iea

Bioenergy

Bioenergy accounts for roughly one-tenth of world total primary energy supply today.

Research and Development for Biofuel to Decarbonize Transport

Fuli Li

Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences

CAS is China's lead national scientific institution in natural sciences and high-tech development and supreme scientific advisory body.

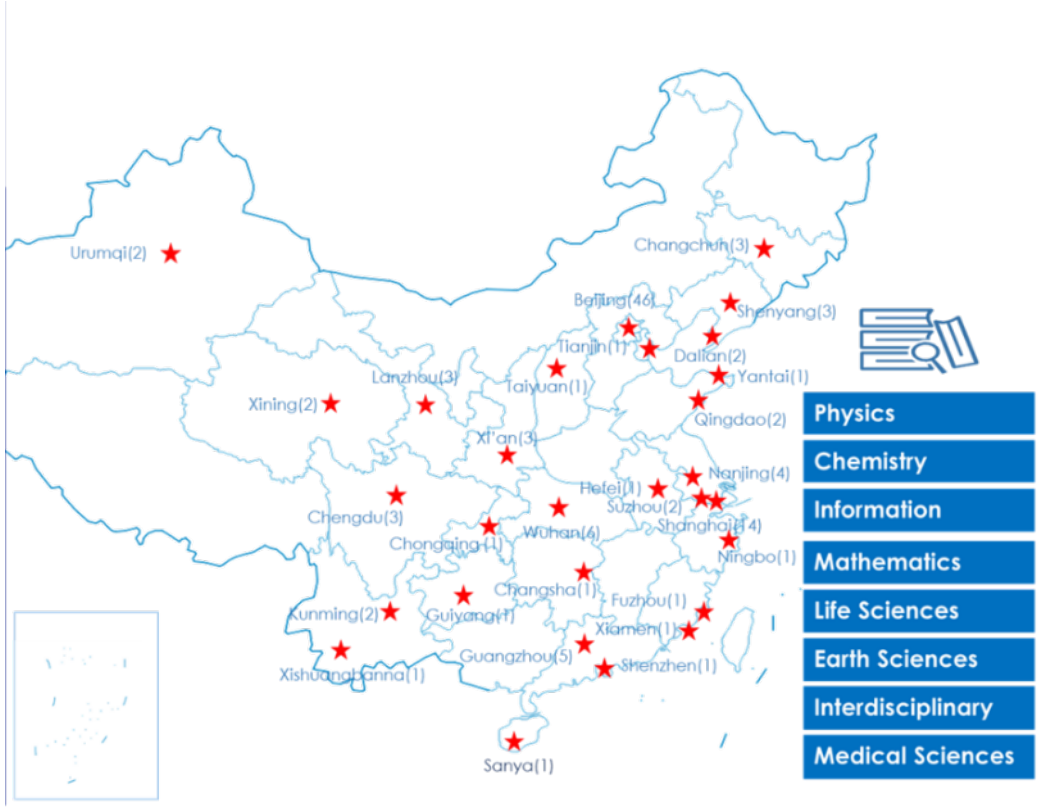
Mandate

Basic and applied research of high relevance
Science-based advice and consultation
Higher education | Technology transfer
Enhancement of international competitiveness and impact

中国科学院
CHINESE ACADEMY OF SCIENCES

Three IN One

1. research & development system
2. a merit-based academic society
3. higher education function



International Outreach Initiative---
9 overseas research organizations

106 *research institutes*

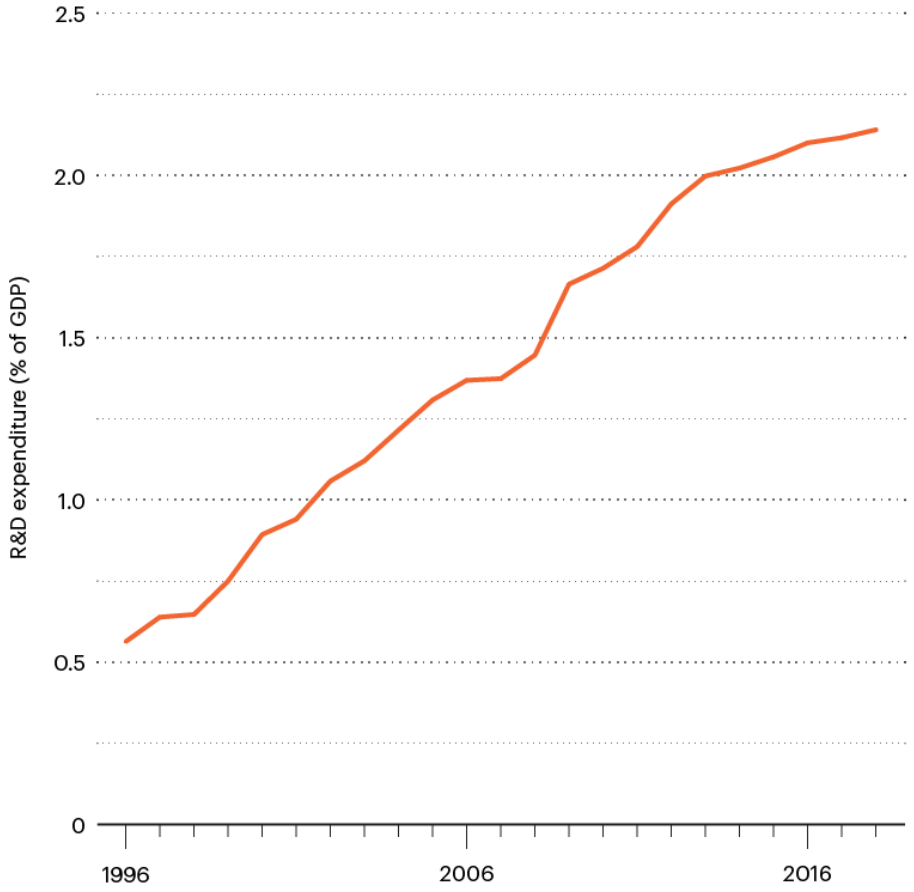
800 *Members*
92 *Foreign Fellows*

3 *Universities*
70,000+ *students*

A Top Contributor of Quality Science

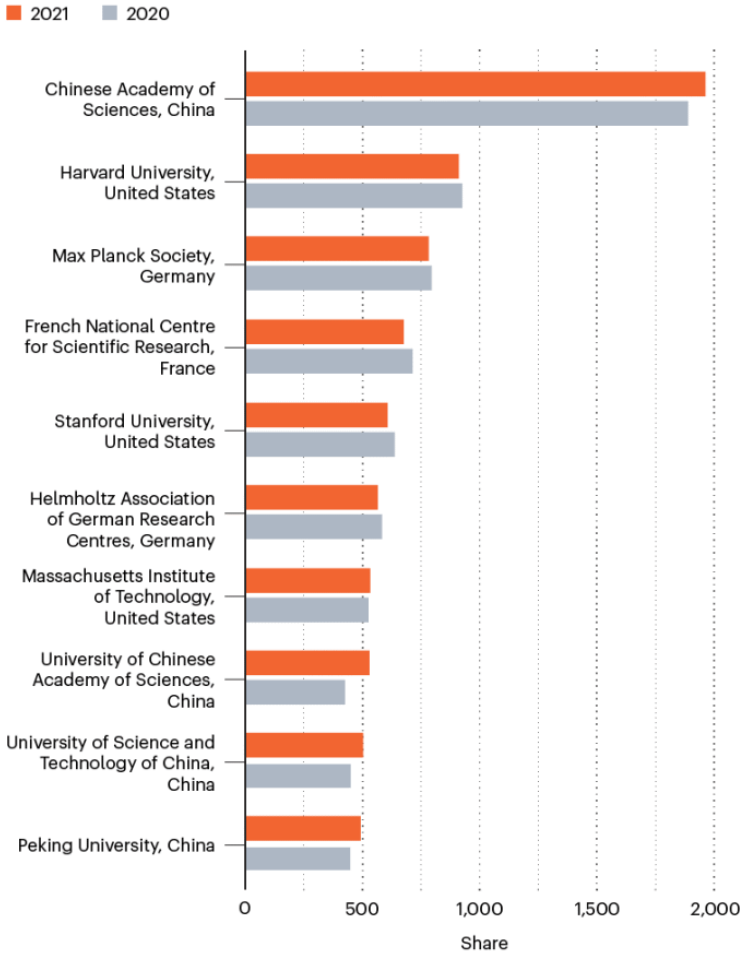
STEADY SPENDING

China's research and development (R&D) spending as a share of its gross domestic product (GDP) has been rising steadily. This has probably contributed to the recent strong performance of its institutions in the Nature Index.



LEADING INSTITUTIONS 2021

The leading institutions by research output as measured by the metric Share in the Nature Index for 2021, compared with their Share for 2020.



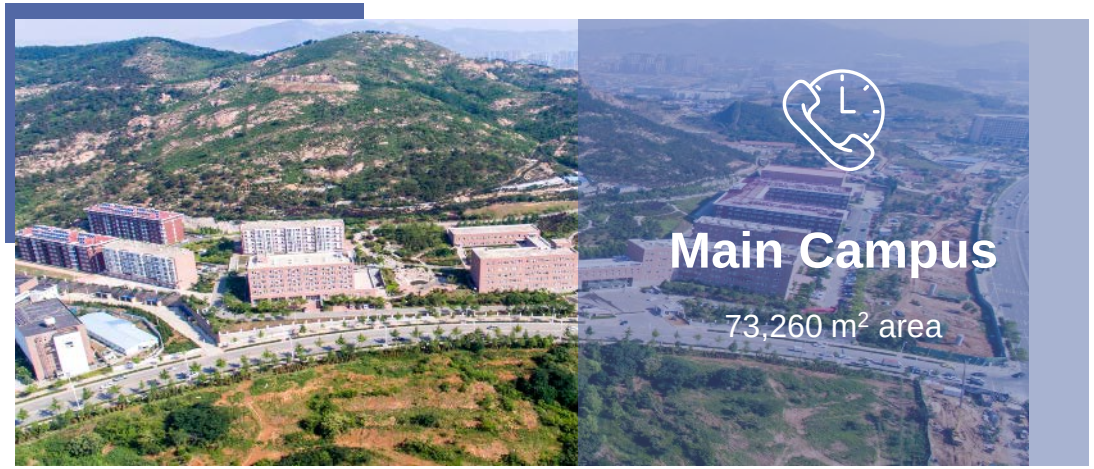
Qingdao Institute of Bioenergy and Bioprocess Technology, CAS

- Qingdao is located at China east coast in Shandong Province;
- Since 2006

17/9/2006, QIBEBT co-construction Agreement signed by CAS, Shandong, and Qingdao

Campus and Demonstration Sites

2 campus +
1 demonstration sites

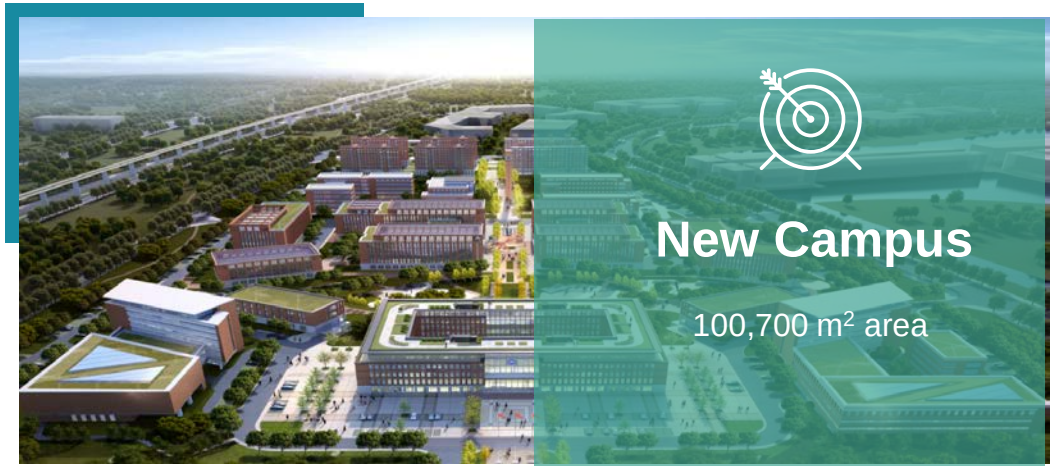


Main Campus

73,260 m² area

Pilot Plant

67,000 m² area
13 pilot-scale projects

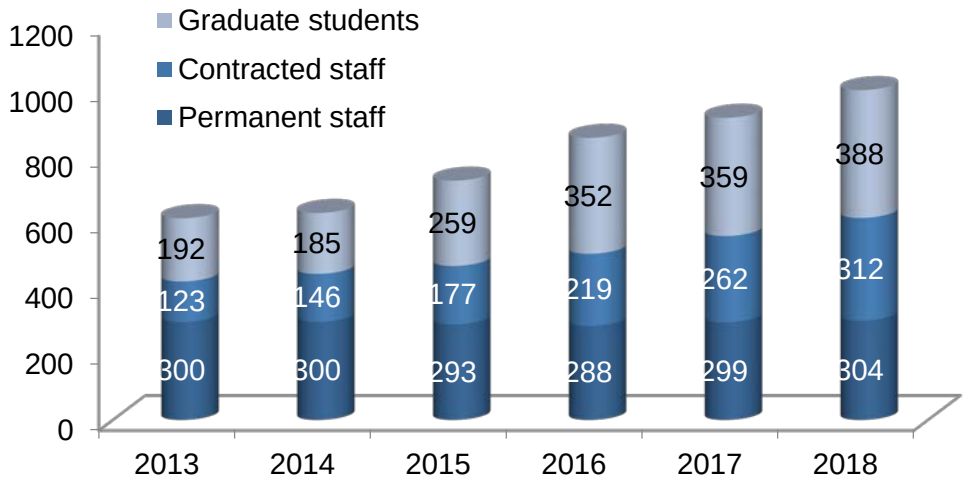


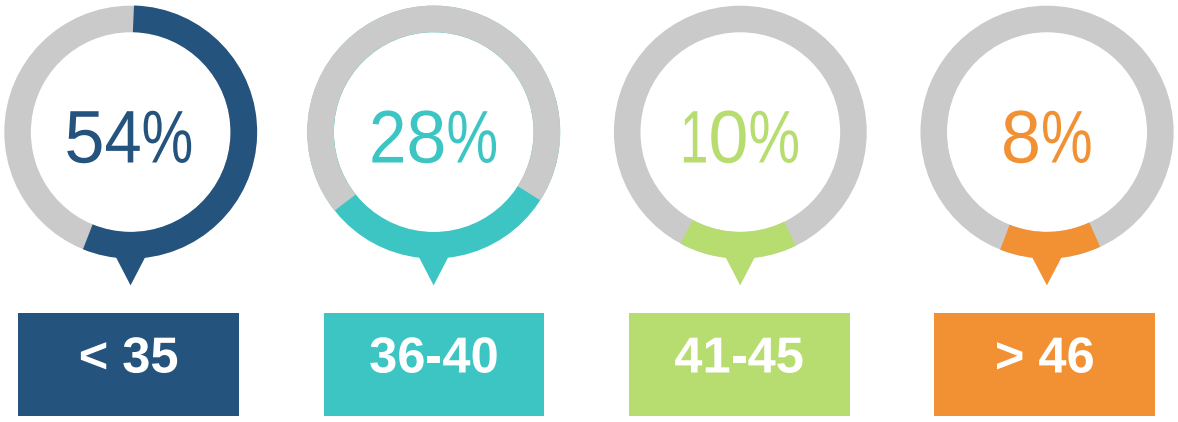
New Campus

100,700 m² area

Human Resource

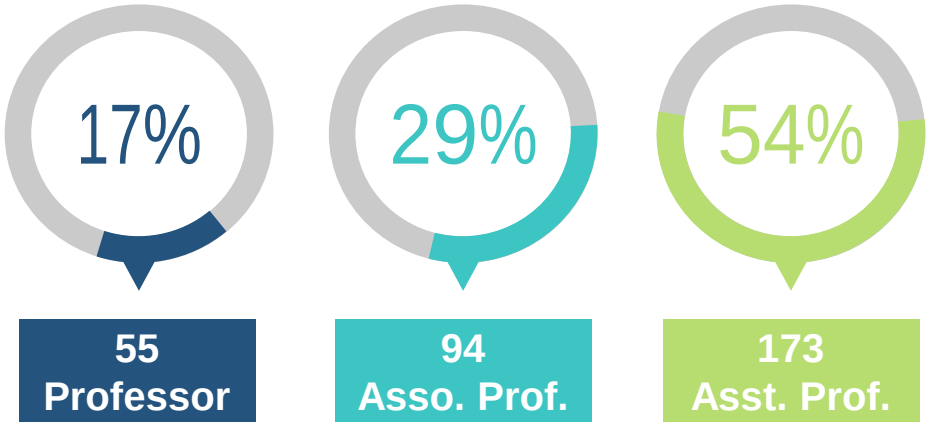
- 1500+ staff and students
- 90% of professors have overseas background
- Average age of full employees is 37





Age of Staff

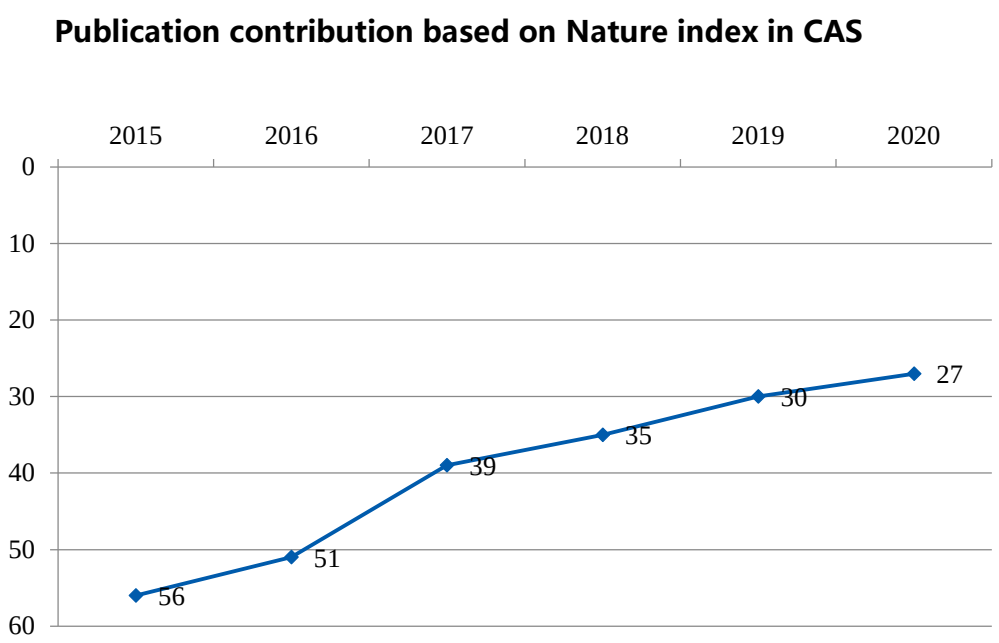
Average age 37

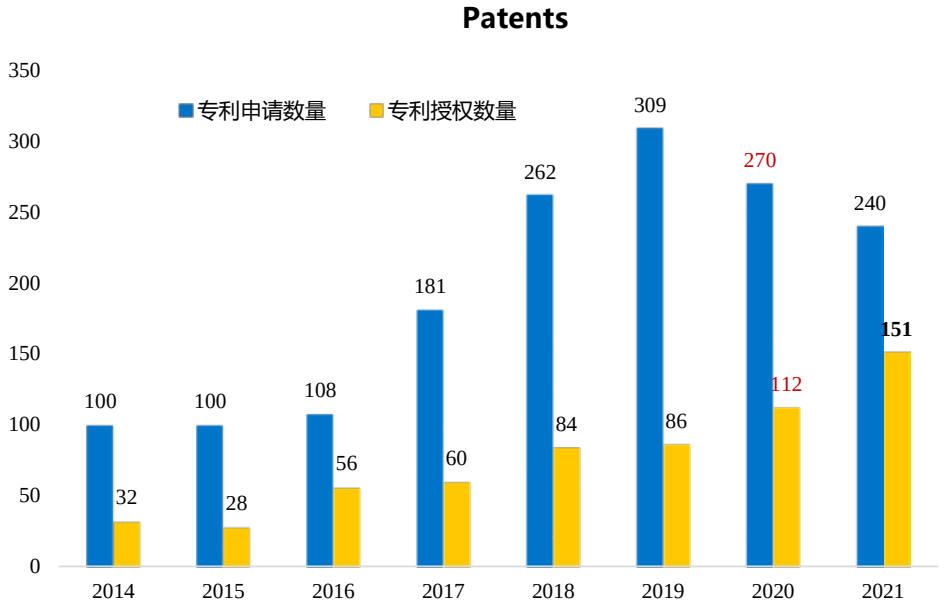


Research staff

20+ National Talent Award

Publications and Patents





Patents and Tech Transfer Rank No.1 among institutes/ universities in Qingdao since 2016

Postgraduate Education

Ph.D. Program

- Biochemistry and Molecular Biology
- Chemical Engineering and Technology
- Materials Science and Engineering
- Microbiology

Master of Science Program

- Microbiology
- Bio-chemical Engineering
- Material Physics and Chemistry
- Biochemistry and Molecular Biology
- Chemical Engineering
- Materialogy

Master of Engineering Program

- Biological Engineering
- Chemical Engineering
- Material Engineering

388 Registered Students:

214 PhD, 174 MS candidates
30+ international candidates

International Cooperation

Multi-level cooperation with over 70 global and domestic institutes, universities and companies: joint laboratories, academic exchange and training, collaborative research projects, and conferences

Fellowships and Scholarships

CSC

CHINESE GOVERNMENT SCHOLARSHIP

- Bilateral Program
- Great Wall Program
- EU Program
- Pacific island Program
- Chinese University Program
- ASEAN University Network
- World Meteorological Organization

MOST

Ministry of Science and Technology

- MOST-BMBF, Bilateral government projects
- Talented Young Scientists Program

NSFC

National Natural Science Foundation of China

- NSFC-DFG
- Res. Fund for International Young Scientists

CAS-TWAS

CAS-TWAS President's Fellowship

To support students/scholars to pursue PhD at the UCAS, the University of Science and Technology of China or CAS Institutes

CAS

CAS President's International Fellowship Initiative (PIFI)

UCAS

UCAS Scholarship for International Students

To support Master's or PhD, or attend courses, conduct research or academic visits at UCAS colleges/CAS institutes

Research Priorities

Frontier Biotechnology

- Gene editing technology
- Single-cell analysis technology
- Synthetic biotechnology
- Microbiome technology
- Metabolic engineering
- Featured bioresources and scale cultivation
- High value biological function products

Renewable Energy

- Biogas
- Jet fuel and biofuel conversion technologies
- New organic solar cells
- Perovskite solar cells
- Large-capacity advanced physical storage
- High-power high-density advanced chemical storage

Advanced Materials

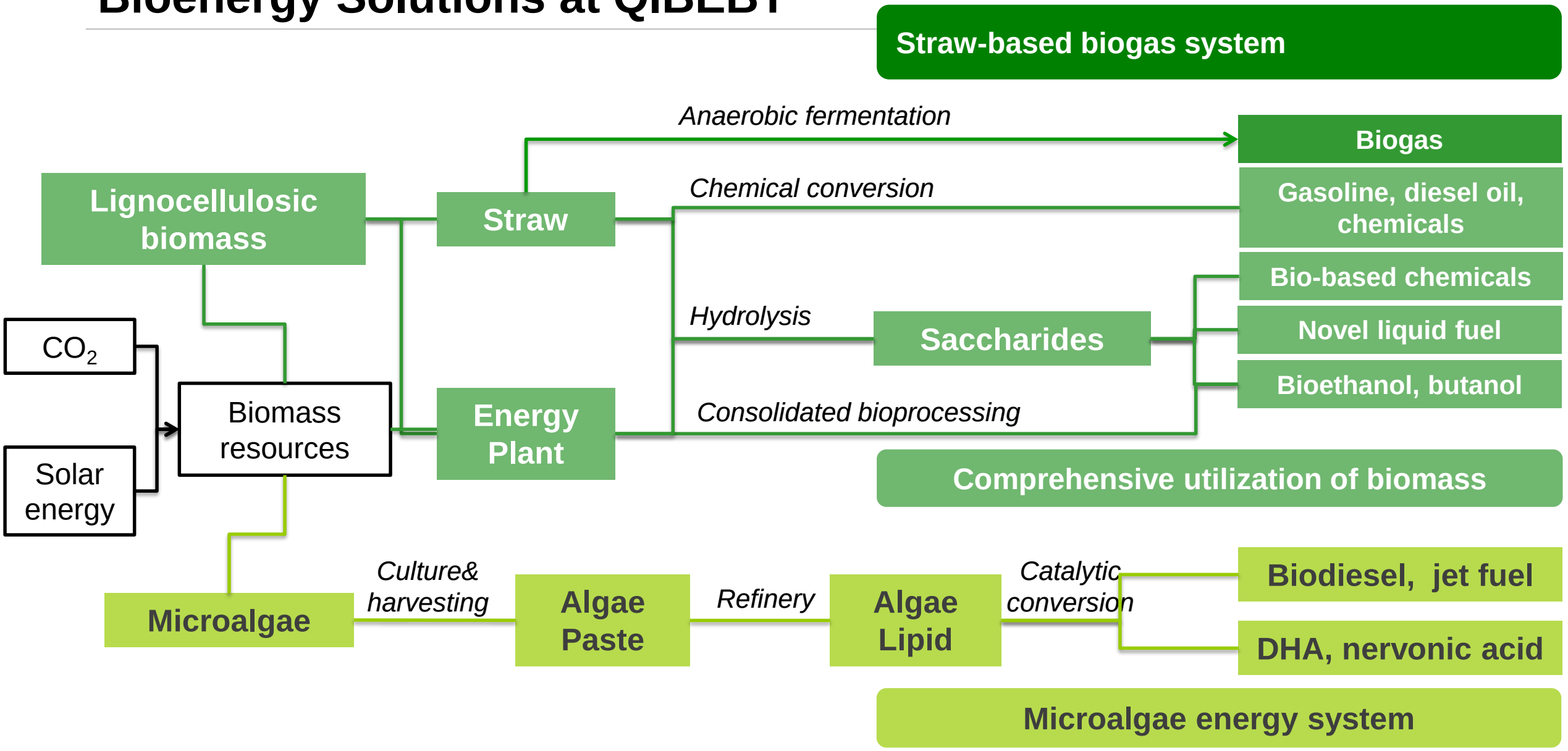
- Biomass-based new materials
- Carbon-based new materials
- Smart bionic new materials
- High-performance membrane materials
- Advanced composite materials

Fundamental Science

Applied Research

Technology Solutions

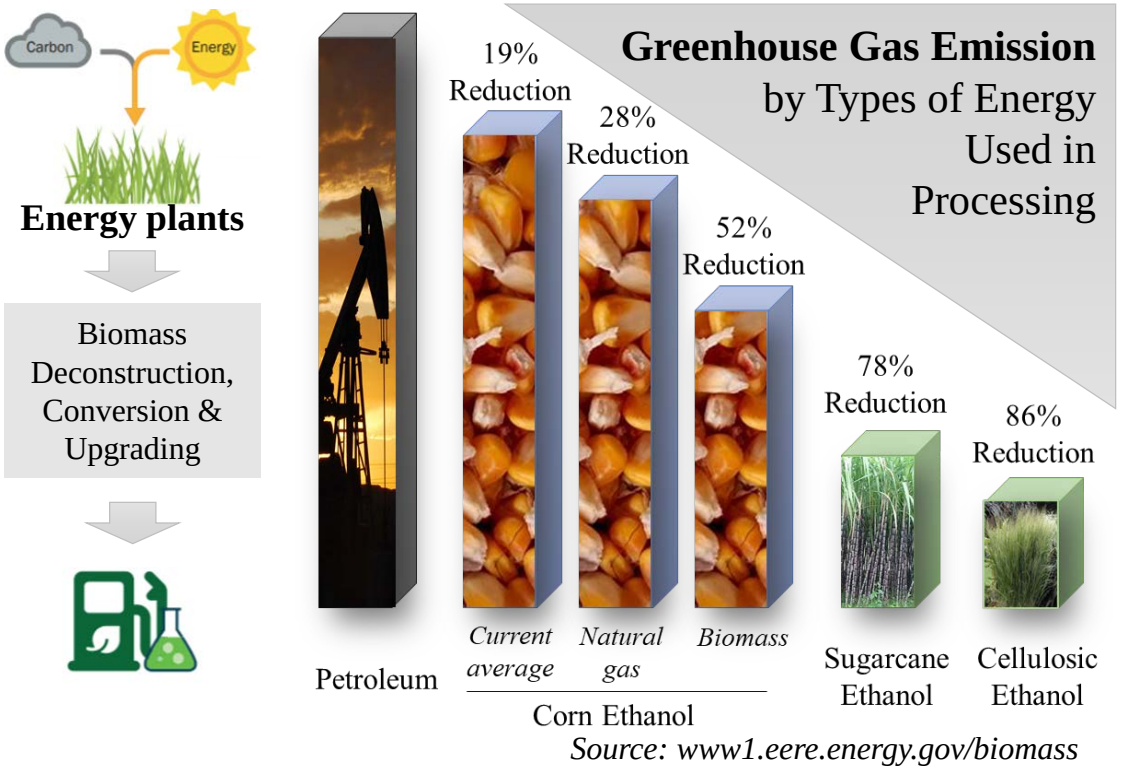
Bioenergy Solutions at QIBEBT



1. Energy plant / microalgae

Prof. Xuefeng Lu Prof. Chunxiang Fu Prof. Shenjun Li

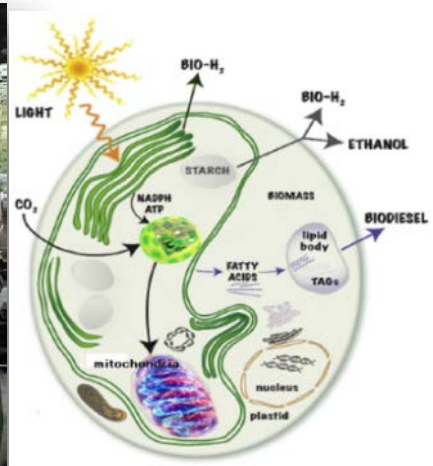
➢ **Current Commercialization Status**



Source: www1.eere.energy.gov/biomass

- Agriculture waste biomass in China: 0.7 billion t/a ≈ 0.35 billion t/a standard coal
- Energy crops including switchgrass, miscanthus, *Arundo donax* L. (**10-30 ton/ha)** are good at storing carbon in soils and can be cultivated on **marginal lands**
- Utilization of energy crops as cellulosic biomass for ethanol production (**30-65 gallons ethanol per dry ton**) **largely reduced the greenhouse gas emission**

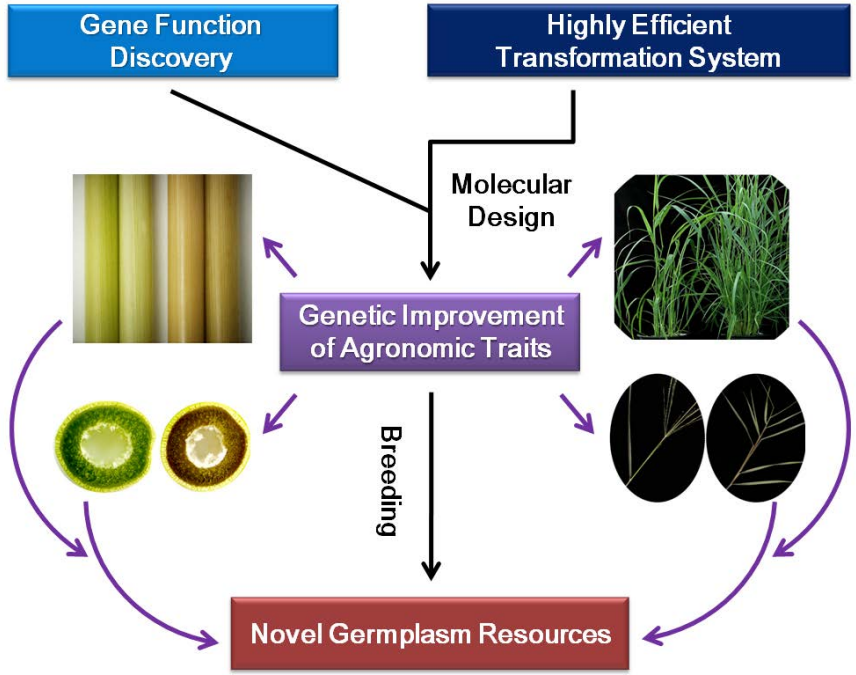
Technical Challenges and R&D



Resistance

Yield

Quality



- Highly efficient **transformation and genome editing** technology system **(>30%)** for energy crop switchgrass
- Rapid platform to characterize **target genes (50-100 genes /person/year)** in switchgrass

2. Bioconversion from cellulose to Ethanol

Prof. Qiu Cui Prof. Yajun Liu Prof. Bin Li

Current Commercialization Status

- Commercial production of bio-ethanol is difficult.
- All facilities producing cellulosic ethanol use on-site or off-site produced fungal cellulases for cellulose saccharification.
- The cellulase preparation technologies are mainly from Novozymes, Clariant Ltd., etc.

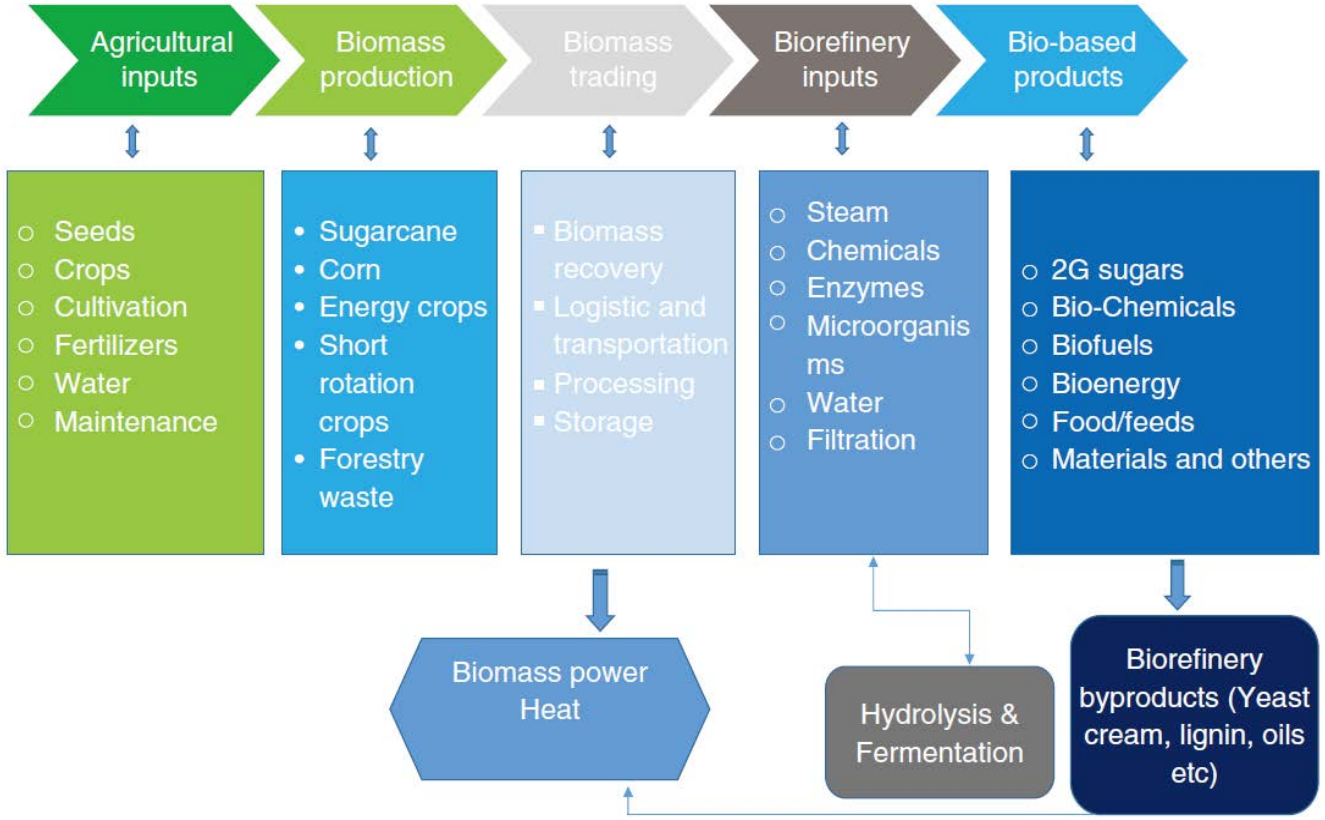
Table 6. China: Suspended or Planned Cellulosic Ethanol Production Capacity (2022 estimates)

Producers	Production Capacity	Status
COFCO Biochemical (Zhaodong)	6.3 million liters	Announced in 2006
Jinan Shengquan	25 million liters	Announced in 2012
Shendong Zesheng	25 million liters	Announced in 2012
Xin Tianlong (Jilin's Siping)	n/a	Announced in 2015
Meijie Guozhen (Anhui's Fuyang)	230 million liters	Announced in 2017
Shandong Longlive	65 million liters	Production suspended
SDIC Jilin Alcohol	101 million liters	Planned
COFCO Biochemical (Anhui's Bengfu)	127 million liters	Planned
SDIC Hailun	38 million liters	Planned
Hebei Yigao	304 million liters	In Trial
Source: Post Industry Sources		

Table 3. China: Production Capacity of China's Fuel Ethanol Licensed producers (2022 estimates)			
	Producers	**Production Capacity**	**Feedstock**
1	SDIC Jilin Alcohol	887 million liters	Corn
2	Henan Tianguan	887 million liters	Wheat, Corn, Cassava
3	COFCO Biochemical (Anhui)	798 million liters	Corn, Cassava
4	COFCO Bioenergy (Zhaodong)	507 million liters	Corn, Cellulosic
5	SDIC (Zhanjiang)	190 million liters	Cassava
6	Shandong Longlive	65 million liters	Cellulosic
7	COFCO Bioenergy (Guangxi)	253 million liters	Cassava
8	Zonergy (Inner Mongolia)	38 million liters	Sweet Sorghum
9	SDIC (Tieling)	380 million liters	Corn
10	Liaoyuan Jufeng Biochemical	380 million liters	Corn
11	Jilin Boda Biochemistry	507 million liters	Corn
12	Jiangsu Lianhai Biotechnology	152 million liters	Corn
13	Shandong Fu'en Biochemical	152 million liters	Cassava
14	Jiangxi Yufan	127 million liters	Cassava
15	Shougang Lanza Tech	58 million liters	Coal, Waste Residues, Industrial Flue Gases
16	SDIC (Hailun)	380 million liters	Corn
17	Wanli Runda (Baoqing)	380 million liters	Corn
18	Hongzhan (Nehe)	380 million liters	Corn
19	Hongzhan (Huanan)	380 million liters	Corn
20	Ningxia Shougang Lanza Jiyuan	57 million liters	Coal, Waste Residues, Industrial Flue Gases
21	Hongzhan (Bayan)	380 million liters	Corn
22	SDIC (Jidong)	380 million liters	Corn
	TOTAL	**7,720 million liters**	
Source: Post Industry Sources			

Technical Challenges

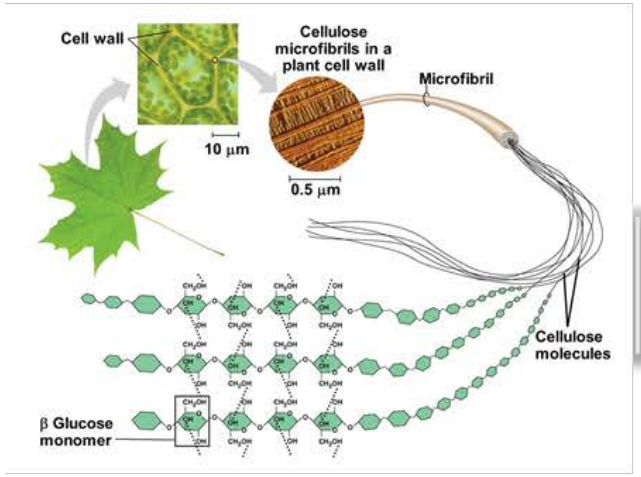
- **Feedstock**: collection, high cost of long-distance transport; season-dependent harvest requires large space for storage; quality control
- **Lignocellulose saccharification and comprehensive utilization**: For China, cost-efficient saccharification technology is critical. Lignin utilization is essential for enhancing the value of the whole technology chain.
- **Process cost and cleanliness**: The coupling of pretreatment, saccharification, fermentation, and lignin utilization would reduce the process cost. The recycling of wastewater in a single process or among different processes would enhance cleanliness.



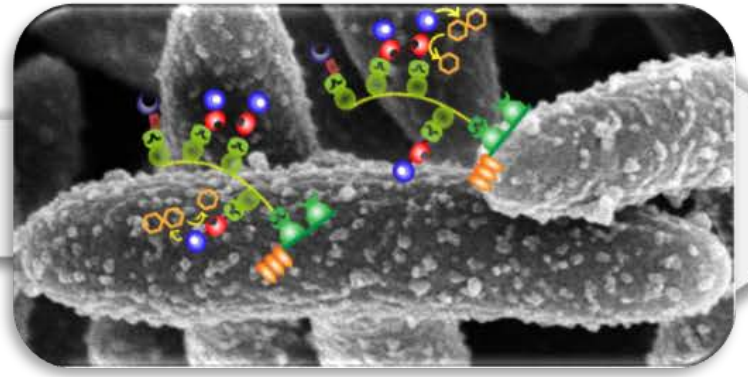
Chandel AK, et al. Comparative analysis of key technologies for cellulosic ethanol production from Brazilian sugarcane bagasse at a commercial scale. **Biofuel Bioprod Biorefin 2019**, 13(4)**:** 994-1014.

Research& Development

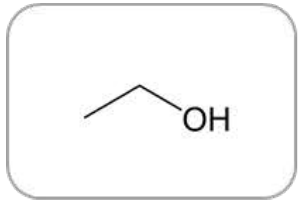
- Novel enzymatic biocatalysts



lignocellulose

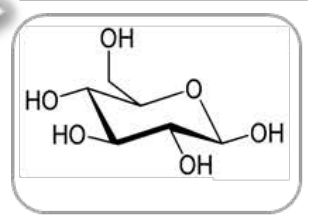


Clostridium thermocellum & the Cellulosome



Bioethanol

Consolidated bioprocessing



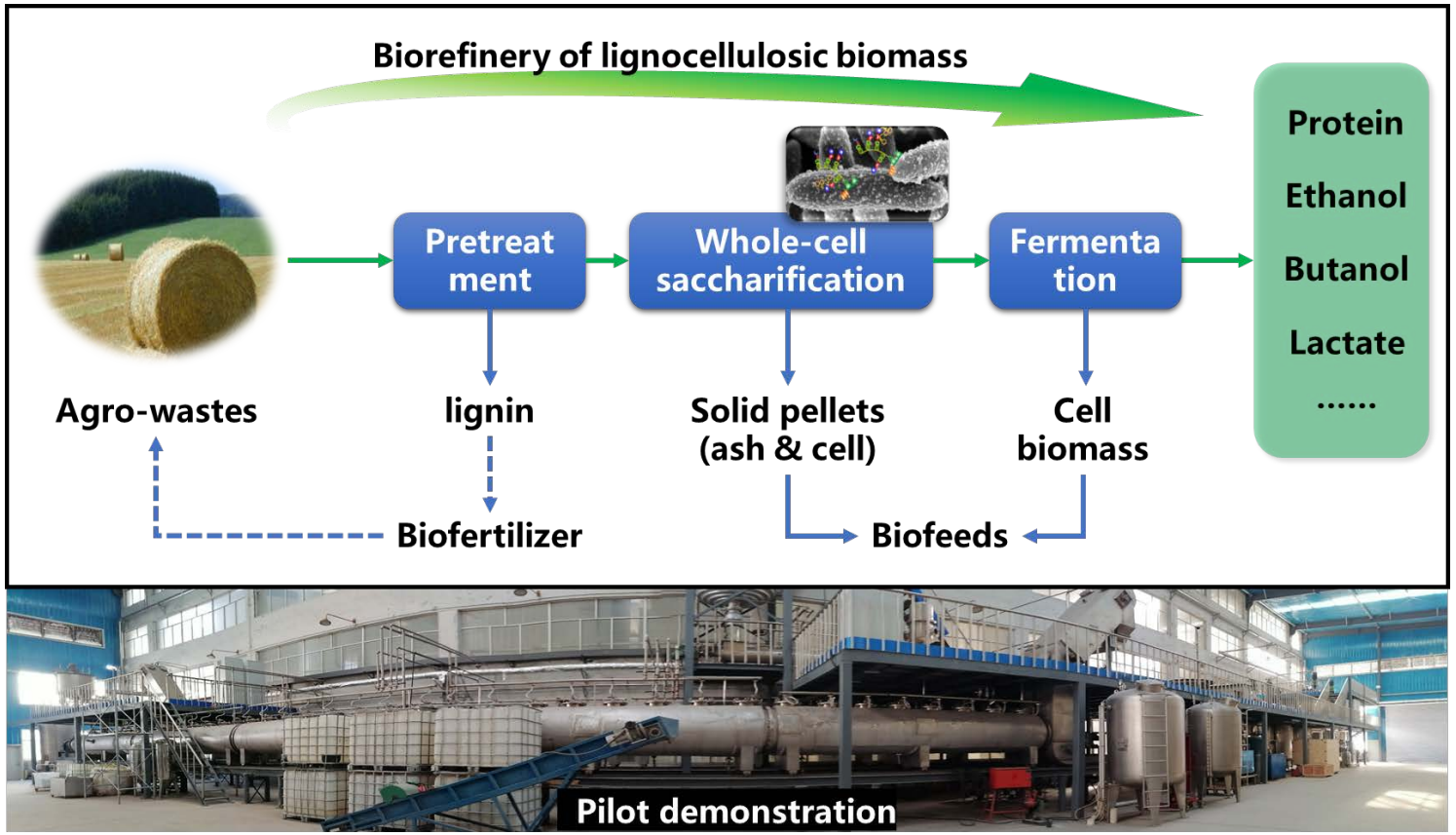
Fermentable sugar

Consolidated biosaccharification

QIBEBT has developed novel lignocellulose saccharification technology using thermophilic and cellulosome-producing *Clostridium* strains as the whole-cell biocatalyst.

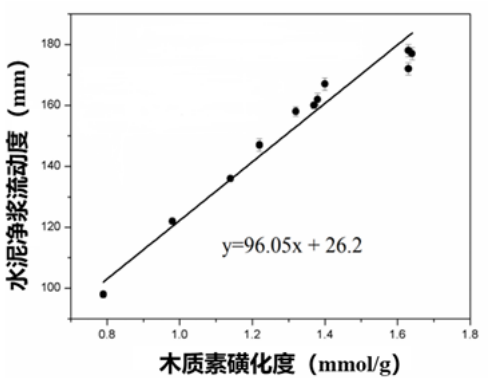
Research& Development

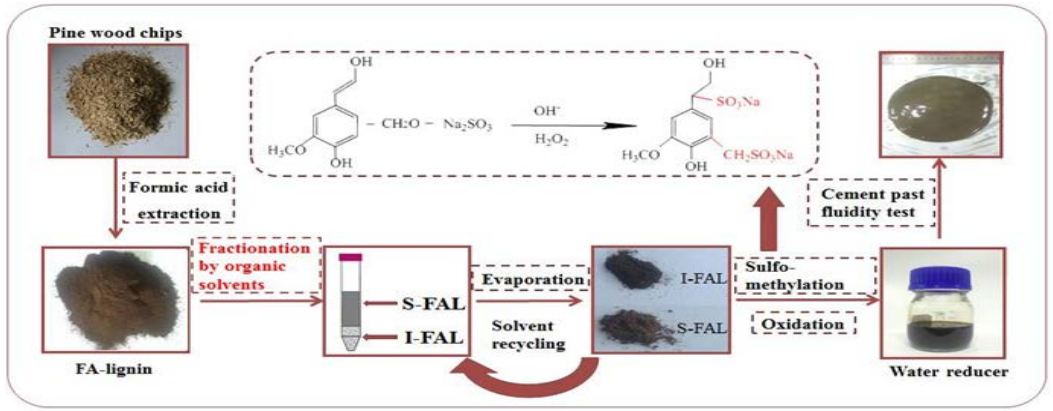
- Coupling of pretreatment, saccharification, and fermentation



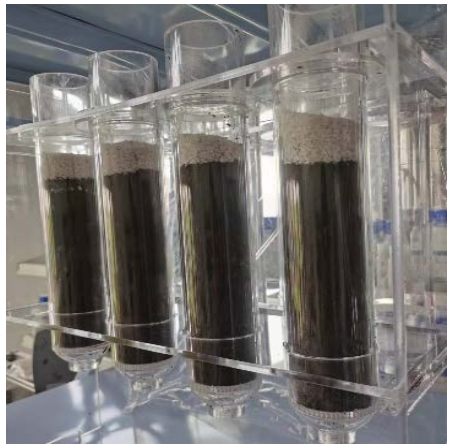
QIBEBT has developed a complete technology chain for lignocellulose bioconversion, including coupled pretreatment, saccharification, and fermentation.
A pilot demonstration 100 t/a has also been constructed.

Research& Development-lignin derived byproducts





Lignin-based concrete water reducer



Lignin-based biofertilizer

BioEthanol from Industry Flux Gas

Prof. Fuli Li

Current Commercialization Status

- Syngas to ethanol: 90 billion m^3 steel industry, coal chemical
  two sets of 45000 t/a (Shougang Lanza Tech, at Caofeidian 2018, Shizuishan 2021)
  20,000 t/a (Jupeng & Lu'an Co. under construction since 2018)
- E10 gasoline in China (10 million ton needed)

Technical Challenges

Gas-Liquid Mass Transfer, Metabolic Efficiency, Feedback Inhibition，
Different industry flux gas or thermal pyrolysis of biomass

Research& Development

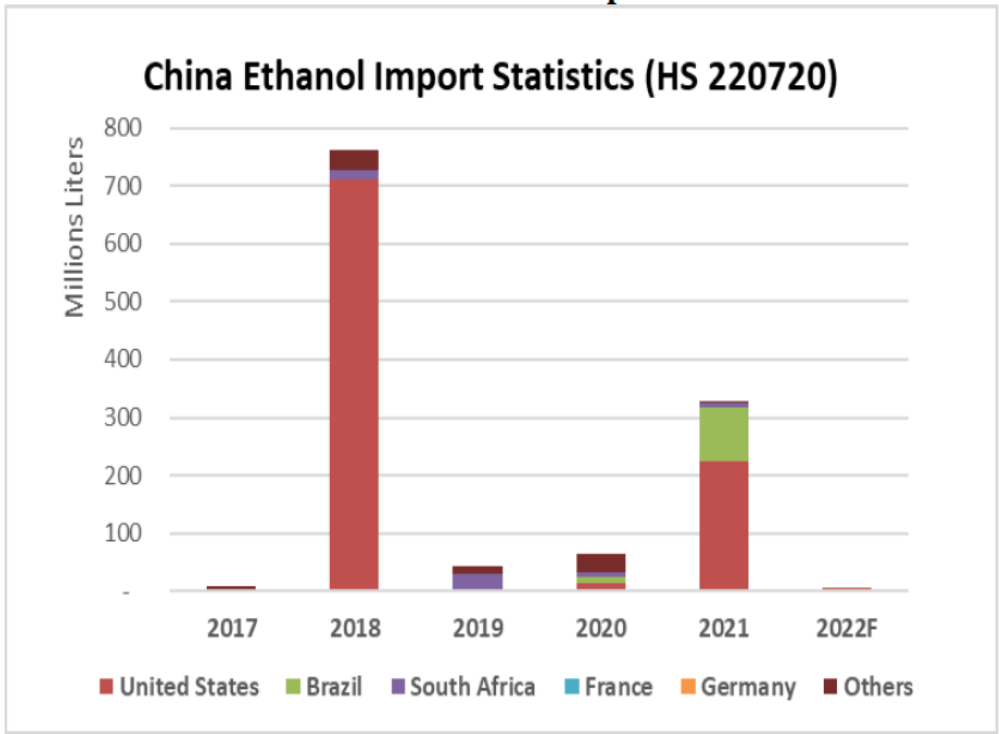
Strain Modification, Medium Optimization, Bioreactor Improvement (SinoPec, RongXin Coal Chemical Co.).

Table 2. China: Ethanol Production, Supply, and Distribution

Ethanol Used as Fuel and Other Industrial Chemicals (Million Liters)										
Calendar Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Beginning Stocks	0	0	0	0	0	0	0	0	0	0
Fuel Begin Stocks	0	0	0	0	0	0	0	0	0	0
Production	5,795	6,921	7,868	8,071	9,211	9,770	10,740	10,830	10,580	11,850
Fuel Production	2,934	2,951	2,914	2,534	3,041	2,914	4,339	3,801	3,421	3,804
>of which fossil-based synthetic	0	0	0	0	0	0	0	30	30	40
>of which biobased	2,934	2,951	2,914	2,534	3,041	2,914	4,339	3,771	3,391	3,764
>of which biobased cellulosic	25	25	38	40	30	20	0	0	0	0
Imports	0	27	687	890	24	1,035	104	69	824	10
Fuel Imports	0	26	477	871	8	759	0	63	550	5
Exports	40	33	25	34	135	79	21	367	13	10
Fuel Exports	2	2	0	1	3	35	7	21	0	2
Consumption	5,755	6,915	8,530	8,927	9,100	10,726	10,823	10,532	11,391	11,850
Fuel Consumption	2,932	2,975	3,391	3,404	3,046	3,638	4,332	3,843	3,971	3,807
Ending Stocks										
Fuel Ending Stocks										
Refineries Producing First Generation, Bio-based Fuel Ethanol (Million Liters) 1/										
Number of Refineries	6	7	7	10	11	12	14	20	22	22
Nameplate Capacity	3,000	3,200	3,200	3,600	4,200	5,000	5,257	6,578	7,720	7,720
Capacity Use (%)	97%	91%	90%	69%	72%	58%	83%	57%	44%	49%
Refineries Producting Cellulosic Fuel Ethanol (Million Liters) 2/										
Number of Refineries	1	3	3	1	1	1	1	1	1	1
Nameplate Capacity	50	129	129	65	65	65	65	65	65	65
Capacity Use (%)	50%	19%	29%	62%	46%	31%	0%	0%	0%	0%
Co-product Production (1,000 MT)										
DDGs	1,652	1,661	1,640	1,427	1,598	1,536	2,796	2,436	2,279	2,471
Feedstock Use for Fuel Ethanol (1,000 MT)										
Corn Kernals	5,277	5,308	5,241	4,558	5,105	4,542	6,763	5,426	4,229	4,694
Rice Kernals						364	2,170	2,357	3,052	3,199
Cassava (dried chips)	2,203	2,215	2,188	1,902	2,283	2,188	1,303	1,132	1,018	1,469
Wheat	na	na	na	na	387	371	552	480	173	96
Celluloic Biomass	na	na	na	na	na	na	na	na	na	na
Fossil Fuels/Waste Gas	na	na	na	na	na	na	na	na	na	na
Market Penetration (Million Liters)										
Fuel Ethanol Use	2,932	2,975	3,391	3,404	3,046	3,638	4,332	3,843	3,971	3,807
Gasoline Pool 3/	130,017	135,837	157,490	164,502	170,477	182,197	193,853	191,631	211,207	209,357
Blend Rate (%)	2.3%	2.2%	2.2%	2.1%	1.8%	2.0%	2.2%	2.0%	1.9%	1.8%

Notes: f = forecast
Corn kernels: 1 MT = 402 (before 2014) to 417 liters (after 2014)
Rice: 1 MT = 400 liters
Wheat kernels: 1 MT = 393 liters
Sorghum (Sweet) 1 MT = 430 (used in 2014 Baseline)
Cassava (fresh root): 1 MT = 143 to 150 liters (25 to 35% starch content)
Cassava (dried chips): 1 MT = 333 to 400 liters (15 to 65% starch content)
Sources: Post estimates and industry sources

Chart 1. China: Ethanol Import Statistics



Sources: Trade Data Monitor, General Administration of China Customs, and Post estimates
Note: News reports indicate that shipment from Indonesia and Malaysia in 2018 were US-origin product.

3. Catalytic Conversion of oil and fat to Biodiesel

Prof. Xuebing Li

Current Commercialization Status

Table 4. China: Biodiesel Production, Supply, and Distribution

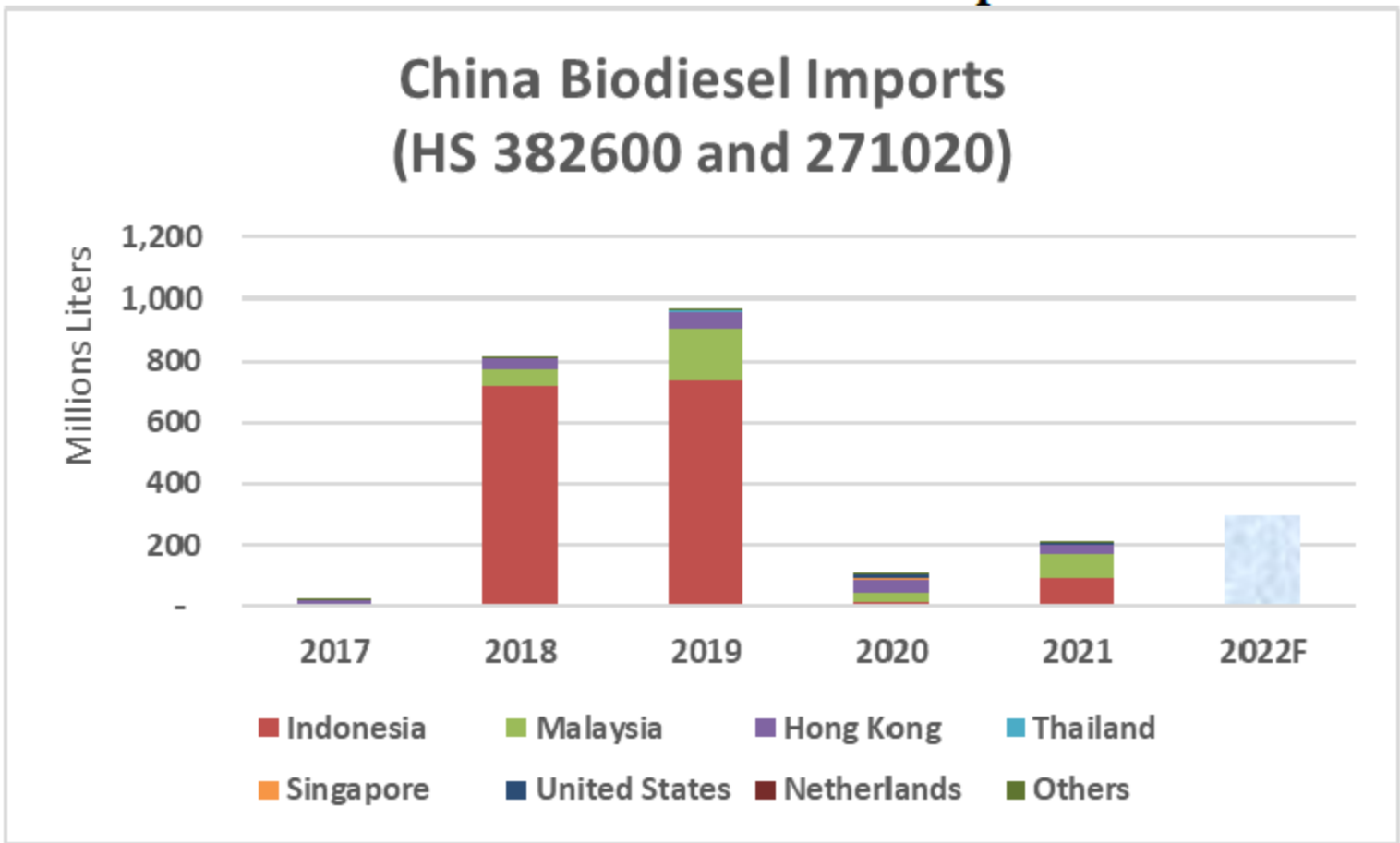
Biodiesel (Million Liters)										
Calendar Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Beginning Stocks		0	0	0	0	0	0	0	0	0
Production	1,079	1,133	787	909	1,043	834	939	1,455	1,835	2,430
Imports	895	1,028	33	8	18	853	953	102	204	295
Exports		43	27	76	194	357	752	1,035	1,475	2,125
Consumption	1,974	2,118	793	841	867	1,330	1,140	522	564	600
Ending Stocks										
Production Capacity (Million Liters)										
Number of Biorefineries	53	53	53	48	46	44	40	42	44	46
Nameplate Capacity	4,000	4,000	4,000	2,680	2,680	2,680	2,680	2,726	2,800	4,700
Capacity Use (%)	27.0%	28.3%	19.7%	33.9%	38.9%	31.1%	35.0%	53.4%	65.5%	51.7%
Feedstock Use (1,000 MT)										
UCO	1,055	1,108	771	891	1,022	816	918	1,426	1,798	2,381
Market Penetration (Million Liters)										
Biodiesel, on-road use	324	340	236	273	313	410	430	250	260	276
Diesel Pool , on-road use	133,383	133,365	134,375	130,564	130,538	126,898	135,370	136,149	141,000	139,828
Blend Rate (%)	0.2%	0.3%	0.2%	0.2%	0.2%	0.3%	0.3%	0.2%	0.2%	0.2%
Diesel Pool, total 1/										

Note: Fuel pools are defined as fossil fuels plus all "bio-components" (biofuels) blended with fossil diesel.
f = forecast; All PSD data are B100 or B100-equivalent (see statistical info section of Reporting Instructions).
Used cooking oil (UCO):1 MT = 1,043 liters of UCOME (UCO methyl ester)
Source: Post and Industry sources

Table 5. China: Major Biodiesel Producers		
	Producer	**Production Capacity**
FAME (Fatty Acid Methyl Esters)	Zhuoyue New Energy	454 million liters
	Hebei Jingu Group	284 million liters
	Bimei New Energy	114 million liters
	Tangshan Jinhai Biodiesel	68 million liters
	Hebei Longhai Biofuel	68 million liters
	Shandong Fenghui	68 million liters
	Zhejiang Jia'ao Environment Protection	171 million liters
	Zhejiang Dongjiang Energy Technology	57 million liters
	Jingzhou Dadi Biotechnology	57 million liters
	Shanghai Zhongqi Environment Protection	41 million liters
HDRD (Hydrogenation-derived Renewable Diesel)	Beijing Sanju Environmental Protection	613 million liters
	Jiangsu's Yangzhou Jianyuan Biotechnology	159 million liters
	Shijiangzhuang Changyou Bioenergy	227 million liters
	Zhangjiagang Eco Biochemical Technology	284 million liters

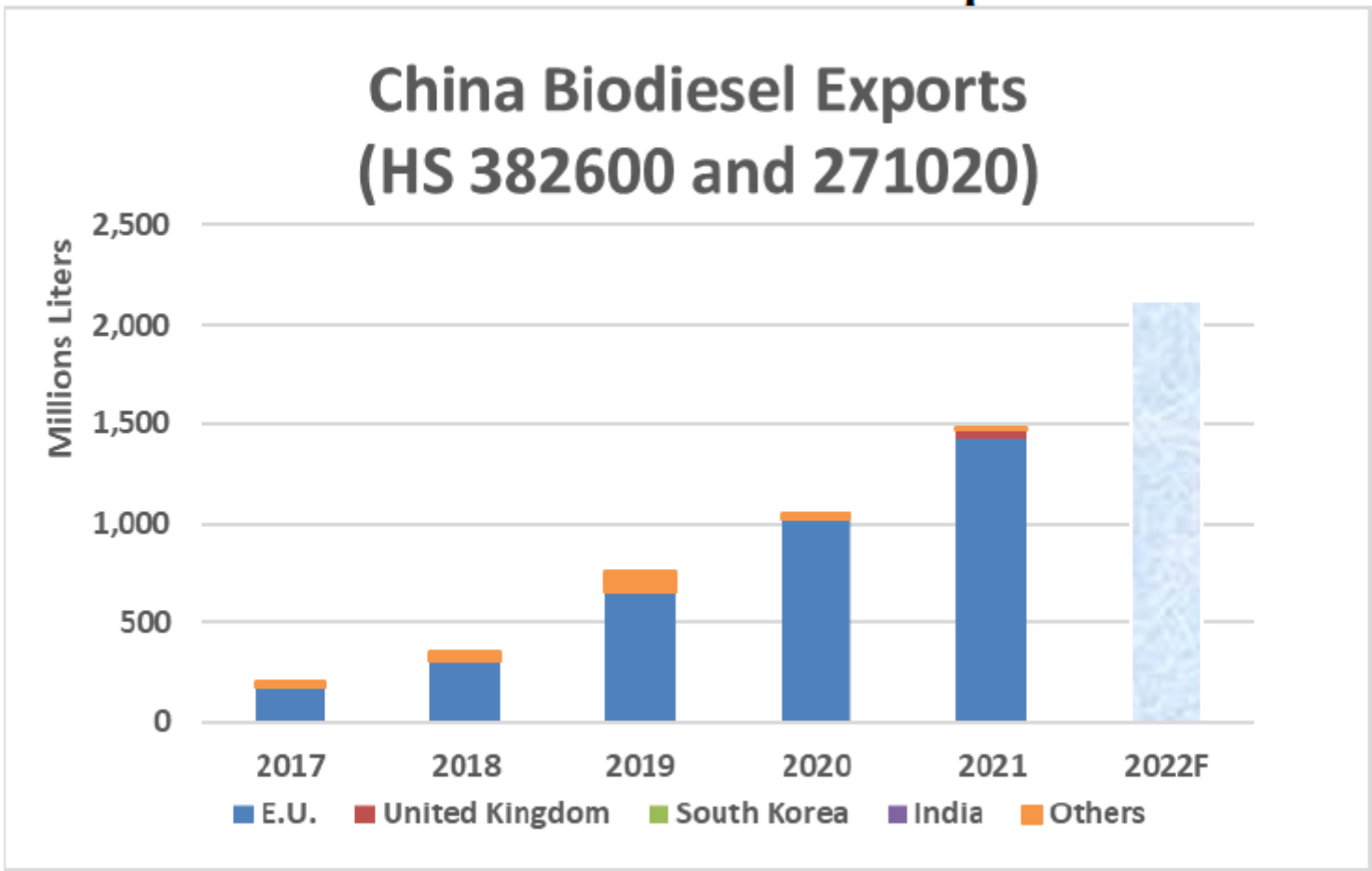
Source: Post Industry Contacts

Chart 2. China: Biodiesel Imports



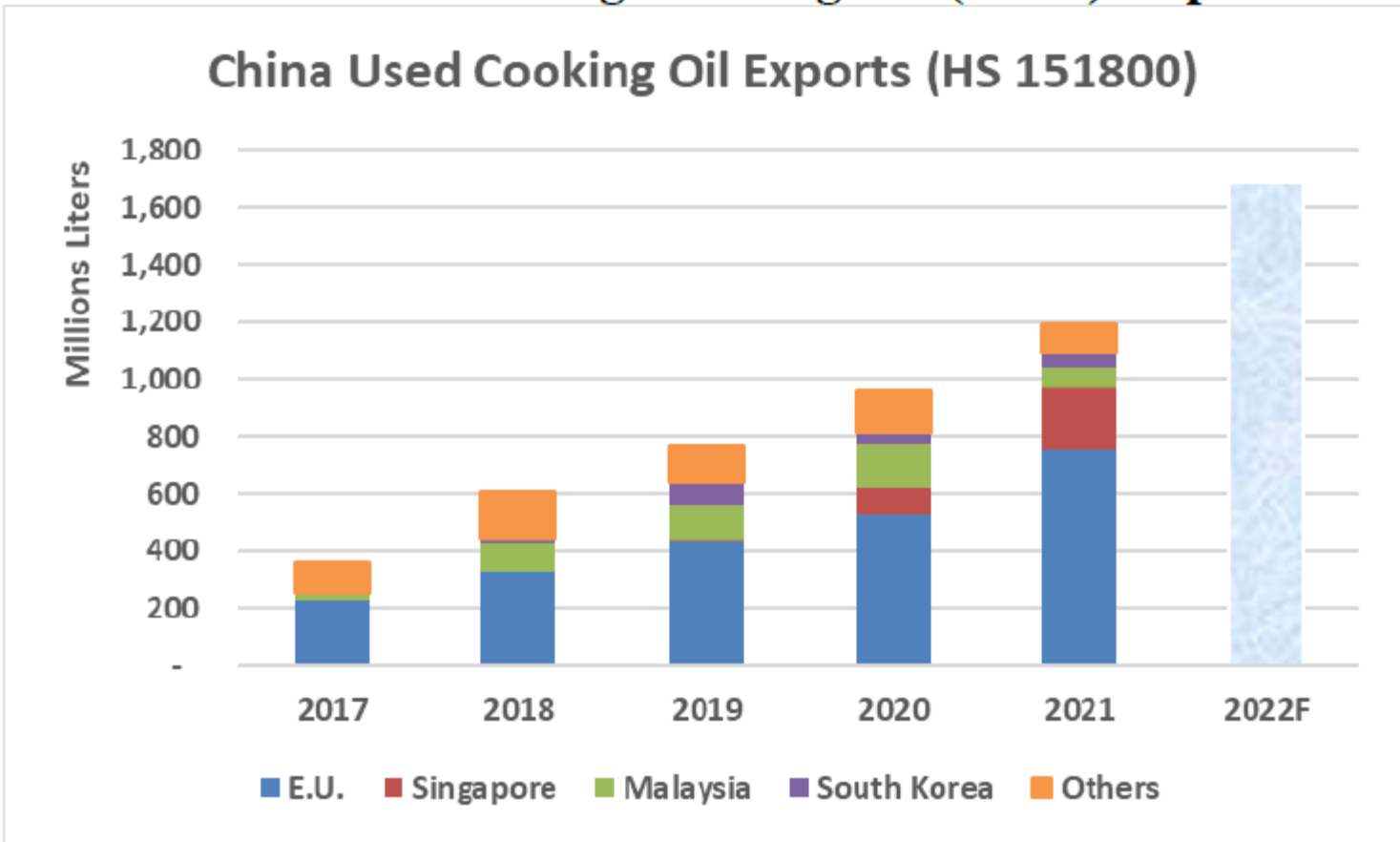
Sources: Trade Data Monitoring and General Administration of China Customs

Chart 3. China: Biodiesel Exports



Sources: Trade Data Monitoring and General Administration of China Customs

Chart 4. China: Using Cooking Oil (UCO) Exports

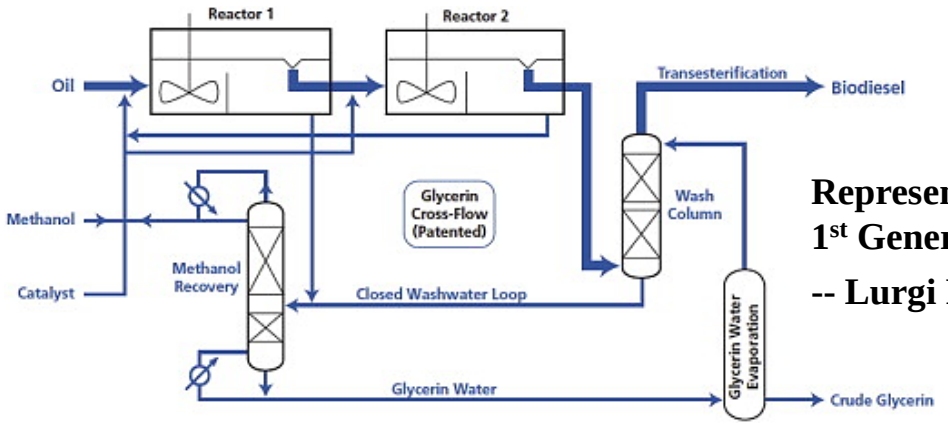


Sources: Trade Data Monitoring and General Administration of China Customs
Note: Used cooking oil (UCO): 1 MT = 1,043 liters of UCOME (UCO methyl ester)

Catalytic Conversion of oil and fat to Biodiesel

Technical Challenges

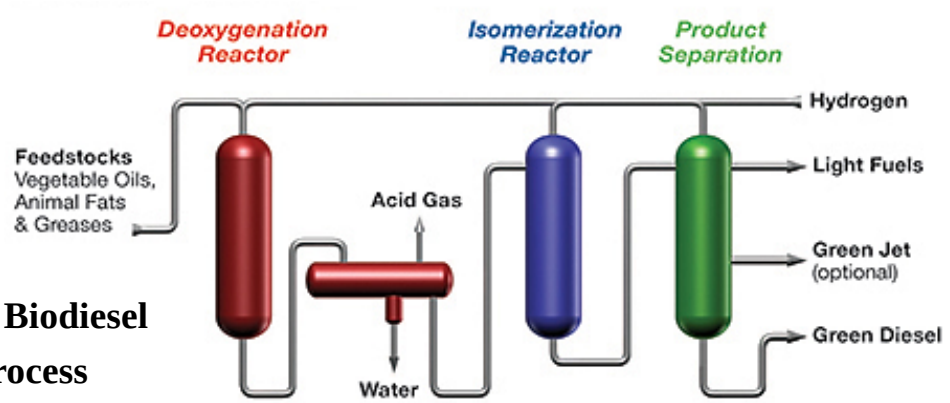
- Corrosivity of Feedstocks and Catalysts
- Impurities in Feedstocks
- Catalyst Life



Representative 1st Generation Biodiesel
-- Lurgi Process

Research & Development

- Catalyst Exploration (Solid acid/base catalysts)
- Process Optimization (Slurry-bed hydrogenation)
- Bioreactor Improvement



Representative 2st Generation Biodiesel
-- Eco-fining Process

[1] *REN21, Renewables 2021 Global Status Repot.*

4. Bio Jet Fuels

Prof. Jinhu Wu

Current Status

- Hydroprocessing of triglyceride (Sinopec, 2022, 100,000 t/a);
- Annex A2 (HEFA SPK) fat hydrogenation
- Bio Jet Fuel certificate of airworthiness approved by China Civil Aviation Administration
- Asia RSB Sustainable Aviation Fuel Certificate Approved by SCS

SCS Global Services does hereby certify that an independent assessment has been conducted on behalf of:

SINOPEC Zhenhai Refining & Chemical Company

Jiaochuan Street, Ningbo, Zhejiang 315207, China

Has demonstrated the operation of a management system that is compliant with the requirements of:

Roundtable on Sustainable Biomaterials

Standard(s): **RSB Global: RSB-STD-01-001 V3.0, RSB-PRO-20-001 V3.2, RSB-PRO-30-001 V3.3, RSB-PRO-50-001 V3.5, RSB-PRO-60-001 V3.3, RSB-STD-01-003-01 V2.3, RSB-STD-01-010 V2.3**

RSB

CB Registration No. 592

The scope of this certificate shall be limited to:

1 Industrial Processor: SAF facility

1 First Collector

[Confidential #] Points of Origin

Input: Used Cooking Oil

Output: Sustainable Aviation Fuel

This RSB certificate was issued under accreditation by a RSB recognized certification body for compliance with the RSB standards and the RSB certification systems.

Certificate Code: **SCS-RSB/PC-0048**

RSB Participant Code: **2217**

Valid from **6 April 2022 to 5 April 2027**

RESPONSIBLE BIOMATERIALS CERTIFIED SCS GLOBAL SERVICES RSB

This RSB certificate is only valid if duly registered in the RSB database(s) of registered RSB certificates and that the validity of this RSB certificate shall be verified in the RSB database(s) of registered RSB certificates. Please see http://rsb.org/certification/participating-operators/. This certificate itself does not constitute evidence that a particular product supplied by the certificate holder is certified to RSB standards. This certificate shall remain the property of SCS, and all copies and reproductions shall be returned to SCS immediately upon request. Products offered, shipped or sold by the certificate holder can only be considered covered by the scope of this certificate when the

SCSglobal SERVICES

Stanley Mathuram, PE, Executive Vice President
SCS Global Services
2000 Powell Street, Ste. 600, Emeryville, CA 94608 USA

Biomass to High Quality Jet Fuels (B2HQJF)

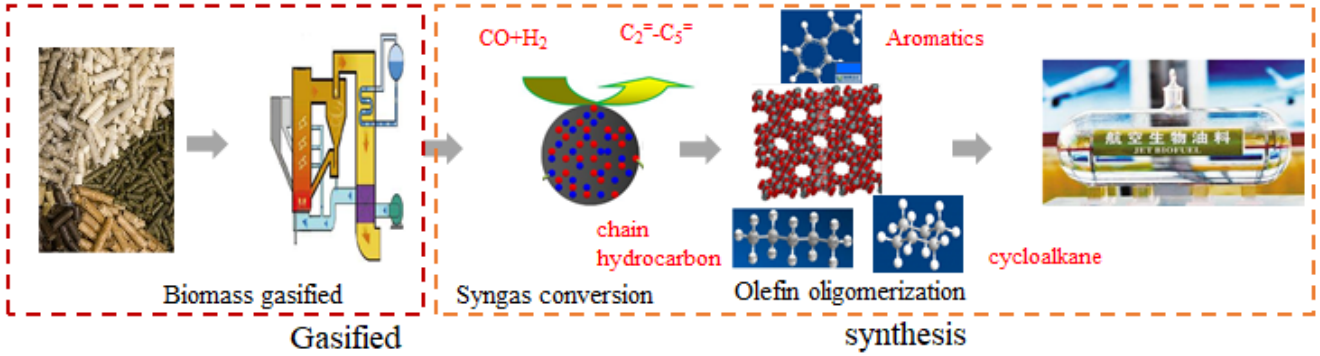
Technical Challenges

- Raw materials limitation. Raw materials, like Fat, Oil, collected difficultly and expensive
- Composition deficiency. Oil molecules are most chain hydrocarbons
- Maximum addition limitation. Less than 50% in practical applications.

Synthetic blending component in aviation fuels	Main molecules structure in components	Preparation routes /Raw materials	Other detail requirements (wt%)	Blending component addtion limited（v%）
Annex A1 (FT SPK)	Linear hydrocarbons	Fischer- Tropsch Synthesis /coal, woods	Cycloparaffins ≤15%，Aromatics ≤0.5%	**≤50%**
Annex A2 (HEFA SPK)	Linear hydrocarbons	Fat hydrogenation/fat	Cycloparaffins ≤15%，Aromatics ≤0.5%	**≤50%**
Annex A3 (SIP)	Iso-paraffins	Hydrogenation of fermentable sugars/ sugars	Saturated hydrocarbons ≥98%，Aromatics ≤0.5%	**<10%**
Annex A4 (FT SPK/A)	Linear hydrocarbons, Aromatics	Fischer- Tropsch Synthesis, light hydrocarbon aromatic/coal, woods	Cycloparaffins ≤15%，Aromatics ≤20%	**≤50%**
Annex A5 (ATJ-SPK)	Linear hydrocarbons	Alcohols dehydration-oligomerization/Alcohols	Cycloparaffins ≤15%，Aromatics ≤0.5%	**≤50%**

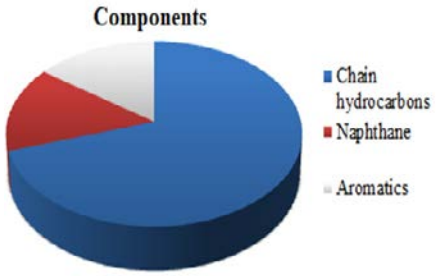
Research& Development in QIBEBT

- A 100 t/a pilot scale system will be operated in April 2023. Producing 1 ton jet fuel may need about 10 tons biomass.
- The obtained oil contained all the components that jet fuel should be needed. It will provide possibilities for 100% bio-jet fuel applications.



Biomass to High Quality Jet Fuel via Gasification-Synthesis Route

Pilot scale system



Components of crude oil

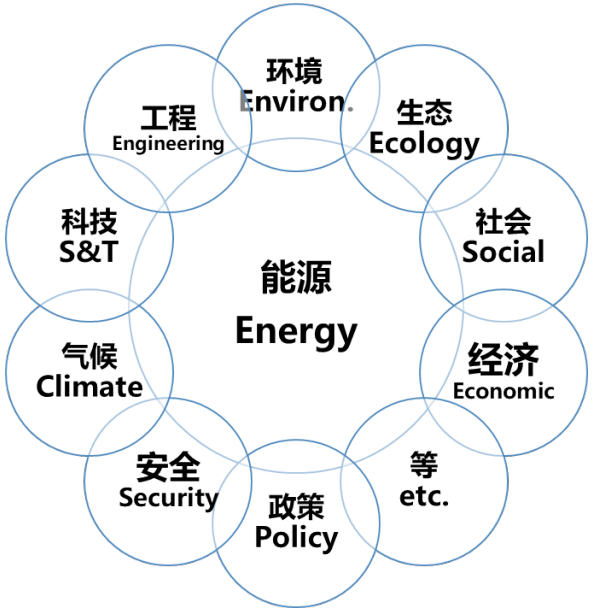
- Cost reduction
  - Gasified-synthesis technology expanded the raw material of biomass.
  - Chemical looping gasification technology did not need the use of air separation.
- Supplementary component
  - Two step synthesis technology supplemented the components of the jet fuel (aromatics, cycloalkane, etc.).

5. Extended Energy Big Data (EEBD)

Prof. Yajun Tian

Innovation Conception

Extended Energy Big Data (EEBD) is a new conception put forward by QIBEBT, it believes that energy is an essential factor of modern society, so with energy as a common core, diverse dimensions such as economy, society, ecology, environment, engineering, science and technology, climate, energy security etc. can be associated, and any disturbance from any dimension can be conducted to others through energy. By digging the big data based on EEBD principle, much new knowledge can be revealed, it will be helpful for smart development.



Current Status

- Conception of EEBD principle has been developed and issued
- A big data based on EEBD principle has been constructed
- A platform used to manage and dig EEBD has been developed

Extended Energy Big Data (EEBD)

Research& Development

- A model used for government intelligent decision has been developed
- A new methodology of GIS-LCA was proposed and related standards are being written
- Some cases of smart plants has been built up.

Applied Energy 312 (2022) 118791

Contents lists available at ScienceDirect

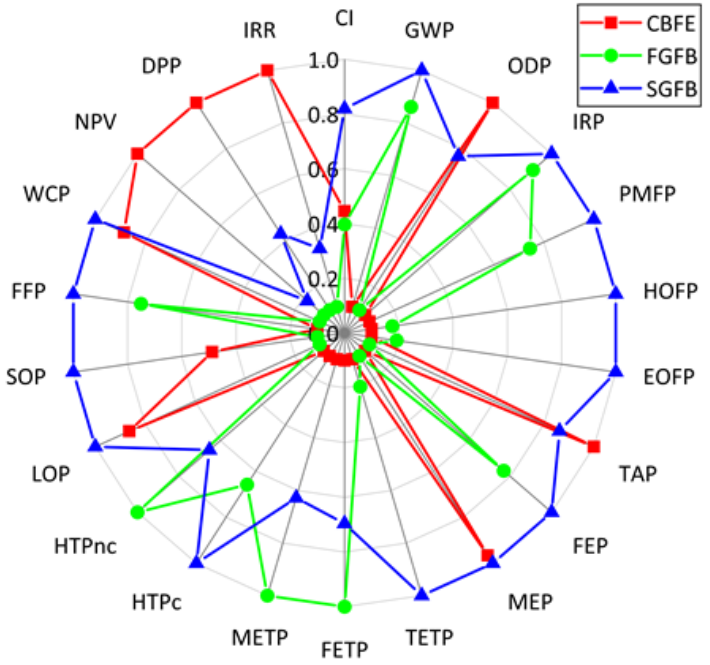
Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Life cycle assessment and techno-economic analysis of ethanol production via coal and its competitors: A comparative study

Junjie Li [a,b,c,d], Yueling Zhang [e], Yanli Yang [a,b,c], Xiaomei Zhang [a,b,c], Nana Wang [a,b,c], Yonghong Zheng [a,b,c], Yajun Tian [a,b,c,*], Kechang Xie [a,b,c,d]

[a] Extended Energy Big Data and Strategy Research Center, Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences, Qingdao 266101, PR China
[b] Shandong Energy Institute, Qingdao 266101, PR China
[c] Qingdao New Energy Shandong Laboratory, Qingdao 266101, PR China
[d] School of Chemical and Environmental Engineering, China University of Mining & Technology – Beijing Campus, Beijing 100083, PR China
[e] MOE Key Laboratory of Resources and Environmental System Optimization, School of Environmental Science and Engineering, North China Electric Power University, Beijing 102206, PR China



中国科学院青岛生物能源与过程研究所
QINGDAO INSTITUTE OF BIOENERGY AND BIOPROCESS TECHNOLOGY,CHINESE ACADEMY OF SCIENCES

Green Carbon is a new, highly selective, open access, and free of charge (before 2026) international journal. The journal is aimed to publish innovative research in all areas of green carbon based science and technology, including fundamental and applied research as well as industrial innovations.

Green Carbon is published by Elsevier and sponsored by the Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences.

Green Carbon

Dedication and Invitation for Cooperation

Author Benefits:

- Rigorous and timely peer review process
- Professional copyediting and typesetting
- Diamond open access: free of article processing charge before 2026
- Honorarium for invited authors
- Wide exposure to a large global audience
- Editorial Manager manuscript tracking system
- Intended future indexed in DOAJ, Scopus, SCIE, etc.
- Fast online publication: two weeks after acceptance
- Free inclusion of supplementary materials (multimedia content)
- Awarding of the most influential papers at the annual conference
- Highlighting new business and supporting young entrepreneurs in dissemination of their technologies and products

Green Carbon offers a comprehensive and interdisciplinary view of highly important and significantly innovative research advances to minimize CO_2 emission for the sustainable development and our greener future. The journal focuses on the utilization of green carbon resources, the development of green conversion technologies, the management of carbon life cycle, and the revolution of carbon research paradigm.

Scopes include, but are not limited to, the following:

- Renewable carbon: resources, environment, energy, chemicals and materials
- Green carbon utilization technologies: electrocatalysis, photocatalysis, chemical catalysis, biocatalysis and bio-manufacturing
- Synthetic biology for carbon fixation and conversion
- Electrochemical energy conversion and storage
- Net-zero and negative carbon technology
- Carbon management: carbon footprint and life cycle assessment, carbon simulation and policy
- Artificial intelligence and data science in green carbon research

中国科学院青岛生物能源与过程研究所
QINGDAO INSTITUTE OF BIOENERGY AND BIOPROCESS TECHNOLOGY,CHINESE ACADEMY OF SCIENCES

Working together for a sustainable planet