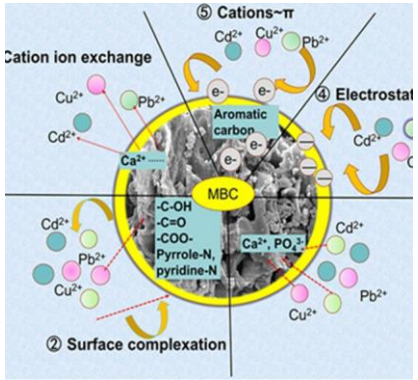
中国农业科学院农业环境与可持续发展研究所
Institute of Environment and Sustainable Development in Agriculture



中国生物炭技术应用现状与展望

Application Status and Prospect of Biochar Technology in China

March 28, 2023

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Biomass resources in China

1.1 Resource potential of raw materials

The main raw materials of biochar were agricultural and forestry residues, including crop straw, Agricultural primary processing residues, forestry residues, etc. The total of these was about 2.2 billion tons in China , with an available potential of 539 million tons.

- **Crop straw:**
  - 865×10^6 tons (yield),
  - 734×10^6 tons (can be collected),
  - 88.1%(comprehensive utilization rate)
- **Agricultural primary processing residues:**
  - corn cob:72.59×10^6 tons
  - rice husk:49.52×10^6 tons
  - peanut husk:4.48×10^6 tons
- **Forestry residues:**
  - 179.89×10^6 hm^2 (area)
  - Forest coverage rate 22.96%
  - residues: 350×10^6 tons

- Biochar from crop straw was about 272,000 tons, and from forestry residues was about 1.758 million tons, only accounts for 3.7‰ of the available resource potential. Raw material resources are abundant.

1.2 Collection, storage and transportation technology

➢ Technical model of straw collection, storage and transportation

Straw characteristics:
- ◆ Low energy density and dispersed distribution
- ◆ Regional and seasonal

Challenges of straw collection, storage and transportation technology:
- ◆ The amount and utilization of resources are unclear
- ◆ The raw material logistics system is dispersed
- ◆ There is no uniform standard for purchase and storage

Bottleneck of technological development

- ◆ **Internet of things**
- ◆ **Big data**

Straw collection, storage, transportation and supply system

- ◆ **Large-scale purchase and storage system**
- ◆ **Improve logistics efficiency, reduce the cost of storage and transportation**
- ◆ **Scientific management and standardization of logistics**

Efficient and comprehensive utilization of straw provides sustainable raw material supply

1.2 Collection, storage and transportation technology

➢ Technical modes

Field collection

On-plant use

Field collection

Stacking storage in storage site

On-plant use

Field baling

Transport

On-plant use

Storage site

Mode 1

Collect after drying in the field——Agricultural vehicle loading——Utilize

Mode 2

Field collection——Storage point drying storage——Utilize

Mode 3

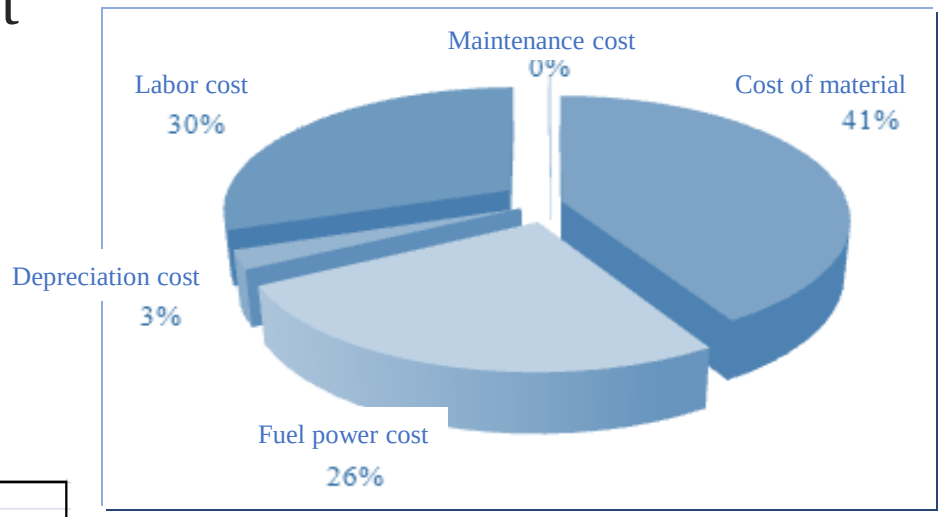
Portable field baling——Collection point storage——Utilize

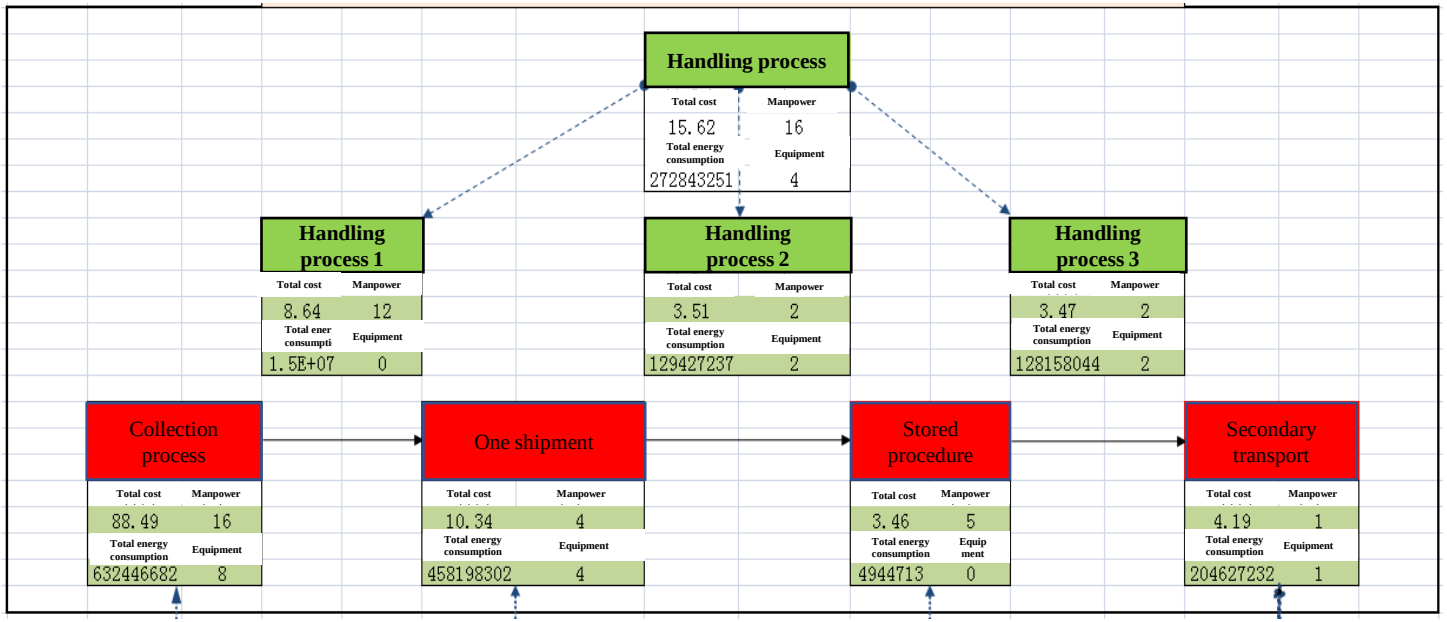
1.2 Collection, storage and transportation technology

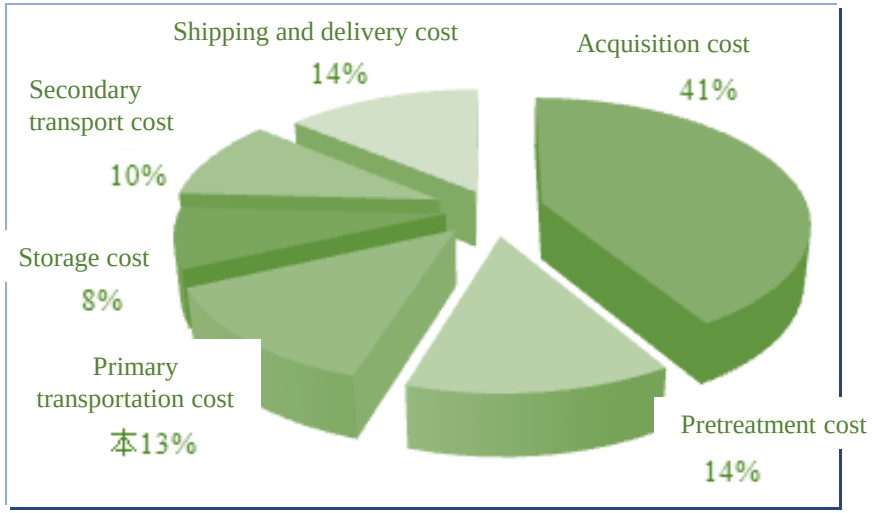
➢ Straw collection, storage and transportation cost

The total cost was about 138 yuan/t :

- collection process :88.49 yuan /t
- transportation : 14.53 yuan /t
- loading and unloading process:15.62 yuan /t.







02

Biochar industry in China

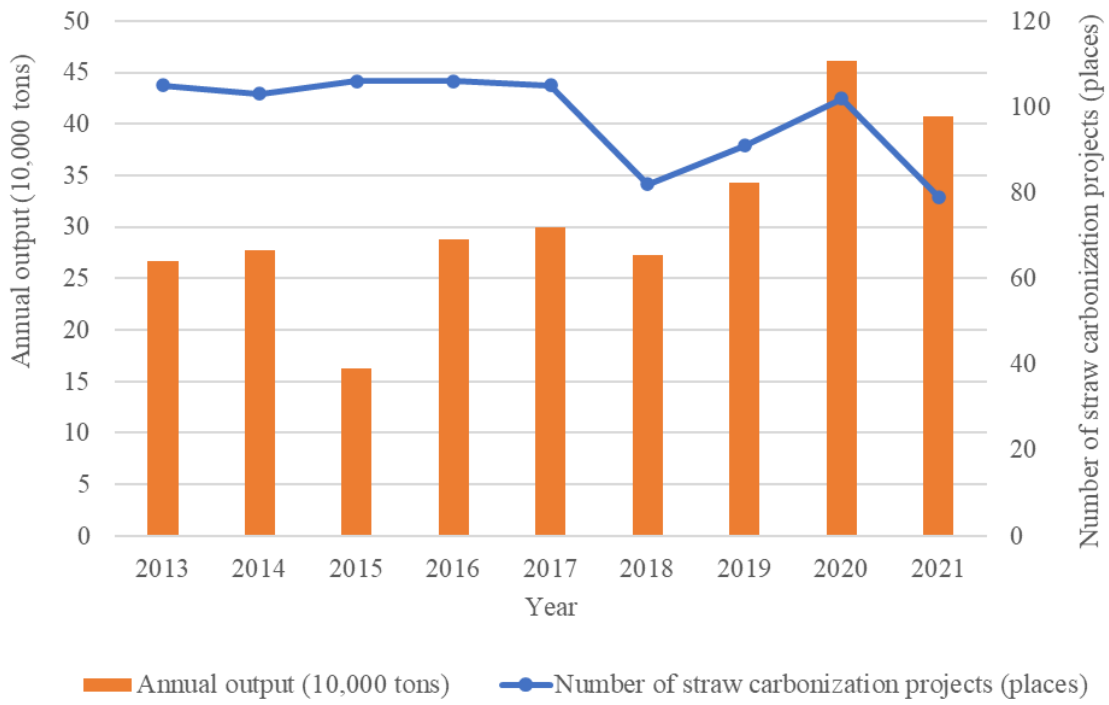
2.1 Market demand

Biochar has been applied in agricultural production, energy and environmental protection. At present, it is mainly used in soil remediation, greenhouse gas emission reduction, water pollution control, energy production and metal smelting.

- Biochar can be used as an adsorbent for water and flue gas pollutants, as a catalyst for tar removal or biodiesel production, and as an electrocatalyst for the preparation of supercapacitors.
- Biochar is a kind of soil conditioner, which can improve the number and diversity of population and maintain soil ecology.
- Biochar is a kind of energy product, which can be widely used for clean heating, cooking and facility agriculture, etc.

2.2 Industry status

- The projects of straw pyrolysis and carbonization in China are mainly concentrated in Hubei, Anhui, Liaoning, Hebei.
- In recent years, the number of projects was about 100, and the production of biochar was 400,000 tons in 2021.



According to the latest official data of the Customs deployment of China in 2018, the export of bamboo charcoal was 25,600 tons, the value was 324 million yuan（about 12642 yuan/ton）; Other charcoal (including fruit shell charcoal) was 55,000 tons, the value was 470 million yuan（about 8,633 yuan/ton）.

2.3 Related Support Policies

National level

- In July 2018, the Ministry of Agriculture and Rural Affairs, PRC (MARA) issued the "Technical Guidelines for Agricultural Green Development (2018-2030)"
  - ✓ ……Integrated demonstration of new products such as biochar-based fertilizers and their production processes; ……Integrated demonstration of efficient carbonization technology for agricultural waste.
- In December 2017, the National Development and Reform Commission (NDRC), MARA, and the National Energy Administration （NEA）jointly issued the "Guiding Opinions on the Construction of Straw Gasification Clean Energy Utilization Projects"
  - ✓ proposes biomass carbonization and carbon-based fertilizer production as a new model for co-production of coal, electricity, and biomass energy.
- In August 2015, "Opinions of the State Council on Accelerating the Transformation of Agricultural Development Mode"
  - ✓ proposes to promote the utilization of agricultural wastes and supports the demonstration of new technologies such as straw carbonization.
- In May 2015, the National Plan for Sustainable Agricultural Development (2015-2030)"
  - ✓ first time included "biochar soil improvement" in the category of supported policies, alongside with straw returning, deep plowing, organic fertilizers application, and planting green manure.

Provincial level

- In December 2020, Hebei Province issued the "Implementation Plan for Comprehensive Utilization of Straw in Hebei Province (2021-2023)
  - ✓ focuses on promoting technologies such as: straw crushing and decomposing, burying returning, carbonization returning, and rapid decomposing with biological agents. The tax department should support enterprises that use straw to produce pulp, fiberboard, and charcoal to enjoy tax rebates and preferential tax policies.
- In December 2022, Harbin City issued the "Implementation Plan for Comprehensive Utilization of Straw in Harbin City in 2022".
  - ✓ supports high-value utilization projects for biomass products, such as biochar-based fertilizers, boards, paper, straw mulching film, biogas, continuously extending the industrial chain of comprehensive straw utilization.

2.3 Related Support Policies

◆ Local regulations

In rural renewable energy and straw comprehensive utilization, policies encourage the development of carbonization technology and provide financial support such as subsidies for the purchase of agricultural machinery.

- In July 2020, the Standing Committee of the Shandong Provincial People's Congress revised and passed the "Shandong Rural Renewable Energy Regulations."。

✓ Chapter 2 states governments should encourage research institutions, enterprises, and individuals to develop technologies for agricultural solar energy, small-scale wind energy, small-scale hydropower, as well as biomass conversion technologies such as straw solidification and carbonization. Policy and financial support should be provided.

- In June 2022, the Standing Committee of the People's Congress of Gansu Province revised and passed the "Rural Energy Regulations of Gansu Province", which came into effect on August 1 of the same year.

✓ Article 11 encourages the development and utilization of rural energy technologies such as "biomass gasification, liquefaction, and carbonization"; Article 13 states "governments should formulate support policies to promote the energy utilization of straw"; Article 18 states that "the equipment purchased for the development and utilization of biomass energy can enjoy subsidies".

- In September 2019, the Standing Committee of the People's Congress of Ningxia Autonomous Region revised and passed the "Measures for the Implementation of the Energy Conservation Law of the People's Republic of China in Ningxia Hui Autonomous Region".

✓ Article 33, Item 2: The following new energy technologies shall be promoted and applied vigorously: (2) Biomass gasification and carbonization technologies, such as straw

- In November 2018, the Standing Committee of the Jiangsu Provincial People's Congress issued a "Decision on Promoting the Comprehensive Utilization of Crop Straw".

✓ Encouraging the development of biomass energy using technologies such as straw bio-gasification (methane), pyrolysis gasification, and carbonization, and arranging the utilization of straw power generation projects; Encouraging feed companies to use straw to produce animal feed; Supporting the edible mushroom production using straw.

- In August 2018, the Standing Committee of Hebei Province issued the "Decision on Promoting the Comprehensive Utilization of Crop Straw and Prohibiting Open Burning".

✓ Article 13: Encourage straw utilization enterprises to invest in the construction of biomass briquette station and develop biomass energy using technologies. Article 15: All levels of government shall actively develop processing industries using straw as raw material, and adopt clean processes using straw as raw materials, soil-improving biochar-based organic fertilizer

2.4 Biochar related technical standards

- At present, there were 27 standards in biomass carbonization for agricultural application in China, including 1 national standard, 6 agricultural industry standards, and 20 local standards.
- In the past three years, 5 agricultural industry standards and 13 local standards were developed.
- In 2022, 3 agricultural industry standards and 3 local standards were developed.
- Contents: Biochar production, fertilizer processing, field experiments, testing and labeling, project management, soil improvement, pollution control, crop cultivation.

Type	Name
National standard	1. GB/Z 39121-2020 Operation and management specifications for crop straw carbonization and returning soil improvement projects
Agriculture Industry Standards	1. NY/T 4161-2022 Technical Specifications for Biomass Pyrolysis and Carbonization Process 2. NY/T 4160-2022 Technical specifications for field trials of biochar-based fertilizers 3. NY/T 4159-2022 Biochar 4. NY/T 3672-2020 General rules for biochar testing methods. 5. NY/T 3618-2020 Biochar-based organic fertilizers 6. NY/T 3041-2016 Biochar-based fertilizer
local standard	1. DB37/T 4546—2022 Technical regulations for biochar preparation from agricultural waste 2. DB12/T 1144-2022 Technical regulations for in-situ passivation and remediation of biochar polluted by four kinds of long-residual herbicides in dryland soil 3. DB23/T 3250—2022 Technical Specifications for the Application of Biochar to Alleviate Continuous Cropping Obstacles in Greenhouse Soils 4. DB14/T 2343-2021 Technical specifications for the use of biochar to control non-point source pollution in greenhouse vegetable cultivation 5. DB1309/T 252-2021 Technical regulations for application of biochar in saline-alkali land 6. DB23/T 2852—2021 Technical regulations for the application of biochar in paddy field with white pulp soil 7. DB23/T 2853—2021 Technical regulations for the application of biochar in white clay cornfield 8. DB23/T 2859—2021 Technical regulations for the application of biochar in soybean fields in acidic soil 9. DB23/T 2862—2021 Technical regulations for the application of biochar in paddy fields in saline-alkali land 10. DB21/T 3314－2020 Technical Regulations for Direct Return of Biochar to Field 11. DB21/T 3318－2020 Technical regulations for synergistic application of fruit and vegetable biochar and microbial agents in facilities 12. DB21/T 3320－2020 Biochar Labeling Specifications 13. DB21/T 3321－2020 Biochar classification and detection technical specification 14. DB2306/T110-2019 Technical regulations for the application of biochar and carbon-based fertilizer in sandy loam cornfield 15. DB23/T 2485—2019 Technical Regulations for Reducing Nitrogen and Phosphorus Non-point Source Pollution by Biochar 16. DB37/T 3825-2019 Technical regulations for biochar application in orchards 17. DB21/T 251-2018 Technical Regulations for Preparation of Biochar by Pyrolysis of Straw 18. DB14/T 1670-2018 Technical regulations for the use of biochar in dryland wheat fields 19. DB21/T 2787-2017 Technical regulations for industrialized biochar matrix seedling cultivation of rice 20. DB21/T 2398-2015 biochar fertilizer

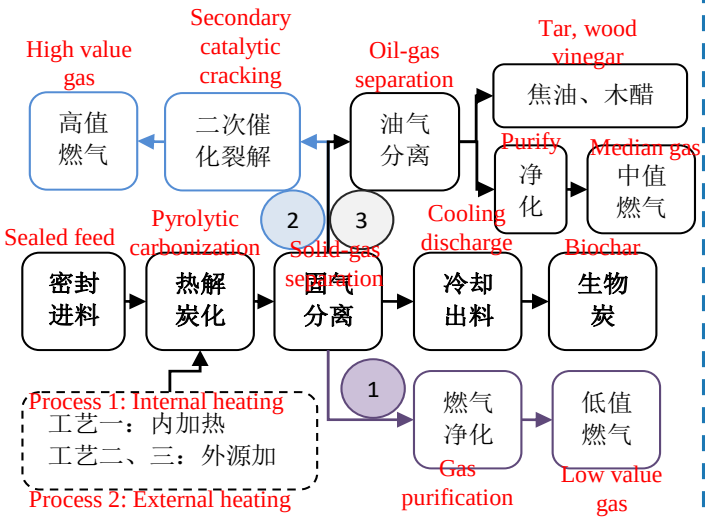
03

Biochar technology in China

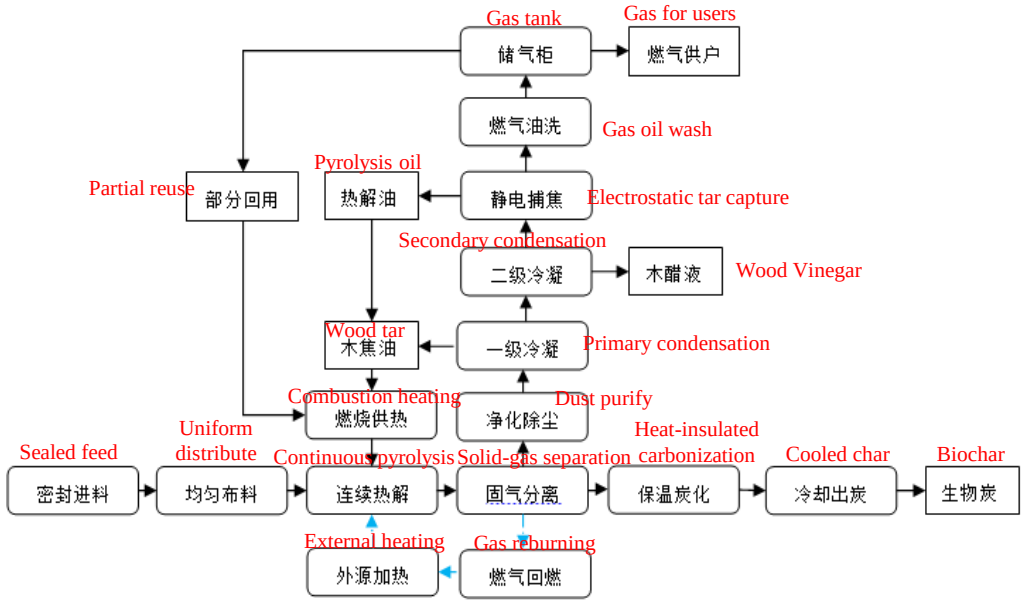
3.1 Main technology

At present, the pyrolysis technologies are mainly based on cogeneration of charcoal, gas and oil. Carbon-gas cogeneration equipment mostly adopts mobile continuous carbonization equipment

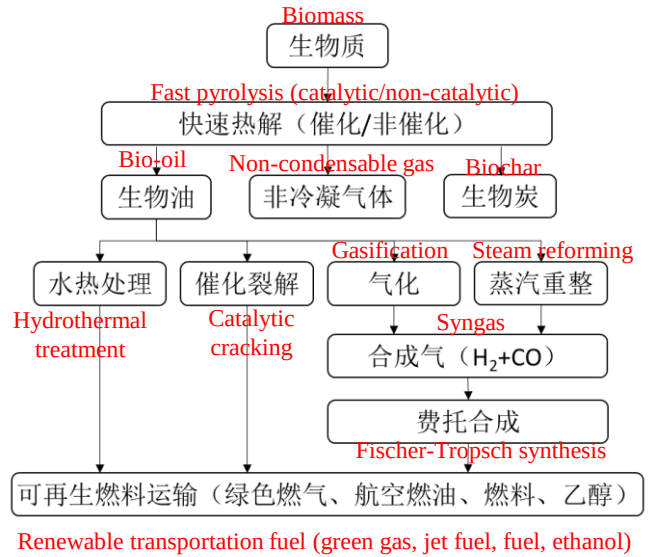
Three main technologies: Internal heating continuous pyrolysis carbon gas cogeneration technology; External heating continuous pyrolysis carbon gas cogeneration technology; External heating continuous pyrolysis carbon gas oil polygeneration technology.



Straw pyrolysis polygeneration process



External heating continuous pyrolysis biochar-gas cogeneration process



Biomass to renewable transportation fuel process

3.1 Main technology

- **Process 1**: Internal heating, the biochar production and pyrolysis gas quality are relatively low; but lower initial investment and less fuel consumption.
- **Process 2**: External heating, through the secondary cracking of tar, the transformation rate and quality of were improved.
- **Process 3**: External heating, products include biochar, gas and oil. High energy conversion efficiency and gas quality. Require more equipment for separation and collection, and the initial investment is high.

Indicators list of three main technologies

Technical indicators	Process 1	Process 2	Process 3
	Internal heating continuous biomass biochar-gas coproduction	**External heating continuous biomass pyrolysis biochar-gas coproduction**	**External heating continuous biomass pyrolysis biochar-gas-oil coproduction**
Principle of Hydrolysis	Pyrolysis Technology of Dry Distillation (Carbonization)	Pyrolysis (Carbonization) and Cracking Technology	Pyrolysis Technology of Dry Distillation (Carbonization)
Pyrolysis temperature（℃）	450~500	450~500	450~500
Secondary cracking	None	Have（secondary cracking of tar）	None（Tar is end-product）
Pyrolytic heat source	**Spontaneous combustion**	**External heating**	**External heating**
External air source	A small amount of air	None	None
End products	Gas, biochar	Gas, biochar	Gas, biochar, oil
Gas production/ton（m^3）	400	350	300
Lower heating value（MJ/Nm^3）	3~6	10~12	8~10
Gas energy conversion rate（%）	**17%**	**28%**	**19%**
Biochar energy conversion rate（%）	**45%**	**60%**	**60%**
Pyrolysis oil/ton（kg）	Small amount, no product	/	280~300
Total energy conversion rate（%）	**52%**	**73%**	**80%**

3.1 Main technology

- Benefit analysis of the actual application of the three processes:

The net profit per ton of straw consumed is 87, 135 and 141 yuan/t, respectively, with a sales profit margin of about 20%. Greenhouse gas carbon emissions trading can increase the net profit by about 8%.

表 2　不同应用模式的产品与温室气体减排量

Table 2　Product and greenhouse gas emission for different scale application models

内容 Content		工艺一 Process 1	工艺二 Process 2	工艺三 Process 3
秸秆用量/t		2 000	5 000	20 000
产量 Yield	年生物炭产量/t	560	1500	6 000
	年燃气产量/万 m^3	80	175	600
	燃气折合标煤量/t	137	658	1 845
	可供气规模/户	2 000	12 000	34 000
	年热解油产量/t	—	—	5 800
温室气体减排 Greenhouse gas emissions	燃气温室气体减排 CO_2 当量/t	501	2 411	6 764
	生物炭（还田）温室气体减排 CO_2 当量/t	470	1 680	6 720
	温室气体减排 CO_2 当量合计/t	971	4 091	13 484

注：生物炭、燃气、热解油单位产量详见表 1。

Note: Unit yield of biochar, gas, oil were showed in table 1.

表 3　不同应用模式的经济环境效益评价[5,25-28]

Table 3　Economic and environmental benefits evaluation for different scale application models

内容 Content		工艺一 Process 1	工艺二 Process 2	工艺三 Process 3
初投资 Investment at beggining/万元		160	1200	3 400
成本 Cost/(Yuan·t^{-1})	原料	200	250	250
	燃料动力	30	100	120
	人工成本	54	29	18
	管理维修等成本	25	30	35
	折旧成本	53	160	113
	总成本	362	569	536
收入 Revenue	生物炭单价/(元·t^{-1})	1 125	1 500	1 500
	燃气单价/(元·m^{-3})	0.3	0.7	0.5
	热解油单价/(元·t^{-1})	—	—	0.3
	销售收入/(元·t) $^{-1}$	449	704	678
经济效益 Economic benefits	年均纯利润/万元	17.3	68	283
	销售利润率/%	19.3	19.2	20.9
	投资利润率/%	10.8	5.6	8.3
环境效益 Environmental benefits	碳排放交易收益/万元	1.55	6.55	21.57
	吨秸秆碳排放交易收益(元·t)$^{-1}$	7.8	13.1	10.8

Huo Lili, Zhao Lixin, Yao Zonglu, Meng Haibo, Cong Hongbin. Utilization model and its efficiency analysis of biochar-gas-oil polygeneration by straw pyrolysis [J]. Transactions of the Chinese Society of Agricultural Engineering (Transactions of theCSAE), 2017, 33(3): 227 — 232.

☐Biochar - Soil improvement

- Biochar can effectively adsorb **heavy metal elements** in the soil and avoid heavy metal pollution. The biochar surface contains a large number of oxygen functional groups, which can promote the transformation of heavy metals.
- Biochar is **highly alkaline** and can significantly **increase soil pH**, thereby indirectly reducing the bioavailability of heavy metals.
- The application of biochar can better promote the accumulation of nutrients in the soil.
- Biochar can increase the **adsorption capacity of soil to organic matter**, thereby increasing the content of soil organic matter, thereby improving soil fertility.
- Biochar is porous and has large specific surface area, which effectively improves the **carbon adsorption and ion exchange.**
- With good **hydrophilicity**, it can reduce **soil hardness** and promote better growth of crops.

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Before
March, 2019

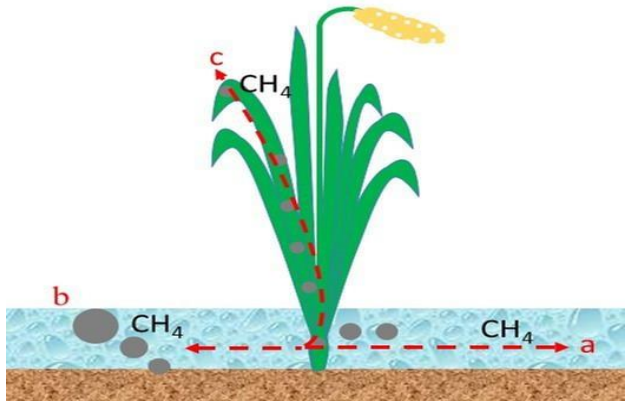
After
November, 2021

Shaoguan City, Guangdong Province

Treatment and restoration of 11 hm^2 waste tailings reservoir.

☐Biochar-based fertilizer - Return to field for carbon sequestration

- The biochar carbon is **stable in soil and form a carbon sink**, and it also has impacts on soil carbon and nitrogen transform.
- Biochar shows a **negative excitation effect**, which can reduce soil CO_2 and N_2O emissions.
- Although the research results are not same, the impact of biochar on soil N cycle is significant.
- In paddy, CH_4 is significantly reduced by biochar.



☐Biochar-based fertilizer - Returning to field for carbon sequestration

Applying biochar to soil can increase soil organic carbon content, improve water and fertilizer retention, and benefit soil microorganisms.

- Studies have shown that applying 50kg/mu of biochar-based fertilizer can increase soil organic carbon by 4~7.5g/kg
- Water holding capacity can be increased by 10%~15%. Soil cation exchange capacity (CEC) can be increased by 0.5~4.6 cmol/kg. In addition, it can promote the formation of aggregate structure and increase the beneficial microorganisms, the fertilizer using efficiency can be increased by more than 20%.
- In the case of wheat and corn rotation, the total crop yield can be increased by 4.5% to 5.0%.

3.2 Biochar product development

☐ Biochar catalyst

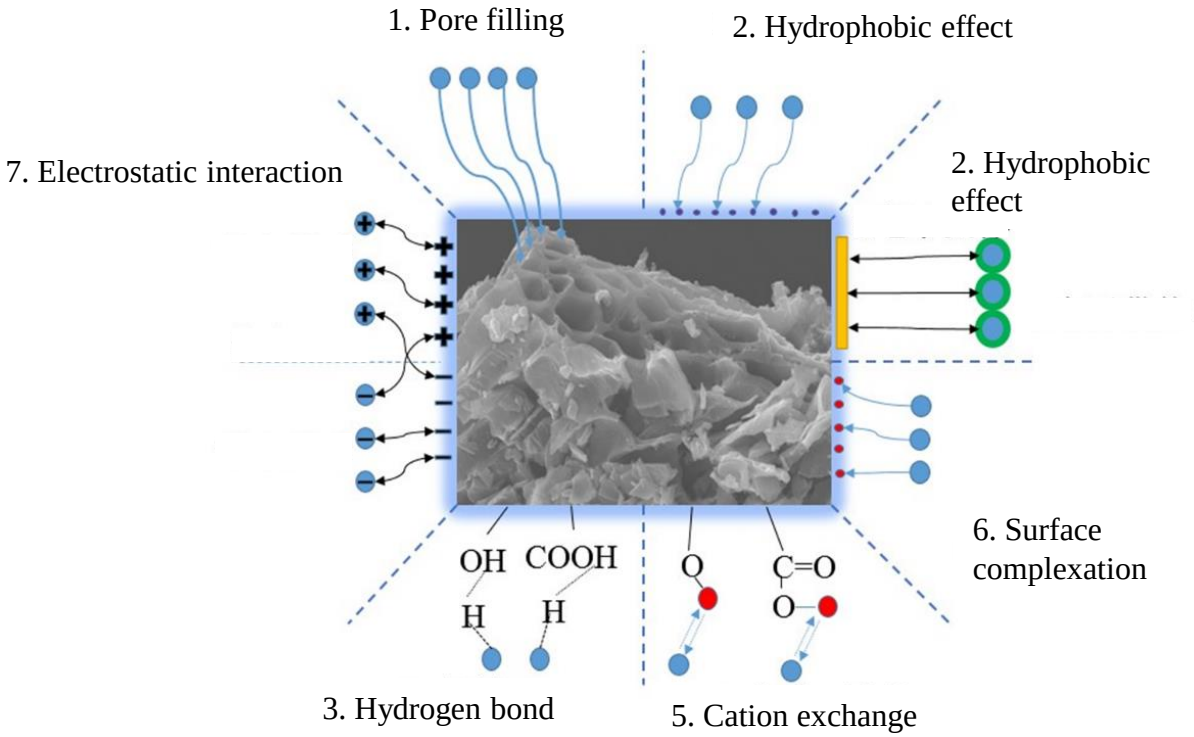
Biochar based material is a kind of green catalyst. By improving the structure of biochar, such as functional group modification, anion doping and supporting metal particles, increasing the reactive site can improve its catalytic activity, selectivity and stability.

Raw material	Carbonization condition	Activation method	Load	Catalysis	Experimental result
Xylan	180-250℃、6-24 h	Two-step acidification	$-SO_4H$	Cellulose hydrolysis Fructose dehydration	optimum condition：220℃、6h
Cellulose	180℃、24 h	One-step acidification	$-SO_4H$、Nb	Cellulose hydrolysis Fructose dehydration	optimum condition：170℃、8 h
Defatted rice bran	180-250℃、1-8 h	Two-step acidification	$-SO_4H$	Cellulose hydrolysis	optimum condition：220℃、3 h
Pine	200℃、1 h	One pot method, dipping method	$Fe(NO_3)_3$	phenol	The one-pot method is superior to the dipping method
Ambary	105℃、6 h、acid concentration42、52、62、72 wt%	One-step acidification	$-SO_4H$	Cellulose hydrolysis	optimum condition：acid concentration52wt%
Tructose	180℃、12 h、pH：2、4、6、8	One pot method	$Fe(NO_3)_3$	Orange II degradation	optimum condition：pH=2
Cladophora	460 ℃	Hydrothermal gasification residue	无	Hydrothermal gasification	The maximum hydrogen production: 9.63 mmol/g
Pine	200℃、20 min	600−800℃ calcine	$Fe(NO_3)_3$	Dechlorinated PCBS	Efficient adsorption and dechlorination of PCBS
Glucose	180℃、4 h	One-step acidification	$-SO_3H$或-COOH	Cellulose hydrolysis	The catalytic effect is better

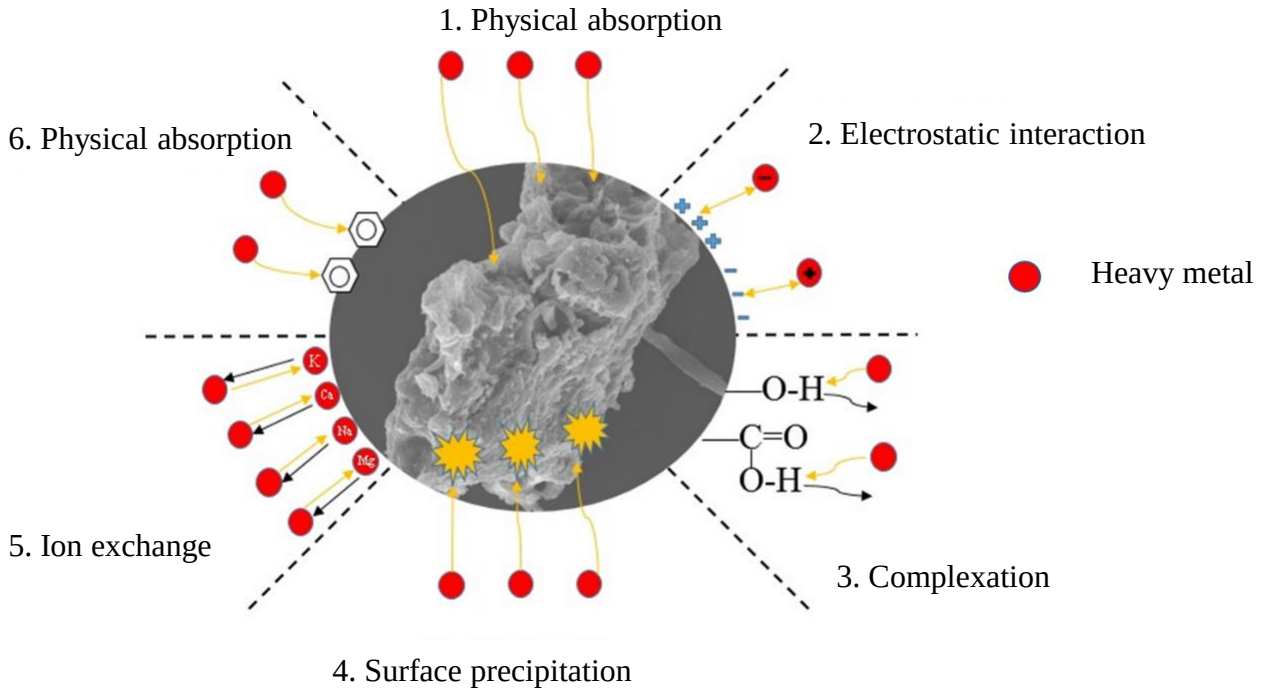
- Used for biomass thermal catalytic quality improvement, such as biomass platform compound conversion, biomass pyrolysis selective gas production
- Used for electrocatalytic REDOX reactions
- Used for catalytic degradation of environmental pollutants such as catalytic persulfate activation, catalytic urea peroxide, etc.

3.2 Biochar product development

☐ Biochar adsorbent-Water treatment



Biochar adsorbs antibiotics



Biochar adsorbs heavy metals

Biochar has not only good molecular adsorption performance, but also good molecular redispersion performance. Biochar can form a "complex" that adsorbs contaminants in water, such as heavy metals, organic matter, chemical oxygen demand, and suspended solids, onto its surface and further removes them, thereby achieving the goal of purification. As well as improve the quality of water.

3.2 Biochar product development

☐ Biochar-electrode material

Important factors: specific surface area and mesoporous volume

Law material	S_{BET} (m^2/g)	pore volume (cm^3/g)	Mesoporous volume（cm3/g）	Capacitance (f/g)	References
Red dates	1941	0.85	**0.26**	518	Zhang et al., 2019
Coal tar pitch	3058	1.58	**0.97**	325	Zhang et al., 2020
Cotton	1508	/	/	278	Jiang et al., 2019
Egg white	2918	/	/	335	Zhu et al., 2019
bits of wood	1185	0.56	/	303	Yang et al., 2019

- Biochar electrode materials have excellent properties such as light weight, developed pore structure, large specific surface area, good conductivity, high temperature resistance, corrosion resistance, etc., and have excellent application prospects in energy storage materials and devices.
- Physical or chemical activation of carbon materials is the most common way to prepare porous carbon materials.

3.3 Technological achievements related to biochar

◆ Main technology

➢ Technical Catalog

- In 2020, "Straw Charcoal Base Fertilizer Utilization Efficiency Enhancement Technology", the top ten leading technologies of the Ministry of Agriculture and Rural Affairs;
- In 2021, "Straw carbonization returning to the field to reduce emissions and carbon sequestration technology", a major leading technology of the Ministry of Agriculture and Rural Affairs;
- In 2021, "Straw Charcoal-Based Fertilizer Production Technology" will be included in the "Straw Comprehensive Utilization Technology Catalog (2021)" (Ministry of Agriculture and Rural Affairs, National Development and Reform Commission);
- In 2021, the "Ten Models of Agricultural and Rural Emission Reduction and Carbon Sequestration" mentioned the "Cogeneration Technology of Straw Pyrolysis, Carbon, Gas and Fertilizer".

……

Chinese official institutions have recommended and approved a series of technologies and catalogs. The public have a new understanding of biochar and biochar-based products. Also, the confidence of biomass carbonization researchers and industry practitioners were strengthened.

3.3 Technological achievements related to biochar

◆ Technology Awards

- 9 technological awards at the provincial and ministerial level in recent years are sorted out. Most are in the field of **biochar production and returning to field**.
- Covers biomass carbonization process, carbonization return technology model, development and application of carbon-based products, soil improvement and carbon sequestration.

Awards in the field of biomass carbonization in agriculture in recent years

	Title	Award time	Award type	Affiliation
1	Construction and application of biochar and straw carbonization technology system	2020-2021	The First Prize of Scientific Research Achievements of Shennong China Agricultural Science and Technology Award	Shenyang Agricultural University
2	Integration and promotion of crop straw scientific returning technology (involving carbonization returning to the field))	2019-2021	National Agriculture, Animal Husbandry and Fishery Harvest Award, First Prize of Agricultural Technology Promotion Achievement Award	Agricultural Ecology and Resource Protection General Station of the Ministry of Agriculture and Rural Affairs
3	Rice seedling substrate innovation and technology integration demonstration and promotion (involving carbon substrate)	2019	First Prize of Liaoning Science and Technology Progress Award	Shenyang Agricultural University
4	Multi-level structure regulation of biochar and its principle of soil carbon sequestration and remediation	2018	First Prize of Zhejiang Provincial Natural Science Award	Zhejiang University
5	Research and Demonstration of Key Technologies for Biochar Improvement of Soybean Soil Barriers in Northeast China	2018	Second Prize of Heilongjiang Science and Technology Progress Award	Institute of Soil Fertilizer and Environmental Resources, Heilongjiang Academy of Agricultural Sciences
6	Development and industrial application of biochar-based fertilizer products	2018	Third Prize of Shanghai Science and Technology Invention Award	Shike Biotechnology (Shanghai) Co., Ltd.
7	Research and Application of Comprehensive Utilization Technology of Biochar and Straw Carbonization	2017	First Prize of Liaoning Science and Technology Progress Award	Shenyang Agricultural University
8	Research and application of soil improvement technology for tobacco planting based on biochar	2017	The third prize of Yunnan Science and Technology Progress Award	Yuxi City Branch of Yunnan Tobacco Company
9	Research and application of key technologies for efficient carbonization and returning of crop straws	2016	Second Prize of Tianjin Science and Technology Progress Award	Environmental Protection Research and Monitoring Institute of the Ministry of Agriculture and Rural Affairs

3.4 Typical engineering example

Biomass Pyrolysis Cogeneration Demonstration Project in Ezhou

Construction site: Ezhou City, Hubei Province

Project scale: Processing **53,000 tons/year** of agricultural and forestry waste, producing pyrolysis gas **10.8244 million m^3/year**, which is used for the living of **6,000 farmers**, and the excess gas is used for power generation. A 3MW gas-fired generator set is built to generate **9.96 million kWh /Year**. The annual output of the project is **11,398 tons** of biochar, **1,922 tons** of pyrolysis oil, and **9,516 tons** of wood vinegar.

Technical process: I**nternal heating pyrolysis cogeneration process**, integrates biomass pyrolysis **gasification**, **carbonization**, and **liquefaction technologies**, and combines **pyrolysis gasification with power generation technology.**

3.4 Typical engineering example

Biochar-Gas Cogeneration Project in Hebei Xingtai

Construction site: Xingtai City, Hebei Province

Project scale: The annual processing capacity of agricultural and forestry waste (straw, tree pruning, etc.) is more than **3,500 t**, the annual production of biochar is **1,000 t**, and the gas is **900,000 m^3**. The agricultural and forestry waste treatment capacity of this project is **0.5 t/hour**, and the gas production is 100m3/hour, with a calorific value of **18 MJ**; **0.15 t** of biochar; and **0.08 t** of wood vinegar.

Technical process: External heating continuous pyrolysis biochar-gas cogeneration technology, integrated pyrolysis biochar-gas cogeneration, gas purification, multi-stage condensation and other technologies.

3.4 Typical engineering example

Straw Pyrolysis Polygeneration Project in Inner Mongolia

Construction site: Keyouqian Banner, Xing'an League, Inner Mongolia

Project scale: The project investment is about 70 million yuan, with an annual power generation capacity of **42 million kWh**, **4,000 tons** of biochar, straw oil, and **40,000 tons** of straw consumption.

Technical process: External heating continuous **pyrolysis biochar-gas-oil cogeneration process**, adopts multiple sets of unit design, flexible and adjustable capacity; container modular design is easy to install and production management; high scalability, can be copied in areas where raw materials are concentrated.

04

Development prospect

4.1 Problems and challenges

Industrial support policy system needs to be improved

The cost of construction, operation and maintenance of biochar projects is high, and the cost of storage, processing and fuel of biomass raw materials have a great impact on the development of the industry. The development and reasonable application of back-end products will be the key to the success of this technology

Diversified investment mechanism has not been established

There is a lack of financial support for the biochar industry, some deviation in the implementation of existing policies, inadequate implementation of the responsibility of the main body of capital investment, and vague cognition of the policy of fund integration; Fiscal leverage is not enough. Finance is the core and blood of modern economy. How to promote the resonance support of finance and finance is an urgent task to effectively promote the biochar industry. There are concerns about social capital participation, and the long-term incentive mechanism of finance is not lasting.

Bottleneck of industrialization technology needs to be broken through

Biochar composition is complex, and the quality improvement and high value utilization technology needs to be further developed. It is still necessary to explore the optimal process parameters suitable for high quality biochar, optimize the existing process route, and promote the high value utilization of biochar.

High-value products need further development

With crop straws as raw materials, there are still many constraints in the preparation of high-value products such as electric storage materials, carbon-based catalysts and adsorbents. The carbon materials prepared have low specific surface area, poor energy storage effect, and complex preparation process path leading to high cost, which is difficult to scale application. It is still a great challenge to optimize the process path and reduce the production cost.

4.2 Development proposal

- **Increase support and provide appropriate subsidies to enterprises using biochar technology**

To increase the subsidies for straw and other biochar, formulate and implement relevant preferential policies, such as tax reduction, price subsidies , discount loans and electricity online, encourage the collection of agricultural waste, and implement VAT exemption preferential policies for carb on-based fertilizer as organic fertilizer products. The transportation cost of agricultural biomass raw materials can be reduced by waiving bridge to lls and issuing logistics subsidies.

- **Establish and improve a diversified investment mechanism for the agricultural biochar industry**

Adhere to the principle of "government guidance and market operation", give full play to the role of financial planning in optimizing resource allo cation, encourage local governments to coordinate existing government investment funds, focus on supporting biochar related projects, and help u pgrade the biochar industry; Actively leverage financial capital to achieve joint financial support; We will improve the incentive mechanism for so cial capital and activate its internal driving force.

- **Promote the application of high-value utilization technology of biochar products**

Promote the upgrading of key technologies such as activated modification of biochar and in-situ carbonization of biochar to field, improve the util ization rate of agricultural waste, as well as the quality of pyrolytic carbon products, reduce reaction time and energy consumption, and promote t he upgrading of technology industry.

- **Improve the standard system of technology and equipment for biochar**

To strengthen the standardization, modularization and automation research of biochar equipment, strengthen the life cycle assessment and calculat ion of carbon sequestration and emission reduction of biochar industry, study and formulate relevant standards for carbon sequestration and emissi on reduction of biochar, including raw material pretreatment, pyrolysis carbonization process and biochar detection and other processes, and stand ardize the development of biochar related technologies.

Thanks for Your Attention !

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