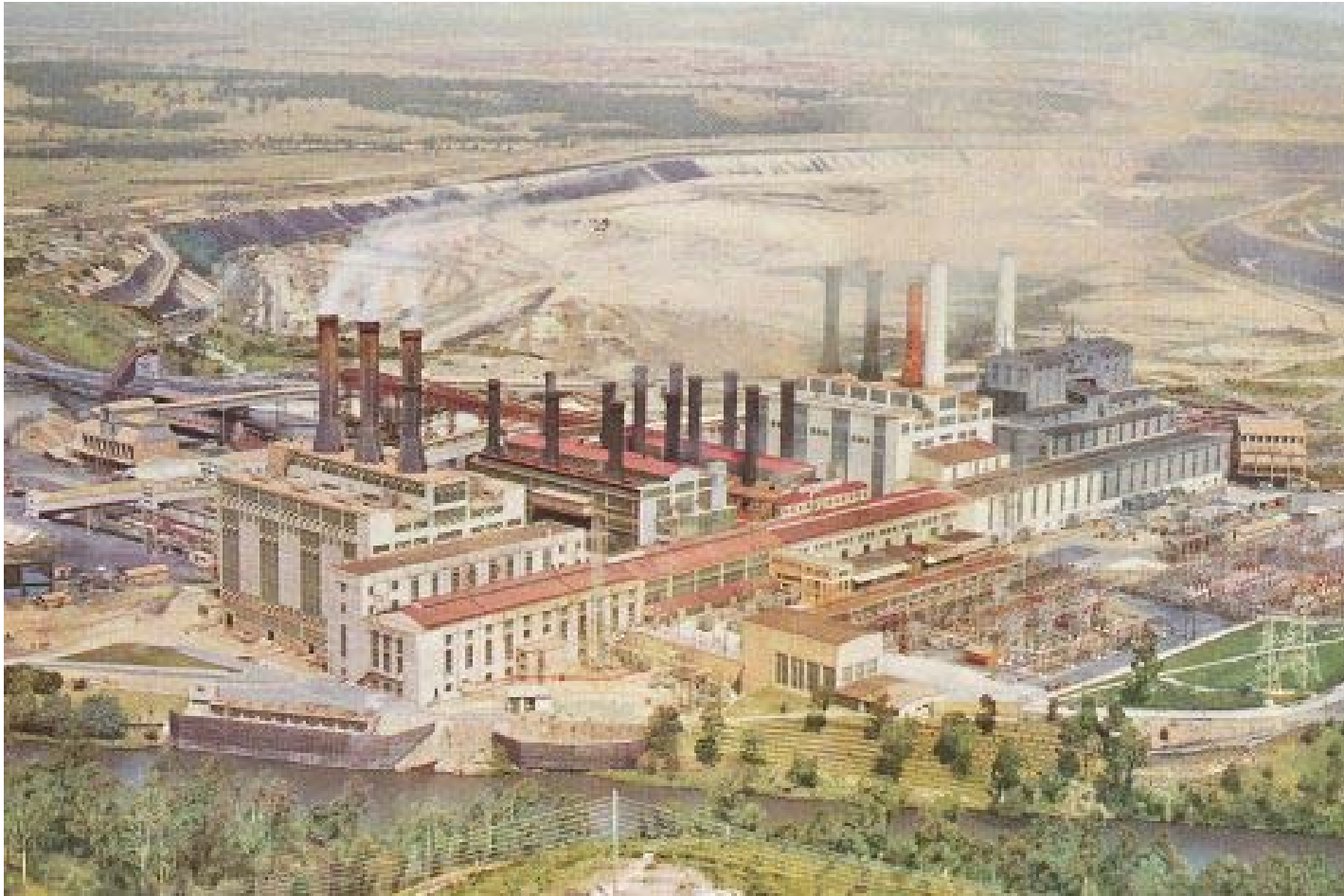


# Advances in Brown Coal Power Generation

|              |                                   |                                                                                               |
|--------------|-----------------------------------|-----------------------------------------------------------------------------------------------|
| 1924 to 1938 | Yallourn A & B Power Stations     | 6 - 10 MW Chain Grate Boilers<br>(22 units totalling 175 MW)                                  |
| 1954 to 1958 | Yallourn C&D and Morwell Stations | 6 x 20 MW Pulverized Fuel (PF) Boilers with mill/drying in recycled flue gas from the furnace |
| 1961         | Yallourn E                        | 2 x 120 MW PF Boilers with mill/drying                                                        |
| 1964         | Hazelwood                         | 8 x 200 MW PF Boilers with mill drying                                                        |
| 1973         | Yallourn W Station                | 2 x 350 & 2 x 375 MW PF Boilers with separation firing                                        |
| 1985 to 1996 | Loy Yang A<br>Loy Yang B          | 4 x 500 MW PF Boilers with separation firing<br>2 x 500 MW units of same design               |
| 1997         | HRL                               | 10 MW Integrated Drying Gasification Combined Cycle (IDGCC) Development Facility              |
| 2015         | CSIRO                             | DICE trials in 8 kW diesel engine – 1 MW trial proposed                                       |

# Yallourn A to E Power Stations commenced 1924, completed 1961

---



A&B 175 MW total from 22 chain grate fired boilers  
C&D 6x20 MW each, pf boilers with mill/drying  
E 2x120 MW

# Hazelwood Power Station

commenced 1964, completed 1971

---

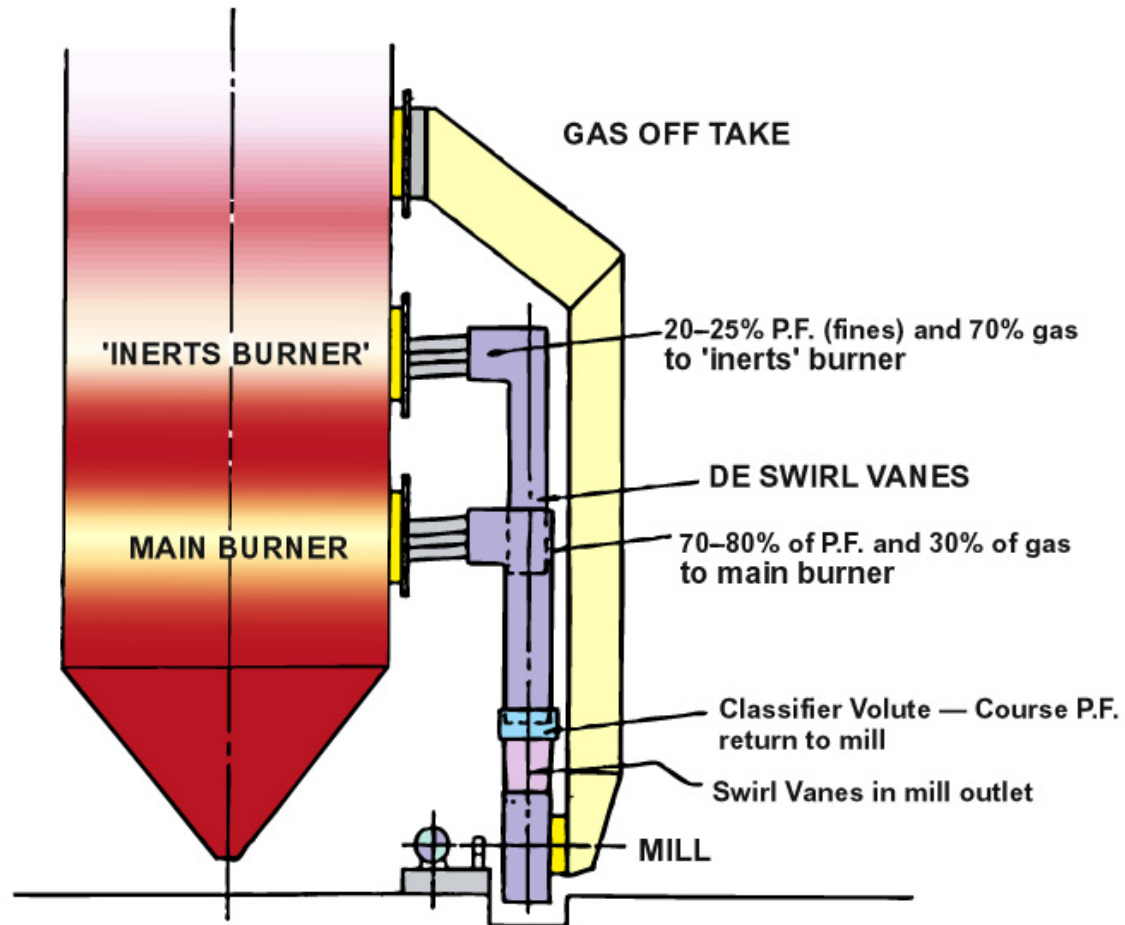


# Yallourn W Power Station commenced 1973, completed 1982

---



# Integrated Mill/Drying System with Separation Firing



# Loy Yang A & B Power Stations commenced 1984, completed 1996

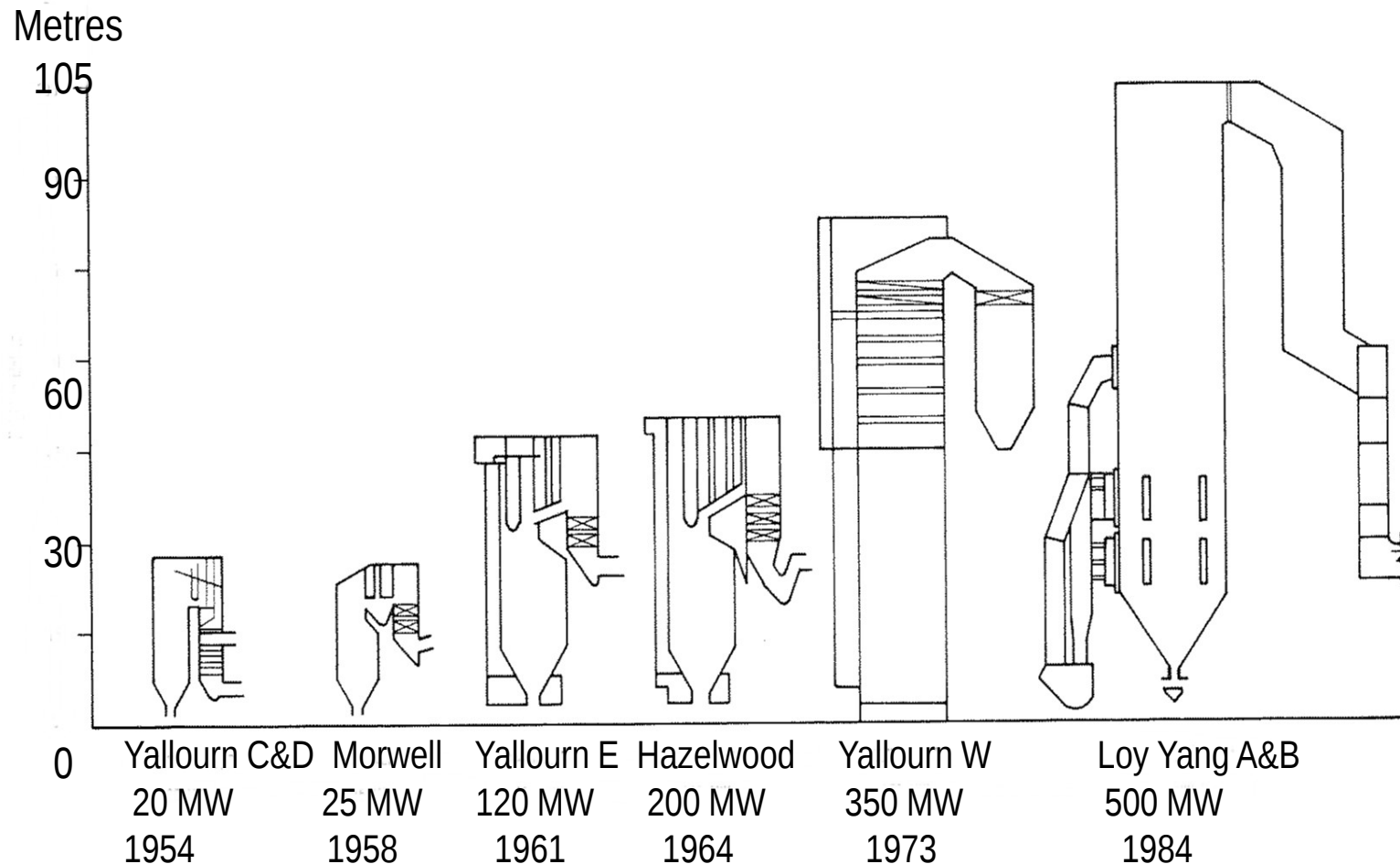
---



Loy Yang B  
2 x 500 MW units

Loy Yang A  
4 x 500 MW units

# Scale up of Brown Coal PF Boilers



Note: Only Hazelwood, Yallourn W and Loy Yang are still operating. No new brown coal plant since 1996.

# Issues in Brown Coal Power Generation

---

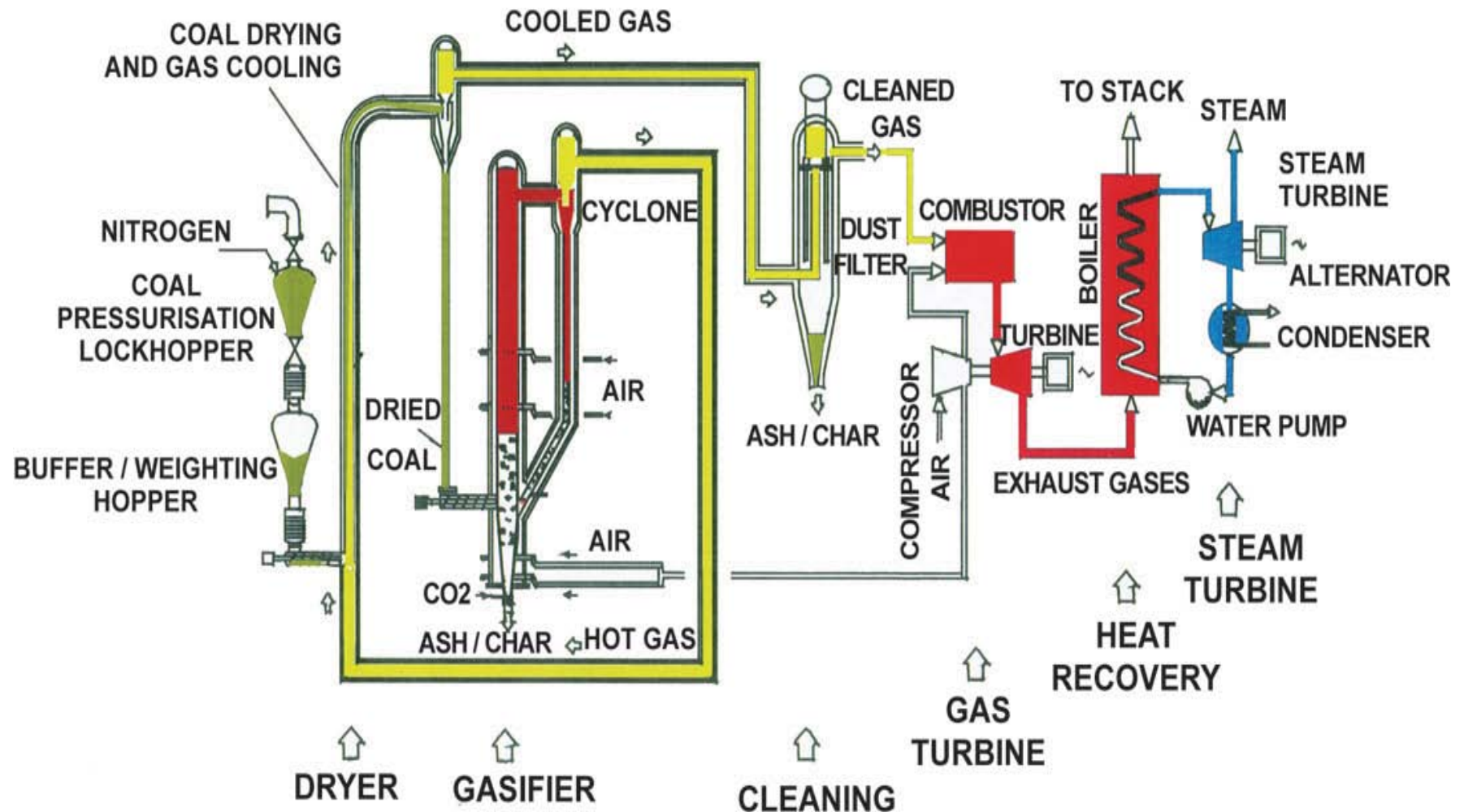
- ❑ Conventional thermal power generation on Victorian brown coal achieves 29% efficiency (HHV basis) . Up to 25% of the coal is required to evaporate the coal moisture leading to CO<sub>2</sub> emissions about 33% higher than a typical black coal power station.
- ❑ If brown coal is to continue to provide base load power, major technology advances are needed to reduce emissions, probably coupled with CCS.
- ❑ Germany is focusing on advanced steam cycles and economies of scale to reduce its brown coal emissions. 1,000 MW Super Critical steam units and other improvements, can give efficiency gains of 6-8%.
- ❑ Victoria has concentrated on advanced combined cycle systems, such as IDGCC, to raise HHV efficiencies >40%
- ❑ DICE has the potential to increase efficiencies to over 50%
- ❑ CCS is being investigated in Victoria with post combustion capture trials at Loy Yang and Hazelwood, storage trials in the Otway Basin, and studies to prioritise the many potential storage sites in the Gippsland Basin through CarbonNet.

# HRL's Integrated Drying Gasification Combined Cycle



- ❑ Proven at 10 MW scale with power supplied to grid
- ❑ Includes pressurised entrained flow drying using hot product gas
- ❑ 30% increase in efficiency
- ❑ 30% lower CO<sub>2</sub> emissions
- ❑ 50% lower water use (compared with current best LV plant)
- ❑ Government support \$150 m
- ❑ Proposed 2x300 MW plant cannot proceed until 600 MW of existing plant closes

# HRL's IDGCC Process



# DICE - Direct Injection Coal Engine

---



8 kw diesel  
engine test

Micronised  
brown coal  
slurry fuel



# Other Commercial Plants

---

|             |                                                                        |                                                                  |
|-------------|------------------------------------------------------------------------|------------------------------------------------------------------|
| 1924 - 1971 | Yallourn Briquette Factory                                             | 700,000 t/yr briquettes                                          |
| 1956 - 1970 | Lurgi Briquette Gasification Plant<br>(Gas & Fuel Corporation) Morwell | 700,000 m <sup>3</sup> /day town gas                             |
| 1959 - 2014 | Morwell Briquette & Power Complex                                      | 1.2 Mt/yr briquettes & 170 MW<br>Cogen power station (8 x 25 MW) |
| 1970 - 2014 | Briquette carbonisation plant<br>(Australian Char P/L) Morwell         | 80 kt/yr char from 180 kt<br>briquettes                          |
| 1992 - 2003 | WTA Steam Fluidised Bed Drying<br>Plant (Lurgi) Loy Yang               | Design Capacity:<br>150 kt /yr dry coal                          |

# Lurgi Briquette Gasification Plant Morwell

---



Produced 700,000 m<sup>3</sup>/d - 1/3 of Melbourne's town gas.

---

# Morwell Briquette & Power Complex

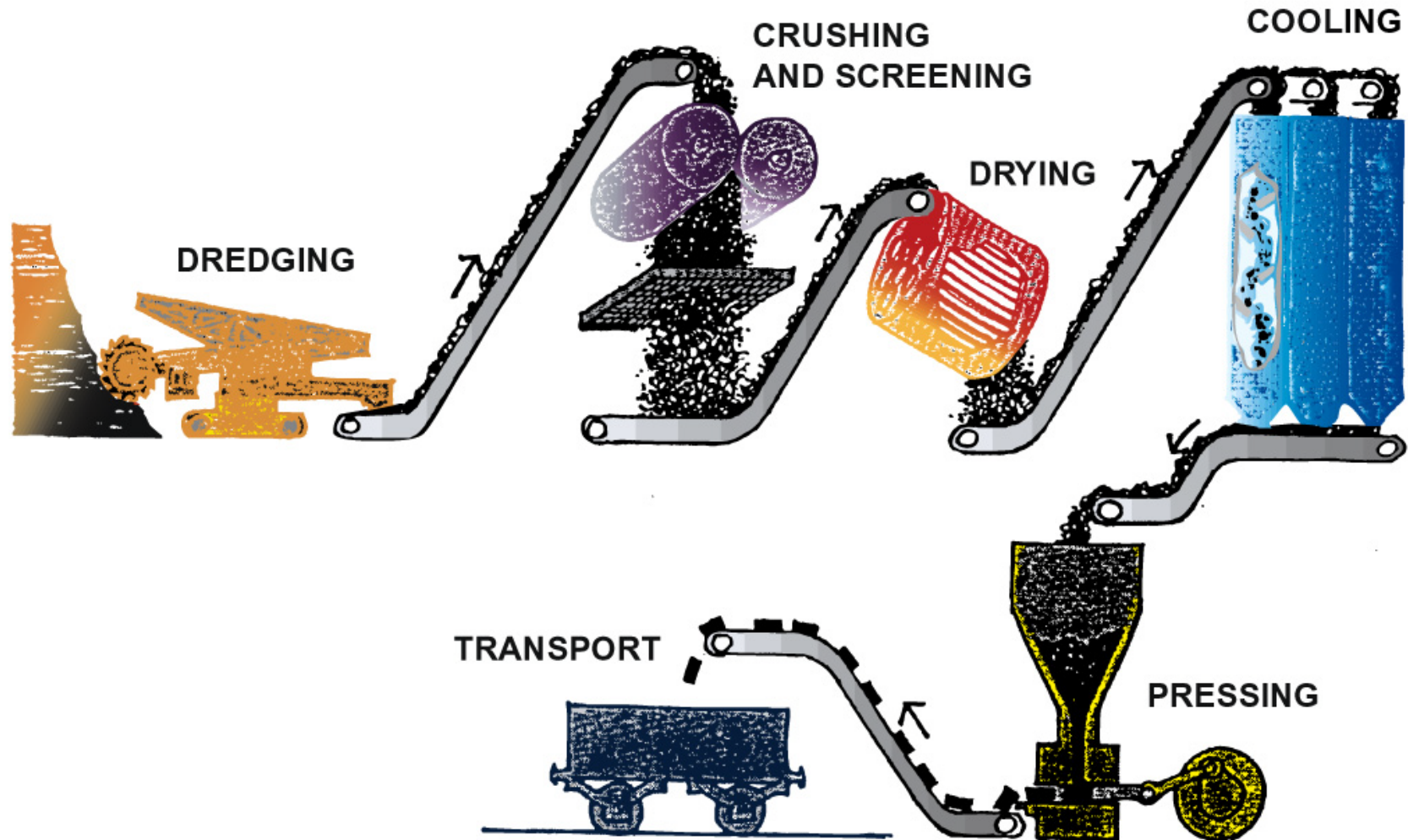
Commenced 1959, closed 2014

---



Capacity initially 1.2 Mt/yr briquettes and 170 MW cogen power  
Gasification plant in background.

# Binderless Brown Coal Briquetting



# AusChar Briquette Carbonisation Plant 1970-2014

---



80,000 t/y of char from 180,000 t/y briquettes

# WTA Steam Fluidised Bed Drying Plant, Loy Yang

---



Built by Lurgi with 150 kt/yr capacity  
Commenced 1992, closed 2003

# Experience with Drying Brown Coal

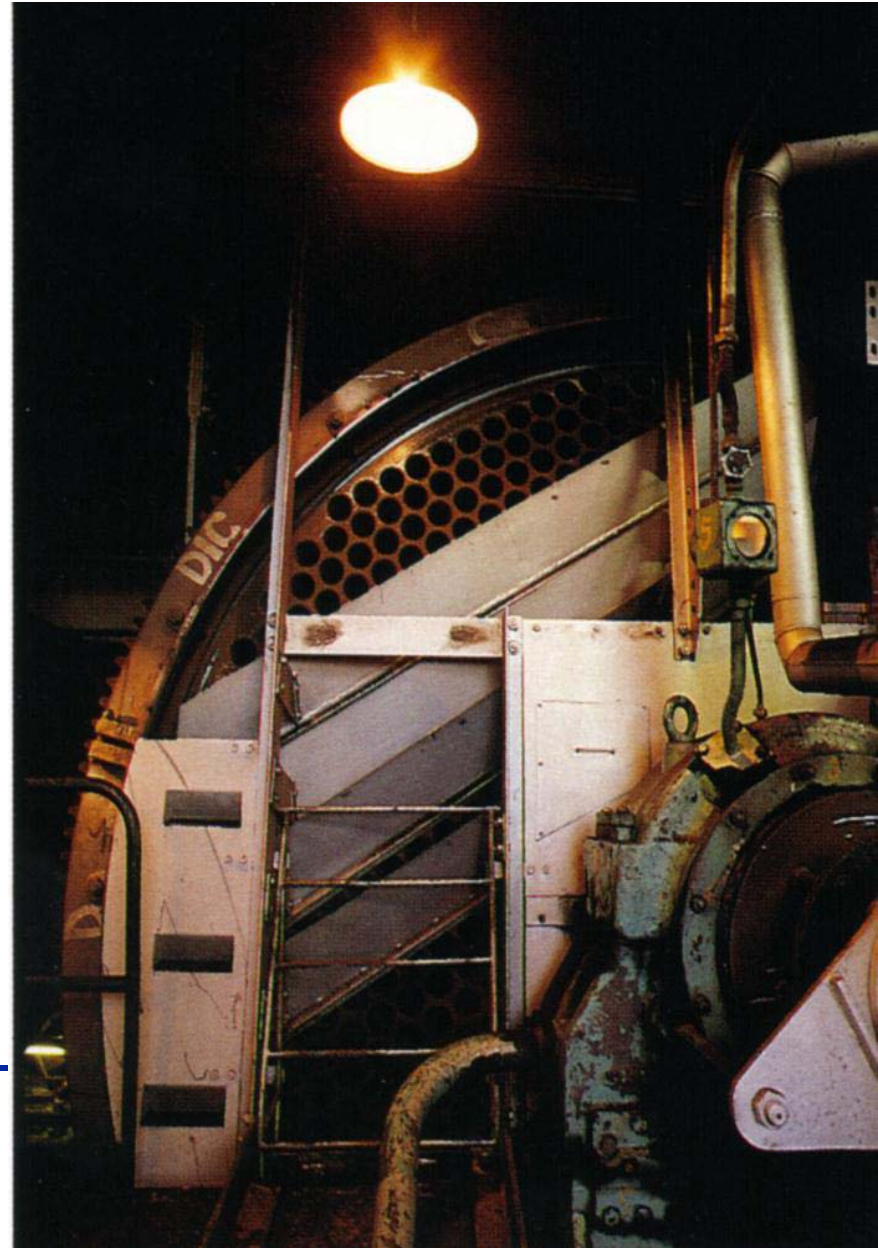
|                                  |                                                         |                       |
|----------------------------------|---------------------------------------------------------|-----------------------|
| <b><i>Evaporative Drying</i></b> |                                                         |                       |
| Flash Mill Entrained flow        | LV power stations                                       | Up to 67 Mt/yr        |
| Coal-in-tube rotary steam drum   | Briquette factories                                     | Up to 4 Mt/yr         |
| Steam fluid bed (WTA)            | Lurgi demo plant at LY                                  | 35 t/hr               |
| Solar dried slurry               | HRL demo at Hazelwood                                   | 2 kt/yr               |
| Oil Slurry 'tempura' drying      | NBCL Morwell,<br>Kobe Steel UBC Kalimantan              | 1,000 t/d feed        |
| Pressurised entrained flow       | HRL IDGCC plant                                         | 8 t/hr                |
| <b><i>Dewatering</i></b>         |                                                         |                       |
| Batch autoclave lump coal        | Fleissner Drying PP at Melb<br>Uni, Kawasaki DK process | ?                     |
| HTD slurry                       | Variations by HRL, CRC,<br>JGC, Exergen, Ignite         | 1-4 t/hr pilot plants |
| MTE hydraulic press              | CRC at Loy Yang                                         | 15 t/hr pilot plant   |

# Rotary Steam Tube Dryer

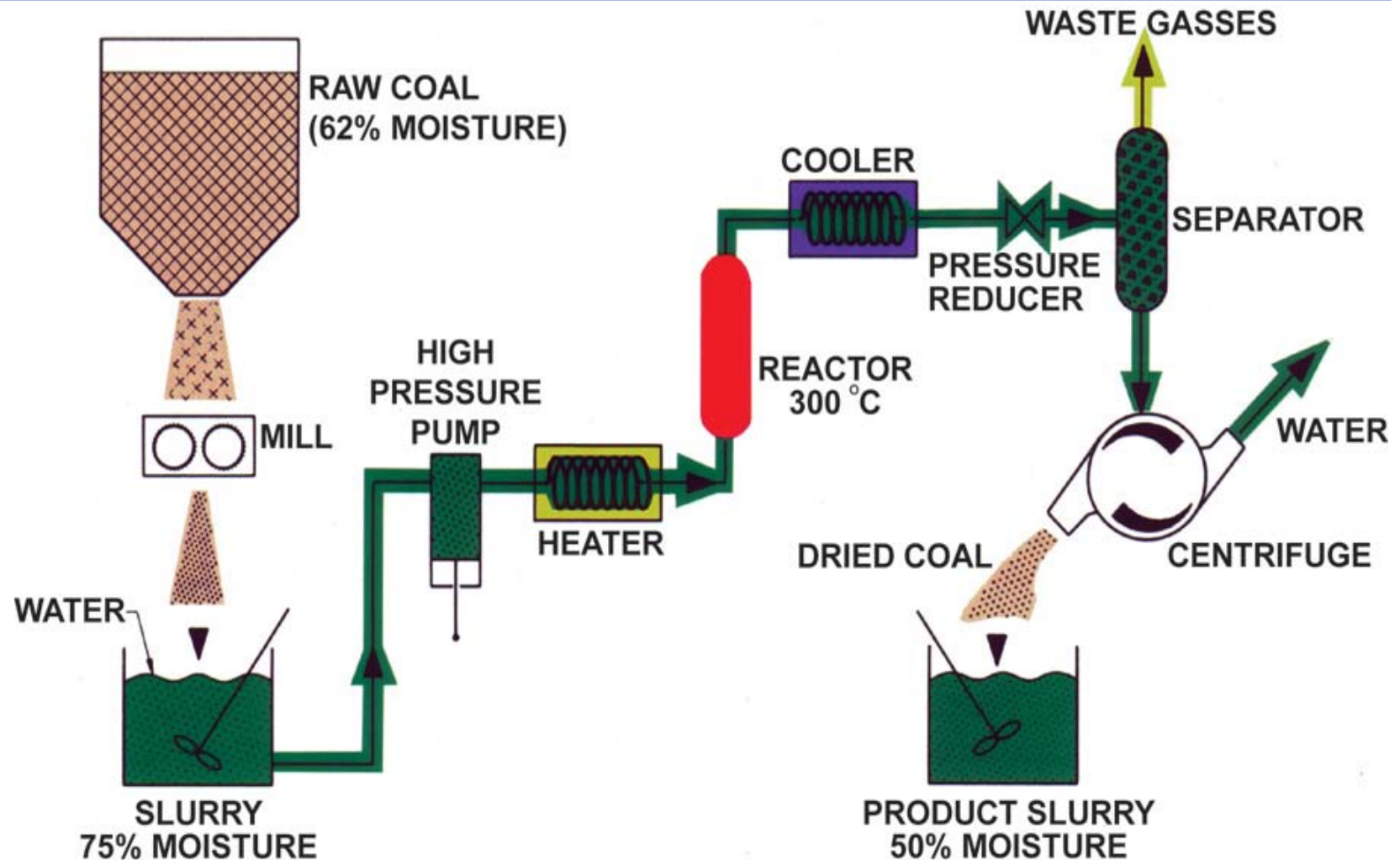
---

Morwell Briquette Factory  
dryer.

Coal-in-tube type used  
for safety

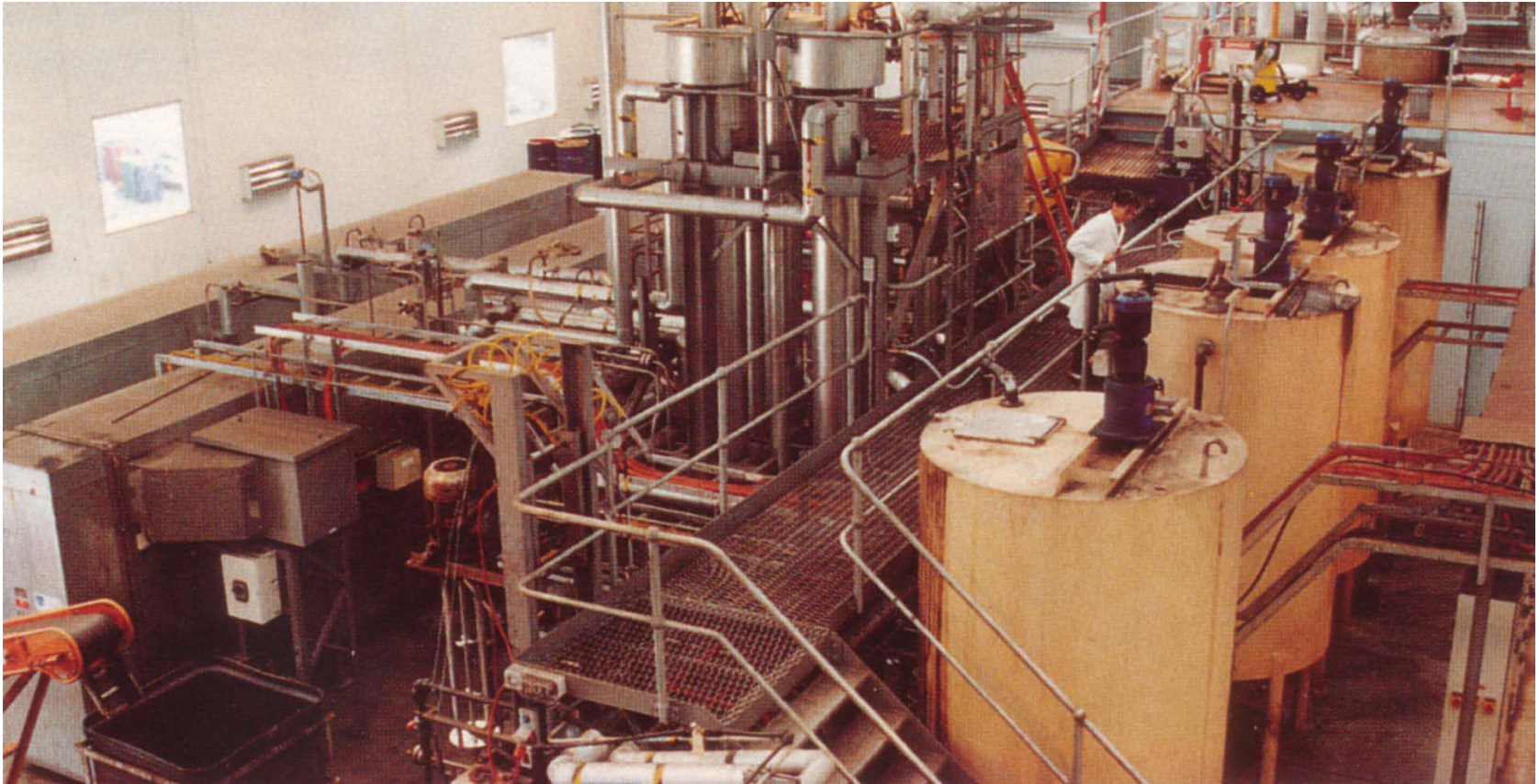


# HydroThermal Dewatering



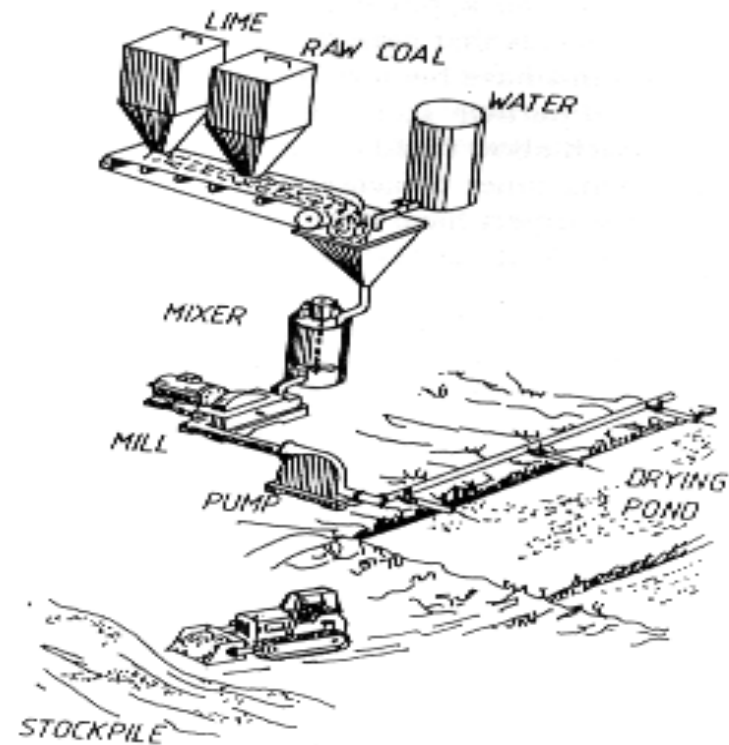
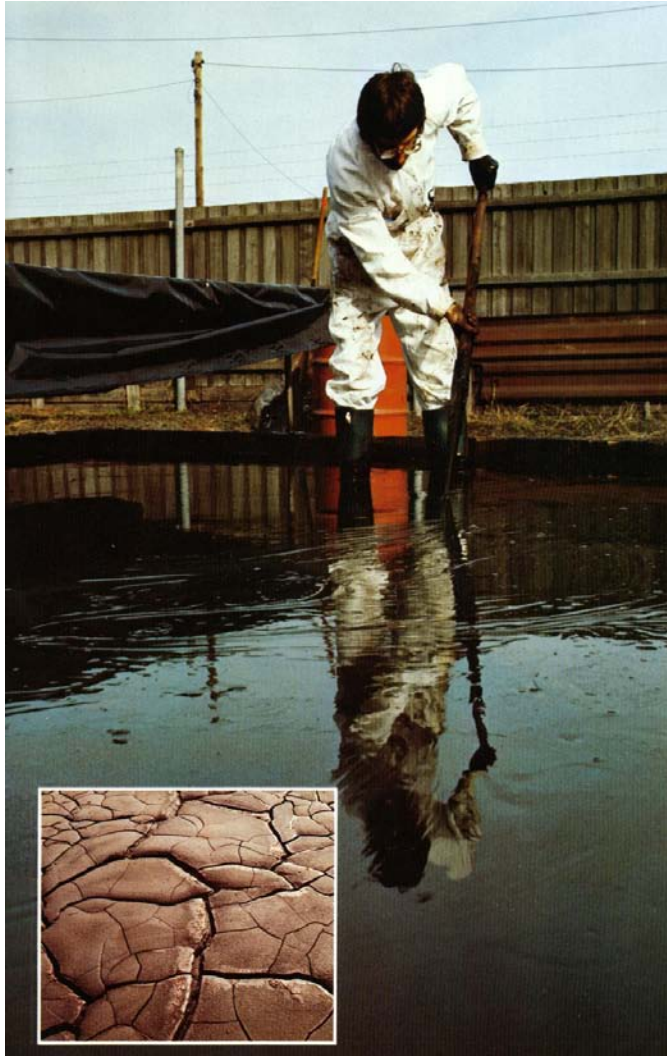
# HRL's HydroThermal Dewatering Pilot Plant

---

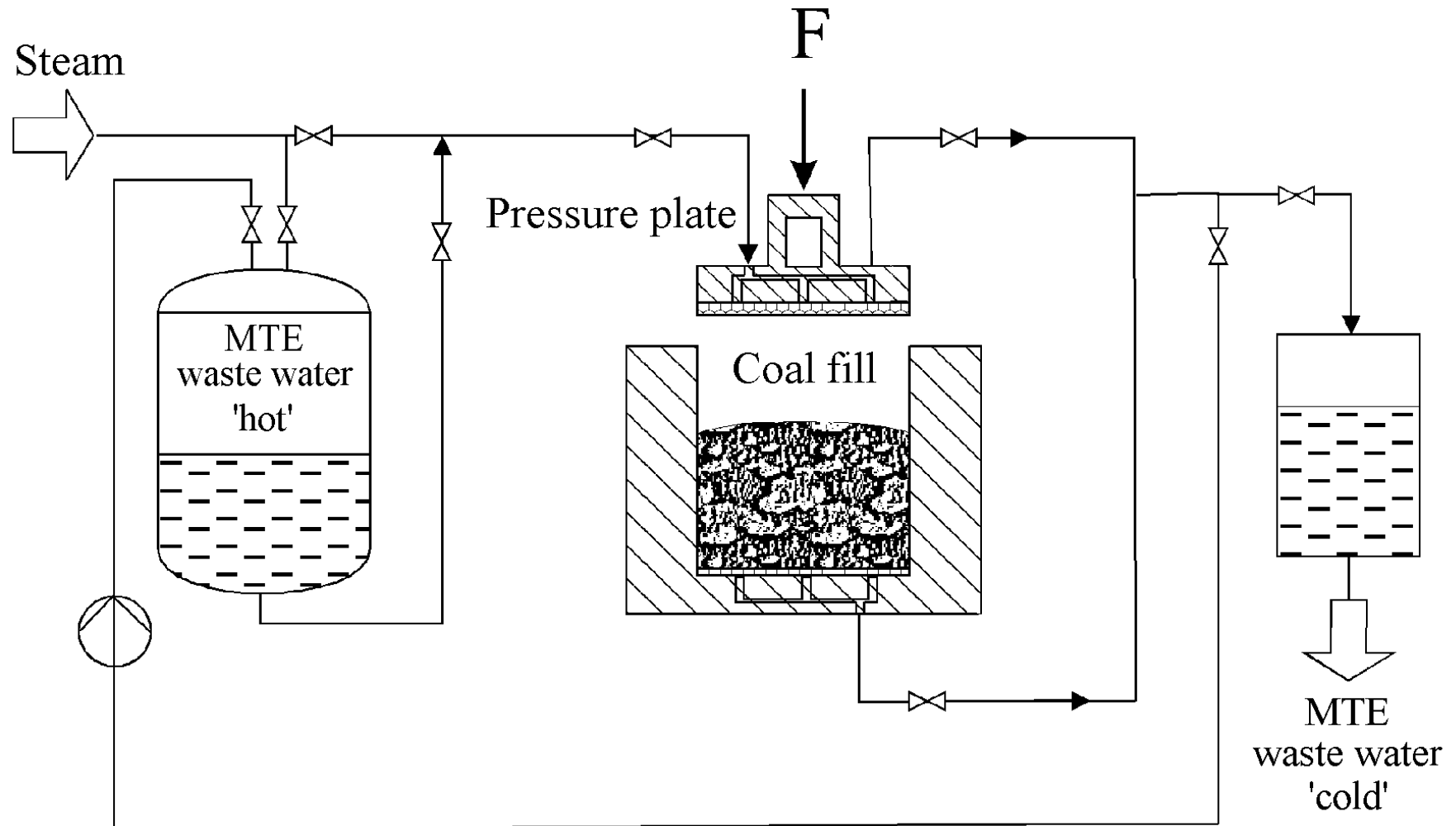


Capacity 1 t/h of raw coal at up to 325°C

# Solar drying of brown coal slurries



# Mechanical Thermal Expression



# MTE 15 t/h Pilot Plant at Loy Yang, 2008

---



# Gasification Experience with VBC

---

|            |                                                                                                                                                      |                                      |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 1956-1970  | <b><i>Moving bed gasification</i></b><br>Commercial Lurgi pressurised steam oxygen plant at Morwell .<br>Needed briquette feed as VBC coal too soft. | 700,000 m <sup>3</sup> /day town gas |
| 1997-1999  | <b><i>Fluid bed gasification</i></b><br>HTW type at 10 MW IDGCC plant, HRL Morwell.                                                                  | 8 t/hr VBC                           |
| 2004, 2008 | <b><i>Entrained flow gasification</i></b><br>Trials at Freiberg for Monash Energy and others simulating Shell and Siemens gasification               | 1,500 t shipments of VBC samples     |

Note: Each of these processes needed to be adapted for the unique properties of Victorian brown coal

---



# Brown Coal Liquefaction

---

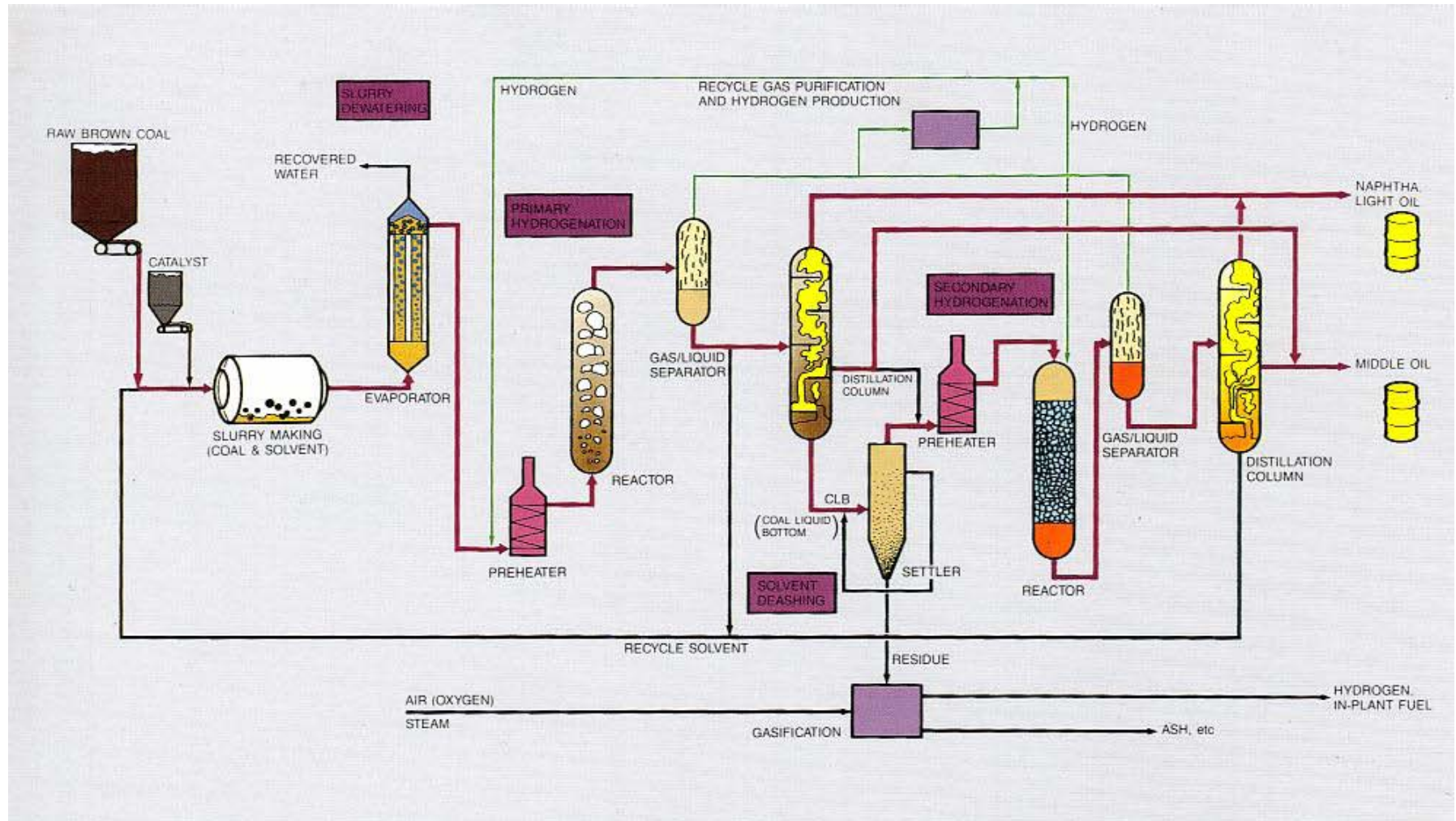
- ❑ The \$1 billion 150 t/d (feed coal) NEDO/NBCL/BCLV pilot plant in Morwell successfully demonstrated direct hydrogenation coal-to-oil technology on Victorian brown coal.
- ❑ As well as being a technical success the project developed a strong bond between the Japanese families and the Latrobe Valley community which still persists.
- ❑ Further development in Japan with smaller scale pilot plants has improved the yield and economics but the current low oil prices are again a deterrent.
- ❑ Other technologies evaluated include the indirect route of gasification and synthesis, and low temperature pyrolysis to maximise tar yield.

# NEDO/NBCL Brown Coal Liquefaction Pilot Plant Morwell 1982-1990

---



# NEDO/NBCL Brown Coal Liquefaction Process



# Other Applications

---

- ❑ Activated carbon production – technically feasible but commercial hurdles to clear.
  - ❑ Humate based fertilisers and soil conditioners – small commercial activity.
  - ❑ Government (State & Commonwealth) announced in 2014 funding under the \$90m Advanced Lignite Demonstration Program for 3 new precommercial demonstration projects:
    - Ignite Energy Resources - Cat HTR process to solid and liquid products
    - Coal Energy Australia (CEA) - Pyrolysis to solid and liquid products.
    - Shanghai Electric Australia Power & Energy Development (SEAPED) – briquetting for export
  - ❑ Other Japanese projects for VBC are being studied with J-Coal support such as KHI hydrogen project.
-

# Conclusions

---

- ❑ Victoria has over 90 years experience in commercial use of its brown coal
- ❑ There is 13,000 Mt of economic coal available for further developments
- ❑ Latrobe Valley brown coal is possibly the most thoroughly explored and best characterised coal resource in the world
- ❑ Extensive research and know how exists on how these coals behave in a wide range of processes and the impact of coal quality on performance
- ❑ The future development of the resource is likely to depend on the implementation of higher efficiency technologies to reduce the CO<sub>2</sub> generation and the application of CCS
- ❑ Promoters of new brown coal projects should make maximum use of the information and experience available on the quality of the coal they will be using and its potential performance in related processes.



---

# THANK YOU



# ALCOA's Anglesea Mine & Power Station

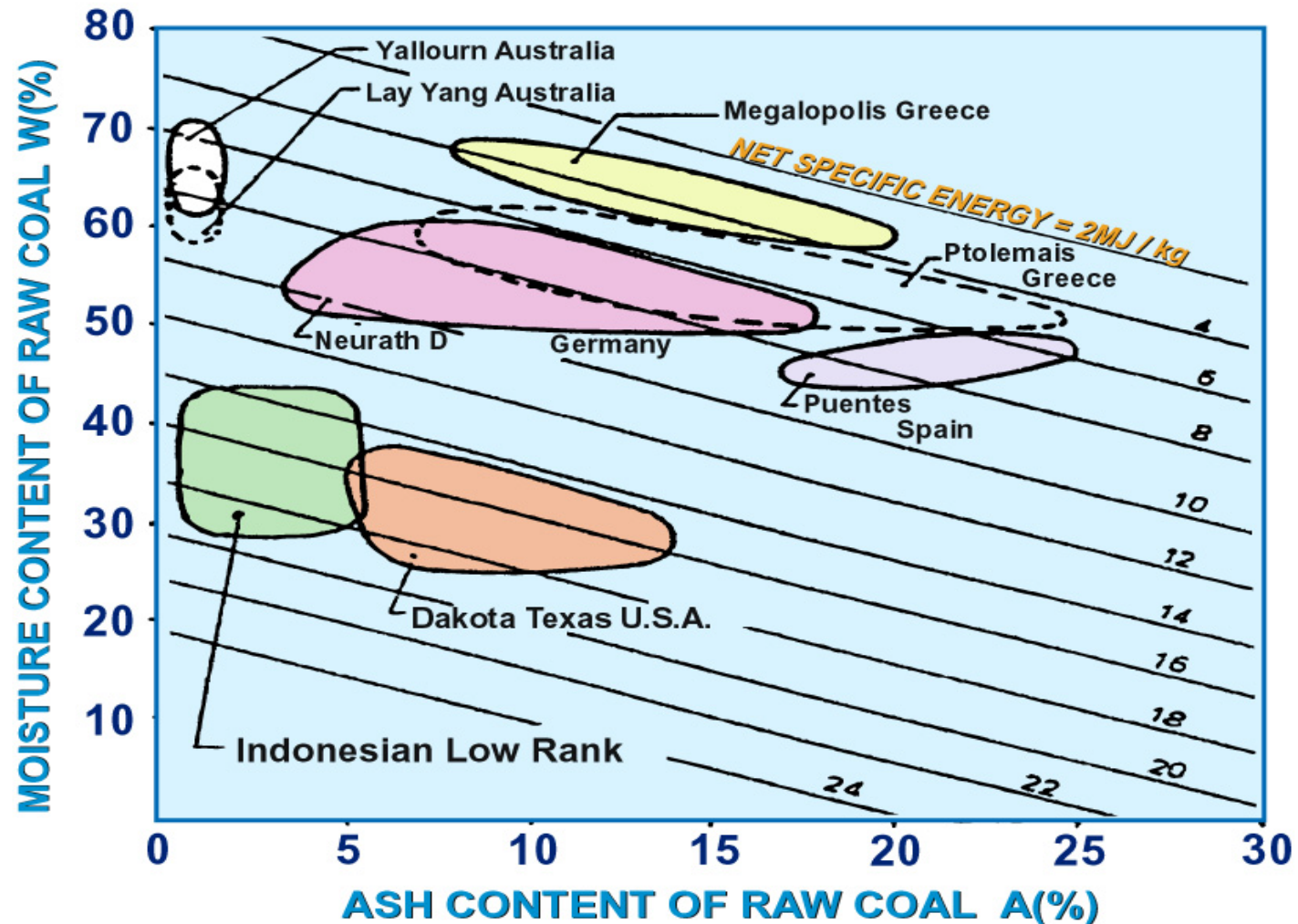
(Commenced 1969 – Closed September 2015)

---



Mine Capacity: 1.1 Mt/yr   Power Station 1x150 MW unit

# Low Rank Coal Quality



# Brown Coal Comparison – dry coal basis

