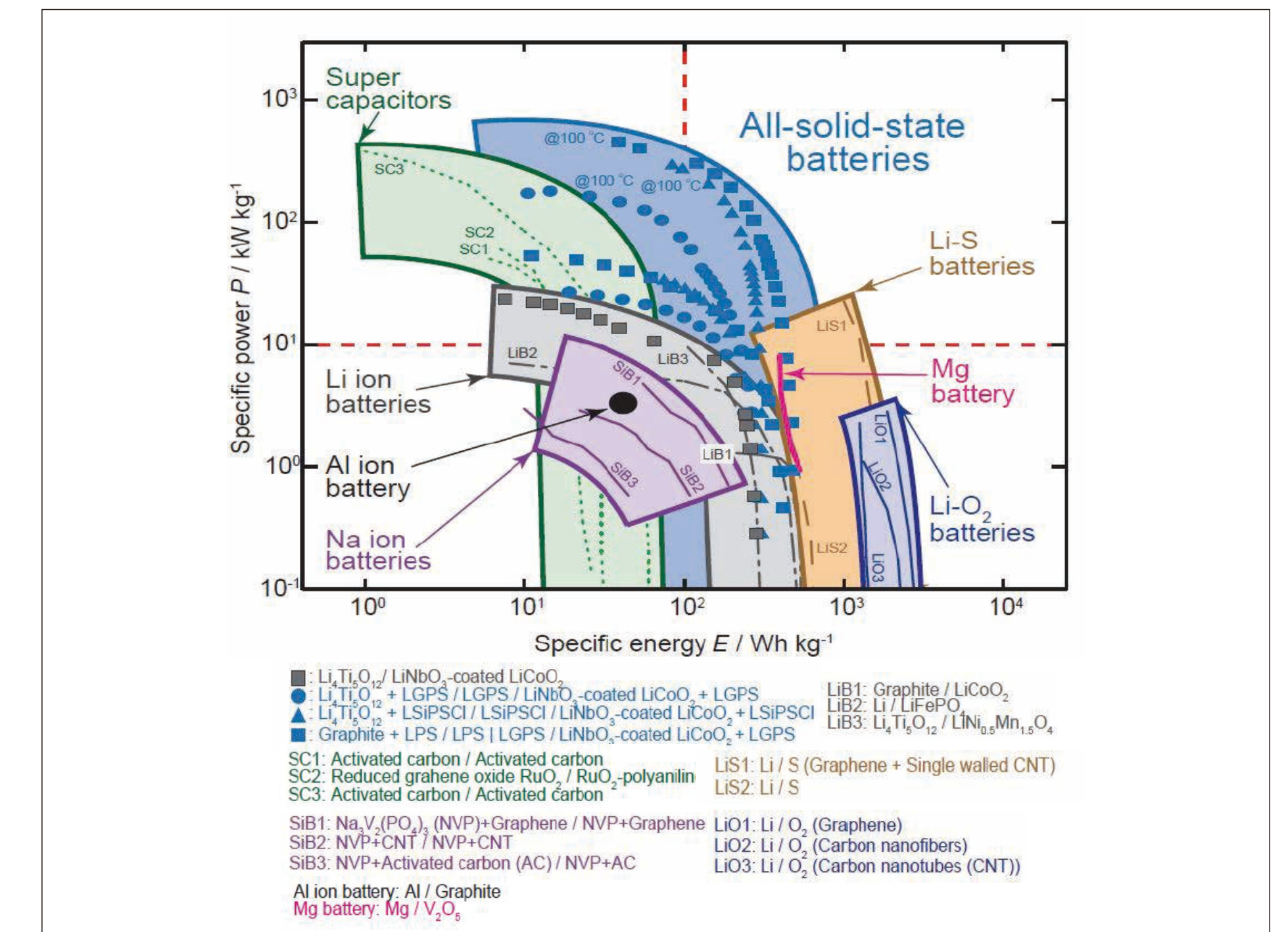
All-solid-state batteries can be used as electric vehicle batteries or stationary storage to support intermittent renewables, contributing to the reduction of GHG emissions.

Innovativeness

While high energy conventional lithium ion batteries have low power density, the research team has developed all solid state batteries with both higher power density and high energy density.

Feasibility

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 commercialized.



Ragone plots of the cells prepared in this study and previously reported batteries and capacitors. Red dashed line indicates the specific energy $E = 10^2 \text{ Wh kg}^{-1}$ and specific power $P = 10 \text{ kW kg}^{-1}$. The devices powered by liquid electrolytes show the inverse relationship between specific energy and power. The prepared all-solid-state cells simultaneously achieved high energy and power ($E > 10^2 \text{ Wh kg}^{-1}$ and $P > 10 \text{ kW kg}^{-1}$) which is difficult to achieve for conventional devices.

Source Kato et al. Nature Energy, 1, 16030 (2016)

Comments by the Top10 Working Group

Provides an opportunity for a cost-effective means to smoothen the electricity from intermittent renewable energy sources. (especially solar)

Title

Long-lasting flow battery could run for more than a decade with minimum upkeep

Organization

Harvard University

Period

Feb/2017

A research team from Harvard John A. Paulson School of Engineering and Applied Sciences has developed a **new flow battery that is non-toxic, non-corrosive with a long lifespan and a low production cost.**

While flow batteries are one of the more promising energy storage technologies that can contribute towards integrating intermittent renewables, they face the challenge of capacity degradation. However, **the flow battery developed by the research team overcomes the challenge of degradation, by dissolving organic electrolyte molecules in pH neutral water; even after 1000 cycles, the battery only loses one percent of its capacity.** Moreover, as the electrolyte is dissolved in neutral water and is non-corrosive, it is safe even when placed in the basement at home, and cheaper materials can be used for components of the battery.

Further research into flow batteries with aqueous soluble organic electrolytes may pave the way for safe, cost-effective, and long-lasting energy storage, contributing to a larger deployment of intermittent renewables.

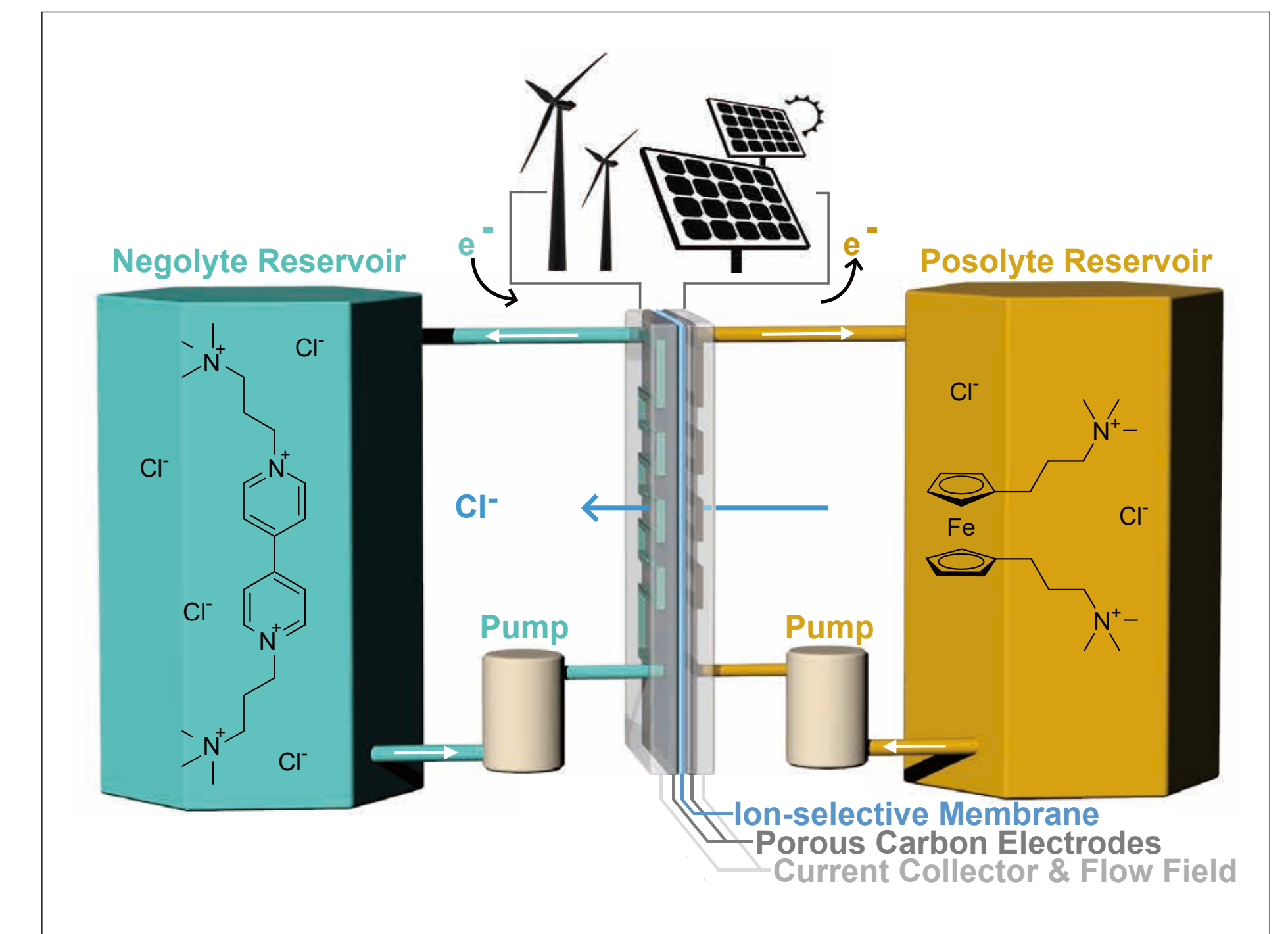


Fig. 2. A flow battery. (a) Schematic of a discharging metal-free organic flow battery

Source © Harvard School of John A. Paulson School of Engineering and Applied Sciences
(<https://aziz.seas.harvard.edu/electrochemistry#metal-free>)

GHG emissions reduction potential

Long-lasting flow batteries are promising energy storage technologies that can contribute towards integrating intermittent renewables.

Innovativeness

This flow battery may overcome the challenge of capacity degradation that conventional flow batteries are faced with.

Feasibility

The technology has not reached the commercialization stage, but researchers are collaborating with multiple companies to scale up the technology to an industrial application level.

Comments by the Top10 Working Group

Innovative research to use organic compounds dissolved in neutral water in order to store energy.

Title

World's tallest wind turbine integrated with pumped storage hydro

Organization

Max Bögl Wind AG, GE Renewable Energy

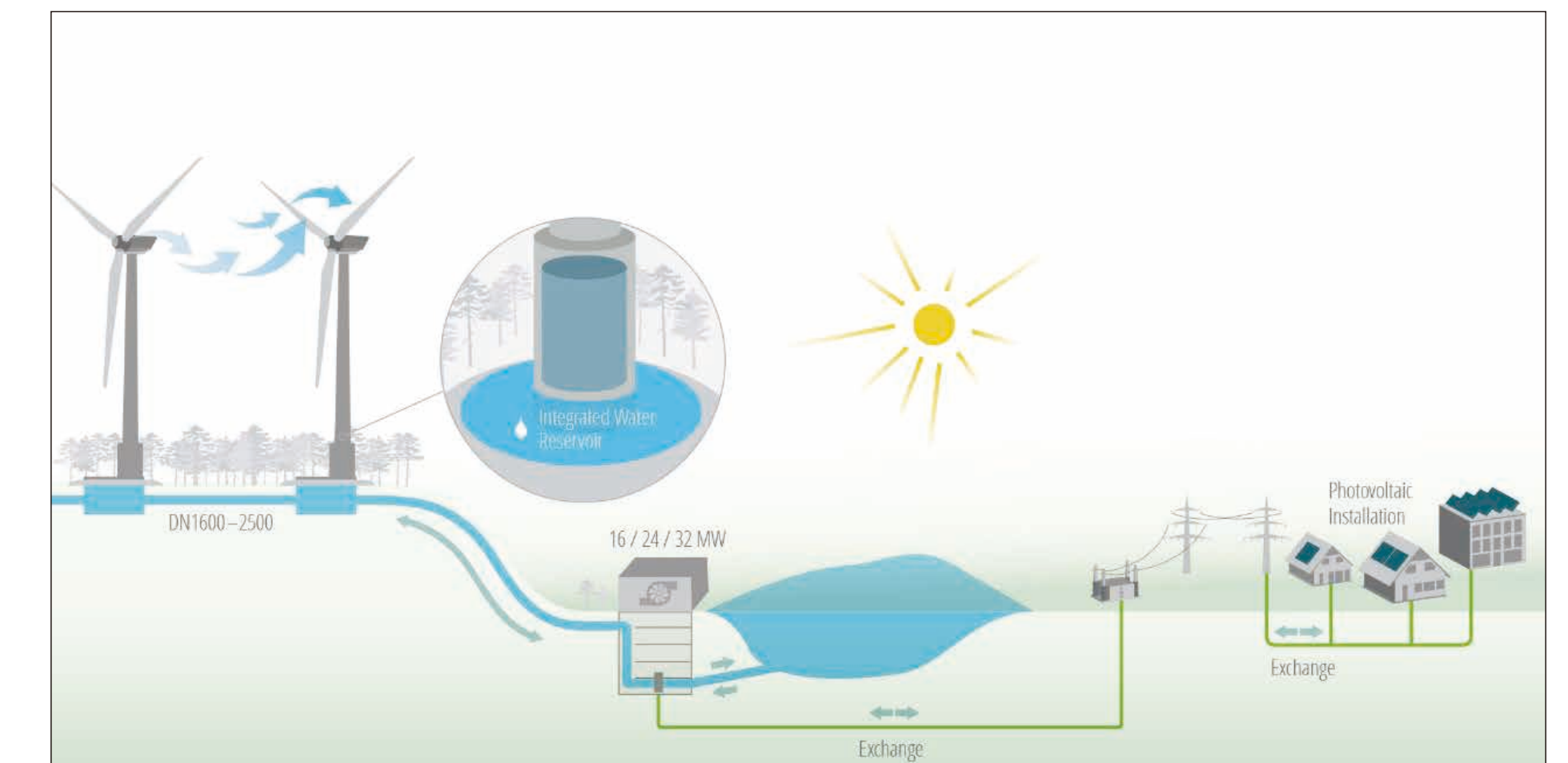
Period

Sep/2016

General Electric Company, through its GE Renewable Energy business, has announced it has signed a Turbine Supply Agreement with Max Bögl Wind AG to deliver and commission **the world's tallest and first ever wind turbine integrated with pumped storage hydro-electric power.**

The full scope of the Gaildorf project, located in Germany's Swabian-Franconian Forest on the Limpurger Berge uplands, will consist of 4 units of GE's new 3.4-137 wind turbine technology and a 16 MW capacity pumped storage hydro-electric power plant, to be supplied under a separate agreement between Max Bögl, Naturspeicher and Voith.

The base and surrounding area of each wind turbine tower will be used as a water reservoir, effectively increasing tower height by 40 meters. **At a total tip height of 246.5 meters, once installed these units will become the tallest wind turbines in the world to date.**



System configuration diagram for wind turbine integrated with pumped storage hydro

Source ©Max Boegl Wind AG
(<http://www.ge.com/reports/unique-combo-wind-hydro-power-revolutionize-renewable-energy/>)

GHG emissions reduction potential

IEA-ETSAP and IRENA Technology Policy envisions the storage capacity needed to accommodate wind power variations by 2050 is estimated to be between 190 GW and 300 GW. This system could greatly contribute to future wind power penetration.

Innovativeness

This wind farm is the first major project that integrates water storage in the turbines themselves. If successful, it should prove to be a template for other projects.

Feasibility

The technology has not reached the commercialization stage. However, this project will be connected to the grid by 2017 and fully operational by the end of 2018.

Comments by the Top10 Working Group

This combination of generation and storage will be an essential requirement for future wind penetration.

Onshore turbine heights of 250m will challenge the acceptance of wind power. In addition, it is unclear whether this plant will be to provide balancing power. (a rather tiny market)

Title

Flight powered by biofuel made from residual wood

Organization

Northwest Advanced Renewables Alliance, ICM, GEVO

Period

Nov/2016

In order to ensure a reliable supply, it is desirable that biofuel is derived from woody sources that do not compete with food supply or consume resources, unlike most of the biofuel available today. **GEVO Inc. and ICM Inc., companies based in the US specializing in bioenergy, have succeeded in producing aviation fuel from woody biomass (forest residues), which was blended with conventional jet fuel to be used in commercial flight (Alaska Airlines)** as a part of Northwest Advanced Renewables Alliance project sponsored by US Department of Agriculture.

GEVO's proprietary microorganisms and process technology were used to produce woody biomass based renewable jet fuel that meets the ASTM specification. The Northwest Advanced Renewables Alliance produced fermentable sugars from the woody biomass sources of hemlock and lodge pole pine, using pretreatment, milling and hydrolysis. The wood based sugars were converted to isobutanol (intermediate to making jet fuel) at ICM's and GEVO's pilot plant co-located in St. Joseph, MO. The jet fuel was produced at GEVO's Demonstration plant located at South Hampton Resources in Silsbee, TX.



An Alaska Airlines jet is fueled with renewable GEVO biofuel

Source © GEVO 2017

GHG emissions reduction potential

IEA Energy Technology Perspectives (2016) predicts that about 40% of aviation fuel is derived from biogenic sources by 2050, in order to meet the 2-degree target. Assuming 70% reduction, the potential can be estimated to be about 200Mt-CO₂.

Innovativeness

It is reported that this project is the first case of renewable aviation fuel derived from woody biomass being used in a commercial flight.

Feasibility

The technology has not reached the commercialization stage. However, using biofuel for aviation purposes is an established technology, and is recognized by International Civil Aviation Organization (ICAO) to be a key measure to reduce greenhouse gas emission.

Comments by the Top10 Working Group

A novel approach in multiple aspects, such as using woody biomass and converting first to alcohol and then to aviation fuel.

Title

100 percent bio-based plastics for beverage bottles

Organization

Anellotech, Suntory

Period

Jan/2016

Suntory, a leading beverage manufacturer in the world, currently uses 30 percent plant-derived materials for their mineral water, and is aiming for a 100 percent bio-bottle.

To achieve this goal, Suntory has entered into an R&D and Commercialization partnership with Anellotech, a U.S.-based venture company specializing in producing biomass-based chemicals. **The aim is to produce 100% bio-based polyethylene terephthalate (PET) to be used in beverage bottles. The key process is thermal catalytic biomass conversion technology** which produces aromatics such as paraxylene (which comprises about 70% of PET) from non-food biomass such as wood chips. Paraxylene is converted to terephthalic acid, which is reacted with ethylene glycol, which can be produced from biogenic sources, to produce 100% biomass-based PET.

A demonstration plant is built in Texas to complete technology development. Based on the result, 100% biomass-derived PET bottles are scheduled to be commercially introduced in 2021.



(Left) Inside of pilot plant located in Texas, USA.
(Right) Outside view of pilot plant

Source Courtesy of Suntory

GHG emissions reduction potential

GHG reduction potential can be significant if wood chips or previously discarded biomass residue is used, since it can lead to reduction in CO₂ and methane.

Innovativeness

This process is innovative since bio-sourced paraxylene, unlike ethylene glycol, has not been produced on a commercial scale.

Feasibility

The technology has not reached the commercialization stage. However, a demonstration plant is built, and commercialization is scheduled for 2021.

Comments by the Top10 Working Group

Highly recommended, since decarbonization of raw materials used in plastic production is a particularly great challenge and all advances in this field should be encouraged.

Title

Demonstration of peer to peer electricity trading using blockchain technology

Organization

LO3 Energy, Siemens

Period

Nov/2016

A community microgrid using blockchain technology is being developed in neighborhoods of Brooklyn in New York. Microgrids are able to operate in an islanded mode even during extreme weather events or emergencies, improving the resiliency of the area. Participants of Brooklyn Microgrid can locally produce and consume their energy, by trading solar-generated energy directly with their neighbors. **The first successful peer-to-peer trading of residential solar surplus using blockchain technology was conducted in April 2016.**

The concept of blockchain microgrid is expected to be further promoted and expanded after the collaboration of LO3 Energy, peer-to-peer trading platform provider for the microgrid, and Siemens Digital Grid, experienced provider of microgrid control solutions. The two companies will work together to further enable the use of blockchain technology for local energy trading.

Blockchain technology has the potential to allow the large-scale deployment of distributed energy resources at the local level at a lower cost, by enabling peer-to-peer trading of local energy resources and balancing out local production and consumption. Utilization of blockchain technology in microgrids may contribute to a more resilient, efficient, and clean neighborhood.

GHG emissions reduction potential

With peer-to-peer trading, higher penetration of renewables may be achieved, contributing to GHG emissions reduction.

Innovativeness

The project conducted the world's first peer-to-peer trading of energy in a microgrid.

Feasibility

The technology is still in its demonstration phase. However, more companies are starting to provide energy trading solutions using blockchain technology.



Picture of a Prosumer in Brooklyn Microgrid.

Source ©Brooklyn Microgrid Prosumer Participant
(<https://www.brooklyn.energy/?lightbox=dataitem-j20jr70i>)

Comments by the Top10 Working Group

This is the world's most famous blockchain application in the electric industry up until now. The results are strongly affecting the discussion on blockchain technology.

Title

Pioneering the networking of storage batteries with blockchain technology

Organization

Tennet, Sonnen, IBM

Period

May/2017

TenneT, Sonnen, and IBM have launched a pilot project to utilize residential batteries for power system operations using a blockchain solution. Sonnen will provide aggregation of its residential batteries for the system operation of Tennet, with a blockchain solution provided by IBM.

As more intermittent renewable energy resources are installed, procuring flexibility in the power system becomes a serious issue for system and grid operation. Batteries, which are able to charge and discharge power in seconds, are expected to contribute to such flexibility. Utilization of decentralized resources for flexibility may reduce the need for acquiring other emergency measures (e.g. regulation of wind parks), contributing to better optimized operation of the power system.

This is the world's first project to utilize residential batteries networked by a blockchain for grid operations. By increasing its ability to integrate more renewables, Tennet is expecting to contribute to reducing Germany's dependence on nuclear and fossil-fuel energy, facilitating its energy transition. After the demonstration of this project, the promotion of similar programs may be accelerated, using the open source-based platform solution for blockchain energy trading developed by IBM.

GHG emissions reduction potential

This project may contribute to Germany's energy transition away from nuclear and fossil-fuel energy.

Innovativeness

It is the world's first project to utilize residential batteries for grid operation using blockchain technology.

Feasibility

While the project is still in its demonstration stage, the blockchain trading platform is being prepared for a wider rollout.



SonnenBatterie eco.

Source ©sonnen

Comments by the Top10 Working Group

It may contribute to Sonnen's business concept of developing a 100% renewable electricity supply for household systems.

Title

Demonstration of Positive Energy Building Begins in Lyon

Organization

Toshiba

Period

Sep/2015~Feb/2017

As part of the smart community demonstration project being conducted in Lyon, France, Toshiba has started **the demonstration of the positive energy building complex HIKARI (“Light”) in NEDO’s project, which produces energy in excess of the amount consumed by the buildings.** Such a performance was made possible through the introduction of PV power generation, storage batteries, and heat storage materials that are controlled by an energy management system. **Energy consumption has been reduced by 10% or more than the calculated amount at the basic design phase.**

HIKARI is a 12,500-m² complex of three mixed-use buildings containing offices, shops and apartments. Three main factors in achieving these positive energy buildings are their bioclimatic architectural design, energy production on-site, and pooled energy resources and data analysis.

As France has set a goal of making all new public buildings constructed positive energy buildings, NEDO is aiming to disseminate the results of the demonstration widely in other cities and countries.



Positive energy building “HIKARI”

Source ©New Energy and Industrial Technology Development Organization (NEDO)
(http://www.nedo.go.jp/english/news/AA5en_100016.html)

GHG emissions reduction potential

Energy demand and GHG emissions from global buildings will reach 40% of total demand in 2050, based on IEA Energy Technology Perspectives (2016). ZEB/ZEH technology can greatly cut down CO₂ emissions.

Innovativeness

This positive energy building complex generates more energy than it consumes by using a comprehensive range of cutting edge-technologies.

Feasibility

This building complex has been verified as a positive energy building. The next step is to make it economically feasible.

Comments by the Top10 Working Group

There is huge potential for this innovation as buildings remain the most common, but commonly ignored, target for rational energy management.