Brazil-Japan cooperation in the Brazilian energy sector

Ultra Super Critical (USC) Power Plant F/S result and further possibilities

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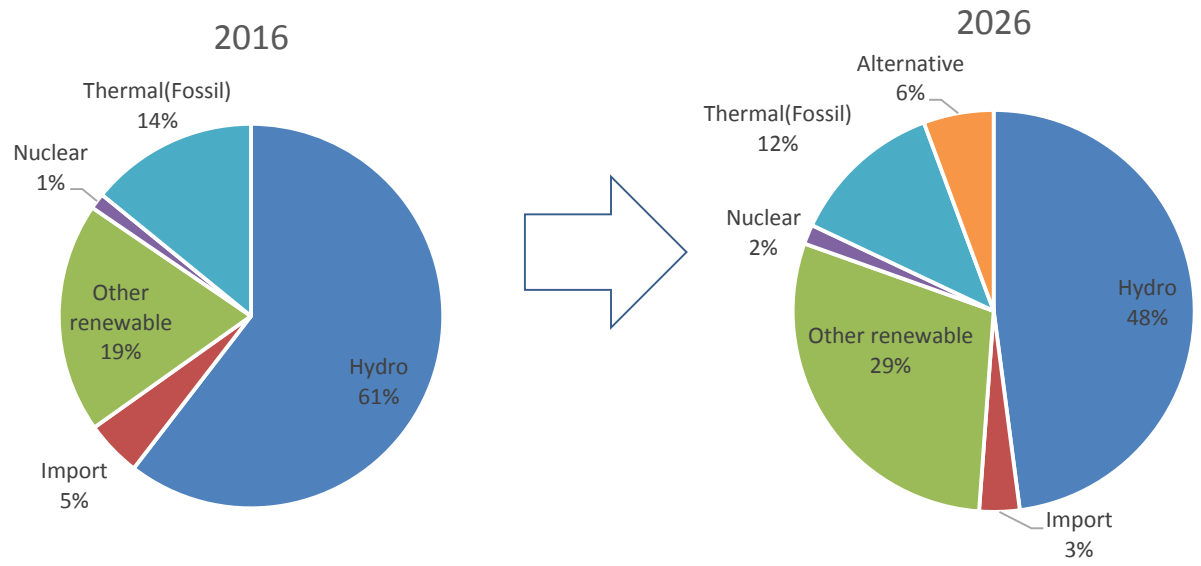
1. Shift in Brazilian power sector

Brazilian Power Sector

Diversification of power source is growing in importance

- Electricity consumption is expected to grow average 1.51% per year from 2016 to 2026
- Brazilian authority is planning to develop 67.5GW new generation units in 10 years
- Share of hydro will shrink from 61% (2016) to 48% (2026), and that of other renewables (wind, solar, small hydro, biomass) will increase from 19% to 29% instead
- Composition of generation types for each load (base-load to peak-load) to be revised
- Action to stabilize the grid, which is getting unstable due to drastic increase of renewable power, is required to be taken promptly

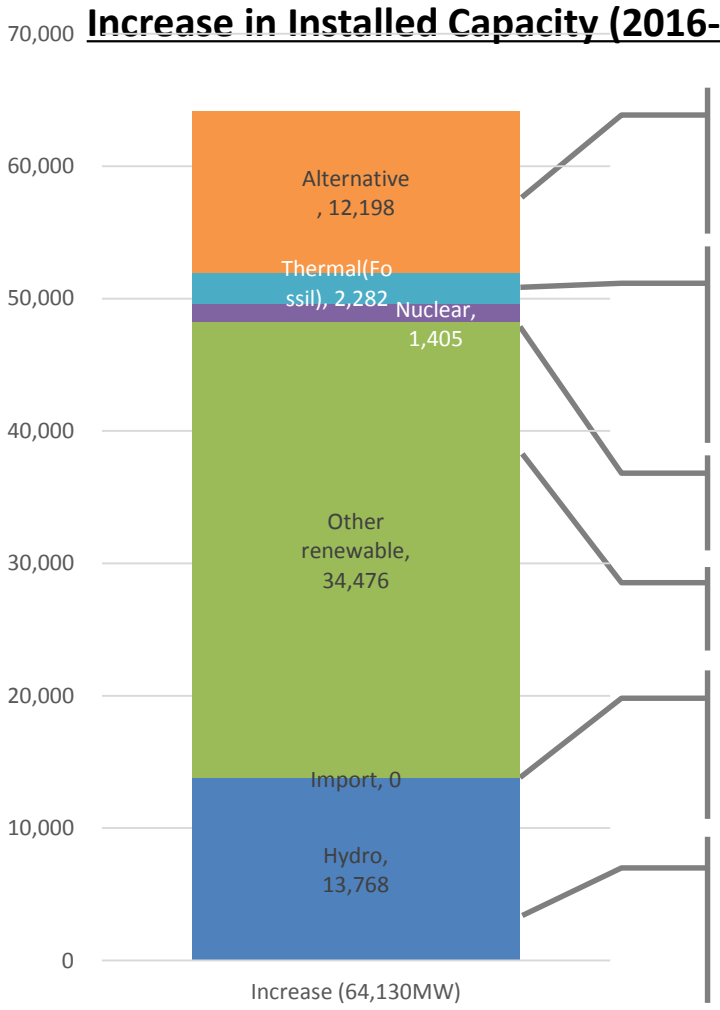
Proportion of Generation Typeby Installed Capacity (2016 and 2026)



Source: PDE2026 draft

Increase in Installed Capacity towards 2026 (67,524MW)

Various tasks are identified for development of each type of generation systems



Source: PDE2026 draft

Issues for development

Alternative:

- Pumped-sorage hydro, Storage battery, Open-cycle etc.are indicative alternatives

Thermal (incl. Oil and Diesel ▲2,800MW)

- Energy security (especially gas pipelines)
- Use of local natural resource (Presal, coal, etc.)
- Modernization of old coal-fired TPPs

Nuclear:

- Technical difficulties

Other renewables:

- Unstable generation pattern and its impact to the grid

Import:

- Currency exchange for imported electricity
- Expiring importation contract from Paraguay (Itaipu) in 2024

Hydro:

- Decreasing reserved water capacity
- Environmental concern
- Long transmission line from upper Amazon area

2. Japanese Clean Energy Technology

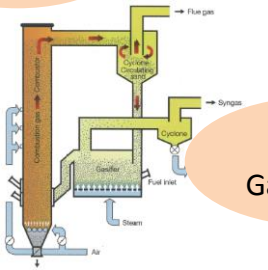
Potential of Japanese technologies

Potential for contribution

With long-term efforts to improve efficiency and save energy, Japan has many tools to contribute to the sustainable development of Brazilian energy sector


In-ground LNG storage tank

LNG Storage



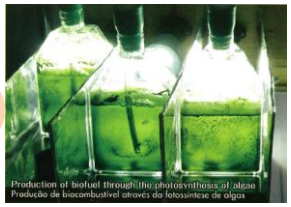
Coal Gasification

Upper stream

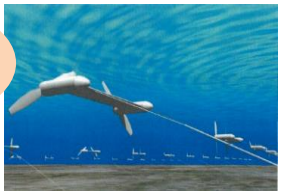
Supply chain

Lower stream

Algae Biofuel



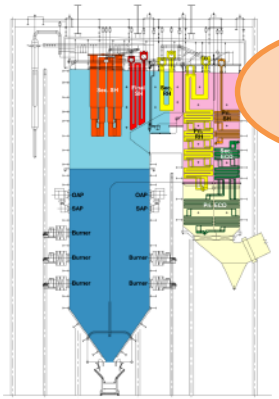
Current Flow



Proven

Technical maturity

New technology



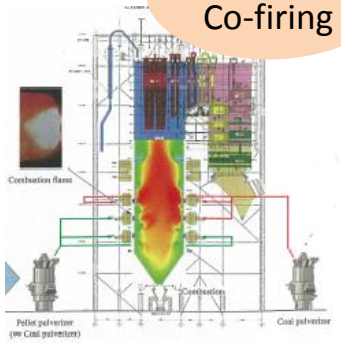
USC

IGCC

A-USC

OTEC

Biomass Co-firing



Smart Grid

Power Storage

Recent progress of New technology

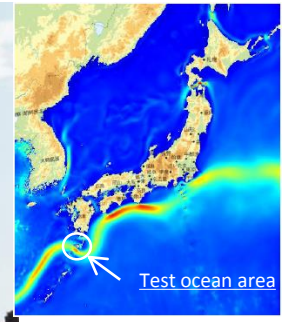
1) Current flow power generator

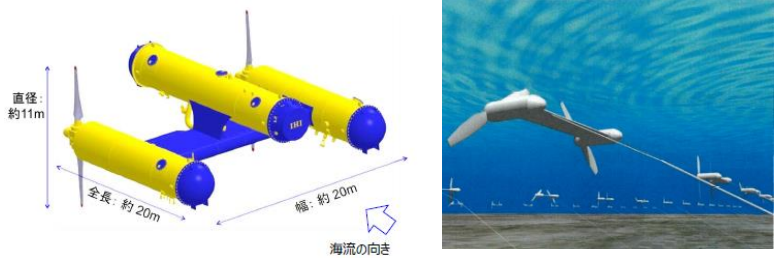
100kW demonstration model was completed (July 7th)

2) Ocean Thermal Energy Conversion (OTEC)

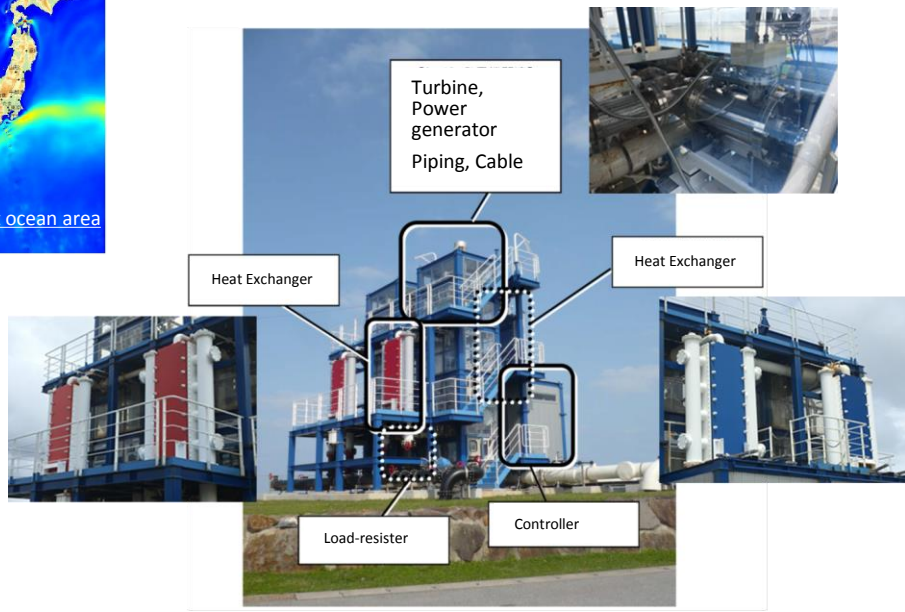
2 stage rankine cycle high efficiency HX (heat exchanger) research test was finished (June 30)

100kW demonstration model





Current flow power generator



OTEC at Kumejima Island

3. USC Coal-fired Thermal Power

As one of possibilities for future collaboration

View on coal-fired thermal power in PDE 2026

Higher efficiency is key to implement the modernization of old existing power plants and to obtain finance for development of coal-fired TPPs from green field

Modernization

- *By replacing old power plants with modern and highly efficient technology, it is estimated that installed capacity can be* ***increase to 1,735 MW (+340MW) by maintaining the same volume of emission***

⇒ ***USC could be a practical options for replacement in middle terms***

Finance

- *New coal-fired TPPs face difficulties in obtaining long term financing.*
- *For new technologies, such as* ***CCS and IGCC****, could be an option for future development* ***after 2026, due to its technical immaturity***

⇒ ***ECA finance is applicable for USC Technology under OECD guideline: Possibility of bringing Japanese public finance to Brazil***

List of candidate plants for Modernization

Usinas	Potência (MW)	Eficiência (%)	Idade (anos)
Charqueadas (1)	72	20,5	54
São Jerônimo (2)	20	14,3	63
J.Lacerda I e II	232	25	51
J.Lacerda III	262	28	37
J.Lacerda IV	363	34,7	19
P. Medici A	126	24,5	42
P. Medici B	320	25	30
Total	1.395	24,57	42,28

Notas: (1) UTE desativada em
(2) UTE desativada em

1735MW

Source: PDE2026 draft p.63

2-year Feasibility Study funded by NEDO

Introduction of Clean Coal Technology to Brazil using Japanese high-efficient USC plant and Brazilian domestic coal

Study in FY2015 (TEPCO, PwC Japan)

- *Identified potential for USC Plant, in Baixo Jacui area of Rio Grande do Sul State*

Study in FY2016 (IHI, TEPCO, PwC Japan)

- *Specific feasibility study of the USC Project at the Baixo Jacui mine mouth*

Assumed Project Summary（F/S Basis）

Plant type	USC coal-fired thermal power
Capacity	1,000MW（net）
Fuel	Coal from Baixo Jacui, RS state
Site	At Baixo Jacui Mine mouth
Auction	Participate in A-5 Auction to be hold by MME
Business type	IPP
Contract	Long term PPA
Finance	ECA finance

High potential of USC as a base load in Brazil

Important Findings of Feasibility Study –

MAIN FINDINGS

A) Policy

- Concept of the project fits to the **modernization policy** of Brazilian coal-fired TPPs.

B) Technical and Environment Aspects

- **Boiler design** needs to consider lower heating value, high ash content, and high erosion/abrasion impact of Baixo Jacui coal
- Considerably **low level of emission gas** (Sox, Nox, dust) concentration, and reduction of **1.1million ton/year of CO2 emission** in Brazil

C) Economy of the Project

USC would be **competitive**, but need a careful study of project scheme, including debt/equity

A) MODERNIZATION POLICY

USC Project with Japanese proven technology and O&M expertise has a great potential to contribute to the Modernization Policy

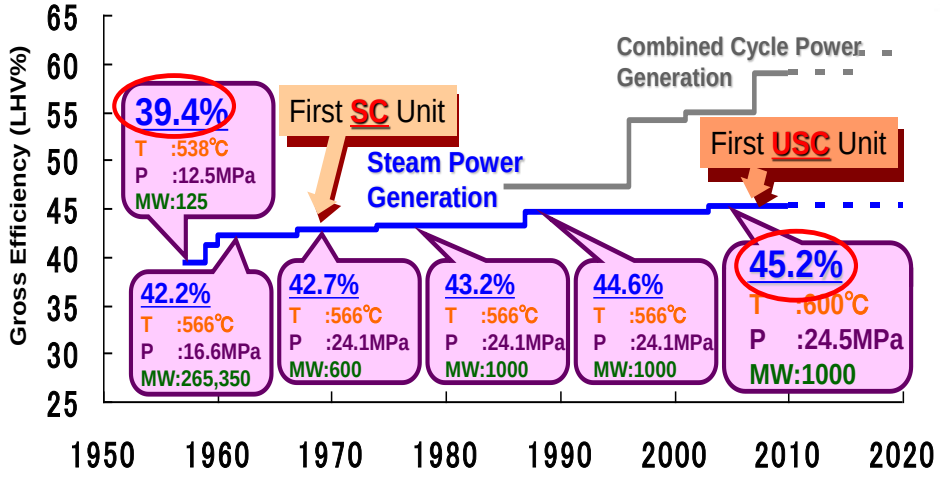
Modernization Policy in Brazil

- *Seven candidates (total 1,395MW) with **average efficiency 24.57%** and operating 42.28 year (ave) are subject to the Modernization Programme*

Japan Technology and O&M

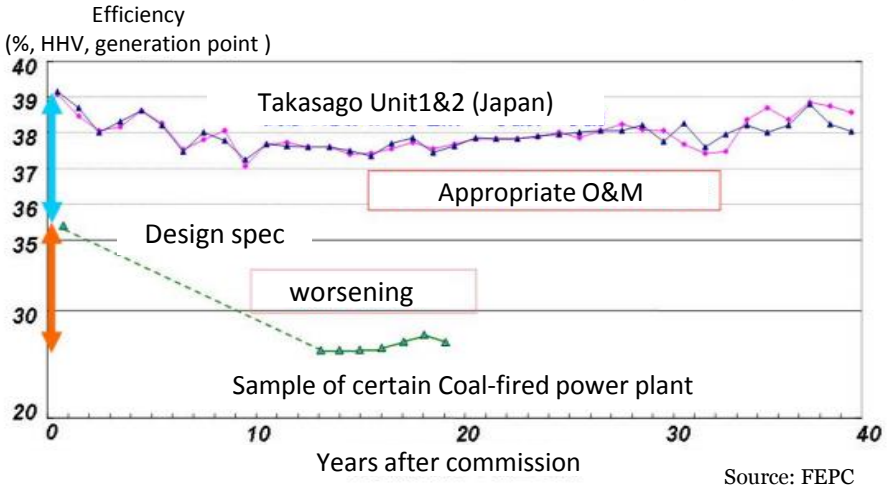
- *Japan has developed technology for higher **thermal efficiency (>40%) since 1960's**, and **USC has 10 years of track record***
- *Appropriate **O&M** by Japanese operators helps power plants to **maintain high efficiency***

Development of thermal efficiency (TEPCO)



Source: Tepco

Efficiency Trend After Commission in Takasago power plant



Source: FEPC

B) TECHNICAL AND ENVIRONMENT ASPECTS

USC technology enables Brazilian coal to achieve high level of thermal efficiency, with lower impact to the environment and competitive CAPEX

Boiler

Test coal import
BJ Coal
CE5200 & CE4700

Test in
IHI Japan

Design concept
- BJ Coal can be applied for USC Boiler
- Some coal characteristics need to be considered

Emission Control

	SOx mg/Nm3	NOx mg/Nm3	Dust mg/Nm3
Plant A, South region	950	600	65
Federal regulation	400	400	50
USC F/S IFC Standard	200	200	30

Overall engineering

Target thermal efficiency:
45% (Gross), LHV
From reference USC plant in Japan

ESTIMATION

RESULT 1

CO2 reduction : 1.1mln t/year *(*)*

= ▲15% from average CO2 emission (in 2015) among existing coal-fired TPPs

RESULT 2

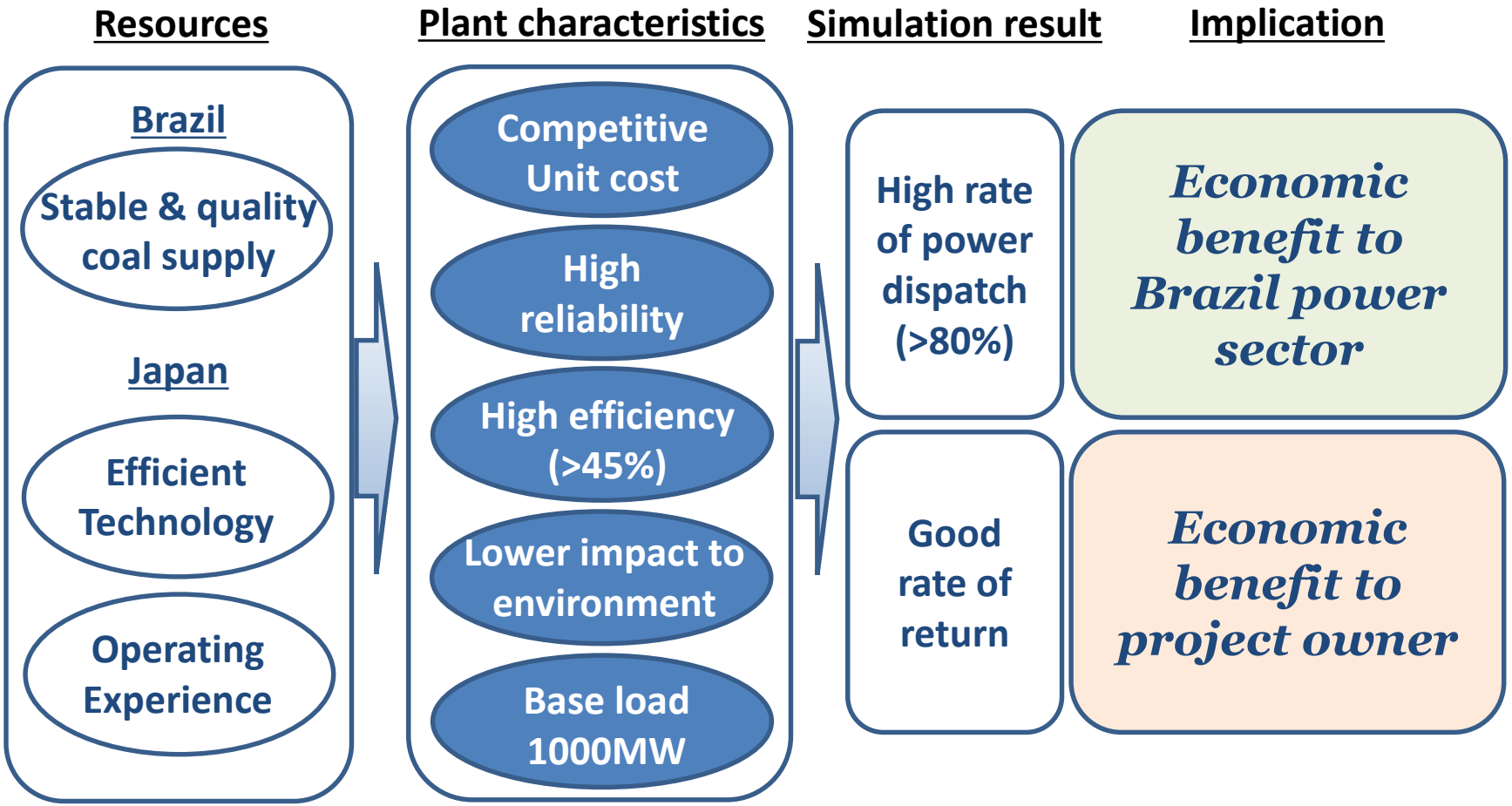
CAPEX: USD 2,000/kw *(**)*

= as competitive as EPE's assumption of CAPEX for a new subcritical coal-fired TPP (efficiency<40%)

(*) Simulation based on the average thermal efficiency η of all coal-fired TPPs in Brazil (in 2015), with certain assumptions of availability (85%), Net calorific value of coal (5,200 for USC, 4,225 for existing plants), carbon content (Brazilian standard), etc.
(**) Based on assumptions made for feasibility study purpose only. Ex-rate USD=R$3.26, USD=JPY114.69

C) ECONOMIC ANALYSIS

Stable power supply from "large scale base load USC Plant" has a big potential to bring benefit to both project owner and Brazil power sector/consumers



C) PROJECT SCHEME

Exchange risk control indispensable to attract Japanese investors and Public Finance for USC

Debt

- Japanese government supports the utilization of Ultra Super Critical (USC) and public finance can be provided

Equity

- Japanese investors, seek new international investment opportunities which utilizes standard technology already in use in Japan.

- Exchange rate risk mitigation indispensable for long term loan and investments.

- Other countries in Asia and in Latin America (ex. Mexico), provide hard currency linked tariff .

Foreign currency linked Tariff is one of key factors to realize USC project in Brazil

Project development efforts after F/S

To be ready to participate in the Auction in an appropriate timing…

1. Building firm relationship with R/S state

- *R/S mission to Tokyo*
  - *Exchanging opinion for the development of USC*
  - *Visit to IHI Headquarters and to Hitachinaka USC power plant (TEPCO/JERA(*))*

2. Study other possible finance schemes

3. Discussion among potential investors is ongoing

4. Prepare for environment assessment

etc.

Missão gaúcha ao Japão busca investimentos e promove o carvão do RS

Publicação: 31/05/2017 às 17h02min

Missão gaúcha ao Japão Cópia

Uma missão liderada pelo governador José Ivo Sartori estará no Japão, entre os dias 5 e 8 de junho, para apresentar as potencialidades do Rio Grande do Sul e atrair novos investimentos para o estado. Também faz parte da agenda, a promoção do carvão gaúcho, em encontros com o governo japonês e empresas do setor de energia. O roteiro inclui as províncias de Tóquio, Shizuoka (Hamamatsu e Iwata) e Shiga (Otsu). A comitiva parte de Porto

Source: www.sema.rs.gov

(*) JV of Tokyo Electric Power Group and the Chubu Electric Power Group

4. Future cooperation between Brazil and Japan

Further contribution in the energy sector

Strengthen Relationship Brazil & Japan

7th Meeting of the Wise Group for the Strategic Economic Partnership between Brazil and Japan, April 5th 2017 in Rio de Janeiro

Wise Group Meeting repot to President Michel Temer, April 6th 2017 in Brasilia

Governor and the Delegation of Rio Grande do Sul visiting to IHI, June 5th 2017 in Tokyo

Foto: Marcos Corrêa/Presidência da República

Co-firing with a high-ratio (33%) of woody biomass to make the most of existing boiler

New Energy Awards
Minister of Economy, Trade and Industry Prize

149 MW coal-fired thermal power plant at Kamaishi Works of Nippon Steel & Sumitomo Metal

1 Logging and collection

2 Transportation

3 Processing

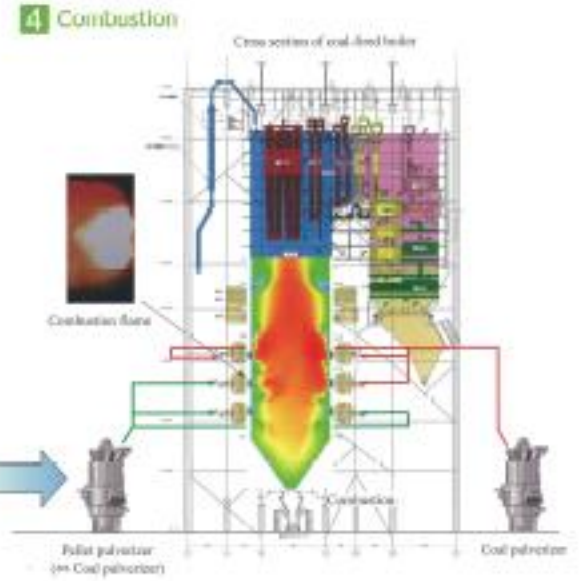
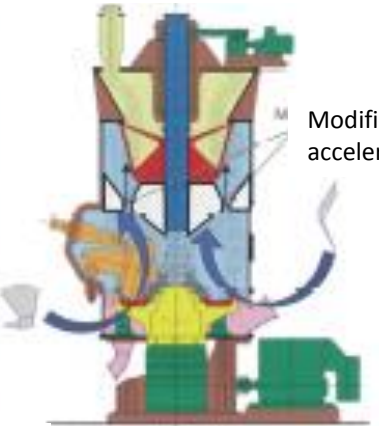


Illustration of the configuration of a high-ratio woody biomass co-firing system

Appearance of pulverizer



Cross section of pulverizer

Modified section (Flow-acceleration ring)

Introduction of IHI

Since 1959, IHI has been doing its activities in Brazil, and had a big shipyard in Rio de Janeiro, which was called ISHIBRAS.

History of Ishibras(1959~1994)

1959	Established ISHIBRAS in a joint venture in Brazil
1961	Delivered the first ship
1974	Inauguration of the Dock(400,000 t)
1976	Received order of Hot Sprit Mill for CSN with IHI
1978	Delivered the tanker (277,000 t)
1987	Delivered the Ore Oil Tanker (300,000 t)
1994	Merged to IVI(Industria Verolme-Ishibras)

Relationship between Paraná State and IHI

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IHI

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Realize seus sonhos