

Development of clean coal technology for energy sector of Kazakhstan



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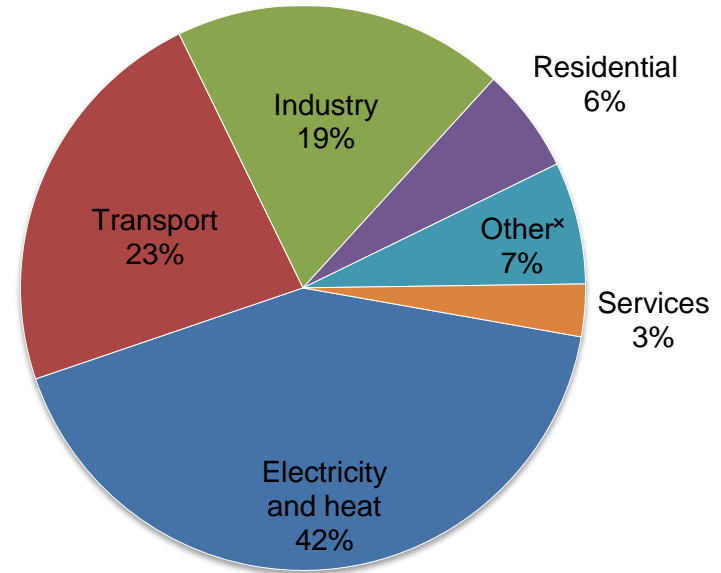
Astana, 15th of June, 2017

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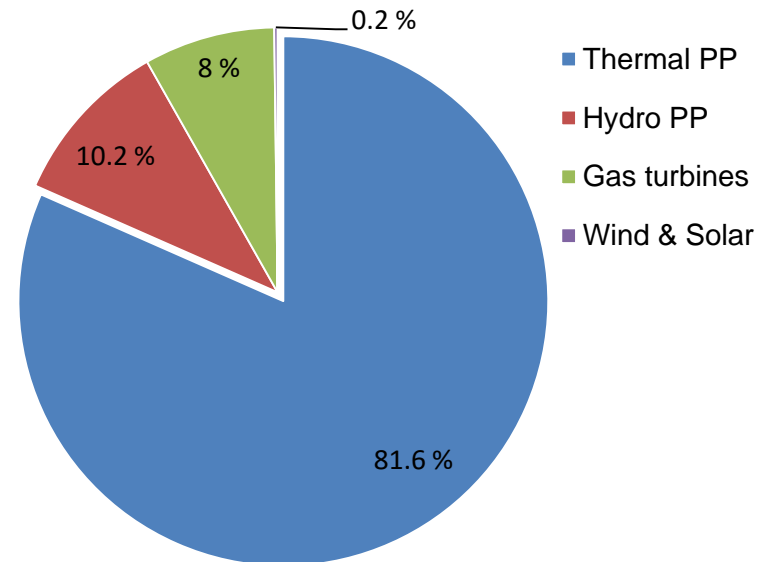
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Introduction

- Currently 42% of world electricity is generated by coal-fired power plants (IEA, 2011).
- According to IEA, 968 g of CO₂ is emitted for 1 kW of produced electricity in coal fired plants (IEA, 2012);
- Coal-fired power plants are dominant technology in Kazakhstan;
- Pulverised coal (PC) combustors are mainly used in almost all coal-fired PP;
- Energy balance shows 82% for thermal PP; 8% for gas turbines, 10% got hydro PP and only 0.2% for solar & wind;



Energy Balance of Kazakhstan by 2015



Energy sector of Kazakhstan

118 power plants:

- Total installed capacity by 2017 - 22.06 GWt (19.44 GW in 2010)
- Available capacity by 2017 - 18.79 GWt (15.29 GW in 2010)

The plants are classified according to their property:

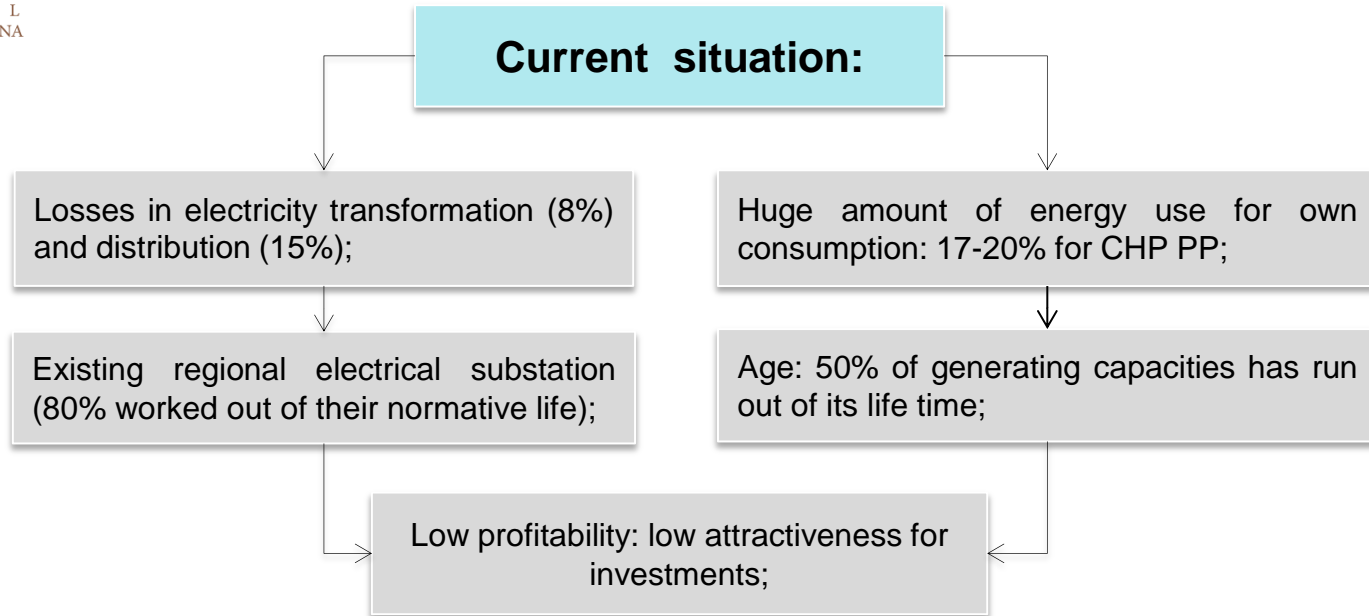
- Public (82% of the total stock)
- Industrial (18%)

3 hydro-plants: Buhtarminskaya, Ust-Kamenogorskaya and Shulbinskaya (10% of the total generation)



The electric system (transmission) of the country is divided by three zones:

- I. South zone:* Almatinskaya, Zhambylskaya, Kzyl-Ordinskaya and south Kazakhstan;
- II. North zone:* Akmolinskaya, Pavlodarskaya, Karaginskaya, Kustanaiskaya, Aktiybinskaya;
- III. West zone:* Atyrauskaya, Mangistauskaya and west Kazakhstan region;



Areas to be addressed:

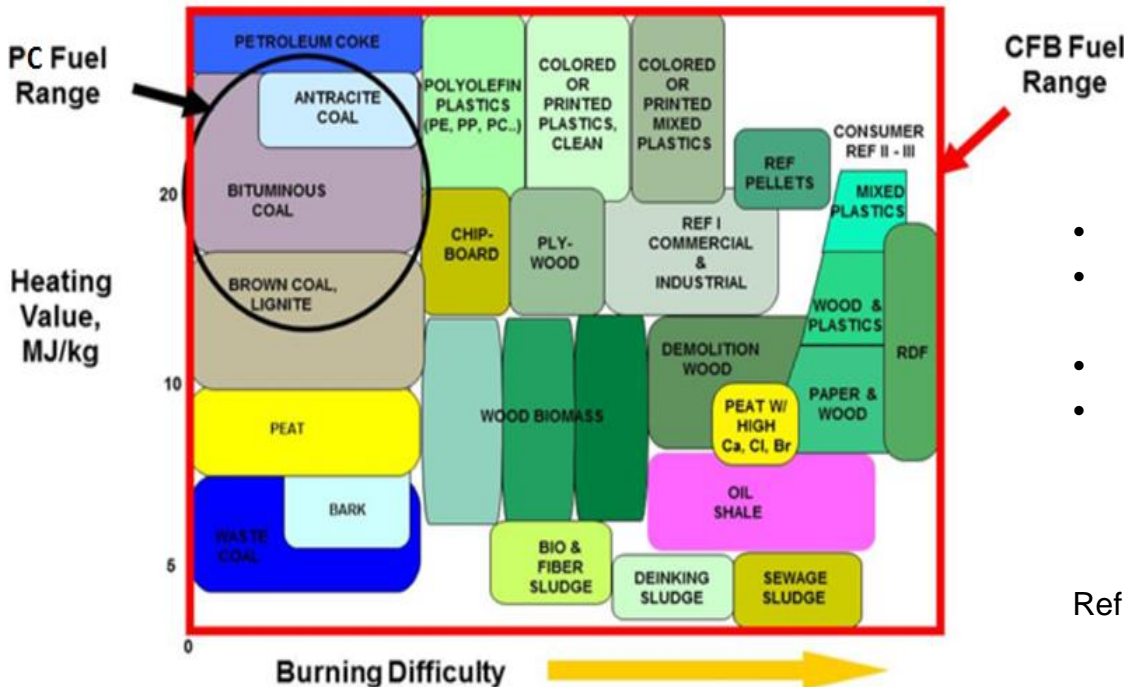
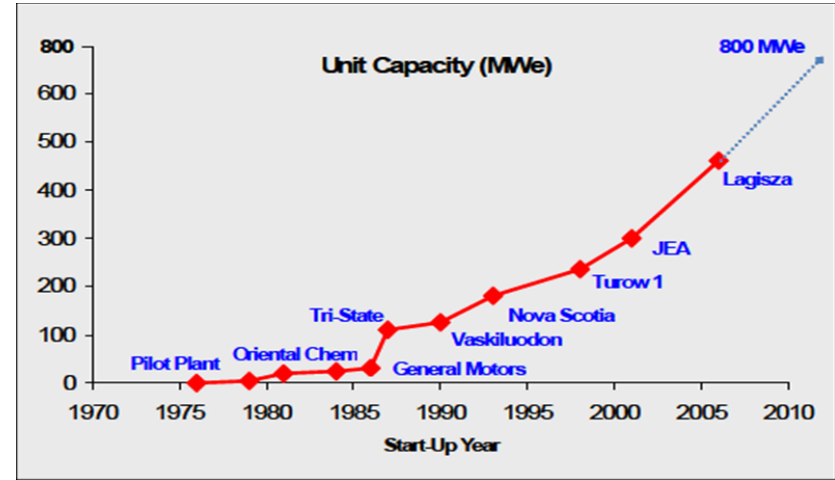
- Public awareness campaigns for efficient energy use/energy savings;
- Energy efficiency campaigns for each region/city;
 - Energy efficiency in buildings
 - Smart grids system/smart distribution
- Municipal solid waste (MSW), biomass utilisation and incineration technologies

New solution/an alternative fuel for energy use:

Clean coal, co-firing and waste-to-energy incineration technologies could be very an attractive option?

Fluidised Bed Combustion

- By 2009, around 900 air-fired CFB boilers were in operation or under construction worldwide with a capacity range of 50 to 400 MWe (Suraniti *et al.*, 2009).
- This trend represents a remarkable progress of technology in a short period of time.

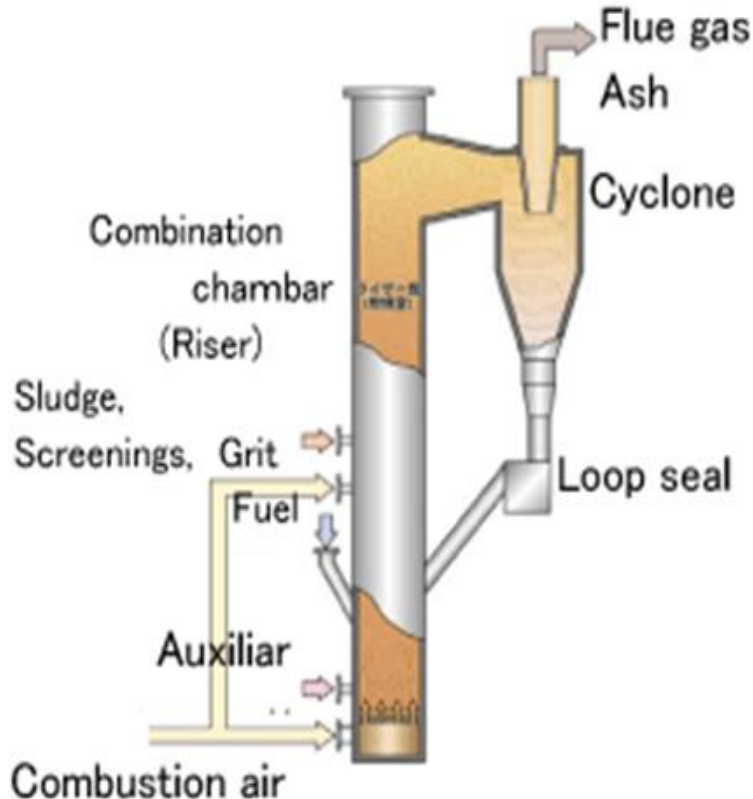


- Fuel flexibility
- Combustion occurs at low temperature conditions
- Lower NO_x, SO_x emissions
- Ability to operate at lower loads

Ref: Foster Wheeler report

Fluidised bed combustors (FBC)

Circulating fluidised bed



Fuel flexibility:

- Coal, refuse derived fuel, biomass;
- Waste-to-energy, renewable energy;
- Electricity production if integrated with PP or CHP;
- Liquids production if integrated with chemical plant;

Technological advantages:

- Scale-ability from 1 MW to 650 MW;
- 100% can be manufactured in Kazakhstan;
- Can operate at reduced load - 50%;

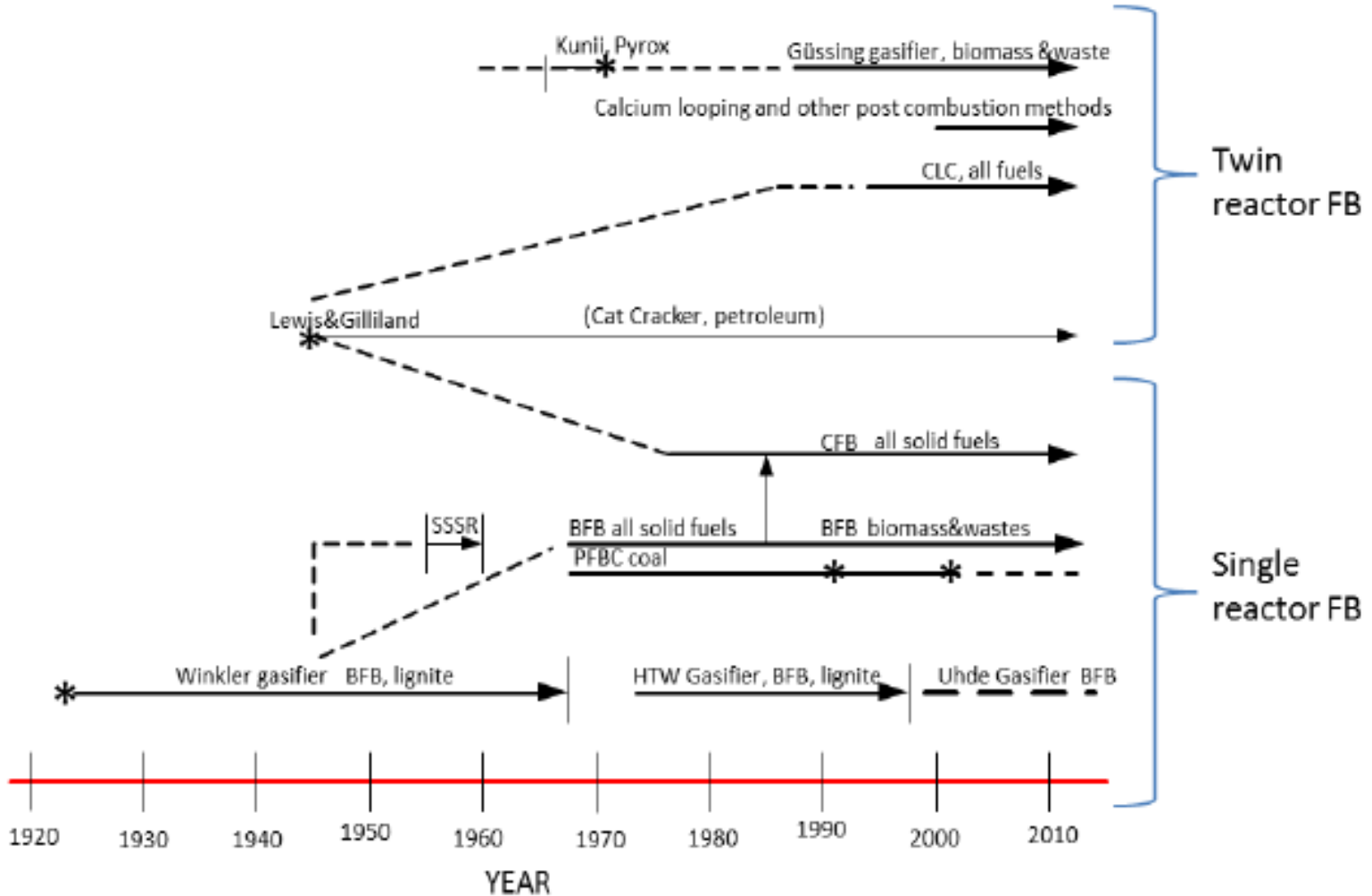
Environmental advantages:

- NO_x less than 200 mg/m³
- SO_x less than 200 mg/m³

Stable supply of energy:

Alternative fuel – coal, biomass, MSW;
Heat-up fuel – heating oil or gas;

Trend of FBC



Development of fluidised bed conversion technology during the last 93 years

L. Bo, "Development of fluidized bed conversion of solid fuels — history and future," in: Proc. 22nd Int. Conf. on FBC, Turku, Finland (2015), pp.2–11.

FBC development in Poland

Total capacity (2760 MWe; 3454 MWth)

Location	Year	Type	Capacity	Fuel used
Bielsko-Biala	1997	CFBC	177/165 MWth	Bituminous coal
Zeran, Warsaw	1997	CFBC	315 MWth	Bituminous coal
PGE Turow Power Plant S.A	1998	CFBC unit 1 and 2	2 x 235 MWe	Brown coal, lignite
Jaworzno II S.A.	1999	CFBC unit 1, 2	2 x 70 MWe	Bituminous coal, coal slurry
PGE Turow Power Plant S.A	2000	CFBC Unit 3	235 Mwe	Brown coal lignite
PGE Turow Power Plant S.A	2002-2004	CFBC Unit 4, 5, 6	235 Mwe	Brown coal lignite
EC Katowice S.A.	2000	CFBC Steam-cooled cyclone	120 MWe	Bituminous coal, coal slurry
Chorzow Elcho	2003	CFBC unit 1, 2	2 x 113 MWe	Bituminous coal
Zeran, Warsaw	2001	CFBC	315 MWth	Bituminous coal
Lagisza	2009	Supercritical	460 MWth	Bituminous coal
Stora Enso Poalnd	2010	CFB	164 MWth	Biomass, wood waste, coal
PGE Dolno Odra Szhecin	2011	BFBC	183 MWth	Biomass
PAK Konin	2012	CFB	154 MWth / 55 MWe	Biomass-20%, crop waste
Sues Polaniec	2012	CFB	447 MWth / 190 MWe	Biomass – wood/ 20% agro waste
Jaworzno II	2012	CFB	139.7 MWth	Biomass and agro waste

Coal

Biomass & Waste

FBC development in China

Capacity, MW	Steam capacity (t/h)	Number of units
6	35	460
12	75	901
25	130	178
50	220	175
135	440	92
300	970	15

Total CFB power plant capacity reached 74712 MWe (over 10% of the total capacity of coal-fired PP in China)

Largest supercritical CFB unit of 600 MWe is installed in China at the Baima Power plant

Chinese boiler manufacturers:

- Harbin Boiler Co., LTD
- Shanghai Boiler Co., LTD
- Donghang Boiler Co., LTD

<http://cornerstonemag.net/tag/china-circulating-fluidized-bed/>



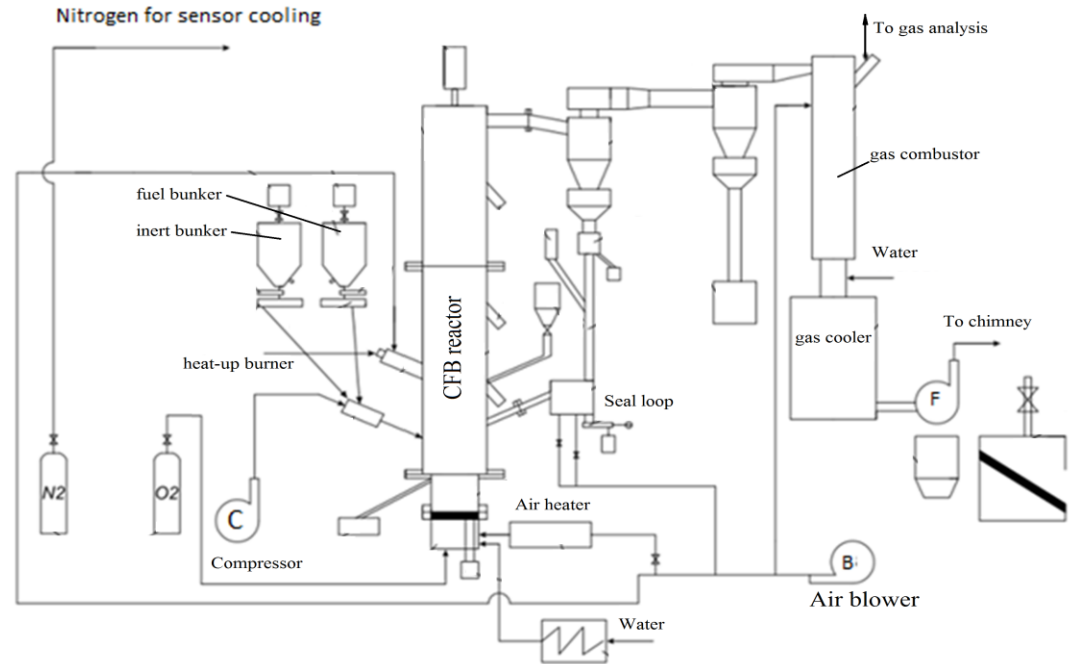
Useful data on municipal solid waste (MSW) of Astana

- Landfilling of MSW is well practised in Kazakhstan;
- Municipal solid waste of Astana city 1118 tones/day (Average value - 1.39 kg per person per day);
- 97% of generated MSW is send to landfill;

Composition of MSW from Astana city [Inglezakis et al., 2016]

MSW	Items	Percentage (%)
Organic	Vegetable and fruit parts, left-over foods, yard trimmings, wood	28
Inert	Rubble, ashes, yard sand bones	12.4
Plastic	Bottles, containers, polythene bags, parts of electrical and electronic goods, worn-out tires	18.5
Paper	Cardboard, newspapers, old/torn books, ruffled paper	13
Metal	Cans, household utensils, wires, auto and bike	0.9
Textile and leather	Clothes, footwear, bags, cutting from tailoring shops	9.8
Landscaping		1.5
Construction		1.4
Glass	Bottles, drinking glass jars, mirrors, louvers, auto windscreens, computer monitor screens	14.5

Experimental facility (L12 x W6 x H8 m)



CFB facility with capacity of 200 kW

Projects

On-going projects:

1. Investigation of municipal solid waste blending effect on reactivity of coals in circulating fluidized bed combustion and gasification processes.
2. Utilisation of landfill gas and leachate from municipal solid waste of Astana city. Process modeling of landfill gas utilisation.
3. Development of municipal solid waste (MSW) combustion and incineration technology for Astana (Kazakhstan); Effect of co-firing on combustion and gasification in CFB processes;

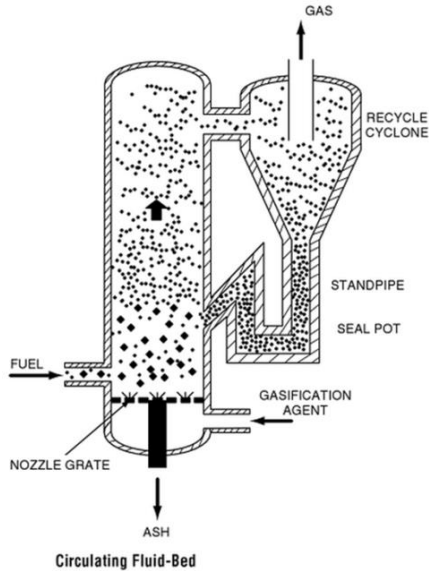
In collaboration with:

Research Engineering and Development Centre ERG (ERG);
The University of Sheffield, UK. **Funded by** Royal Academy of Engineering 20 k£ out of 50 k£ total.

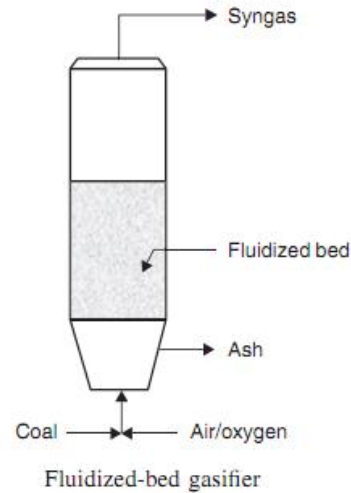
City council of Astana; Ekopoligon-Astana;
Budget: 14 mln tenge (40 USD).

In collaboration with:
Municipality of Astana city;
Funded by NU for 3 years

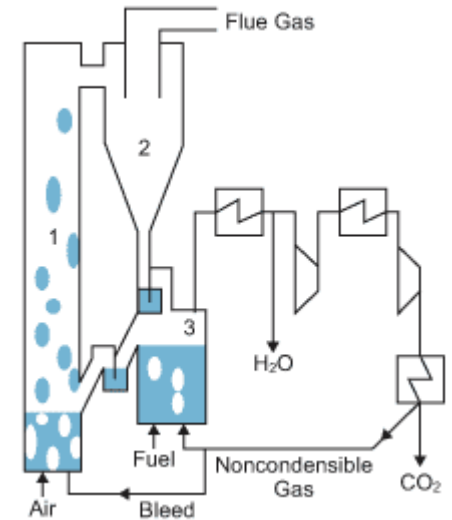
Prospective experimental installations



1) Circulating fluidized bed technology (large-scale CFB)



2) Fluidized bed reactor (FB)



3) Chemical looping cycle (CLC)

Acknowledgements

Should be addressed to colleagues:

MSc Diyar Tokmurzin (PhD Candidate, Researcher at NLA, NU);

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Internal collaborators: Dr V. Inglezakis (School of Engineering, NU);

Dr S. Pouloupoulos (School of Engineering, NU);

Summary

- Co-firing, biomass/MSW to energy could take an integral part in the energy sector of Kazakhstan;
- Reduction on coal use;
- Positive impact on greenhouse house emissions;

Thanks for your attention!