

Develop Physical Processing for Clean Utilization of Coal

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Content

1

Objective and Significance of Clean Utilization of Coal

2

Clean Coal Technology

3

Methods and Applications of Physical Processing

4

Prospect the of Physical Processing Industry

5

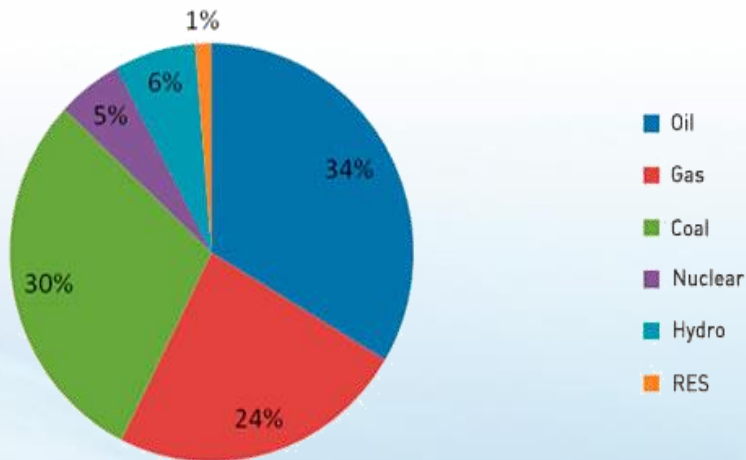
Diverse and Integrated Development of Physical Processing

Part I

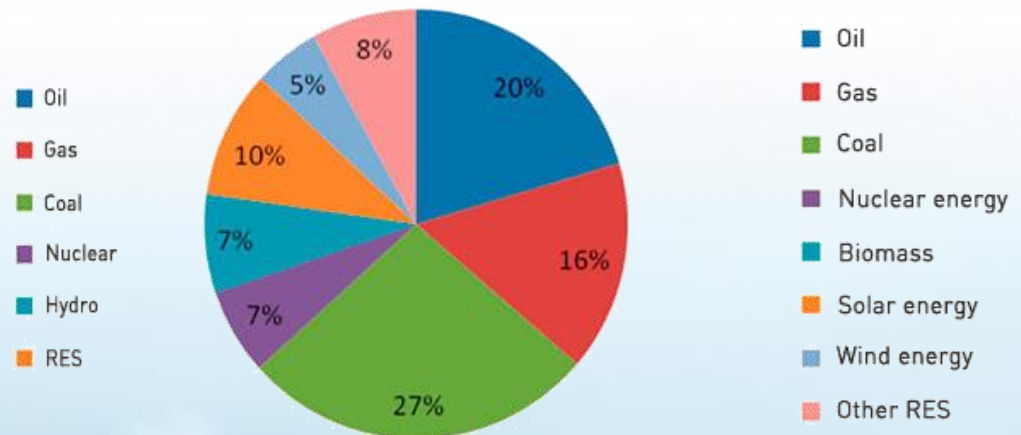
Objective and Significance of Clean Utilization of Coal

Consumption Ratio of Coal in the World's Energy structure

■ 2014年



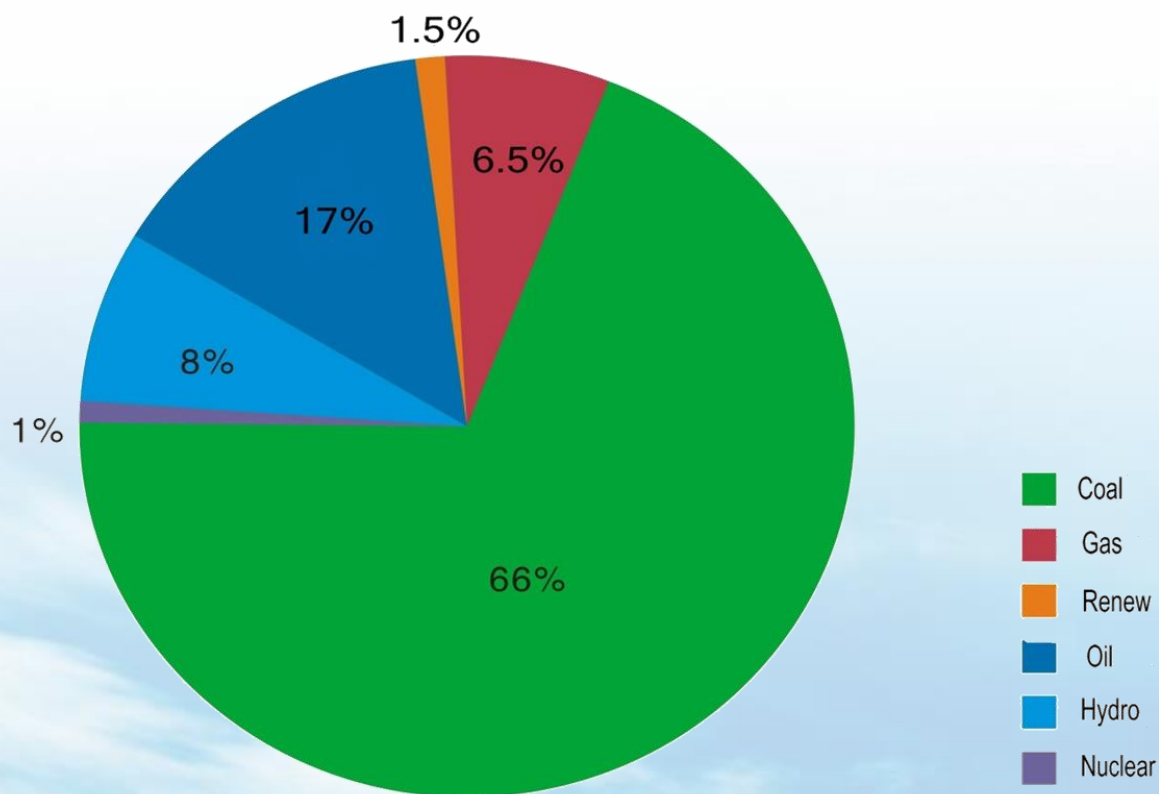
■ 2050年（forecast）



The consumption ratio of coal will decline from 30%(2011) to 27%(2050).However, coal is still the primary energy resource.

Current Energy Situation of China

Primary energy consumption ratio of China at 2014



Negative Effect of Coal Utilization

Since 1865, the coal industry had grown very fast. Especially from the second industrial revolution to the middle of the last century, the coal consumption of the developed countries made up a large proportion of the world's. Along with the huge depletion of coal, the economy of the developed countries had greatly promoted, however, they have paid lots of cost on the environment. As coal is the primary energy of china right now and still will be main energy resource in the future, we have met the same problem between economic development and environment protection. Since 1950s, the developed countries have explored many clean coal technologies, aim at protecting the environment along with economic development. China have also made many efforts in this area.



煤炭清洁利用是煤炭消费发展的方向

Clean Utilization of Coal is the direction of coal consumption

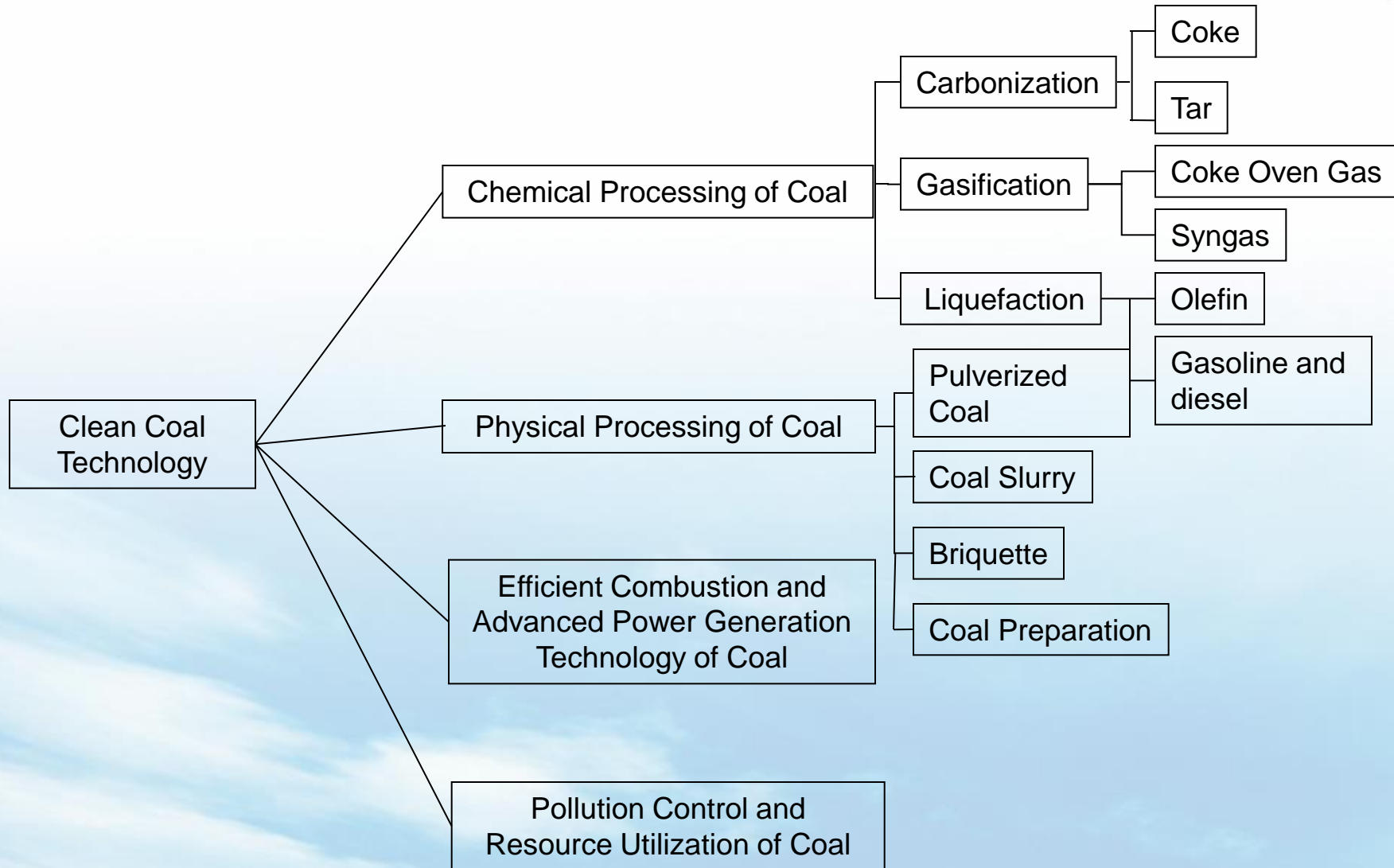


The key of the development of coal utilization lies on the change of consuming concept, consuming pattern and the reduction of environmental pollution caused by extensive utilization of coal. So clean and effective utilization of coal will be the direction of coal utilization.

Part II

Clean Coal Technology

Clean Coal Technology





Part III

Methods and Applications of Physical Processing

3.1.1 Current Situation of the Pulverized Coal Technology



China

Small to medium pulverized coal boiler have been explored for almost 10 years. Now, this technology is under popularization and the corresponding technology standards are constantly improved.



USA

Focus on the research of pulverized coal combustion technology. This technology can meet the zero mission standard of the power generation by the way of burning coal in a O₂/CO₂ atmosphere, which can recycle CO₂ in the flue gas.



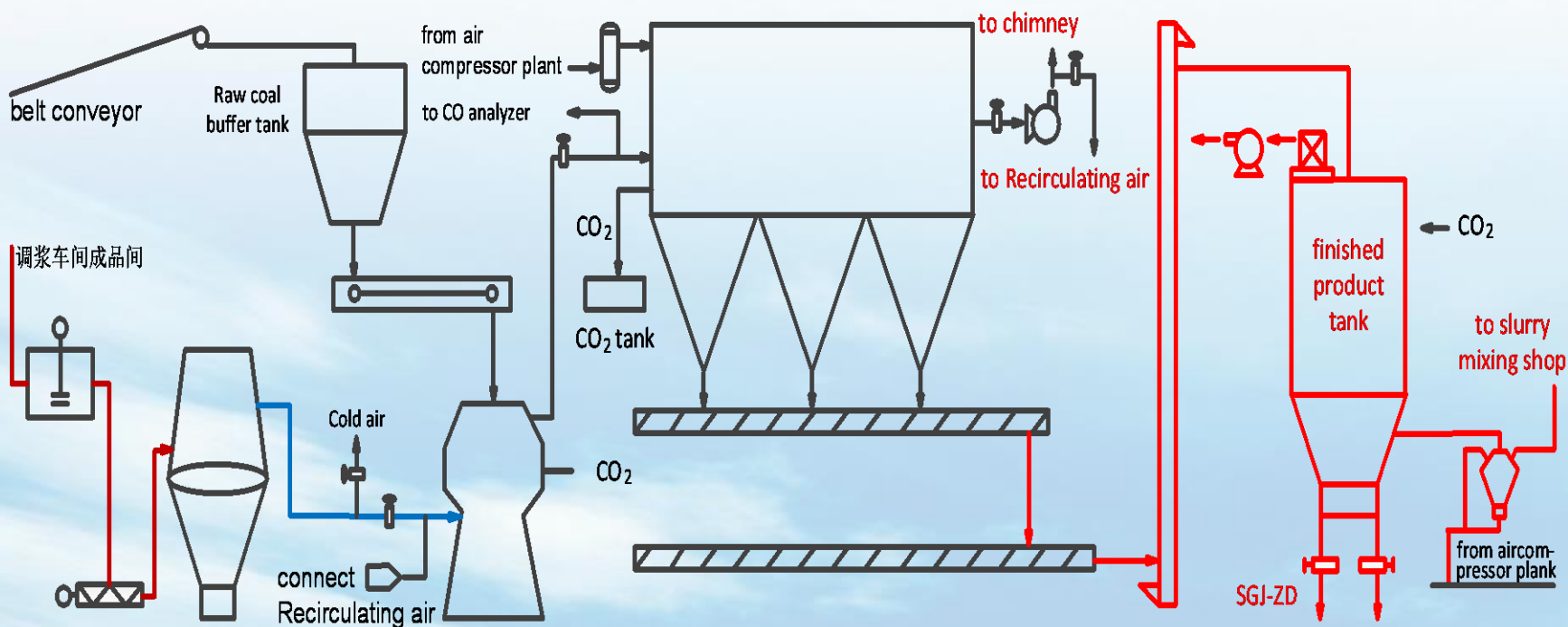
Germany

Have the mature technology of small pulverized coal boiler, and made the standard of coal, combustor, furnace body and so on. Own hundreds of patents for invention.

3.1.2 Pulverized Coal Preparation Technology of SHCCIG

Pulverized coal is a micron-sized coal product with different diameter and made by milling raw coal or washed clean coal according to different applications. And according to different applications, some products need additives.

Flow diagram of the fine coal workshop of coal slurry plant





3.1.3 Pulverized coal product and its application of SHCCIG

1. Pulverized coal for small and medium industrial boiler

(1) Product properties

- a. Sufficiently demineralized
- b. Diameter less than 74 μm
- c. Contain some desulphurization mineral(added in the milling process)

(2) Advantages

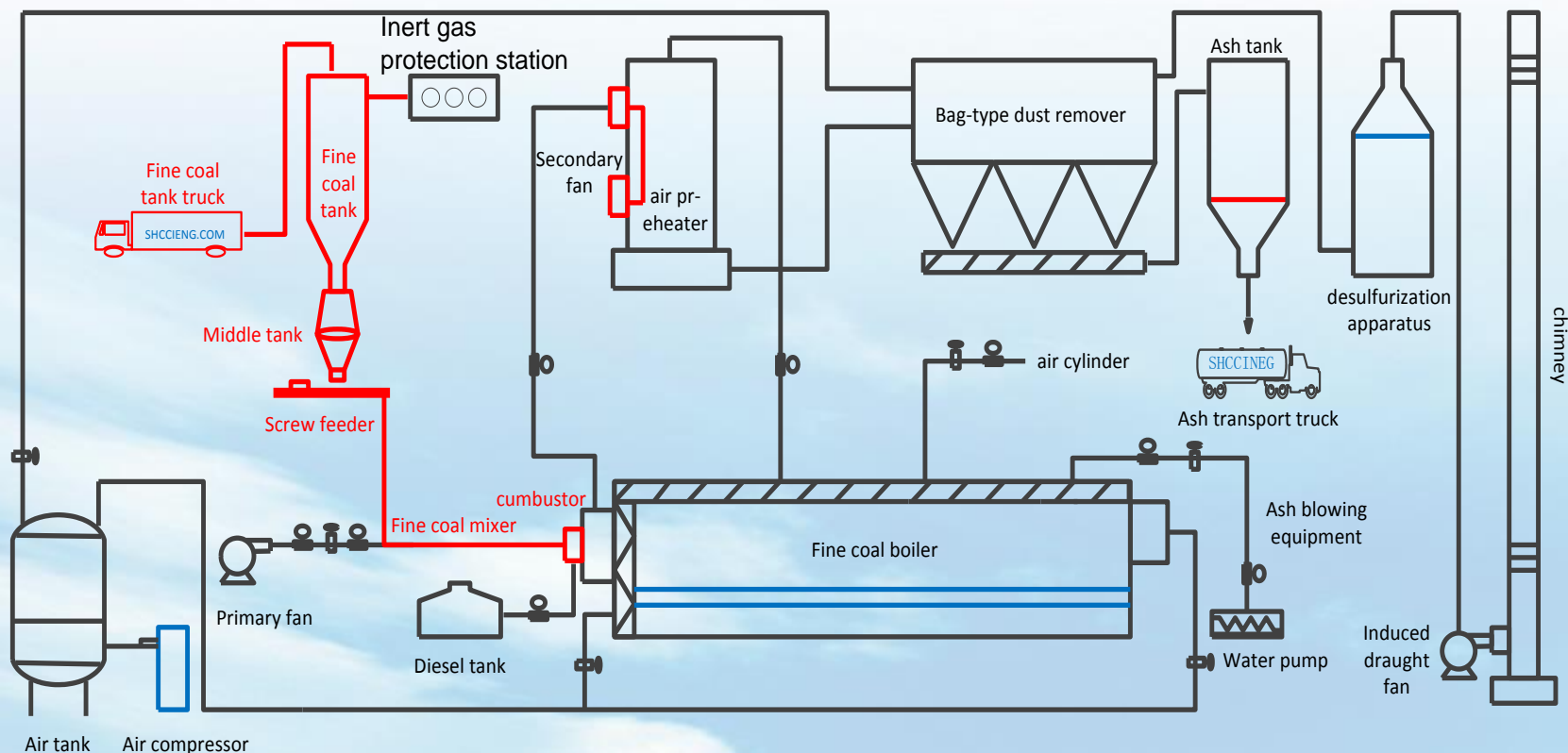
- a. Coal consumption of the boiler reduced by 30% compared with the raw coal product
- b. Initial emission of SO_2 reduced by adding desulphurization mineral and NO_x reduced by suspension combustion of fine coal and temperature control
- c. The difficulty of flue-gas disposing and the cost of operation was lowered

3.1.3 Pulverized coal product and its application of SHCCIG

(2) Application

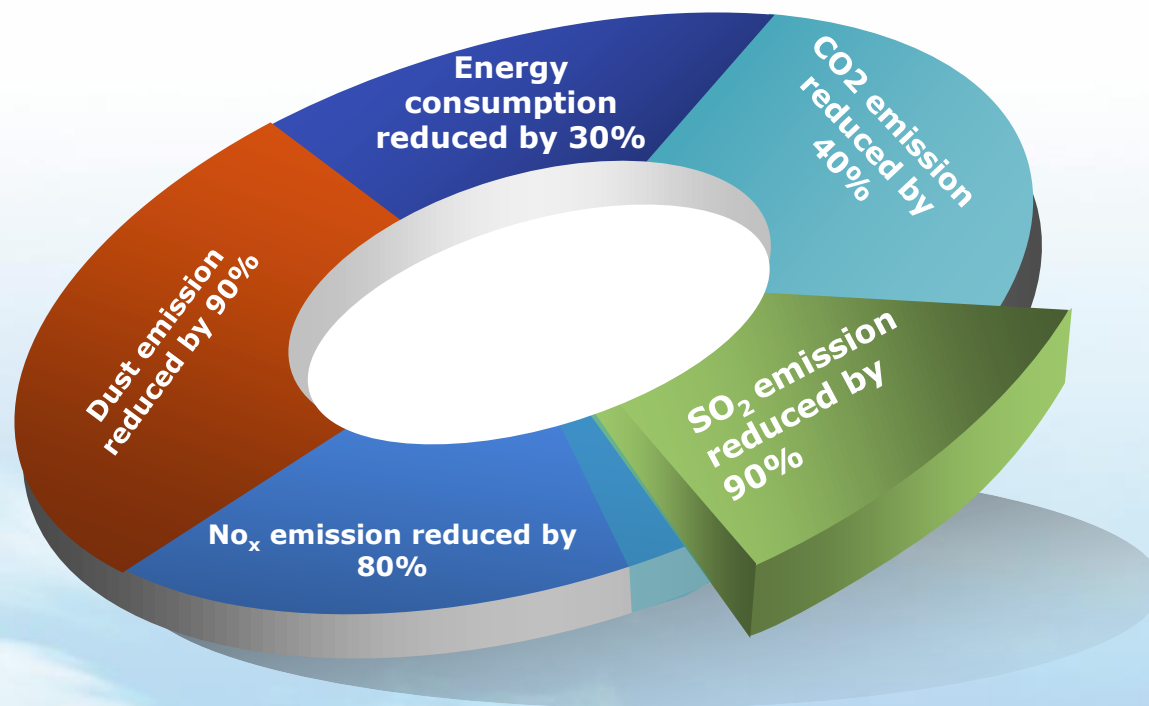
Pulverized coal is mainly used in the small industrial boiler. And the application is to produce steam by pulverized boiler for spinning, clothing, pharmacy, heat supply and urban heat supply.

Schematic diagram of fine coal boiler system



3.1.3 Pulverized coal product and its application of SHCCIG

(3) Advantages of the application of pulverized coal



Pulverized coal combustion technology is more efficient in energy conservation and environment protection.

3.1.3 Pulverized coal product and its application of SHCCIG

2. Pulverized coal for the injection of blast furnace

(1) Product properties

According to the request of the quality of coal of the steel company, bituminous coal and anthracite(or semi coke) was mixed to made dedicated pulverized coal for the injection of blast furnace. And the pulverized coal can partially or totally replace anthracite.

Properties of pulverized coal mixed by bituminous coal and anthracite

Total moisture	Inherent moisture	Ash	Volatile	LHV	St	>200 mesh
4.91%	2.13%	16.18%	16.84%	6281kcal/kg	0.32%	86%

Properties of pulverized coal mixed by bituminous coal and pulverized semi coke

Total moisture	Inherent moisture	Ash	Volatile	LHV	St	>200 mesh
4.23%	3.68%	7.96%	24.15%	6989.7 kcal/kg	0.35%	87%

3.1.3 Pulverized coal product and its application of SHCCIG

Application advantages in combustion

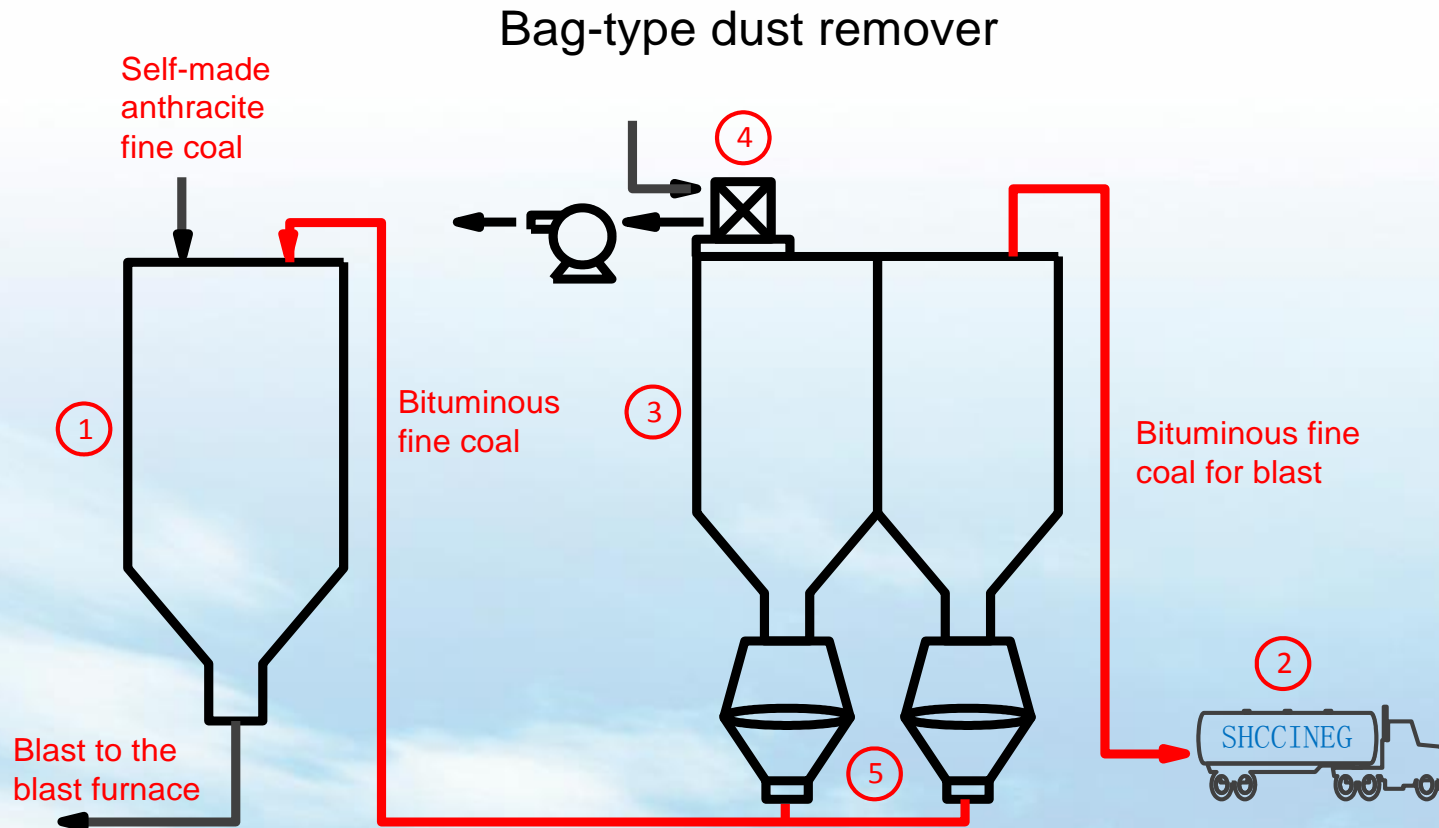
- ◆ Thermal efficiency of the pulverized coal boiler is higher than 90% and burn-out rate of the fine coal is 98%;
- ◆ Emission of NO_x is low, and the amount of NO_x is reduced by 30% compared with other combustion method due to the lower combustion temperature;
- ◆ Storage and transportation is clean.

Measured emission data of pulverized coal boiler compared with the "Emission standard of air pollutants for boiler" of China.

Pollutant	Standard			Measured emission data
	Raw coal boiler	Oil boiler	Gas boiler	
Dust	50	30	20	10~30
SO ₂	300	200	50	30~100
NO _x	300	250	200	≤150
Smoke blackness	≤1			< 1

3.1.3 Pulverized coal product and its application of SHCCIG

(2) Application: Mainly used for blast furnace





3.1.3 Pulverized coal product and its application of SHCCIG

(3) Advantages of application

- ① Replace part of the coke
- ② Easy to burn and accept by the blast
- ③ Strong deoxidizing ability of the gas produced by the use of pulverized coal and in favor of the reaction of indirect reduction and the use of high temperature and oxygen-enriched air
- ④ Saving energy and lowering the cost of steel
- ⑤ An effective method for semi coke utilization



3.1.3 Pulverized coal product and its application of SHCCIG

3. Pulverized coal for industrial furnace

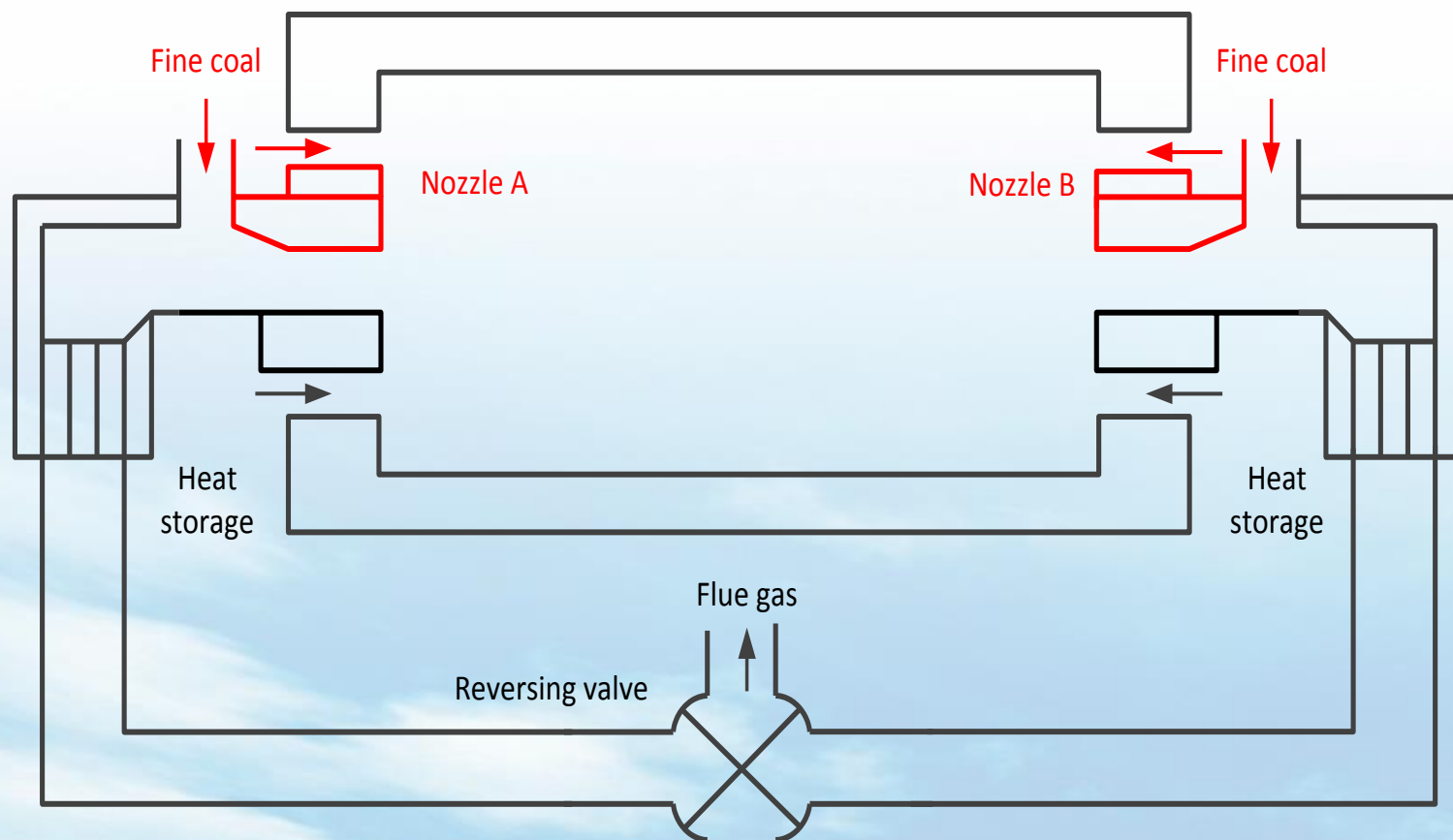
(1) **Application:** Replace the traditional industrial furnace(Nickel iron furnace and pitch heating) which adopt syngas by fine coal。

(2) **Application advantages:**

- ① Saving energy by 35%
- ② Increased the combustion temperature and improved the combustion efficiency.
- ③ Adjusting the blast amount and temperature at any time
- ④ Less emission compared with the use of syngas
- ⑤ Lowered the cost of combustion

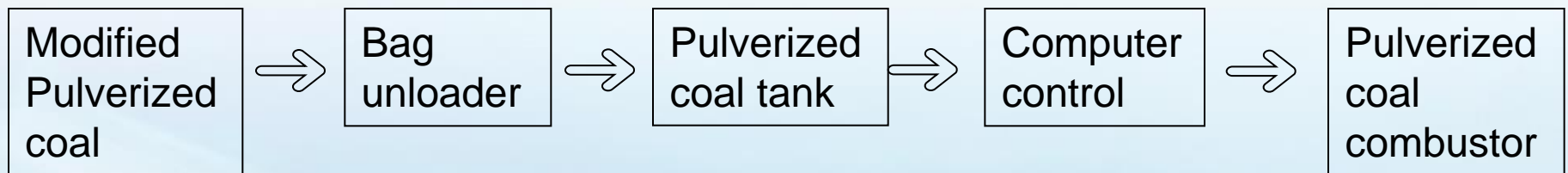
3.1.3 Pulverized coal product and its application of SHCCIG

Diagram of energy-saving principle of HTAC



3.1.3 Pulverized coal product and its application of SHCCIG

Diagram of pitch stirring and heating



3.1.3 Pulverized coal product and its application of SHCCIG

4. Pulverized Coal Compound Biomass Fuels

This kind of fuel is made by mixing pulverized coal with sawdust.

(1) Properties:

- ① Combustion rate is increased with the increasing of sawdust amount.
- ② Time to reach the peak temperature of the fuel was shortened.

(2) Application: Biomass fuel boiler。

(3) Comparison of the index: (shown bellow)

3.1.3 Pulverized coal product and its application of SHCCIG

Comparison of biomass fuel with compound coal

Item	Biomass Particles	Compound Coal
LHV (kcal/kg)	3800	4600
Volatile	80%	58%
Fixed Carbon	17%	33%
Moisture	9%	10%
Sulfur	0.05%	0.12%
Ash fusion point	1.80%	5.80%
Supply stability	Unstable	Stable

Comparison of emission standards between biomass fuel with compound coal

Item	Biomass Particles	Compound Coal
Dust (mg/m ³)	55	30
SO ₂ (mg/m ³)	0	0
NO _x (mg/m ³)	200	300



3.2.1 Current situation of coal slurry technology

1. Current situation of international coal slurry technology

Coal slurry technology was developed due to the crisis of oil at 1970s. It derived from Soviet Union, and then America, France, Italy, Germany and Sweden start to develop this technology. Now it has been a mature technology, and widely spread and applied.

2. Current situation of the coal slurry technology in China

In China, the research of coal slurry technology started from 1980s. This technology has been mature after studying and exploring for decades. Now, it is on the industrial application stage with a consumption of slurry of 3000 million/a for combustion and 8000 million/a for gasification.



3.2.2 Preparation method of coal slurry

Preparation method of coal slurry

1. Wet preparation technology

Coal, water and additives was directly milled according to certain ratio to make slurry.

2. Dry milling and wet mixing technology

Coal was firstly milled into powders, then mixed with water and additives to make slurry.



3.2.2 Preparation method of coal slurry

Comparison of the two technologies:

Wet preparation technology has been very mature, however, the concentration of the raw material was allowed to be stable and to reach certain value. Moreover, it is hard to control the big particle and impurities in the raw material. The cost of mid to long distance transport is also high. Dry preparation technology can overcome these shortcomings.

The application of dry preparation technology is rare in China. And the main problem lies on the week stability and difficulty in PSD processing.

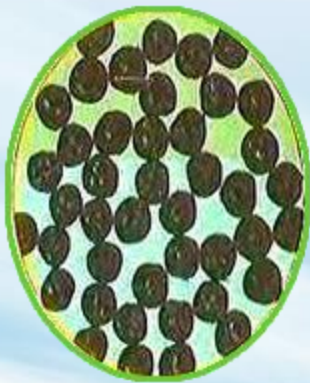
Currently, SHCCIG has overcame these difficulties and got a better solution.

3.2.3 CWS Preparation Technique by Dry Process(SHCCIG)

The way to improve slurry ability of CWS: PSD process

- Using doublet PSD technique and Alfred model, the coarse and fine pulverized coal are mixed in proportion properly.
- The packing efficiency is improved and the concentration of CWS is increased from 60% to 67%.

Pictures of pulverized coal and CWS stack(67%, 1000mPa.s)



No. 1 ↑



No.2 ↑



No.3 ↑



No.4 ↑



No.5 ↑

3.2.3 CWS Preparation Technique by Dry Process(SHCCIG)

Table 1 Fractal characteristics of the different particle size

中位径/ μm	线性相关 系数 R	线性回归 斜率 b	分形维 数 D
6	0.97	0.84	2.16
29	0.98	0.77	2.23
90	0.99	0.75	2.25

The fractal dimension of coal particle without PSD is below 2.3.

Table 2 Fractal characteristics of the PSD coal particle

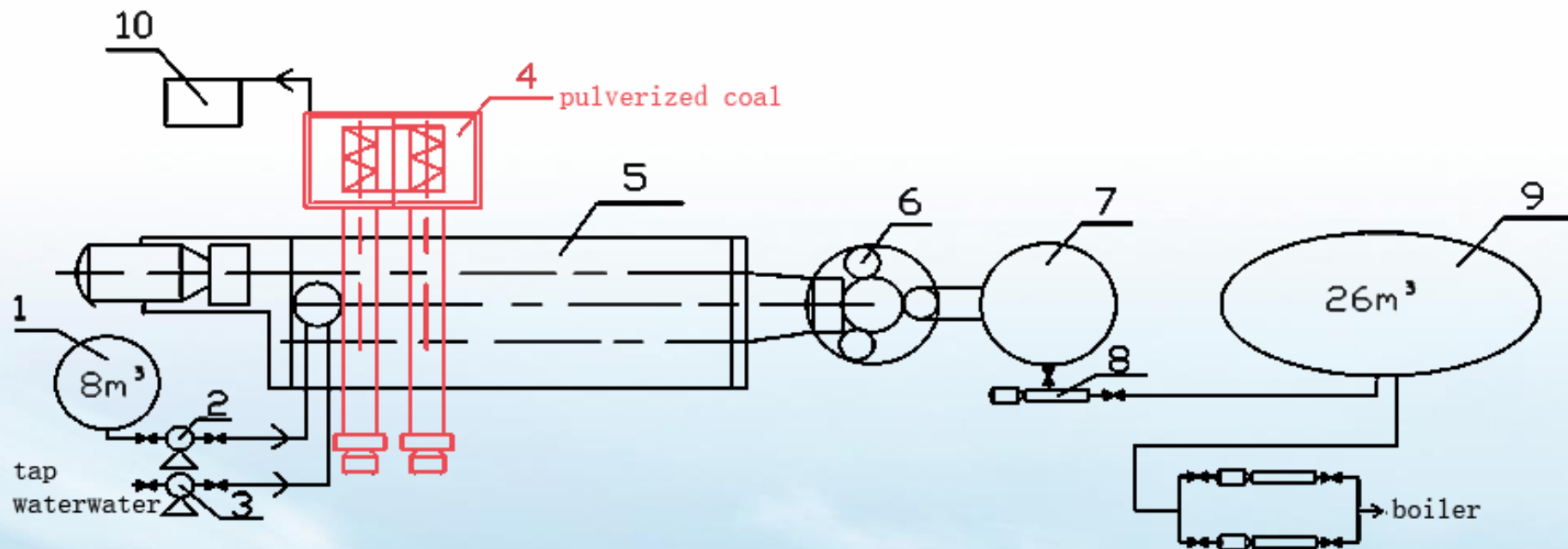
级配煤粉	线性相关 系数 R	线性回归 斜率 b	分形维 数 D
Alfred 模型	0.99	0.39	2.61
R-R 模型	0.98	0.48	2.52
级配样品 1	0.96	0.49	2.51
级配样品 2	0.93	0.46	2.54

The bigger fractal dimension, the higher packing density, and the better slurry property.

The fractal dimensions of the Alfred model, Rosin-Rammler model and the two samples are all above 2.5, superior to coal particle without PSD.

3.2.3 CWS Preparation Technique by Dry Process(SHCCIG)

CWS preparation system for user terminal



- | | |
|--------------------------|--------------------------|
| 1 additive stirring tank | 2 additive pump |
| 3 tap water pump | 4 double-screw feed |
| 5 pulping machine | 6 slurring machine |
| 7 dense slurry blender | 8 screw pump |
| 9 storage tank | 10 bag-type dust remover |

3.2.4 Application of CWS Preparation Technique by Dry Process(SHCCIG)



Strict requirements of environmental protection



Prohibition of building the pulverized coal plant



Abundant in water and industrial waste water



High transportation cost of CWS



Remote pulverized coal plant

transportation of pulverized coal

Local CWS preparation plant

for direct use

Make use of industrial waste water and obtain the CWS

3.2.4 Application of CWS Preparation Technique by Dry Process(SHCCIG)

Application situation 1

Pulping with other industrial waste liquid or tap water.

By pulping CWS with pulverized coal, pharmaceutical wastes and beverage wastes, etc., the problem of liquid waste disposal for pharmaceutical and beverage industry can be solved.

Effects: Increasing CWS concentration from 60.7% to 64.9%.
Increasing the yield of syngas (CO+H₂) produced by CWS gasification from 79% to 82%.





3.2.4 Application of CWS Preparation Technique by Dry Process(SHCCIG)

Application 2

Concentration of CWS for chemical industry

(1)The features of product:

- The product is composed of pulverized coal with different diameters
- it could be added during the wet pulping process, in order to increase the concentration of CWS

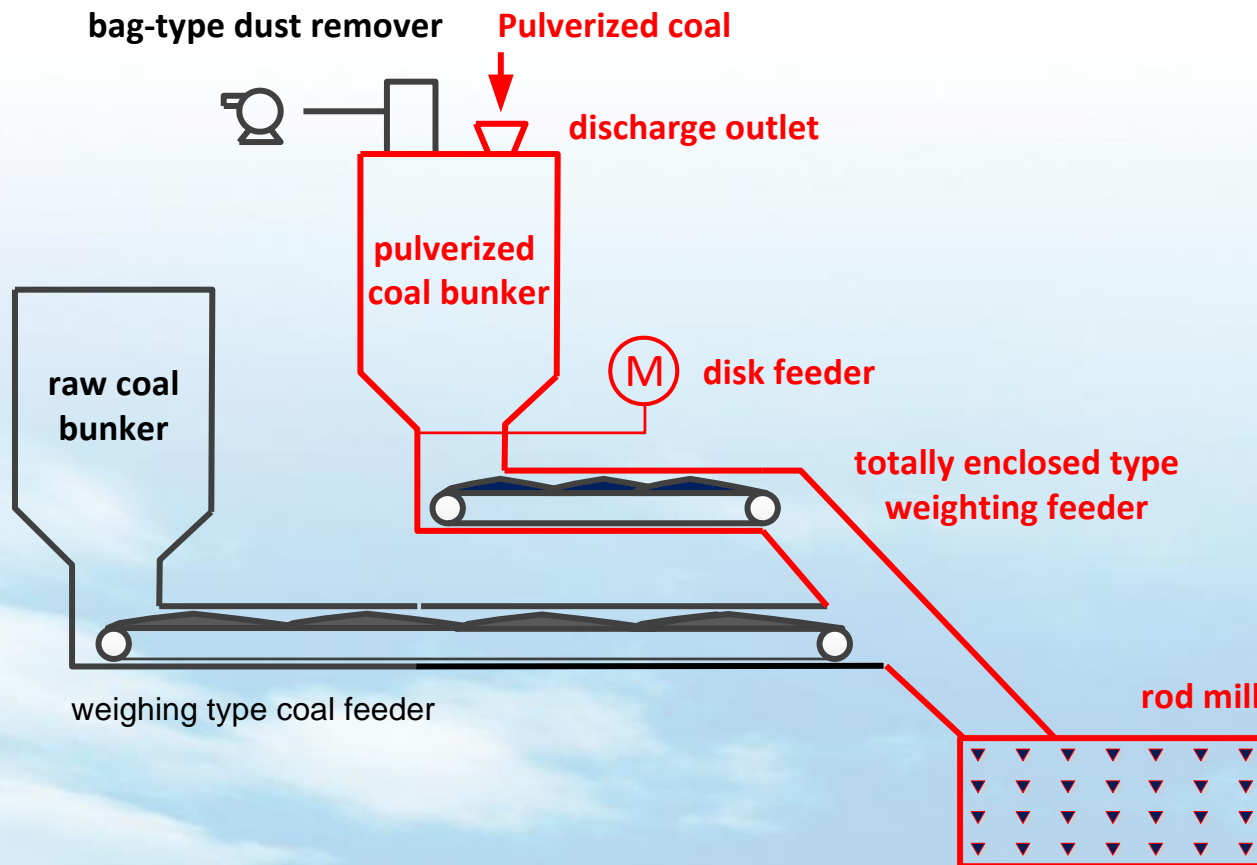
(2)Application: Coal chemical industry

(3)Effects: Increasing CWS concentration from 60.7% to 64.9%.

Increasing the yield of syngas ($\text{CO} + \text{H}_2$) produced by CWS gasification from 79% to 82%.

3.2.4 Application of CWS Preparation Technique by Dry Process(SHCCIG)

Schematic of pulverized coal addition and chemical concentration technique



3.3.1 Pulverized coal and CWS preparation technology achievements(SHCCIG)

(1) Pulverized coal preparation by dry process and CWS preparation by wet process technique:

awarded as International Advanced Technology by Shaanxi Science and Technology Department

(2) An inhibitor that can prevent pulverized coal self-ignition during storage and transportation:

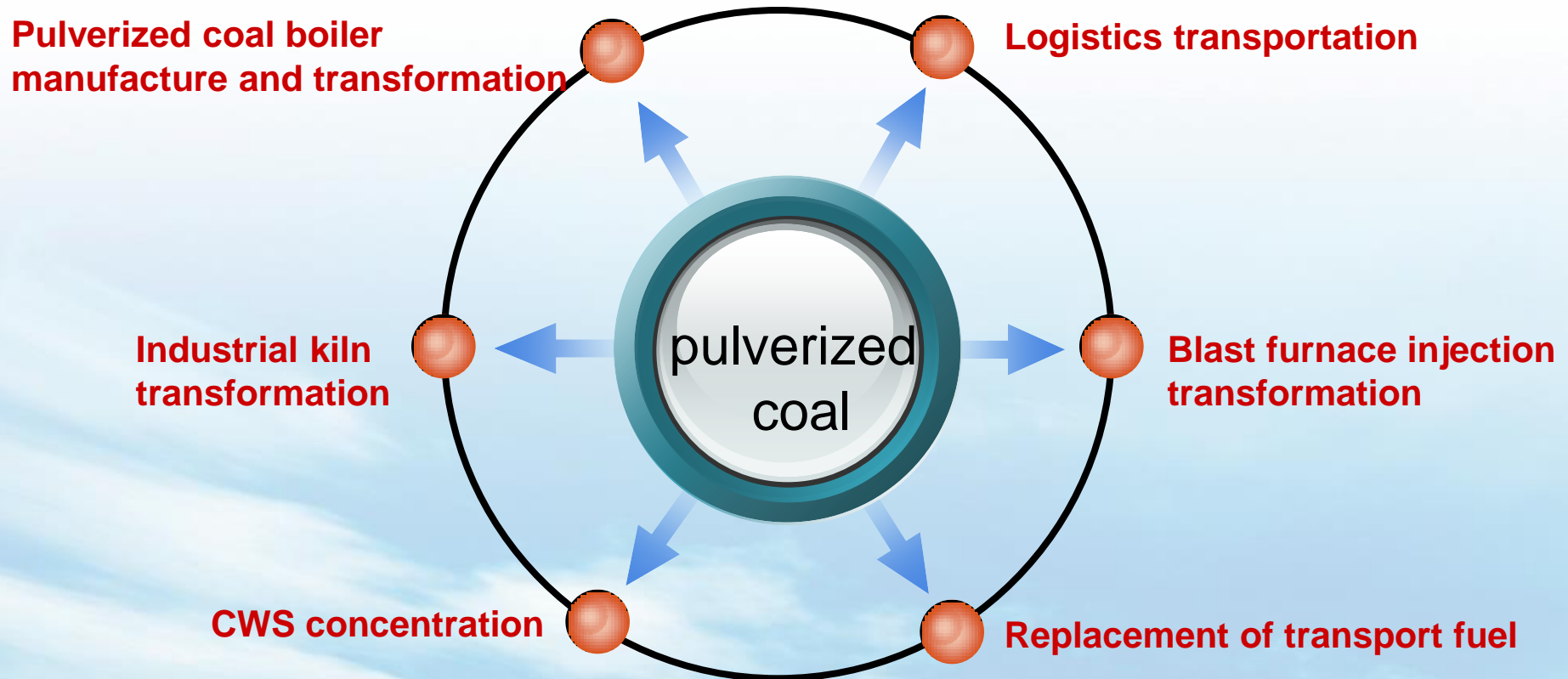
awarded as International Advanced Technology by Shaanxi Science and Technology Department

(3) Six patents granted by State Intellectual Property Office of P. R. China, and other two under review.



3.3.2 Preparation of pulverized coal

Preparation of pulverized coal has driven the rapid development of related industries.



3.4 Briquette preparation technique(SHCCIG)

Briquette preparation technique has been developed maturely at home and abroad. According to the development situation and enterprise facts in China, our company is mainly committing to developing the technology of producing formcoke by using semi-coke.

(1)Formcoke product characteristic

- Materials: 60% semi-coke, 20% coking coal, 10% anthracite and 10% asphalt,
- Technical process: crushing, stirring, kneading, press forming, and high temperature carbonization treatment.
- Size: above 110mm.



3.4 Briquette preparation technique(SHCCIG)

(2)Application

- Widely used in smelting, chemical, boiler combustion, etc.
- Completely substitute the coke.

(3)Effect

- Reduce the energy waste, increase the coke yield and get larger economic benefits.
- Compared to coke, the formcoke has a series of advantages such as lower cost, easier to be processed and transported.
- Reduce the environment pollution effectively.
- CO emission reduced by 70%-80%,
- Smoke dust reduced by 60%
- Smoke lower than $\frac{1}{2}$ Ringelmann black degree
- Total sulfur capturing ratio is 54%-74%

Part IV

Prospect of Physical Processing Industry



4.1 High applicability

Physical processing technology:

- Pulverized coal preparation
- CWS preparation
- Briquette preparation
- Coal washing

Characteristics of Physical processing:

- Small investment and simple preparation technology
- Coal molecular structure not changed
- Most ash, moisture and sulfur content in coal removed
- Facilitates the direct use and indirect conversion utilization of coal
- High applicability

4.2 A broad customer base

Cleaned coal users:

chemical, electricity, steel, etc.

Pulverized coal users:

centralized heating, steel, traffic, etc.

CWS users:

chemical, papermaking, glass, ceramics, etc.

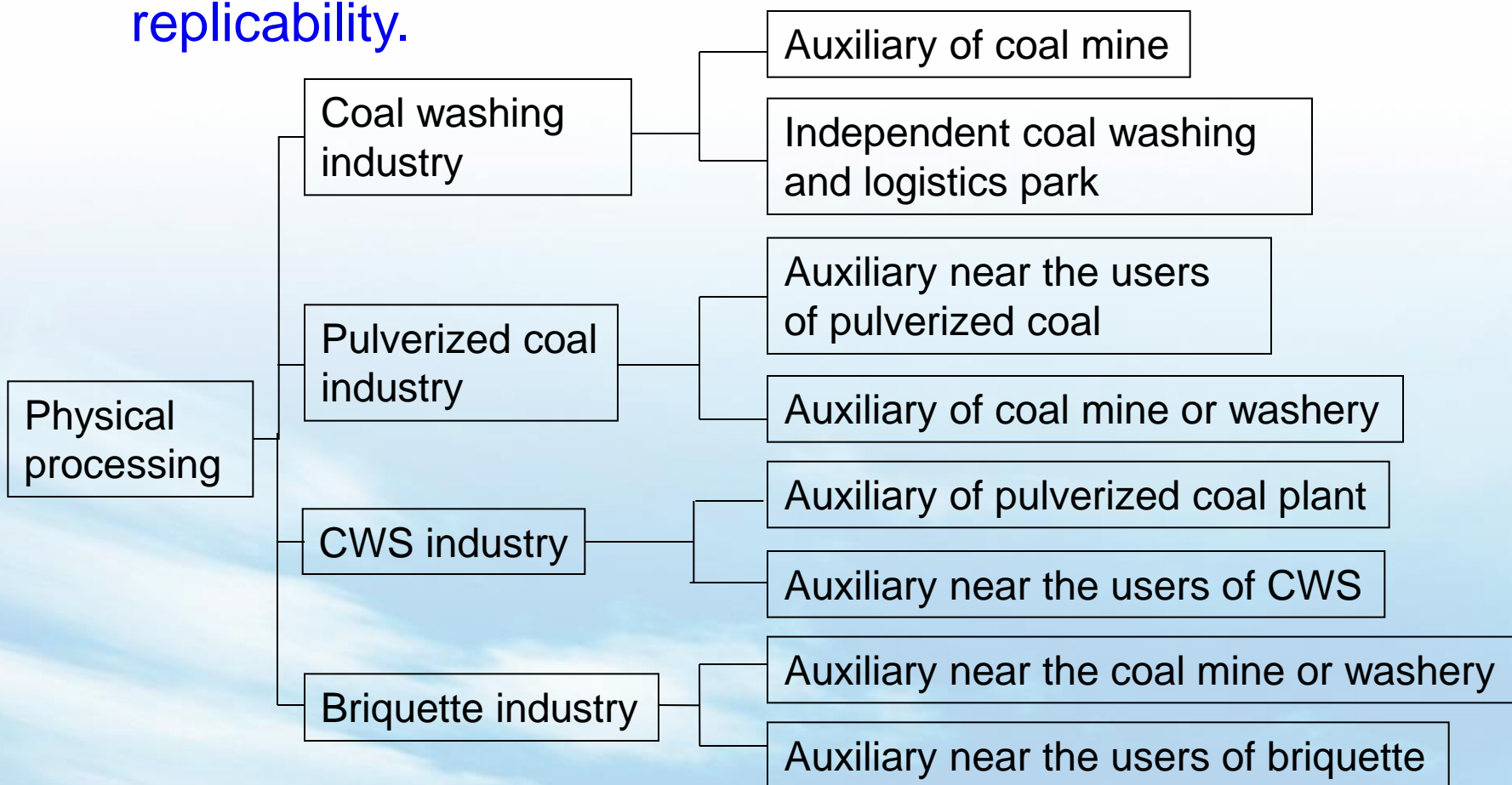
Briquette users:

chemical, municipal engineering, etc.

- Wide customer base
- Large market demand
- Bright prospect

4.3 General replicability

The industrial chain of physical processing has good replicability.





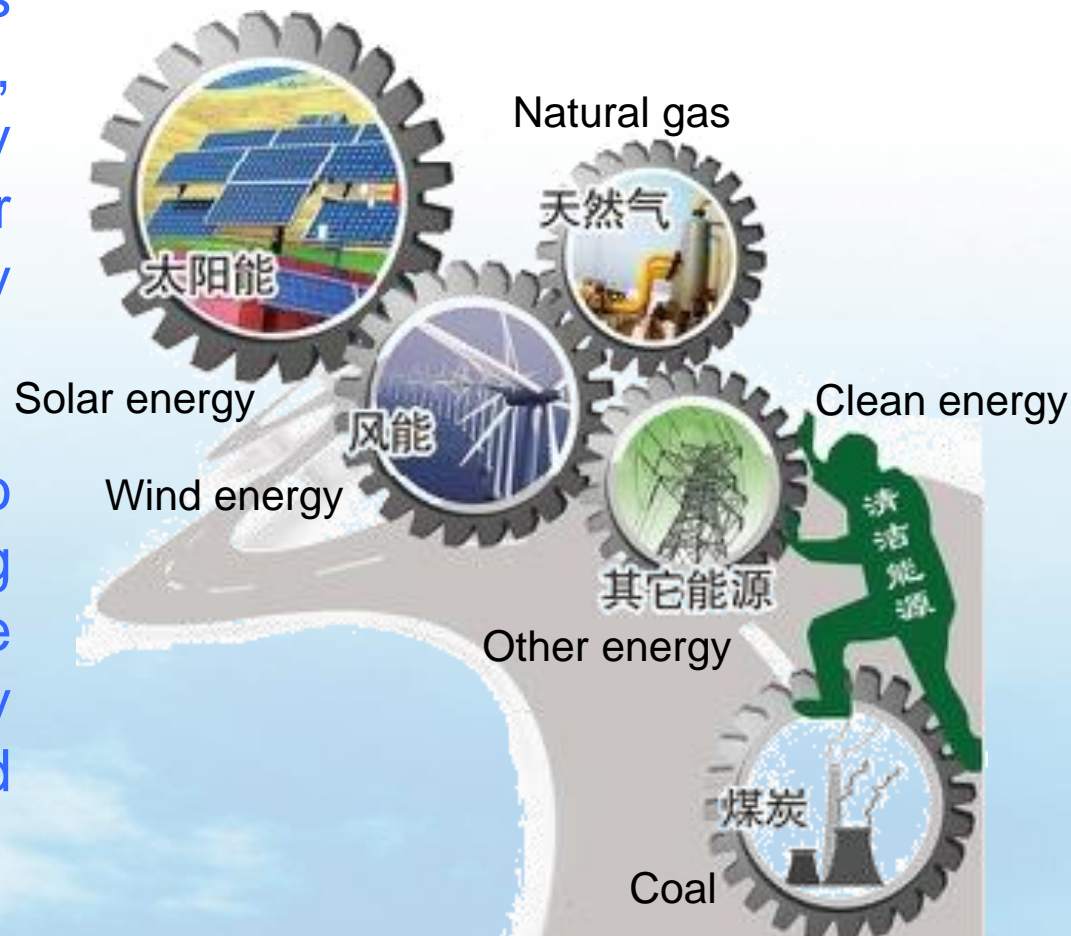
Part V

Diverse and Integral Development of Physical Processing

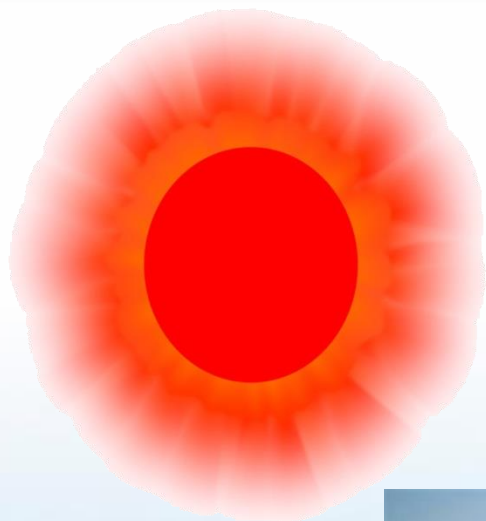


The integral development of physical processing and new energy is a win-win way

- Physical processing needs not only self development, but also the complementary development with solar energy, geothermal energy and biomass energy.
- The ultimate purpose is to combine coal processing with new energy and realize the win-win way of energy consumption and environmental protection.



5.1 Coupling development with solar energy



1. Solar PV heating can increase the inlet temperature of water in pulverized coal boiler, thus saving coal and energy. A 10°C temperature increase per cubic meter water can save 1.5kg coal.



solar power generation

2. Distributed generation system using solar PV technology can be utilized on rooftops of centralized heating center and pulverized coal preparation center for electricity generation, thus can lower the production cost.



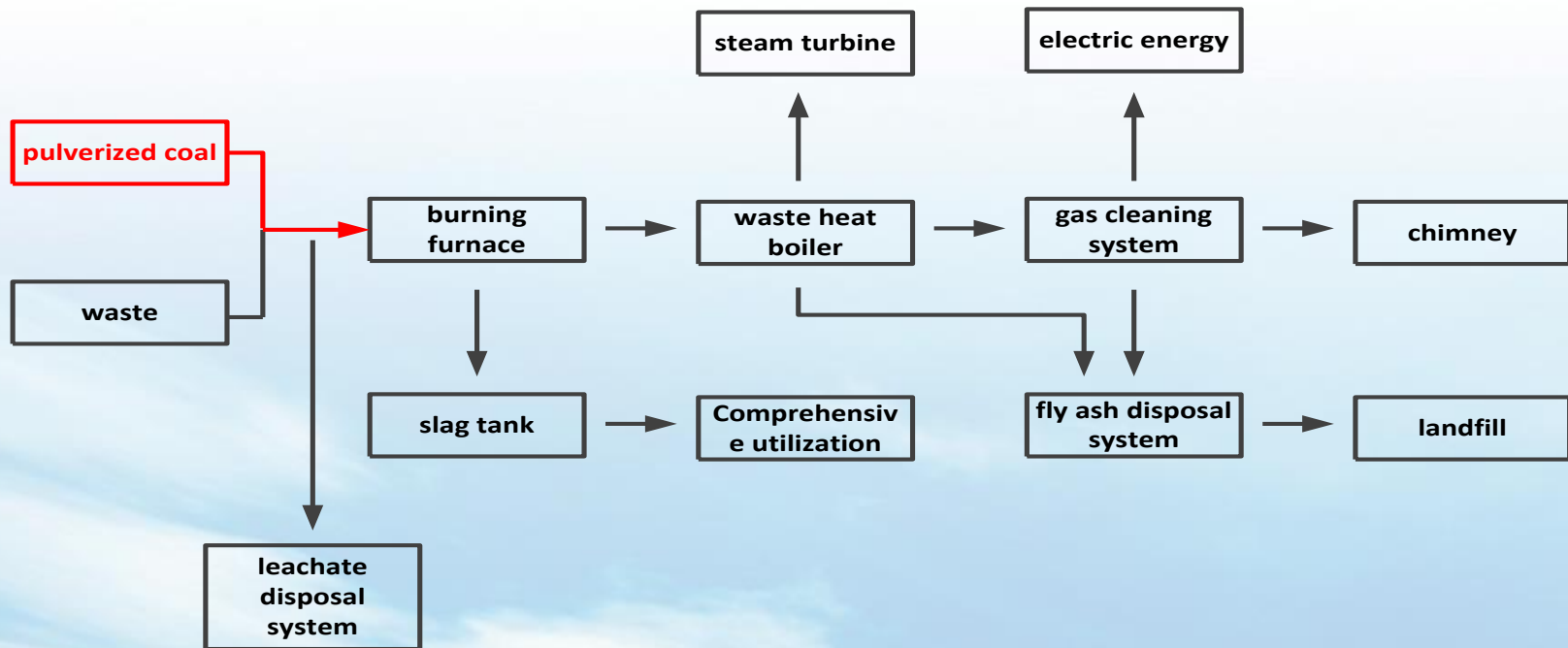
solar hot water heater

5.2 Coupling development with biomass energy

co-combustion of pulverized coal and household waste:

build waste-to-energy plant, to dispose household waste

build waste-to-energy plant, to dispose household waste

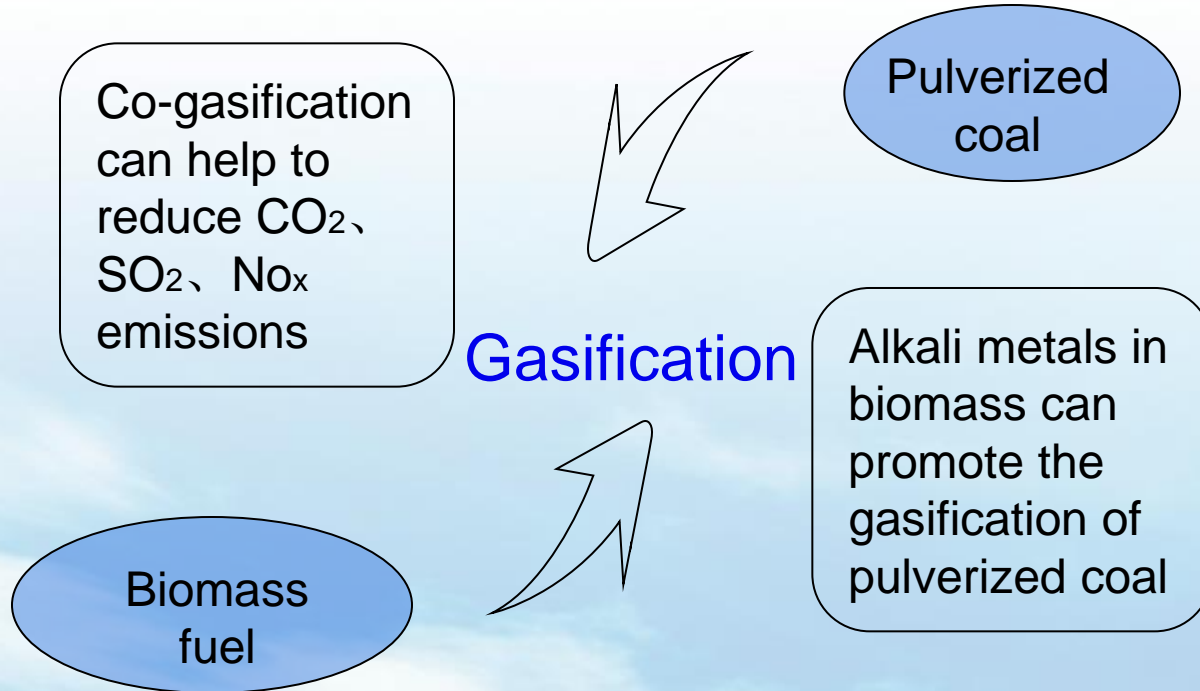


schematic of co-combustion of pulverized coal and household waste for electricity generation technique

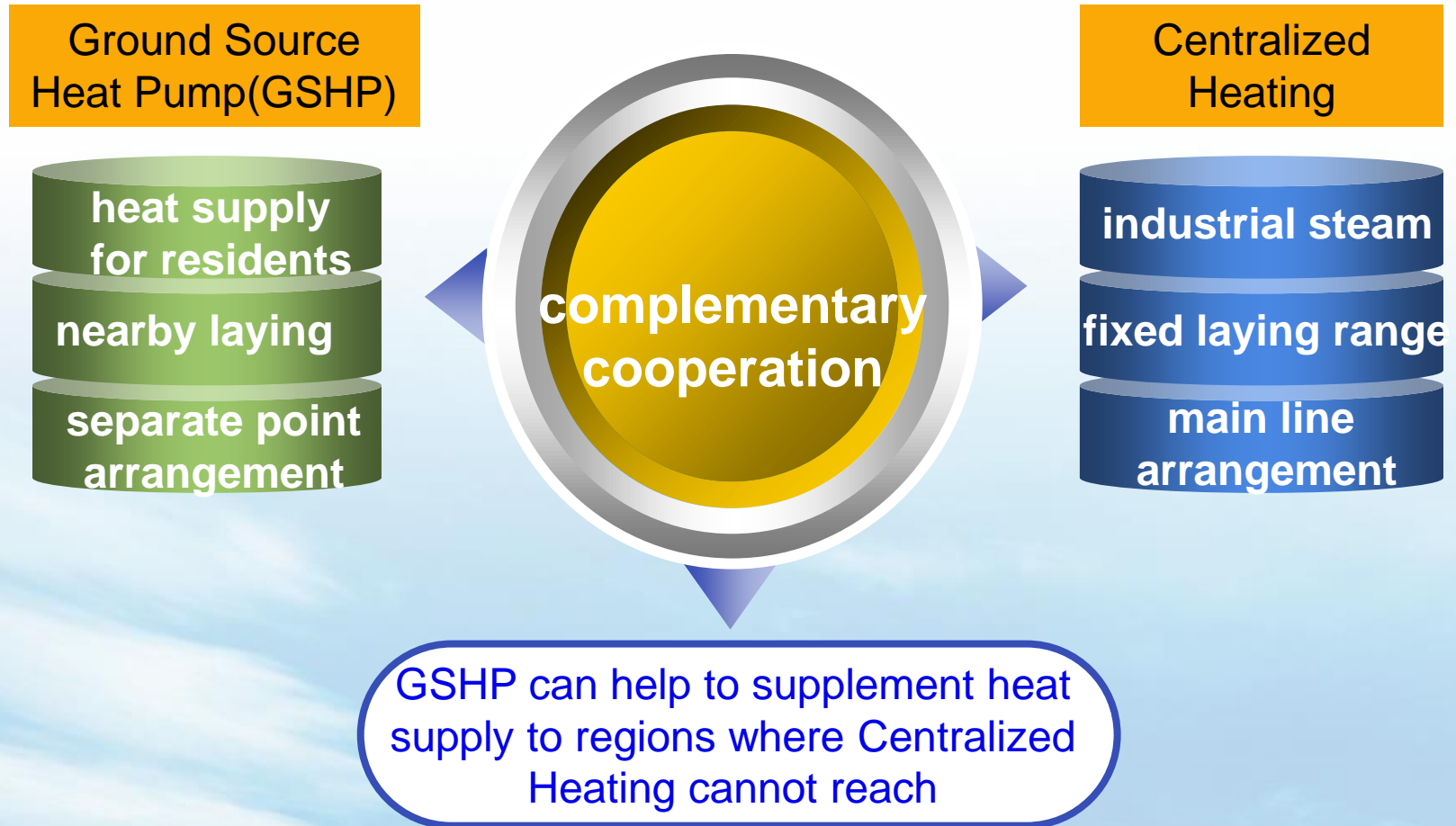


5.2 Coupling development with biomass energy

Co-gasification of pulverized coal and biomass energy:
gasification fuel production



5.3 Coupling development with geothermal energy



Develop Physical Processing for Clean Utilization of Coal

By developing the physical processing industry, we have broadened our mind for the exploitation of coal resource and found the new way to the utilization of clean coal: the energy utilization efficiency is improved, the coal product additional value is increased and the pollutant emission is lowered. The high performance of our products has been accepted widely by customers. The complementary development of coal processing and photovoltaic power generation, ground source heat pump and biomass energy, promotes the clean development of coal and makes coal as a bridge to new energy utilization.



We sincerely invite the friends all around the world to come to Xi'an for a visit and communication. Let's join together to promote the development of clean utilization of coal, offer clean energy and built a beautiful home!



Shaanxi Coal and Chemical Industry Group Co., Ltd.

Thank You!