

4. New Businesses

4-1 : Expansion of Hydrogen Utilization Toward a Carbon-Neutral Society

Honda is striving to realize carbon neutrality for all products and corporate activities. Honda is involved in by 2050. Aiming for “zero environmental impact” of not only its products but the entire product lifecycle including its corporate activities, Honda is focusing on the following areas as the “three-pillars” of its initiatives: “carbon neutrality,” “clean energy,” and “resource circulation.” In its initiatives, Honda positions hydrogen as one of the high-potential energy carriers, along with electricity. The “hydrogen circulation cycle,” which starts with renewable energy, consists of three phases –“generate,” “store/transport” and “use.” To be more specific, with the use of water electrolysis technology, electricity derived from renewable energy sources can be converted into “green hydrogen” making it less susceptible to fluctuations in power generation due to seasonality and weather conditions, and it becomes possible to transport the energy to where it is needed in the form of “green hydrogen” via appropriate methods such as transport by land, sea, and pipeline. Honda will expand the applications of its fuel cell system, the core of Honda hydrogen technology, not only to Honda FCEVs but also to various internal and external applications, thereby serving to stimulate demand for hydrogen and facilitating the carbon neutrality of society through the “use” of hydrogen.



*Hydrogen produced by electrolyzing water using renewable energy, which emits no CO₂ during the production process.

4-2: Further advancement of the fuel cell system ,the core of Honda hydrogen technology

Honda was one of the first companies to focus on the potential of hydrogen toward the realization of a carbon-neutral society and has been conducting research and development of hydrogen technologies and FCEVs for more than 30 years. Since 2013, Honda has been working with GM on the joint development of the next-generation fuel cell system.

Advancement of the fuel cell system

In 2024, in North America and Japan, Honda will launch an FCEV model equipped with the next-generation fuel cell system jointly developed with GM. While cost and durability are viewed as typical challenges that needed to be addressed to facilitate widespread use of fuel cell systems, this next-generation fuel cell system, which leverages the knowledge, know-how and economies of scale of both companies, will reduce the cost to one-third compared to the cost of the fuel cell system in the 2019 Honda Clarity Fuel Cell. This significant cost reduction was achieved by various measures including the adoption of innovative materials for electrodes, advancement of a cell sealing structure, simplification of the supporting equipment (“balance of plant”) and the improvement of productivity. Moreover, the durability of the system was doubled by the application of corrosion-resistant materials and controlled suppression of deterioration, and low temperature resistance was also increased significantly.

Building on these achievements through co-development with GM, looking ahead to the future around 2030, when fuel cell use is expected to begin to advance toward full-fledged popularization, Honda has begun fundamental research on future fuel cell technologies with targets to halve the cost and double the durability compared to the fuel cell system co-developed with GM. In doing so, Honda is striving to realize usability and total cost which will enable the fuel cell system to be on par with conventional diesel engines.

Utilization of hydrogen technologies in the field of space technology

Honda is conducting advanced research and development of hydrogen technologies while envisioning use in outer space, another potential area where hydrogen technologies can be utilized. In addition to water and food, people need oxygen, as well as hydrogen for fuel and electricity for various activities supporting life in space. To enable sustainable space activities, it is necessary to reduce the need to resupply these resources from Earth as much as possible. One of the solutions to this challenge is to create a circulative renewable energy system, which combines a high differential pressure water electrolysis system that produces oxygen and hydrogen using solar energy to electrolyze water, and a fuel cell system that generates electricity and water from oxygen and hydrogen. To create such a system, Honda conducted joint research and development with the Japan Aerospace Exploration Agency (JAXA) during the 2021 and 2022 fiscal years (period ended March 31, 2022). Moreover, in 2022, Honda signed a research and development contract*1 with JAXA regarding the “circulative renewable energy system” that is designed to supply electricity to maintain the functionality of the living space and various systems of lunar rovers. Based on this contract, Honda will be commissioned by JAXA to first conduct concept studies, then to develop a “breadboard model”², an early-stage prototype, by the end of the 2024 fiscal year (ending March 31, 2024).

*1 “A contract regarding concept study and prototyping of functional elements for the regenerative fuel cell system for a manned pressurized rover.” A regenerative fuel cell system consists of a water electrolysis system and a fuel cell system. A water electrolysis system electrolyzes water to produce oxygen and hydrogen, and a full cell system generates electricity from hydrogen and oxygen. Honda’s regenerative fuel cell system is called “circulative renewable energy system” as it features Honda’s original high differential pressure water electrolysis system.

*2 Systems to be used in outer space are typically developed by building prototypes in stages, such as a “breadboard model,” “engineering model” and “flight model,” depending on the stage of development.

Starting external sales and expanding applications of the fuel cell system

In light of environmental trends in the world, Honda will continue expanding the application of its fuel cell systems, the core of Honda hydrogen technology, beyond its FCEVs in order to contribute to the realization of a carbon-neutral society. To this end, Honda will begin external sales of the next-generation fuel cell system modules in the mid-2020s. Honda is envisioning the initial sales level of 2,000 units per year and will strive to expand sales in stages, with goals to increase sales to 60,000 units in 2030, and to a few hundred thousand units per year by the second half of the 2030s.

Four core domains

Due to the unique characteristics of hydrogen, which can store and transport energy at high density and fill the tank quickly, the fuel-cell system is expected to be particularly effective as a power source for heavily used large-size mobility products and large-scale infrastructure as well as for mobility products that require quick refueling where it is difficult to be powered by batteries. Moreover, multiple units of the fuel cell system can be connected in parallel to achieve higher output. Based on these characteristics and strengths, Honda has identified four core domains for its fuel cell system applications for the early phase of its entry into hydrogen business: Honda FCEV models, commercial vehicles, stationary power stations and construction machinery and has begun developing hydrogen businesses targeting business-to-business (B2B) customers as well.

1) FCEVs

Honda is planning to begin sales of the all-new FCEV model in 2024 in North America and Japan. This model will be based on the CR-V introduced last year in North America and equipped with the next-generation fuel cell system. In addition to the advantages of FCEVs, which enables long-distance driving with short refueling time, this all-new FCEV model will feature a plug-in function that offers the convenience of EVs which can be recharged at home.

2) Commercial vehicles

In Japan, Honda is planning to start demonstration testing on public roads of a prototype fuel cell-powered heavy-duty truck being researched jointly with Isuzu Motors Limited, before the end of the upcoming fiscal year 2024 (ending March 31, 2024). In Hubei Province, China, in January 2023, Honda began demonstration test driving of commercial trucks equipped with the next-generation fuel cell system in collaboration with Dongfeng Motor Group Co., Ltd.

3) Stationary power stations

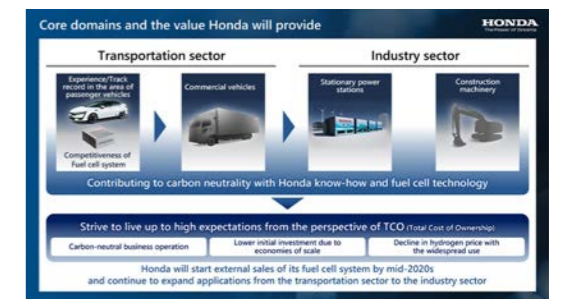
In recent years, the power requirements of data centers have been growing rapidly due to the expansion of cloud computing and big data utilization, and the need for backup power sources has been increasing from the perspective of business continuity planning (BCP). To accommodate such needs, Honda will propose the application of its fuel cell systems in the area of power generation, starting from the application as a clean and quiet backup power source. As the first step, a stationary fuel cell power station with an approximate capacity of 500kW, which reuses fuel cell systems from Honda Clarity Fuel Cell vehicles, was installed on the corporate campus of American Honda Motor Co., Inc. in California, U.S. The demonstration operation of the station as a backup power source for the data center will begin later this month. Subsequent to this testing, Honda will begin applying stationary fuel cell power station technologies to Honda factories and data centers around the world, through which Honda strives to reduce greenhouse gas emissions from its operation as well.

4) Construction machinery

Honda will take initiative to apply its fuel cell system first to excavators and wheel loaders, which account for a large segment of the construction machinery market, contributing to the realization of carbon neutrality for construction machinery. Concerning hydrogen supply for construction machinery which is considered difficult to handle with conventional stationary hydrogen stations alone, Honda will work with construction industry associations and related parties to work toward resolving the challenge.

Expansion of the value chain

In order for more businesses to actively utilize fuel cell systems, it is important to solve issues such as reducing development investment and man-hours for installation, suppressing total cost and ensuring a stable and inexpensive supply of hydrogen. Honda will offer not only development support to adapt its fuel cell system to the customers’ products but also operational support such as after-sales maintenance and a stable supply of hydrogen, thereby making a one-stop contribution to the customers’ efforts toward carbon neutrality.

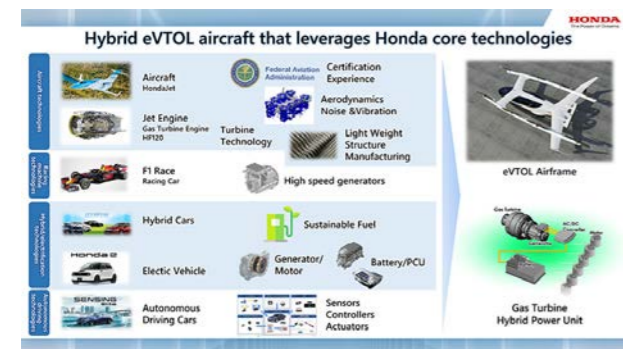


4-3 : Initiatives toward the establishment of hydrogen ecosystems

To achieve widespread utilization of fuel cell systems, it is critical to establish hydrogen ecosystems, that include hydrogen supply. Honda has been supporting the expansion of hydrogen station networks in Japan by participating in the Japan Hydrogen Station Network Joint Company (Japan H2 Mobility/JHyM) and in North America by supporting hydrogen station businesses such as Shell and FirstElement Fuel. From here forward, as a new area, Honda will take an active role in establishing hydrogen ecosystems which center around stationary power stations and start from where demand for hydrogen exists. Honda will also proactively participate in projects organized by national and local governments that utilize large volumes of imported hydrogen at ports and other locations. Through these initiatives, Honda will work to build partnerships with companies involved in this new area. In Japan, working toward the establishment of a hydrogen ecosystem, together with Marubeni Corporation and Iwatani Corporation, Honda has begun discussing the prospects for hydrogen supply and the utilization of fuel cell commercial vehicles. In Europe, Honda is currently planning for demonstration testing of an energy ecosystem that combines renewable energy and hydrogen.

4-4 : Honda eVTOL (electric vertical take-off and landing) aircraft: will make mobility in the skies more accessible for people

To make the mobility in the skies Honda realized with its original HondaJet even more accessible for more people, Honda is developing its eVTOL (electric Vertical Take-off and Landing) aircraft by taking advantage of a wide range of Honda's core technologies. In addition to clean operation realized by electrification technologies, eVTOL features safety at a level equivalent to that of commercial passenger airplanes realized by its simple structure and decentralized propulsive system and quietness due to relatively small diameter of rotors. This makes it possible for eVTOL to take off and land in the middle of a city without causing noise issues. Because of such features, the development race for eVTOL aircraft is getting increasingly vigorous. However, all-electric eVTOL aircraft face a range issue due to limited battery capacity, therefore the realistic use area is limited to intra-city (inside city) transportation. To address this issue and realize user-friendly inter-city transportation with longer range, Honda will leverage its electrification technologies and develop Honda eVTOL equipped with a gas turbine hybrid power unit. Moreover, in addition to electrification technologies, Honda eVTOL will feature technologies Honda has amassed in a number of different areas such as combustion, aerodynamics and control technologies. Honda will strive to create new value for people by establishing a "mobility ecosystem" featuring eVTOL aircraft at its core, coordinated and integrated with mobility on the ground.



Honda eVTOL which leveraged Honda's core technologies

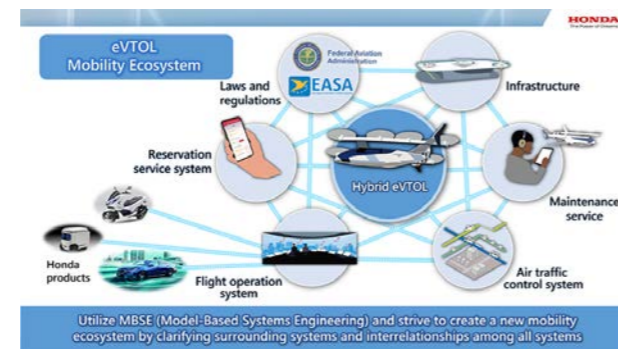
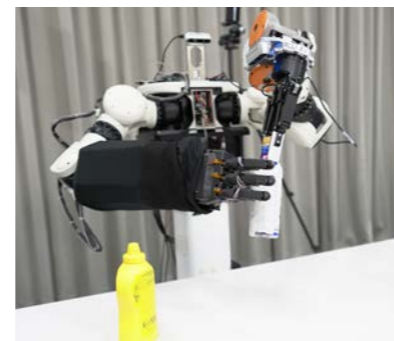


Image of "Mobility ecosystem"

4-5 : Honda Avatar Robot: will make virtual mobility possible

Striving to expand human potential and make people's lives without constraints and more enjoyable, Honda has been continuously working on robotics research, including the research and development of its bi-pedal robot ASIMO. As a part of next-generation Honda robotics, Honda is pursuing development for the practical applications of Honda's original avatar robot to expand the range of human ability virtually without the constraints of time and place.

The greatest merit of an avatar robot, which can act as a second self of the user, is that the user can perform tasks and experience things without being there in person, including the realistic sense of handling objects remotely. What will become the core of the realization of such an avatar robot is the multi-fingered robotic hand developed while leveraging Honda's strengths in robotics technologies and Honda's original AI-supported remote control function. Therefore, Honda strived for an avatar robot which is capable of using its



Multi-fingered hand

multi-fingered hand to make full use of tools designed for human use and performs complex tasks quickly and accurately based on the AI-supported and more intuitive control by the user. To date, Honda has realized a multi-fingered hand with the ability to both delicately pick up a small object with the fingertips and the strength to open a tight jar lid, at the level of the human hand. This has long been a challenge in the field of robotics research. Moreover, in order to enable its multi-fingered hand to grasp an object smoothly in one sequence of moves and handle a tool with precise control of force, Honda is working on the further advancement of its original AI-supported remote control function.

Honda is currently working on downsizing the hardware and further improvement of the precision of robotic hand movements such as "grasping" and "manipulation." Honda is striving to begin technology demonstration testing of the Honda Avatar Robot before the end of the fiscal year ending March 31, 2024, with a vision to put it into practical use in the 2030s.

4-6 : Taking on challenges in the field of space technology

Honda views the field of space technologies as a place to take on new challenges to realize the "dreams" and "potential" of people worldwide while leveraging its core technologies. By leveraging core technologies unique to Honda, such as combustion, guidance, fuel cell and robotics technologies, Honda is pursuing technology development with a goal to create new value in the ultimate environment of outer space.

Challenges on the lunar surface:

- Circulative renewable energy system- Application of Honda technologies to remote-controlled robots

As international momentum for expanding the range of human activities outside the Earth continues to grow, Honda began initiatives to strive for the expansion of human activities and development on the lunar surface. It is said that there is water on the Moon, and various possibilities for the use of water may open up are attracting attention. Honda is conducting a joint research with the Japan Aerospace Exploration Agency (JAXA) with a goal to build the circulative renewable energy system on the lunar surface by leveraging fuel cell technologies and high differential pressure water electrolysis technologies Honda has amassed to date.

By combining Honda's fuel cell technologies and high differential pressure water electrolysis technologies, and by using electricity from renewable energy sources, the system electrically decomposes water and stores hydrogen and oxygen. Then, using that hydrogen and oxygen, Honda's fuel cell technologies, can generate and supply electricity. The oxygen also can be used for people staying at living quarters on the lunar surface, and the hydrogen also will be used as fuel for rockets. By building such a circulative renewable energy system, Honda will strive to contribute to a wide range of human activities on the lunar surface.

Moreover, for the remotely-controlled robots on the lunar surface, which can minimize the risks astronauts will be exposed to and enable people to virtually enjoy the experience of being on the Moon from Earth, Honda is expecting to apply a number of its core technologies. This includes the multi-fingered robotic hand technology and AI-supported remote control technology being developed for the Honda Avatar Robot and the highly-responsive torque control technology for collision mitigation. These research themes were adopted by the JAXA Space Exploration Innovation Hub and the joint research began in February 2021.

Reusable small rocket which will apply Honda's core technologies

Honda also is working on the development of small rockets. This rocket development was initiated by the proposal made by young Honda engineers who wanted to build a small rocket by utilizing core technologies, such as combustion and control technologies, that Honda has amassed through the development of various products.

Artificial satellites are indispensable for various purposes including the observation of the global environment, such as global warming and abnormal weather conditions and also to enable wide-area communication, which is an effective means to provide connectivity to mobility products. However, currently, there are not enough rockets available to meet demand for satellite launches. To address this issue, Honda is developing a small rocket with a goal to use it as a launch vehicle for small low-earth orbit satellites. Moreover, Honda is conducting research with an assumption to make its rocket "reusable" by enabling at least some of the rocket components to land back on earth after the launching. For this challenge, Honda will strive to utilize control and guidance technologies Honda has amassed through the development of automated driving technologies.

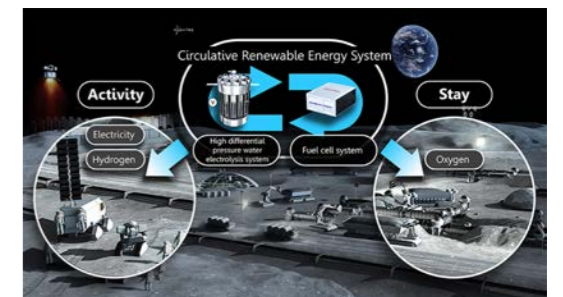
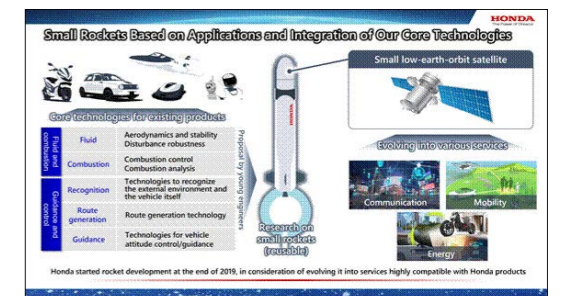


Image of utilizing a circulative renewable energy system on the lunar surface



Reusable small rocket being developed by leveraging the core technologies of Honda

Source: 2021 news release/2023 news release