

Untapped Potential: Coal and Biomass Cofiring



Vice President of WBA
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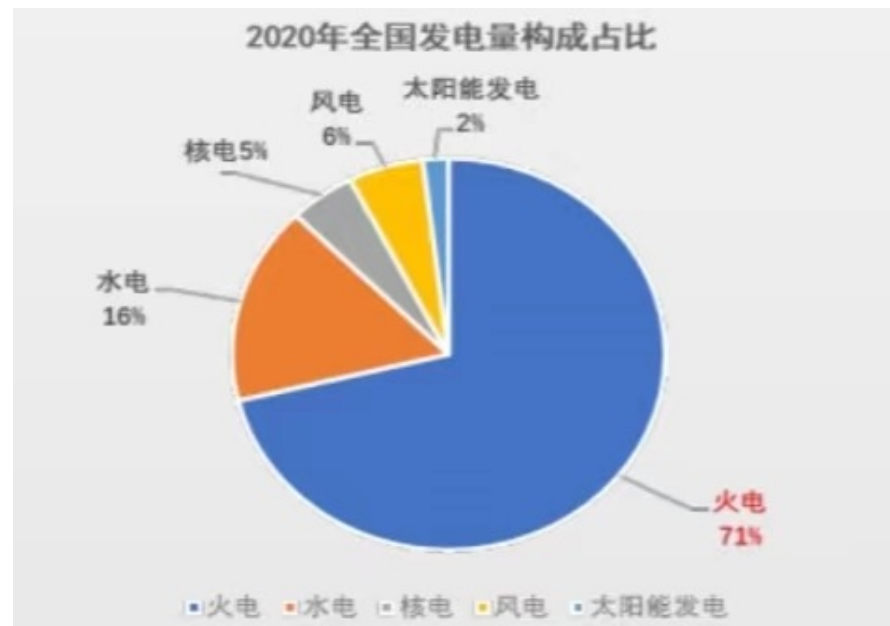
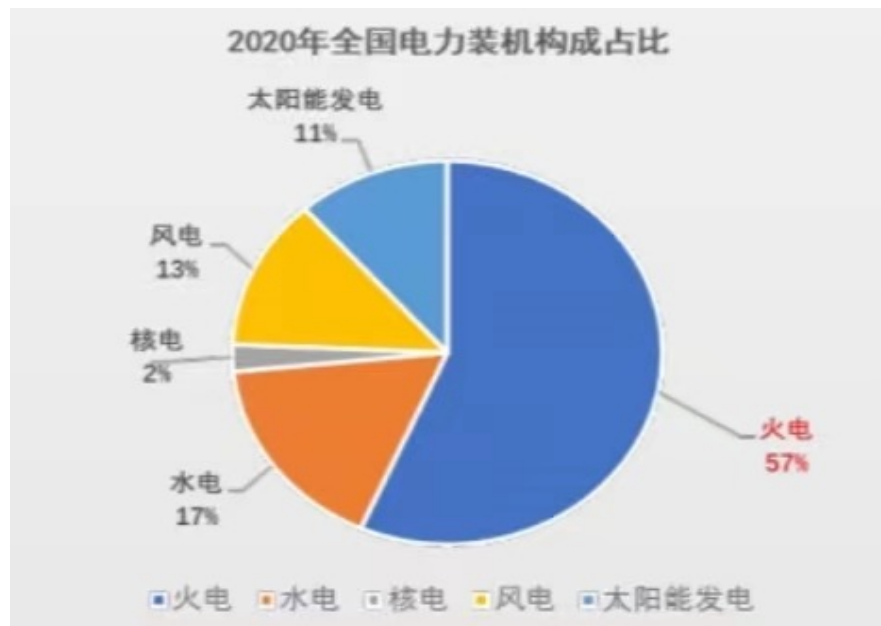
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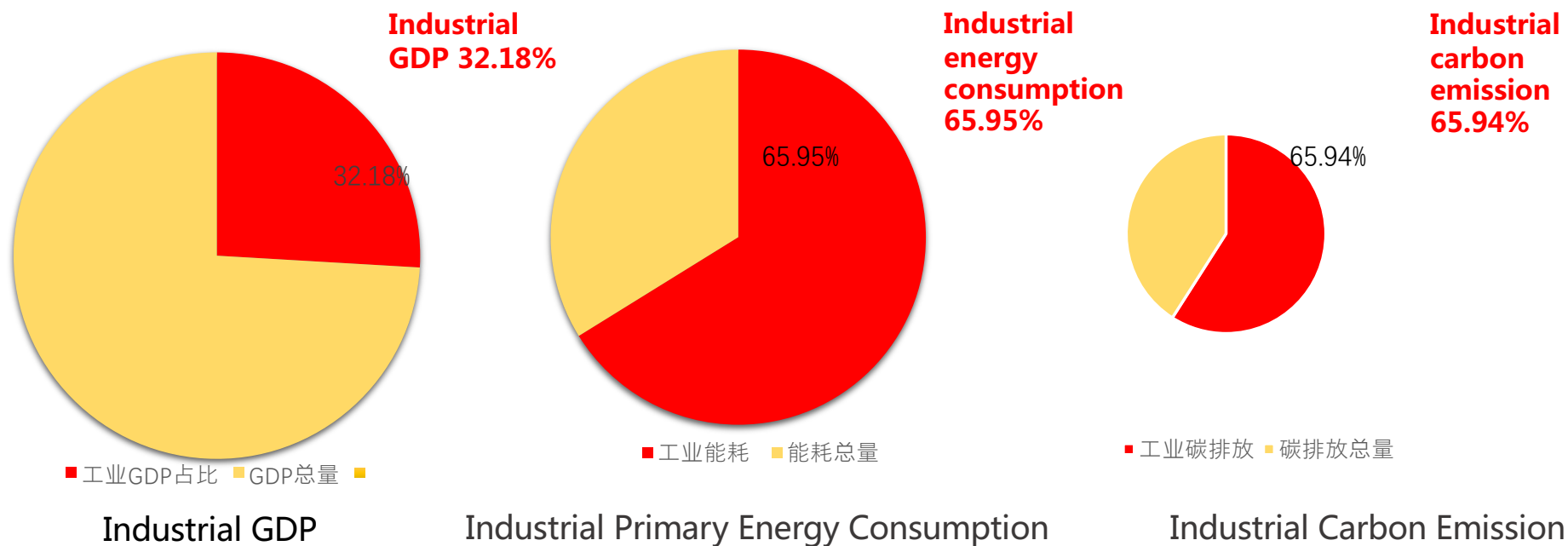
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World's largest installed capacity of coal-fired power China's largest source of carbon emissions



China's Industrial GDP, Energy Consumption and Total Carbon Emission



In 2018, China's total industrial GDP was 30.15 trillion, accounting for **32.18%** of the total GDP.

In 2018, China's industrial primary energy consumption was 4.719 billion tons of oil equivalent, accounting for **65.95%** of the total.

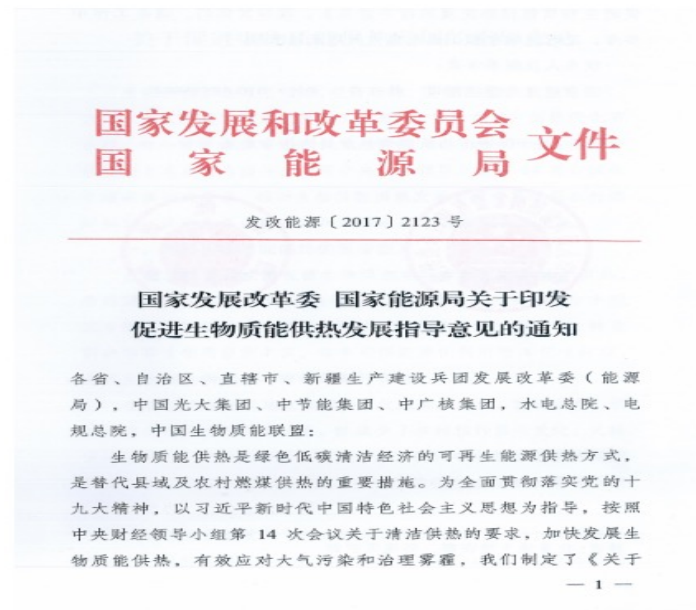
In 2018, China's industrial carbon emissions accounted for **65.94%** of the total carbon emissions.

China's Carbon Neutrality Goal Faced Challenge

China's Total Energy Consumption and Industrial Energy Consumption, 2013-2018

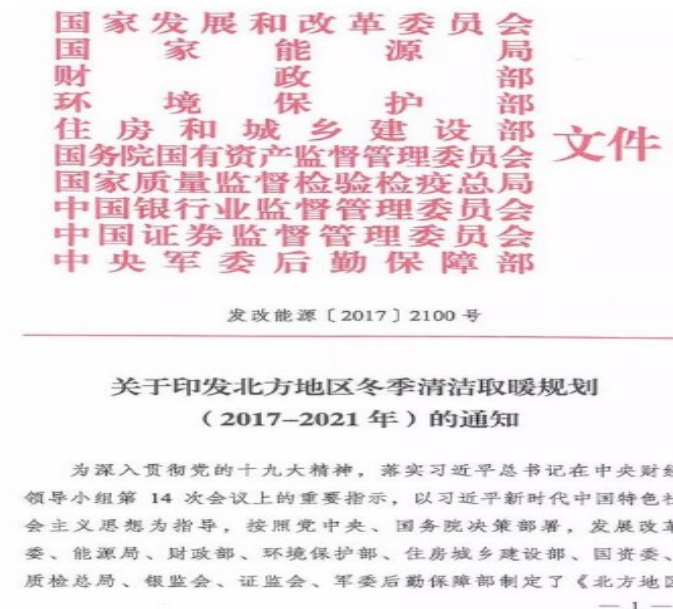
Y	Final energy consumption, tce (In unit of 10 ⁸ tons)	Proportion of industrial energy consumption	Power consumption(in unit of 10 ⁸ kwh)	Power consumption converted into coal (in unit of 10 ⁴ tons)	Proportion of power consumption in industrial energy consumption	Energy consumption in heat supply (in unit of 10 ⁴ tce)	Proportion of heating consumption in industrial energy consumption
2013	41.69	69.82%	39,237	85,144	29.57%	202,831	70.43%
2014	42.6	69.40%	40,803	88,543	31.74%	190,390	68.26%
2015	42.99	67.97%	41,550	90,164	33.60%	178,163	66.40%
2016	43.6	66.58%	43,089	93,503	36.04%	165,913	63.96%
2017	44.85	65.66%	46,053	99,935	39.18%	161,128	60.82%
2018	47.19	65.95%	49,095	106,536	12.84%	165,395	87.16%

国家发改委 能源局印发 《关于促进生物质能供热发展的指导意见》



<Directive on Promoting the Wider Use of Bioenergy in Heating>, jointly issued by National Development & Reform Commission, and National Energy Administration, in 2017.

十部委印发《北方地区冬季 清洁取暖规划（2017-2021）》



<Campaign for Supplying Clean Heat in Northeastern Area 2017-2021>, jointly issued by ten ministries.

Supplying bioheat to 2.1 bln m² by 2021

Supplying natural gas heat to 1.8 bln m² by 2021

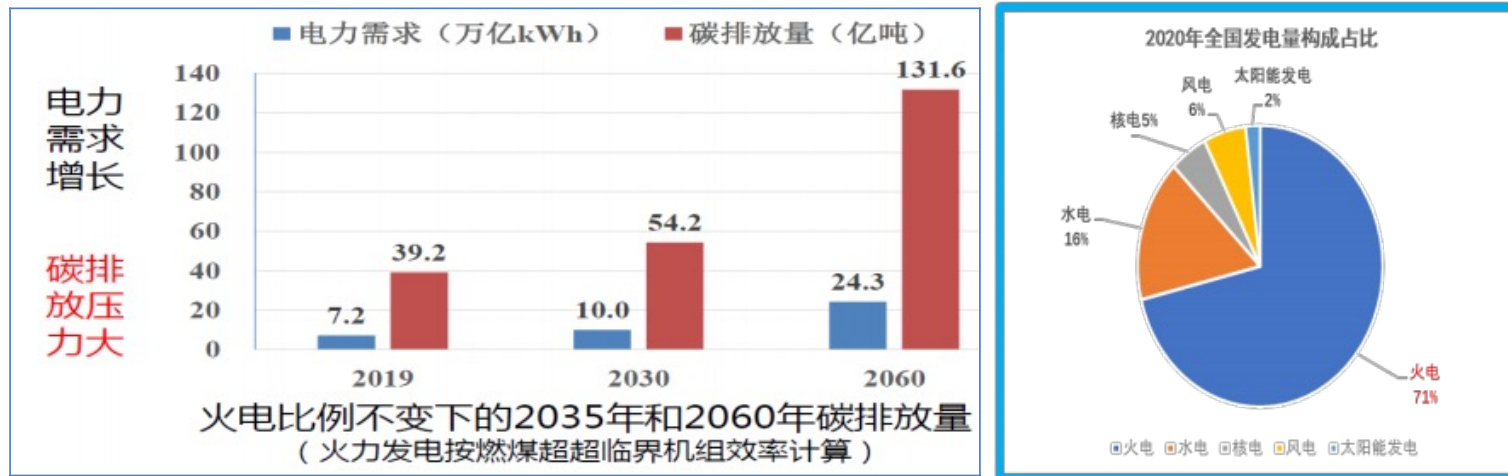
Supplying electric heat to 1.5 bln m² by 2021

National Development and Reform Commission, nationwide retrofit of coal power plants:

-Coal consumption more than 300g standard coal / kWh: speed up energy-saving retrofit, phase out and shut down the plants that cannot be retrofitted, and turn the plants that meet the conditions into emergency standby power supply as appropriate.

-Order issued by the state for the retrofit and upgrading of coal-fired power plants. Energy conservation, consumption reduction, and flexibility in retrofit.

Substitute of Coal with Biomass

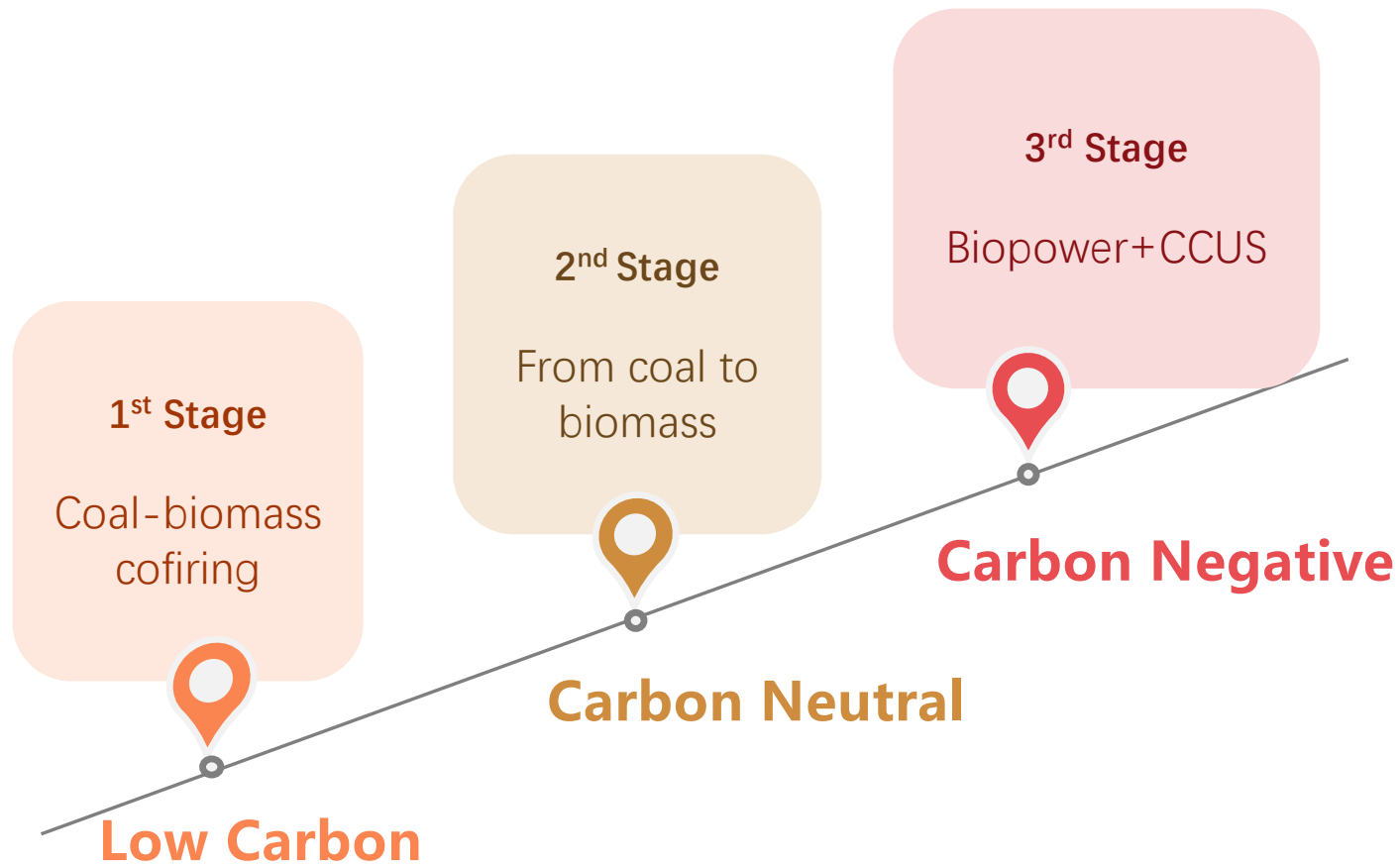


Given the current percent of thermal power, if no measures are taken, the carbon emission will reach 5.42 billion tons by 2030 and 13.16 billion tons by 2060 (assume the annual increase of power demand is 3%)

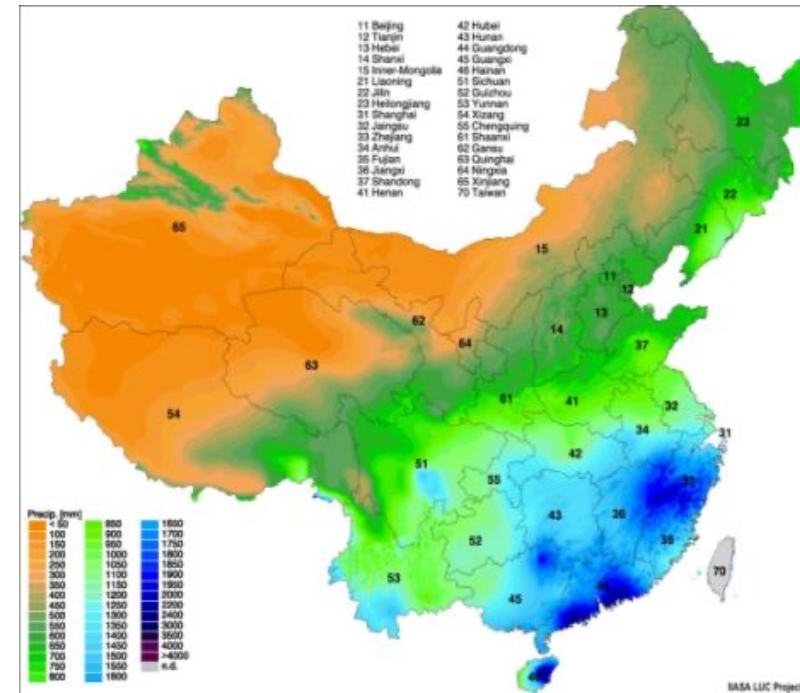
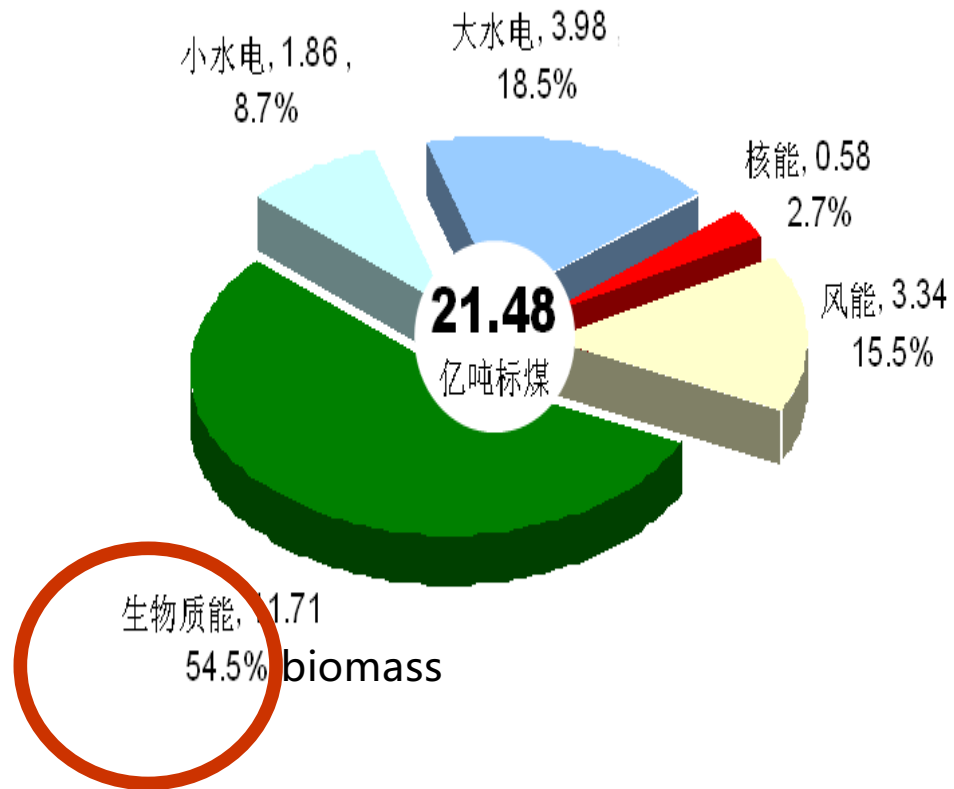
By 2060, the carbon emission of the power industry should be controlled within 4.02 billion tons

The carbon emission of the power industry needs to be reduced from 0.542 kg/kwh to 0.166 kg/kwh, a decrease of 70%, which is a great challenge. The only way out: coal+ biomass cofiring, until the complete phase out of coal.

Coal Power: Go Carbon Neutral



Resources



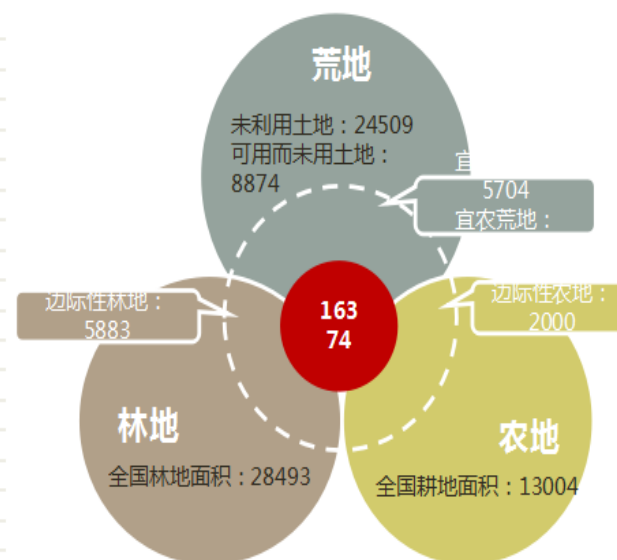
Biomass resources is 2 times of hydroenergy, or 3.5 times of wind energy

Data source: Chinese Academy of Engineering

Total availability of China's biomass resources: 690 M tce,
2030 projection: 1.171 bln tce (marginal land included)

资源来源	可利用资源量	
	实物量 (万吨)	折合标准煤量 (万吨)
农作物秸秆	90000	45000
稻谷秸秆	25020	12510
小麦秸秆	17550	8775
玉米秸秆	28620	14310
油料秸秆	5490	2745
豆类秸秆	3600	1800
薯类秸秆	2070	1035
棉花秸秆	1620	810
其他秸秆	6030	3015
农产品加工剩余物	11752.45	5876.224
稻壳	5622.075	2811.038
玉米芯	5615.8	2807.9
花生壳	514.572	257.286
林业木质剩余物	24400	12200
畜禽粪便	84000	2800
城市生活垃圾	7500	1200
有机废水	435000	1600
有机废渣	95000	400
合计		69076.22

可供生物质原料生产的边际性土地



Data source: 13th Five-Year-Plan for Development of Bioenergy Industry

China's Renewable Energy Industry Development Report 2015

Forestry Biomass Resources



China's forest area: 208 M hec,
increase of natural forest: 2.15 M
hec.

Total yield of forest vegetation: 17.02 bln tons
total carbon storage: 8.427 bln tons

Total forestry residue availability: 120 M tce

Data source: The 8th National Forest Census

Agro Residue Resources

Total availability of China's biomass resources: 690 M tce,
2030 projection: 1.171 bln tce (marginal land included)

Agro residue availability in 13 major grain producing provinces in China

Distribution of various straw resources in China



Data source: National Statistics Bureau 2015 data

Province	wheat straw	rice straw	corn straw	rice husk	corn cob	peanut shell	total
grain/straw ratio	1.366	0.623	2.000	0.270	0.250	0.313	
Heilongjiang	29.8	1370.4	7088.2	593.9	886.0	1.6	9970.0
Henan	4782.4	331.1	3707.4	143.5	463.4	151.9	9579.7
Shandong	3205.5	59.2	4101.8	25.7	512.7	100.0	8004.9
Anhui	1927.4	909.1	992.6	394.0	124.1	29.5	4376.8
Liaoning	3.7	291.4	2807.0	126.3	350.9	14.0	3593.2
Hebei	1960.2	34.0	3340.8	14.7	417.6	39.9	5807.2
Jilin	0.1	392.6	5611.4	170.1	701.4	17.5	6893.1
Inner Mon	216.2	33.1	4501.6	14.4	562.7	1.3	5329.4
Jiangxi	3.6	1262.9	25.6	547.3	3.2	14.5	1857.2
Hunan	12.8	1647.7	377.6	714.1	47.2	9.5	2809.0
Sichuan	582.3	967.3	1531.4	419.2	191.4	21.2	3712.8
Hubei	574.9	1128.1	665.8	488.9	83.2	21.3	2962.2
Jiangsu	1603.7	1216.4	504.4	527.2	63.1	11.0	3925.7

High yield energy plants miscanthus and super asparagus



Energy plant miscanthus

Miscanthus: adapt to arid and cold environment, different types of marginal land: abandoned mines, wetland, saline-alkali soil.

Excellent energy grass originated from China. High yield, adaptive to environment, In southern Germany, under the local annual precipitation of 700mm-800mm, the height of triploid giant awn can reach 7-10 meters, the unit yield of biomass is much higher than that of switchgrass, and the theoretical unit yield can be as high as 22 tons / ha per year.

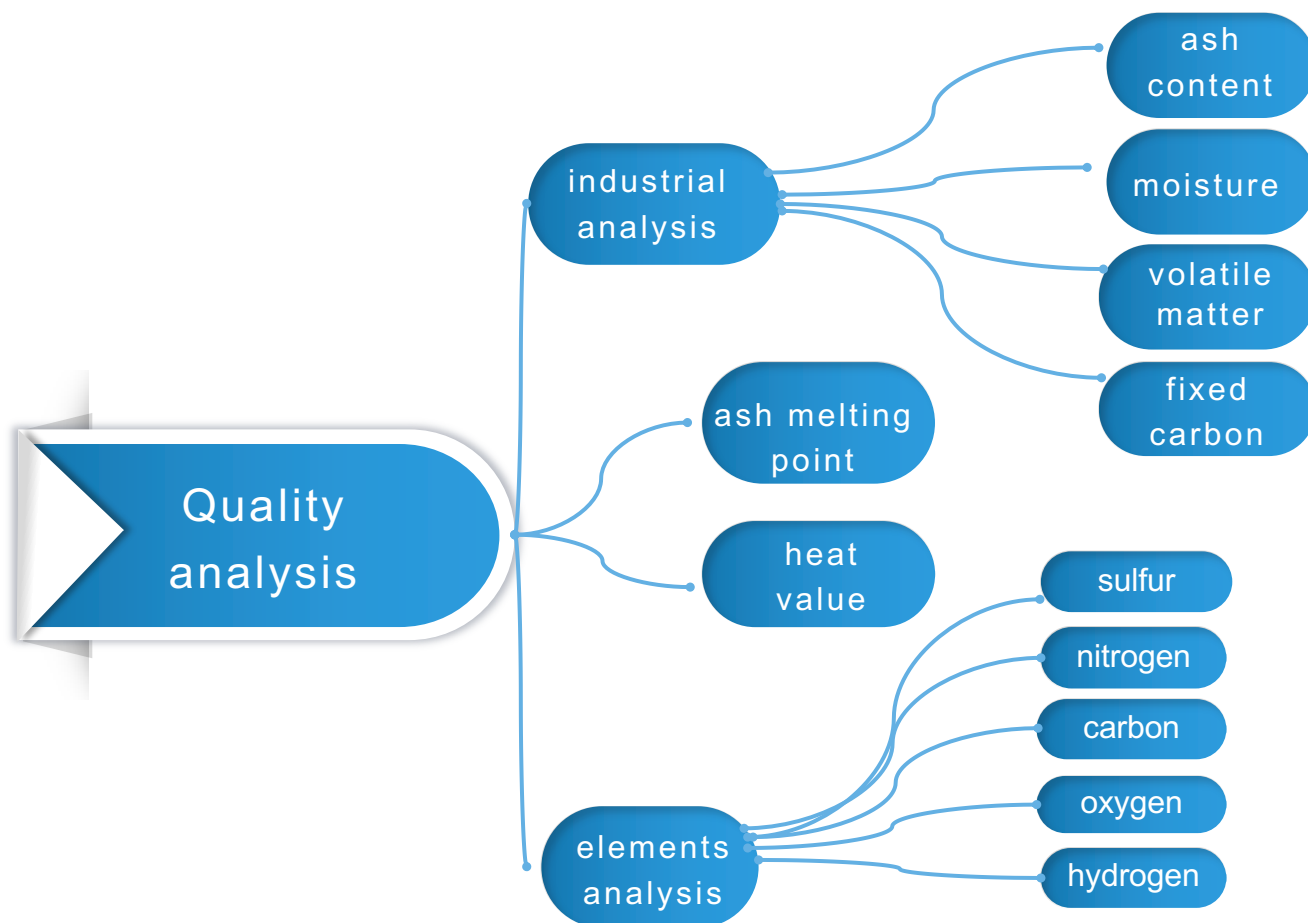
Super bamboo reed, dry matter yield: over 10 tons/0.06 hectare, the yield of straw of traditional crops such as rice and wheat straw is only about 1 ton. Hope of China's biomass energy



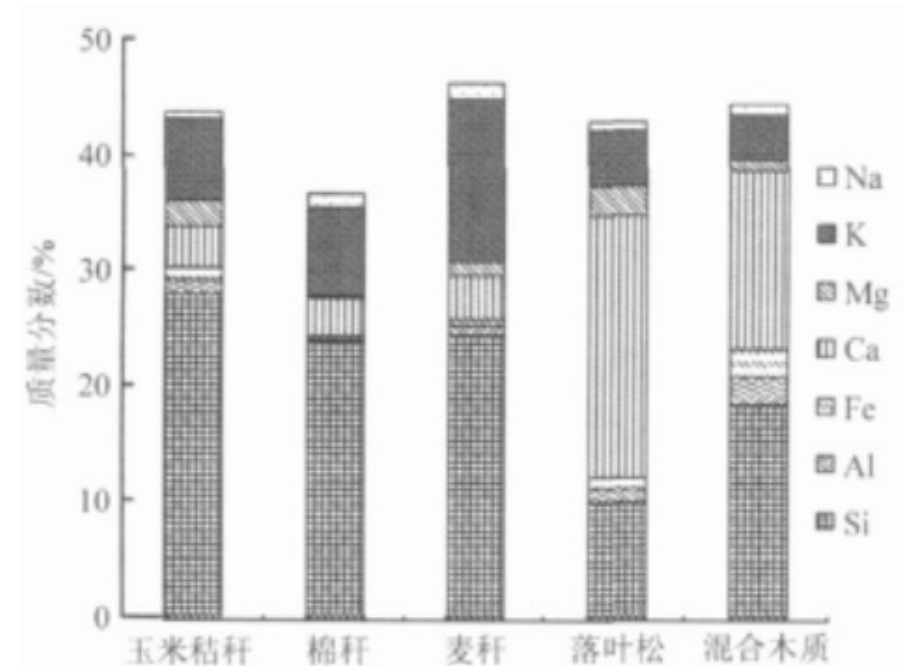
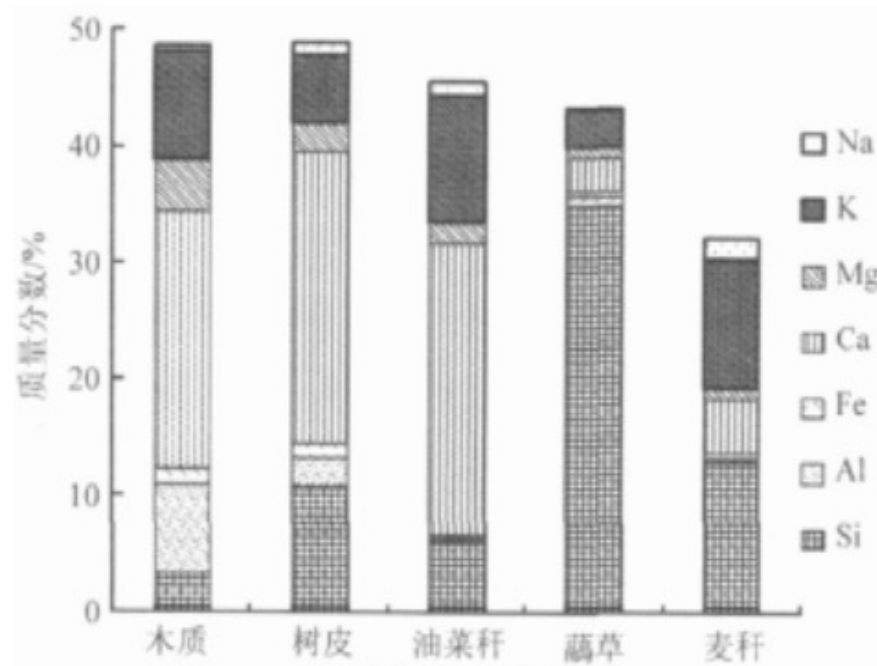
Fuel Quality Analysis Lab



Fuel quality analysis lab



Chemical Property of Agro Residue



High content of Si, K, and alkali induced slagging, which limits the wider use of agro residue.

Quality Analysis Standard

Nr.	Assay	Analyzer	National standard
1	heat value	calorimeter	GB/T 30727-2014
2	Moisture, ash, volatile matters, fixed carbon	industrial analyzer	GB/T 28731-2012
3	whole sulfur	sulfur analyzer	GB/T 28732-2012
5	ash melting	ash melting analyzer	GB/T 30726-2014
6	moisture	moisture analyzer	GB/T 28733-2012
7	carbon, hydrogen, nitrogen	carbon, hydrogen and nitrogen analyzer	GB/T 30732-2014
8	fluorine, chlorine	fluorine, chlorine analyzer	GB/T 30729-2014

National standards to follow for quality analysis

Analysis Results

Fule	Moisture	ash	volatile	sulfure	whole water	Heat value			sample origin
	M _{ad} (%)	A _d (%)	V _d (%)	S _{t, d} (%)	M _t (%)	Q _{b,ad} (MJ/kg) (kal/kg)	Q _{gr, d} (MJ/kg) (kal/kg)	Q _{net,ar} (MJ/kg) (kal/kg)	
pine pellet	1.18	0.6	84.69	0.06	6.34	20.18	20.42	17.72 4237.21	满洲里
poplar pellet	2.5	8.93	75.24	0.03	8.62	17.95 4292.20	18.14 4337.63	15.5 3706.36	长 春
straw pellet	0.92	4.98	76.42	0.06	9.18	18.20	18.37	15.32 3663.32	舒 兰
straw pellet	2.30	16.66	66.76	0.06	6.18	16.25	16.63	14.14 3445.72	长 春
straw pellet	0.66	22.56	64.84	0.14	5.64	15.13	15.23	13.26 3170.73	四 平
rice husk pellet	1.06	16.58	66.86	0.04	7.83	16.41	16.58	14.07 3364.42	黑龙江
rice husk pellet	1.30	16.52	67.44	0.04	8.24	16.46	16.68	14.08 3366.81	舒兰市
peanut shell pellet	2.40	11.15	70.22	0.12	11.68	17.63	18.06	14.63 3498.33	辽 宁
peanut shell pellet	1.78	10.34	70.50	0.04	10.63	17.94	18.26	15.00 3586.80	松 原

Wood pellet: highest heat value

Rice husk: easy access, low cost, ash content high

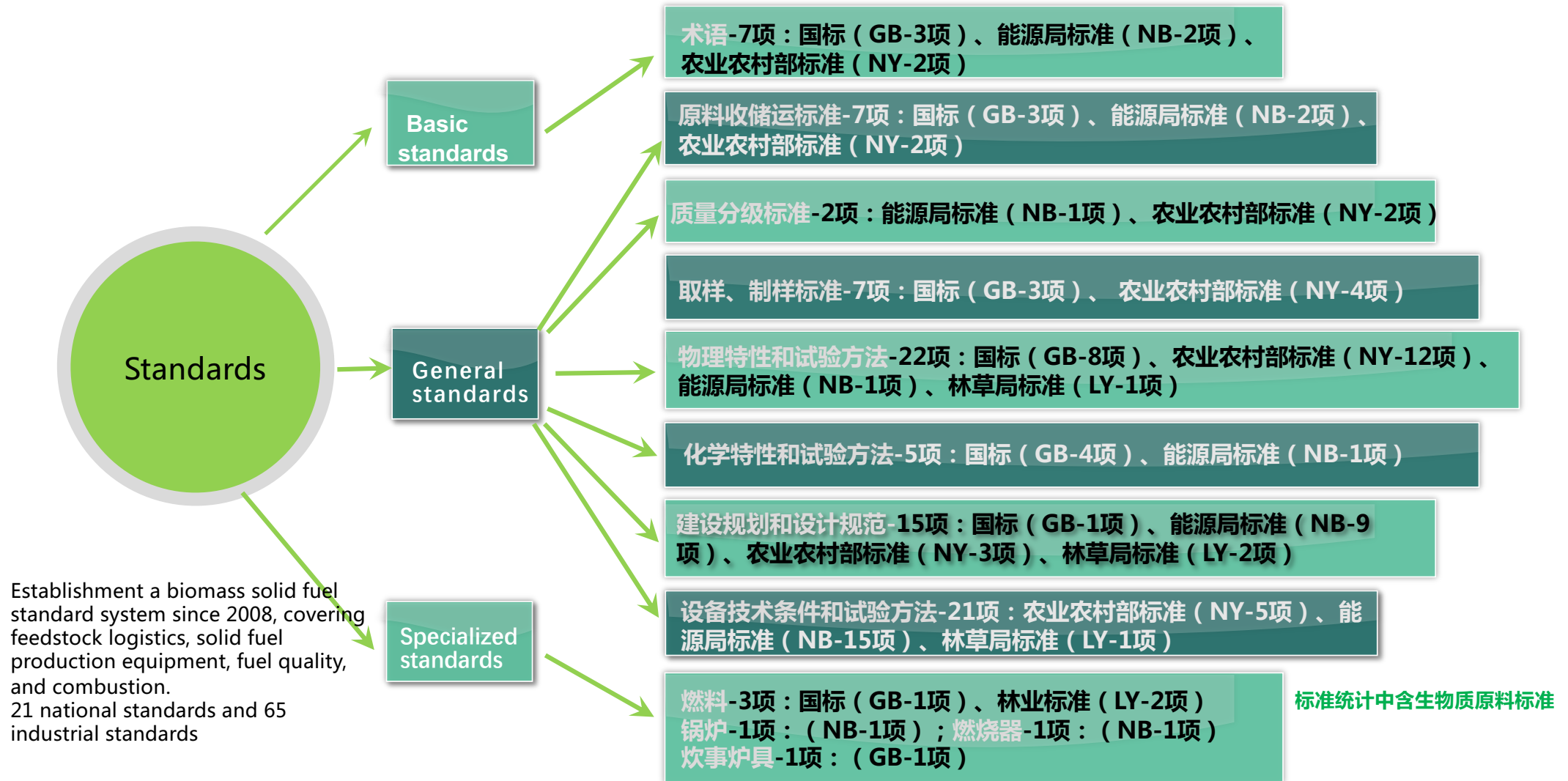
Straw pellet: high moisture, ash content high, instable heat value

Challenges

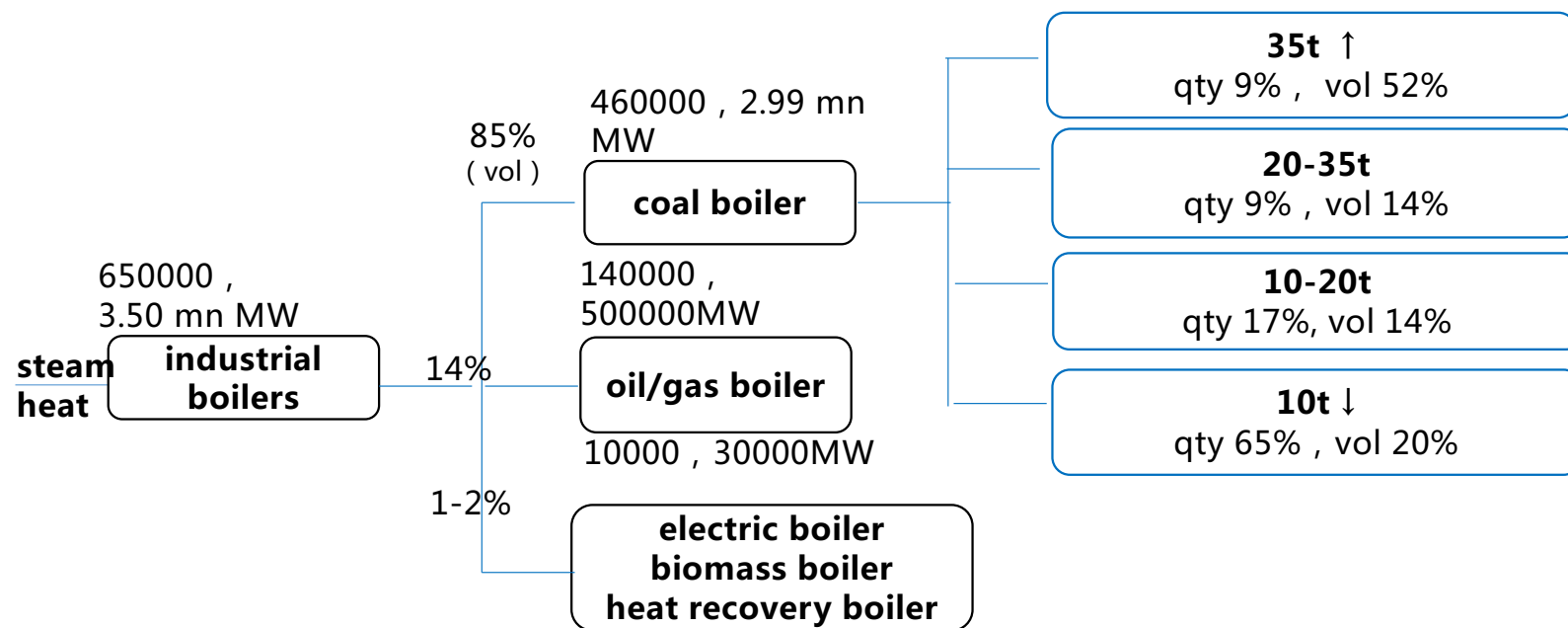


Physical and chemical property induced fouling, slagging, corrosion (high alkali content, low ash melting point, etc).

Solid Biomass Fuel Standard

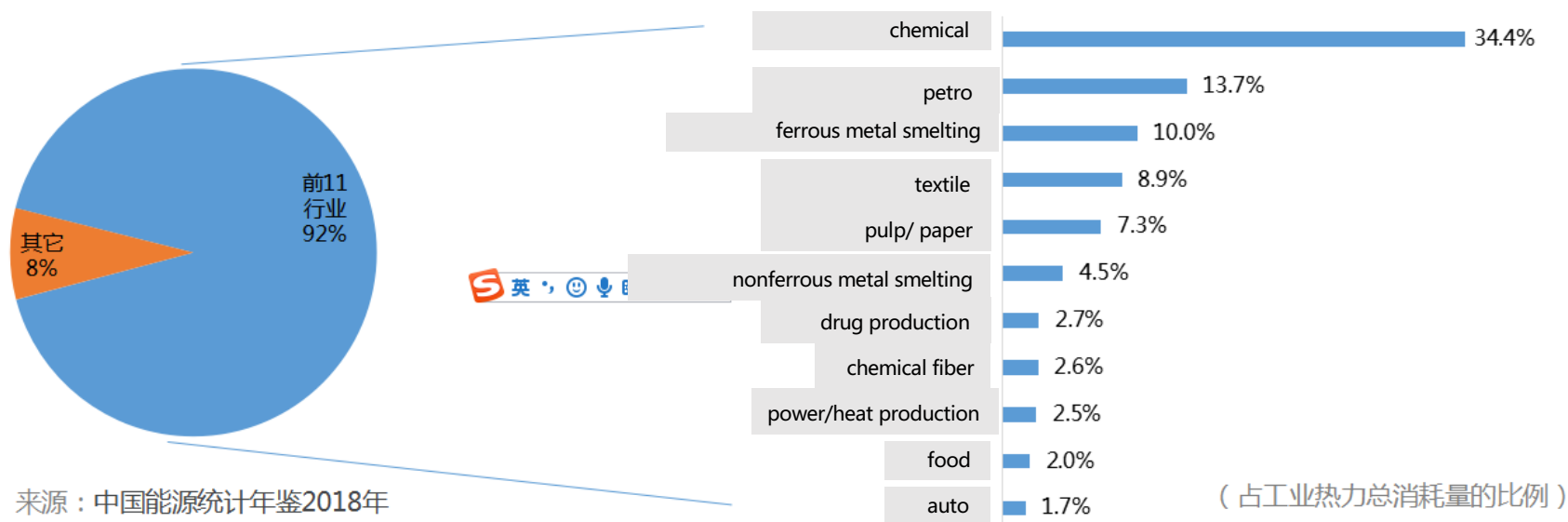


Statistics on heat only boilers



Coal→biomass solid fuel, market potential: 400 bln CNY.

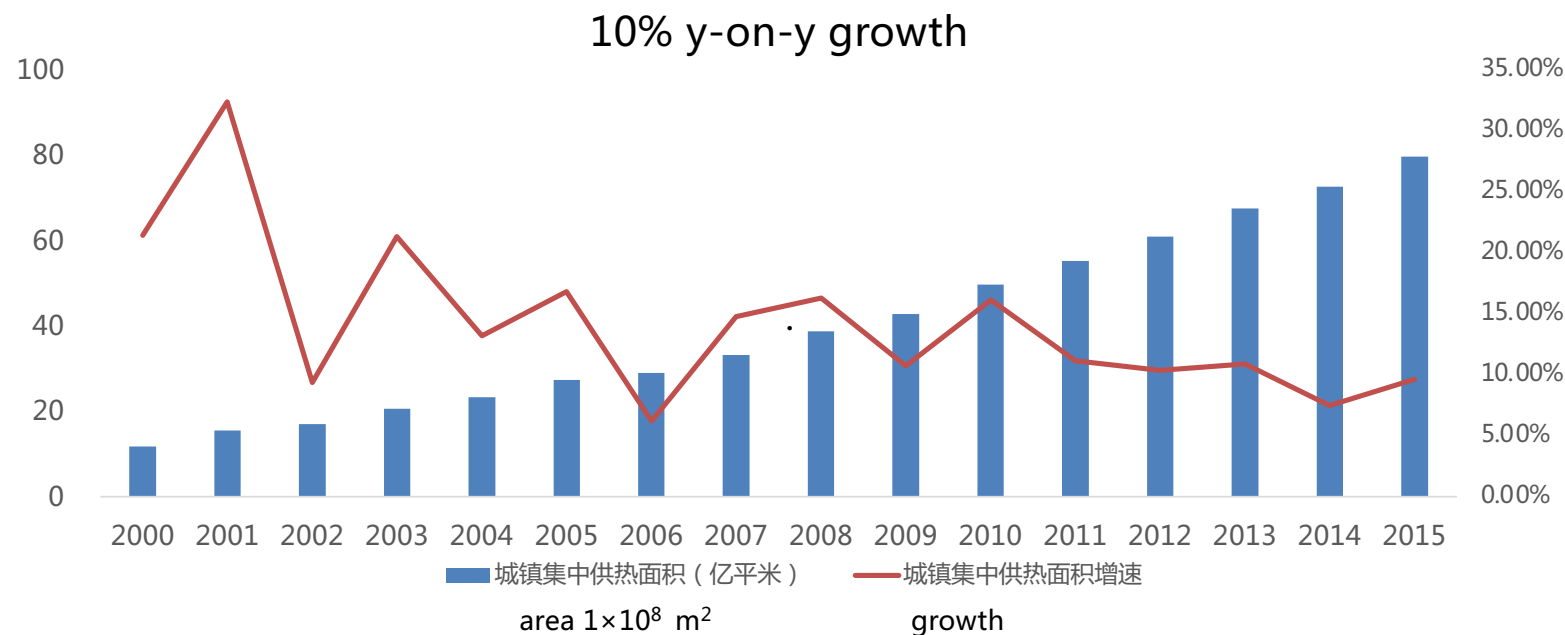
Total heat supply to 11 industrial manufacturing sectors in 2017



Data source: China Energy Statistics Yearbook 2018

Total heat supply: 586 mil. tons \approx 146.5 bln CNY.

Sustained growth of heat supply in urban area in China, 2000-2015



Projected market size 480 bln CNY

Economical Comparison

Fuel	Heat value		Unit price		Unit heat price		Efficiency	Heat value/cost
straw pellet	3200	kcal/kg	600	CNY/t	52.69	CNY/GJ	85	1
coal	5000	kcal/kg	700	CNY/t	51.44	CNY/GJ	65%	0.98
wood pellet	4100	kcal/kg	1100	CNY/t	75.39	CNY/GJ	85%	1.43
NG	8600	kcal/m ³	3.5	CNY/m ³	105.66	CNY/GJ	92%	2.01
electricity	860	kcal/kWh	1	CNY/kWh	286.32	CMY/GJ	97%	5.43

备注：煤价、天然气和商业用电价格依据当地价格计算。以上测算为产生同等热量单价比。公式：单位热量÷热值×单价×效率

Straw is a cost efficient fuel

Emission Comparison

Boiler type		Applicable area	ash/dust mg/ m ³	SO ₂ mg/ m ³	NO _x mg/ m ³
coal fired boiler	natural draft furnace	class I	50	300	300
	other boilers	class I	50	300	300
oil fired boiler	light diesel	class I	30	200	250
	other fuel oil	class I	30	200	250
gas fired boiler		all areas	20	50	200

National limits for coal/oil/gas fired boilers

Emission Comparison

吉林省生物质成型燃料锅炉大气污染排放标准 (DB22/T 2581—2016)

单位: mg/m³

Pollutant	Limit	Sampling point
Particulate matter	30 ^a	stack/duct
SO ₂	50	
NO _x	250	stack/duct
Ringelman blackness	≤1	discharge outlet
^a 对于 0.35 MW(0.5 t/h) 及以下小型锅炉颗粒物排放浓度限值可放宽至 40。		

Limits for biomass boilers in Jilin Province, Northern China

Case Study

Conversion of coal fired energy system (5* 56MW boilers) into wood pellet fired plant for auto industry in 2015



Before conversion



After conversion



Wood pellet

China's biggest bioheat supply project with emission as same as NG without SNCR

Case Study



Supplying heat to universities (1.2M m² in total) by using rice husk pellet

Case Study



Supplying steam (2*10.5MW biomass boiler) to drug producer



Fuel: peanut shell pellet

Case Study



Multi-generation technology - cool, heat, electricity, steam, fertilizer. Total investment: 310M CNY.

Use of corn straw

Case Study



Supplying steam to agricultural products processing factory by
combustion of wood chips in Northern China.
Ultra low emission (10, 35, 50)

Case Study

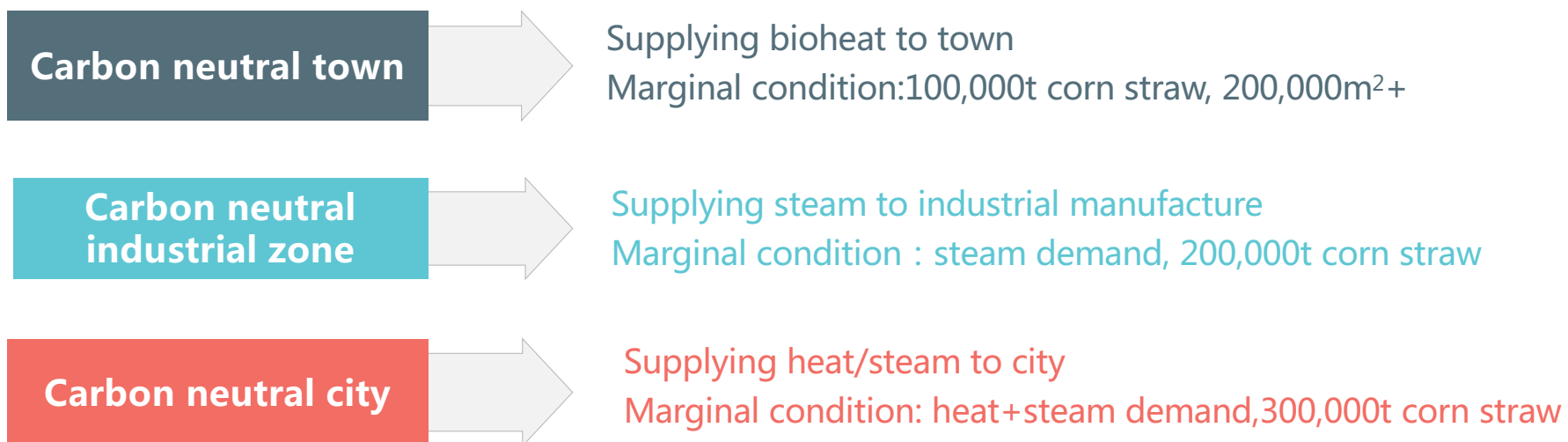
Coal fired grain drying system → biomass fired system



Briquette fuel made from corn straw is used to dry grain



Carbon Neutral Bioheat



Principle: local origin, local use



Thanks
