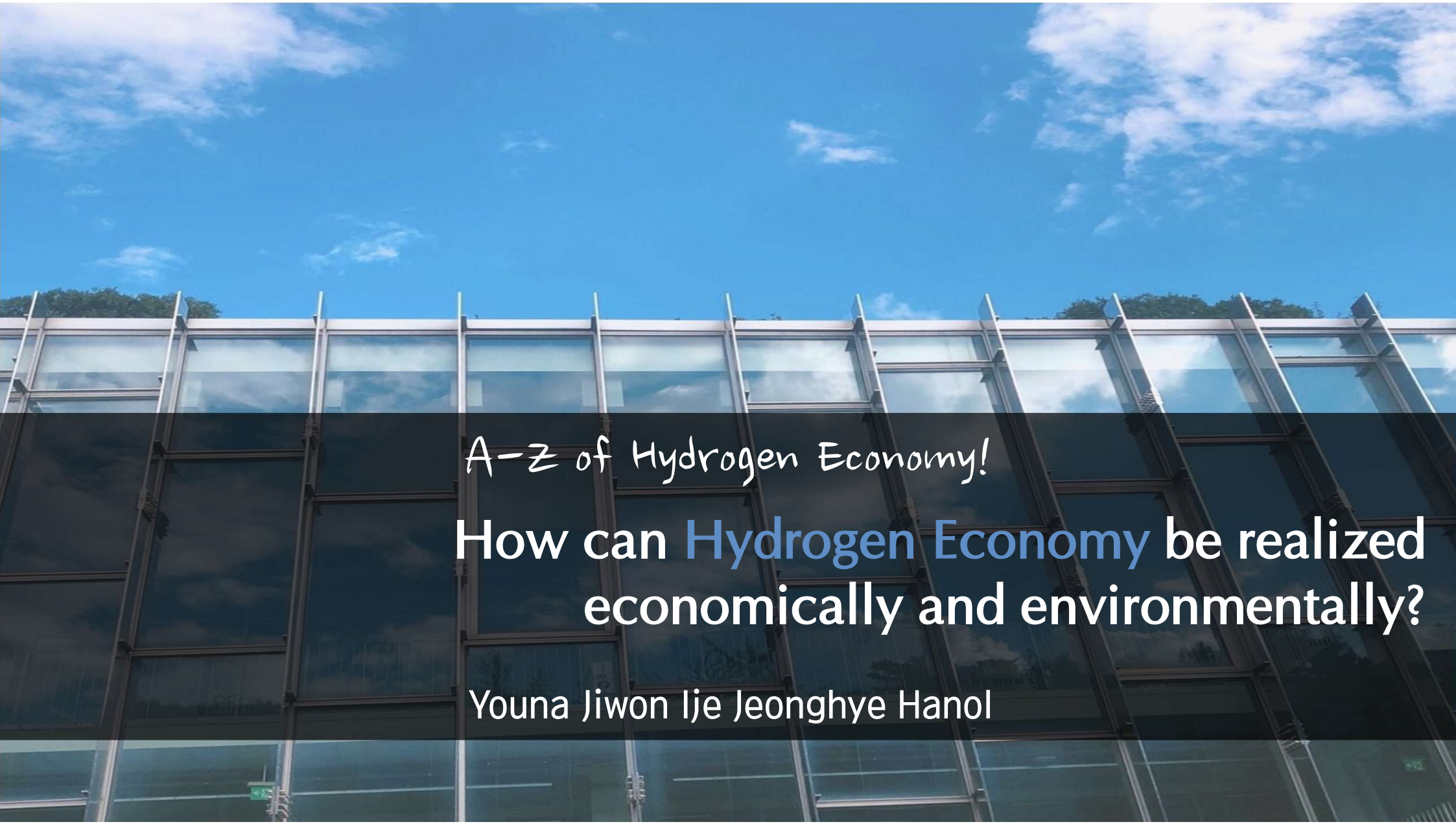
Notice Before Presentation

To help you understand,
we created a “Korean version Card News”
and uploaded it to the “기후에너지시스템 17” in 카카오톡 ☺

You can read it during the presentation,
and also you can read it after the presentation
to learn about the “Hydrogen Economy"



A-Z of Hydrogen Economy!

How can Hydrogen Economy be realized economically and environmentally?

Youna Jiwon Ije Jeonghye Hanol

Contents

Hydrogen Economy?

Concept

Hydrogen Economy?

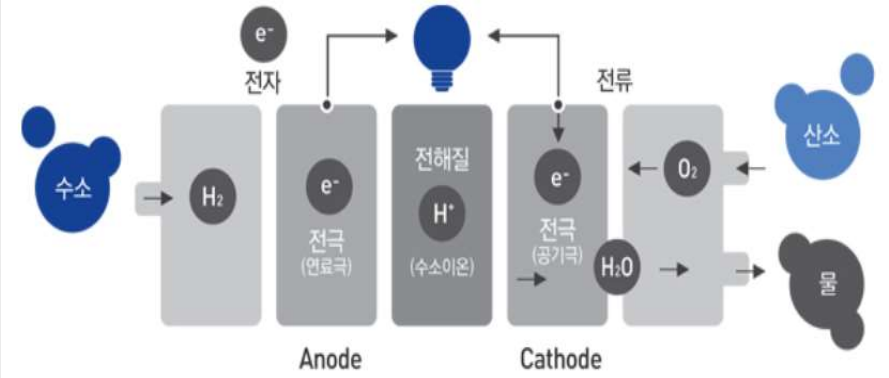
Economic & Industrial structure using Hydrogen as a main energy source

Background

- Currently, the world relies on fossil fuels for 86 percent of its energy, but fossil fuel resource scarcity is a problem.
- Hydrogen energy is a clean energy that can be produced by dissolving water, which is an almost infinite resource.
- As a result, hydrogen economy, which builds an energy society based on hydrogen, is drawing attention.

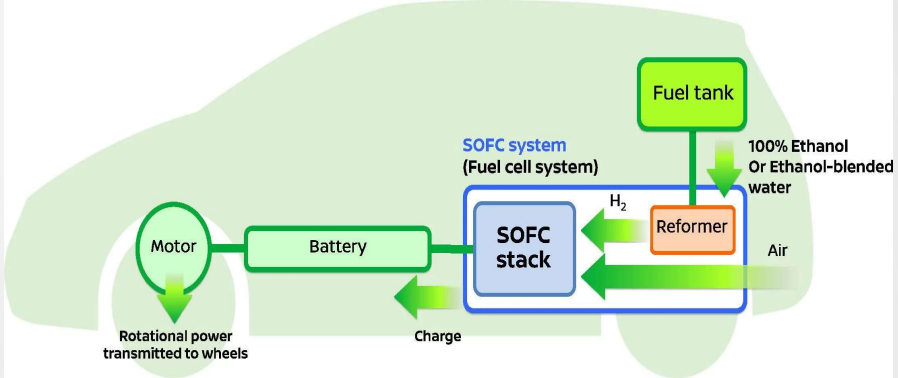
Hydrogen Economy?

Concept



Hydrogen Fuel Cell

- A power-generating device that changes chemical energy directly into electrical energy by electrochemical reactions.
- Fuel cells are largely divided into low temperature fuel cells and high temperature fuel cells.



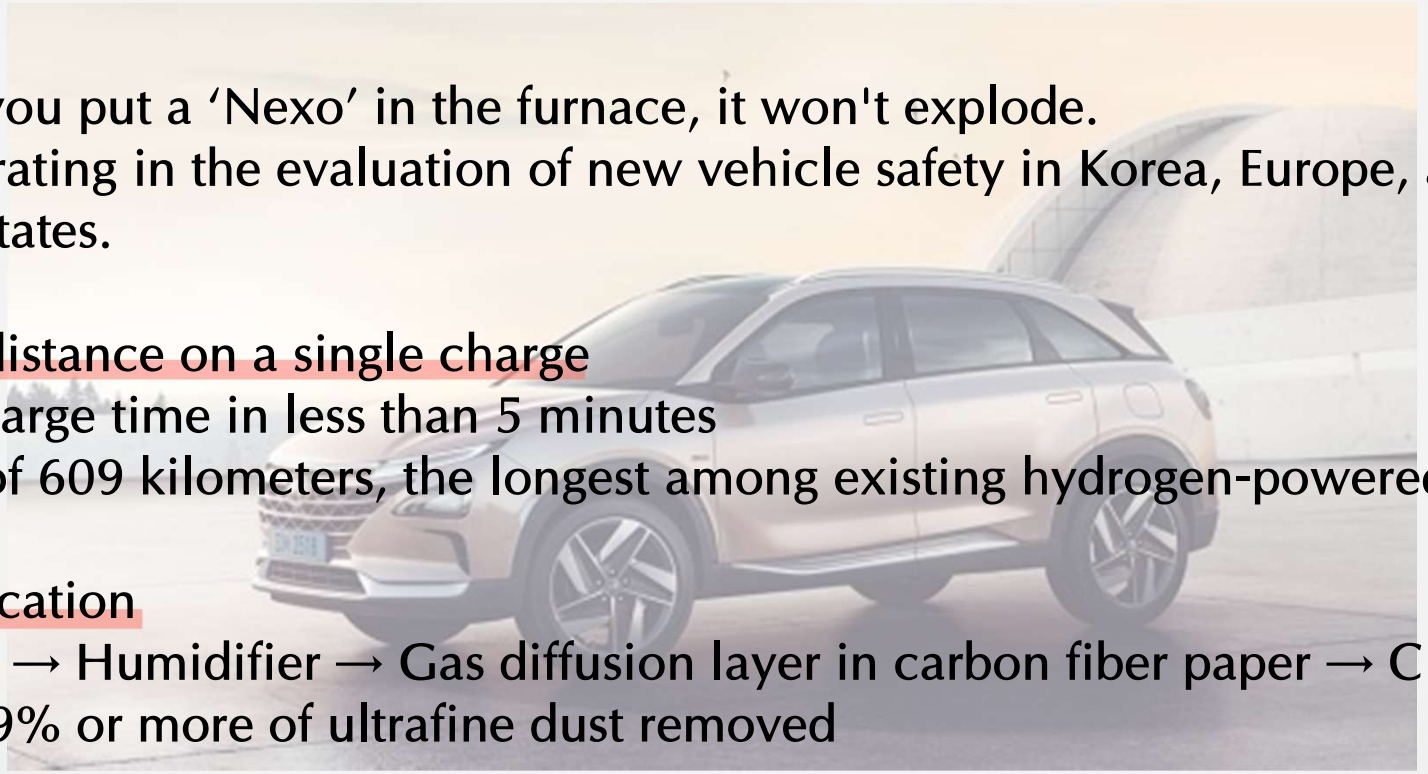
Hydrogen Electric Car

- A car that uses hydrogen and oxygen to generate electricity and drive a motor in an electrochemical reaction.
- Hydrogen electric car is eco-friendly cars that emit only water without any air pollutants or greenhouse gas emissions.

All about Hydrogen Economy

Truth

Next-generation fuel cell electric vehicle ‘Hyundai Nexo’



1. Safety
- Even if you put a ‘Nexo’ in the furnace, it won't explode.
- highest rating in the evaluation of new vehicle safety in Korea, Europe, and the United States.

2. Driving distance on a single charge
- Short charge time in less than 5 minutes
- a range of 609 kilometers, the longest among existing hydrogen-powered vehicles.

3. Air Purification
- Air filter → Humidifier → Gas diffusion layer in carbon fiber paper → Clean air with 99.9% or more of ultrafine dust removed

All about Hydrogen Economy

Truth

Q. Running hydrogen bomb?

1. In its natural state, 100 million °C of hot air is not generated for hydrogen bomb explosions, and hydrogen is also impossible to convert into deuterium and tritium. Since there is no atomic bomb that acts as a detonator, **it is impossible for the hydrogen-powered fuel tank to explode in natural state.**

2. Hydrogen **explodes** only when the concentration in the air is within the **4-76%** range. If hydrogen is leaked from the hydrogen tank of the hydrogen electic car, the hydrogen concentration in the section is **over 75%.** Since the concentration drops to less than **4%** due to strong diffusion, **the risk of explosion is eliminated.**

3. Nexo and other hydrogen-powered vehicles are applying a number of **devices to ensure safety** with Emergency Braking System, Gas Leakage Warning System.

Q. Is the purchase price expensive?

1. Buy incentives of fuel cell electric vehicle: up to 35 million ₩
   - Impossible to buy for between 33.9 million ₩ and 37.2 million ₩
   - Equivalent to a typical Korean mid-sized multipurpose sports vehicle.

2. Buy incentives of Electric vehicle: at least 5 million ₩ and up to 11 million ₩
   - Impossible to buy about 46 million ₩
   - Paid differently depending on driving distance from 2018 and subsidies are decreasing gradually.

All about Hydrogen Economy

Truth

Q. Hydrogen car? Electric car?

- Unlike 'pure electric vehicles' that require electric charging from outside, **'hydrogen electric car' have electricity that is used directly through fuel cells in cars.**
- “Hydrogen electric car" has a **shorter charging time** than the "pure-electric car," and can **physically transport** hydrogen like gasoline or diesel.
- Hydrogen electric car are more **eco-friendly** than pure electric cars. Hydrogen can be produced sufficiently with natural gas or water, but electricity must be dependent on existing power generation systems such as nuclear power and thermal power

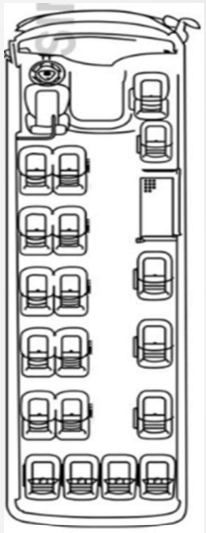
Hydrogenization In Ewha

Economic

When you change the source of energy used in schools to hydrogen,
What changes will be made economically and environmentally friendly?

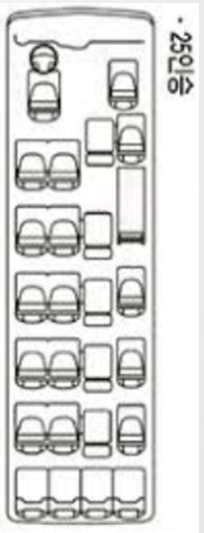
The Birth of Ewha's Hydrogen Economy with Hydrogen Shuttle Bus

Fossil Fuel Shuttle Bus in Operation



- Daewoo Bus Resta (for 15 passengers)

Hydrogen Fuel Shuttle Bus, Target of Operation



- Hyundai Electcity (for 25 passengers)

Hydrogenization In Ewha

Economic

Operation Timetable

정문 정규 노선(주간) Main Gate Local Route(Day time)

정문 - 조형예술관 - 포스코관 - 공대삼거리 - 한우리집 - 산학협력관(회차)

운행 시간		출발 시각
오전	07:50 ~ 11:50	00, 10, 20, 30, 40, 50
오후	13:00 ~ 21:00	

정문 정규 노선(야간) Main Gate Local Route(Night time)

입학관 - 포스코관 - 한우리집(주차장) - E House(회차)

운행 시간		출발 시각
평일	21:10 ~ 23:40	00, 10, 20, 30, 40, 50
토요일	18:00 ~ 23:40	00, 10, 20, 30, 40, 50

정문 직행 노선 Main Gate Direct Route

정문 - 포스코관 - 공대삼거리(회차)

운행 시간		출발 시각
오전	08:45 ~ 11:15	00, 15, 30, 45
오후	13:30 ~ 17:15	

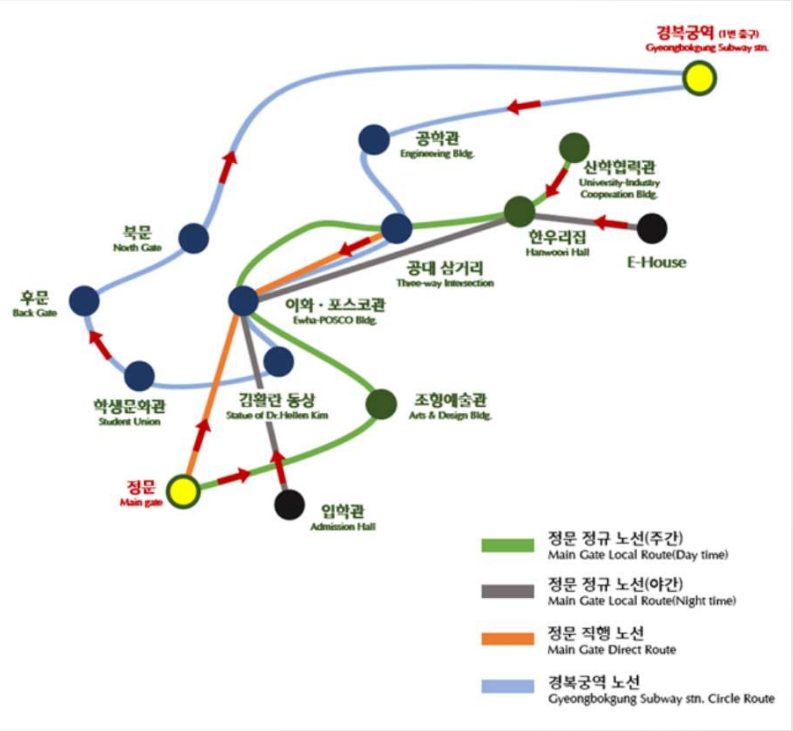
경복궁역 노선 Gyeongbokgung Subway stn. Circle Route

경복궁역(1번 출구) - 공학관 - 공대삼거리 - 포스코관 - 김활란 동상 - 학생문화관 - 후문 - 북문

운행 시간		출발 시각
오전	07:40 ~ 11:00	00, 20, 40
오후	16:10 ~ 19:10	10, 40

Two shuttle buses drive a total of 125 times a day.
One drive 62.5 times.

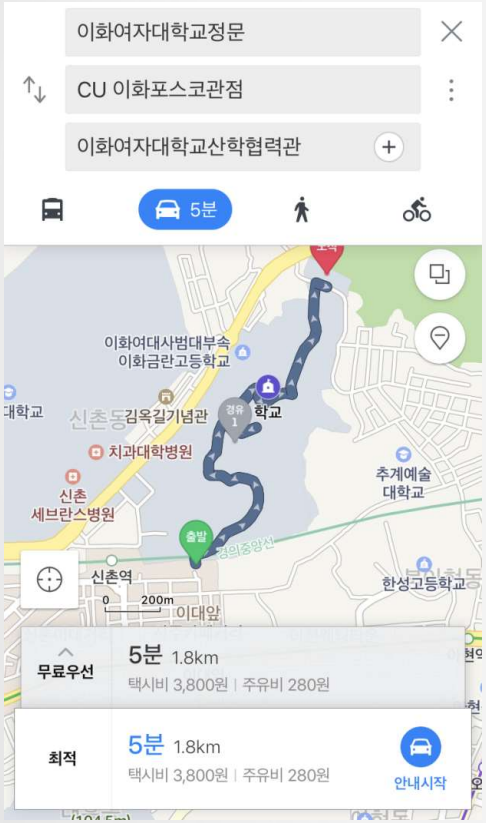
Operation Rout Map



Hydrogenization In Ewha

Economic

The Route of The Bus

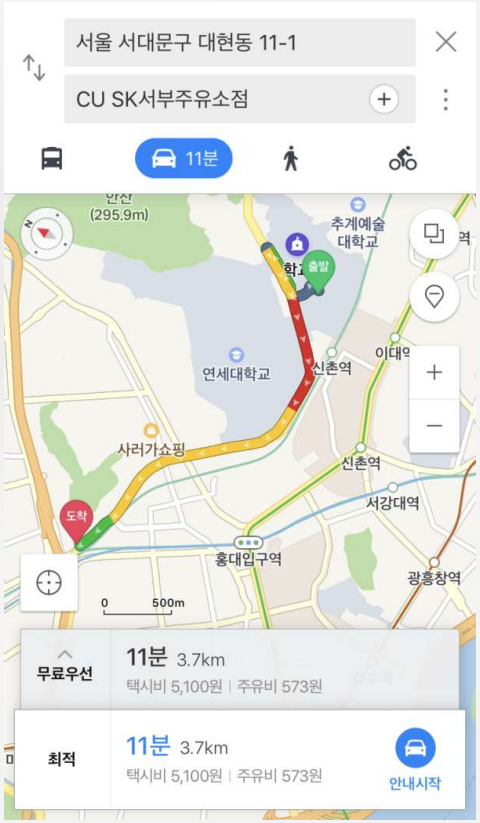


✓ Moving:
Main gate
<->
Industrial-Academic
Cooperation Center

✓ One Run Distance:
1.8 km

✓ Total Distance:
62.5 times*1.8 km
=112.5 km

The Location of Gas Station



✓ Location:
Yeonhui Intersection
Sk West Main Station

✓ Period:
Every morning

✓ One Run Distance:
3.7 km*2 = 7.4 km
round trip

✓ Total Distance:
119.9 km

Hydrogenization In Ewha

Economic

The Foundation of Analysis

	The fossil fuel bus	The hydrogen bus
Charging amount	Charge 70 liters daily	25 kg per charge
Fuel efficiency when using fossil fuels for hydrogen	3km/1kg	5km/kg
Certified fuel efficiency (Continuous Drive)	10 km/L (constant) → 7 km/L (in city)	16.66 km/L (constant) → 11.66 km/L (in city)
Driving distance	50000km (Total)	713 km (per charge)
Air purification effect	x	4.83 1 kg/km Clean up fine dust
Emission material	exhaust gas	water

✓ Daewoo Resta
Fuel efficiency

국토교통부
Ministry of Land, Infrastructure and Transport

□ 정속주행연비 : 4개 차종

제작사	차종	구분	조사결과(km/ℓ)
기아	봉고3 12톤	제원연비	15.0
		측정연비	14.3(-4.7%)
오텍	그랜드스타렉스 구급차	제원연비	12.4
		측정연비	13.2(6.5%)
대우버스	레스타	제원연비	10.7
		측정연비	10.7(0.0%)
현대	트라고엑시언트	제원연비	4.3
		측정연비	4.3(0.0%)

※ 정속연비 판정기준 : -5% 이내

Hydrogenization In Ewha

Economic

Analysis 1. Economic Effects When Supporting Hydrogen Fuel Charging (Standard: 22 days)

- ✓ Costs incurred using an existing bus = 70L*1439 (won/L)*22 (days)= 2,216,060 won
- ✓ Current bus daily driving distance = 70L*7 (km/L) = 490 km
- ✓ Amount of hydrogen bus fuel needed to drive = [490 (km) / 16.66 (km/L) = 29.41 L = 25.30 kg]

- ✓ Q1. If hydrogen fuel charging is supported (Currently in Seoul)?
  Costs arising from the use of hydrogen buses = 25.30 kg *(0 won)*22 days = 0 won
- ✓ Q2. Calculation of the Charging Cost of Hydrogen Fuel in Seoul and the Current Excluding Seoul?
  Costs incurred when using a hydrogen bus = 25.30 kg * 7675 (won/kg) * 22 days = 4,271,905 won
- ✓ Result: The price is about 1.93 times different.

Hydrogenization In Ewha

Economic

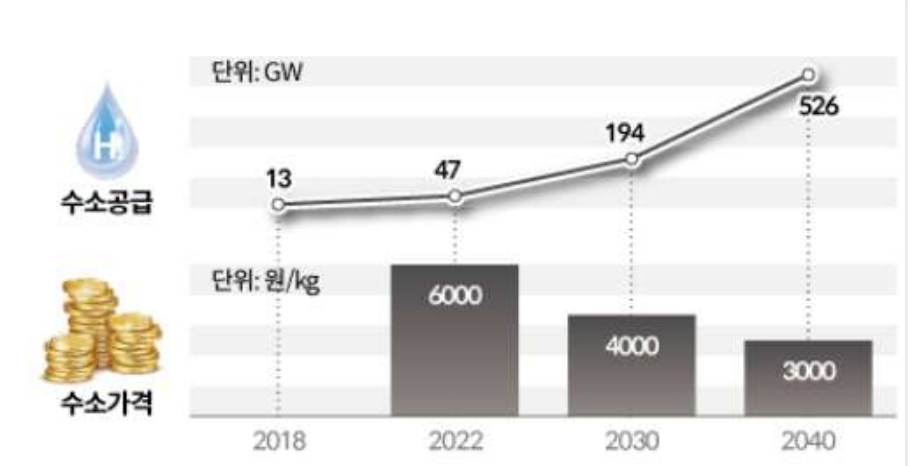
Applicable Government Policy 1. Hydrogen Fuel Price Reduction

서울	상암 수소충전소	서울 마포구 하늘공원로 84	무상
부산	서부산엔케이수소충전소	부산 강서구 가락대로 347	8,800
광주	진곡수소충전소	광주 광산구 진곡산단중앙로 55	8,200
광주	등곡수소충전소	광주 광산구 등곡로 324	8,200
대전	학하수소충전소	대전 유성구 유성대로 437	8,200
울산	그린복합충전소	울산 울주군 온산읍 온산로 256	7,000
울산	신일복합충전소	울산 울주군 웅촌면 웅촌로 490	7,000
울산	매암 수소충전소	울산광역시 남구 장생포고래로29번길 5	7,000
울산	정동수소충전소	울산 북구 북부순환도로 1165	7,000

KHIA (사)한국수소산업협회 Korea Hydrogen Industry Association

In Present

- ✓ Seoul: Free
- ✓ Ulsan: 7000 won
- ✓ The Rest of The Rural Areas: 8200-8800 won



In Future

In Hydrogen Economic Activation Roadmap

- ✓ By 2030: 4,000 won for goal.
- ✓ By 2040: 3,000 won for goal.

Hydrogenization In Ewha

Economic

Analysis 2. Economic Effects of Hydrogen Car Support (Standard: 22 Days)

✓ Existing bus (Daewoo Resta) purchase cost = 62,164,800 won

✓ Cost of purchase of hydrogen buses = 480,000,000 won
: Subsidy = 200 million won (100 million won from the Ministry of Land, Infrastructure and Transport, and 100 million won from the Ministry of Environment)

✓ How to Receive Subsidy?
: Hyundai Nexo's application for a public offering.

✓ A Problem
1200 applications for public subscription, but 500 only.

Measures are needed as the support falls short of the demand.

Hydrogenization In Ewha

Economic

Applicable Government Policy 2. Initial Purchase Cost of Hydrogen Car

Increased Government Subsidies

- Currently, the purchase subsidy for the purchase of hydrogen cars is 22.5 million won for the state budget, and 12.5 million won for local expenses in Seoul.
- Moreover, tax reduction (up to 7.2 million won) when purchasing hydrogen cars, highway tolls and public parking lot fees are reduced

Changing fuel source

- Yamanashi Kotsu Co.,Ltd through FY2011-2013. Developed a bus based on the hydrogen engine bus of Tokyo City University. The bus was modified from Hino Liesse (KK-RX4JFEA).
- It is the first case in Japan for a hydrogen engine bus to run as route bus.

Hydrogenization In Ewha

Economic

Analysis 3. Current Problems of Hydrogen Charging Station Infrastructure

구 분	설치연도	공급방식	용량(kg/일)	비 고
서울(상암)	2010	개질(매립가스)	65	연구용/일반가능
서울(양재)	2010	튜브트레일러	110	연구용/일반가능
울산(매암)	2012	튜브트레일러	520	
광주(진곡)	2014	튜브트레일러	220	
충남(내포)	2015	튜브트레일러	430	
경남(창원 팔룡)	2017	튜브트레일러	250	
울산(옥동)	2017	튜브트레일러	250	LPG 수소 복합
광주(동곡)	2018	튜브트레일러		
2018 보급계획 (개소)	(공공 7) 충남 1, 대전 1, 울산 1, 창원 1, 광주 1, 강원 2			
	(민간 3)			

주 : 연구용을 제외하고 일반사용 충전소만 제시
자료 : 환경부 내부자료

Currently hydrogen charging station is insufficient

- ✓ Number of charging stations in Seoul: 2
- ✓ Distance from School: Sangam (9.6km) and Yangjae (20km)
  (The charging capacity of the Yangjae is 20 units a day based on Hyundai's hydrogen-powered vehicle Nexo and 10 units by hydrogen bus.)

Hydrogenization In Ewha

Economic

Applicable Government Policy 3. Charging Station Infrastructure

Policy Proposal 1. Additional Hydrogen Charging Station to Be Installed

- By <The Government's Roadmap to Revitalize the Hydrogen Economy>, 310 hydrogen charging stations will be established by 22 years.
  (Up to 1.5 billion won can be supported by government for charging station installation fee)

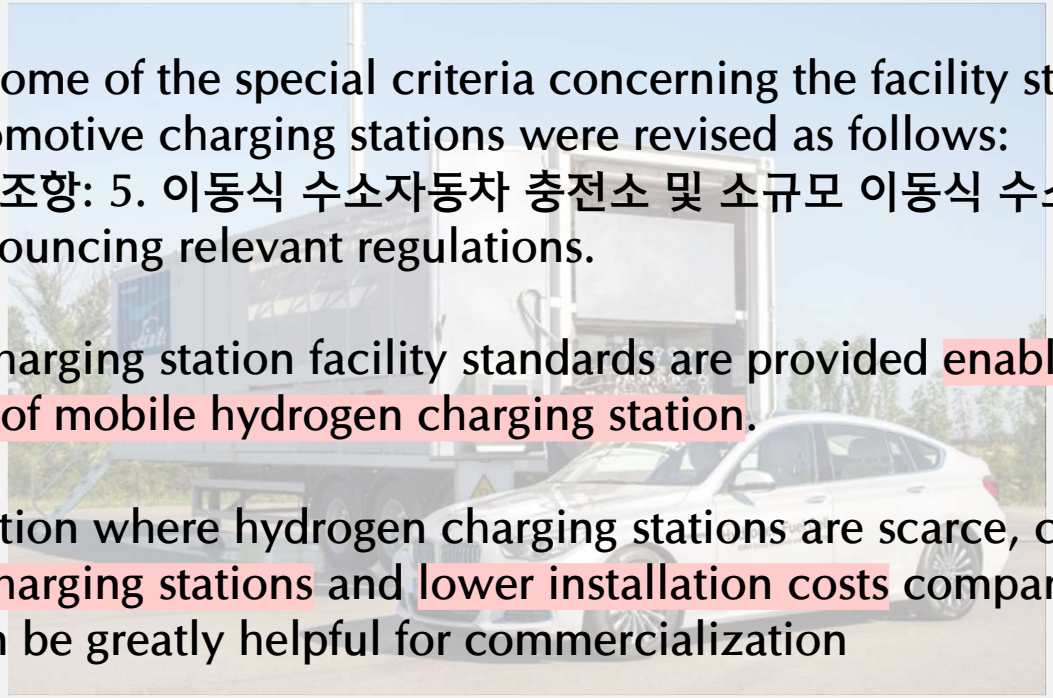
- It will be installed in the downtown area (150 BY Environment) : Improved accessibility to charging stations

Hydrogenization In Ewha

Economic

Applicable Government Policy 3. Charging Station Infrastructure

Policy Proposal 2. Operation of Mobile Hydrogen Charging Station



- In October 2018, some of the special criteria concerning the facility standards for refueling and packaged automotive charging stations were revised as follows:
  5제 1-2조 5호 신설 조항: 5. 이동식 수소자동차 충전소 및 소규모 이동식 수소자동차 충전소
  amending and announcing relevant regulations.

- Mobile hydrogen charging station facility standards are provided enabling commercialization of mobile hydrogen charging station.

- In the current situation where hydrogen charging stations are scarce, consumers have greater access to charging stations and lower installation costs compared to fixed charging stations, which can be greatly helpful for commercialization

Hydrogenization In Ewha

Economic

Extra Applicable Government Policy: Post Management by AS Center

Policy Proposal 1.

- The government plans to provide 1,000 hydrogen buses by 22 years and operate 24 AS centers for hydrogen vehicles.
- Hyundai Automotive Regional Service Center (21 locations) + Maintenance Technician (3 locations)

Technology For Hydrogen

Eco-Friendly

The Korean government's Hydrogen Economic Roadmap

- **Vision:** Green Hydrogen Producer Country which is hydrogen production, storage, transport and utilization in an eco-friendly way

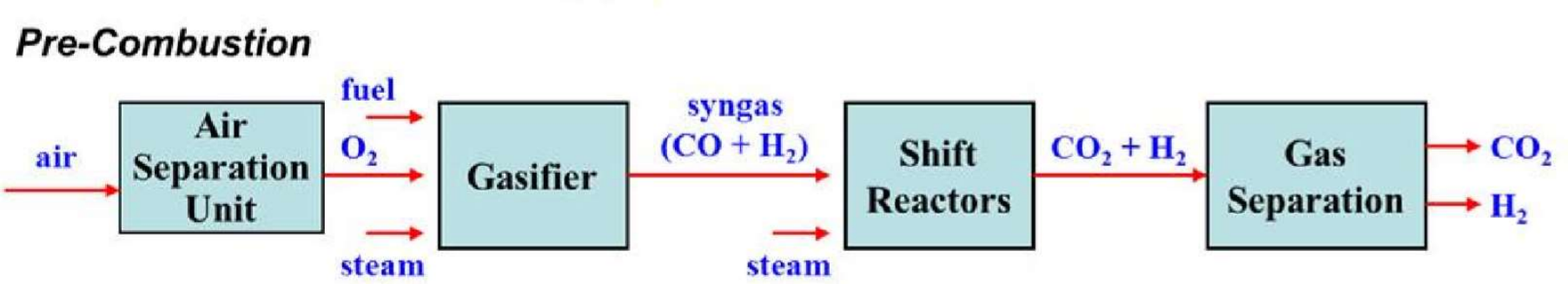
Hydrogen production

- The most important thing in the hydrogen economy is to make hydrogen cheaply and mass-produced
- There are hydrogen production method such as the modification of chemical fuel, the electrolysis of water, biological methods, the use of thermochemical cycles, etc.
- But these methods are not truly clean energy because they must emit air pollutants such as carbon dioxide (CO2) and provide energy generated from energy sources such as fossil fuels.
- Hydrogen Production Alternatives : presentation are pre-combustion capture, nuclear energy and artificial photosynthesis

Technology For Hydrogen

Eco-Friendly

Ⅰ. Pre-combustion: 연소 전 포집



- Hydrogen production through pre-combustion capture during carbon dioxide capture.
- Applying a steam(H20) to a solid-state fuel to capture carbon dioxide through a gasification process that changes gas-conditioned fuel without combustion.
- It makes useless CO2 which is green house gas. (But not completely eco-friendly)

Technology For Hydrogen

Eco-Friendly

Ⅱ. Nuclear-energy: 원자력

- How to produce?

Separating hydrogen from water by heat using nuclear energy.

There are thermochemical method and hot electrolysis as way to separate.

- Future hydrogen produced by “Nuclear-energy”

Currently, most nuclear power plants are below 350°C and are not economical in hydrogen production. So we need to More Developed Technology!

- Developing a next-generation nuclear power plant (VHTR:very high temperature gas-cooled reactor).

- To meet sustainability/nuclear proliferation resistance/high oil safety.

Technology For Hydrogen

Eco-Friendly

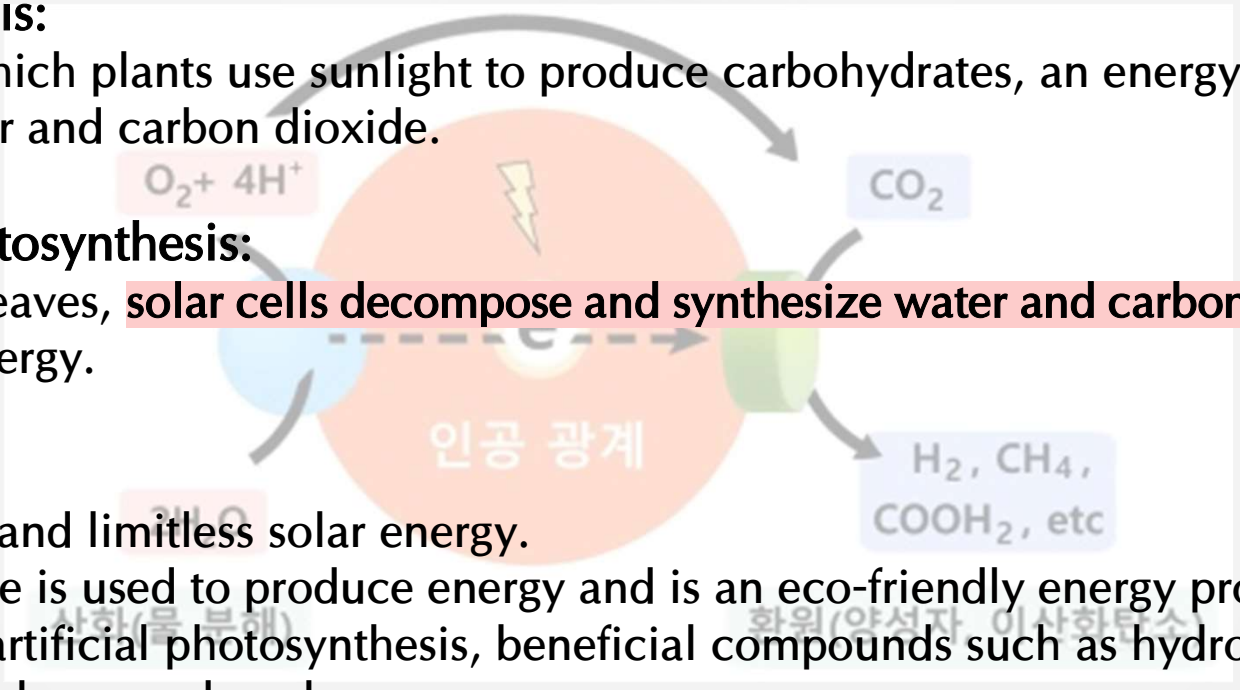
Ⅲ. Artificial Photosynthesis: 인공 광합성

- **Photosynthesis:**

the process by which plants use sunlight to produce carbohydrates, an energy source for living things, from water and carbon dioxide.

- **Artificial Photosynthesis:**

Instead of plant leaves, **solar cells decompose and synthesize water and carbon dioxide** in the air to produce energy.



- **Advantages**

- Utilize airless and limitless solar energy.
- Carbon dioxide is used to produce energy and is an eco-friendly energy production system.
- As a result of artificial photosynthesis, beneficial compounds such as hydrogen, methanol, and formic acid are produced.

Technology For Hydrogen

Eco-Friendly

Ⅲ. Artificial Photosynthesis: 인공 광합성

- **The present and future of artificial photosynthesis:**
- Low efficiency: Plant photosynthesis efficiency is between 4 and 6%, while artificial photosynthesis is currently only 0.1%.
- Low economy: Because expensive and toxic catalyst must be used in the artificial photosynthesis process
- Future hydrogen produced by “Nuclear-energy”: Various studies are being conducted around the world to enhance efficiency and economy

- **Case of Study**
- KOREA: Development of "artificial leaves" for artificial photosynthesis
- JAPAN: A chemistry professor at Tokyo University of Ishitaniomam, develops a new photocatalytic system through a combination of copper and manganese compounds during the study of carbon-dioxide deoxidation photocatalytic using “Nonmetals“.

Special Section

Safety

Safety for Future Hydrogen Economy


정부 '강릉 수소탱크 폭발'에 비상...수소경제 추진에 악재 우려

산업부 "수전해 실험시설서 일어난 예외적 사고...안전관리 강구"

입력 : 2019.05.24 10:39:17 수정 : 2019.05.24 14:20:11

- It is happened at a research institute

: Completely different from the hydrogen car or hydrogen charging station that can be seen around us. An exceptionally unfortunate accident that occurred in an unstandardized process because it was an experiment.

- Needs a policy infrastructure in experiments for technology development
  - standardized policy regulations
  - safety management regulations

Q & A

Q & A

Any
Question?

Referece

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A-Z of Hydrogen Economy!
Thank You ☺
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