

# NEXO

## STORY



2018 R&D STORY VOL.1  
HYUNDAI MOTOR GROUP



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## C O N T E N T S

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The contents of this booklet is based on information available during the development of NEXO and specifications may differ from the final version of the product.

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# CONCEPT

A silver Hyundai Tucson ix is shown in profile, parked on a paved area overlooking a rocky coastline. In the background, there is a body of water, a small gazebo-like structure, and a prominent white lighthouse on a hill under a clear blue sky.

## **Journey to the next generation FCEV: From Tucson ix to NEXO**

Creating a ground-breaking product is never easy and the development of NEXO was no exception to the rule. Will a hydrogen society ever become the reality? Will customers make the transition if we offer a compelling fuel cell electric vehicle (FCEV)? How can we establish the hydrogen charging network which is essential for the transition to a hydrogen society? Hyundai Motor overcame all of the doubts and concerns to become the first automaker to mass-produce an FCEV. Hydrogen charging stations are now being installed around the world. We firmly believe that great rewards await those who overcome great challenges. This is the Hyundai Motor motto and what has made the development of Tucson ix and NEXO possible.

# H I S T O R Y

**1998**  
Fuel cell development team incorporated



**2002**  
**Mercury I -P#6**  
• Driving range : 230km  
• Fuel cell system output : 75kW  
• New feature : Incorporation of secondary battery



**2005**  
**Polaris II -80kW**  
• Driving range : 384km  
• Fuel cell system output : 80kW  
• New feature : Localization of fuel cell system

Mercury I \_ P1

Mercury I \_ P6

Mercury II

**2000**  
**Mercury I -P#1**  
• Driving range : 141km  
• Fuel cell system output : 65kW  
• New feature : Hyundai Motor's first FCEV



**2004**  
**Mercury**  
• Driving range : 337km  
• Fuel cell system output : 80kW  
• New feature : Cold-start (-20°C) capability

**2004**  
**Polaris I -P#1-2**  
• Driving range : 205km  
• Fuel cell system output : 35kW  
• New feature : First in-house developed fuel cell stack

**2007**  
**Tucson FCEV - 100 kW**  
• Driving range : 370km  
• Fuel cell system output : 100kW  
• New feature : Localization of electrical drive system

Pioneering a new frontier

## NEXO: The long journey to its creation

Hyundai Motor began developing fuel cell electric vehicles more than 20 years ago, which led to the creation of the fuel cell R&D team in 1998. By 2003, successful in-house development of fuel cell set foundation for independent FCEV development. Hyundai Motor began production of the world's first mass-produced FCEV, the Tucson ix, in January 2013, setting another milestone. Hyundai Motor is one of the most important pioneering forces in the FCEV industry and NEXO will only further accelerate the emergence of a hydrogen society.



Tucson ix FCEV

**2011**  
Development of low-cost materials and mass production technology



Tucson ix mass production model

**2015**  
**1. WardsAuto's 10 Best Engines Award**  
 • World's first FCEV to received 10 Best Engine Award  
 • Exceptional quietness, quick charging, long range and etc. hailed for advancing FCEV technology  
**2. Eco-friendly car of the year 2015 award**  
 by La Revue of France



**2010**  
 1. Fuel cell car achieved 2 million km of driving  
**2. Tucson ix FCEV**  
 • Driving range : 635km  
 • Fuel cell system output : 100kW  
 • New feature : 700 bar high pressure hydrogen tank  
 3. Modularization of core components and development of universal green car components

**2013**  
 1. Cumulative FCEV mileage reaches 2 million km  
 2. Tucson ix mass production model  
 • Driving range : 594km (NEDC cycle)  
 • Fuel cell system output : 100kW  
 • **New feature : World's first mass-produced FCEV**  
 3. 'Price Future Auto' Award received by Federation of Automotive reporters in Belgium  
 • Awarded for technology innovation  
 4. Korean Technology Awards (Silver) / Selected as one of Top 10 new technologies

## Beginning a brand new chapter of automobile industry

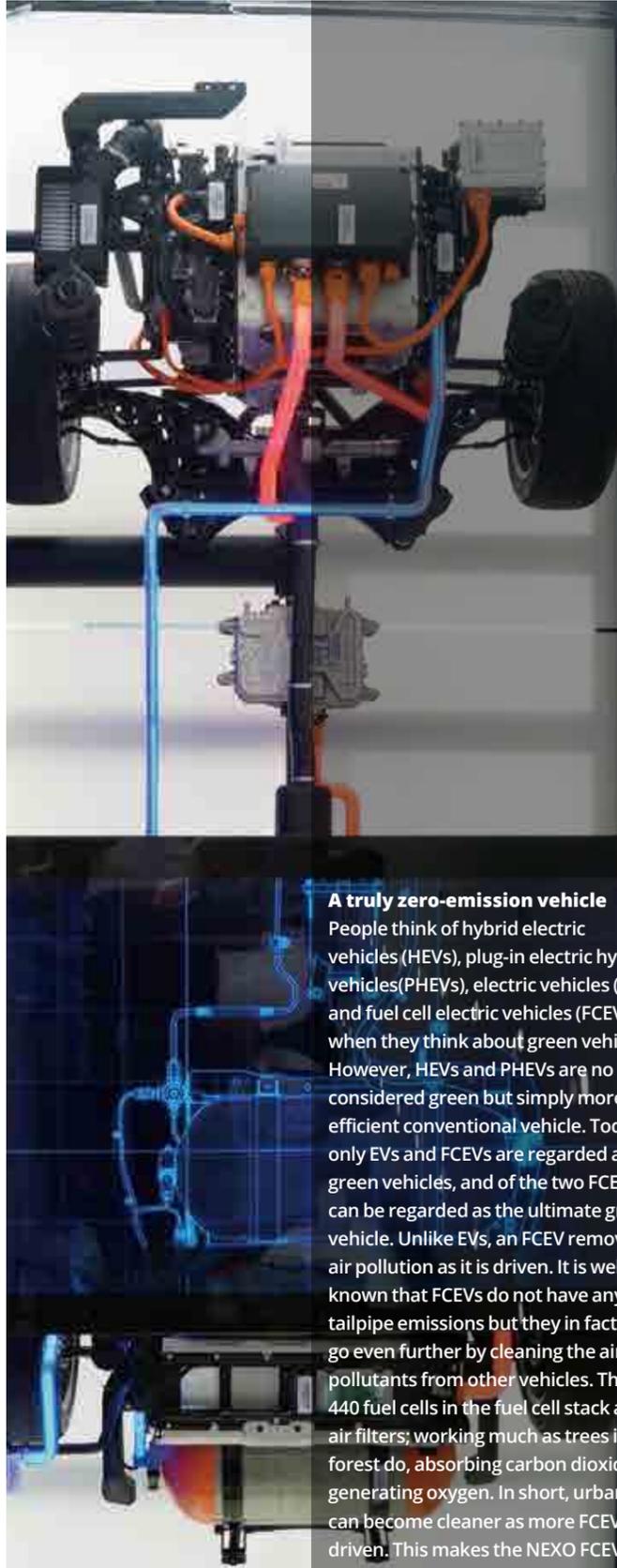
### Philosophy behind the development of NEXO

# New Generation Leader

The automobile is one of the more revolutionary inventions in the history of humanity and it is about to go through a revolution itself. FCEVs are not just an improved version of an old technology but are a revolutionary new technology which will change the way we live and how we interact with the environment. Here is a brief overview of the key milestones which have led to the successful development of NEXO.

The world is changing and the transition to a low carbon economy from a fossil fuel based economy is an important part of it. To encourage this change, many governments have implemented new policies to reduce GreenHouse Gas (GHG) emissions. The South Korean government also announced a national GHG emission reduction plan and roadmap in line with other leading nations. Fuel cell technology is one of the key technologies which has the potential to contribute to the halting of global climate change. Hyundai Motor foresaw the need for low carbon technologies, and planned and worked accordingly to build their capacity during the last 20 years and has now captured the world's attention with NEXO.





## A Truly Zero-Emission Vehicle

**A truly zero-emission vehicle**  
 People think of hybrid electric vehicles (HEVs), plug-in electric hybrid vehicles (PHEVs), electric vehicles (EVs) and fuel cell electric vehicles (FCEVs) when they think about green vehicles. However, HEVs and PHEVs are no longer considered green but simply more efficient conventional vehicles. Today, only EVs and FCEVs are regarded as green vehicles, and of the two FCEVs can be regarded as the ultimate green vehicle. Unlike EVs, an FCEV removes air pollution as it is driven. It is well-known that FCEVs do not have any tailpipe emissions but they in fact go even further by cleaning the air pollutants from other vehicles. The 440 fuel cells in the fuel cell stack act as air filters; working much as trees in a forest do, absorbing carbon dioxide and generating oxygen. In short, urban air can become cleaner as more FCEVs are driven. This makes the NEXO FCEV the ultimate green car.



## The Best Driving Range

**The World's longest driving range**  
 Currently, the biggest difference between EVs and FCEVs lies in the driving range per charge. The NEXO has the longest driving range yet among FCEVs at approximately 600km. This was made possible thanks to in-house development capacity for example the Membrane Electrode Assembly (MEA) for NEXO's fuel cell. The MEA in Tucson ix FCEV was supplied from an external source. In 2005, Hyundai Motor set up an R&D facility at the NGV of Seoul National University and began R&D for MEA which is now mass produced at the Hyundai Mobis plant. Thanks to technology improvements, the size of MEA has been reduced leading to improved power output and ultimately a longer driving range. The long hours and hard work of the R&D staff has made this achievement possible.



## New Technology

**Futuristic user interface and the latest technologies**  
 NEXO stands out with its futuristic exterior design and impressive driving range, yet its user interface may stand out even more. The center fascia information cluster displays energy flow and other useful information to support the driver. It also displays the location of hydrogen charging stations and the hydrogen tank status for ease of mind. The user interface was developed through a sophisticated process which included careful research of user opinions. For examples, the developers organized test drive sessions with potential customers. Overall the user interface was created through a truly user-oriented process. NEXO is also equipped with top of range advanced driver assistance features, including Lane Following Assist (LFA) and Remote Smart Parking Assist (RSPA) which can give the driver a glimpse into the future.



## Halo Effect

**Enhancing Hyundai's brand image**  
 NEXO is an impressive showcase of Hyundai Motor's latest technology. FCEVs cannot attract buyers if their performance, cabin comfort or noise level is inferior to conventional vehicles. While, other FCEV manufacturers have made compromises, Hyundai Motor made the NEXO a zero-compromise vehicle. NEXO is as quiet as an EV and large enough to comfortably seat three adults in the back row with an 840-liter large trunk space. It also has decent acceleration making it a compelling model for consumers and setting it apart from other FCEVs in the market. A great vehicle model can boost brand image. Built with the latest technology, NEXO is a true showcase of Hyundai Motor's latest technologies which will become synonymous with FCEVs and boost Hyundai Motor's brand image.

# PREVIEW

## Creating a big wave from a humble beginning

Hyundai Motor has been pushing for larger scale production of FCEVs since it began successful mass-production of FCEVs in 2013. Hyundai Motor premiered a new FCEV concept at the 2017 Geneva Motor Show in March 2017 and later opened a hydrogen concept house, which gave visitors a glimpse into the future. In addition to communicating with the public to help familiarize them with hydrogen technology, Hyundai Motor has been also working to expand hydrogen station networks. Hyundai Motor's FCEV program had a humble beginning two decades ago but is now creating waves around the world.

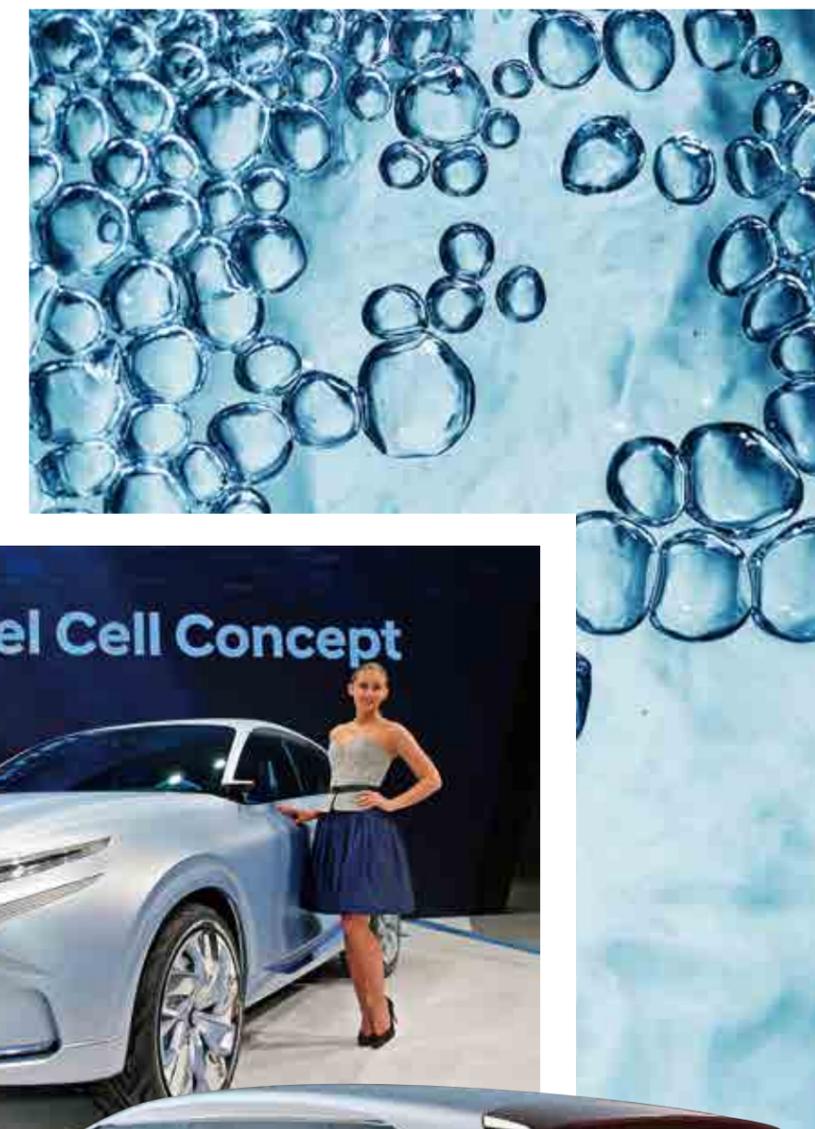


# FE Fuel Cell Concept



## FE Fuel Cell Concept

New models premiered at major motor shows generate different reactions, ranging from disappointment to a great buzz. Hyundai Motor's NEXO was definitely the latter; generating a great buzz as it presented an exciting glimpse into some new possibilities for the future. Here is a summary of how it generated such a buzz as a concept model at the Geneva Motor Show and on its debut as a part of the hydrogen concept house.



### NEXO: Premiere at 2017 Geneva Motor Show

The Geneva Motor Show is one of the five largest motor shows in the world, along with international motor shows in Frankfurt, Detroit, Tokyo and Paris. Held at Geneva Palexpo convention center in early March, the Geneva motor show is the largest motor show held in a country without a major domestic automaker and has become the event for premiering concept models. Because of its timing in the year, it has a reputation for being the showcase for new trends in automobile design.

On March 7th, 2017, Hyundai Motor surprised the world with its premiere of the FE FCEV concept at the Geneva Motor Show. The FE concept set a new benchmark in FCEV technology with performance on par with the latest conventional vehicles, an outstanding range of 600km per charge, and a new fuel cell system which is 20 percent lighter and 10 percent more energy-efficient than the fuel cell

system in the Tucson ix FCEV. The FE concept was also hailed for its streamlined design profile, with such elements as the stylish rear spoiler and C-pillar vent for improved aerodynamics.

Over 900 new models were displayed at the 2017 Geneva Motor Show, with 148 models making their world or European premiere. A large number of new models were green vehicles, providing a clear indication of the transition to a green vehicle market.

Hyundai Motor has been pushing for public uptake of hydrogen cars since it became the first automaker to mass-produce an FCEV in 2013 and began selling FCEVs in 17 countries. At the Davos Forum held in January 2017, Hyundai Motor became an official member of the Hydrogen Council and announced its plan to launch a next-generation FCEV equipped with an advanced driver assistance system at the 2017 CES held in the same month. The premiere of the FE concept further bolstered Hyundai Motor's position as a leader in FCEV technology.

### Unveiling the next-generation FCEV - using Hyundai Motor's heritage and built to lead

Hyundai Motor unveiled the next-generation FCEV, which was then displayed between August 17th through November 17th at the hydrogen concept house built at the Yeouido Han River Park last year. Hyundai Motor hosted a next-generation hydrogen concept house media event at the 63 Convention Center and unveiled its green vehicle strategy. The new FCEV, slated for 2018 release, announced at the event, was a mass-production model based on the FE FCEV concept car unveiled at the Geneva Motor Show. Built with Hyundai Motor's latest electric powertrain, fuel cell system and other advanced automotive technologies, the next-generation FCEV impressed media reporters and industry professionals who attended the event.

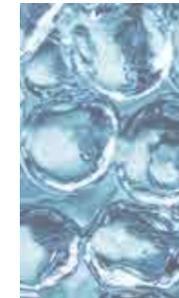
The new FCEV had many improvements over the Tucson ix FCEV which was released in 2013. With its improved performance characteristics, greener image, distinctive exterior design and the seamless integration of advanced technologies, the new FCEV generated an excited buzz from the media. For example, its maximum power output was rated at 163 horsepower which is 20 percent higher than the Tucson ix FCEV.

The fuel-cell SUV also has improved cold-start capability which has long been an obstacle to proliferation of FCEVs in cold regions. It can now be started at temperatures as low as -30 degrees Celsius. Its fuel cell system boasts vastly improved durability of 10 years and 160,000 kilometers, which is equivalent to a conventional vehicle.

Thanks to the optimized hydrogen tank package, it boasts the highest hydrogen storage density. Slated for official launch in early 2018, the next-generation FCEV comes equipped with advanced driver assistance systems such as Lane Following Assist (LFA) and Remote Smart Parking Assist (RSPA), greatly enhancing driver convenience and safety.

Hyundai Motor also unveiled its green vehicle roadmap which aims to increase its green vehicle lineup from the current 14 models to 31 models by 2020. R&D efforts will continue to further improve the fuel cell system so that it can be smaller, lighter and more powerful, and thereby making a sedan FCEV model possible.



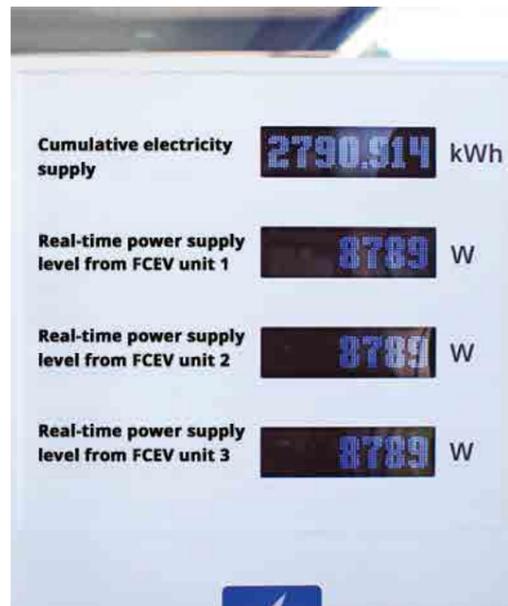


**Unveiling the world's first hydrogen concept house**

The unveiling of the world's first hydrogen concept house received a lot of media attention alongside the next-gen FCEV that was announced on the same day. Built in collaboration with Seoul Metropolitan Government, the house gives a glimpse of how a hydrogen car can power our house and change the way we live. The concept house is powered using electricity generated by an FCEV which uses clean hydrogen as fuel. The concept house gives a taste of how our life can change when FCEVs, which generate clean electricity, become the norm.

The hydrogen concept house covers over 231m<sup>2</sup> with two FCEVs displayed inside. It has kiosks and interactive booths which allow visitors to experience various aspects of FCEVs and the hydrogen house including the operation mechanisms of an FCEV, how FCEVs generate electricity and how zero emission vehicles work. It also has a hydrogen science booth for young children. The house is staffed with docents and Augmented Reality (AR) tools. They help visitors understand the technologies in the hydrogen house by guiding them through the house with interactive demonstrations to enhance the learning experience. Overall, the hydrogen concept house demonstrates how hydrogen can not only change the way automobiles work but how it can change the entire way we live.

Hyundai Motor has long been serving as an official partner at the EU FCEV demonstration program and supplies 70% of the FCEVs sold in Europe until the first half of 2017. With worsening air pollution problems in every major city, the importance of clean vehicles is constantly increasing. Hyundai Motor's next-generation FCEV continues Hyundai's heritage and its industry leadership and is positioned to play a major role as we make the transition to a hydrogen society.





# Preparing for a hydrogen society: Hydrogen fueling network construction plan

FCEVs have many positive qualities that make governments worldwide welcome them. However, the current lack of hydrogen charging stations make the wide deployment of FCEVs difficult. Many governments have now announced hydrogen station network expansion plans to tackle this problem. Here is an overview of the plans that have been announced by governments and the current state of the network.

### US : 123 hydrogen stations by 2023

In 2013, the US government announced Transportation Energy Futures which aims to reduce oil consumption in the automobile sector by 50 percent by 2030 and achieve an 80 percent reduction in oil consumption and related air pollution by 2050. The plan predicted 27 percent of new cars sold in the US by 2050 will be FCEVs.

In 2013, the US Department of Energy also published the Hydrogen Production Technical Team Roadmap. The plan aims to reduce the proportion of conventional vehicles powered using fossil fuel to 10 percent by 2050, by increasing the use of hydrogen energy in the transport sector.

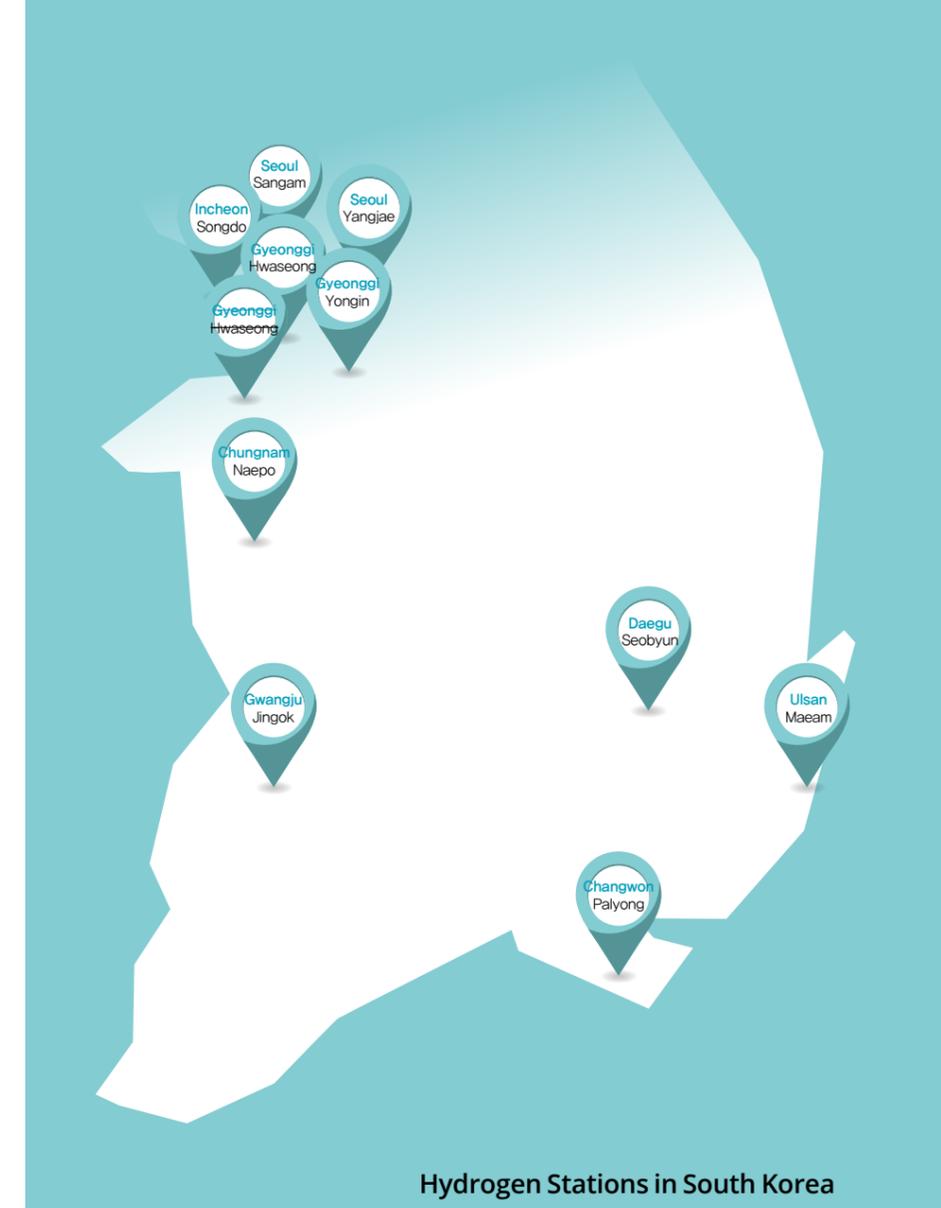
California state government announced 'A California Road Map : The Commercialization of Hydrogen Fuel Cell Electric Vehicles' in 2014. The plan includes construction of 123 hydrogen stations and cumulative FCEV sales of between 30,000 and 60,000 by 2023.



### Hydrogen network expansion in Europe

According to the UK H2 Mobility plan announced in 2012, the UK government plans to build 65 hydrogen stations by 2020 and 1,150 stations by 2030. The plan also aims for sales of 274,000 FCEVs by 2020 and 1,586,000 FCEVs by 2030.

In 2013, the French government announced 'H2 Mobility France' which aims to deploy 800,000 FCEVs and 600 hydrogen stations by 2030, which is significantly less ambitious than the UK government plan. Denmark and Norway announced Nordic Hydrogen and Fuel Cells Roadmap in 2013 outlining their targets. According to the plan, Denmark aims to build 185 hydrogen stations by 2025 and increase it to 1,000 stations by 2030. The plan includes a subsidy scheme to support the construction of hydrogen stations. Germany is a clear leader in FCEV technology development in Europe. Already in 2006, Germany announced their National Innovations Program. In 2011, the German government announced H2 Mobility plan which aimed to build 373 hydrogen charging stations and deploy 156,000 FCEVs.



Hydrogen Stations in South Korea

**Japan’s three-phase plan and China aiming to be a global FCEV leader**

The Japanese government announced its hydrogen fuel cell strategy roadmap to 2040, which plans to make the 2020 Tokyo summer Olympics a turning point in the transition to a hydrogen society. The first phase is to make FCEVs available for the 2020 Tokyo Olympics. The 2nd phase aims to deploy hydrogen-electricity generation with advanced hydrogen storage and transport technologies by 2030. The third phase goal is to create CO<sub>2</sub>-free hydrogen supplies by 2040. As of early 2018, Japan has 91 hydrogen stations. The plan aims to construct 1,000 and 5,000 hydrogen stations by 2020 and 2030 and deploy 50,000 and one million FCEVs by 2020 and 2030 respectively.

The Chinese government recently designated FCEVs as a future industry and announced a FCEV deployment target of 5,000, 50,000 and one million units by 2020, 2025 and 2030 respectively. Hydrogen station construction targets are 100, 300 and 1,000 stations by 2020, 2025 and 2030 respectively. China aspires to become a leader in the FCEV industry and plans to focus its effort in the Shanghai region. Initial goals for Shanghai is deployment of 3,000 FCEVs and construction of 5 to 10 hydrogen stations by 2020 and 30,000 FCEVs and 50 hydrogen stations by 2025.

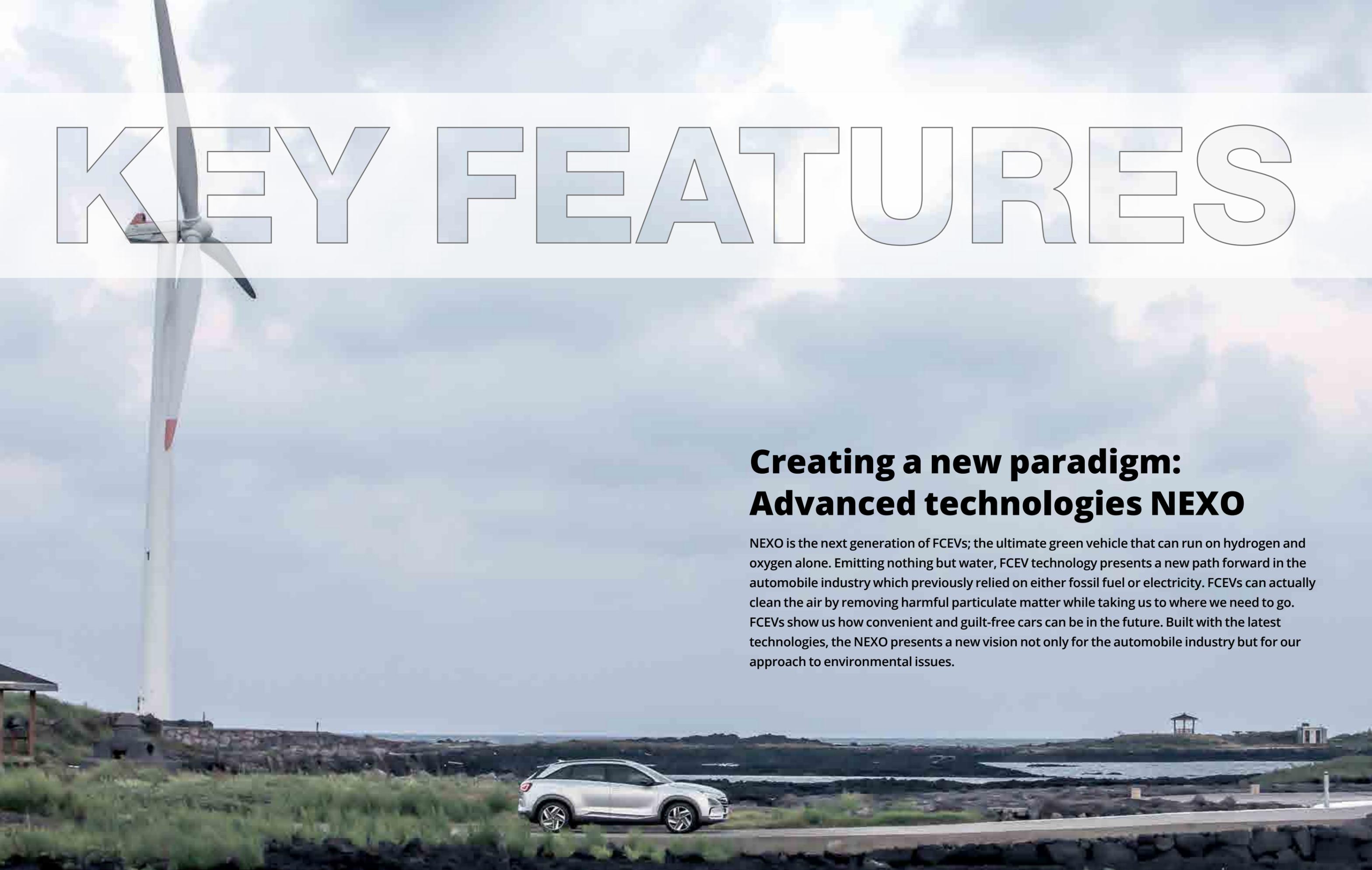
**South Korea’s plan for hydrogen station network expansion**

As of March 2017, South Korea has 114 FCEVs according to

official government registration data. South Korea has 11 hydrogen stations including the first LPG-hydrogen charging station constructed in Ulsan in August 2017. In 2018, two additional hydrogen stations will be built in Pyeongchang and Gangreung city as part of the Hydrogen Electric Bus Charging station monitoring program, prior to the start of the Winter Olympics. Construction of hydrogen stations has been slow considering Tucson ix FCEV’s mass production started in 2013. The South Korean government announced FCEV and hydrogen station deployment goals of 10,000 units and 100 stations by 2020 respectively. The Ministry of Land and Transport (MOLIT) recently announced plans to support the establishment of 200 rest areas each with hydrogen chargers, EV chargers and LPG chargers with shops and restaurants.

The FCEV industry welcomed MOLIT’s announcement and other ministries made statements to support the implementation of MOLIT’s plan. According to the plan, 60 of the rest areas will be built along national highways and 60 will be built along major public roads near large cities. The rest will be built in urban areas including city beltways. Alternative fuel suppliers including CNG, LPG and electric charging station operators are expected to experience a boost to their business. Expansion of the hydrogen station network is an essential prerequisite to the emergence of a hydrogen society alongside continued improvements to FCEV technologies.

# KEY FEATURES

A silver NEXO SUV is parked on a paved road in a coastal landscape. In the background, a large white wind turbine stands tall against a cloudy sky. The foreground shows green grass and a low stone wall. The overall scene is bright and open, suggesting a clean, sustainable environment.

## **Creating a new paradigm: Advanced technologies NEXO**

NEXO is the next generation of FCEVs; the ultimate green vehicle that can run on hydrogen and oxygen alone. Emitting nothing but water, FCEV technology presents a new path forward in the automobile industry which previously relied on either fossil fuel or electricity. FCEVs can actually clean the air by removing harmful particulate matter while taking us to where we need to go. FCEVs show us how convenient and guilt-free cars can be in the future. Built with the latest technologies, the NEXO presents a new vision not only for the automobile industry but for our approach to environmental issues.



**FCEV:  
In a league of its own**

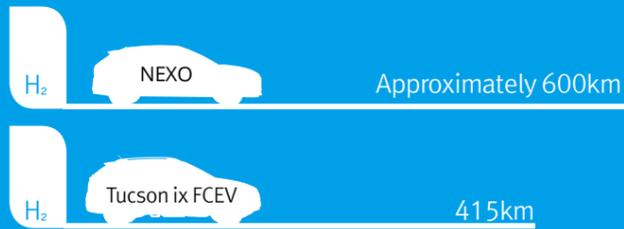
NEXO is the next-generation FCEV and very different from the typical automobile currently seen on the road. It does not require polluting fossil fuels or a heavy battery to run. Instead it only needs hydrogen and oxygen to generate its own electricity which in turn powers the electric motor that turns the wheels. It is a technologically sophisticated green vehicle which offers everything a conventional vehicle offers. Thanks to its high energy efficiency, long range travel is not a problem and it can be conveniently refueled in just a few minutes. FCEVs even remove particulate matters on the go, making it truly a next-generation vehicle.

*Requiring superb endurance and will power, cross country skiing is often referred to as a marathon on snow.*

**Going the distance**

In terms of energy density, hydrogen is the lowest while fossil fuels have the highest. Amongst the transport fuels, diesel has a higher density than gasoline. However, hydrogen becomes a highly competitive energy when it is stored at high pressures and processed through a fuel cell for electricity generation. In short, a hydrogen fuel cell is three times more efficient than gasoline.

NEXO the next-generation FCEV that runs on a highly efficient hydrogen fuel cell, continuing the legacy of the Tucson ix FCEV, the first mass-produced FCEV in the world. NEXO boasts a significantly improved system level energy efficiency of 60 percent thanks to the improved fuel cell stack and components. It has a driving range of 600km based on the official test cycle of South Korea, giving NEXO drivers the freedom to go anywhere they want to go.



**Saving precious time**

The speed of technological improvements is often faster than expected. For example, we already have EVs which can travel 600km per charge, equivalent to a compact ICE sedan. EVs are zero emission and relatively cheap to charge. Many governments also offer generous subsidies for EVs, making them affordable. Yet, EVs still account for only approximately 1 percent of sales in major markets, largely due to their long charging time. There is also a general concern about the lack of EV chargers but the long charging time is the biggest problem. EVs with a range comparable to ICE vehicles take more than one hour to fully charge even using a rapid charger. Whereas, hydrogen cars can be charged much faster. For example, a NEXO with a 700-bar hydrogen tank can be fully charged in 5 minutes, saving precious time.

	Tailpipe emissions	Charging time
NEXO	Zero	Less than 5 minutes
EV	Zero	30 minutes to 4 hours
HEV	CO <sub>2</sub> , CO, NOx	Within 5 minutes

**Considerate choice for our future**

FCEVs are powered using electricity generated through a chemical reaction between hydrogen and therefore do not use fossil fuels, or emit air pollutants or greenhouse gases from the tailpipe. NEXO takes things a step further by removing fine particulate matters from the air that is passed through its air intake system supplying oxygen to the fuel cell. The air intake system first removes particulate matters and other pollutants using a filtration system. Approximately 97 percent of particulates with size of 2.5 micrometer (µm) in diameter gets filtered. The carbon paper within the fuel cell stack removes most of the particulate matters that were not removed by the filtration system. They are then either burned when electricity is generated or removed by water. Overall, NEXO is built to take care of the environment.





## Bringing the future closer to us

NEXO is equipped with a 4th-generation fuel cell system which has all the merits of the fuel cells currently available in the market. The 4th-generation fuel cell system is what sets NEXO apart from other FCEVs. Most importantly, the new fuel cell system boosted the basic performance characteristic of NEXO to the next level.

While other green vehicles compromise in different ways including range and performance, NEXO makes no compromises with high power output and outstanding efficiency. It has 163 horsepower and a 600km driving range, comparable to most conventional vehicles. In short, the 4th-generation fuel cell system has brought the age of FCEVs closer to reality.

*Speed skating is an intense ice sport, in which the winner is decided by a split second acceleration, muscle endurance, and agility are required to win.*

**Opening a new chapter in energy: fuel cell system**

It has been a while since we realized the urgency of solving the environmental problems created by using fossil fuels. Collectively, we concluded that a transition to clean energy is necessary and solar and wind energy emerged as prominent alternatives. Many believe that using electricity from solar and wind energy can solve the problems we face. However, fossil fuels continue to dominate. This is because there is a mismatch between location and the time of electricity generation and consumption with wind and solar.

In short, renewable energy sources cannot be utilized effectively without large batteries to store electricity during peak production periods and release it during peak consumption periods. Even larger batteries are needed to store excess electricity produced on especially sunny or windy days. Yet, there are technological limitations with regard to how much electricity can be stored in a battery. The cost and weight of a battery increases with size, leading to reduced efficiency especially in automobile applications.

Fuel cells have emerged as a solution to these problems. First because a hydrogen tank has a much higher energy density and lower cost compared to a battery. Hydrogen can also be transported much more easily in a compressed form. Here is an overview of how a hydrogen fuel cell energy system could work. First, generate electricity using renewable energy. Second, use the electricity to produce hydrogen from water. Third, collect the hydrogen in a storage tank. Fourth, use the hydrogen to generate electricity.

Hyundai Motor saw great potential in fuel cell technology and came to firmly believe it was the ideal powertrain of the next-generation of automobiles. Hyundai Motor began researching and developing FCEVs at the beginning of the 21st century and shortly thereafter surprised everyone with the world's first mass produced FCEV in 2013. In 2018, Hyundai Motor surprised the world once again with the release of the 2nd-generation FCEV, NEXO. Equipped with a 4th generation fuel cell system, NEXO outcompetes all other FCEVs in the market with unprecedented performance characteristics.



**Advanced core components of fuel cell system**

**Generating electricity: Fuel cell stack**

Fuel cells rely on a reverse electrolysis process. A hydrogen fuel cell consists of cathodes and anodes with electrolyte membrane between them. On the anode side, hydrogen diffuses to the anode catalyst where it later dissociates into protons and electrons. The protons are conducted through the membrane to the cathode, but the electrons are forced to travel in an external circuit (supplying power) because the membrane is electrically insulating. On the cathode catalyst, oxygen molecules react with the electrons and protons to form water. A single fuel cell, consists of the three components and generates electricity at 1 voltage level. The fuel cell stack consists of individual fuel cells connected in a series to increase the voltage high enough to operate an automobile.

**Membrane electrode assembly produced with multi-facet bonding technology**

Each cell in a fuel cell stack is made up of a cathode, anode and electrolyte membrane which is also referred to as a Membrane Electrode Assembly (MEA). Within the fuel cell stack, MEA plays the critical role of generating electricity through the chemical reaction between hydrogen and oxygen. Therefore, the performance characteristics of MEA are directly linked to the performance of FCEVs including power output, durability and cold-start capability. MEA is manufactured by bonding cathodes and anodes onto an electrolyte membrane and bonding a gas diffusion layer on both sides of the membrane.

**Accelerating the dawn of a new age:  
4th generation fuel cell system**

Fuel cell systems can be classified into two types, depending on the fuel cell stack operation pressure. Each type has its own strengths and weaknesses. A low-pressure system boasts higher energy efficiency as well as NVH and durability. However, its power output is reduced at high altitudes and in high temperatures. It is also more difficult to reduce the size of fuel cell stack.

A high-pressure fuel cell requires less water for humidification of the stack and operates favorably in high-temperatures, and can be cooled more easily. However, the high-temperature electrode membrane still needs much improvement and the high-pressure system has inferior NVH compared to the low-pressure system. Hyundai Motor's Tucson ix FCEV employs a low-pressure system while competitors employ a high-pressure system.

NEXO's 4th generation fuel cell system is neither a low-pressure or high-pressure system. Hyundai Motor learned a great deal while developing the Tucson ix FCEV and used this knowledge to develop a brand new system tailored especially for the NEXO. Built to achieve superior performance, efficiency and range, Hyundai Motor developed a new variable pressure fuel cell system which brings the best of both types of fuel cell stacks. The 4th generation fuel cell system has brought the dawn of the new age in FCEVs faster than anyone anticipated.



**System output**

135kW (Stack 95kW + Battery 40kW)  15kW

**The fuel cell subsystem**

Efficiency (urban mode): 60%  4.7%

Power density: 3.11kW/L  1.01kW/L

Durability (warranty basis): 10 years / 160,000km  6 years / 80,000km

Cold start-up / Cold-start capability : -30°C, 40 seconds  -5°C

**Electric drive subsystem**

Motor output: 120kW  20kW

Motor torque: 395Nm  95Nm

**Hydrogen storage system**

Hydrogen storage capacity: 6.33kg  0.7kg

Storage capacity: 156.6L (3 tanks)  16.6L

Hydrogen storage density: 5.7wt%  1.3wt%

NEXO

FUEL CELL



**Hydrogen Storage System**  
 Three equally-sized tanks for maximum range at lowest possible cost

**PFC (Powertrain of Fuel Cell)**  
 Fuel cell and electric powertrain integrated in a single module to for easier mass-production

**Hydrogen storage system**  
 - Three 52-liter tanks for cost reduction  
 - Maximum range with increased hydrogen stored per volume

**BHDC**  
 - Battery charge/discharge control

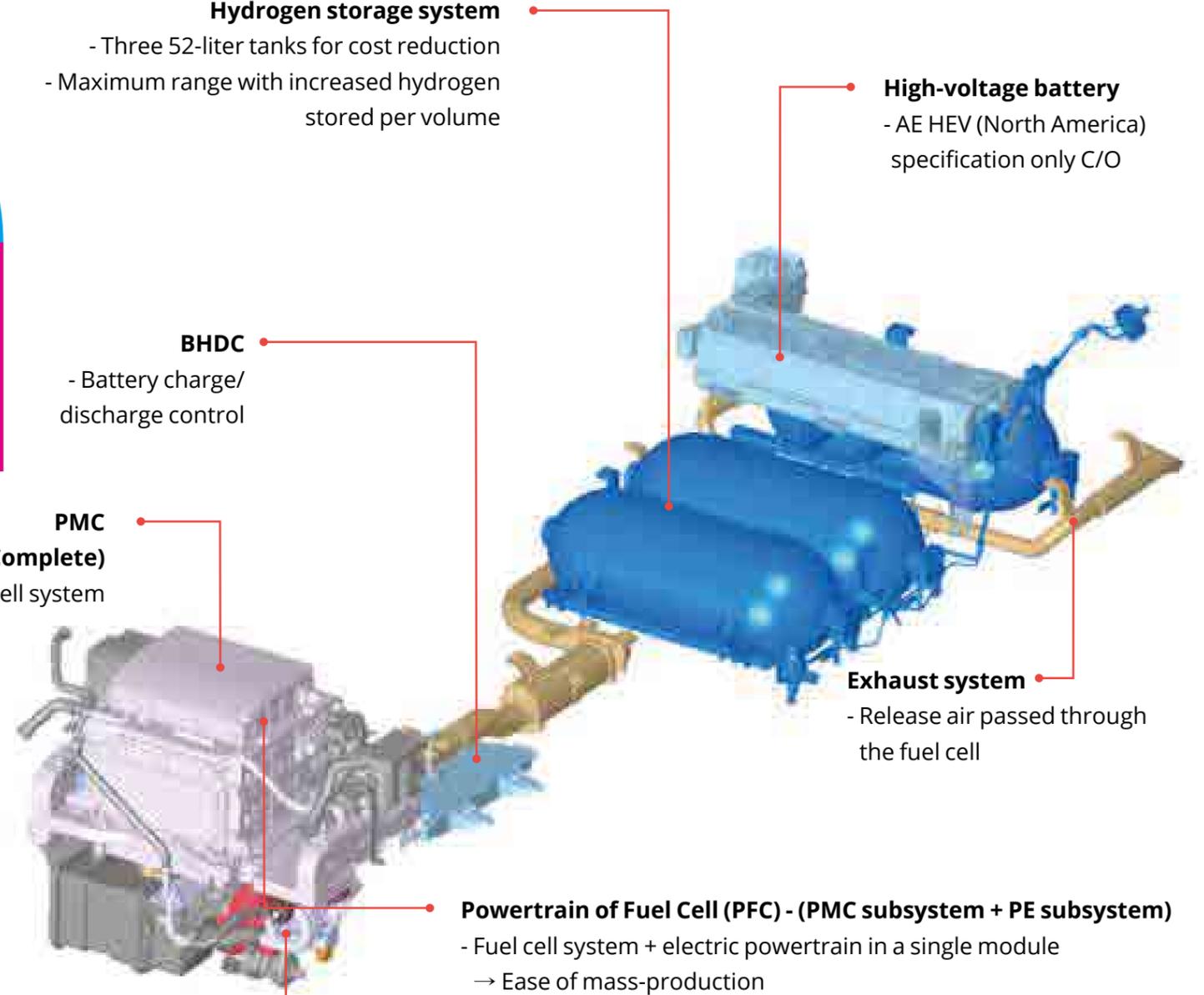
**PMC (Power Module Complete)**  
 - Fuel cell system

**Power Electric (PE)**  
 - Electric motor + reduction gear + inverter

**Powertrain of Fuel Cell (PFC) - (PMC subsystem + PE subsystem)**  
 - Fuel cell system + electric powertrain in a single module  
 → Ease of mass-production  
 - Consists of PMC + PE (electric motor/reduction gear/inverter)

**High-voltage battery**  
 - AE HEV (North America) specification only C/O

**Exhaust system**  
 - Release air passed through the fuel cell



## Tomorrow's technology today

As an automobile, NEXO can be used to drop the kids off at school, to go to the supermarket and for weekend trips. It provides a space where intimate conversations can take place and great stories and music can be listened to on the sound system. NEXO may be with us today but it is a car of the future. Thanks to the innovative fuel cell inside, it does not emit any pollutants. It has the potential to not only change how automobiles work but how our energy system itself works. NEXO might be the automobile of tomorrow but it is here today. NEXO's design reflects how it is built with tomorrow's technology for today.

*The artistry sets figure-skating apart from other winter sports  
great performance requires both outstanding technique and the best artistic talents.*



All designs are made for the future, as every product designed today is then made and used later. Even the incorporation of retro elements in a design are made for the future as well. The same rule applies to automobile design. It takes between three to five years to develop a new model from start to finish. It usually takes five years and sometimes longer to bring a vehicle to market from the day of inception. A newly released car was generally conceived at least five years ago on a sketchbook. It usually takes five years for a next-generation model to be released, so the design at conception stage needs to stay relevant for the next 10 years.

New models incorporate improved technologies as well as technologies that did not exist before, to provide a better driving experience. Such technologies make futuristic designs possible, especially for green vehicles. Green vehicles are built

for a cleaner and better future and their designs reflect this. For example, IONIQ Electric does not have a front grille and the Sonata hybrid has a different tail lamp color. Such design choices are made for various reasons including technological and marketing purposes. This is also the reason why green vehicles by Japanese automakers have quite eccentric looks. Such designs are ways to express how different they are compared to conventional cars. NEXO's designers struggled to find ways to create a distinctive design to set it apart from not only conventional vehicles but from other green vehicles as well. The design had to reflect NEXO's distinctive identity as an automobile equipped with a fuel cell system which may revolutionize our entire energy system. NEXO's design had to reflect its significance as the next-generation fuel cell electric vehicle, equipped with technologies and features

that allow us to experience the future. A great design had to be created to instantly communicate the essence of NEXO to everyone who sees it.

The NEXO design team began with a fresh new design unlike any conventional vehicle in the market, incorporating distinctive new elements and setting a new design direction. Effort was made to create new design elements to emphasize its greenness. However, after some time the decision was made to scrap the initial design concept for a complete overhaul.

The decision was made because NEXO is not a concept car for the future but instead it is a mass production car for today. Although it is equipped with cutting-edge fuel cell technology, NEXO is built to be sold at a dealership and not just at motor shows. Therefore, its design should be familiar to customers

who will be driving NEXO on the road today. Its greenness should be expressed in a subtle and natural manner.

In the end, a pebble served as the new design motif for NEXO's exterior. Created by nature, each pebble has a natural round shape sculpted by the rain, rivers and other natural processes over many hundreds of years. Its natural and highly aerodynamic curves made a pebble the ideal source of inspiration for NEXO.

Futuristic elements were incorporated into many of the small details of NEXO's exterior which gives NEXO a fresh new look unlike any other mass-produced model by Hyundai Motor so far. Its simple interior was also inspired by nature, with a hint of the future including matte materials and a smooth center console. NEXO has the best blend of today and tomorrow in a single package.



### ● Horizon positioning lamp

The front of NEXO has Hyundai Motor's latest SUV family look. Front of NEXO is designed in line with Hyundai SUV's family look. A horizon positioning lamp stretches across the front hood line just above the headlamps. NEXO is the first Hyundai vehicle with a horizon positioning lamp, giving NEXO a distinctive look. The horizon positioning lamp along the front hood line is precisely blended into the bonnet line, enhancing safety during the day and creating a cool look at night.



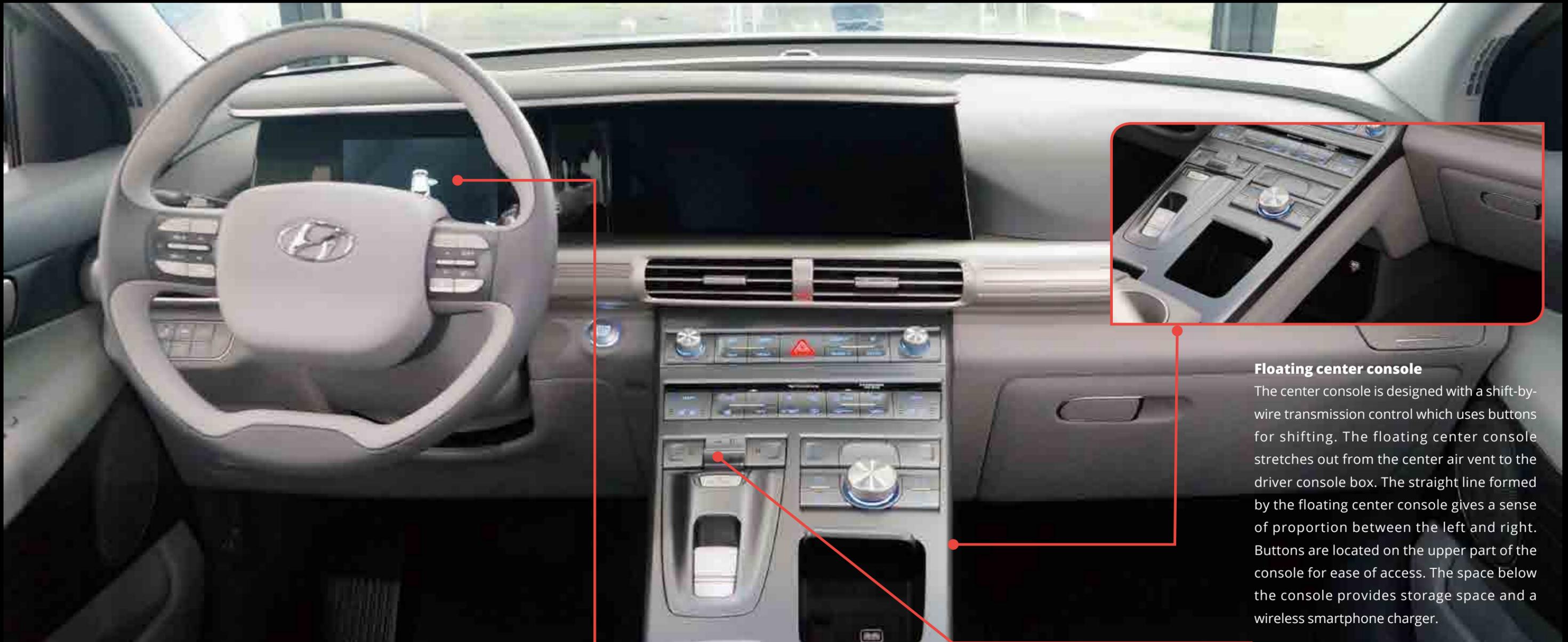
### ● Hidden rear wiper

Front wipers are generally stored under the front end of a windshield beneath the bonnet line for reduced air drag and a streamlined clean-cut front look. However, rear wipers are exposed in most models leading to the collection of dust on the rear windshield. The rear wiper of NEXO is stored away when it is not in-use and swings down during operation, eliminating the possibility of dust collection on the rear windshield while further enhancing its clean-cut design.

### ● Auto flush door handle

Pebbles with smooth natural curved lines served as the design motif for not only NEXO's exterior but for other design elements. Many of the design elements were carefully crafted to enhance NEXO's smooth exterior. The auto-flush door handles, which hide away when locked, is a key example. The door handle pops out when touched and is tucked away when NEXO is been driven, giving NEXO a futuristic look.





**Floating center console**

The center console is designed with a shift-by-wire transmission control which uses buttons for shifting. The floating center console stretches out from the center air vent to the driver console box. The straight line formed by the floating center console gives a sense of proportion between the left and right. Buttons are located on the upper part of the console for ease of access. The space below the console provides storage space and a wireless smartphone charger.

**Integrated display screen**

A 12.3-inch integrated display screen functions as a digital instrument cluster and infotainment screen. Spanning about half of the center fascia in width, it allows for the effective communication of information. Drivers can effectively obtain the necessary information from the display screen. The screen setup is also ideal for FCEV's specific user interface. The smooth curved lines give a futuristic flair to NEXO's interior.



**SBW (Shift By Wire)**

NEXO uses hydrogen to generate electricity which in turn operates the electric motor. Because it does not have a mechanical transmission, gear changes are made with the press of a button thanks to the shift-by-wire technology. It has four buttons corresponding to P-R-N-D in place of a transmission lever, allowing for a clean-looking layout. Finally, the hand rest is ergonomically designed for ease of use.



## Boosting energy efficiency with aerodynamic design

NEXO is the first 2nd generation mass production FCEV model built with know-how from the 1st generation FCEV model. While increased power output and improved system efficiency helped increase the overall operation efficiency, improved aerodynamics played a significant role as well. NEXO's 600km driving range was achieved thanks to its exterior design which not only looks great but is highly aerodynamic.



*Nicknamed as F1 racing on ice, bobsleighbing requires sleds with exceptional aerodynamics.*



# D Pillar Air Curtain & Auto Flush Door Handle

## D-PILLAR AIR CURTAIN

NEXO's rear windshield glass is tilted forwards, this design choice was made to help create an extra smooth exterior design. This created variance in the distance of air traveled along the side of NEXO to the rear end of NEXO, which in turn created stronger turbulence than usual. D-Pillar air curtain with a smaller opening in front and larger opening in the rear increases the speed of airflow which in turn reduces turbulence, counteracting the turbulence with a powerful wind.

## AUTO FLUSH DOOR HANDLE

Auto flush door handles do not just create a high-tech image but also reduce air drag. Door handles are not needed while a car is being driven and in fact they negatively affect aerodynamics. The NEXO development team created an auto flush door handle which is tucked inside the door when its not in-use. The door handle then pops out when its pushed and tucks back in when the door is closed.

## AIR CURTAIN

Air curtains are becoming increasingly common and NEXO is no exception. Air curtain allows air to flow through a vent underneath the headlamps and out around the wheels, creating a smooth flow of air from the front of NEXO. The enhanced air flow leads to reduced air drag compared to a conventional design where all the air that makes contact with the front bumper is then pushed to the side of the vehicle.

## TWO PIECE AERO WHEEL

Wheels with larger openings between the spokes provide greater airflow which in turn creates greater air resistance. However, eliminating the opening can make wheels heavier and brake cooling more difficult. As a solution, NEXO engineers developed a two piece aero wheel which has a five spoke wheel and additional lightweight piece to reduce air drag with minimum increase in weight.



# Air Curtain & Two Piece Aero Wheel

## Great features for great choice

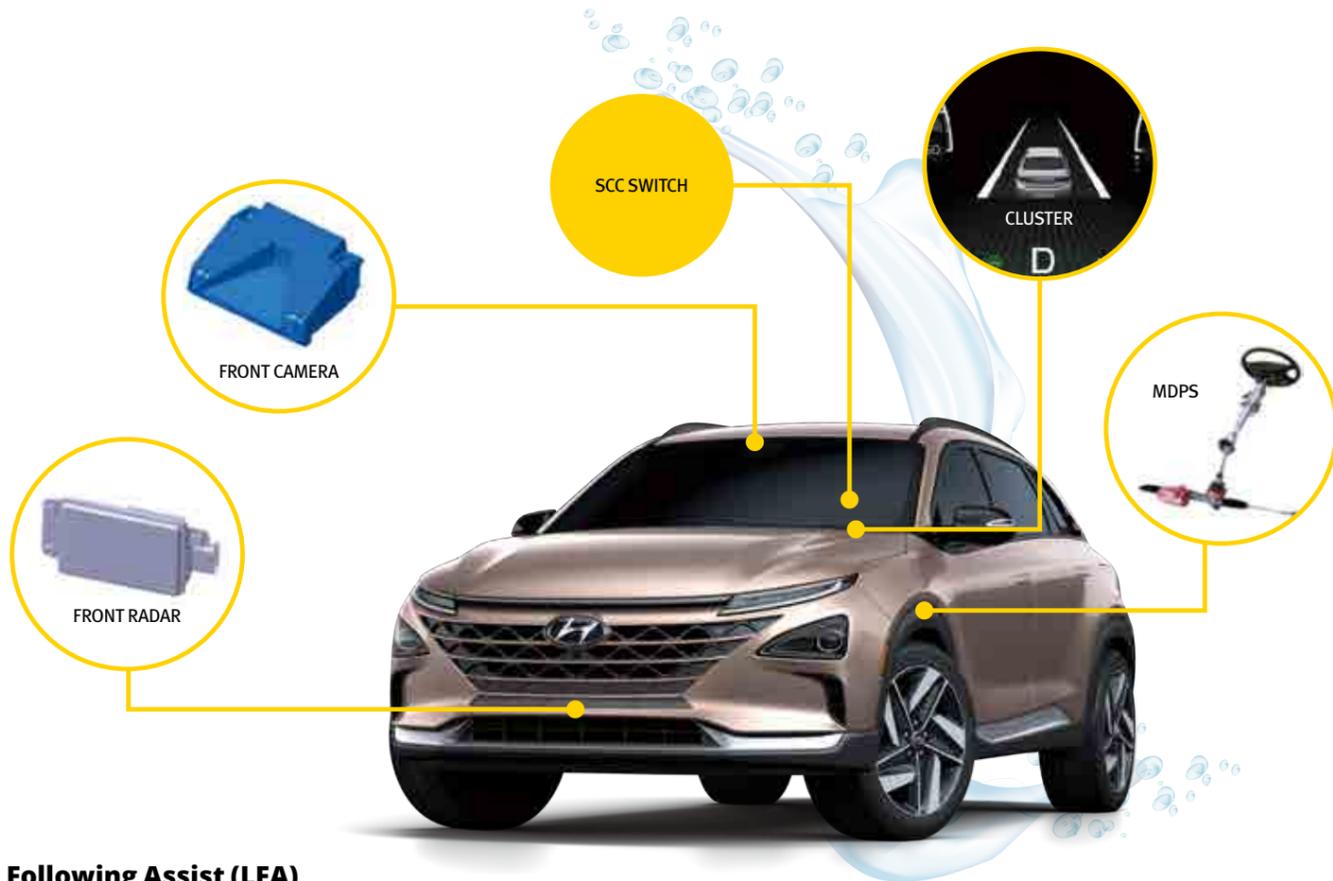
NEXO is equipped with advanced safety technologies which satisfies the hands-on SAE Level 2 semi-autonomous system requirements. NEXO is built to provide a better driving experience. For example, a comprehensive set of FCEV-specific information is provided through the integrated display. NEXO is also equipped with the latest features, to provide the best possible driving experience and ensure drivers feel proud.

*A competition of artistry and acrobatic moves, freestyle skiing requires precise execution of highly challenging moves.*



**Cutting-edge Advanced Driver Assistance System (ADAS)**

NEXO is equipped with some of the world's most advanced technologies, for a safe and comfortable driving experience. One of the most futuristic features of NEXO is its next-generation ADAS. Some of the ADAS features have never before been offered in a Hyundai vehicles.

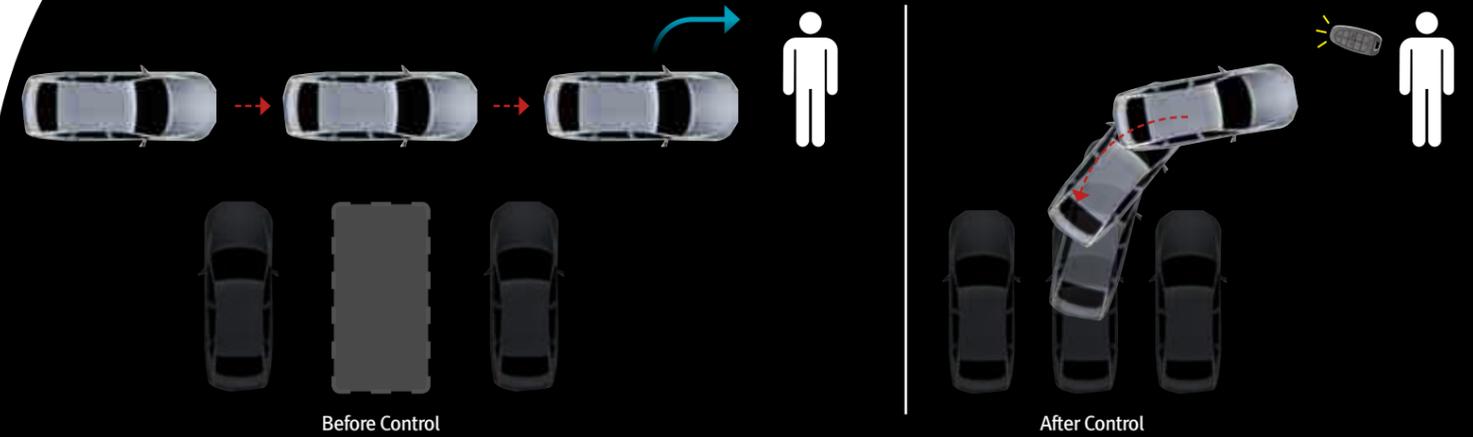


**Lane Following Assist (LFA)**

Some Genesis models have a Highway Driving Assist (HDA) feature, which recognizes road lanes, vehicles in front and uses GPS information to observe the speed limit. HDA is capable of ensuring a vehicle stays in lane and maintains speed without driver input. However, as its name suggests, HDA only works during highway driving. Unlike HDA, LFA, offered with NEXO, functions both on highways and non-highway roads. Unlike a lane keeping assistance system which helps prevent unintended lane changes, LFA keeps NEXO in the center of a road lane. LFA works in connection with the smart cruise control system and stop and go to automatically bring NEXO to a full stop and restart in line with the flow of traffic. This is the most important capability for level 2 autonomous driving.

**Functionality**

	LKA (Lane Keeping Assist)	LFA (Lane Following Assist)
<b>Operation threshold</b>	Alerts when vehicle approaches road lane mark 	Keeps vehicle in the center of the lane 



**Remote Smart Parking Assist (RSPA)**

The RSPA system improves on the previously released Smart Parking Assistance System (SPAS). Using SPAS, drivers can park their cars using only the gear lever change and without steering input. Equipped with RSPA, NEXO drivers can park their cars without steering or gear lever input. New technologies including shift-by-wire allow the transmission and brake system to be controlled electronically. The driver only needs to keep an eye on the car while it parks itself, while pressing RSPA button down. The RSPA system supports all types of parking maneuvers including parallel parking, right angle parking and even exiting from parked positions. As the name suggests, the driver can operate RSPA remotely from outside of NEXO using its smart key. RSPA is an important part of NEXO's level 2 autonomous driving technology.



How to deal with Blind-Spot



BVM (Cluster)

**BVM: Blind-spot View Monitor (Rear side view monitor)**

Even the best side view mirrors have blind spots with limited visibility. BVM improves on the Blind Spot Detection system which alerts the driver to objects in their blind spot. Using the surround view monitoring camera which provides a 360-degree view during parking, BVM shows objects in the driver's blind spot. The view is provided to the driver in real time to help them avoid objects hidden in their blind spots. BVM is activated when the driver activates the turn signal and the view is provided on the integrated display screen. The system provides a clear view of the blind spots on either side of the NEXO even when there is only a little ambient light or during rain. Not only does it help prevent accidents but it is also aesthetically pleasing.

**FCEV user interface contents**

Who will be the first buyers of FCEVs? We believe that the early buyers of FCEVs will be those who are prepared to try new technologies and believe that small things can change the world for the better. The FCEV user interface contents are designed to help them navigate the new technology. One of the goals of creating the FCEV interface is to alleviate concerns about new technology, to generate interest and

provide answers to the questions people might have. For example, detailed operational information about the FCEV is displayed on the screen to help manage anxiety about the new technology and to make the driver feel happy and proud of their contribution. Information about how much the FCEV is contributing to the environment, and whether there is any issue with the hydrogen tanks is also communicated with graphics.

**User interface development concept**

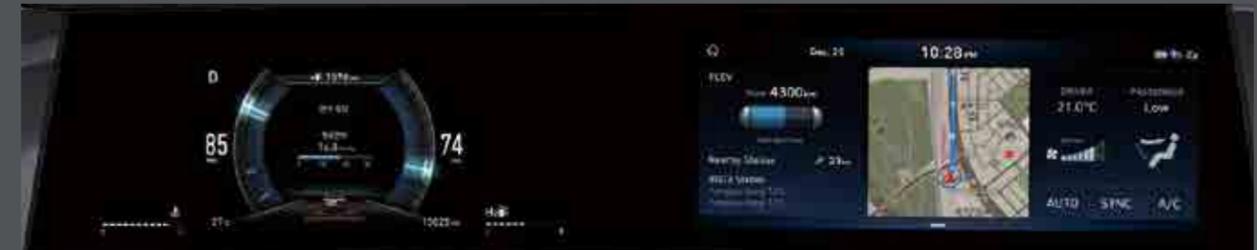
UX VALUE	USER VOICE
Premium	• Premium feel and refinement that matches price level
Credible	• Accurate information about vehicle operation status • Provision of comprehensive information on vehicle functionality and operation
Pride	• Increased interest in environment and appreciation of exceptional NVH • Sense of pride as an early adapter

**ECO Contents**



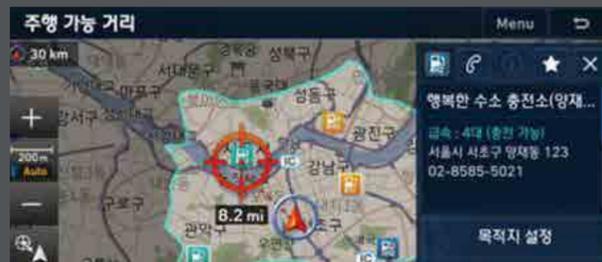
**Energy flow diagram**

The diagram shows where the energy originates and how it flows through the fuel cell stack, electric motor, hydrogen tank and battery during operation.



**Driving range**

Estimated driving range using remaining hydrogen is displayed in kilometers.



**Hydrogen station location indicator**

Travel range reflecting traffic conditions is shown on the map. Nearest hydrogen station is displayed on the navigation map. Driver can tap on the icon to find detailed information about the hydrogen station including operation status in real time.



**Hydrogen tank status**

Current status of hydrogen tank such as temperature and pressure is displayed. The system generates alerts when problems such as overcharging or overheating are detected.



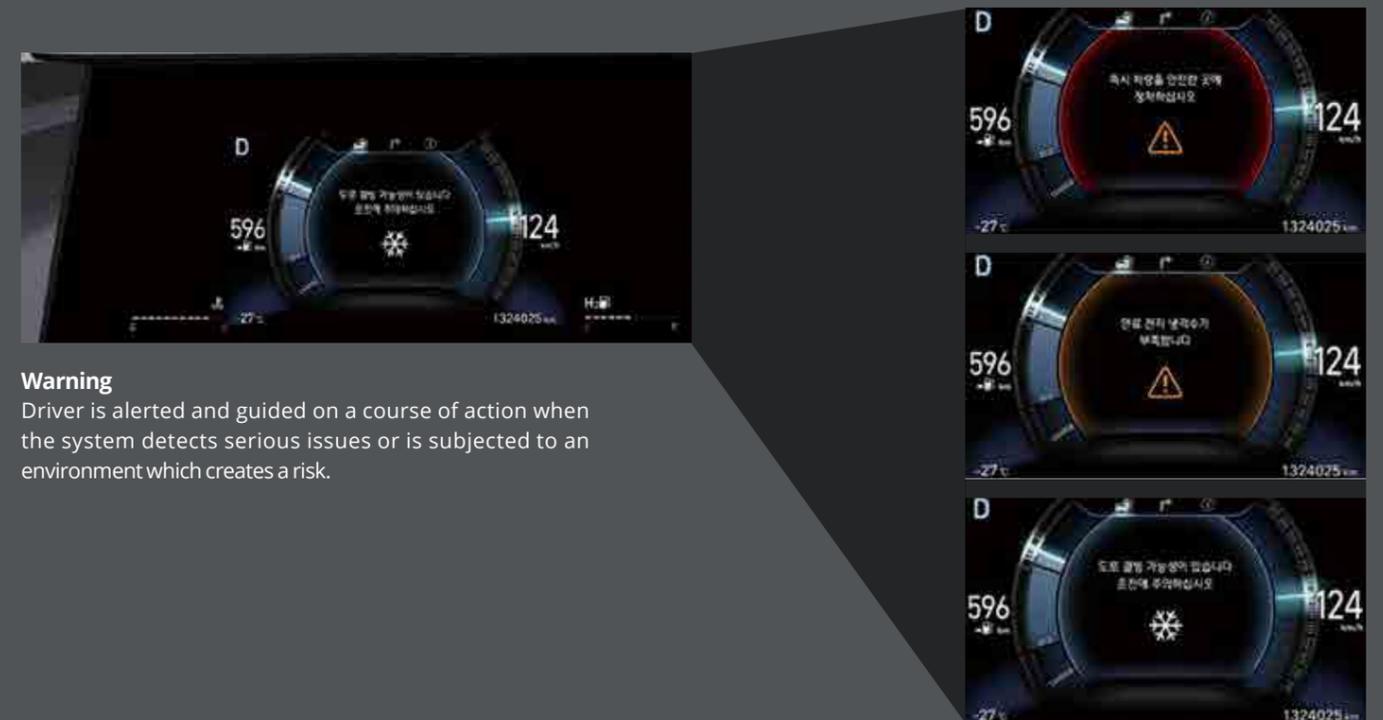
**Energy efficiency track record**

The amount of hydrogen consumption is displayed on the screen. A record point is created every five minutes and the average distance travelled using one kilogram of hydrogen is shown.



**Environmental contribution**

Environmental contribution from operating the FCEV, such as how much air was cleaned through the fuel cell system and how much less CO<sub>2</sub> was emitted compared to a conventional gasoline engine car are all displayed for the driver.



**Warning**

Driver is alerted and guided on a course of action when the system detects serious issues or is subjected to an environment which creates a risk.

## Ensuring utmost safety

NEXO runs on hydrogen which is stored in high pressure tanks. Hydrogen tanks have some inherent risks just like all high-pressure gas storage tanks. However, this does not make NEXO unsafe because it has been designed to prevent all possible risks. For example, the hydrogen tank is made using newly developed materials in a multi-layer structure to ensure the highest safety. It is also capable of monitoring and managing risks by itself. Its safety in every kind of situation has been tested incredibly thoroughly.

In general, people have fears about hydrogen and are reminded of negative things such as explosions. In 2013, Hyundai Motor proudly announced the world's first mass-produced FCEV, Tucson ix FCEV. Despite Hyundai Motor's hope to be in the spotlight for their technological advancement and leadership, instead many responded with concerns about hydrogen explosions.

Some people even expressed the idea that hydrogen cars should not be allowed on the streets. The source of this fear about hydrogen is in fact the hydrogen bomb even though the hydrogen used in bombs is different from the hydrogen used in FCEVs. Hydrogen bombs use uncommon heavy hydrogen which is called Deuterium (hydrogen-2) or Tritium (hydrogen-3) which can be fused in extreme high-temperature-pressure environments. However, FCEVs run on light hydrogen which is commonly found in the world.

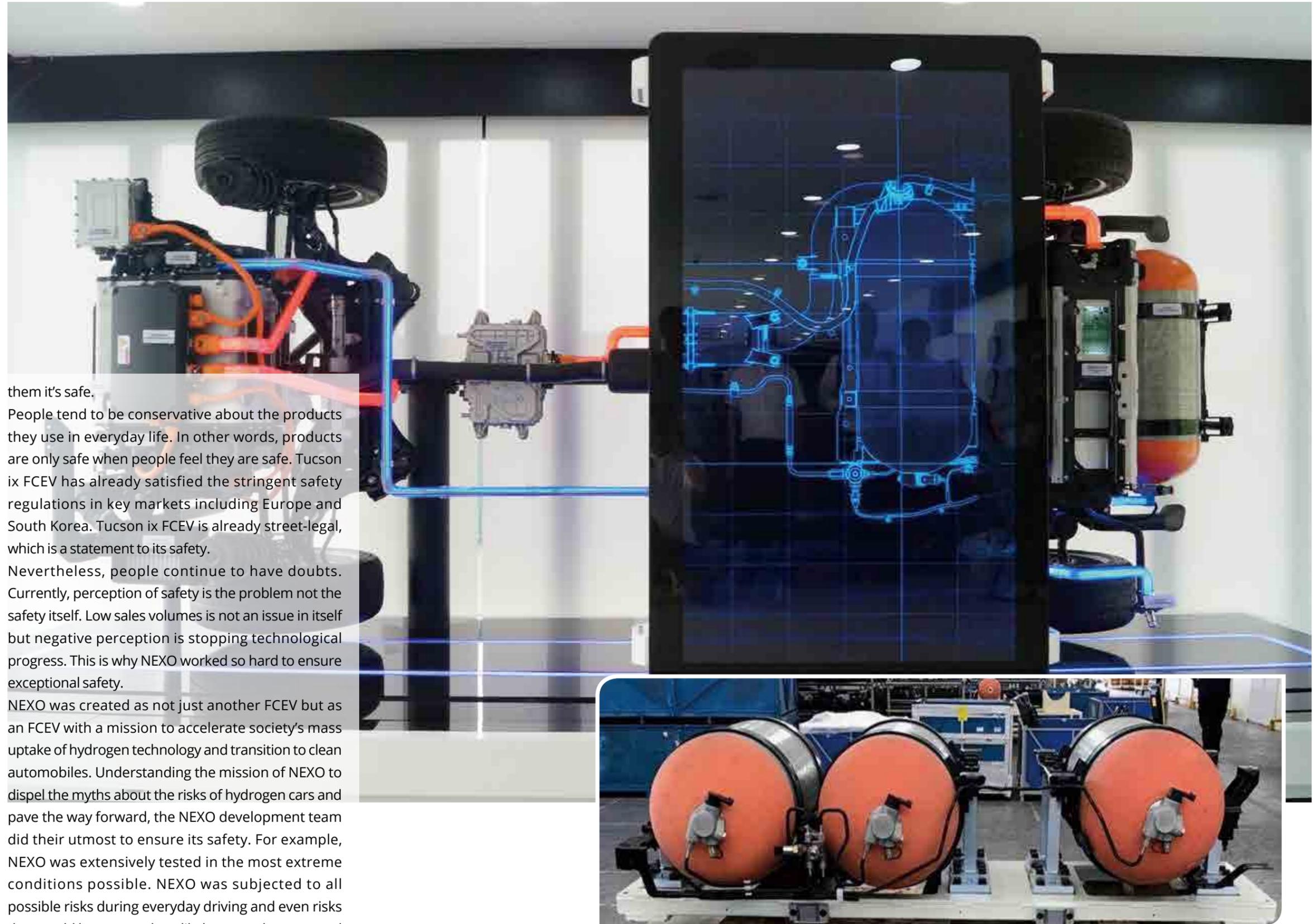
The light hydrogen used in FCEVs is not capable of creating a powerful explosion. However, people are not experts on hydrogen technology and will also not become experts overnight. For now, many people feel uncomfortable about hydrogen technology and their attitude won't simply change because we tell

them it's safe.

People tend to be conservative about the products they use in everyday life. In other words, products are only safe when people feel they are safe. Tucson ix FCEV has already satisfied the stringent safety regulations in key markets including Europe and South Korea. Tucson ix FCEV is already street-legal, which is a statement to its safety.

Nevertheless, people continue to have doubts. Currently, perception of safety is the problem not the safety itself. Low sales volumes is not an issue in itself but negative perception is stopping technological progress. This is why NEXO worked so hard to ensure exceptional safety.

NEXO was created as not just another FCEV but as an FCEV with a mission to accelerate society's mass uptake of hydrogen technology and transition to clean automobiles. Understanding the mission of NEXO to dispel the myths about the risks of hydrogen cars and pave the way forward, the NEXO development team did their utmost to ensure its safety. For example, NEXO was extensively tested in the most extreme conditions possible. NEXO was subjected to all possible risks during everyday driving and even risks that would be extremely unlikely to ever happen, and was proven to be safe.



Hydrogen tank

Hydrogen tank test



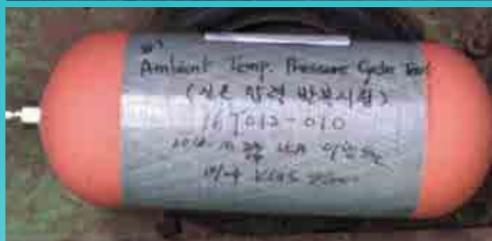
Drop impact test



Bursting test



Environmental test



Repeated high-pressure test



Permeation test



Repeated hydrogen gas filling test



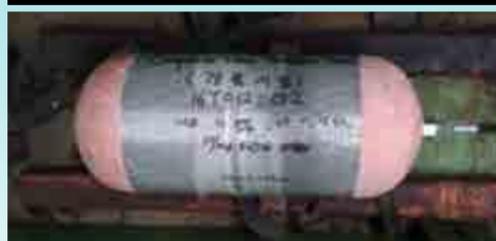
Repeated extreme temperature test



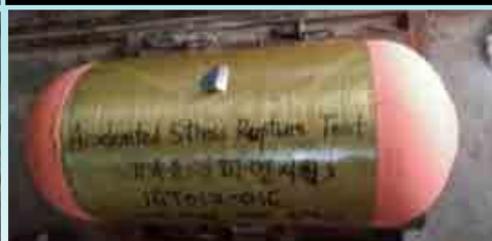
Flame test



Gunfire penetration test



Artificial defect test



Accelerated stress test

Crashworthiness

Collision performance evaluation



: Rear end crash 80km/h / Offset 70%  
: Front end crash 56km/h / Offset 40%

Core safety of hydrogen tanks

People often say a hydrogen tank could pose a risk because it stores hydrogen at 700bar, which is indeed very high. However, a high-pressure hydrogen tank can be very safe if it satisfies three conditions. The three key conditions for hydrogen tank safety, recognized in Europe and South Korea are as follows.

The first is impermeability; which is the ability to contain the hydrogen stored in the tank without leaks. Second, fire resistance; the ability of the tank to not explode during a fire. Third is impact resistance; which is the tank's ability to stay functional when involved in an accident or when dropped. The hydrogen tank used in NEXO satisfies all three safety requirements.

A new material with exceptional impermeability was used. The inflammability requirement was met through a high-pressure gas release device, which immediately releases all hydrogen when a flame touches any part of the tank not just the release device. The tank is also fire resistant and can withstand fire for over an hour which is more than enough for evacuation.

Lastly, a reinforcement protector using foam material was added to the dome portion of the hydrogen tank, which is its weakest part. The 37kg tank can be dropped from a 1.8-meter height and repeatedly charged safely.

NEXO's hydrogen tank passed all internal safety tests as well as South Korea's national certification requirements. It also passed European safety tests and even the UN's global safety standard test which subjects a hydrogen tank to extreme pressure, repeated charging pressure, a bonfire, and a drop test using a single hydrogen tank.

The UN's international safety standard is not a requirement in any market yet. The NEXO development team applied for the test and received certification to reassure drivers of its safety.



**NEXO STORY**  
THANK YOU