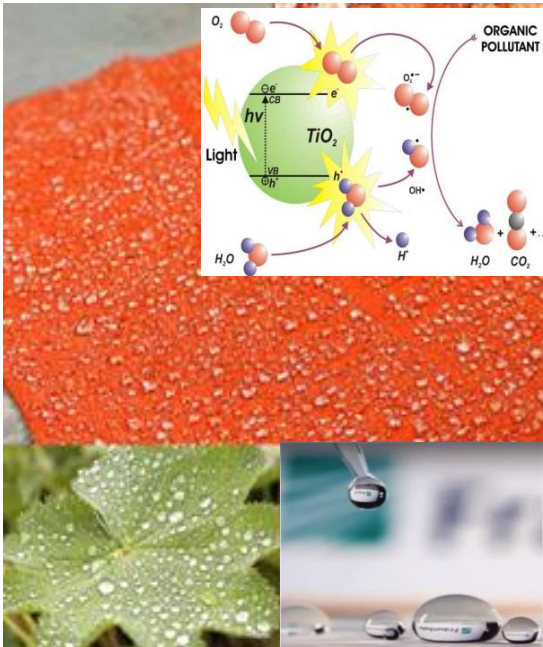


Introduction of New Concept of CCU Technology for Smart Farm Network Model based on CHP(Combined Heat and Power)



Resume



Recent R&D Research Interest

Smart Farm Solution R&BD Convergence Project

Energy-IOT Smart Farm Development Project

Energy IOT-Smart Farm Tech.Assistance for Venture Company Project



Research Career

(2004. 07 – 2012. 06) Senior Researcher , Korea Institute of Energy Research (KIER)

(2012. 07 – 현재) Principal Researcher, KIER

(2013. 12 – 2015. 11) Chief of Energy Network Lab., KIER

(2015. 11 – 2018.10) **Smart Farm Solution Development Convergence Group**, Korea Institute of Science and Technology(KIST)

IEA-DHC “Low Temperature District Heating and Cooling” TS1 member



Field of interest

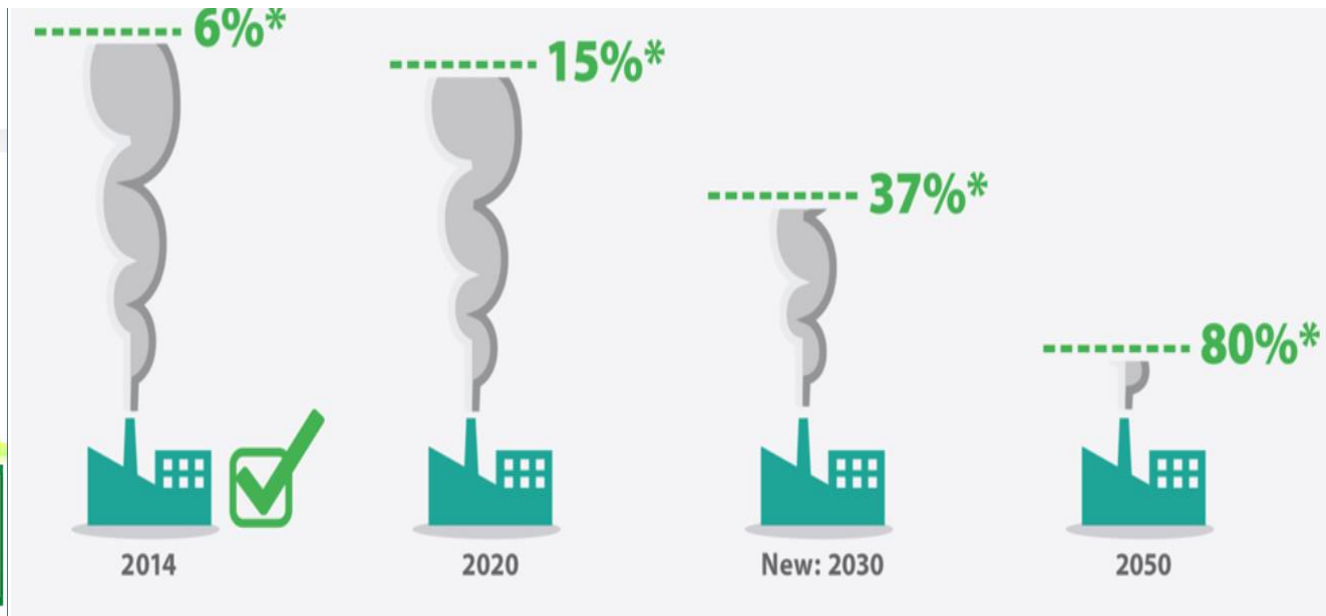
- Combined Heat & Power
- District Heating and Cooling
- Smart Energy Network System & Smart City Platform
- Smart Farm Energy Management System



R&D Accomplishment

- IP: Smart Farm Energy Management Tech. 18 (Registration 4/ Application 14)
- IP: Smart Energy Network System 58(Domestic 51/ Oversea 7)
- SCI Journal 9 (Energy Network Optimization etc.)

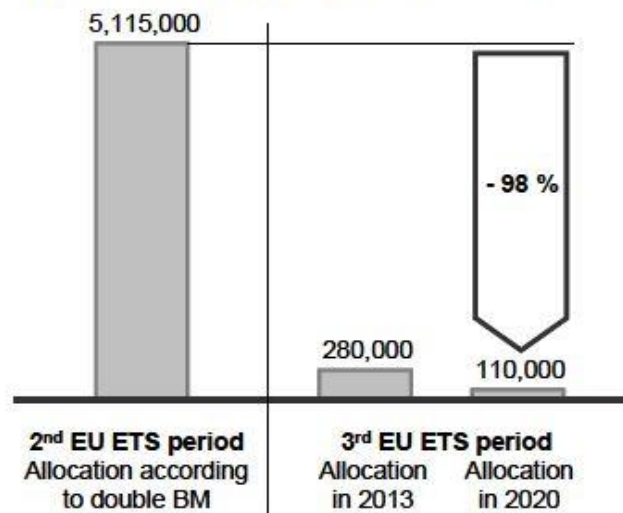
Needs: Climate Change & GHG Reduction



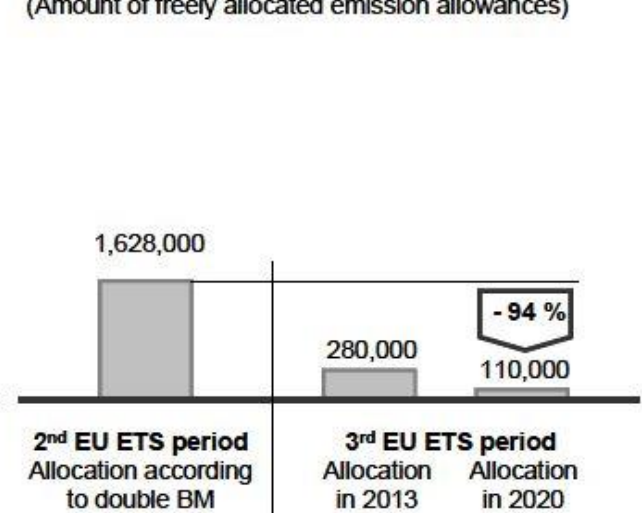
2030년 주요 부문별 온실가스 감축목표

주요 부문	감축률 (%)	감축량 (만t)
국내 발전 (전환)	19.4	6,450
산업	11.7	5,640
건물	18.1	3,580
에너지신산업		2,820
수송	24.6	2,590
공공·기타	17.3	360
폐기물	23.0	360
농축산	4.8	100
국내 감축	25.7%	2억1,900만
국외 감축	11.3%	9,600만

Annual allocation of a coal-fired CHP plant for DH*
(Amount of freely allocated emission allowances)



Annual allocation of a gas-fired CCGT-CHP plant for DH*
(Amount of freely allocated emission allowances)

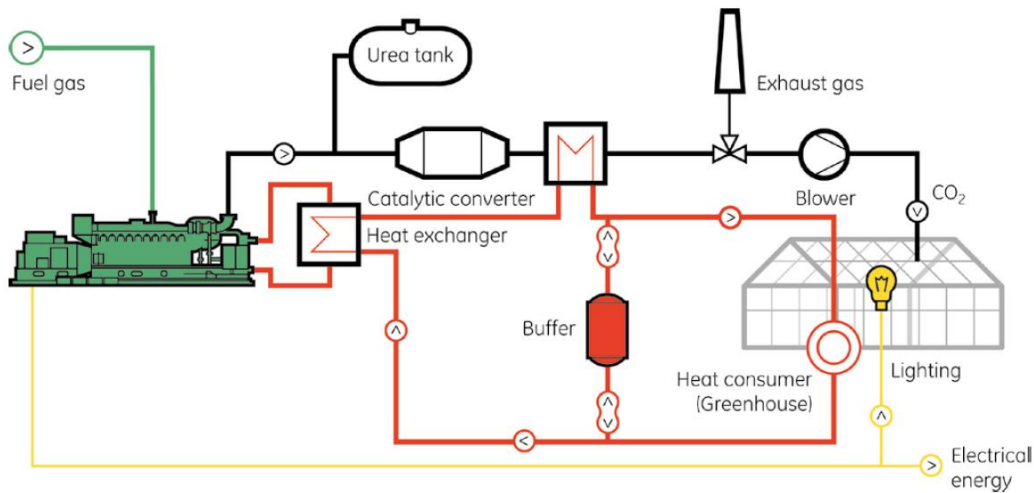


* Technical assumptions according to table 4

Needs on Business: CCU on Smart Farm

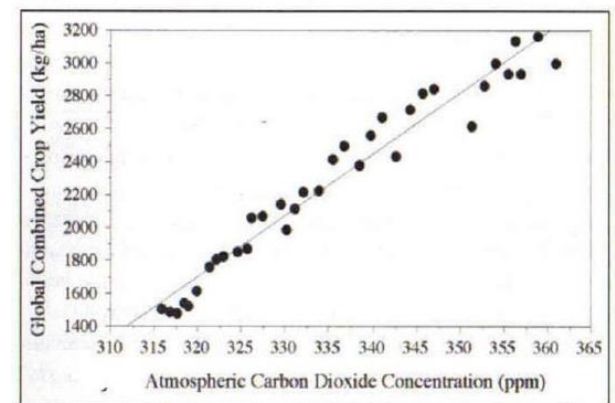


[Fig.] CO₂ Fertilization with CHP



[Fig.] CO₂ Fertilization based Poly-Generation System (Source: GE)

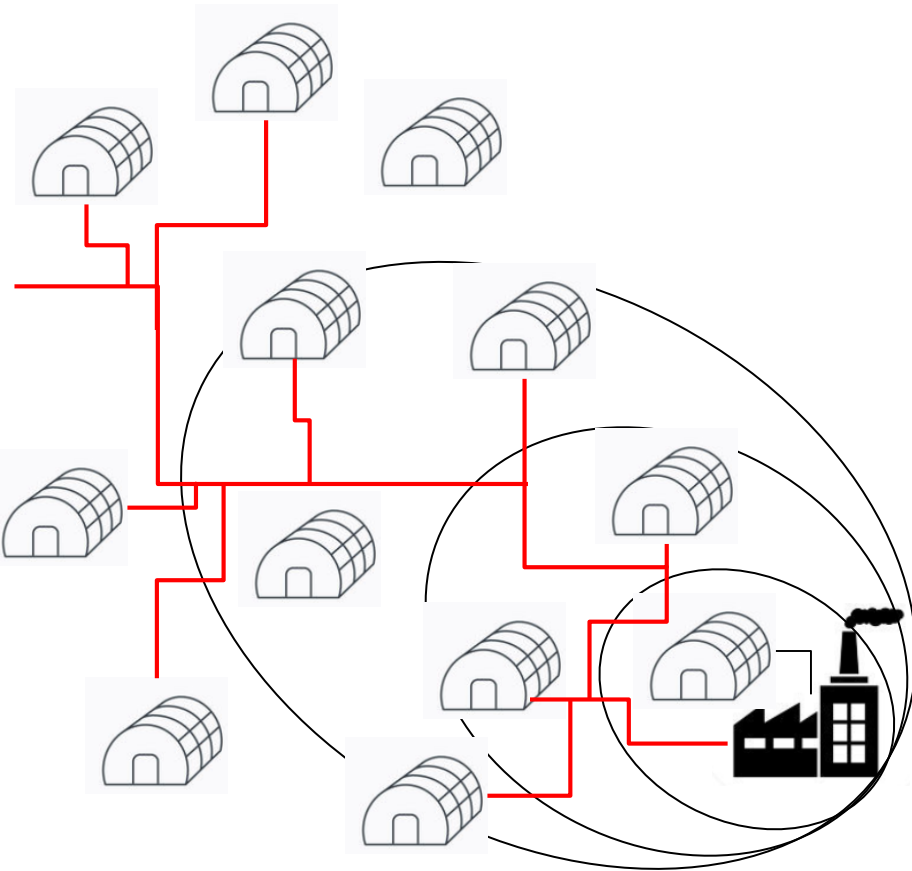
CO₂ and Crop Yields



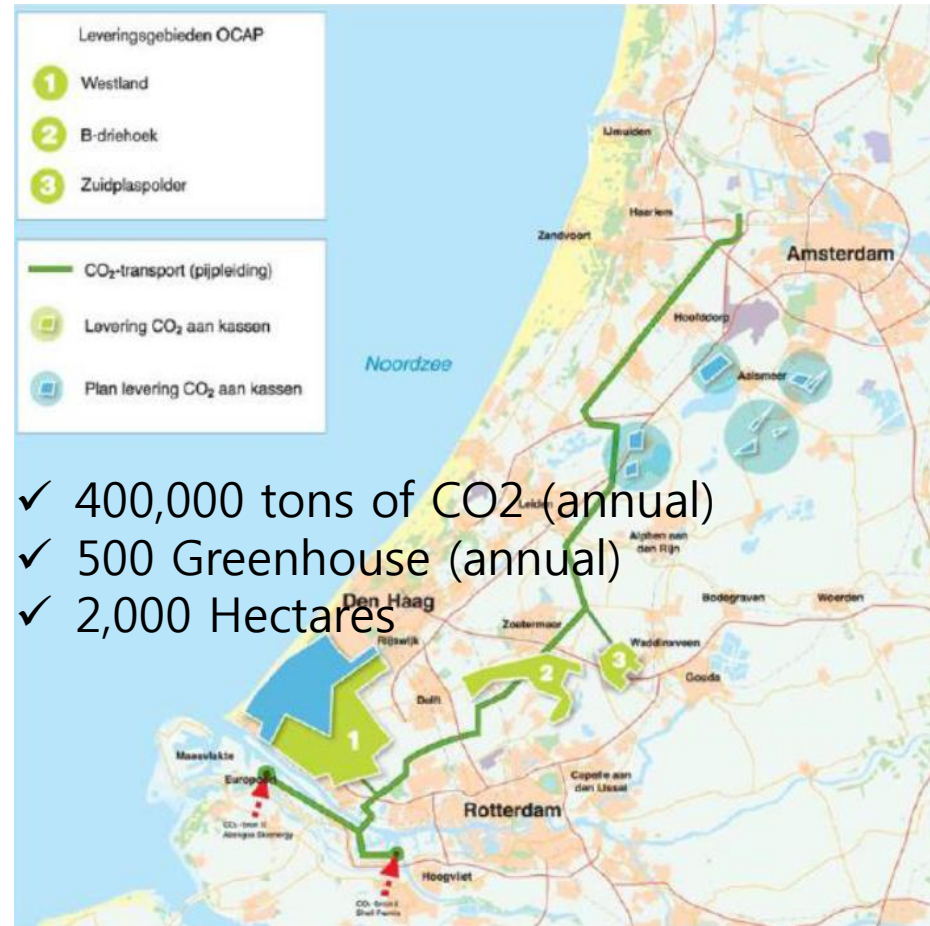
UN Study Graph Blick 2009

[Fig.] Effect of CO₂ Fertilization on Crop Yields

Business Target : Smart Farm Network



Connected Network is required!!



- ✓ 400,000 tons of CO₂ (annual)
- ✓ 500 Greenhouse (annual)
- ✓ 2,000 Hectares

Pipe network for supplying CO₂ to Green House

Approach...

❖ Gaseous CO₂ vs Liquid CO₂

- ✓ **Gaseous CO₂** : Capital Costs Increase by extra pipe implementation, Blowing Power
- ✓ **Liquid CO₂** : Cost for CO₂ compression beyond 50 bar, Capital cost for high pressure pipe
- ✓ Not Adequate for **long distance CO₂ transportation** at the moment...



Aqueous CO₂ solution

- ✓ Co-transportation of CO₂ with Hot water (or Chilled water)

Approach : Co-Transportation of CO₂ & Heat

❖ Aqueous CO₂ Solution Transportation via Pipe Network

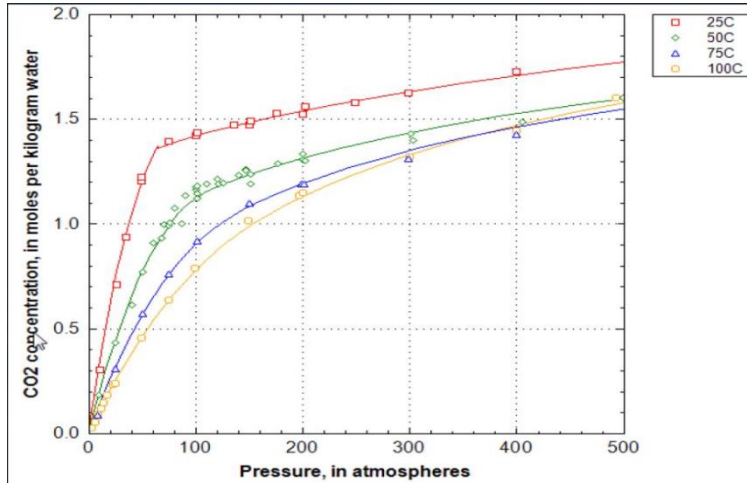
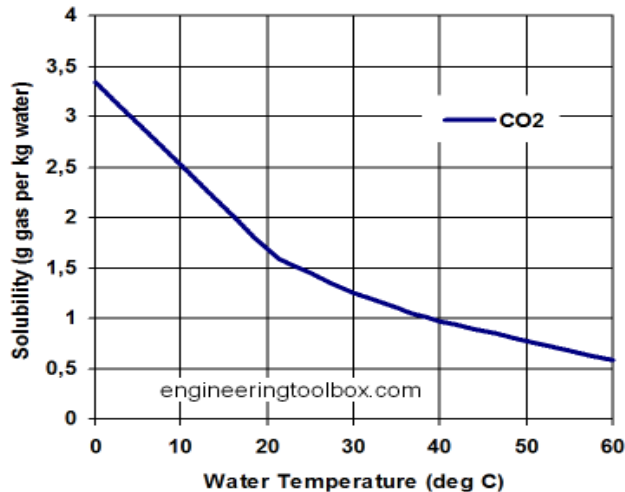


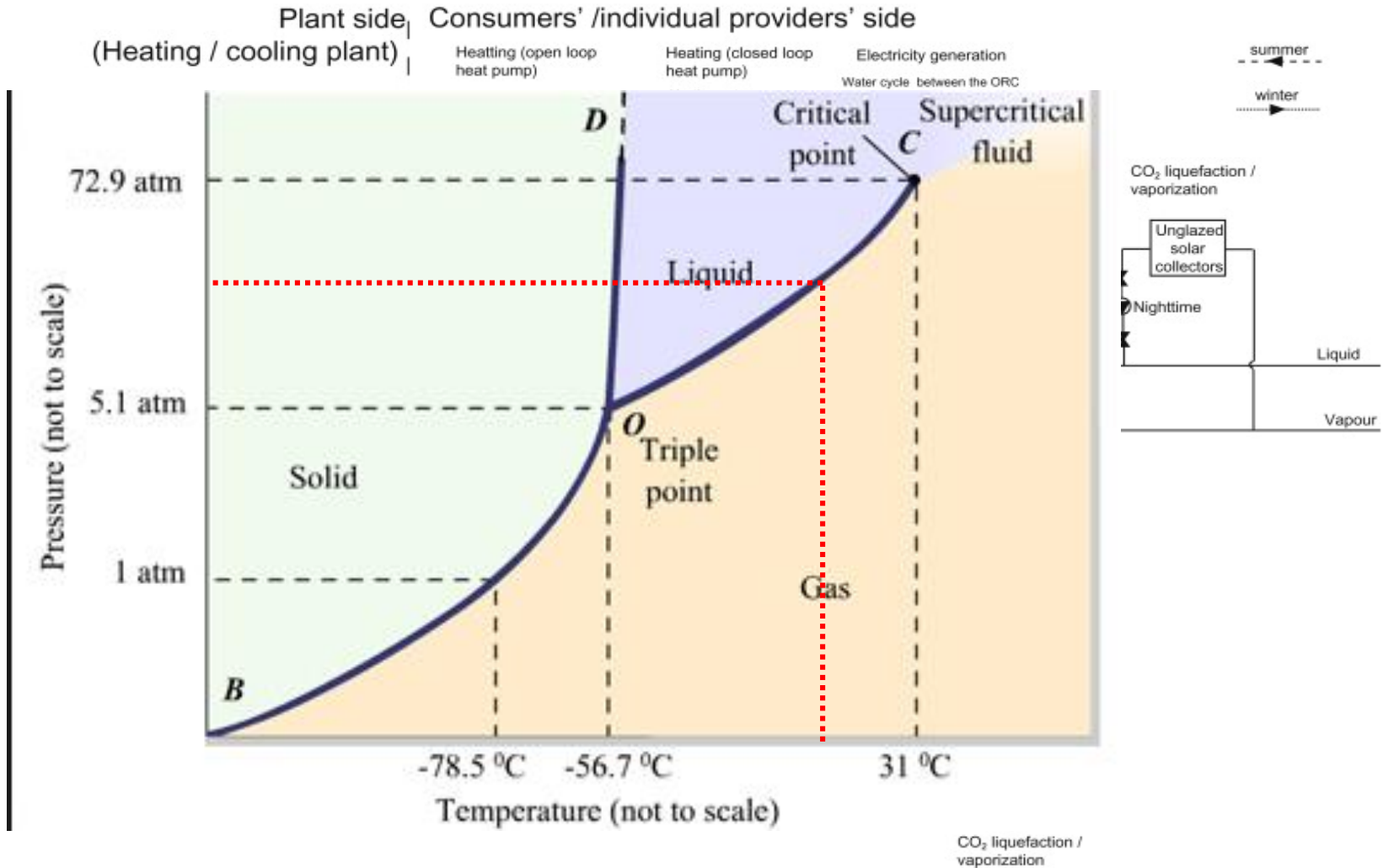
TABLE 4. Calculated solubilities for carbon dioxide in water at various CO₂ partial pressures

Temperature (°C)	Solubility of CO in water at various partial pressures (Solubility in mole fraction × 1000, pressure in kPa)			
	50	101.325	200	500
0	0.671	1.355	2.66	6.52
10	0.477	0.963	1.89	4.65
20	0.353	0.713	1.400	3.45
25	0.308	0.622	1.223	3.01
30	0.271	0.548	1.077	2.66
40	0.216	0.437	0.858	2.12
50	0.178	0.359	0.706	1.75
60	0.150	0.304	0.598	1.480
70	0.131	0.264	0.520	1.288
80	0.116	0.236	0.463	1.148
90	0.106	0.214	0.422	1.046
100	0.098	0.199	0.391	0.971
110	0.093	0.188	0.370	0.917
120	0.089	0.180	0.354	0.880
130	0.086	0.175	0.345	0.856
140	0.085	0.172	0.339	0.844
150	0.085	0.172	0.338	0.841
160	0.085	0.173	0.340	0.846



Competitors and Competitiveness

❖ CO₂ Pipe Network (Liquid Phase, > 50 bar)



Status of the patent

지식재산권정보				출원정보				등록정보				발명자	
신청번호	특허명	구분	국가	출원번호	출원일	출원명	등록번호	등록일	등록명	주 발명자	주발명자부서	발명자목록	
RESI2040900019	이산화탄소와 온수 통합	특허	대한	10-2013-0053098	2013-05-10	이산화탄소	10-1398395	2014-05-16	이산화탄소와 온수 통합 이송배관을 구비한 온	임용훈	에니	임용훈(20409), 이재용(21206)	
RESI2040900026	이산화탄소 시비용 열병	특허	대한	10-2013-0078225	2013-07-04	이산화탄소	10-1484715	2015-01-14	이산화탄소 시비용 열병합발전 시스템	임용훈	에니	임용훈(20409), 강새별(20702), 박병식(18210), 이재용(21206)	
RESI2040900020	이산화탄소와 온수 통합	특허	PCT	PCT/KR2013/00760	2013-08-26	이산화탄소			이산화탄소와 온수 통합 이송배관을 구비한 온	임용훈	에니	임용훈(20409), 이재용(21206)	
RESI2040900056	이산화탄소와 온수 통합	특허	미국	US 14/404,587	2014-11-28	이산화탄소			이산화탄소와 온수 통합 이송배관을 구비한 온	임용훈	에니	임용훈(20409), 이재용(21206)	
RESI2040900057	이산화탄소와 온수 통합	특허	유럽	EP 13884351.1	2014-11-28	이산화탄소			이산화탄소와 온수 통합 이송배관을 구비한 온	임용훈	에니	임용훈(20409), 이재용(21206)	



The Director of the United States Patent and Trademark Office

Has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this

United States Patent

Grants to the person(s) having title to this patent the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States of America or importing the invention into the United States of America, and if the invention is a process, of the right to exclude others from using, offering for sale or selling throughout the United States of America, or importing into the United States of America, products made by that process, for the term set forth in 35 U.S.C. 154(a)(2) or (c)(1), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b). See the Maintenance Fee Notice on the inside of the cover.

Joseph Matz

Performing the Functions and Duties of the Under Secretary of Commerce for Intellectual Property and Director of the United States Patent and Trademark Office

US909756793B2

(12) United States Patent
Im et al.

(10) Patent No.: **US 9,756,793 B2**
(45) Date of Patent: **Sep. 12, 2017**

(54) **COMBINED HEAT AND POWER SYSTEM FOR GREENHOUSE CARBON DIOXIDE ENRICHMENT WITH UNITED TRANSMISSION PIPES FOR HOT WATER AND CARBON DIOXIDE**

(58) **Field of Classification Search**
CPC: A01G 9/18; A01G 9/24; A01G 9/245; F24D 1000/18; F02E 10/28
(Continued)

(56) **References Cited**
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(Continued)

FOREIGN PATENT DOCUMENTS
JP 2005-137462 6/2005
JP 2009-027011 2/2009
(Continued)

(21) Appl. No.: **14404,587**

(22) PCT Filed: **Aug. 26, 2013**

(86) PCT No.: **PCT/KR2013/00760**

(87) Date: **Nov. 28, 2014**

(88) PCT Pub. No.: **WO/2014/181932**
PCT Pub. Date: **Nov. 13, 2014**

(65) **Prior Publication Data**
US 2016/0057943 A1 Mar. 3, 2016

(30) **Foreign Application Priority Data**
May 10, 2013 (KR) 10-2013-0053098

(51) **Int. Cl.**
A01G 9/18 (2006.01)
A01G 9/24 (2006.01)
F24D 1000 (2006.01)

(52) **U.S. Cl.**
CPC: A01G 9/18 (2013.01); A01G 9/245 (2013.01); F24D 1000 (2013.01); (Continued)

6 Claims, 5 Drawing Sheets

(19) (11) **EP 2 868 871 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
04.10.2017 Bulletin 2017/40

(51) Int. Cl.:
F01K 19/00 (2006.01) F01K 21/00 (2006.01)
A01G 9/18 (2006.01) F24D 1000 (2006.01)
A01G 9/24 (2006.01)

(21) Application number: **13884351.1**

(86) International application number:
PCT/KR2013/007607

(22) Date of filing: **26.08.2013**

(87) International publication number:
WO 2014/181932 (13.11.2014 Gazette 2014446)

(54) **COMBINED HEAT AND POWER SYSTEM FOR GREENHOUSE CARBON DIOXIDE ENRICHMENT PROVIDED WITH INTEGRATED HOT WATER AND CARBON DIOXIDE CONVEYING PIPES**
KOMBINIERTES WÄRME- UND STROMERZEUGUNGSSYSTEM ZUR ANREICHERUNG VON KOHLENDIOXID FÜR GEWÄCHSHÄUSER MIT INTEGRIERTEN HEISSWASSER- UND KOHLENDIOXIDFÖRDERLEITUNGEN
SYSTÈME À CHALEUR ET ÉLECTRICITÉ COMBINÉES POUR ENRICHISSEMENT EN DIOXYDE DE CARBONE DE SERRE POURVU DE TUYAUX D'ACHÈMEMENT D'EAU CHAUDE ET DE DIOXYDE DE CARBONE INTÉGRÉS

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IT LI LT LV LU MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **10.05.2013 KR 20130053098**

(43) Date of publication of application:
06.05.2015 Bulletin 2015/19

(74) Proprietor: **Korea Institute of Energy Research Daejeon 305-343 (KR)**

(72) Inventors:
IM, Yong Hoon Daejeon 35201 (KR)

• **LEE, Jae Yong Seoul 135-272 (KR)**
(74) Representative: **Petrz, Gilberto Luigi et al GLP S.r.l. Viale Europa 171, 33100 Udine (IT)**

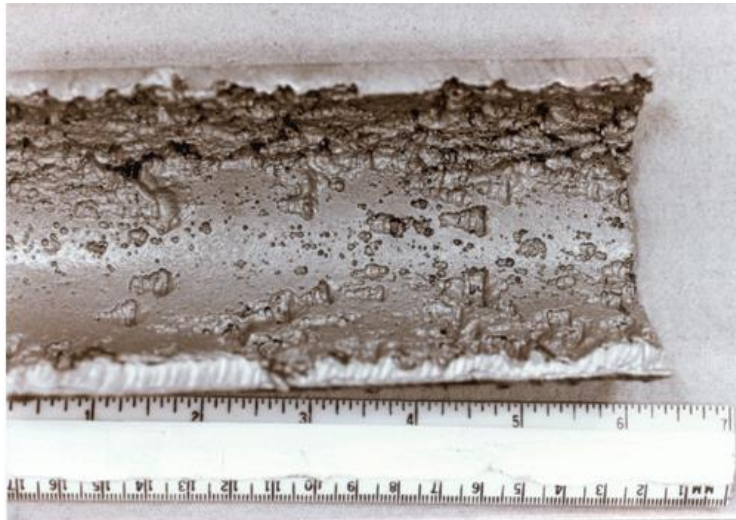
(56) References cited:
WO-A1-2009/038487 JPA-2005 137 482
JPA-2010 022 331 KR-B1-101 044 375
KR-B1-101 063 372 KR-B1-101 063 372
KR-B1-101 194 168

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Printed by Acom, 75001 P6803 (FR)

EP 2 868 871 B1

Technology Development and Verification



Carbon dioxide corrosion of carbon steel. Image credits: [Pipeline Observer](#).



Mid&Small Scale Network

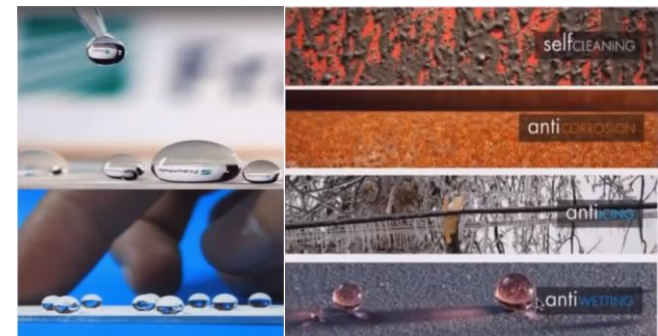
PEX pipe
(No Corrosion)



Large Scale Network

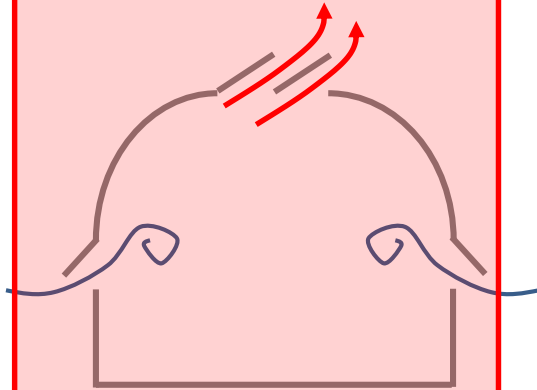
Protective layer of corrosion

- Super-hydrophobic coating
- Reduce friction
- Anti-corrosion of CO₂



Greenhouse Development Stage by HVAC

Windows
Open/Close
TRL 10

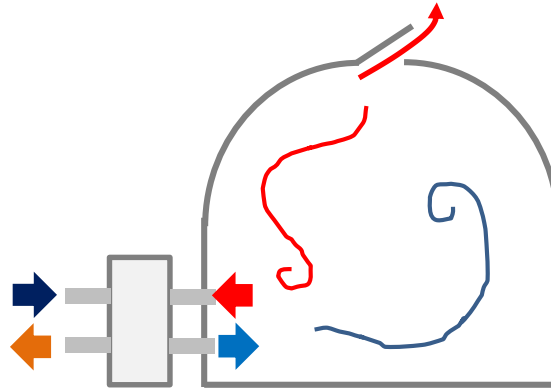


Conventional GH
(Window Open)

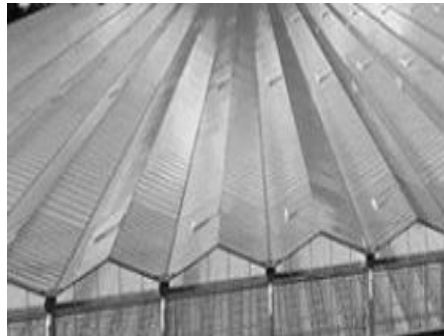


Semi-Closed

TRL 7

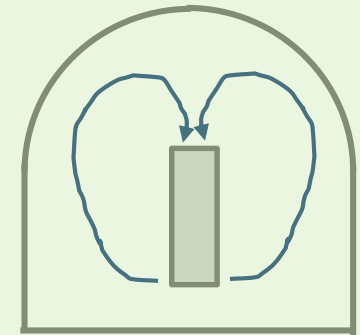


Semi-closed GH
(Screening Ventilation)



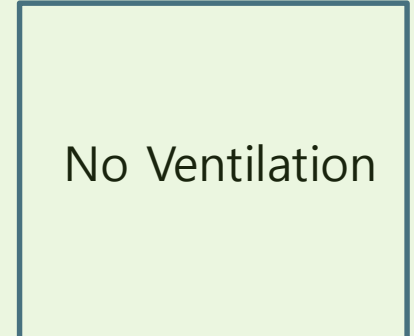
Almost Closed

TRL 2



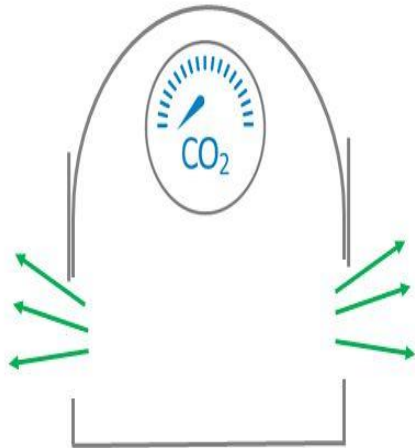
Closed GH
(Self- Purification)

No Ventilation



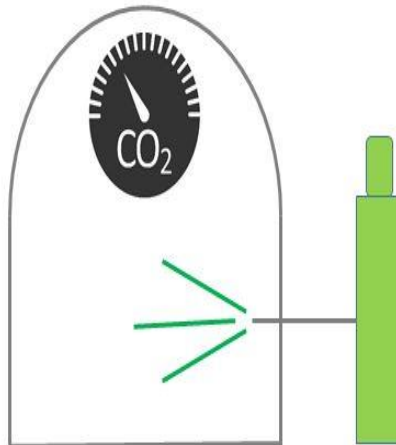
Competitiveness : CO₂ fertilization cost down

Greenhouse with Window

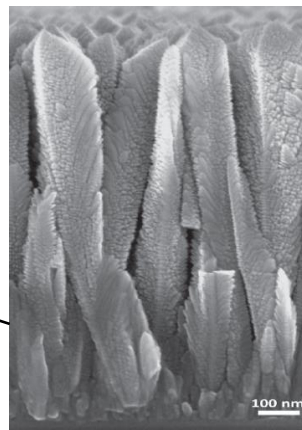
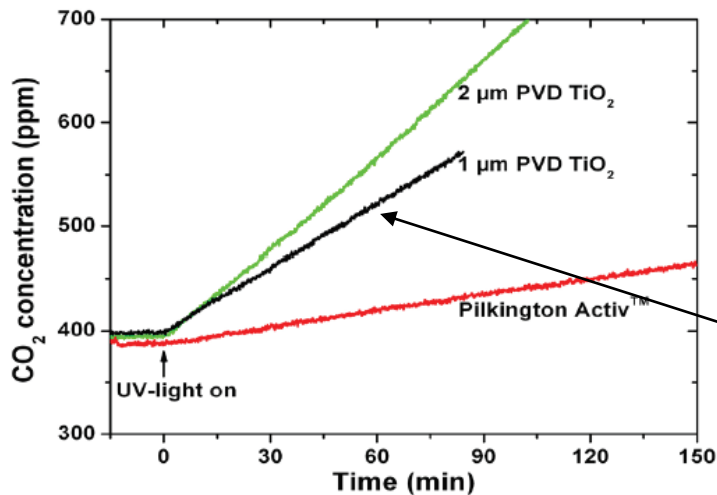


Windows Open&Close
(CO₂ Supply Cost)

Windowless Greenhouse

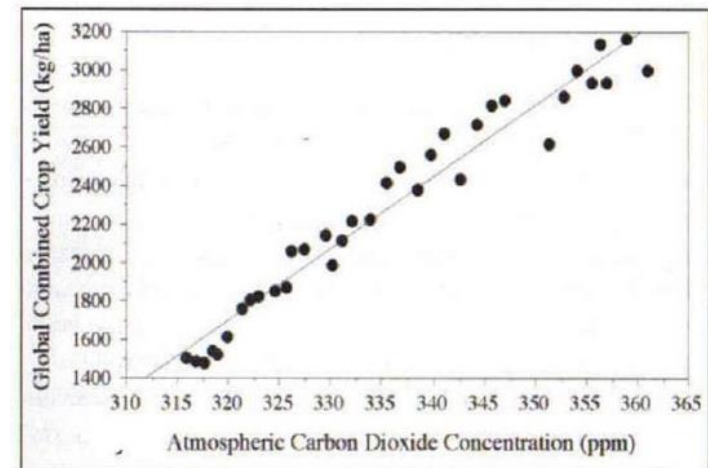


Almost Closed GH
(CO₂ Supply Cost Reduction &
Productivity Up)



TiO₂ SEM image(1μm)

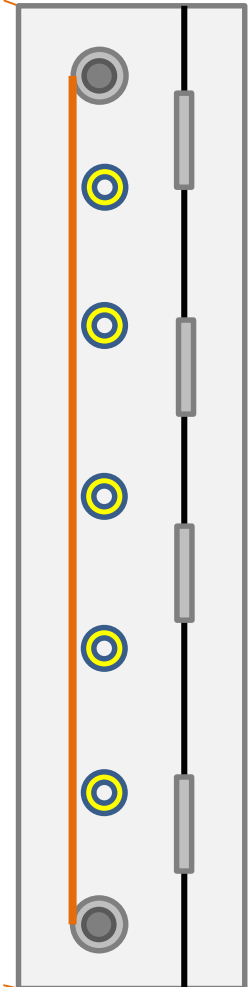
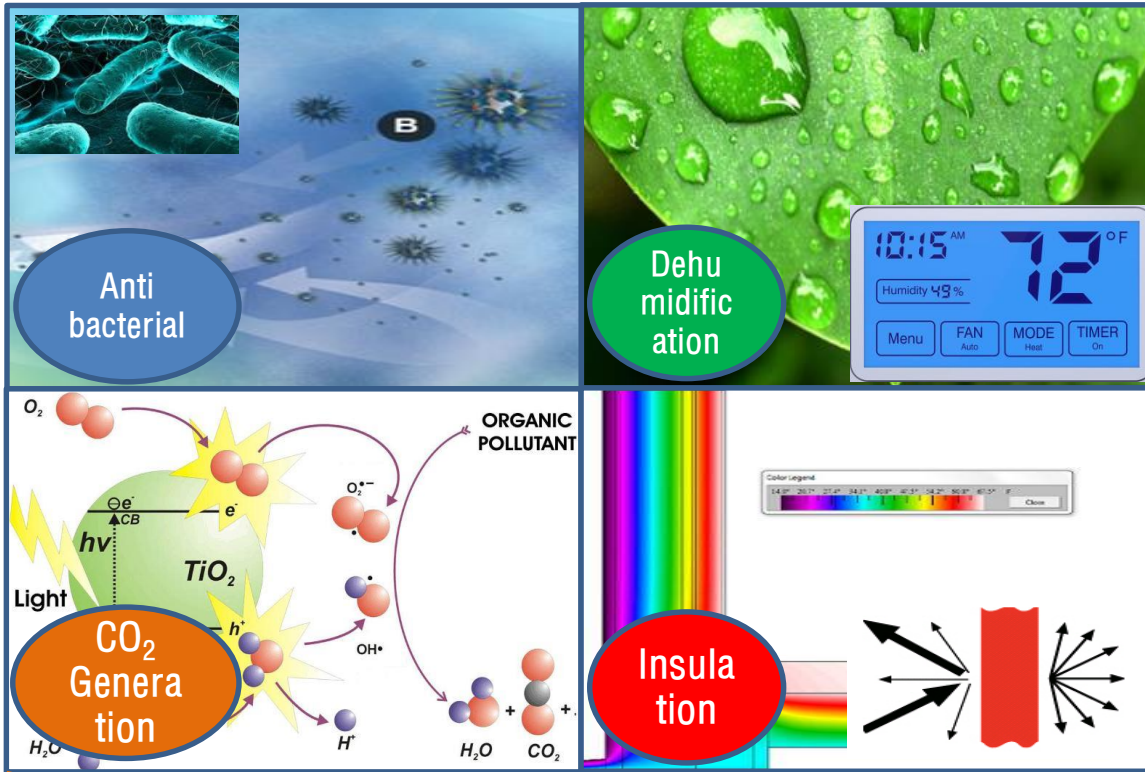
CO₂ and Crop Yields



UN Study Graph Blick 2009

The Technology: Smart HVAC System for A.C. Greenhouse

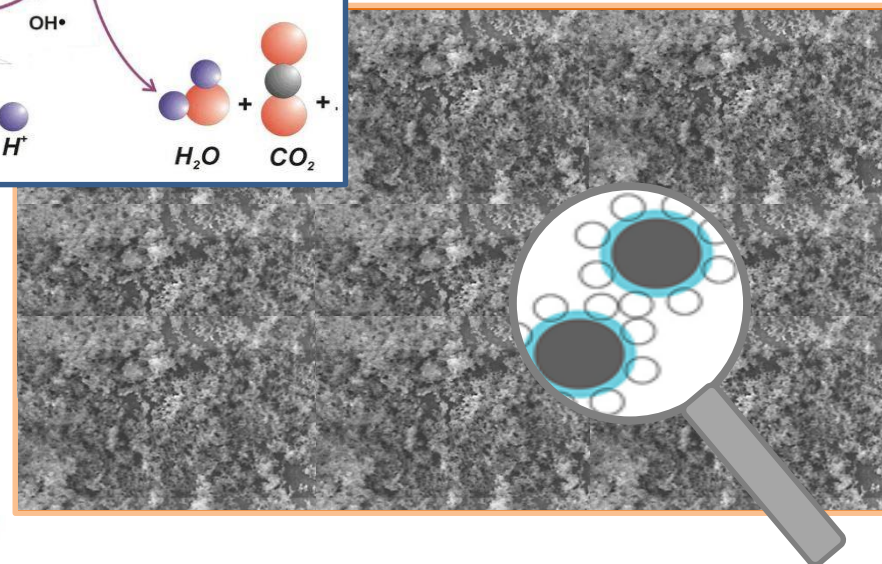
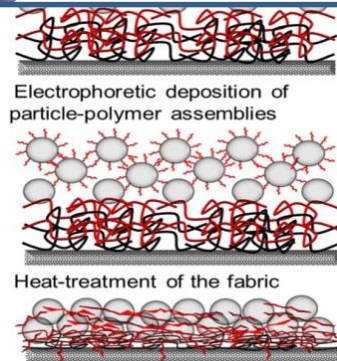
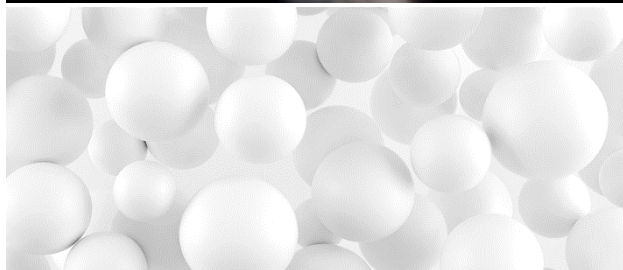
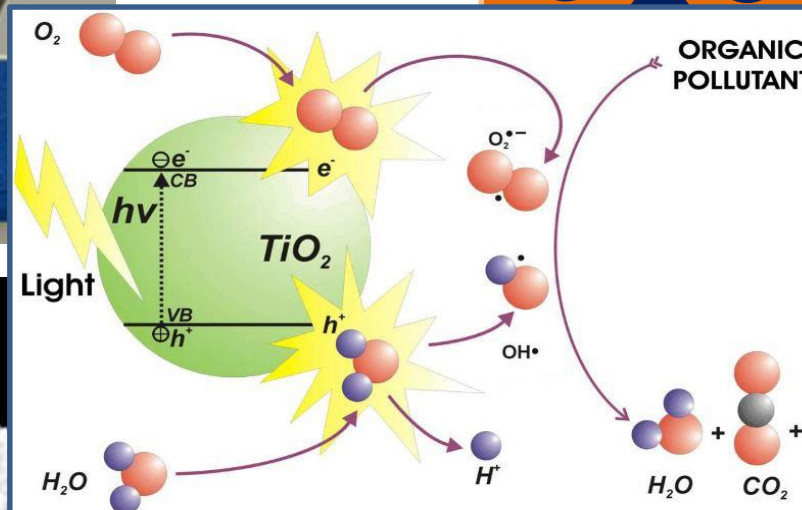
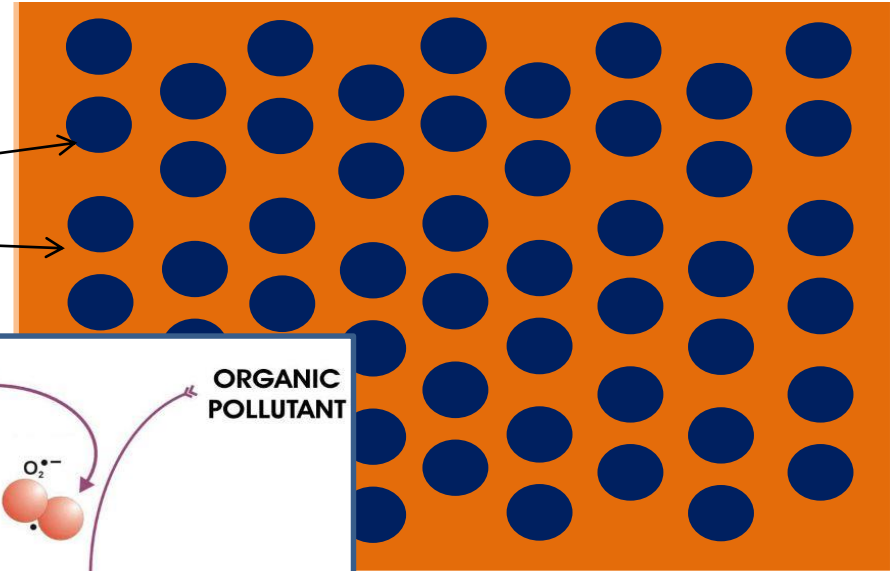
Passive Skin



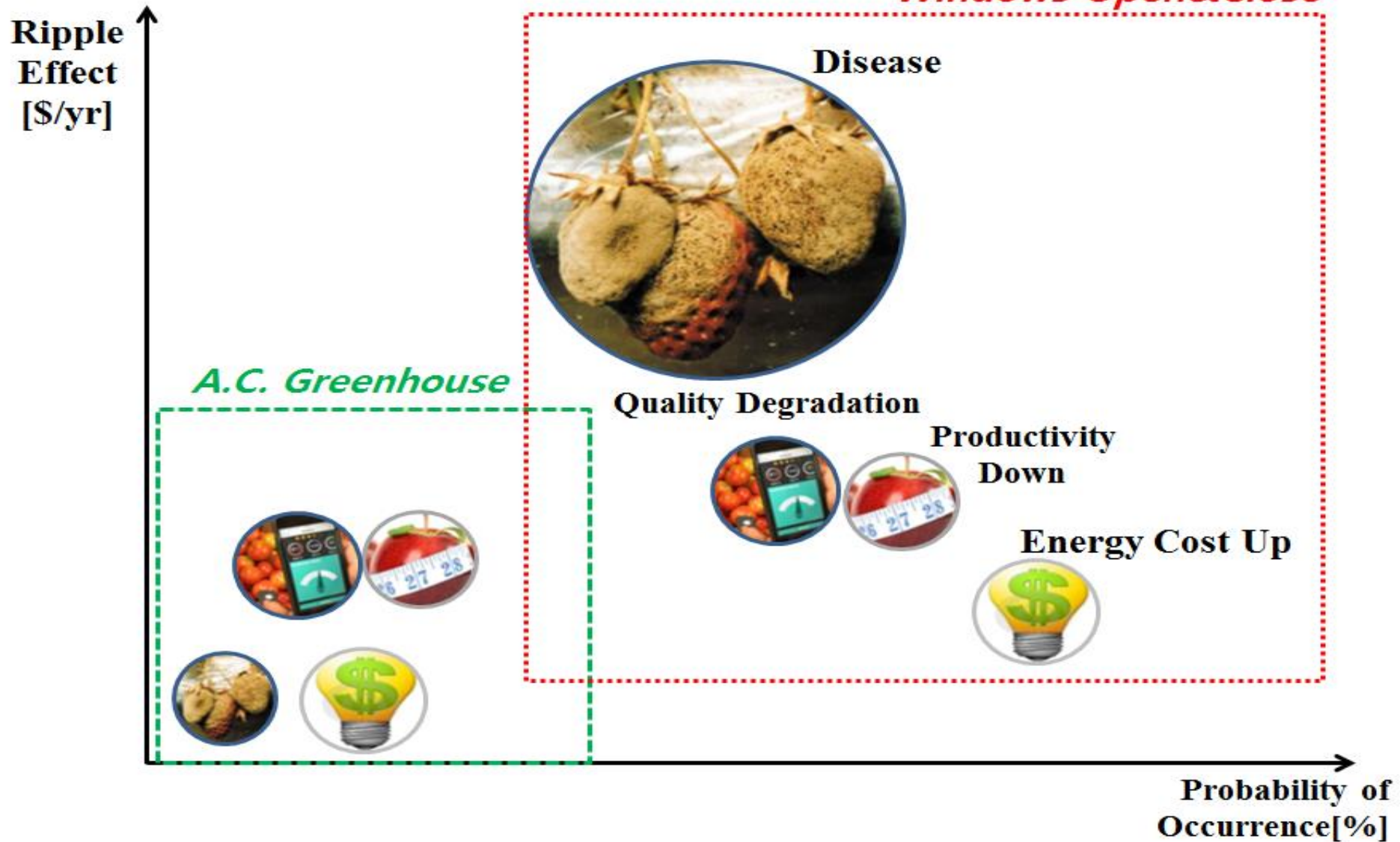
Photocatalytic Process(Nano Scale Coating of TiO_2)



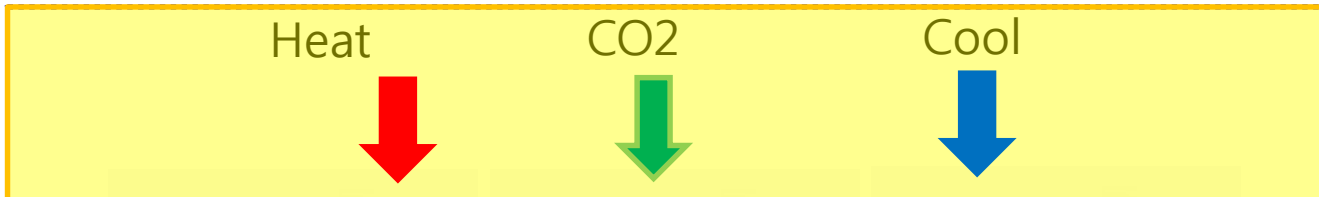
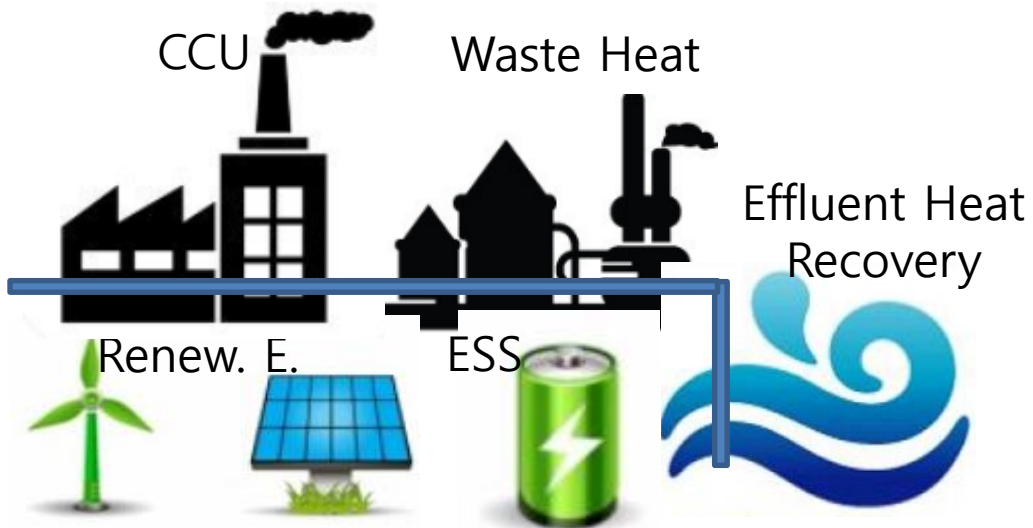
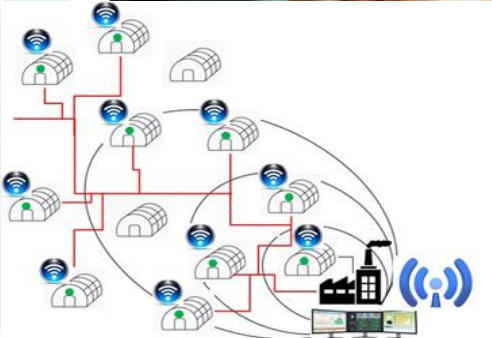
TiO_2



Benefits & Business Target



Benefits: Business Model



תודה

Dankie Gracias

Спасибо

شكراً

Merci Takk

Köszönjük

Terima kasih

Grazie Dziękujemy

Dėkojame

Ďakujeme

Vielen Dank

Paldies

Kiitos

Täname teid

谢谢

Thank You

Tak

感謝您

Obrigado

Teşekkür Ederiz

Σας Ευχαριστούμε

감사합니다

Bedankt

Děkujeme vám

ありがとうございます

Tack

<http://www.kier.re.kr>

Tel: +82-42-860-3327

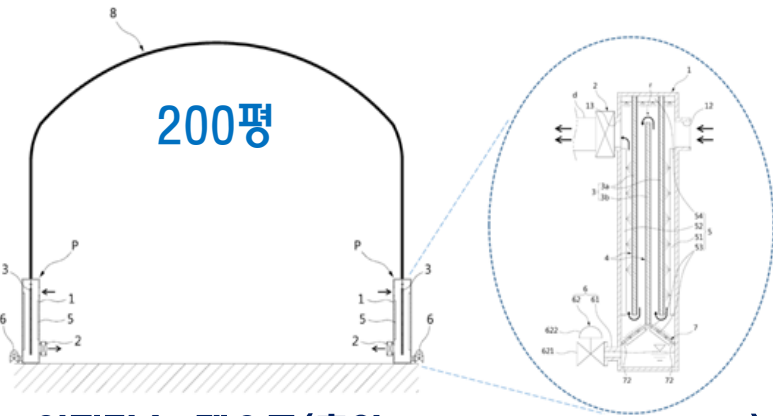
E-mail: iyh@kier.re.kr

기술적용 효과 분석: 이전 기술의 우수성

❖ 항균성 : 온실 공기 중 병원균 (3.2log/h)

$$A = \log(N_{\text{TiO}_2}) - \log(N_{\text{control}}) = \log\left(\frac{N_{\text{TiO}_2}}{N_{\text{control}}}\right)$$

- N_{TiO_2} : TiO_2 가 없는 대조군 생존 세균 수
- $N_{2\text{control}}$: TiO_2 적용시 생존 세균 수
- $N_{\text{TiO}_2} = 10^A \times N_{2\text{control}} = 10^{3.2} \times N_{2\text{control}} = 1,584 \times N_{2\text{control}}$
- **1,584분의 1로 세균 감소**



이전기술 개요도(출원: 10-2017-0142689)

❖ 제습성능 (1.23 kg/m²h):

- 벽체 모듈 당 면적 = 3m²
- 벽체 모듈 당 제습성능 = 3.7kg/h
- 200평 온실 제습성능 = 3.7(kg/h · 개) × 140(개) = 518kg/h
- 제습기준 : 27gr/m³(@ 32°C RH80%) - 10.9gr/m³(@ 24°C 50%) = 16.1gr/m³
- (200평 온실 체적 = 3,305m³ / 수분제거 필요량 = 3,305 × 16.1/1000 = 53.29 kg
- **약 10분 이내로 RH 30% 저감 가능 (ΔT=8C)**

❖ CO₂ Self-Generation (3.0 g/m²h):

- 벽체 모듈 당 면적 = 3m²
- 벽체 모듈 당 CO₂ 생산 = 9g/h · 개
- 200평 온실 CO₂ 생산 = 9g/h · 개 × 140(개) = 1,260g/h = 1.26kg/h
- 200평 온실 체적 = 3,300m³ (H=5m)
- 1ppm(CO₂)=1.8mg/m³
- 1260000/2300 = **380ppm/h**

