How can CCUS be connected to a smart technology?

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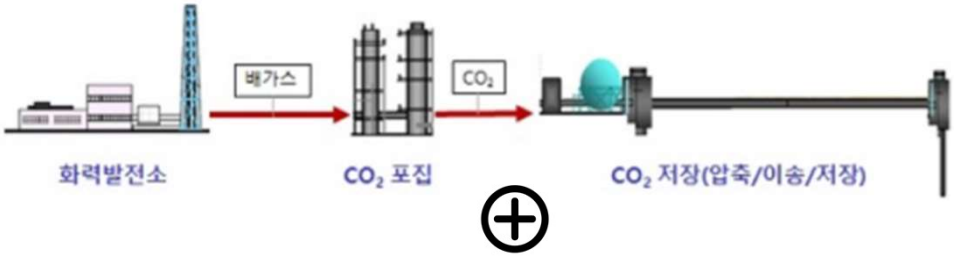
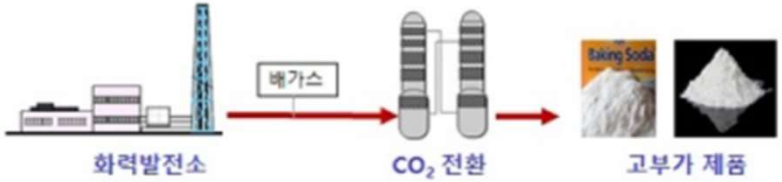
CCS(Carbon Capture & Storage)



CCU(Carbon Capture & Utilization)



CCUS

Source : http://www.energy-news.co.kr/news/articleView.html?idxno=45684

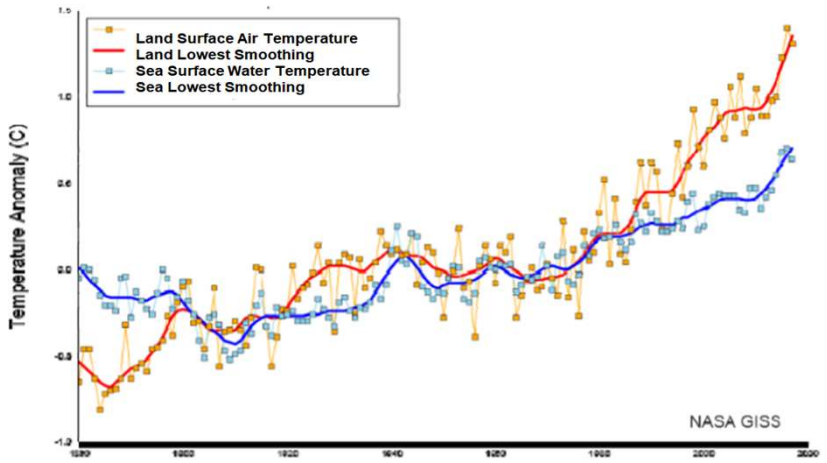
CCUS : A technology that collects CO2 emitted from thermal power plants, steel mills and cement plants, then utilizes it into 2 ways
1. Store it underground or under the sea floor after a compressed transportation process
2. Recycle it as a high value-added carbon compound

CCUS is an extended concept from capturing and storing CO2 to using captured CO2

The concept includes CCS, a capture and storage technology and CCU, a capture and recycling technology

Why do we need CCUS?

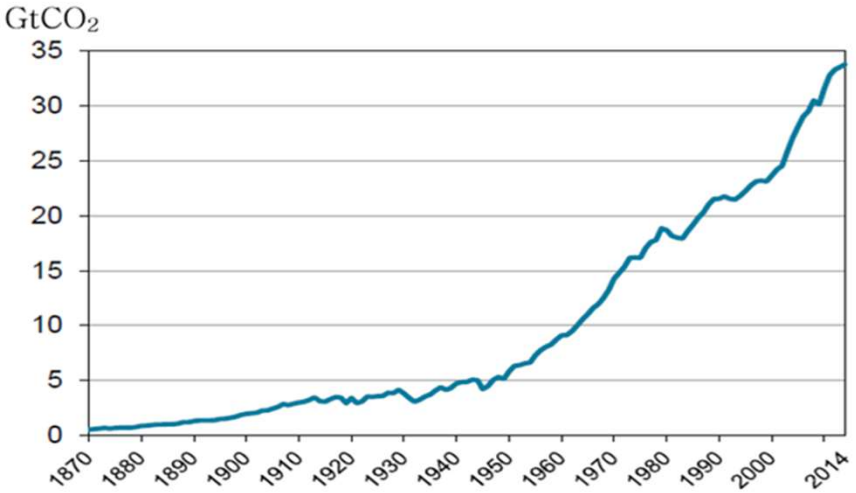
<Temperature Anomalies over Land and over Ocean>



Source : NASA Goddard Institute for Space Studies

Main cause of global warming is increased greenhouse gas emissions, with the highest proportion of CO2

<CO_2 emissions from fossil fuel combustion, 1870-2014>



Source : International Energy Agency (2017)

Excessive carbon dioxide reduction could lead to a weakening of the industry's competitiveness
Because energy use efficiency in the industry is currently at its highest level

What is Smart?

1. Concept of Smart

- High performance and high quality of many recent products and services
- To develop a technology that is more comfortable and efficient by introducing automation or new technologies into existing technologies or objects

2. Significance

- Reduce unnecessary waste and maximize efficiency by aligning demand and supply
- Make people's lives more comfortable, and operate eco-friendly technologies

3. Example of Smart Technology – IoT

Source : 한국정보통신기술협회 정보통신용어사전

-Service infrastructure to provide advanced services by connecting various objects in the physical world and the virtual world based on information communication technology

- A concept that extends the concept of communication of things to the Internet and interacts with all the information in the real and virtual worlds.

Examples of Smart Technology Applications

1. Smart Grid
-Next-generation electrical grid incorporating ICT technology into existing electrical grid
-Based on two-way communication between suppliers and consumers, we can effectively respond to changes in power demand

2. Smart Farm
- A system for maintaining and managing the proper environment of plants by applying IoT
-Automatic management increases efficiency and convenience of production

3. Smart Factory
-Factory that improves productivity and quality by applying ICT technology combined with automation technology
-Install IoT to collect data and control factory

4. Smart City
-A city where people can live more comfortable by utilizing ICT
-The goal is to improve people's quality of life by optimizing urban transportation,IT infrastructure, etc.

※ICT: A technology that forms a alternative society foundation combining telecommunications and computers

Technology for commercializing CCS : KIERSOL

Source : HelloDD.com 뉴스

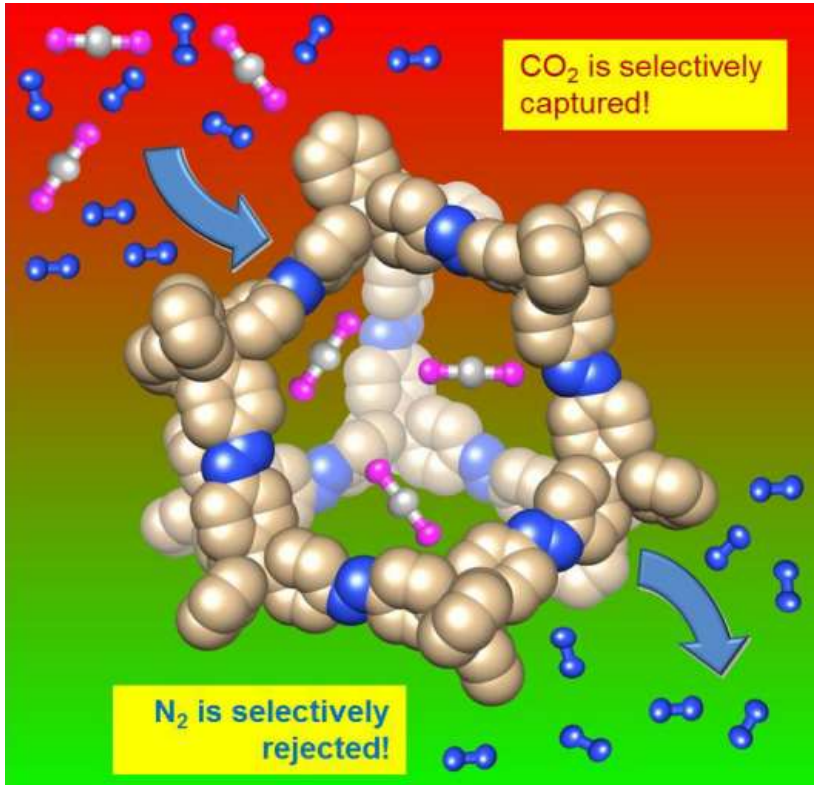
Main reactant : K2CO3
Capture CO2 continuously at 1atm, 20~60℃
-Reduce process costs by downsizing the device
-Long-time operation at high speed with little supplement
-Renewable Energy is 30% less than today, WORLD BEST VALUE
-Very resistant to SOx + low price of sorbent
Capture Cost ≤ 27$/ton CO2 (90%≤Efficiency)
Process can be tailored to customers' needs
In March, got Green Technology Certification first in the field of Carbon Capture
Selected as 100 technologies to lead Korea in 2025
Possibility as a future-oriented technology in CO2-related industry

Under pilot step, evaluating prototype with 13 patent

Source : 한국에너지기술연구원

1	2	3	4	5	6	7	8	9
기초연구		실험		시작품		실용화		사업화

Technology for commercializing CCS : Aso-COP



Source : 교육과학기술부 보도자료

Aso-COP : Invented by KAIST 자페르 야부즈 교수,
알리 조스쿤 교수, 정유성 교수 공동연구팀

<Dry Absorbent>

-Capable of capturing CO2 selectively

-Stable at extreme circumstances (High T, Humid state)

-Relatively simple manufacturing process

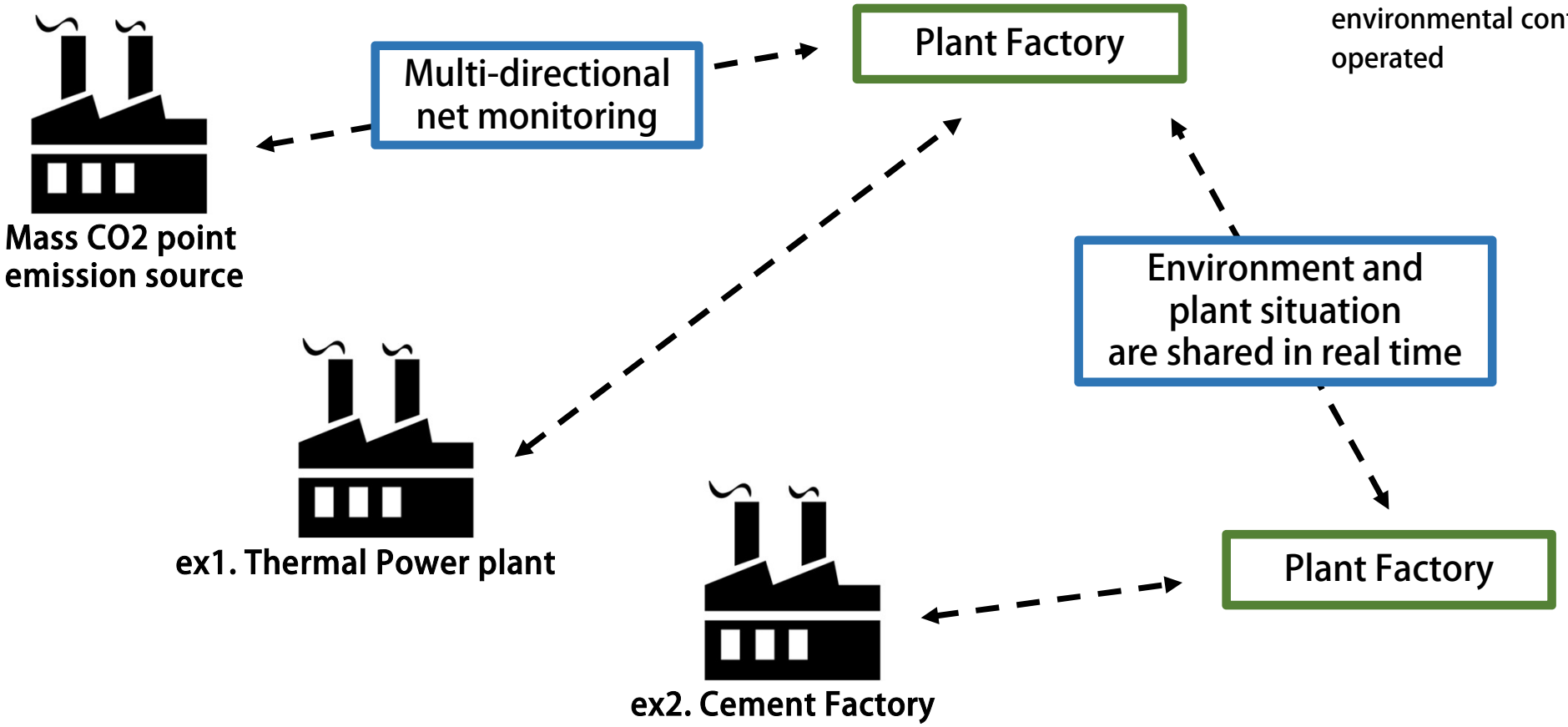
-Cheap solvent ingredient

-Increase of capture efficiency

Development of Technology could lead to
CCS commercialization !

1. Large-scale : Plant factory

-It uses the photosynthesis of plants to achieve carbon fixation in plant factory
-Facilities with complex environmental controlare self-operated



Mass CO2 point emission source

Pipeline with smart sensors

IoT environmental control plant imaging

Source : ㈜ 바이오웍스

Liquid CO2 Storage

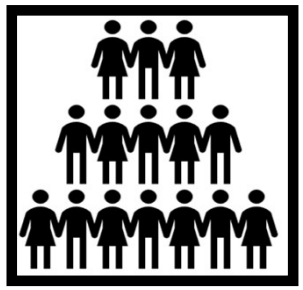
The synergistic effect of CO2 concentration on the growth and yield of crops depends on the type of crop.

Species	CO2 concentration	Increased Growth Rate
Leafy vegetables	1000-1500ppm	24%
Tomato	750 – 800ppm	30%

박경섭 외(2013)
Mortensen, (1987)

Source : OA-LAB 건축연구소

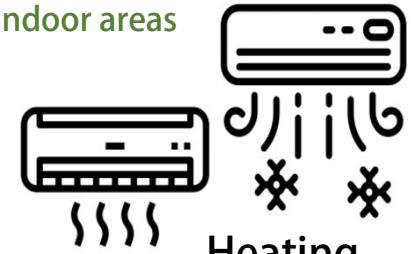
Process of mix-use building



High population Density

Collect CO2 from indoor areas

OR



Heating & Air Conditioning

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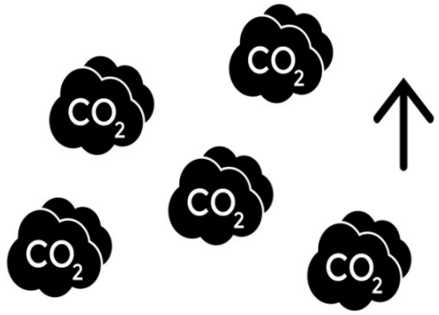
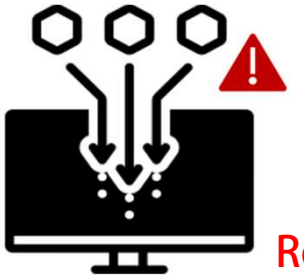


CO2 emission Increase

Assume that the building has automatic detecting sensor

Detect CO2 increase



Response to sensor, Activate capture system

Role of IoT

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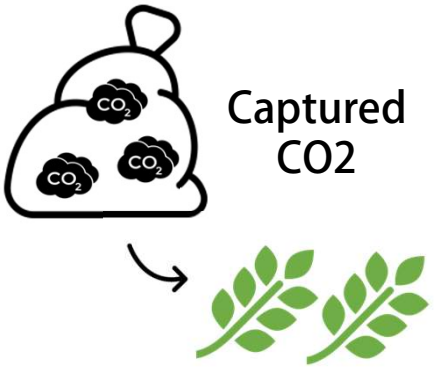
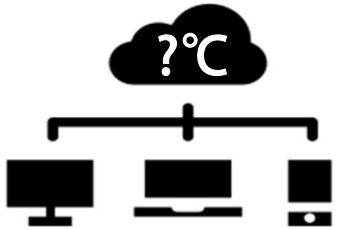


Captured CO2

To the plants

SMART Technology Application to Carbon Capture Control System
-Combination of demand prediction & CCS process-

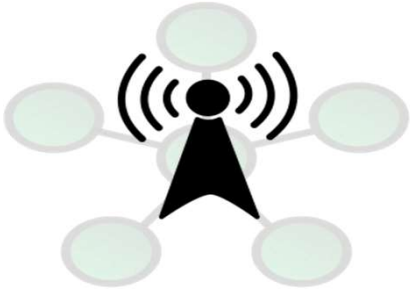


$$WLST_{w,p} = \frac{\triangle NL_{w,p}}{\triangle Temp_{w,p}} \times 100(\%)$$

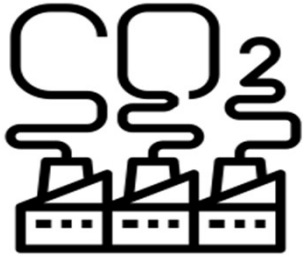
Calculation power demand sensitivity
using **live temperature data**

-Combination of SMART technology and CCS technology
-We can get a real-time information using SMART technology(e.g. IoT)
-The way to maximize efficiency by controlling carbon capture process based on live data.

Demand prediction of
air conditioning or heating
in the building



SMART Control
using IoT technology



Activate capture system
or
Inhibit capture system

Smart Highway & CCS

Source : https://returntooza.tistory.com/102

-Information from Traffic Control Center

-Capturing CO2 by increase of

CO2 concentration

-Carbon Air Capture

-Electricity required is filled by

solar soundproof wall

Source : http://m.segye.com/view/20180914004960

3. Small-scale : CO2 Capture in public transport

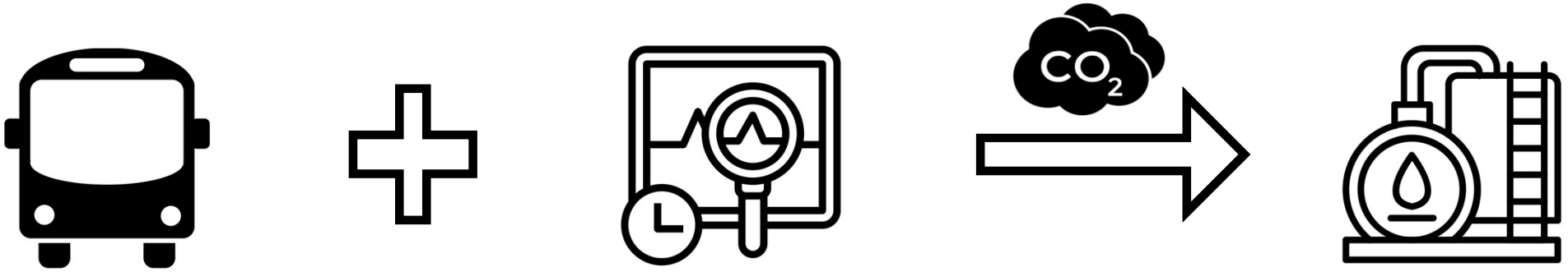
- Capture CO2 generated by passengers inside the vehicle

-Install a small CO2 absorption system in the air vent which is in passenger's car or indoors

- Measure the concentration of CO2 **in real time : SMART**

- Start capture automatically **when concentration reaches 1000 ppm**

- About 2m³ of storage installed



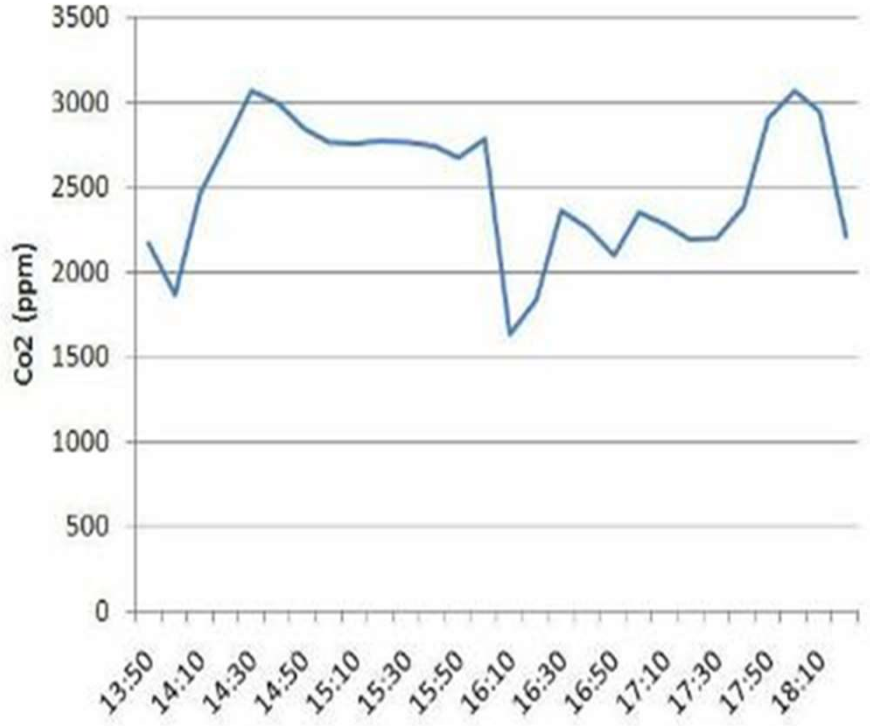
3. Small-scale : CO2 Capture in public transport

Capture capacity calculation procedure

- Calculation based on express bus
-Since the transit usage is increasing rapidly during rush hour, it is assumed that CO2 is collected for two hours each during rush hour and after work
-The express bus is 12m long, 2.495m wide and 3.34m high (The size of the room where ventilation is conducted is set to 2.1m, although the room is 3.34m in full)
-According to the graph, CO2 level increases at every 20 minutes, so it is assumed that we collect CO2 12 times during commuting time
-The concentration of CO2 on express buses during rush hour is 2,505 ppm in summer, on average, and 3,345 ppm in winter; So the total average is 2,925 ppm

>>12m*2.495m*2.1m*(0.002925-0.0005)%*12=1.8m^3

< CO2 change in Primary Down Train Measurement >



Source : 노경환,Natural Ventilation System of Express Bus for Indoor Air Quality and Saving Energy(2009)

3. Small-scale : CO2 Capture in public transport

Limitations

-The amount of CO2 is small
for storage or utilization

-There is not enough electricity in the vehicle
for absorption and storage (risk of discharge)

-Require space on existing buses
to install storage

-Require storage system for captured CO2

Significance

-Even a small amount of carbon dioxide can be prevented from discharging into the atmosphere

-Improve air quality in the car

CCS+SMART CITY

PLANT FACTORY

SMART HIGHWAY

MIX-USE BUILDING

TRASPORTATION

SMART CITY

It is a city designed by us that combines CCS technology and SMART technology together

Application of CO2: Carbon Resourcing

- Technology that produces high-value chemical products by recycling them into carbon sources
- Contributing to reducing national greenhouse gas emissions
- Eco-friendly innovation technology that can prepare for a circular economy future society
- It can be a one way of the CCU

구분	기술개념	최종제품(Application)
화학제품 생산 (Chemical production)	CO_2를 화학적 변환을 통해 화학제품의 원료로 전환	메탄올, 우레아(Urea), CO, 메탄 등
광물 탄산화 (Mineralization)	CO_2를 광물질(칼슘염 등)과 반응시켜 건축자재 등을 생산	탄산염(Carbonates) 등
바이오연료 생산 (CO_2 to fuels)	CO_2 흡수가 빠른 미세조류 (플랑크톤 등)를 연료로 전환	바이오디젤 등

Source: 기후변화의 주범 이산화탄소, 미래 자원으로 가능성은? POSCO 경영연구원

Application of CO2 : Energization of Carbon Market

Carbon-use products are expected to form a market worth up to $70 billion in 20 years

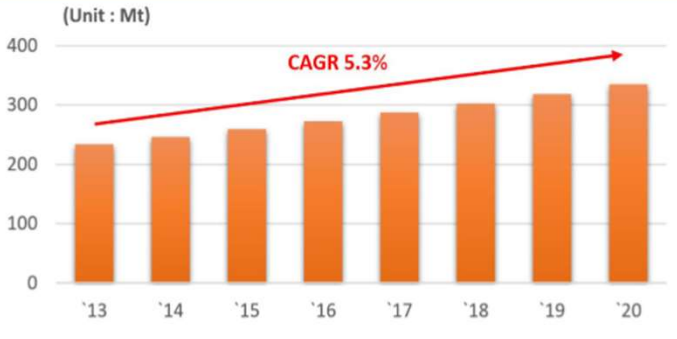
form a market worth up to $837 billion in 30 years with an annual growth rate of 13.8%

Graphs of Carbon Use Product Market

< Global Methanol Demand and Prospect >

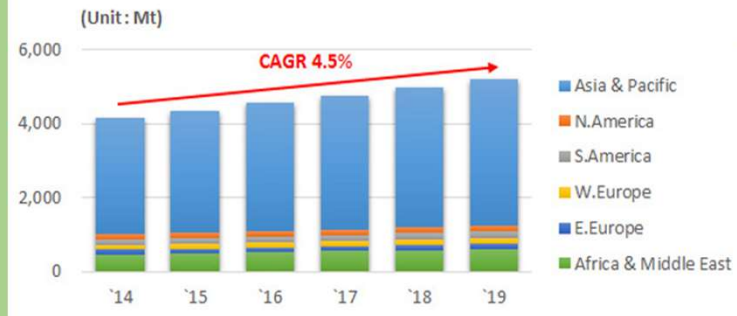
출처: IHS Chemical, 2016

< Global Polymer Demand and Prospect >



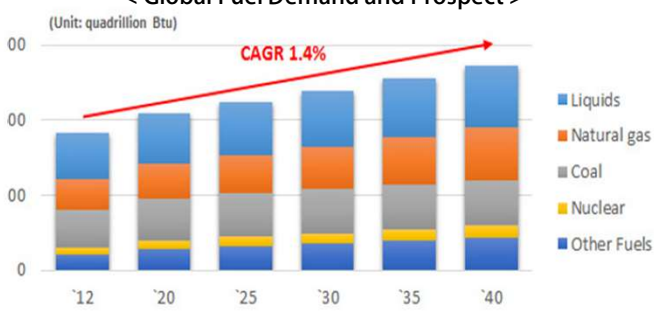
출처: Grand View Research, 2015

< Global Concrete Demand and Prospect >



출처: Freedonia, 2015

< Global Fuel Demand and Prospect >



출처: Energy Information Administration(EIA), 2016

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Limitation of CCUS+SMART City

- In the designed city, there are assumptions that the technology that has not been commercialized yet has been commercialized
- There is a lack of technology to capture not only large-scale capture but also various scales and sources of emissions for commercialization of CCS
- CCS is not economically viable today, so when combined with smart technology, there is little economics
- We cannot expect large amounts of carbon dioxide to decrease by small-scale storage or utilization in the city
- The R&D should be carried out to effectively store and utilize the captured CO2

Significance of CCUS+SMART City

- It is meaningful in terms of CO2 level reduction in the atmosphere
- Captured CO2 can be used in various industries that need CO2
- Emitted CO2 in the city could be stored or utilized in the city itself = SMART
- If this type of smart city is established and all cities are built using the system, there is also an expectation that it will contribute more to the reduction of CO2
- If CCS technology becomes common, it can be expected to vitalize the market through CO2 trading

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