The Trend of Development for Low Rank Coal Utilization Technology and Issues toward the Spread

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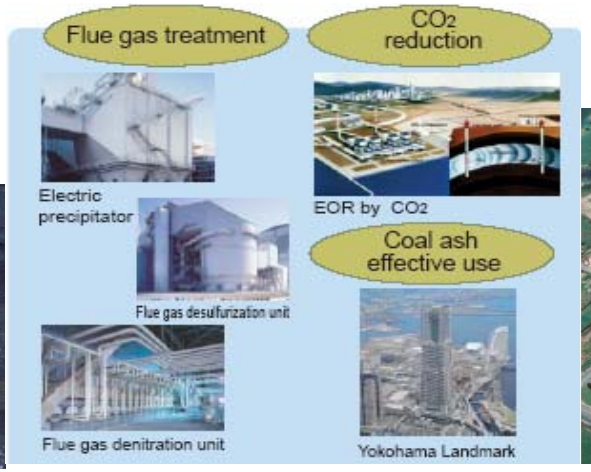
JCOAL

- Established as a foundation in 1990（with its origin back to 1948）
- Covers all coal related issues from upstream to downstream
- Promoting as “One-stop Shop for Coal”
- Member companies: 117 (as of Sep., 2015)
- Supervision by METI (Ministry of Economy, Trade and Industry of Japan)
- Budget: 2 billion yen（FY2013）
- Basic assets: 763 million yen
- Personnel: 68（as of Sep. 1, 2015）

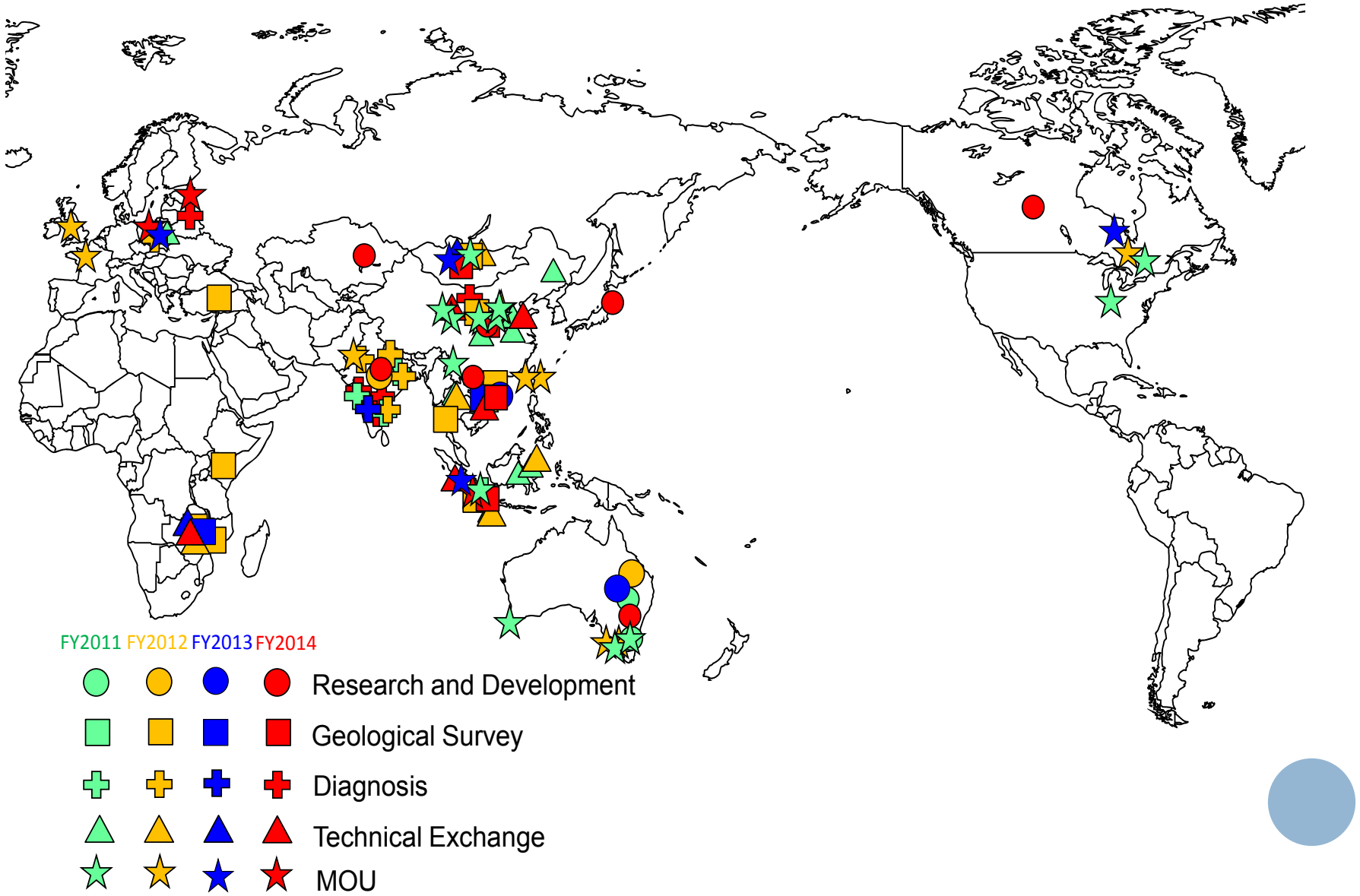
Exploration

Mining & Preparation

Promotion of environmentally friendly coal utilization



JCOAL Activities in the World



Coal Policy in Japan

◆ Security of stable supply of coal

○Security of stable supply of coal resource that contributes to stabilization of energy demand/supply and enhancement/ maintenance of industrial competitiveness.

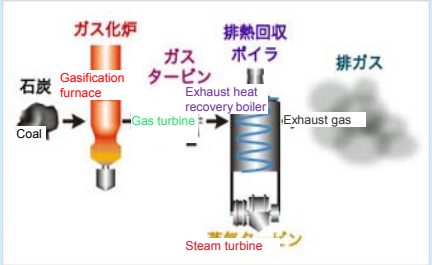
＜Security of interests＞
＜Enhancement of relationships with coal producing countries＞
＜Moderation of coal demand/supply (utilization of low rank coal)＞

【Policy tools】
- Policy discussions between governments
- Budget, investment/liability assurance, ODA, yen credit, JBIC, and NEXI

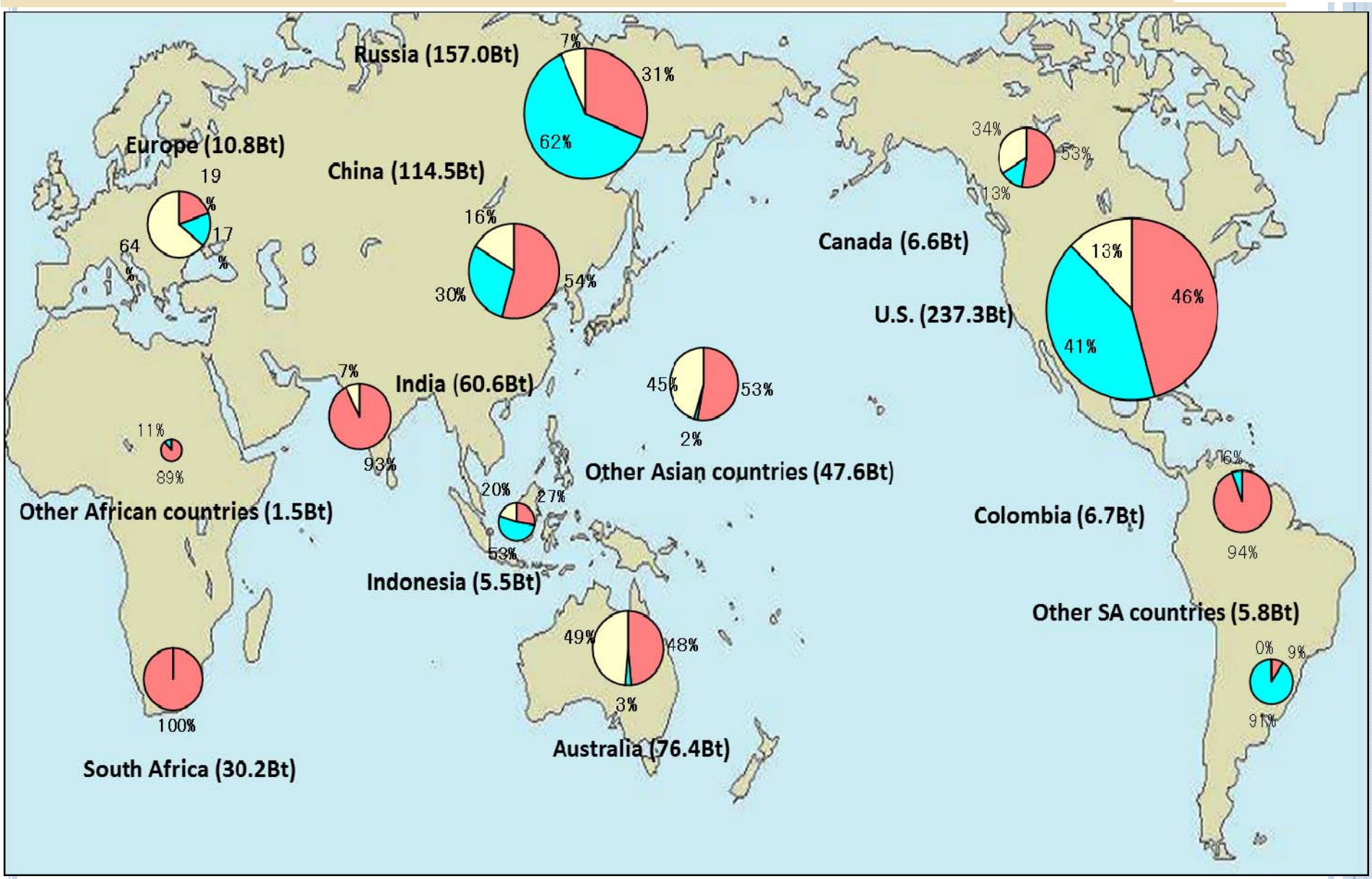
◆ Promotion of coal utilization technologies

○Development promotion and overseas deployment of clean coal technologies

＜Efficiency improvement, CO2 reduction, utilization of low rank coal, etc. ＞
＜Contribution to CO2 reduction overseas through overseas deployment of clean coal technologies＞



Recoverable Coal Reserves in the World



Source: WEC “Survey of Energy Resources 2010,” BP Statistics 2010

Reserves and Production

Proved Reserves

Unit : M ton

No.	Country	Bituminous / s / Anthracite	Sub-bituminous	Lignite	Total	(%)
1	USA	108,501	98,618	30,176	237,295	**26.6**
2	Russia Federation	49,088	97,472	10,450	157,010	**17.6**
3	China	62,200	33,700	18,600	114,500	**12.8**
4	Australia	37,100	2,100	37,200	76,400	**8.6**
5	India	56,100		4,500	60,600	**6.8**
6	Germany	99		40,600	40,699	**4.6**
7	Ukraine	15,351	16,577	1,945	33,873	**3.8**
8	Kazakhstan	21,500		12,100	33,600	**3.8**
9	South Africa	30,156			30,156	**3.4**
10	Indonesia		28,017		28,017	**3.1**
11	Serbia	1	10	13,400	13,411	**1.5**
12	Turkey	322		8380	8702	**1.0**
13	Colombia	6,366	380		6,746	**0.8**
14	Brazil		6,630.		6,630	**0.7**
15	Canada	3,474	872	2,236	6,582	**0.7**
16	Poland	4,178		1,287	5485	**0.6**
17	Greece			3,020	3,020	**0.3**
18	Bosnia・Herzegovina	484		2,369	2,853	**0.3**
19	Mongolia	1,170		1,350	2,520	**0.3**
20	Bulgaria	2	190	2,174	2,366	**0.3**
	Other	7,105	2,767	11,213	21,065	**2.4**
	World Total	403,197	287,333	201,000	891,530	**100.0**

SOURCE) Survey of Energy Resources 2013, WEC

Life of minable Coal Coal

Total Coal Reserves	119 year
Bituminous /Anthracite	73 year
Sub-bituminous & Lignite	**245 year**

Utilize LRC by priority which is the long life in the kind of Coal

Coal Production

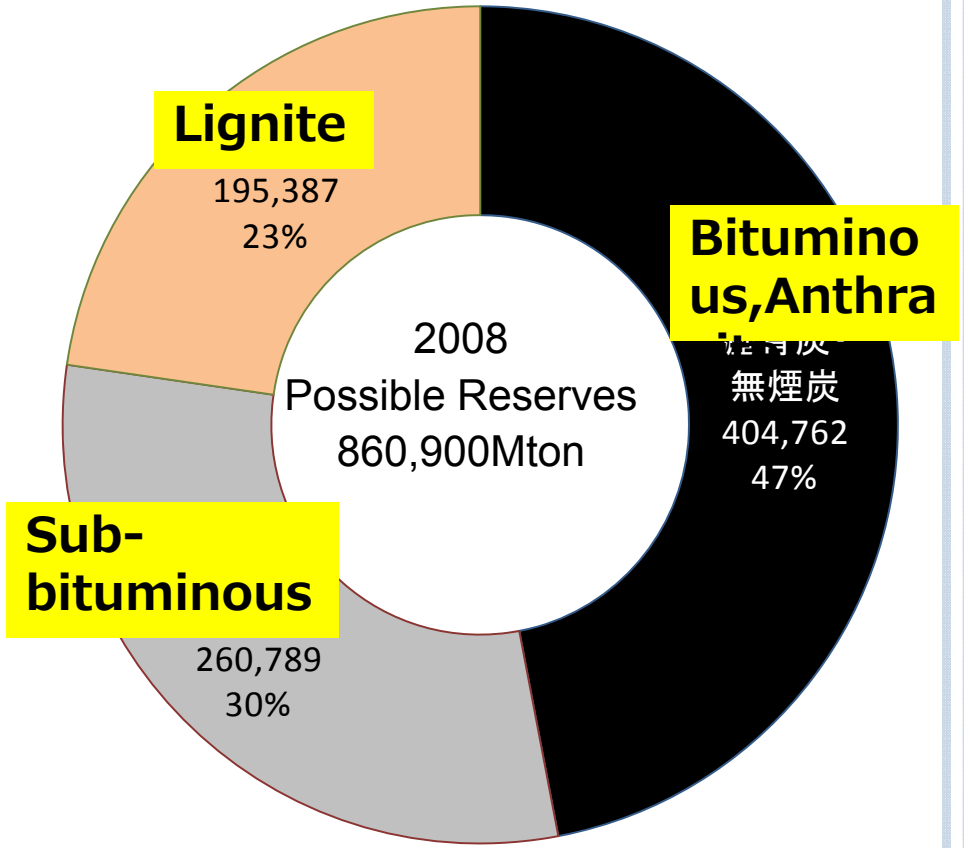
Unit : M ton

No	Country	Bituminous / Anthtacite	Sub-bituminous	Lignite	Total
1	USA	500.5	510.5	81.0	1,092.0
2	Russia Federation	246.0		80.5	326.5
3	China	3,236.8		146.9	3,383.7
4	Australia	295.6	36.5	65.5	397.6
5	India	483.7		32.1	515.8
6	Germany	12.9		176.5	189.4
7	Ukraine	59.5		0.2	59.7
8	Kazakhstan	116.3		8.4	124.7
9	South Africa	251.0			251.0
10	Indonesia		353.3		353.3
11	Serbia	0.0	0.7	40.0	40.7
12	Turkey	2.6		74.3	76.9
13	Colombia	85.8	0.0		85.8
14	Brazil		5.5		5.5
15	Canada	34.6	22.8	9.7	67.1
16	Poland	67.6		62.9	130.5
17	Greece			65.7	65.7
18	Bosnia・Herzegovina			11.2	11.2
19	Mongolia	0.2		9.6	9.8
20	Bulgaria	0	2.7	34.5	37.2
21	Czech Republic	11.3		46.6	57.9
22	Vietnam	39.8			39.8
23	North Korea	26.0	7.4		33.4
24	Thailand			18.0	18.0
25	Romania	2.8	0.6	31.8	35.2
26	Spain	7.3	2.9		10.2
27	Slovenia		0.5	4.0	4.5
28	Other	44.8	30.6	23.6	99.0
	World Total	**5,525.1**	**974.0**	**1,023.0**	**7,520.1**

SOURCE) Survey of Energy Resources 2013, WEC

LOW RANK COAL

- Almost half of reserves are Low Rank Coals in the world.
- Japan has been using high grade of Bituminous Coals.
- Supply of Bituminous Coals will short ?
- Japan should develop clean utilization of Low Rank Coals to have stable supply of coals.
- Japan will also contribute with Low Rank Coal Utilization Technology in the future.

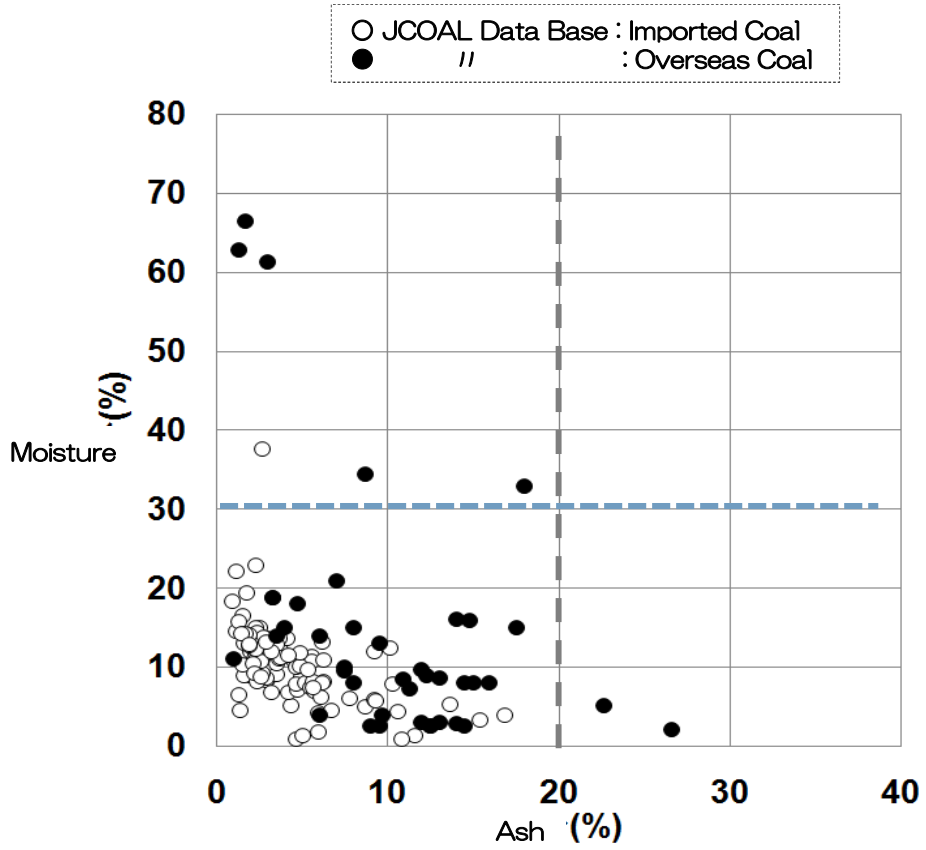


From WEC

LRC Definition & Aspect（1）

Coal Aspect Data in the Japanese Coal Bank

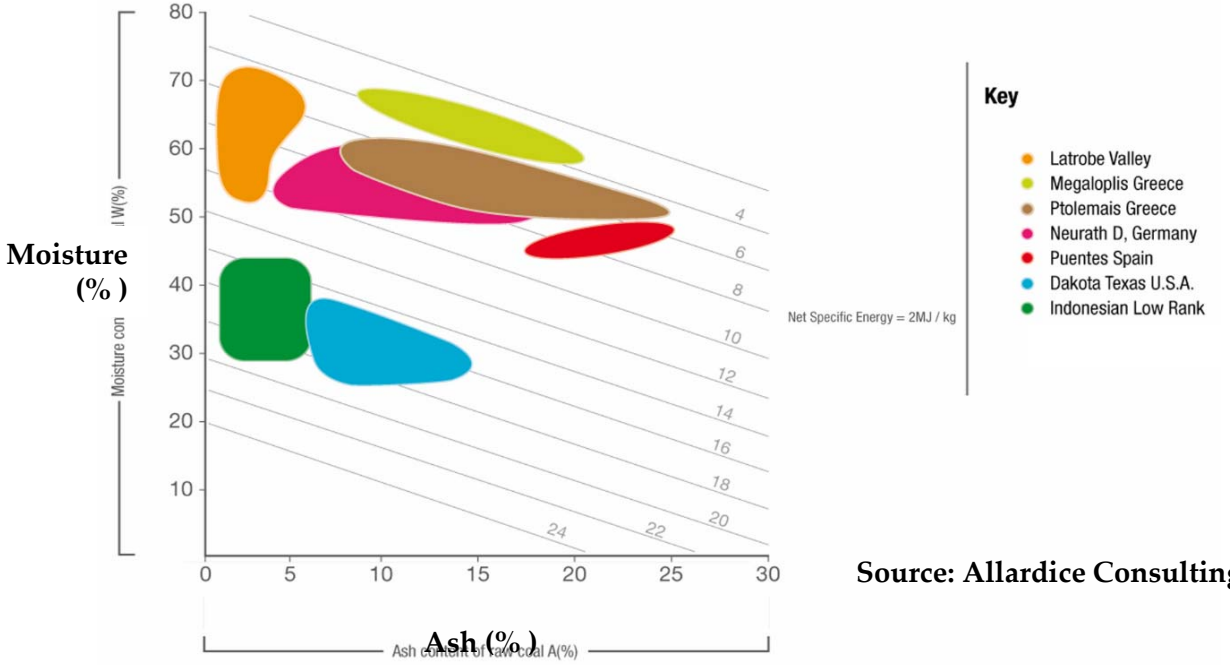
- Calorific Value(HHV)； 5,700kcal/kg（daf）≧
- High Moisture Coal；30%≦
- High Ash Coal；20%≦
- High Sulfur Coal；1.5% ≦



LRC Definition & Aspect（2）

- LRC : utilize in the Industrial field and is not International Article for Trade
- Definition : is different depending on produced countries, and are no unified standards, generally, using calorific value as a guideline.
- Kind of Coal : Sub-bituminous coal and lignite

IEA	■ Lignite & Sub-bituminous ■HHV≦5,700kcal/kg（daf）、Volatile Matter ≧31%(daf). However not include Sub-bituminous in case of 11 countries（Japan, Australia, USA, etc.）
ASTM	HHV≦10,500Btu/ l b（5,833kcal/kg）
Indonesia	Medium（5,100～6,100kcal/kg）& Low（～5,100kcal/kg）as National Standard
China	HHV ≦24MJ/kg（5,732kcal/kg）



Source: Allardice Consulting

R & D, Commercialization for LRC

- Subject Technology : Drying, Reforming, Gasification, Coking
- Target Countries : Indonesia, Australia, mainly etc.

Subject Technology	Use Application	Process	Development Company, University	Status	Target Country
Drying	Electricity	—	MHI, Tokyo Uni.	Pilot Test	Australia
Drying	Electricity	STD	Tsukishima, Sojitsu	Commercialize	Indonesia etc.
Reforming	Electricity	UBC	Kobelco	F/S for Commercialize	Indonesia etc.
Reforming（Fluidization）	Boiler Fuel	JCF	JGC	Demonstration P	Indonesia etc.
Combustion	Electricity	CFBC	SHI	Commercialize	Indonesia etc.
Gasification	Fertilizer etc.	TIGAR	IHI	Demonstration P	Indonesia etc.
Gasification	SNG etc.	—	MHI	F/S, Commercialize	Indonesia etc.
Gasification	SNG etc.	ECOPRO	NSENGI	Pilot P & F/S	China
Gasification	Liquid H2	—	KHI	F/S for Commercialize	Australia
Pyrolysis	Electricity	—	KEPCO, Kyushu Uni.	Pilot P & F/S	Australia
Coking	Casting etc.	—	Kyushu Uni. NSENGI Gr.	Basic Study	Indonesia
Coking	Steel etc.	SCC	Chiyoda Itochu	Basic Study	Indonesia
Pyrolysis	Steel etc.	PCI Coal	MHI	Pilot Test	Indonesia, etc.

Brown Coal Liquefaction Project（BCL）

- Operation Period : 1982 ~ 1990、 ■ Site: Morwell, Latrobe Valley, Victoria, Australia
- Company Name：Brown Coal Liquefaction of Victoria Pty（BCLV：Kobe Steel Ltd、Mitsubishi Chemical Corporation、Nissho Iwai Corporation、Idemitsu Kosan Co, Ltd.、Cosmo Oil Co, Ltd = 5 Companies J/V）。
- Total Project Period:1982 ~ 1990　50t/d（db）Pilot Plant
  Construction : Stage I :1982 ~ 1985、Stage II ：1985 ~ 1987.
  Operation : Stage I : 1985 ~ 、Stage II :1987 ~ 1990.
- High oil yield over 50%（Achieved at 52%）、Continuous and stable operation for longer than 1000hours.（Achieved at 1056hours)、De - ashing performance at ash concentration less than 1000ppm.(Achieved at700ppm).

Photo 1 Fifty t/d Pilot plant (Australia)

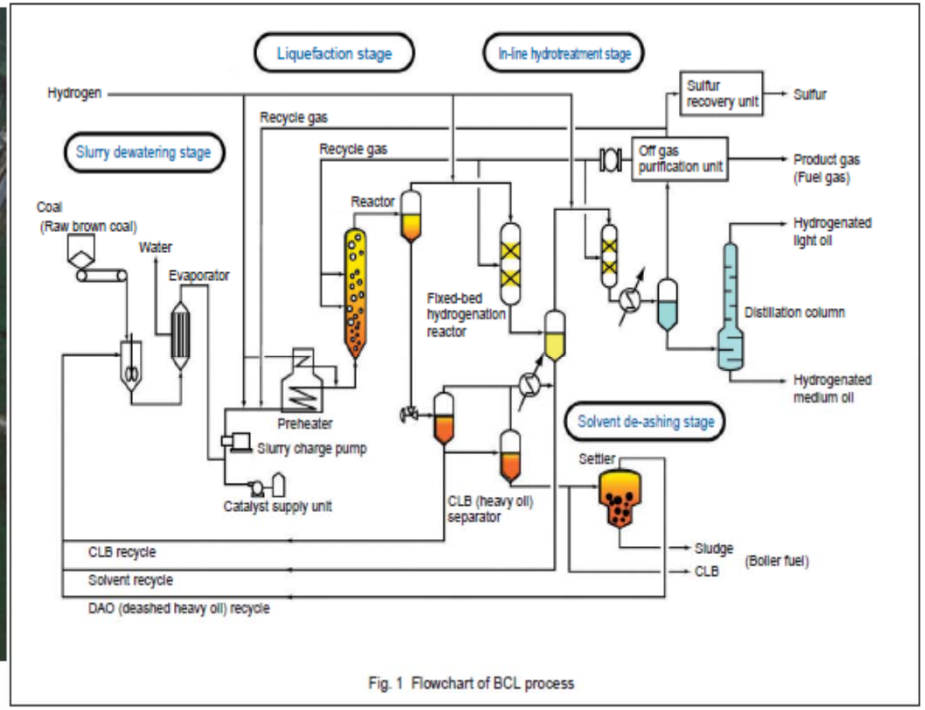


Fig. 1 Flowchart of BCL process

Opinion for Lignite liquefaction Project(BCL)

1 The reason was not commercialized (commodification)

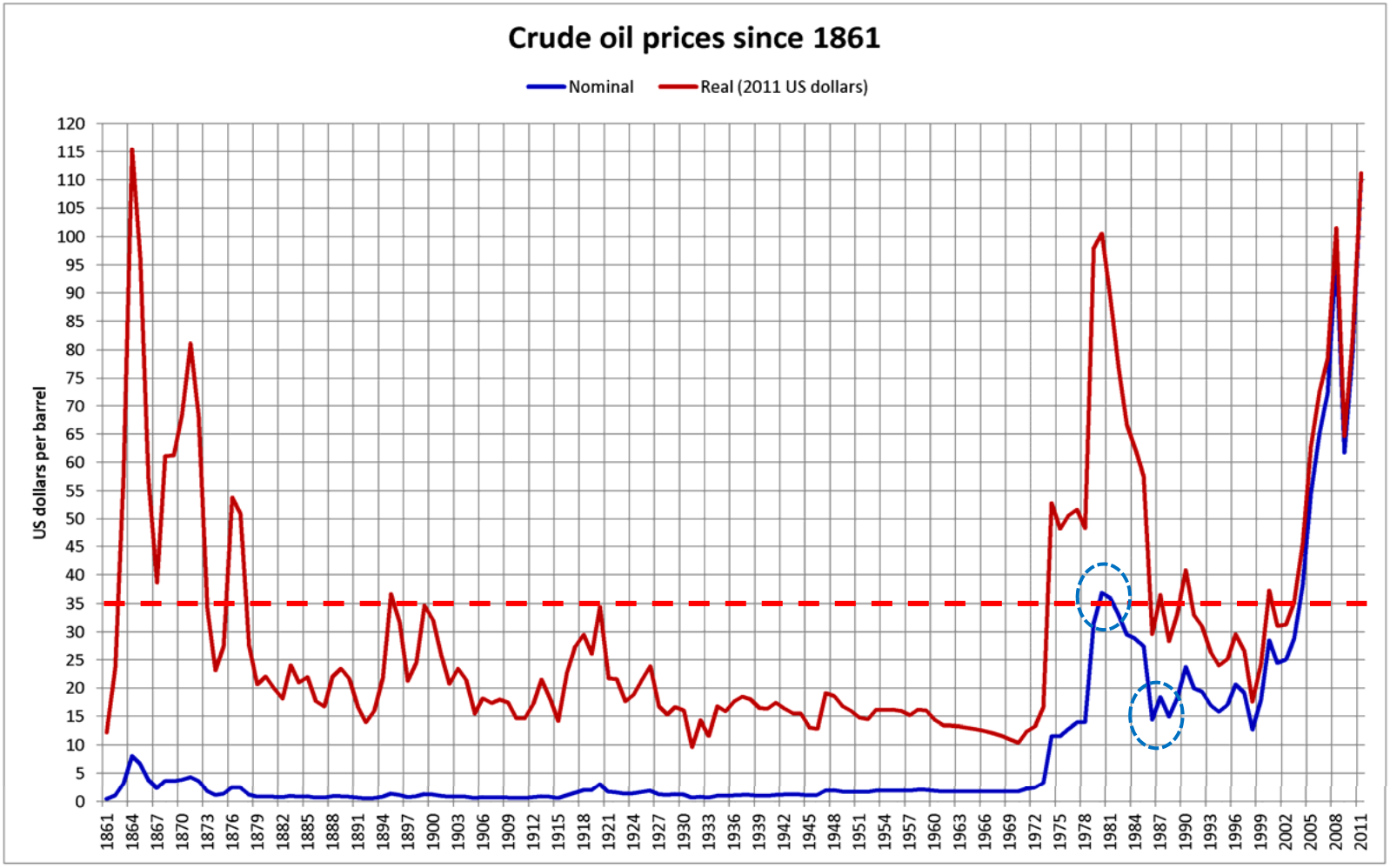
- ✓ The collapse in world oil prices after the project commenced. This was seen as the over-riding reason for the cancellation of oil from coal projects around the world and particularly affected the economic viability of any commercial BCL proposal.
- ✓ The high cost of funds for Australian partners (high local interest rates for debt financing)
- ✓ The increasing capital and construction cost of chemical processing plants. Strikes were held frequently.
- ✓ The identification of suitable low rank coals with lower moisture content in Indonesia, coupled with shorter transport routes to the Japanese market, led to a lower delivered cost of an Indonesian oil from coal product in Japan.

2 Opinion

- ✓ There was the just cause called the securing of energy security, but a project is started based on the oil price prospect that is considerably higher than a fact, and there is room for improvement such as the objective setting of the cost target.
- ✓ The oil price had already fallen at the time of the construction start of Stage II and should have classified a price reduction into an target of the technology development.
- ✓ JV Co. management permitted the frequent occurrence of the strike without being able to hold the management of the local worker, and the personnel management including the appointment to the management of the local staff has considerable improvement room.
- ✓ The Australia side felt dissatisfaction in the Japanese staff asking a judgment of the head office by the close decision making, needing time for the agreement formation between JV companies again. When I compose JV, Consortium, the quick system which can make decision is indispensable.
- ✓ As a result, term of works, cost increased twice or more as much as the assumption, and the cost management was not possible.

Opinion for Lignite liquefaction Project(BCL)

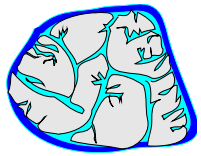
Trend of Oil Price



UBC (Upgrading of Low Rank Coal)

- World Demand for Coal is surging in many countries as well as in China and India. It is anticipated that low rank coal, which is well-distributed all over the world, will be utilized on a large scale.
- UBC process changes low rank coal into high quality coal with clean property and that will be utilized in the international market energy source.
- UBC process can be applied for upgraded low rank coal to development to an international coal market.

Raw LRC

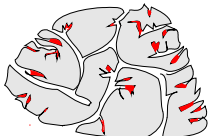


- Low Calorie (High Moisture)
- Self-Heating
- Local Energy

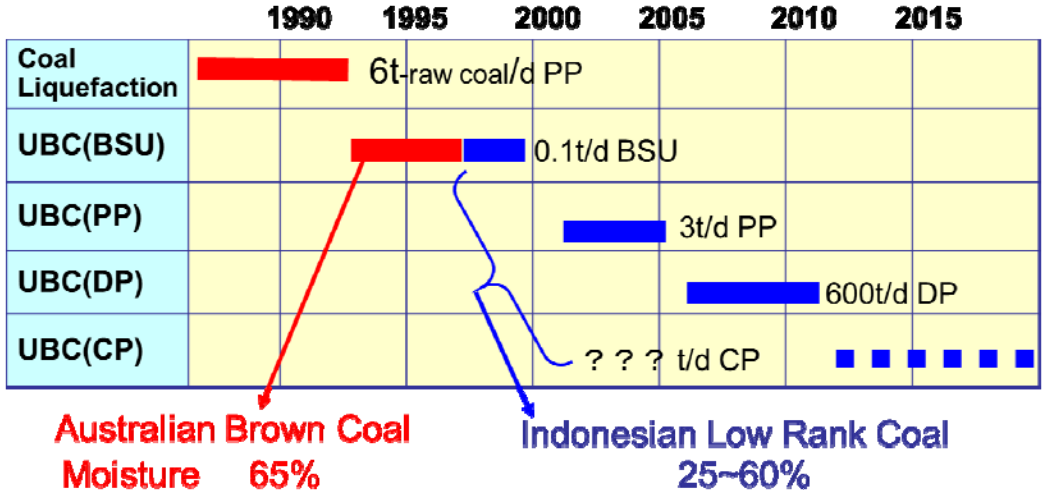
- Economical Dewatering
- Product Stabilization

Upgrading

UBC



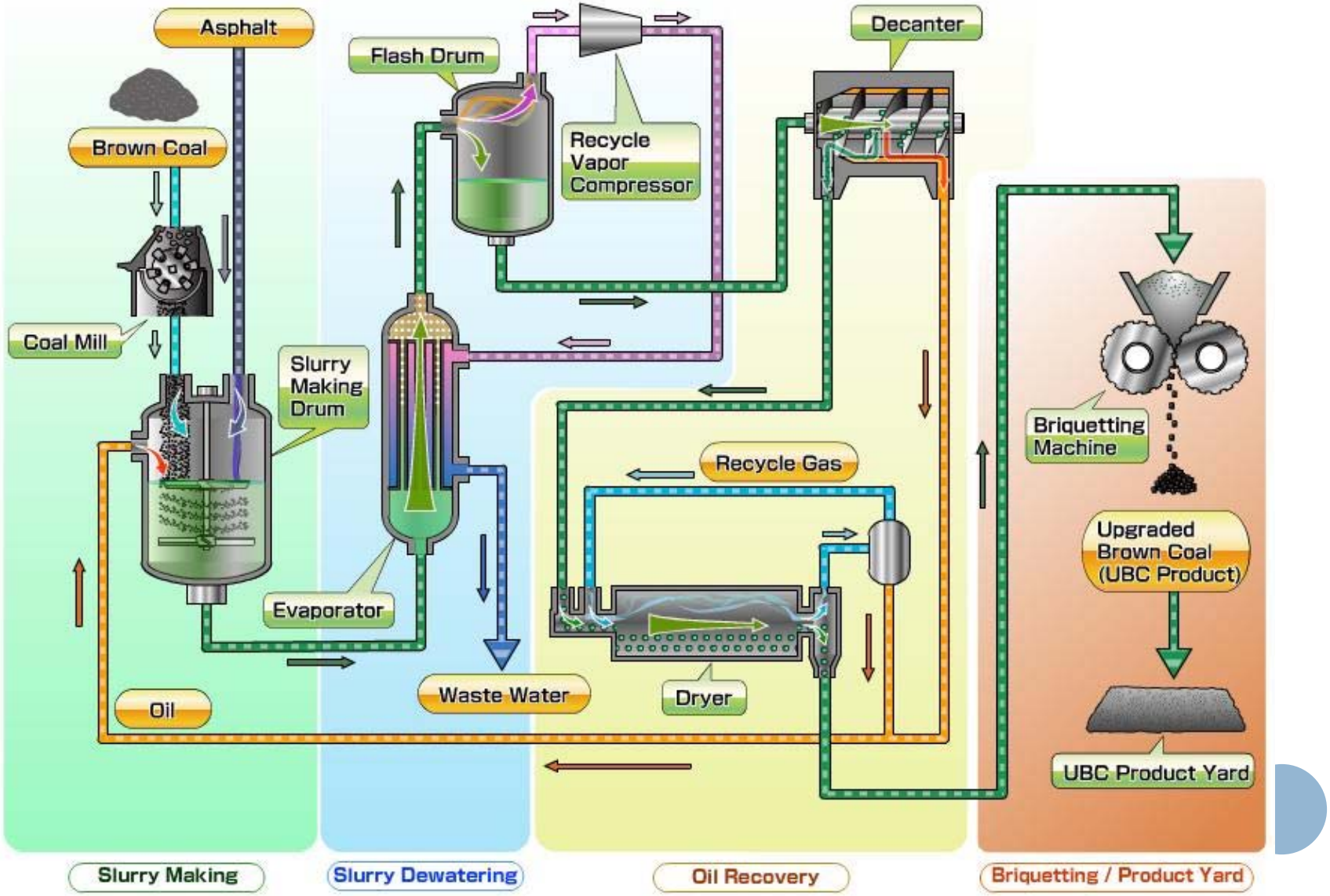
- Abundant Resource
- Clean Property
  Low ash, Low sulfur
- High Combustion Rate
- Low Cost



- 600t/d Demonstration plant (1,000 t/day on feed coal basis)
- Location: Satui, South Kalimantan

- A feasibility study for a 5-million-ton/y project in Sumatra is now under way.
- Kobe Steel is ready to discuss commercial projects with mine owners, power utility companies, traders and engineering companies.

Process Flow



Opinion for Upgrading of LRC －UBC (Upgraded Brown Coal)－

1 The reason was not commercialized (commodification)

- ✓ Reforming cost results (USD20/ton) exceeded the target value (USD15/ton).
- ✓ It's also a cause the reason that the reforming cost became expensive depended because it was changed to more low rank South Sumatra coal (moist. 60%, 2500kcal/kg) from the marketable coal (moist. 35%, 4200kcal/kg) which had gone out to first schedule coal type as well as a technical reason
- ✓ The infrastructure cost was high because the site was changed to a distant site in South Sumatra, so the FOB cost of production wasn't competitive any more.
- ✓ There was evaluation that a UBC process is complicated and costs a lot more than other processes from the local side.

2 Opinion

- ✓ The quality of raw coal, the procurement cost and a perspective of market conditions of an end product were insufficient, and while proving, the procurement company of raw coal supply was changed.
- ✓ It became that it took for the enormous cost in an infrastructure arrangement as a result. It should be more deepen consideration that such as searching for an inexpensive site of the infrastructure cost.
- ✓ It's a high evaluation that an off-taker (overseas electric enterpriser) was already fixed. When the market conditions improve ,as thinking in optimistic way, there is a possibility of the commercialization.

Improvement in the management of National Project

1 Selection of support coverage & Study of cost cut in the National PJ

Up to now, Player aimed at technical novelty too much at the selection point of a project. Therefore it was liable that the technology with a lot of hurdles was being selected until commercialization.
Originally, commercialization should be the technical development project which supports business-push including cost reduction technically targeted near completion.

2 Objective cost setting target

Up to now, a manufacturer put cost target setting into effect. As a result, cost setting often became superficial and the demonstration which (tends to be the cheap of raw coal price and the rather high of end-product price) couldn't support the user's investment decision sufficiently. The Objective cost setting is a key factor of success, and the player which manages should establish a realistic cost target.

3 Build up of Operating Structure

Up to now, unit of R & D of a manufacturer was doing complete patronage from planning stage until plan decision through project management and execution and it was an unreasonable system. Player should include the user in a system from the planning stage of R & D and development primarily, establish the target which the user is convinced by business model.