OPERATIONAL FLEXIBILITY OF COAL POWER PLANTS AND CARBON CAPTURE

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50 YEARS | 1975–2025
INTERNATIONAL CENTRE FOR
SUSTAINABLE CARBON

PRESENTATION OUTLINE

- Increasing flexibility of coal power plants
- Integrated coal power plants and carbon capture
- Flexibilisation of carbon capture plants
- Trade-offs of flexible operation of carbon capture plants
- Key messages

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Technology Collaboration Programme
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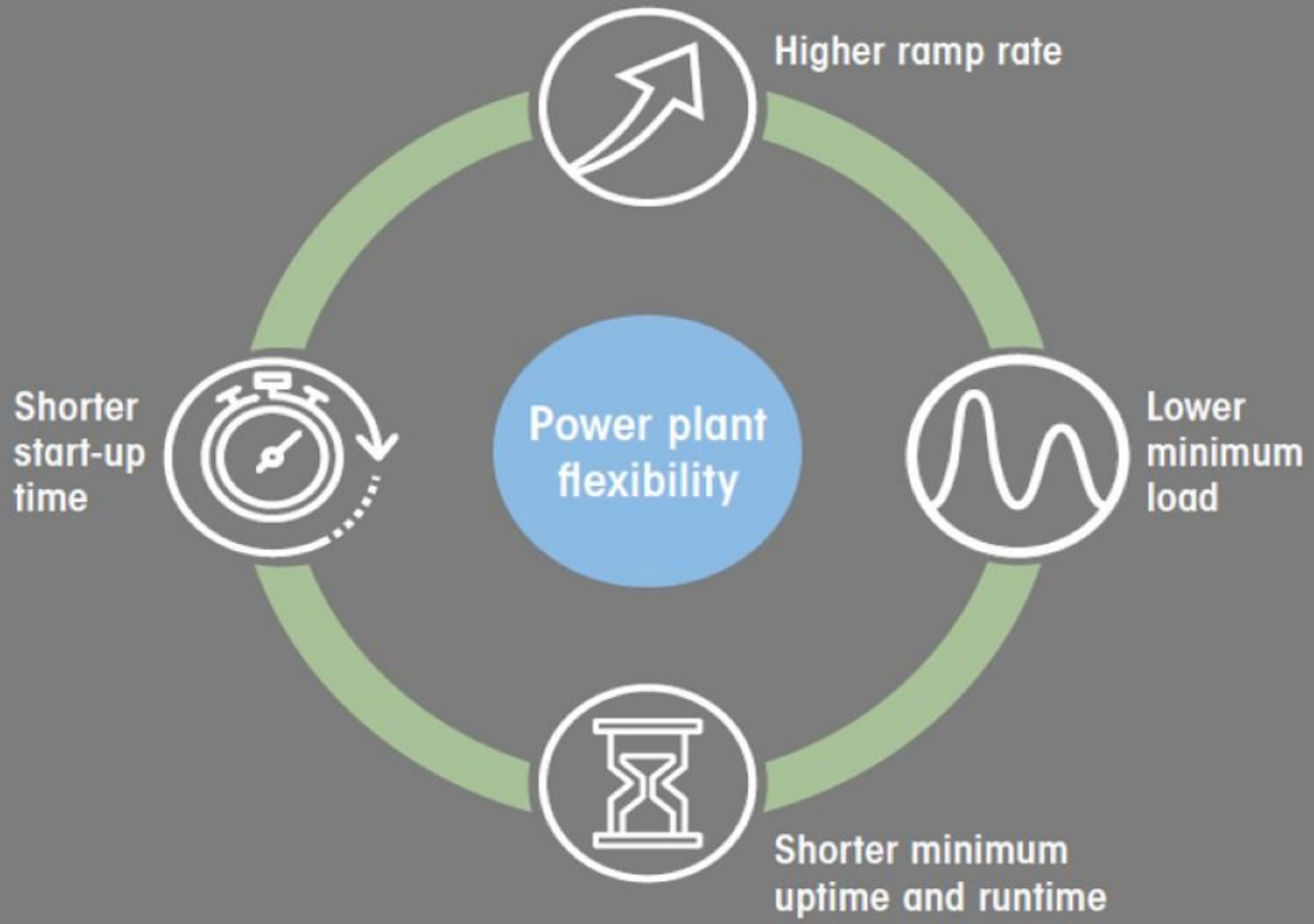
INCREASING FLEXIBILITY OF COAL POWER PLANTS

Refurbishments can increase the flexibility of conventional power plants, enabling the integration of higher shares of variable renewable energy (VRE)



Reduced VRE curtailment

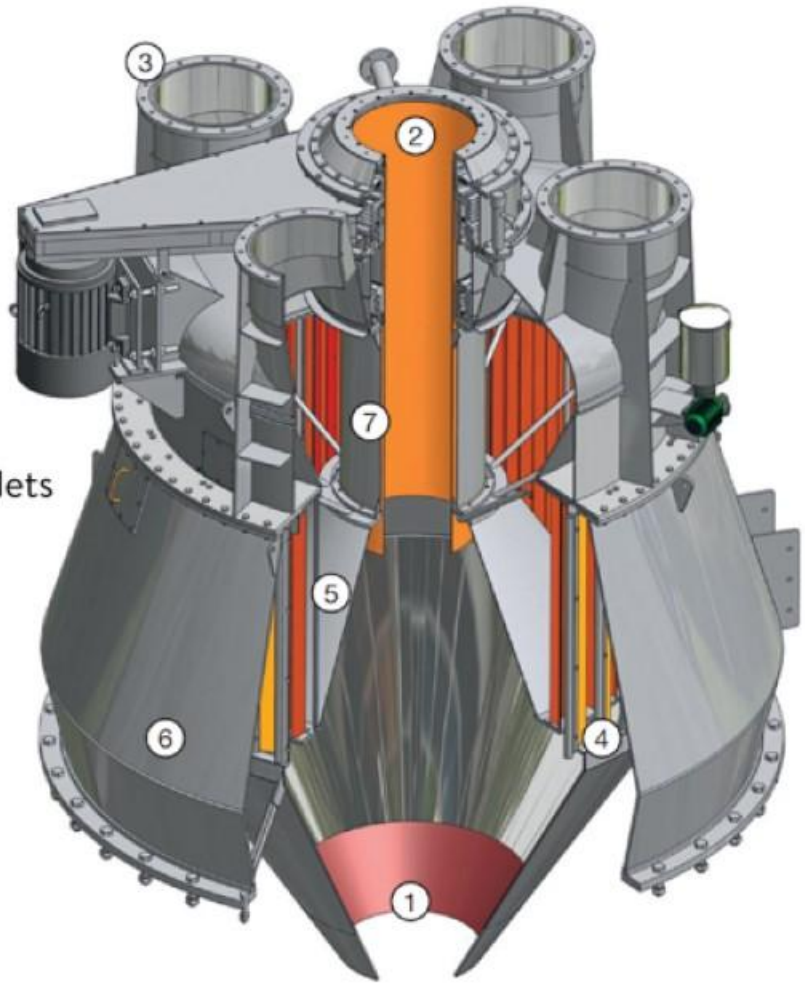
Greater system flexibility

OPTIMISING COMBUSTION SYSTEM

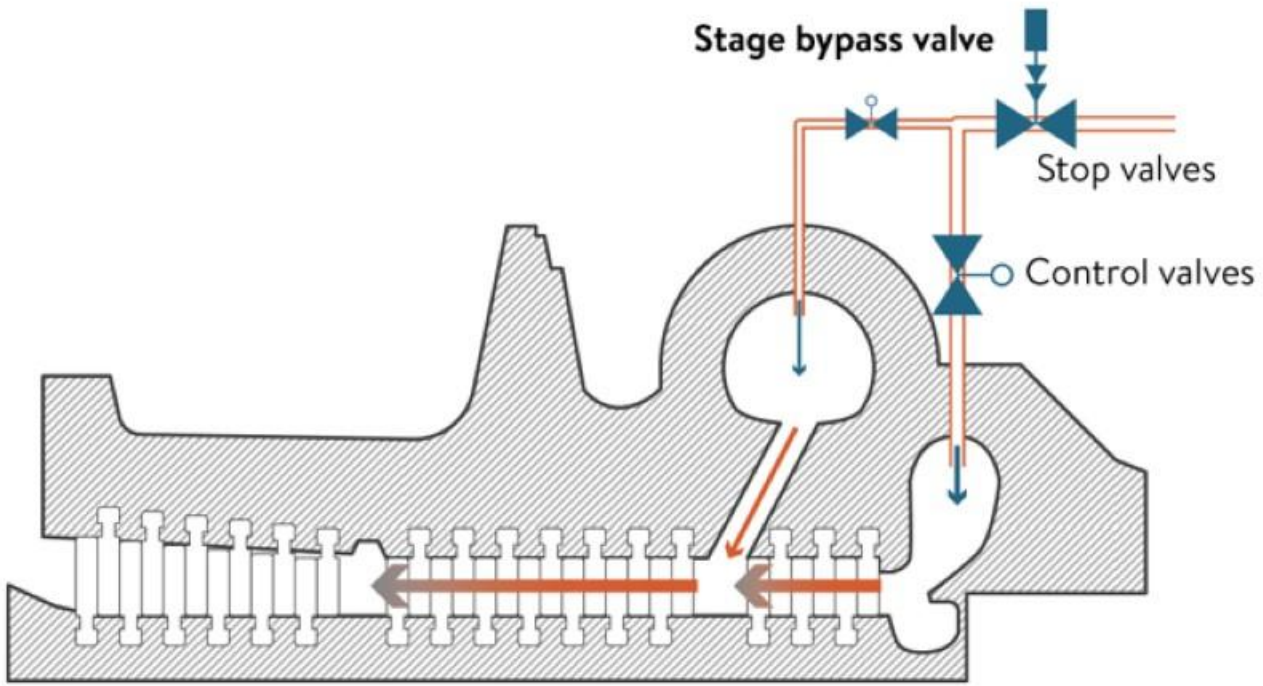
- Milling and fuel distribution system
  - Retrofitting mills with dynamic classifiers
  - Optimising fuel distribution system
  - Reducing minimum load of mills
  - Switching to single mill operation
  - Installing indirect firing system
  - Low-grade fuel for low-load operation
  - Installing hot gas generator
- Boiler
  - Advanced burner designs
  - Reliable flame detection
- Auxiliary systems

LOESCHE HIGH EFFICIENCY DYNAMIC CLASSIFIER FOR THE POWER INDUSTRY

1 – Grit cone
2 – Coal feed tube
3 – Pulverised coal outlets
4 – Guide vanes
5 – Rotor with blades
6 – Housing
7 – Rotor shaft



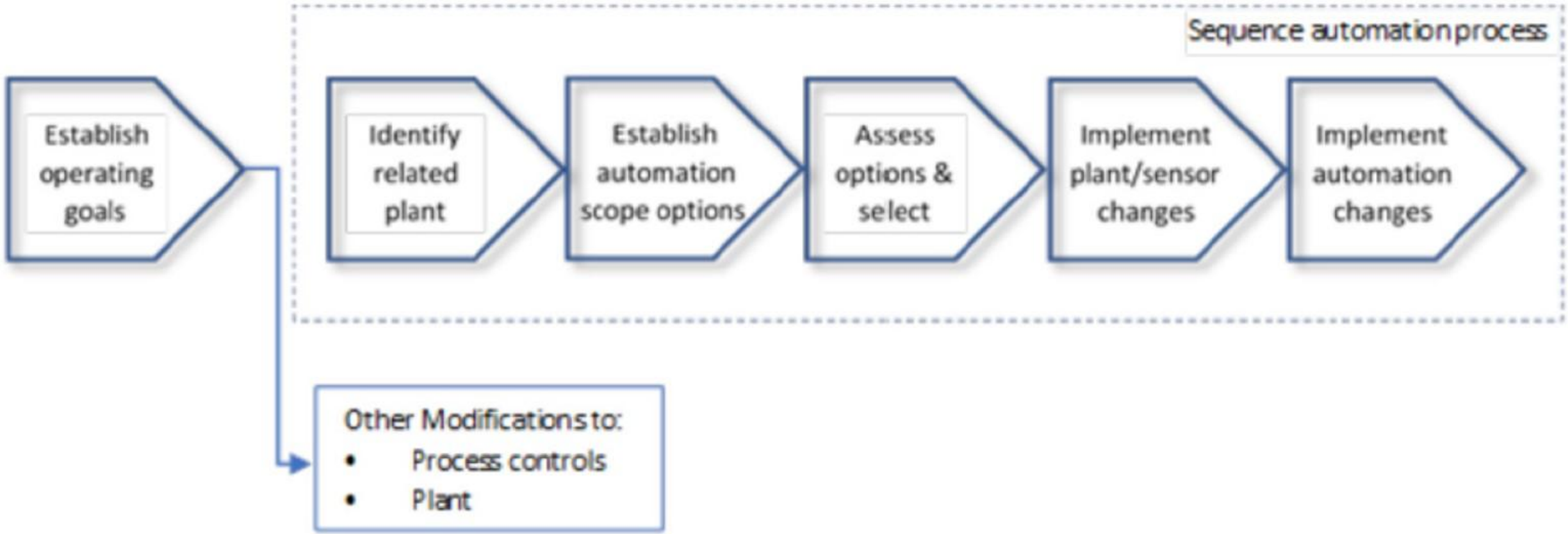
OPTIMISING WATER-STEAM CYCLE AND TURBINE SYSTEM



HP stage bypass (Sinha, 2020)

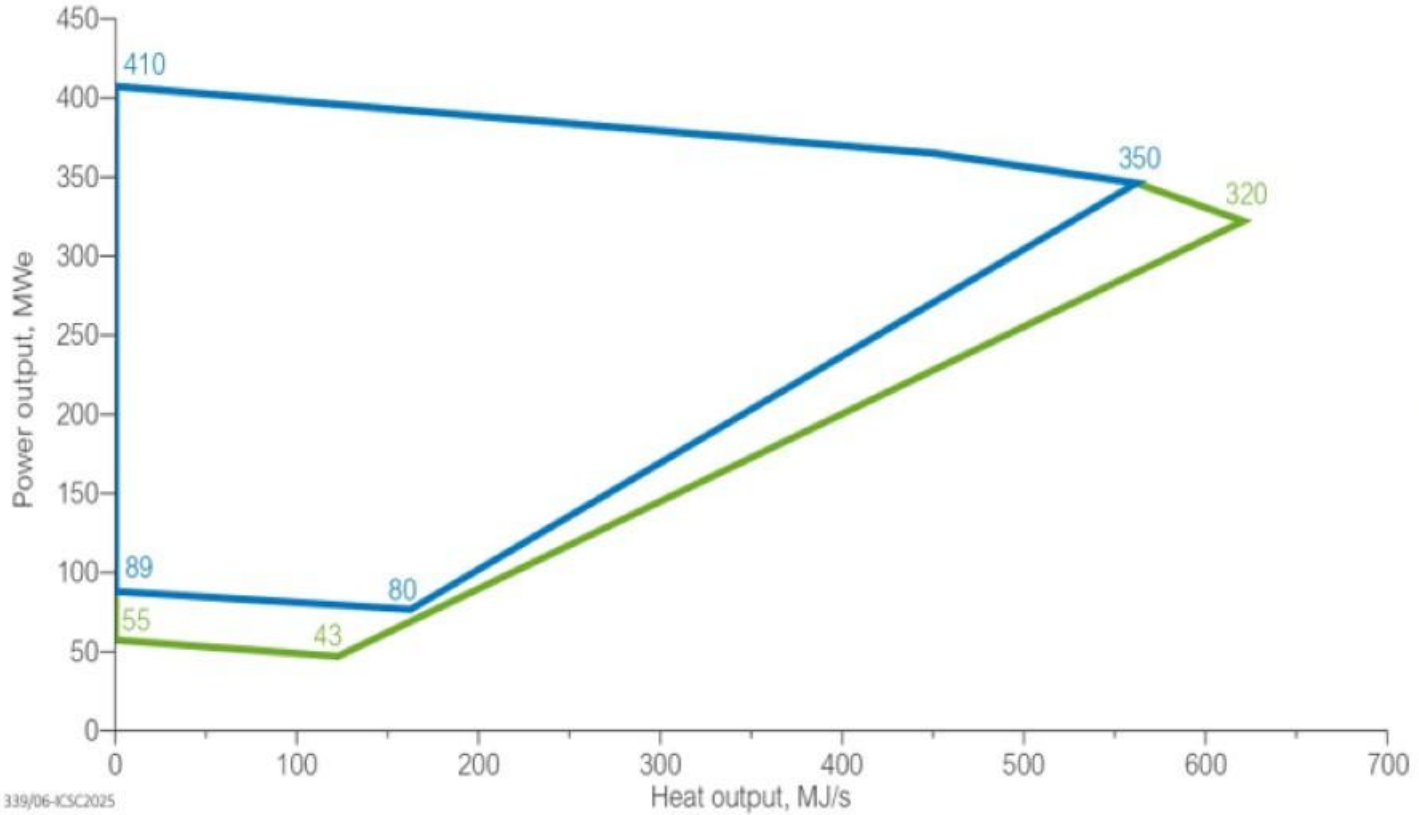
- Reducing thermal stress to thick-walled components
- High pressure turbine stage bypass
- Sliding pressure operation
- 'New' turbine start
- Feed water repowering
- Condensate throttling

DIGITALISATION AND ADVANCED I&C TECHNOLOGY



Automation assessment, scoping, design and implementation process (EPRI, 2022)

CASE STUDY 1: RETROFIT OF UNIT 7 FYNSVAERKET CHP PLANT TO EXPAND ENERGY OUTPUT AND REDUCE MINIMUM LOAD



Enhanced flexibility of Fynsvaerket Unit 7 (CEM, 2018)

Measures

- retrofitting a water-based heat storage tank to expand power output (P, MWe) during peak time
- tuning of the feed water supply controller to lower the minimum load
- shutting off low-pressure preheaters to increase maximum heat output (Q, MJ/s)

CASE STUDY 2: MODERNISATION OF RWE NEURATH UNIT D

Measures taken:

- Modernising plant components including boiler and condenser
- Upgrading instrumentation and control (I&C) system

Results

- the ramp rate increased from 5 MWe/min to 15 MWe/min
- the minimum load decreased from 440 MWe to 270 MWe

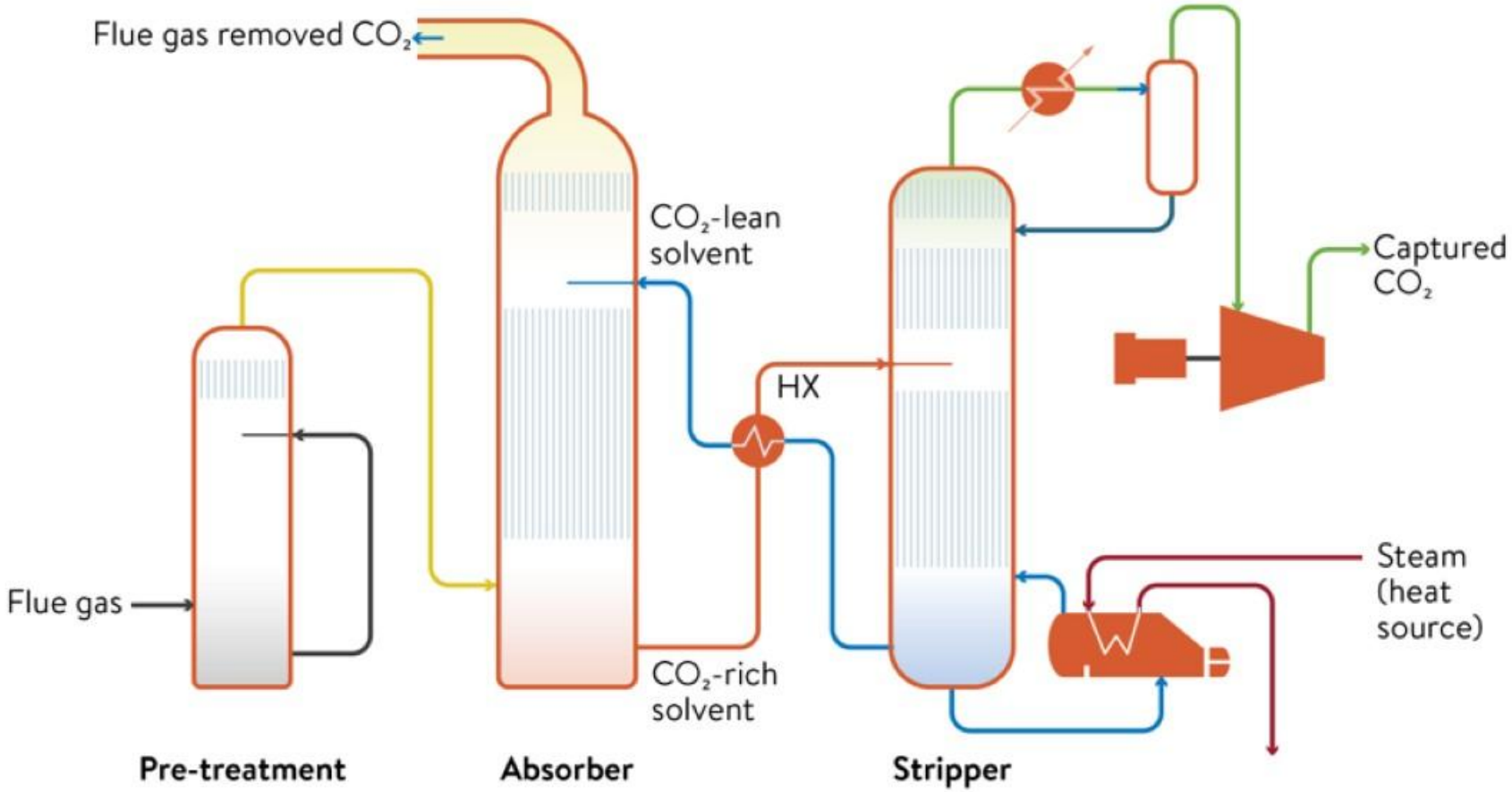
CASE STUDY 3: OPTIMISING STANDARD O&M PROCEDURES

- Measures taken: revise the existing standard operating procedures to take one boiler feedwater pump out of service during low load operation

- Results:
  - Units minimum load reduced from 800 MWe to 550 MWe
  - Saving about $2 million/y

INTEGRATED COAL POWER PLANTS WITH CARBON CAPTURE

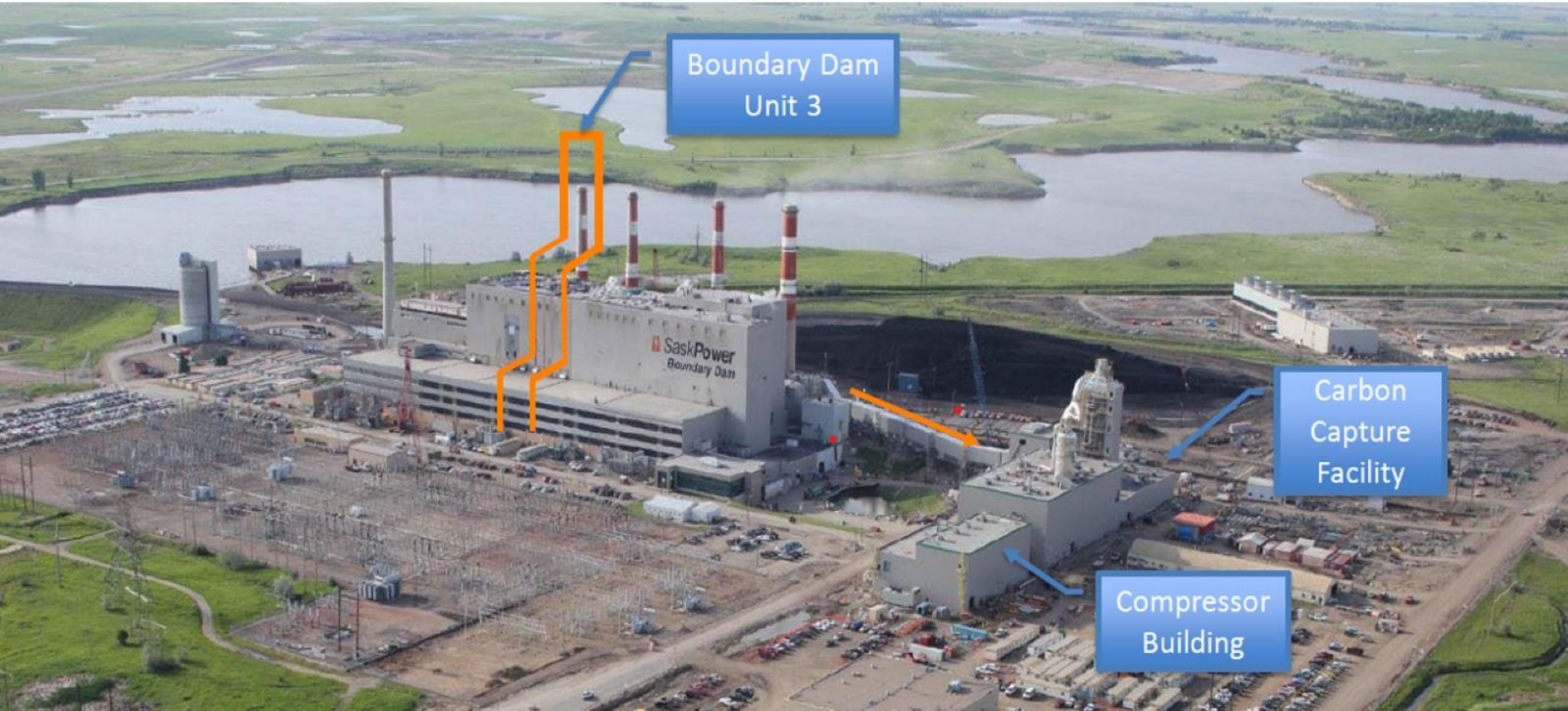
CARBON CAPTURE TECHNOLOGIES



- Amine-based chemical absorption processes
- Adsorption process using solid adsorbent
- Chilled ammonia process
- Membrane separation process

A flow chart of a typical amine-based CO_2 capture process (GCCSI, 2022)

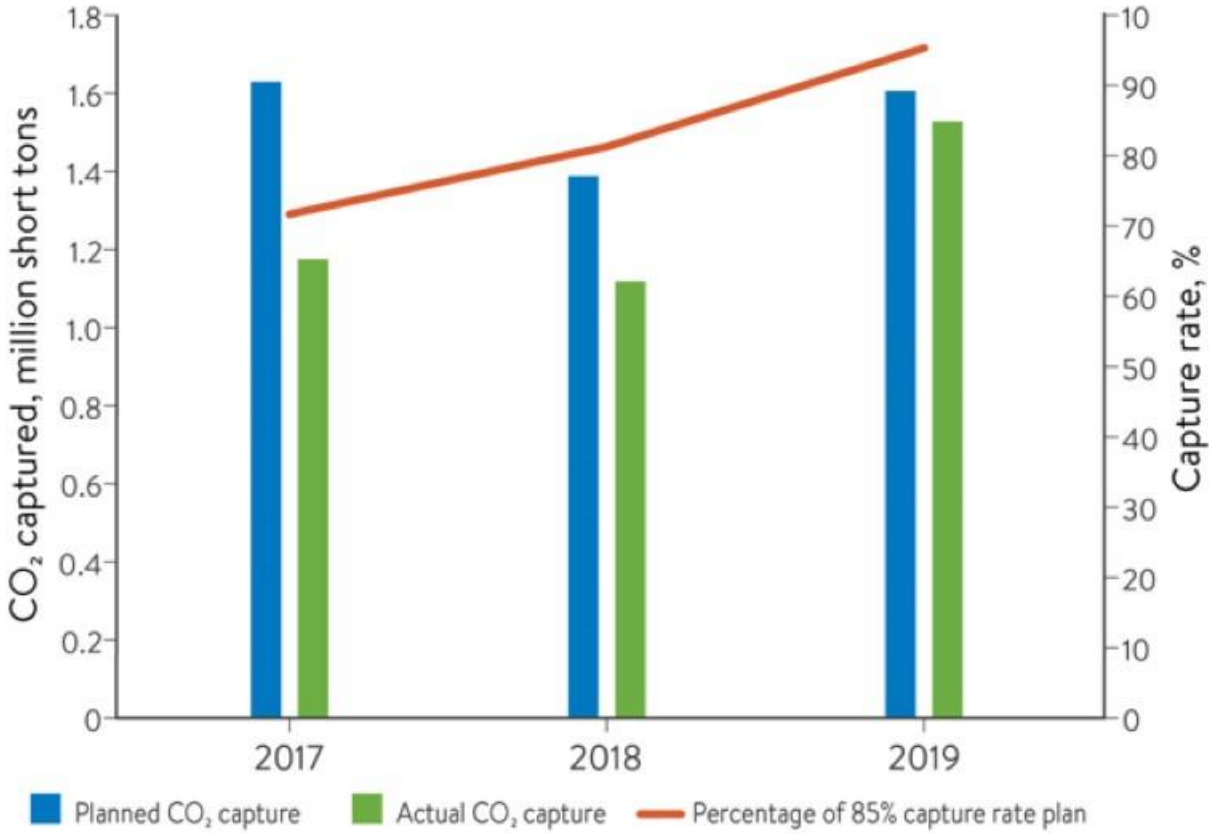
BOUNDARY DAM CCS PROJECT



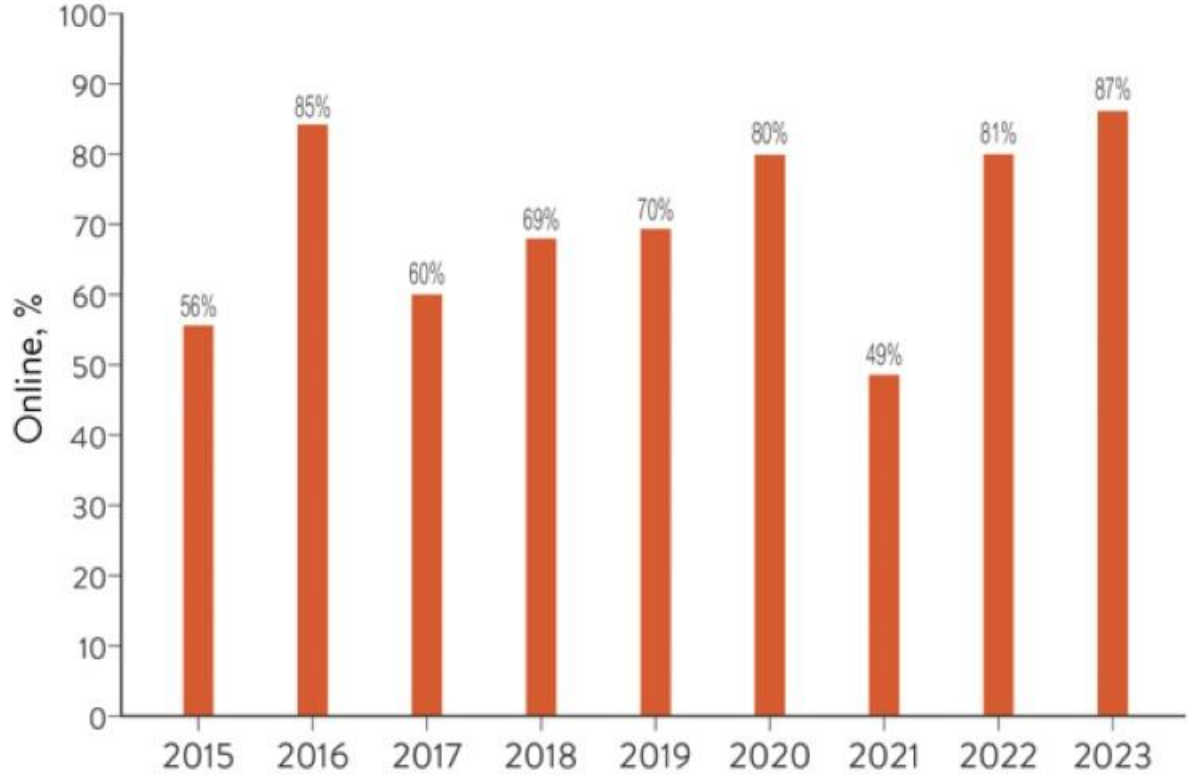
LARGE COAL POWER-BASED CCUS DEMONSTRATION PROJECTS IN CHINA

	Capacity, $MtCO_2/y$	Commissioning year
China Energy Jinjie Power Plant	0.15	2021
China energy Taizhou Power Plant	**0.5**	2023
SPIC Changxing Island Power Plant	0.1	2023
Shenwu Energy	0.2	2024
Huaneng Dansu Longdong CCUS Project	**1.5**	Under construction

Huaneng Longdong CCUS Project: injection well located 300 metres away from the CO_2 capture plant (Liu, nd)



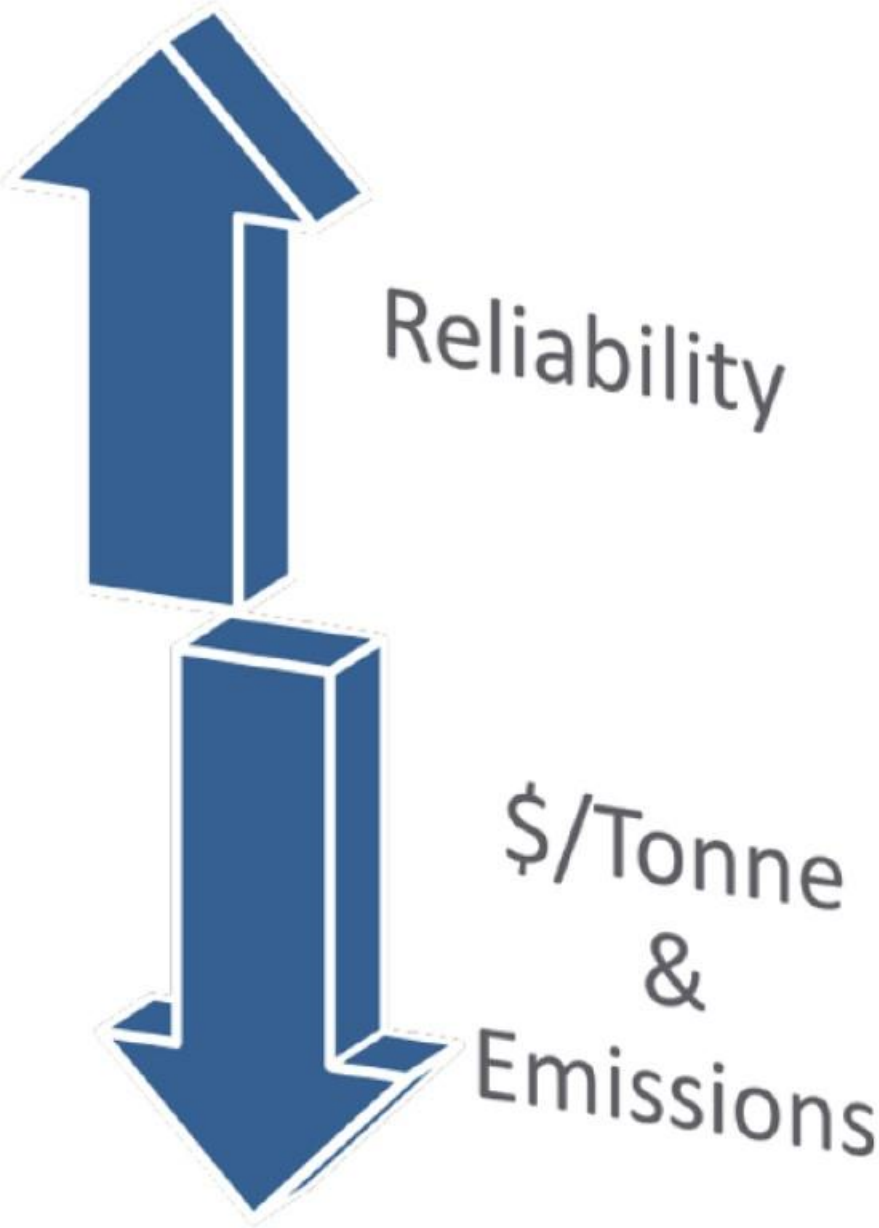
CO_2 capture performance of Petra Nova CCS Project (Lockwood, 2024)



Reliability of the CO_2 capture plant at Boundary Dam's Unit 3 (Epp, 2023)

PCC ON COAL POWER PLANTS

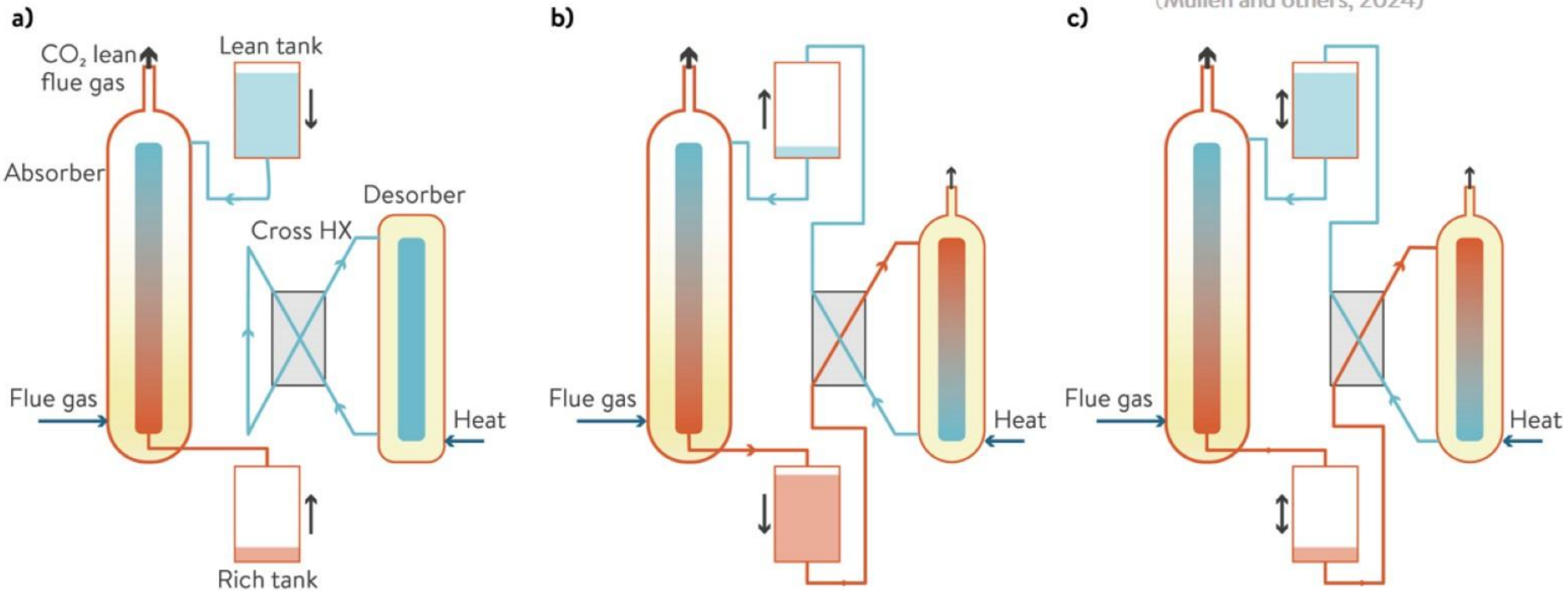
- Amine solvent-based PCC processes work as intended with capture rate above 95%
- The technology has continued to evolve leading to optimised process and engineering designs, improved performance and reliability of the processes, and lowered capital and operating costs
- Carbon capture can be used to decarbonise coal power generation



FLEXIBILISATION OF CARBON CAPTURE PLANTS

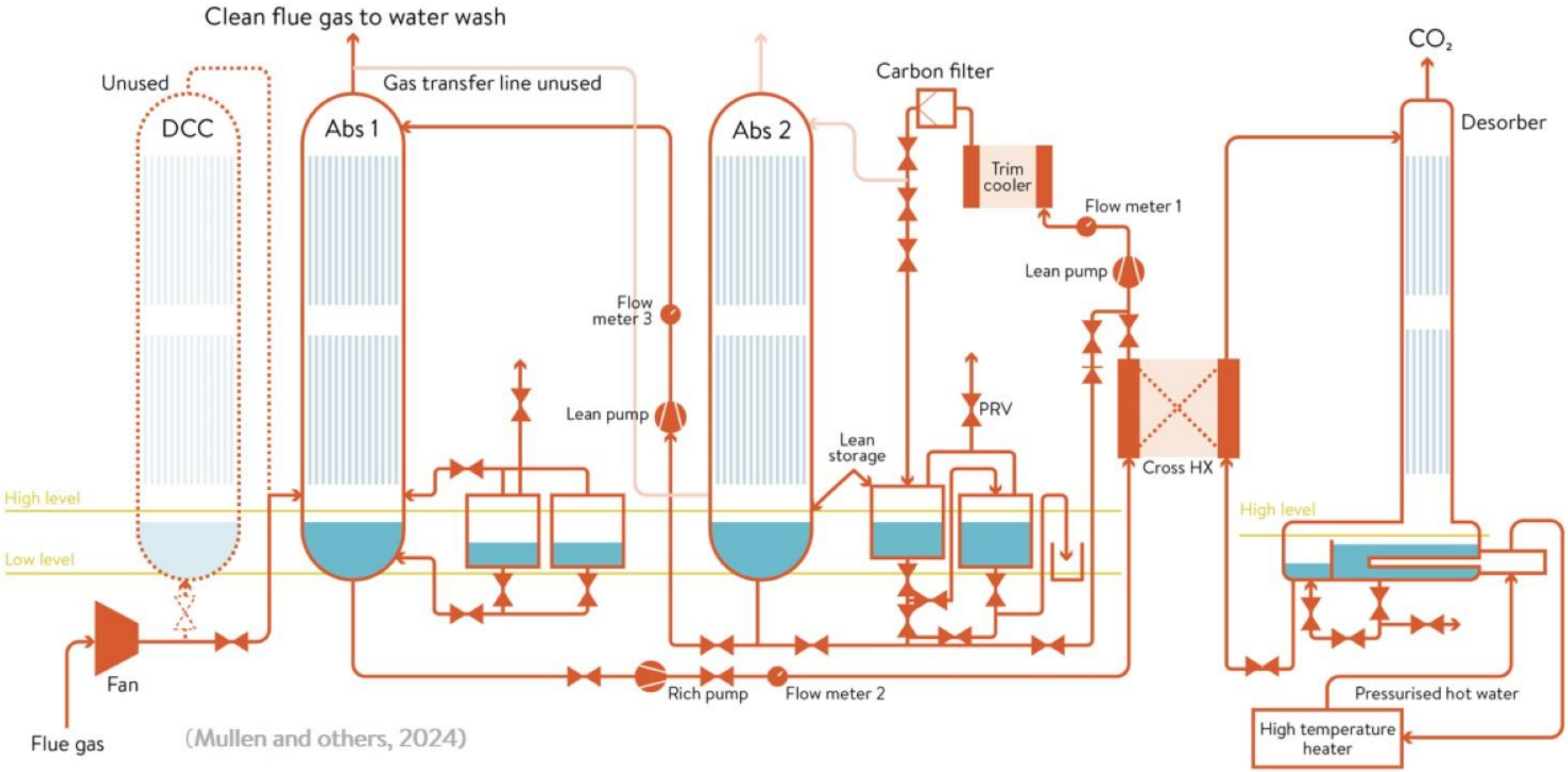
SEGREGATED SOLVENT INVENTORY WITH LEAN AND RICH SOLVENT STORAGE

(Mullen and others, 2024)



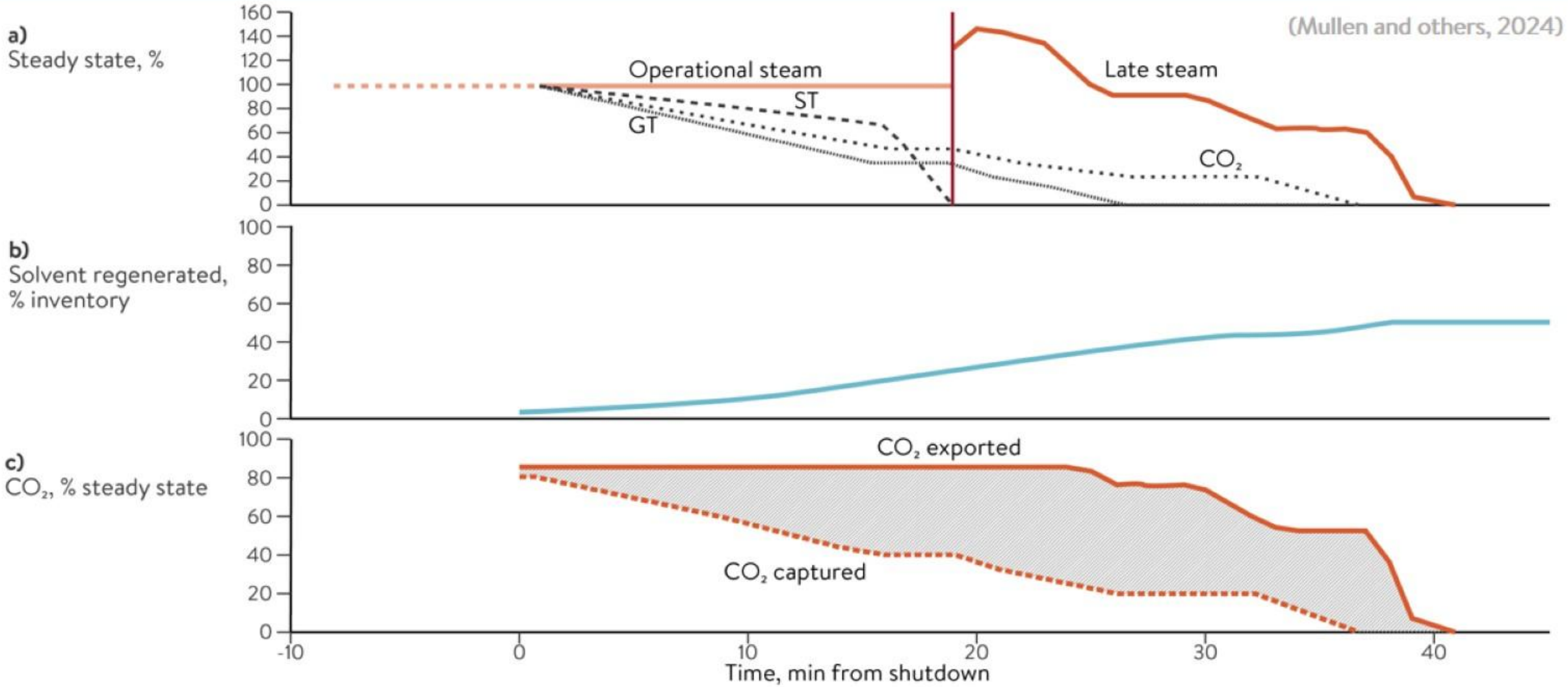
a) CO_2 capture before desorber reaches operating conditions; b) Rich solvent regeneration concurrently with CO_2 capture; c) Normal operation

SOLVENT STORAGE



(Mullen and others, 2024)

FAST-STARTING STEAM CYCLE TECHNOLOGIES



Analysis of CCGT shutdown using late steam for solvent regeneration with 100% solvent inventory set at a standard CCGT without additional solvent for enhanced storage

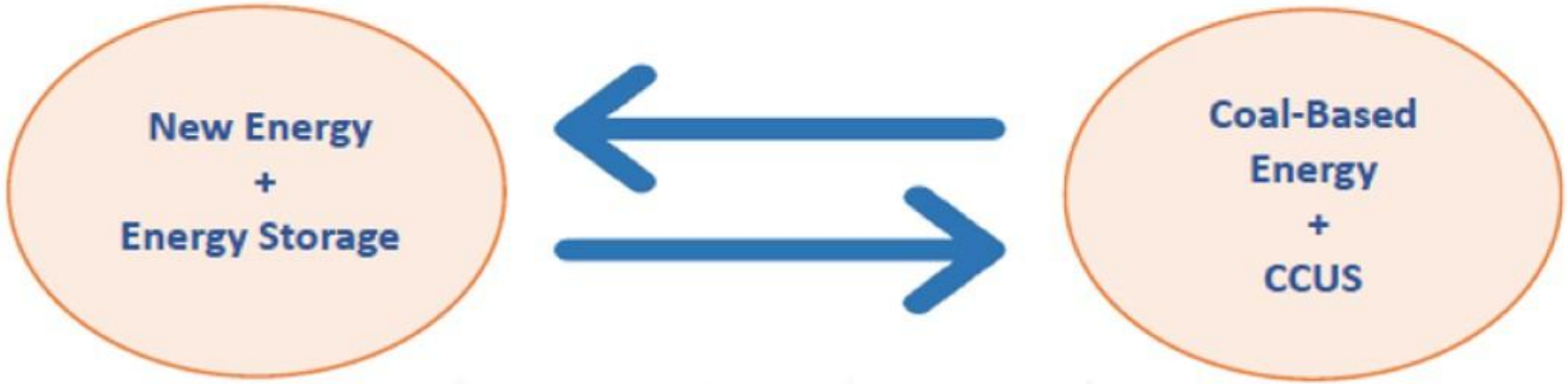
OTHER MEASURES

- Thermal energy storage
- Use of multiple smaller absorbers/desorbers
- Selection of CO_2 compressor and/or use multiple compressors
- Advanced and sophisticated I&C systems

Integrally geared compressors for CO_2 Compression in CCUS applications (Siemens, 2024)

TRADE-OFFS OD FLEXIBLE OPERATION OF PCC

- Increased capital and operating costs, and reduce net power output resulting in an increase in generation cost
- Reduced CO_2 removal efficiency
- Can have some economic benefits by allowing operators to generate and sell more electricity at higher prices during peak demand period



KEY MESSAGES

- The role of coal power in the energy transition will not disappear but rather it will evolve into a more dynamic and responsive function
- CO_2 capture technology works on coal power plants at commercial scale with CO_2 capture efficiency of above 95%, so it can help decarbonise coal power plants
- PCC equipped coal power plants can operate flexibly, and have an important role in modern power systems to provide low-emission flexibility, capacity and other vital system services to the grid

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THANK YOU FOR LISTENING

ANY QUESTIONS?

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