CCUS and WPC Development in China

Wayne Song, Ph.D. , Vice President
Tolam Lam, President
Wood-Plastic Composite Council (WPCC) of China

Wayne Song, Ph.D., President
C4X Technologies Inc. & CCLINK Materials Co., Ltd.

The 15th International Symposium on Bioplastics, Biocomposites & Biorefining: Circular Economy for Bioproducts Innovation
July 24 - 27, 2018, Guelph, Ontario, Canada

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www.ccccx.net and www.cclink-china.com & wayne.song@cclink-china.com

Summary

- Carbon XPRIZE Finalist & CCUS in China
- C4X and partner teams
- US CCUS Tax Credit Law 45Q
- Our products

- China Market Basics
- WPC Development in China
- The newest development and directions
- Key WPC Players in China
- PE based WPC for interior applications is just started
- The development of WPC interior wall and ceiling systems in China
- Development of Structural WPC

CO_2 Capture, Conversion & Utilization

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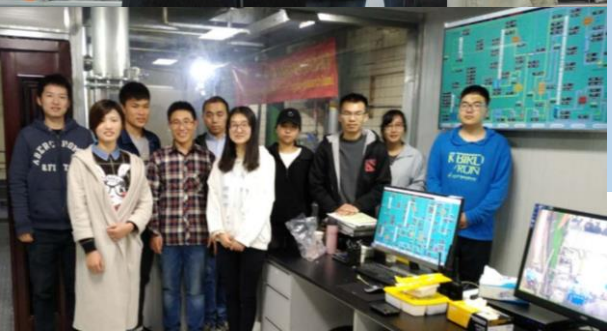
nrg | cosia CARBON XPRIZE

Dr. Wayne Song, CEO

C4X - China Canada CO_2 Conversion X Team

Finalist of Carbon XPRIZE





1. Unique Technology , Social & Business model

Integrating commercial value, CO2 emission reduction, and smog elimination !

2. System Patent Pending and CO2 economics planned

From CO_2 Capture, conversion and super critical CO2 foamed products

3. Team in Tech, Management & Marketing from China & Canada

18 people, 5 people core, 3 Eng. Academy Fellows, 6 universities in Canada & China, and over 40 years R&D and industrial experiences in 8 industrial fields

4. Bright Commercialization Future & Overturn Energy Industry

Our current CO2 tech. gives the value of CO2 from flue gas about 17 times that of electricity from coal. CO_2 conversion and utilization will overturn energy industry

5. CO_2 is asset and treasure, not liability!

C4X Technologies Inc. and Green Carbon Technologies (Suzhou) Co., Ltd.
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Canada: 2 Maldaver Ave., Mississauga, ON Canada L5M 1W3 China: 201 CN-23, Nanopolis, 99 Jinji Hu Ave., Suzhou, China 215123



Wyoming ITC Opened Apr, 2016



Future Energy Summit, New York



Carbon Xprize CCUS setup by June 2019

Wyoming ITC and the 420MW coal power station



May 17, 2018, Governor of Wyoming Mr. Matt Mead with 5 Carbon Xprize Finalists



Prof.s Sain & OZIN with Dr. Wayne Song



Carbon Xprize Trumph

C4X Team - Tech+Management+Marketing

Top Management and Technical Team



Dr. Wayne Song, CEO Trained in chem., mech., civil & material eng. at Peking U, McMaster Univ & U. of Toronto, in industry for over 25 years, **scaled up technology to commericialization**



Prof., Dr. Yuehui Li, CTO LICP, SIOC, China, LIKAT, Germany, catalysts for small molecule (CO_2, CO, MeOH, ...)



YanGao Wu General Manager M. Eng. Mat. Over 10 years top management in real estate, managed and built the $690 Million the 1st Edition Hotel in **China in 4 years.**



S Deng, VP Sales, Sales of machinery, plastics, public co. experience, & channel development, dealer management and logistics, etc.



Yan Fan, VP Coal Power, 13 year coal power (1860MW) tech & management & desulfurization and denitrification

CO_2 Utilization International Coop

CO_2 Catalysis R&D

Management & execution

Sales & marketing

Coal Power Operation

Advisors on CO2 Capture & Conversion



Prof. Sain



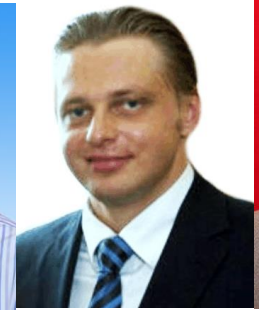
Prof. Ozin



Prof. K Ding



Prof. C Xia



Prof. Solovev



Prof. Fang

CCU Technical Teams



Prof. Y Zhang, 33 years experience in CO2 capture & conversion



Prof. T Wang, experience in CO_2 capture & energy



Prof. L He, experience in CO2 catalysis & conversion



Prof. C Liu, experience in CO2 catalysis & conversion



Prof. J Xia, experience in CO2 catalysis & conversion



Dr. S Chen, experience in CO_2 capture & conversion



Dr. W Dong, experience in CO_2 capture & energy

C4X UofT Gas to Fuel Team with Solar Catalysts







Roland Dittmeyer

Director of the Institute for Microprocess Engineering, KIT

Co-Founder, Ineratec Germany



Erik Haites

President, Margaree Consultants Toronto

Climate Policy Kyoto Paris Expert



Aldo Steinfeld

Director of Institute of Energy Technology and Renewable Energy, ETH Zurich

Co-Founder Clime Works and Solar Jet, Switzerland



Peter Styring

Chair European CCU Network

U Sheffield Head of Chemical Engineering & Chemistry

Professor of Public Engagement,



Christos Maravelias

Professor U Wisconsin Chemical, Industrial, Process Systems Engineering

Expert Life Cycle Assessments

Cooperating with the Solar Fuels Cluster of University of Toronto

C4X Partners and Customers

Canadian partners

- PolyBio Inc.
- G2F Technologies
- C4X Technologies Inc.
- PERDC – Ford Motor, Canada
- Walkerville Brewery

American partner

BOEING

UNIVERSITY OF TORONTO

Ford

WALKERVILLE BREWERY

Hiram Walker & Sons
Pernod Ricard

Chinese customers

中国华能
CHINA HUANENG

Chinese largest power group

SINOPEC SEG
中石化炼化工程（集团）股份有限公司
SINOPEC ENGINEERING (GROUP) CO., LTD.

Chinese largest Petrochemical Co.

辽宁万利集团

Wanli Group

Chinese large mining group

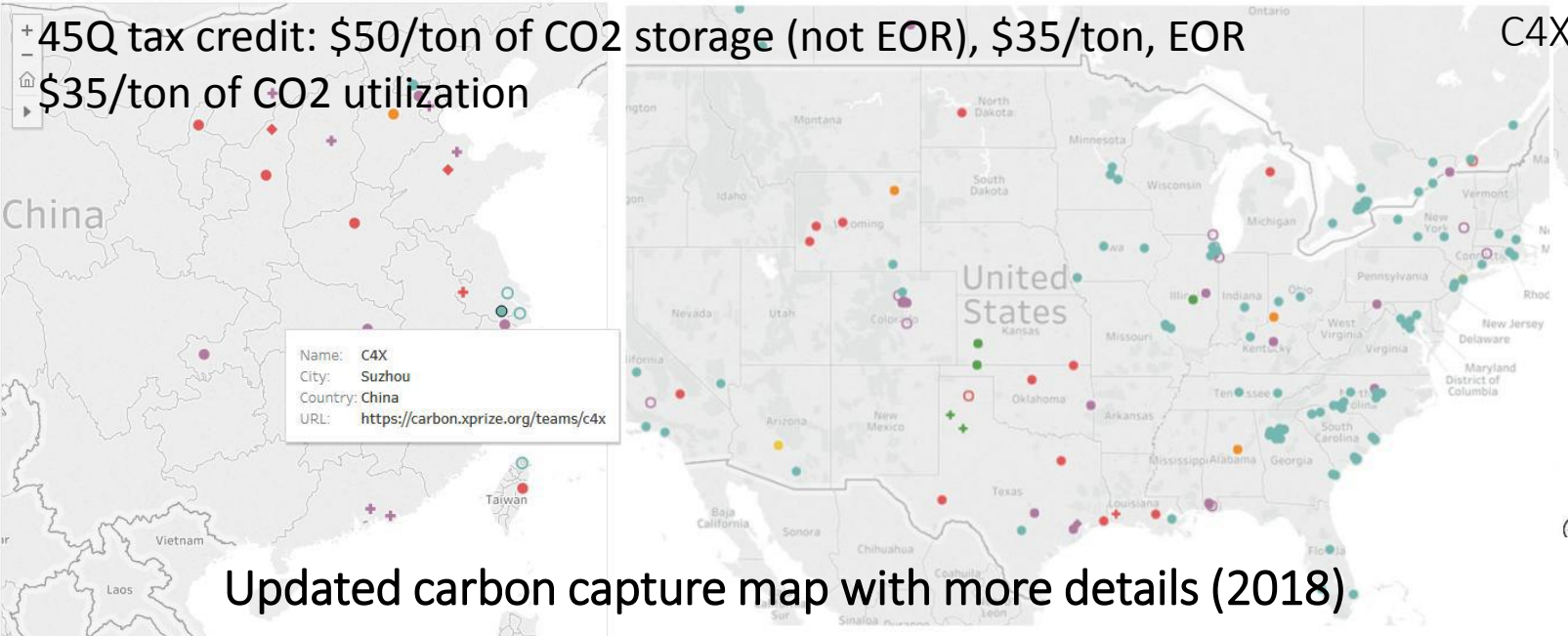
CURRENT USA CARBONTECH LEGISLATION

Policy	Description	Status
45Q Tax Credit	Tax credit for any new fossil-fuel plant with carbon capture or industry producing carbon dioxide that begins construction before 2024	Current Law
USE IT Act	Authorizes initiatives that support carbon utilization and direct air capture research and development, and foster cooperative planning and permitting of pipelines for CO2 transportation	Passed Senate Committee, No action in House
Fossil Energy R&D Act	Authorizes expansion of Department of Energy R&D, including for CCUS technologies	Introduced in the House, No action in Senate
Carbon Utilization Act	Allows emerging carbon utilization technologies to access USDA loan guarantees, research programs, and rural development loans	Introduced in the Senate, No action in House
MLP Parity Act	Expands eligibility of Master Limited Partnerships under the tax code to include CCUS projects, among other technologies	Introduced in House and Senate

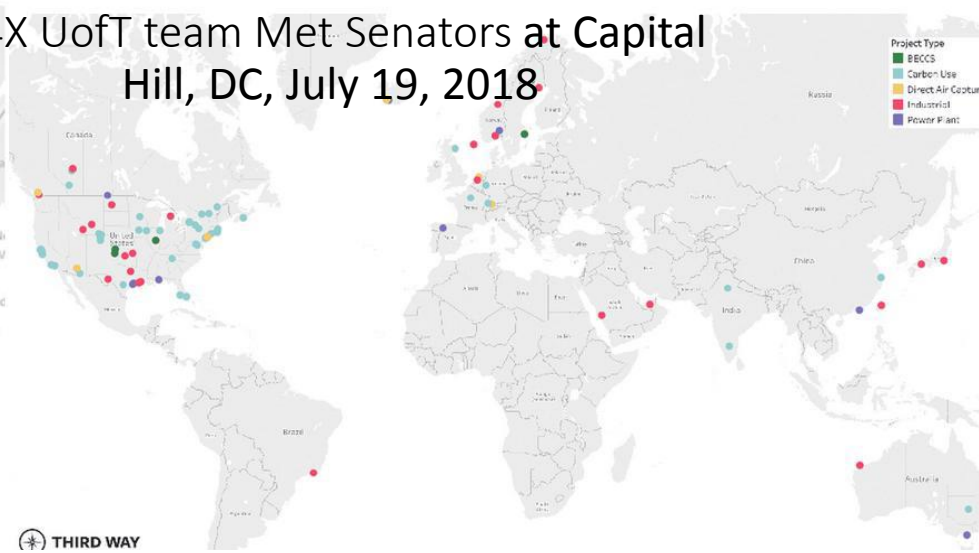


C4X UofT team Met Senators at Capital Hill, DC, July 19, 2018

45Q tax credit: $50/ton of CO2 storage (not EOR), $35/ton, EOR
$35/ton of CO2 utilization

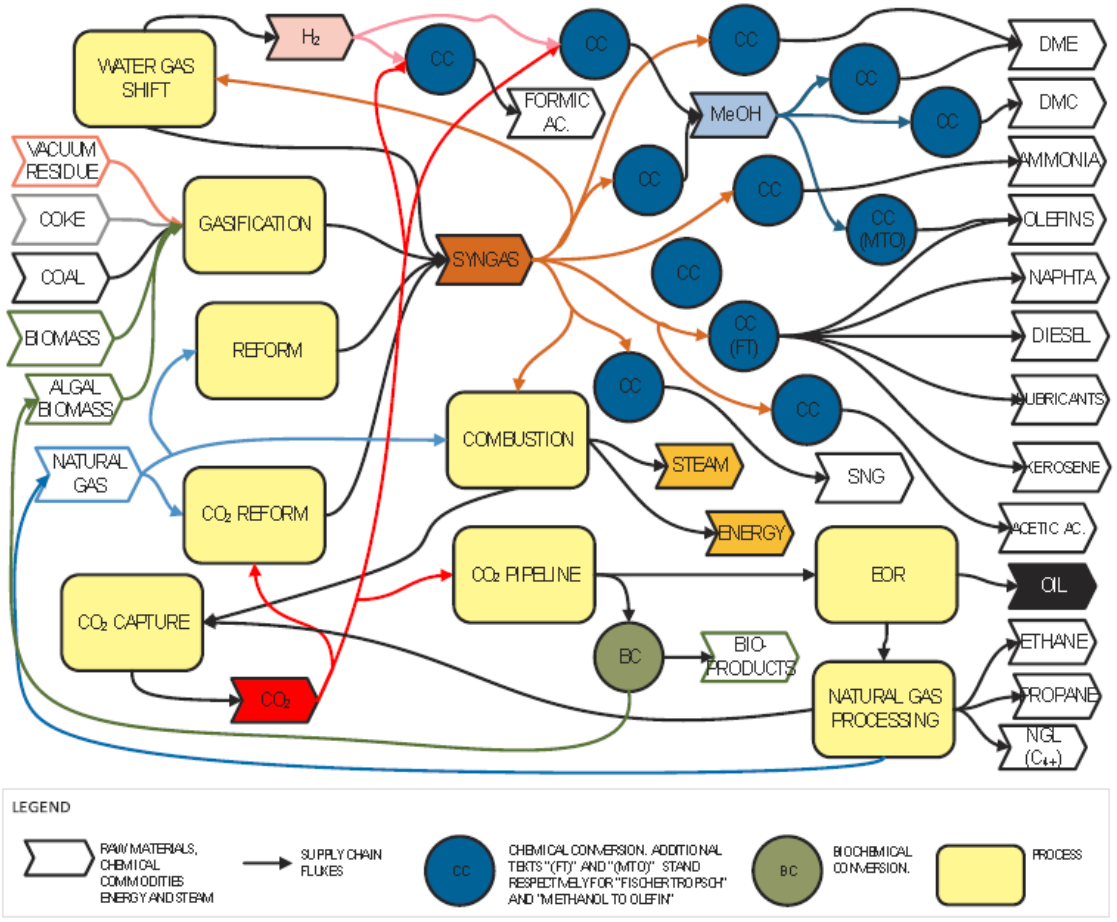


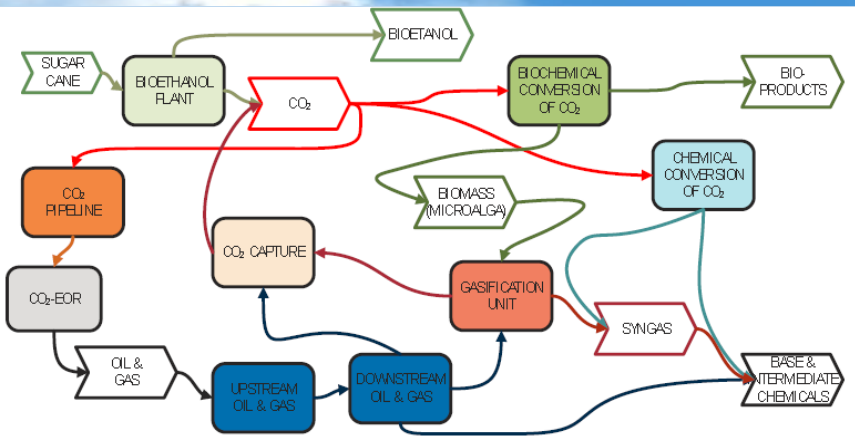
Updated carbon capture map with more details (2018)



Mapping carbon capture projects (2017)

Roadmap of CO2 Conversion

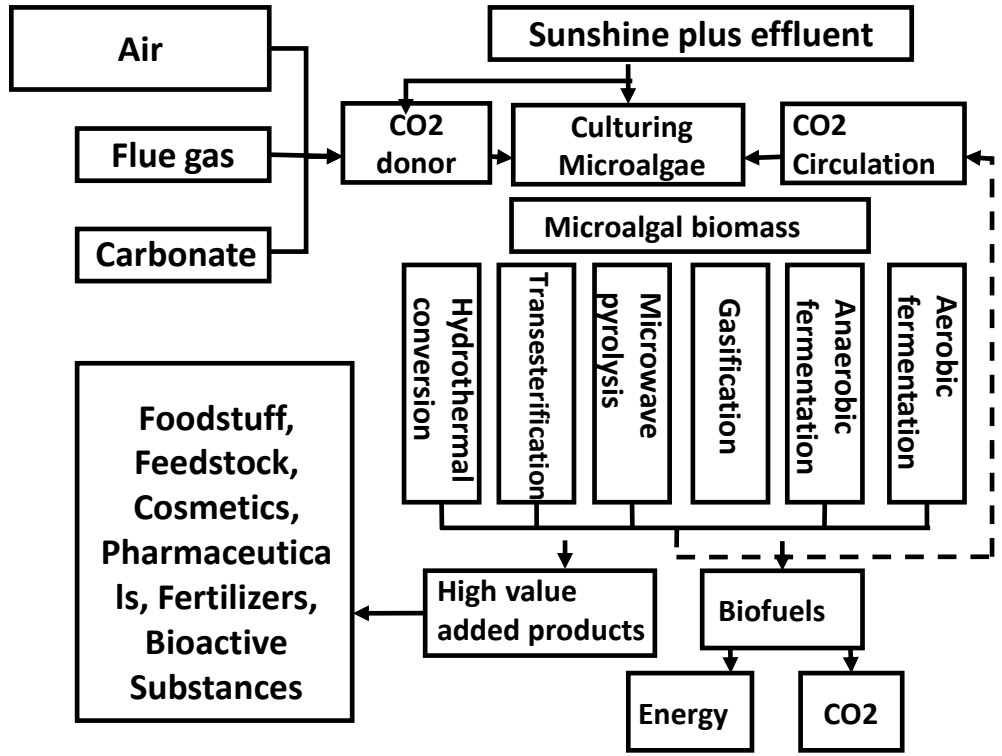




CO2 capture and utilization in the oil and gas supply chain

Coexistence of fossil and biomass feedstock uses: CO2 capture and utilization dropped into existing production infrastructure

CO2, biomass, coal, natural gas and petroleum are five feedstocks



Biochemical system of fixing CO2 by Microalgae

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Systems of CO_2 Capture & Conversion

NRG Cosia XPRIZE and Southern Research visited and verified our Systems of CO_2 Capture & Conversion.
Results: Captured CO_2>1,500 kg/day at 93% rate, CO_2conversion rate at 91.5%



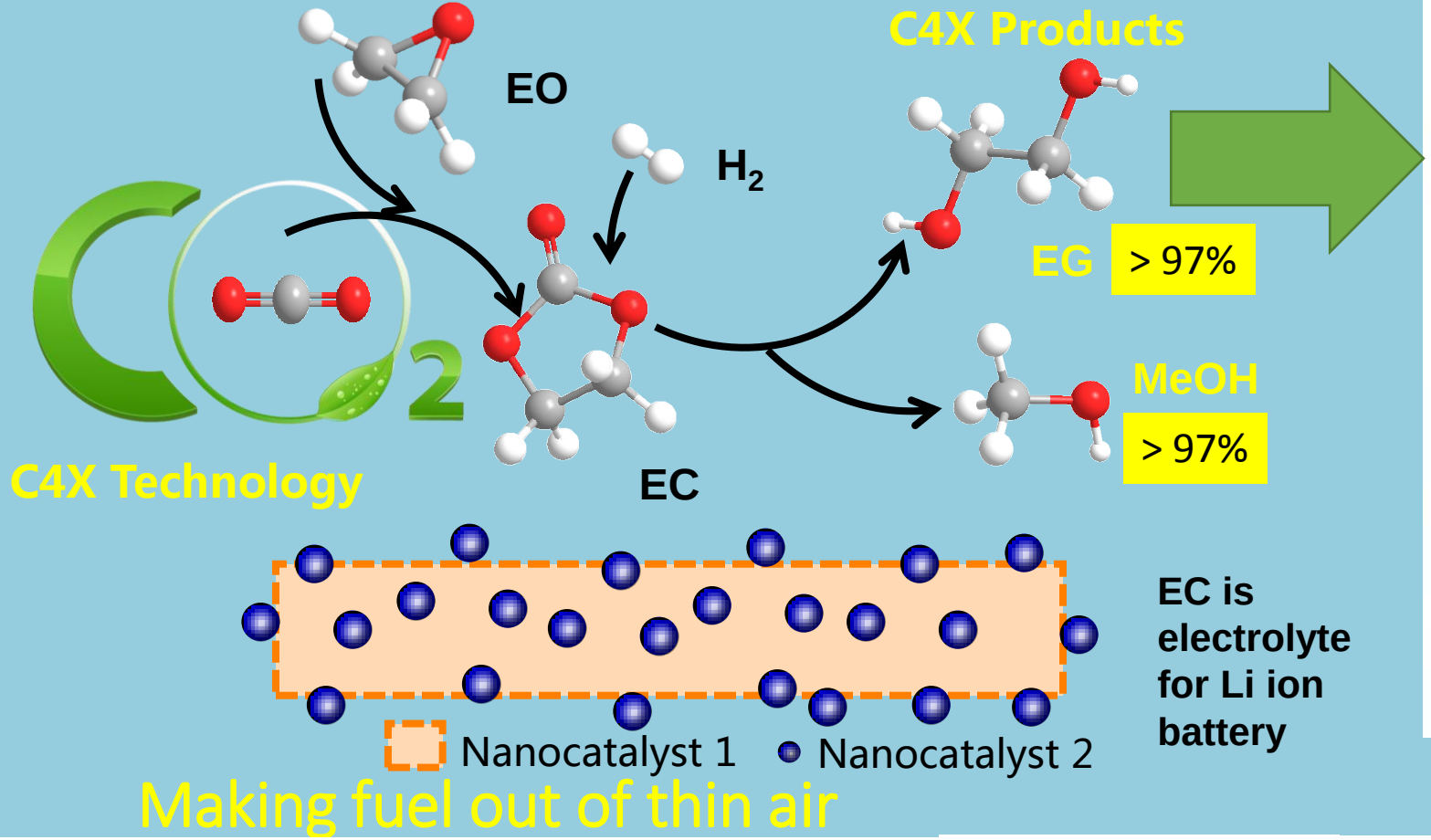
CO2 capture system



XPRIZE & Team at CO2 conversion to EC site



System to make EG

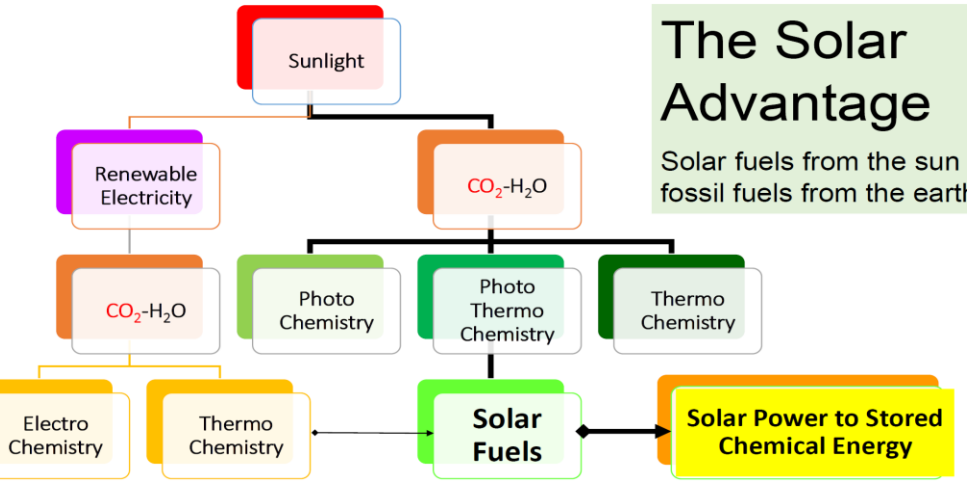


EC is electrolyte for Li ion battery



EG to make PET(bottles & textile)
MeOH is fuel

Making fuel out of thin air



The Solar Advantage

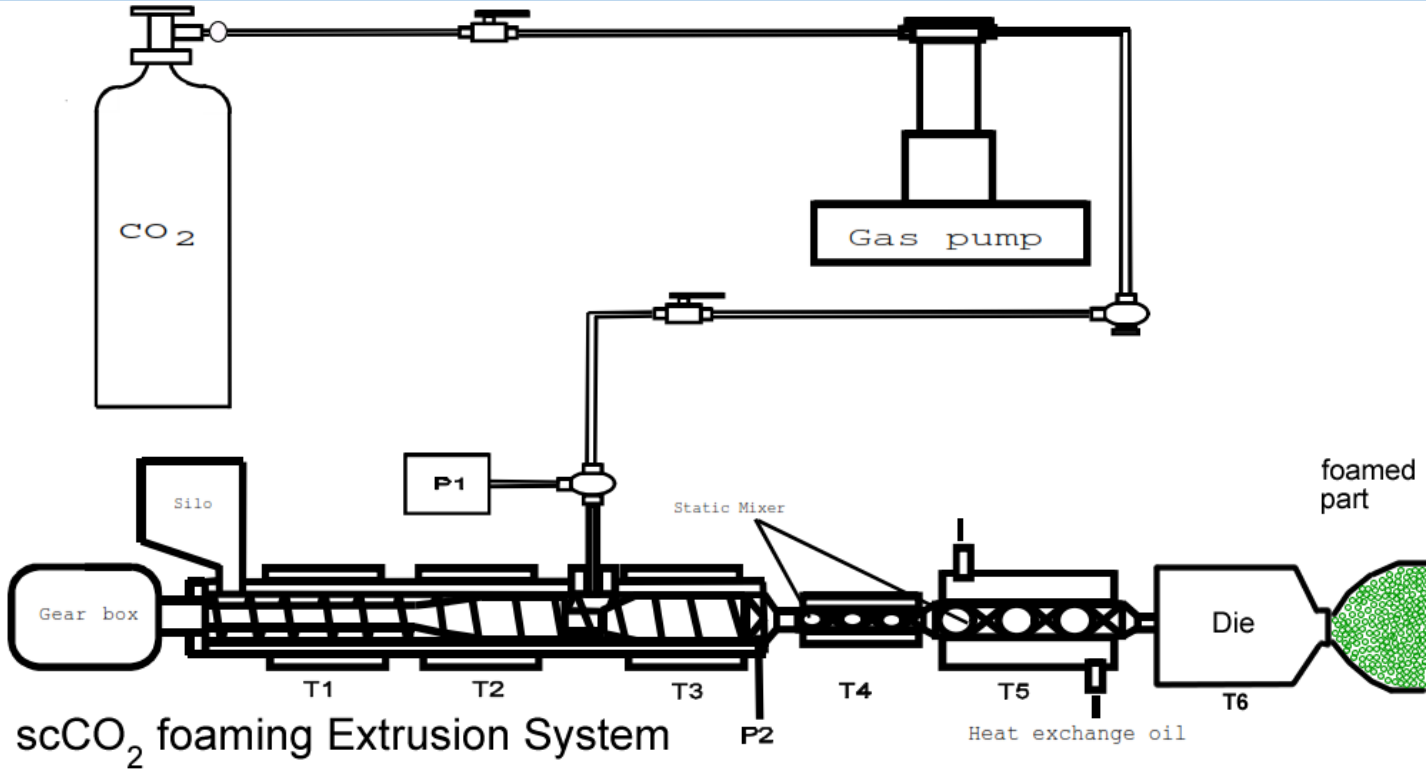
Solar fuels from the sun not fossil fuels from the earth





III. Supercritical CO_2 to make nano fiber reinforced microscopic foamed products

- Processing materials: PVC, PS, PP with nano cellulose fiber
- Microscopic foaming: 3% - 20% wt CO_2 used, 14 - 40 times foamed
- Foaming Conditions: 150 - 200 ^oC and 10 - 20 MPa
- Foamed product's density 25 - 100 kg/m^3
- Energy saving insulation products: (10℃), conductivity k≤0.028W/(m.K)
  heat resistance ≥0.89 (m2.K/W)
- Compression strength:
  500 - 1500 KPa better than Dow Corning
- Currently, Freon foaming agent used, very bad for environment! inferior properties (150 - 500 KPa)



scCO2 foaming Extrusion System

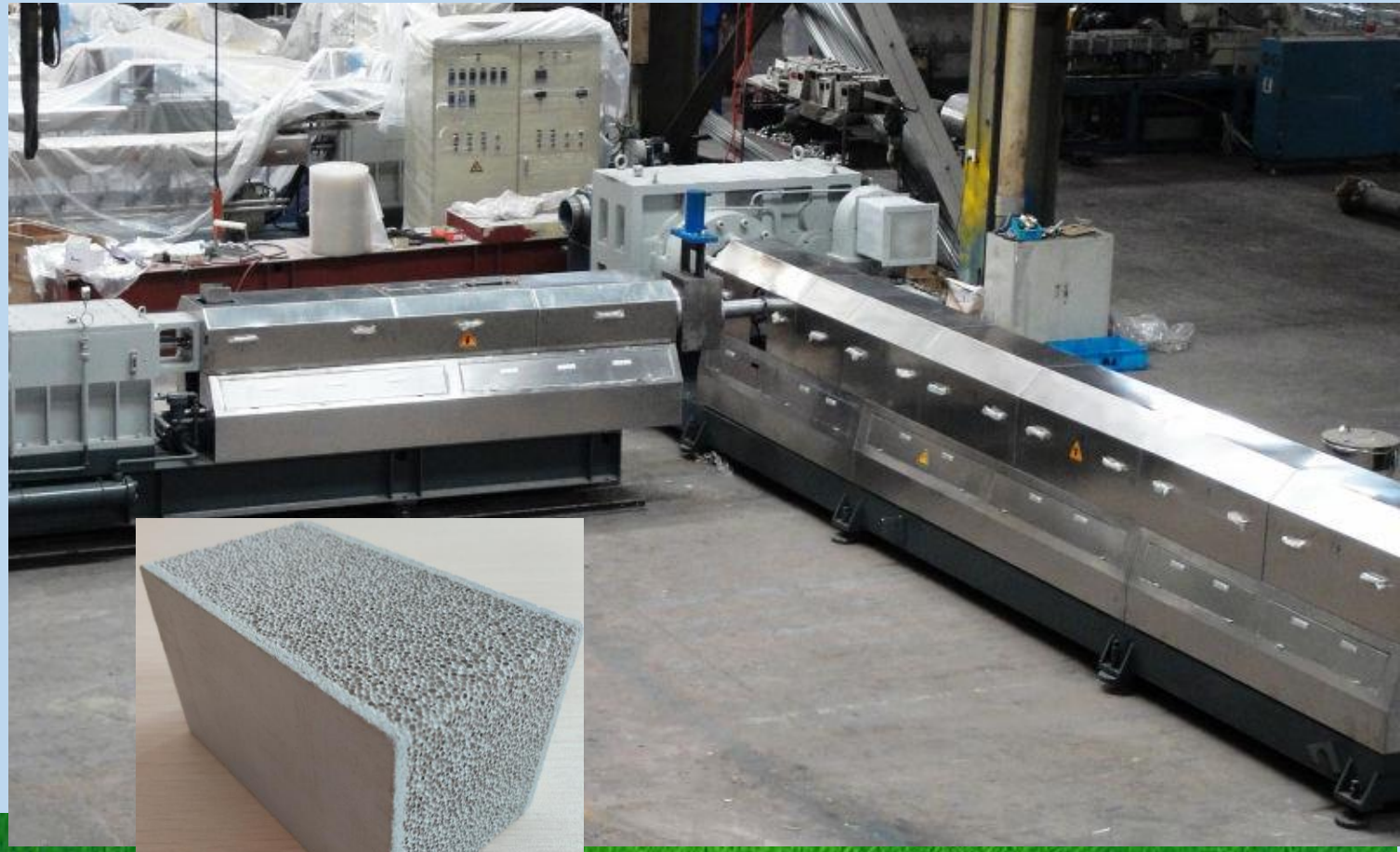
Supercritical CO_2 to make nano fiber reinforced microscopic foamed products

- Foamed nano biofiber reinforced plastic panels:
- Exterior insulation wall panel, pavement for airport, ceiling, etc.
- Automobile and aircraft interior, ceiling, door trim, foot mat, etc.
- Packaging, coffee cup, etc.

- Foamed concrete
- Foamed glass

Foamed nano fiber reinforced plastic panel





Foamed concrete

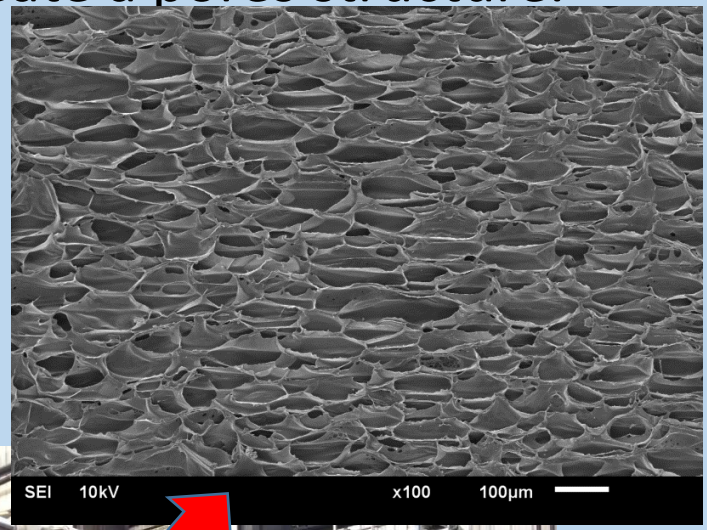
CO_2 Foaming Process by PolyBio Inc.

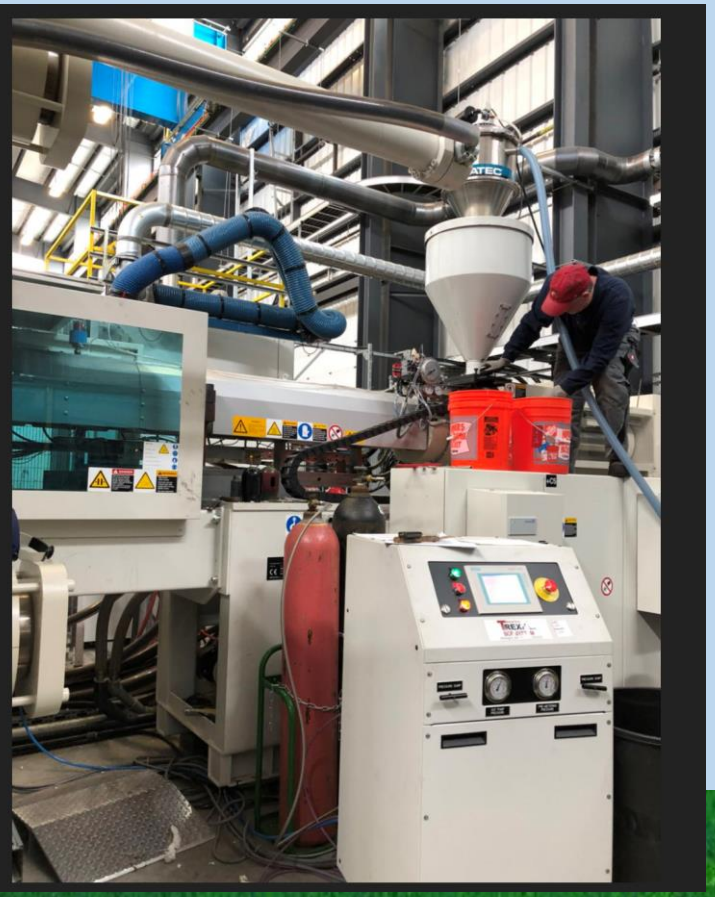
In this process, Super-Critical CO_2 is added to the molten polymer to create a pores structure.

- **$250,000/MT**
- **TOTAL MARKET: $8.5 BILLION**

	Supercritical CO_2
Cell Size (µm)	120
Foam Density (kg/m^3)	100
Reduction (%)	95
Cell Density (cells/cm^3)	7.5 x 10^6







Injection molding machine equipped with high pressure pump

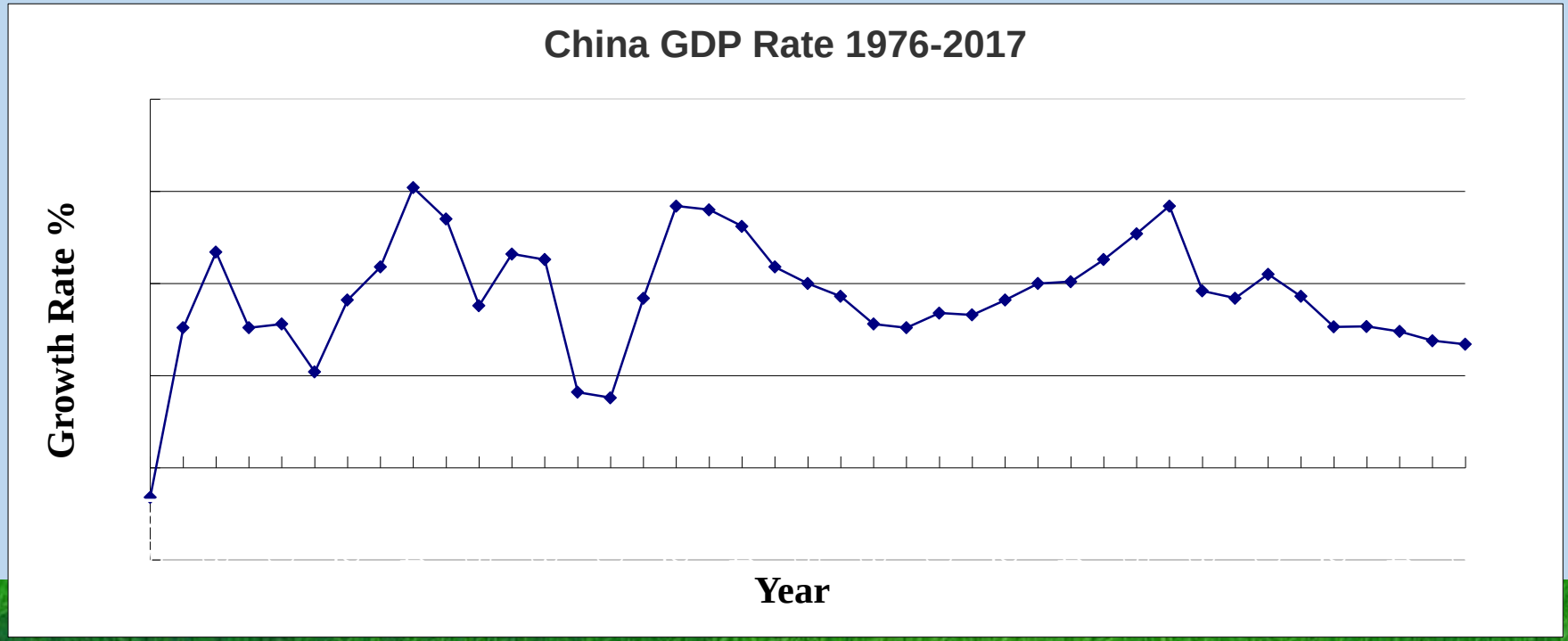




PVDF foam sheet

China Market Basics

- 1.39 billion population (2017)
- 2017 GDP: US$12.1 trillion, 82 trillion RMB, 2nd in the world (US, US$19.4 trillion)
- Growth rate: 1976-2017 (averaged 9.3%/year over 40 years)
- Growth rate of 2017 was 6.9%



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WPC Development in the World

	2010	2016	Annual growth rate	World % 2016
China	520,000	1,925,000	25%	47.65%
North America	900,000	1,404,000	8%	34.75%
Europe	150,000	277,500	11%	6.87%
Japan	60,000	138,000	15%	3.42%
Russia	10,000	103,600	48%	2.56%
South Asia	30,000	62,150	13%	1.54%
South America	10,000	69,000	38%	1.71%
Inda	5,000	60,800	52%	1.50%
Total tons	1,165,000	4,040,050	13%	100.00%

Europe 2015 190,000 tons, 2018 225,000 tons, AMI Consulting

WPCC in 2017 & 2018

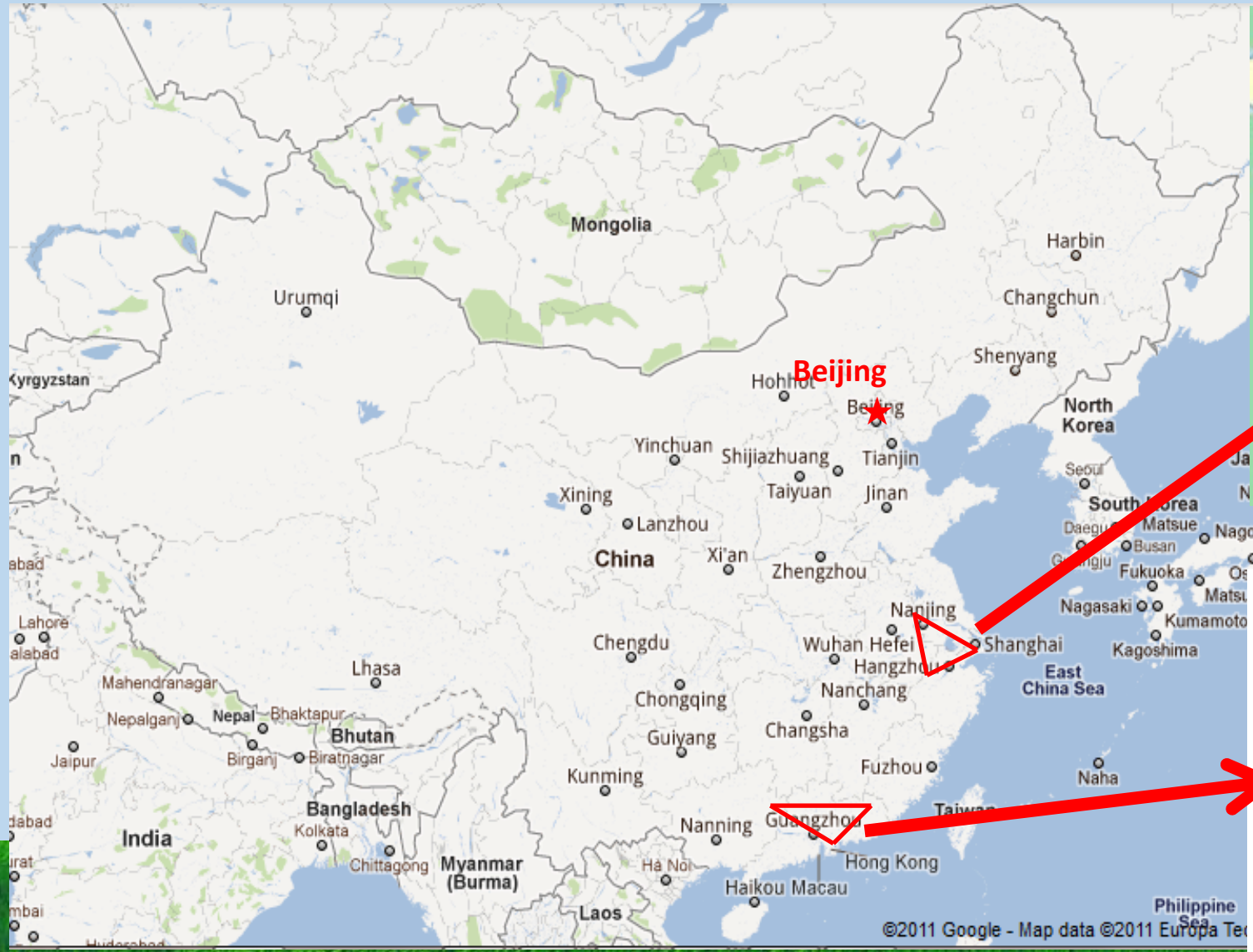
- Wood-Plastic Composite in China has grown over 20% in 2017
- Over 20 new WPC companies established in the central and west regions of China in 2017
- The 12th China WPC Forum in Sept. 26-27, 2018
- Over 15 WPC comanies sales over 10,000 tons/year



Wood plastic composite development in China

WPC industry concentrated in **Yangzi River Dalta**
22 cities
156 million people
2.19% area
21.3% GDP
1.8 trillion USD in 2013

Pearl River Delta
11 cities
57.2 million
0.44% area
13.1% GDP
1.4 trillion USD in 2016







C4X WPC Future: 100 million tons and 200 billion USD markets in China

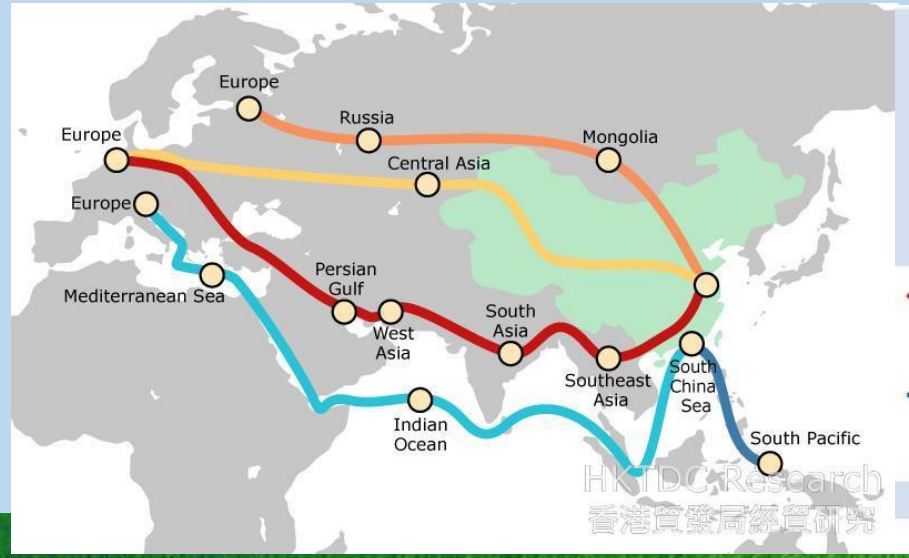
Construction	million m^2	WPC million m^2	million tons	Billion RMB	Billion euro	Billion $
Interior door	720.4	100.9	3.8	38	4.85	5.75
Window	720.4	210.7	6.5	130	16.58	19.67
Indoor siding	7,000	2,100	16.8	252	32.14	38.12
Outdoor siding	7,000	1,050	14.7	210	26.79	31.77
	million m^3	WPC million m^3			0.00	0.00
Plywood	170.4	52.2	25.6	256	32.65	38.73
other MDF boards	150.3	45.8	22.4	224	28.57	33.89
Deck, railing	9.9	3.0	2.7	21.6	2.76	3.27
	Billion RMB				0.00	0.00
Concrete form	300			60	7.65	9.08
	cars/year				0.00	0.00
Auto interior	20,000,000		0.75	19.5	2.49	2.95
High speed train interior	400		0.35	9	1.15	1.36
	million tons		million tons		0.00	0.00
PE WPC pellet	17.0		2.6	25.5	3.25	3.86
PP WPC pellet	16.6		2.5	19.9	2.54	3.01
PVC WPC pellet	16.3		2.4	14.7	1.88	2.22
Total			101.1	1,280.6	163.3	193.7

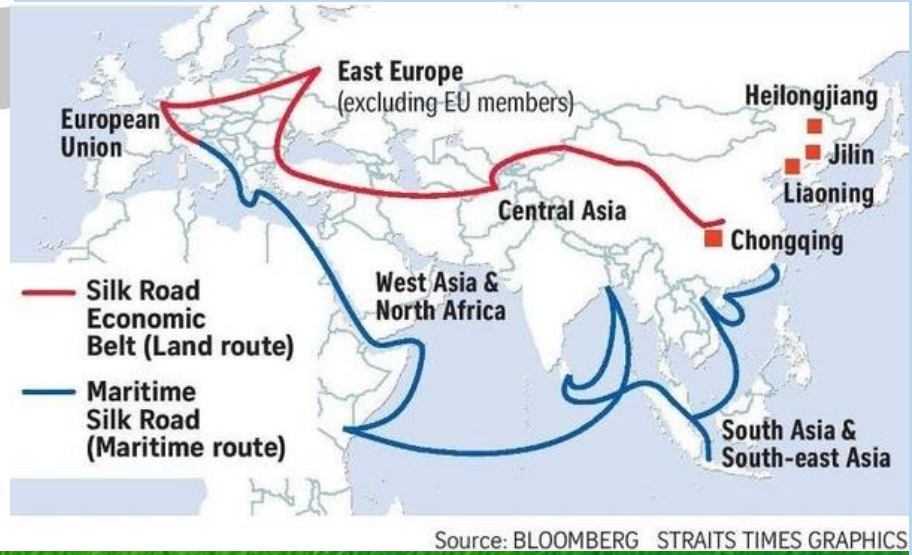
The newest development and directions

- The Belt and Road Initiative of China
- Integrated housing and (WPC) wood house for domestic tourist and retirement centers, and “Special Town” initiative
- Co-extruded and multi-layer extruded products for exporting
- Structural WPC
- Interior applications into ordinary Chinese families (wall and ceiling, door, floor, furniture, ...)
- WPC for the high speed train and auto interior
- Class A and B flame retardant WPC for cladding and windows
- Biomass (straws, natural fibers) and biochar composites...

The Belt and Road Initiative of China

- The Silk Road Economic Belt and the 21st-century Maritime Silk Road, better known as the Belt and Road Initiative (BRI), is a development strategy proposed by China's paramount leader Xi Jinping that focuses on connectivity and cooperation between Eurasian countries, primarily China, the land-based Silk Road Economic Belt (SREB) and the oceangoing Maritime Silk Road (MSR).
- The strategy underlines China's push to take a larger role in global affairs with a China-centered trading network. It was unveiled in September and October 2013 for SREB and MSR respectively. It was also promoted by Premier Li Keqiang during the state visit to Asia and Europe.
- In the past three years, the focuses were mainly on infrastructure investment, construction materials, railway and highway, automobile, real estate, power grid, and iron and steel.
- The next 5 years, infrastructure investment 3 trillion US dollars, benefit 65 countries along the roads, radiate to 120 countries and regions.
- China will finance it.





The Special Town Initiative of china

- Supply-side reform
- "Triple integration" with manufacture, living and ecology; a new model of "four in one" in manufacture, city, people and culture
- Example of Jiangsu province

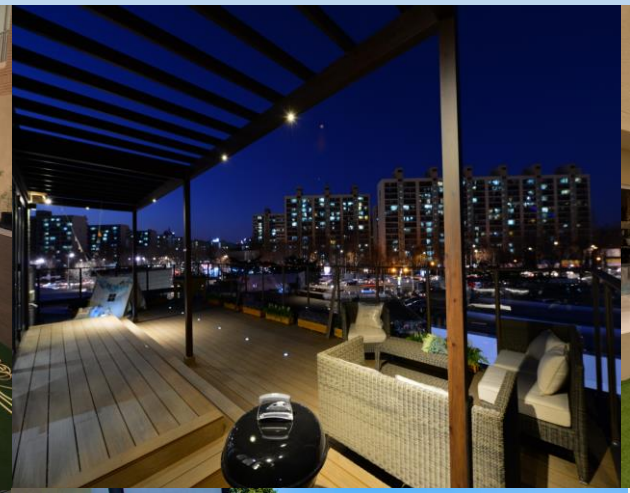
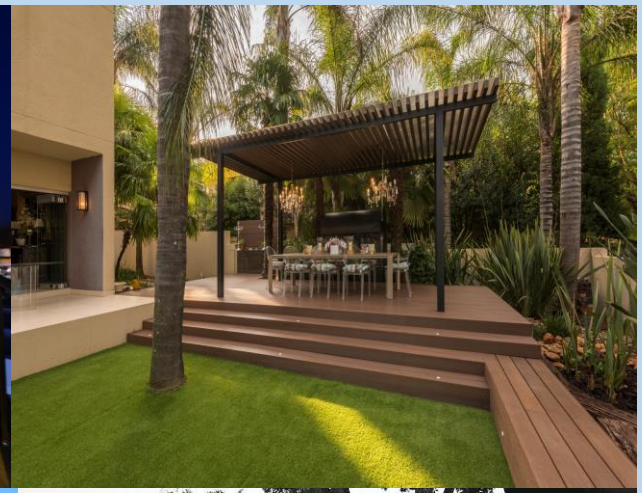
Nanjing:	Jiangning , Gaochun of porcelain future network
Wuxi:	Hongshan, Internet of things, Taihu, film & TV, Newbridge, Fashion
Xuzhou:	Sha Ji, e-commerce
Changzhou:	graphene, Yin village, Vocational Education, intelligent sensing
Suzhou:	Suzhou embroidery, East Shahu fund, Kunshan, Intelligent Valley, Luzhi, Mold
Nantong:	Lu Sixian, fishing , Haimen, Football
Lianyungang:	Crystal
Huaian:	Xuyi, lobster
Yancheng:	Digital dream, car
Yangzhou:	Medical device
Zhenjiang:	navigation, Danyang, eye glasses, Jurong, clean energy
Taizhou:	Huanggiao, pharmaceutical
Suqian:	**e-commerce**

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Chinese WPC exported

Australia	Kuwait	Korea	South Africa
Mexico	Norway	USA	China





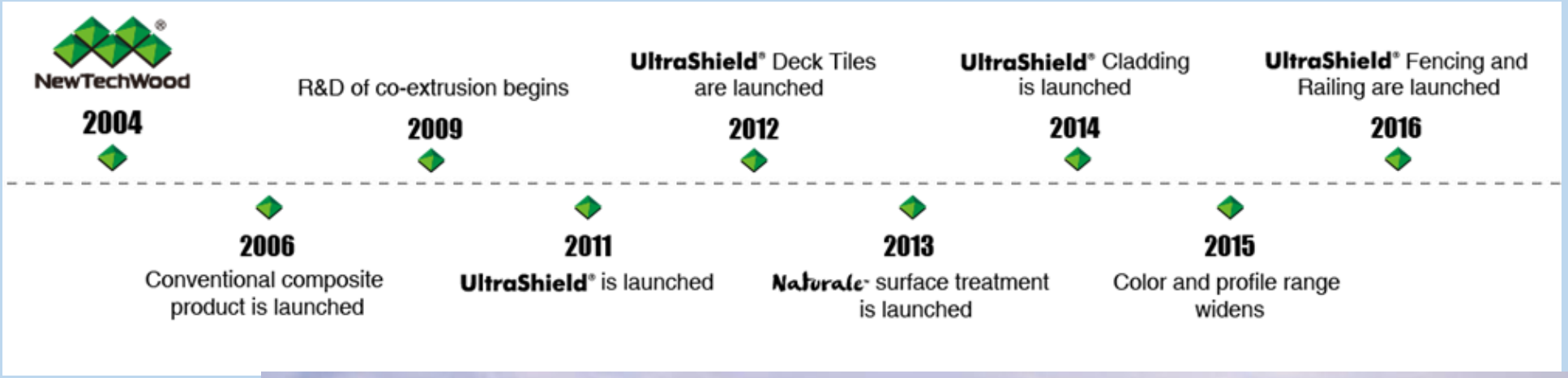


Key WPC Players in China

	Company	Sales tons 2017	People	extrusion lines	export %	tons co-extruded
1	Sentai	50,000	660	180	85%	12,000
2	Newtech wood	30,000	>300	>50	80%	27,000
3	Chengcheng	30,000	280	65	95%	
4	Hualong	15,000		38	>80%	
5	Huasu	>12,000		57	90%	
6	Huabang	10,000		26	85%	
7	Macrotech	10,000	100	20	70%	20%
8	Jiajing	10,000	100	20	80%	40%
9	Nanchang Huiteng Wood Floor	600,000	200			
10	CCLINK	5,000	50	10	40%	window & door, etc.

Key WPC Players in China

Meixin Manufacturing Co.,Ltd

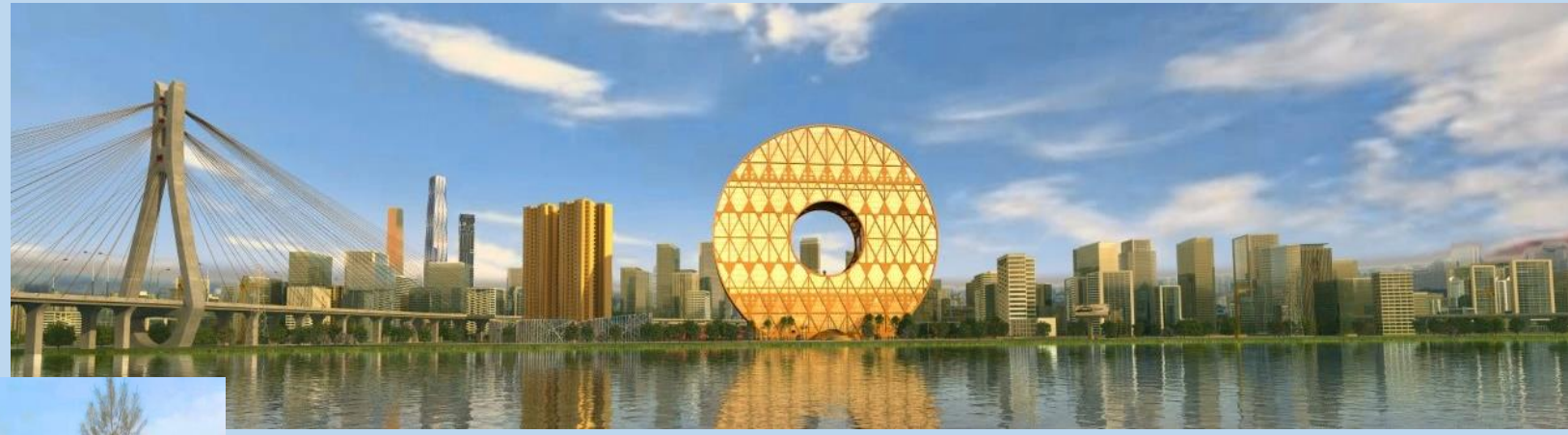


- > 30,000 tons sold
- > 90% Co-extruded PE WPC deck
- > 300 people
- > 50 lines
- > 80% exported
- Sell own brand name only - Newtech wood, utrashield, etc.



Key WPC Players in China

- **Gold Material/Jincai/Hongda Xingye**
- > Series of PVC WPC products
- > Public company w/5 billion USD sales
- > WPC marketing platform
- > 90% domastic



Headquarter of Hongda Xingye











WPC houses built

Key WPC Players in China



Concrete forms by Jincai





4' x 8' sheet
3' x 6' sheet

PE based WPC wall and interior products

- Over 95% interior WPC products are PVC based now.
- PE based WPC, totally environmental friendly
- Excellent durability
- Flame retardant with environmental friendly additives
- Foamed for light weight
- Co-extruded as option
- Mildew resistant
- Exterior and interior applications

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Flame retardant PE WPC products



Sanya Edition Hotel - Marriot Hotel Group





by CCLINK

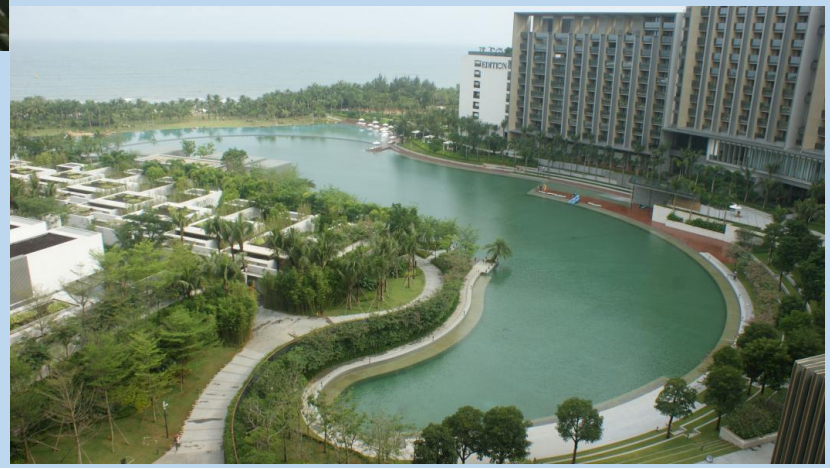
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Flame retardant PE WPC products





- Over 50,000 m^2 exterior siding used
- All function areas used WPC
- The largest project of using WPC products in a single building in China!



C4X The development of WPC interior wall and ceiling systems in China

- WPC interior wall & ceiling systems for family houses first from 2000 - now (Great wall panel series and PVC WPC), 200 or so manufactuerss
- Franchised network, large one, 50 - 400 franchisees each
- WPC interior wall & ceiling: most PVC WPC
- Fast installation WPC interior wall & ceiling systems - “Installing today, moving in tomorrow, less formaldehyde



Development of Structural WPC

- Fully encapsulated aluminum curtain wall systems
- Fully encapsulated aluminum window systems
- Fully encapsulated aluminum sliding-pivot-doors
- Fully encapsulated aluminum railing systems

Structural WPC products

Co-extruded PVC based WPC windows and doors, curtain wall, railing, ceiling,

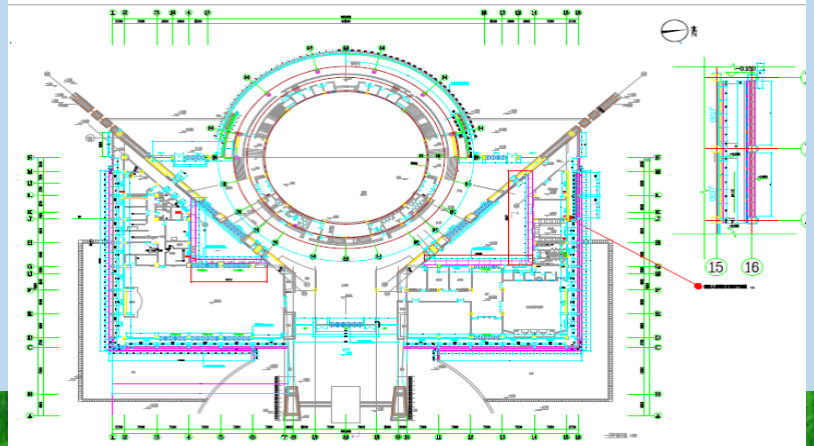






WPC products by CCLINK

General layout



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Structural WPC products

Aluminum Curtain Wall



塑木明框幕墙

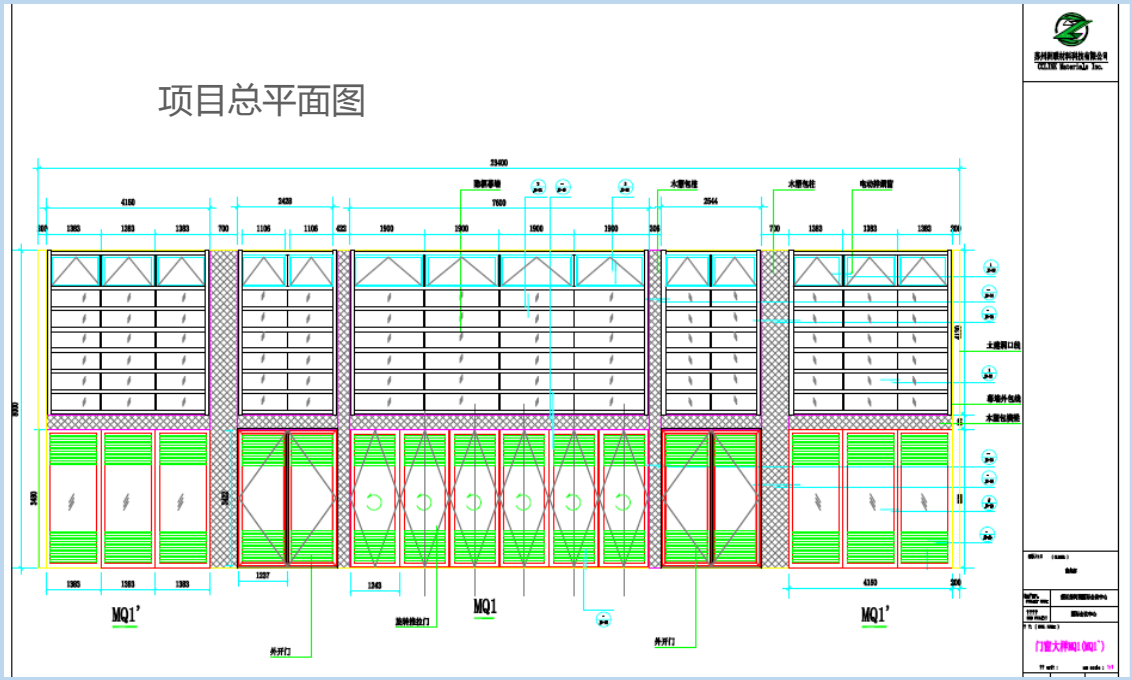




Structural WPC products



Curtain Wall:
(Aluminum core +
WPC +
skin layer)



C4X

Structural WPC products

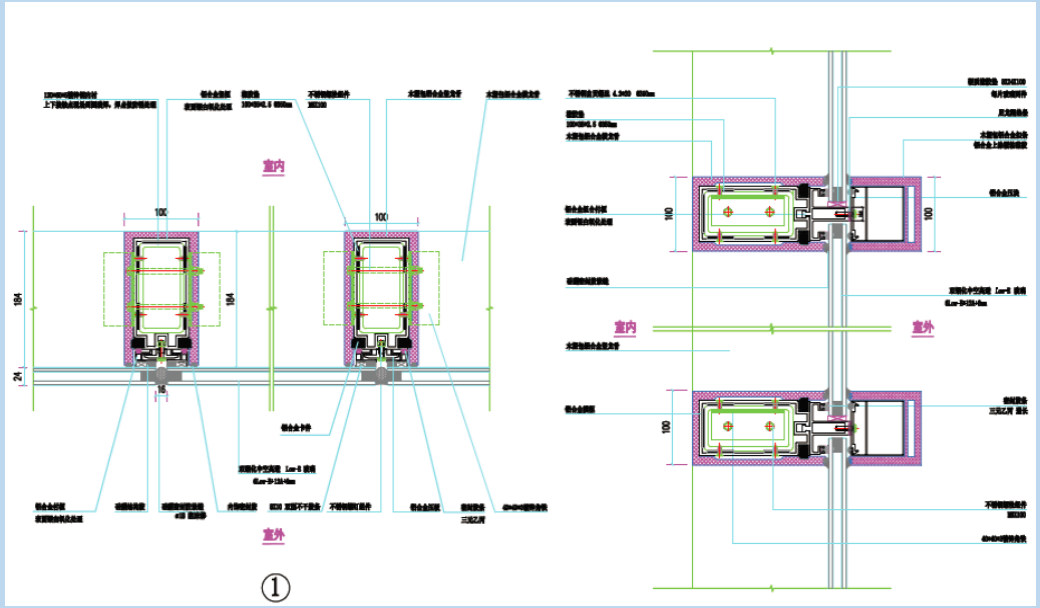




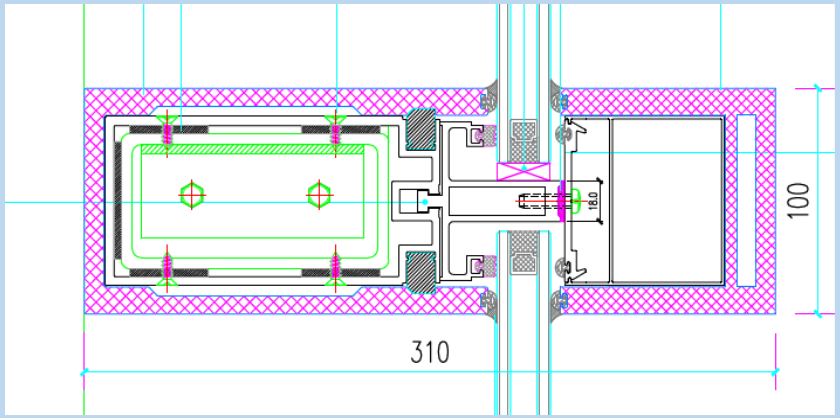
Curtain Wall (Aluminum core + WPC + skin layer)

C4X

Structural WPC products



hidden frame & open glass curtain wall





Open frame curtain wall

Curtain Wall (Aluminum core + WPC + skin layer)

C4X

Structural WPC products



塑木明框幕墙

Curtain Wall (Aluminum core + WPC + skin layer)

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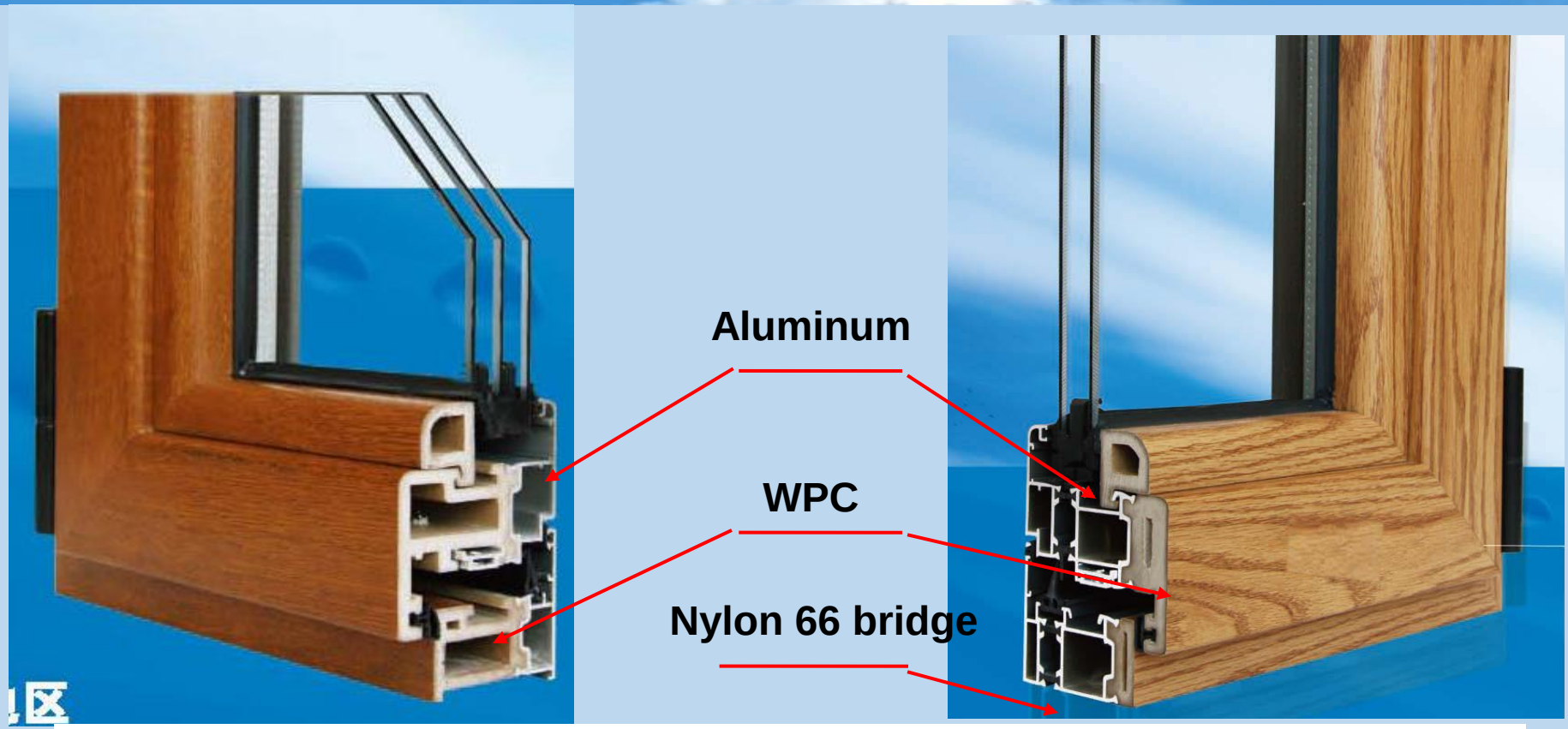
Structural WPC products



Curtain Wall (Aluminum core + WPC + skin layer)

C4X

Patented WPC Windows



Combined Aluminum's strength and
WPC's heat barrier and beauty
On the market since 2009

Aluminum core + WPC + skin layer

Skin – Weather resisting & beauty

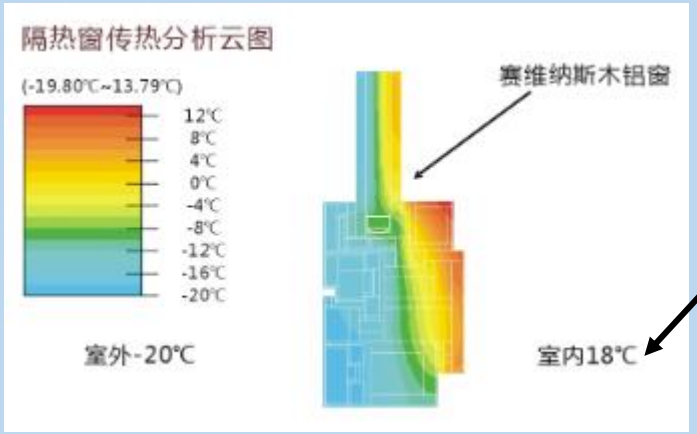
Flesh – WPC heat barrier

Bone – Aluminum



WPC window





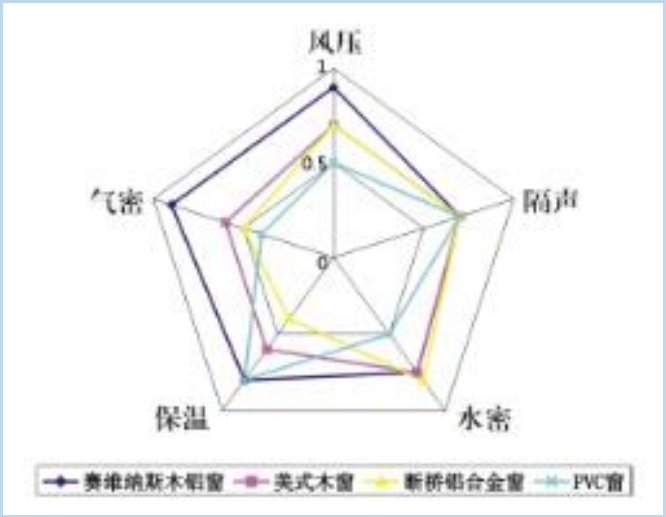
−20˚C **Outside**

18˚C **Inside**

Wind

Air barrier

Sound barrier



Heat barrier

Water barrier

Started in 2007, Stiffness by Aluminum, energy saving by WPC, weather resistant by the skin (ASA, etc.)
Patented design, CTE of WPC tuned to be consistent with Aluminum

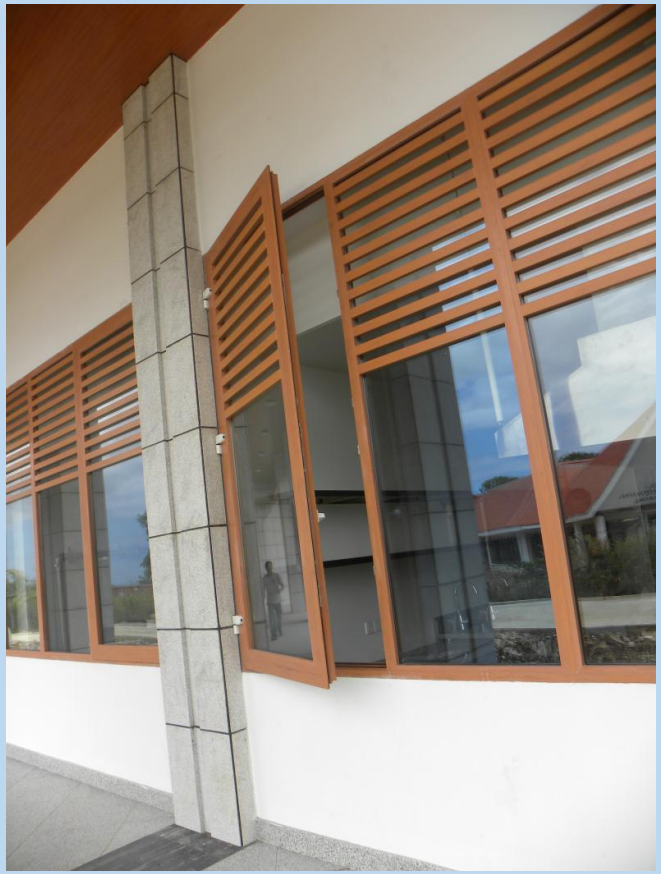
Syl, wood, bridged Aluminum, & PVC

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Structural WPC products

Fully encapsulated aluminum windows and doors



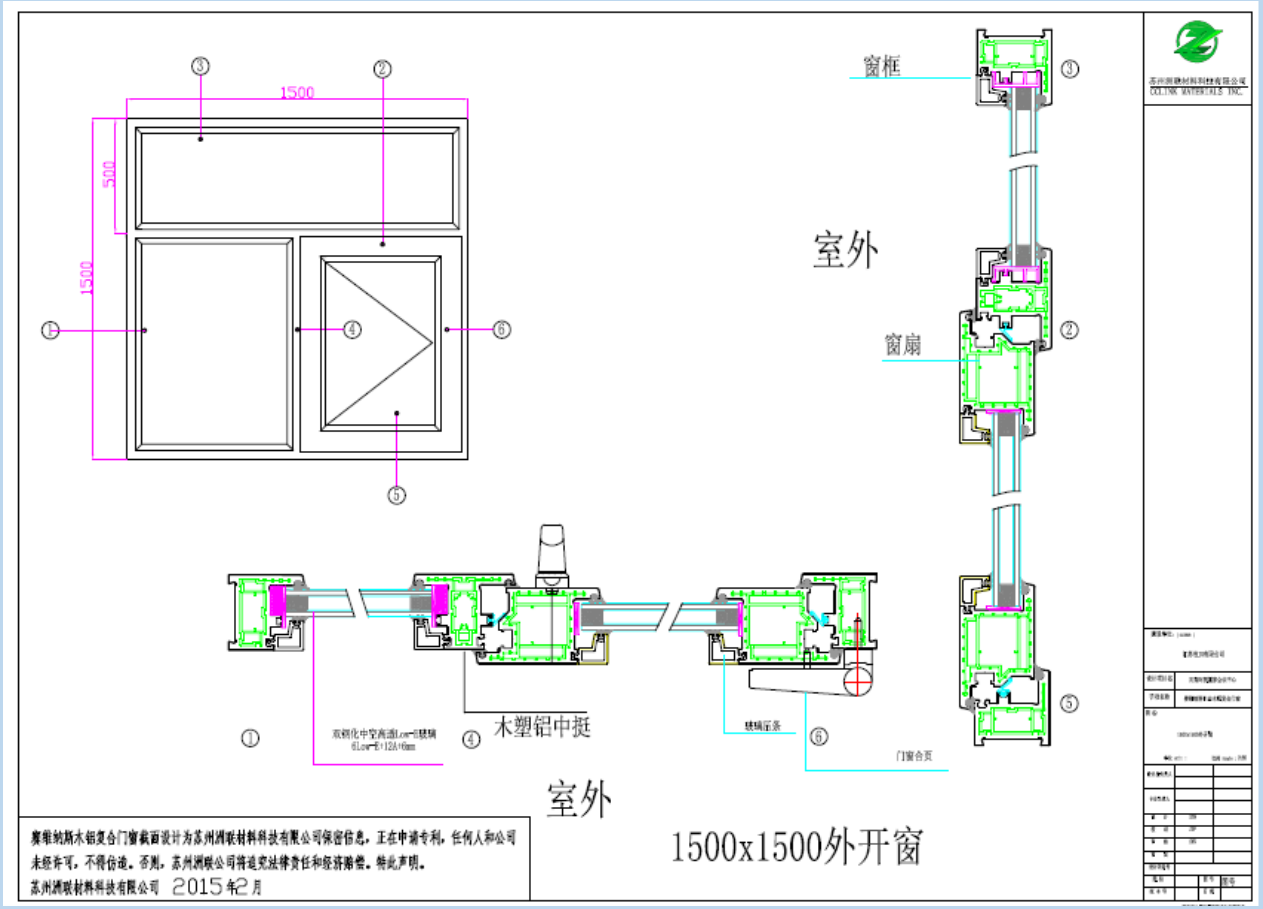


Windows & Doors (Aluminum core + WPC + skin layer)

Structural WPC products

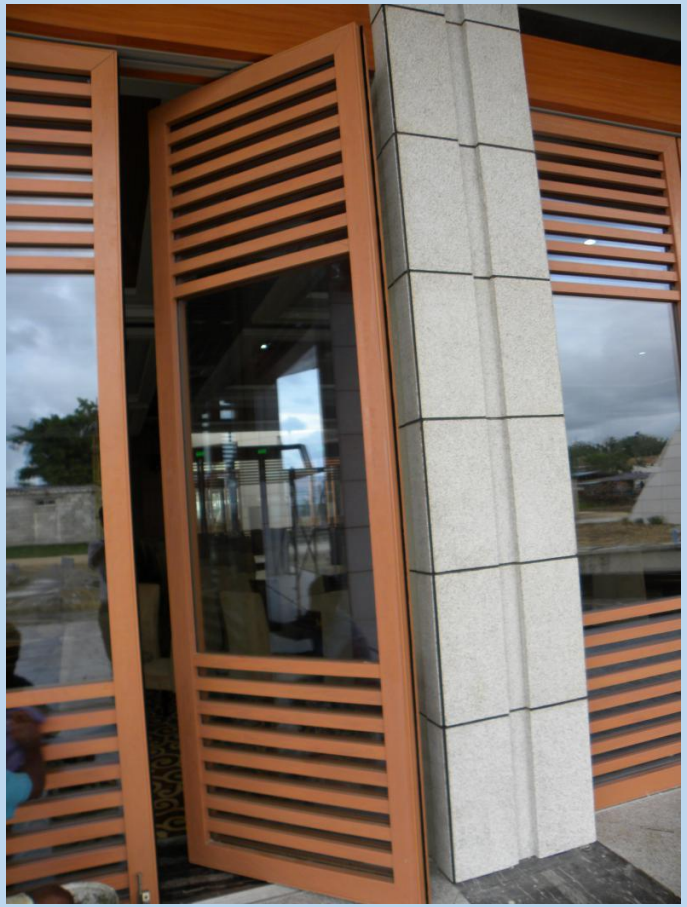
Fully encapsulated aluminum windows and doors

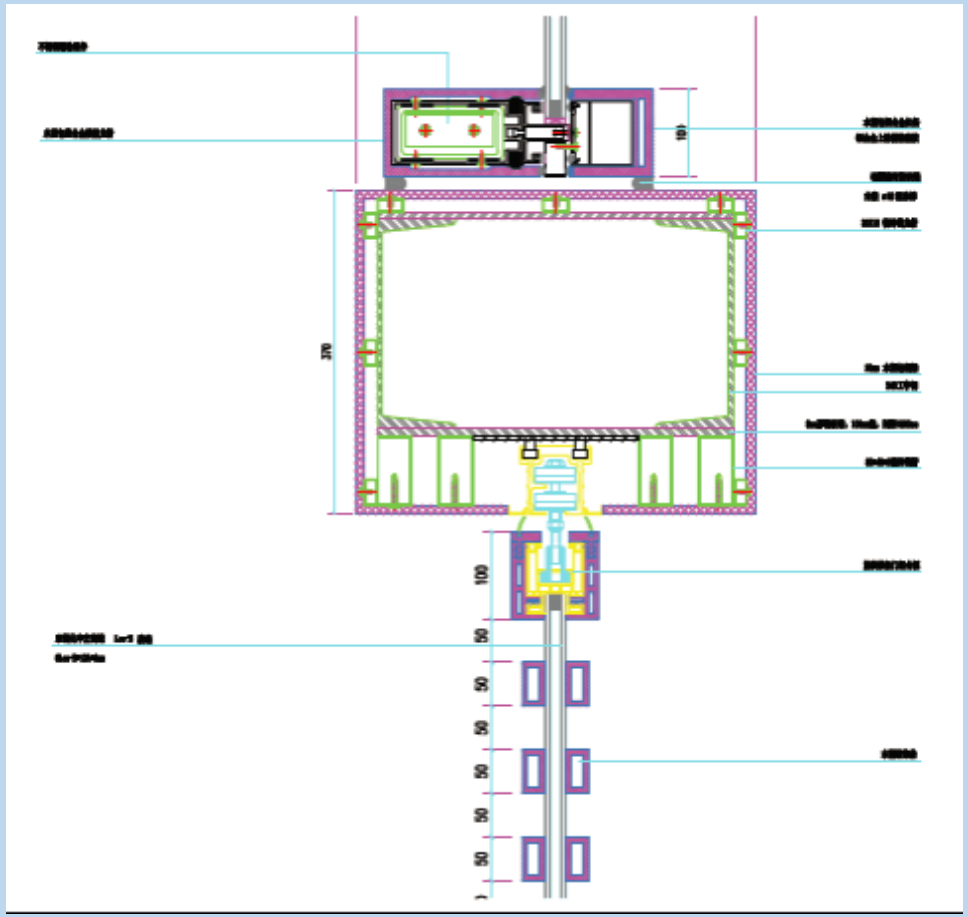




Structural WPC products

Fully encapsulated aluminum sliding-pivot-doors



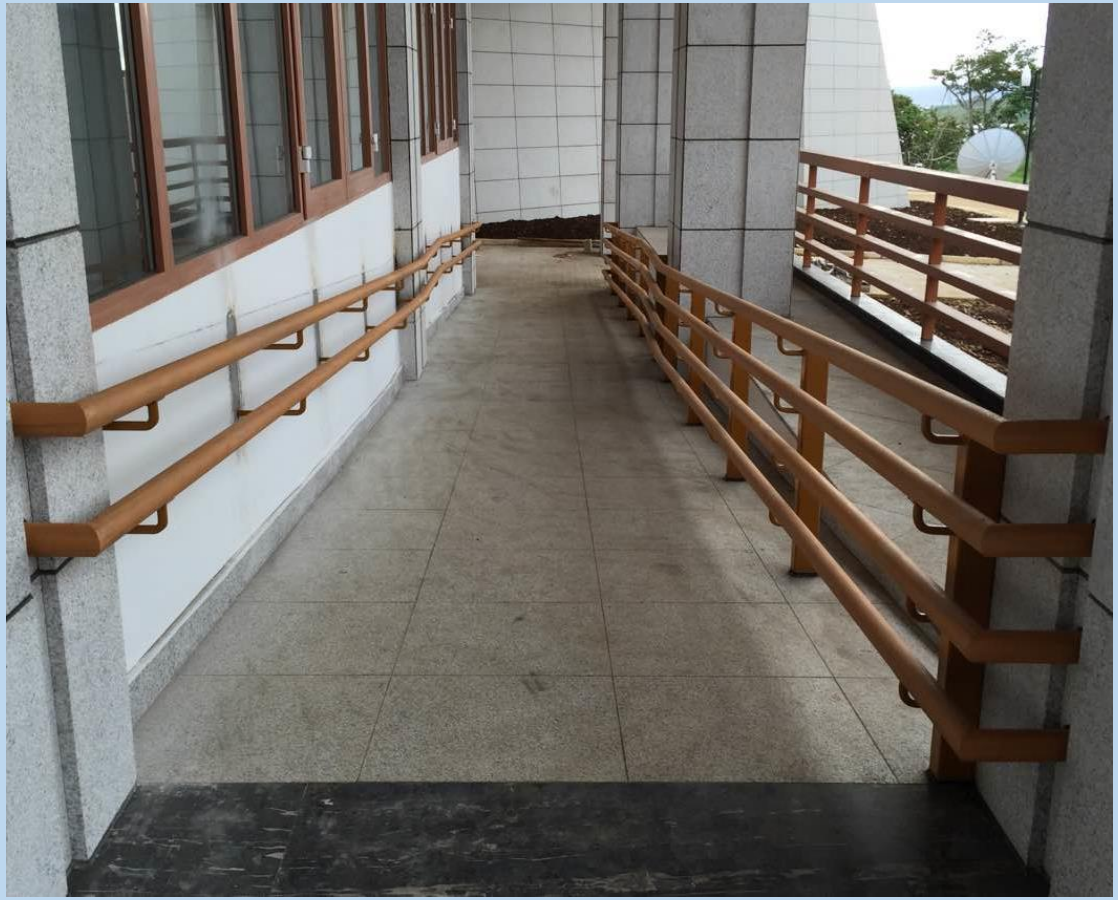




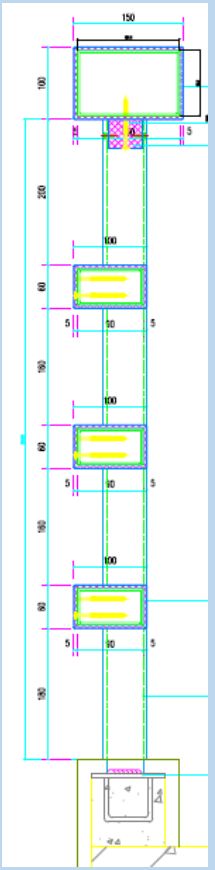
Pivot Doors (Aluminum core + WPC + skin layer)

C4X

Structural WPC products







Railing (Aluminum core + WPC + skin layer)

Conclusions

- CO_2 is not a liability anymore, it is asset!
- We have captured CO_2 from flue gases and converted it into EC, EG, etc. and utilized in supercritical CO_2 foamed plastics.

- China's WPC industry has been in rapid development period.
- WPC housing, interior wall and ceiling WPC products have picked up momentum in recent years.
- A lot of new development and products are emerging.

Thank you!

Acknowledgement

- WPCC, related companies and experts are appreciated for sharing data and helping this presentation.

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