GLOBAL IGCC DEVELOPMENT AND DEPLOYMENT

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MISSION ENERGY: GASIFICATION INDIA DECEMBER 2020

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CLEAN COAL CENTRE

SCOPE OF PRESENTATION

ho we are, what we do and why we do it

asification for clean coal power generation: advantages and allenges

arning from early demonstration projects

chnology champions

few words on coal to future fuels

licy considerations

IEA
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Technology Collaboration Programme
by iea

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DR ANDRE
MINCHENER

General Manag

WHO WE ARE

IEA
CLEAN COAL CENTRE

Technology Collaboration Programm
by iea

e IEA Clean Coal Centre is part of a
twork of autonomous collaborative
rtnerships focused on a wide range of
ergy technologies known as Technology
llaboration Programmes (TCPs)

e TCPs are organised under the auspices of
e International Energy Agency (IEA), but the
Ps are functionally and legally autonomous

- We are funded by national governm
(contracting parties) and by corpora
industrial organisations (sponsors)
- We are dedicated to providing
independent information and analys
how coal can become a cleaner sour
energy, compatible with the UN
Sustainable Development Goals

OUR MEMBERSHIP

IEA CLEAN COAL CENTRE

EUROPEAN COMMISSION

TRALIA

ITALY

APAN

POLAND

H AFRICA

USA

AngloAmerican

ANGLO AMERICAN THERMAL COAL

BRICC

BEIJING RESEARCH INSTITUTE OF COAL CHEMISTRY

BHEL

EPPEI

ELECTRIC POWER PLANNING & ENGINEERING INSTITUTE OF CHINA

SUEK

WE SUPPORT THE SUSTAINABLE DEVELOPMENT GOALS

operating framework is designed to identify and publicise the best
tice in every aspect of the coal production, transport, processing and
ation chain within the rationale for balancing security of supply,
rdability and environmental issues, thereby countering any unwanted
cts to ensure the wellbeing of societies worldwide.

onsider policy and regulatory issues, financial resourcing, market issues,
nology development and deployment including efficiency improvements,
ring greenhouse- and non greenhouse-gas emissions, reducing water
s, ensuring poverty alleviation through universal access to robust and
ble electricity, and social licence to operate.

RECENT OUTPUT FOR THE STUDIES PROGRAMME

Reports issued within the last twelve months
Modularisation systems for clean coal
Update on finance for coal-fired power plants
The economic and strategic value of coal
Water issues for coal-fired power plants
Power plant design and management for unit cycling and load fluctuation
Support mechanisms for cofiring biomass
Global coal power fleet efficiency improvement
Understanding the role of HELE coal in the energy trilemma
Beneficial uses of coal fly ash
Electricity market designs for a reliable grid and their impact on coal plant

ONGOING STUDIES

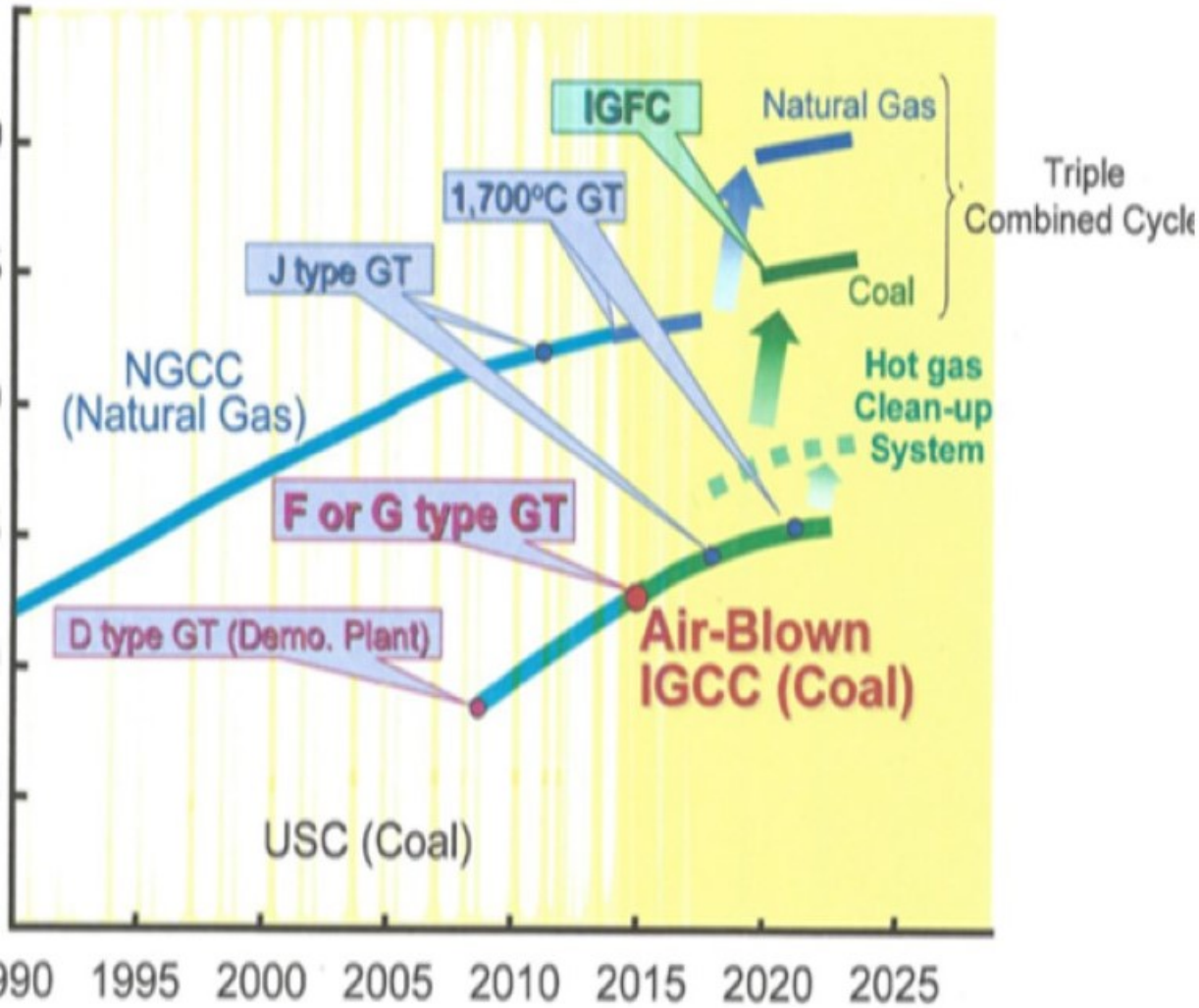
Studies in preparation and under review
Non-energy products from coal - an update
HELE Roadmap
The impact on and perspective for coal under ETS or carbon tax schemes
Increasing the efficiency of pulverised coal fired power plant
Potential markets for high efficiency and low emissions (HELE) coal-fired technologies
Digital transformation of the coal sector
CCUS status, barriers and potential
Coking coal: the strategic raw material
Technology developments for cofiring biomass with coal
Hydrogen production from coal

POLICY AND MACROECONOMIC DRIVER

Environmental Policy	• Climate targets • Technology neutral policies
Electricity sector expansion	• High annual growth • Electricity 'starvation' • Reserve margins
Macroeconomic issues	• Higher population growth • Low per capita income • Financial and business drivers

IGCC NEAR TO MEDIUM TERM POTENTIA

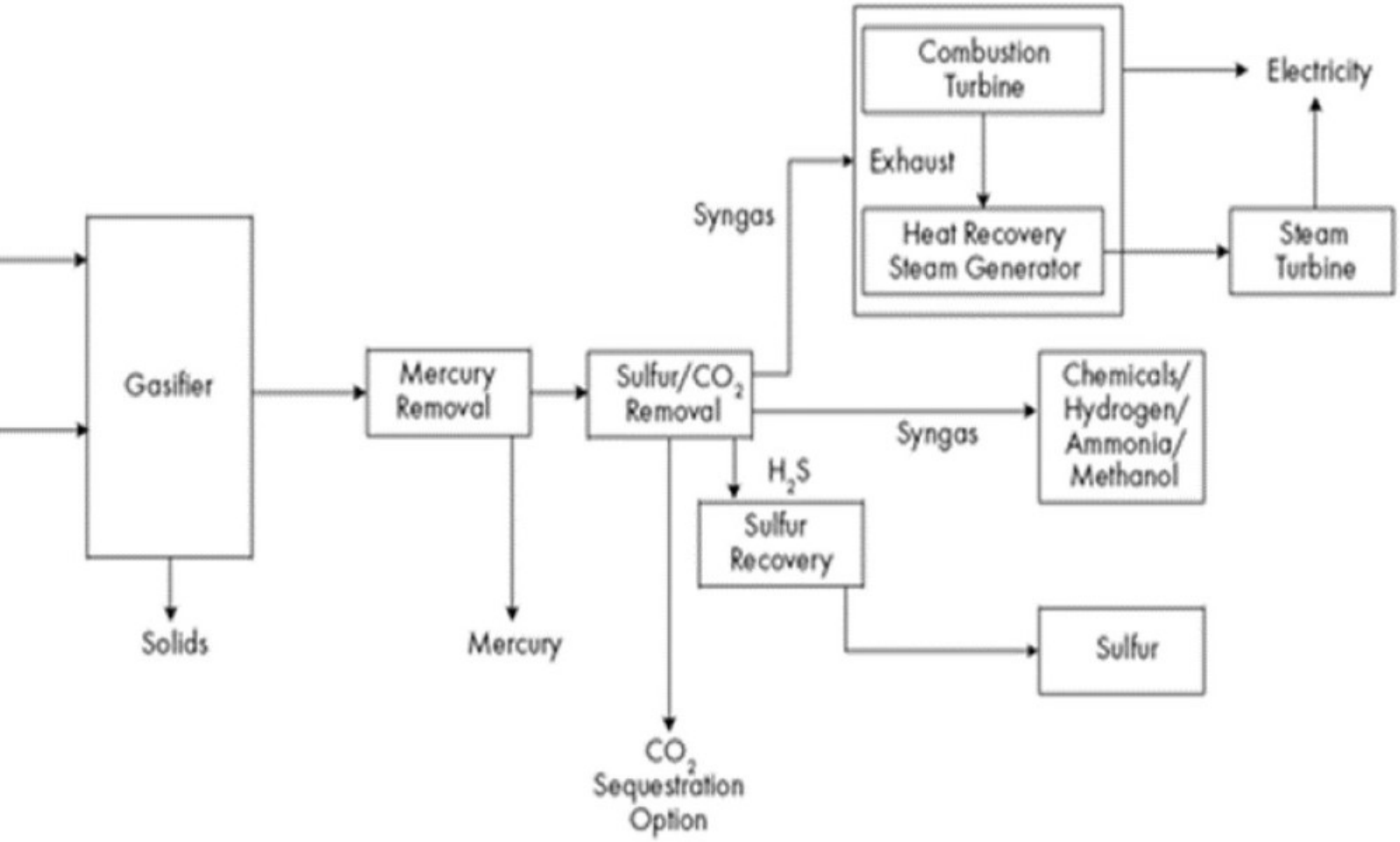
(SAKAMOTO 2011)



Gas turbine development roadmap (Sakamoto 2011)

- IGCC produces a synthetic f gas that can be modified to meet operational needs
- As gas turbine efficiencies a improved, this offers opportunity to raise power plant efficiency
- Also offers opportunity to sl composition of syngas, remo CO2 from gas stream and us hydrogen to drive a fuel cell

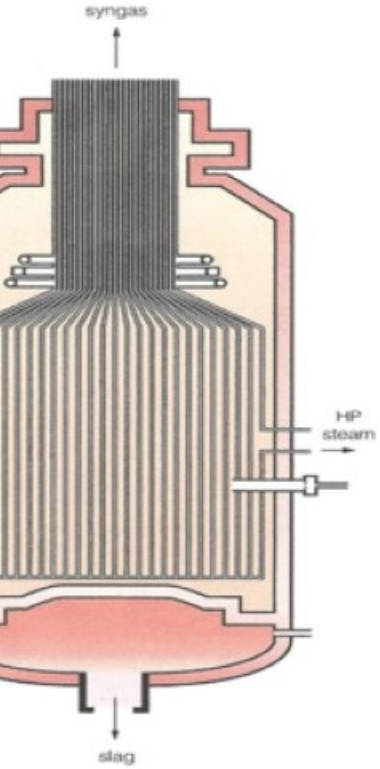
CHARACTERISTICS OF IGCC



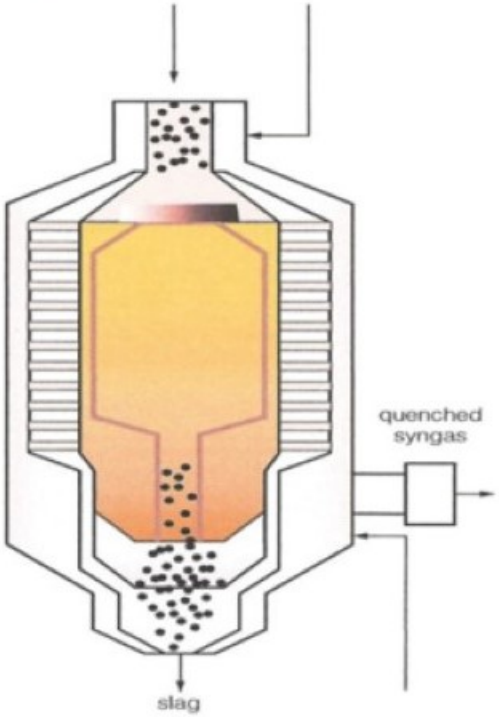
- Carbonaceous feedstock is gasifi and the fuel gas produced (CO an is purified to remo gaseous pollutant particulates befor being fired to driv gas turbine-based generator
- Heat recovered fr the gas turbine ex gas can be used to steam to drive ste turbines for additi power

PROVEN GASIFICATION OPTIONS (NETL 2013)

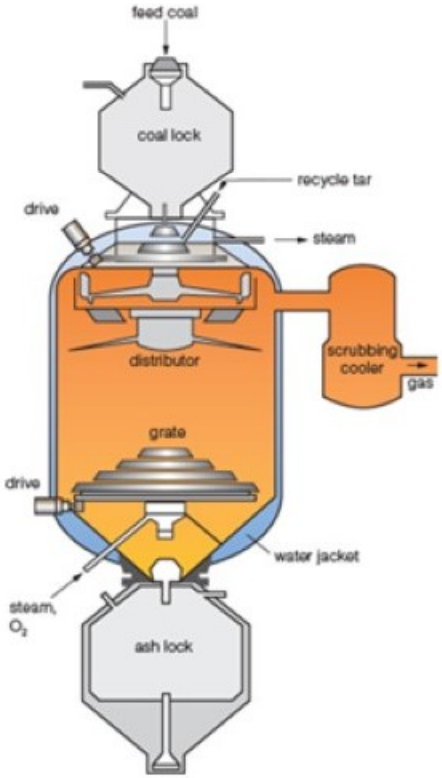
feed entrained
w gasifier



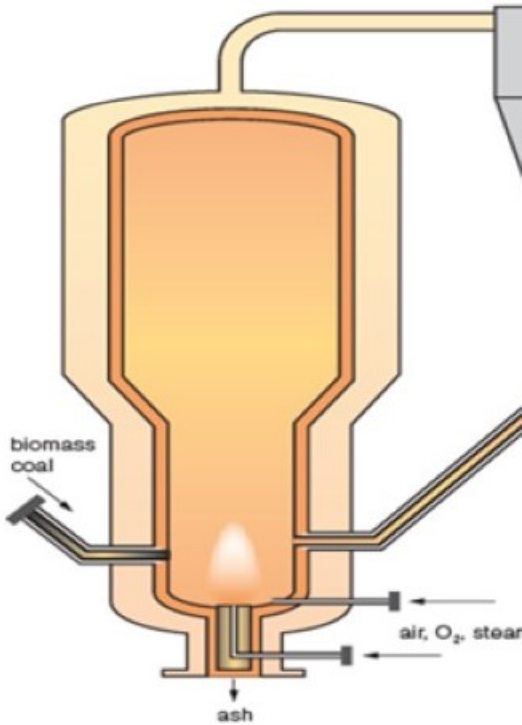
- slurry fed entrained flow gasifier



- moving bed gasifier



fluidised bed ga



IGCC TECHNOLOGY DEMONSTRATIONS

Buggenum, The Netherlands
Wabash River, USA
Vresova, Czech Republic
Polk Power, USA
Puertollano, Spain
EAGLE, Japan
Nakoso, Japan
Edwardsport, USA
Osaki Coolgen
Huaneng, China
Taean, South Korea

FIRST MAJOR COAL-FIRED IGCC POWER PLANTS ESTABLISHED WORLDWIDE

IGCC	Capacity(MWe)	Operational	Issues	Availabilit
ggenum, therlands	253 (entrained flow)	1994-2013	Syngas/waste water, comb cycle opn,leakages	<70%
bash River, USA	262 (entrained flow)	1995-2015	Component cracking/corrosion/wear, slag blockages, gas turbine hot spots	<79%
rsova, Czech Rep	400 (fixed bed) 160 (Entrained flow to process wastes from fixed bed units)	1996- 2006-	Limited load following, lack of fuel flexibility, issues with pollutant control prior to 160MWe installed	Limited loa following, lack of fuel flexibility
k Power, USA	260 (entrained flow)	1996-2017	Corrosion/erosion/fouling	<82%
ertollano, Spain	335 (entrained flow)	1998-2015	Corrosion/erosion/fouling, gas turbine vibrations	

LESSONS LEARNED AND IMPLICATIONS FR THE EARLY PROJECTS

Inappropriate design and integration approaches for different pieces of process equipment, coupled with inadequate operational procedures, led to poor operation

Tighter the integration of ASU, gas turbine and gasifier , the more efficient the IGCC can be but operational availability will be highly vulnerable to an outage of any one of these systems, causing knock-on effects

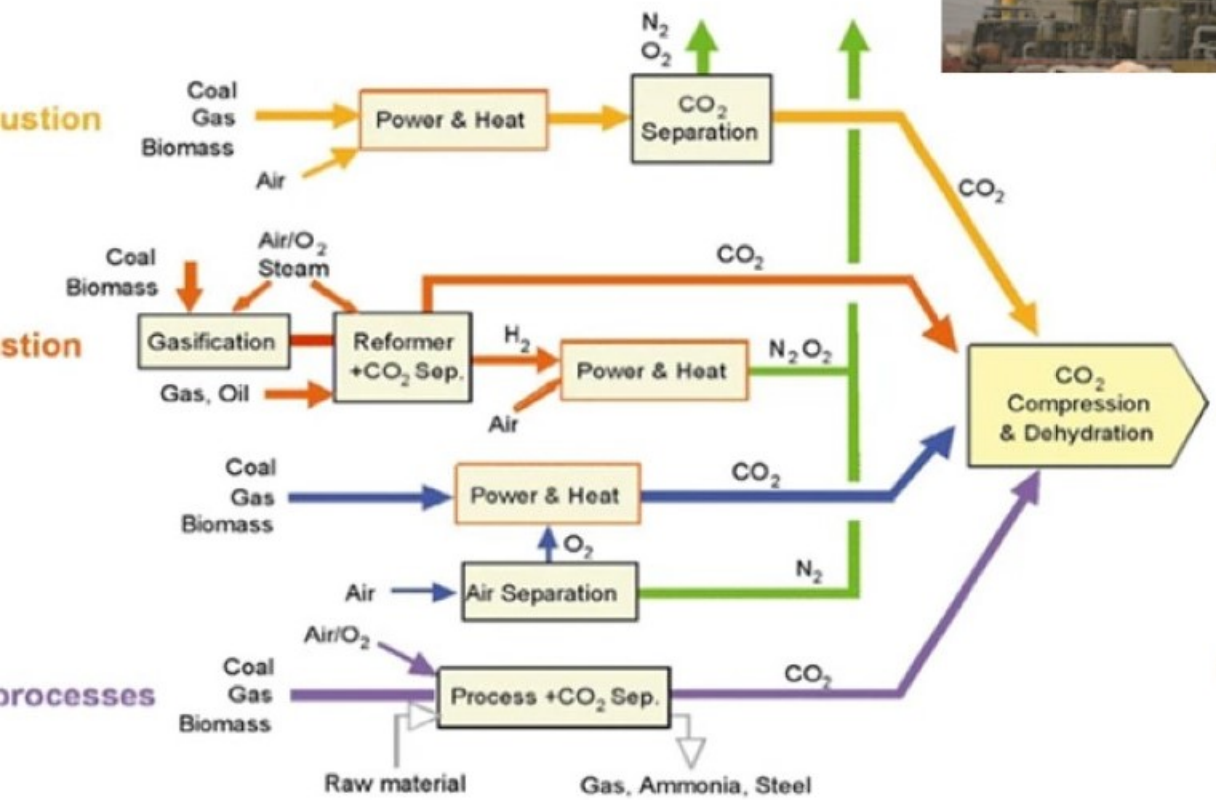
Performance of some components of the technology were very susceptible to changes in quality and composition of various coal types and other feedstocks.

Operation of individual pieces of equipment have not followed earlier predictions based on small scale results

Adapting the gas turbines to run on either syngas exclusively or a combination of syngas and natural gas may be problematic for future plant

LATER PROJECTS SHOW CONSIDERABLE PROMISE

ANENG GREENGEN IGCC PROJECT



- The first phase of Huaneng's "Green Power Plan" includes the Tianjin IGCC Power Station, with an installed capac 2650 MW.
- Operational performance has been g and in 2018 it achieved continuous operation of 3,918 hours, breaking th world record.
- Since its inception, the project has generated more than 5.8 billion kWh green electricity.

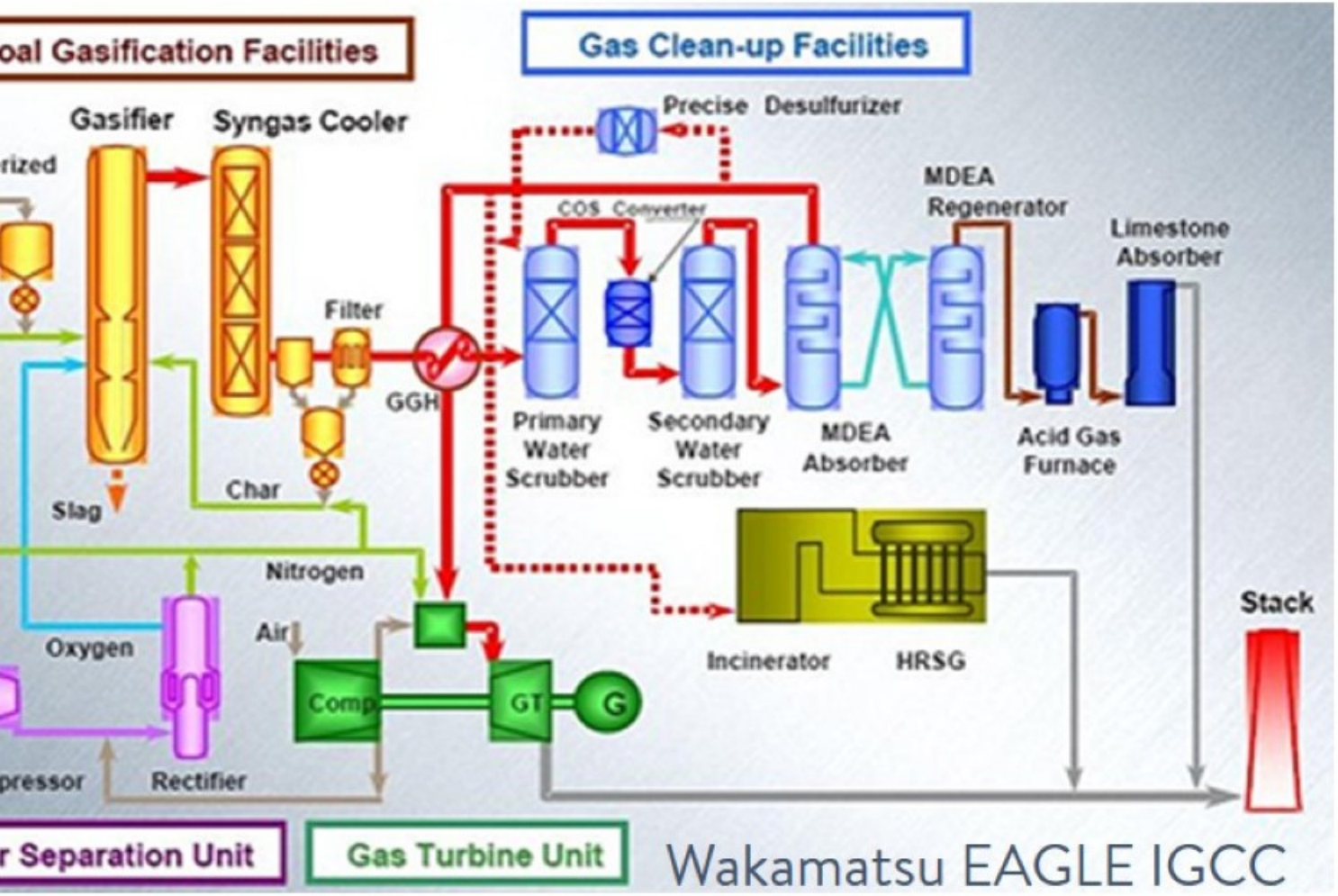
THREE PHASE DEMONSTRATION TESTING AT THE EAGLE IGCC

(SASATSU 2013)

Phase 1 (1995–2006) Gasifier development
elopment of oxygen-blown entrained flow gasifier
blishment of gas clean-up technology
Phase 2 (2007–09) Multiple utilisation and coal diversification
ture of carbon dioxide from coal gas stream through chemical absorption
stigation of alternative coal feedstocks, including high ash melting nts)
earch into trace element behaviour
Phase 3 (2010–13) Next generation development, including CCS
bon dioxide capture by physical absorption at higher pressures
ling of advanced developments
ey of innovative CO2 capture technology

APAN ESTABLISHES A VIABLE WAY FORWARD

(WWW.NETL.DOE.GOV (2020)

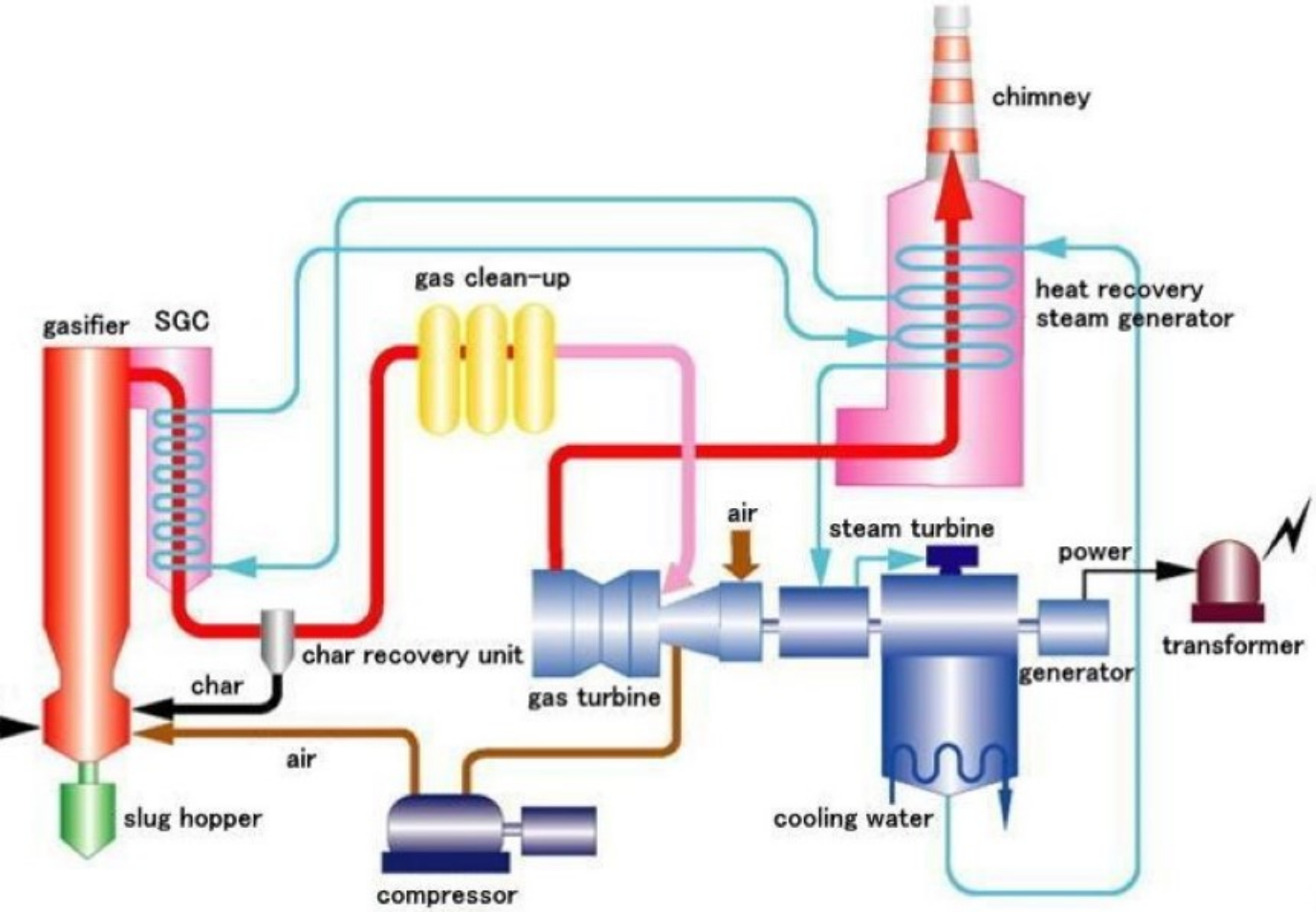


Wakamatsu EAGLE IGCC

- The EAGLE IGCC proje funded by the Electric Development Compan Japan, in collaboration Japan's New Energy ar Industrial Technology Development Organisa and is based at J-Powe Wakamatsu Research Institute in Kitakyushu Japan
- EAGLE stands for Ener Application for Gas, Li and Electricity. Its goa develop a Japanese-bu oxygen-blown, entrain flow coal gasifier, suita multipurpose applicati

se include the generation of electric power and production of thetic fuels, chemicals, and hydrogen. It considers all poly- eration aspects as well as the longer term prospect of using a ifier to produce hydrogen for fuel cell applications

NAKOSO AIR BLOWN IGCC AND BEYOND (MAKOT



- More than 16,000 hours o operational testing to end
- Plant now operated on a commercial basis by Joban PowerCo
- Nakoso achieved 42% effic achieved with a 1200oC D turbine
- MHPS suggests that a 480 net plant would achieve 48 efficiency with a G-class ga turbine and 50% for a 580M unit with a J-class machine
- Tokyo Electric Power Co. is building two new 540 MWe fired IGCC plants in Fukush Prefecture

COMMERCIAL OPERATION OF IGCC IN JAP

- IGCC offers potential for hig efficiency with very low emissions.
- Nakoso #10 250MWe unit at Joban Power Company in Jap is prime example

OSAKI COOLGEN PROJECT

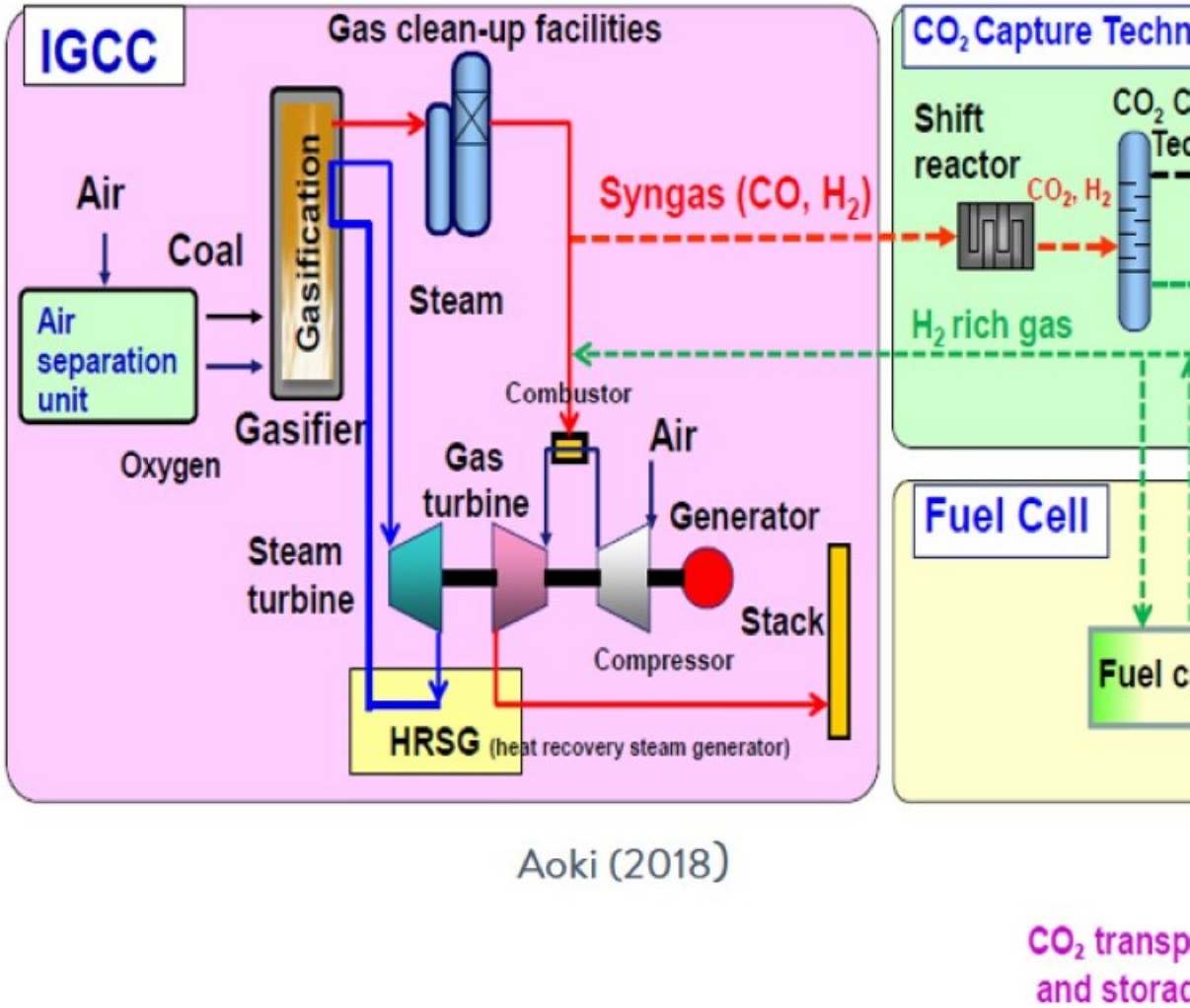
ts from EAGLE (Coal Energy
cation for Gas, Liquid and
ricity) pilot plant

own, entrained flow
cation

ver 90% CO_2 with a purity of
99%

l_2 to generate power through
ells, in addition to gas turbines
team turbines

all goal is IGFC with net
nal efficiency of 55% by 2025

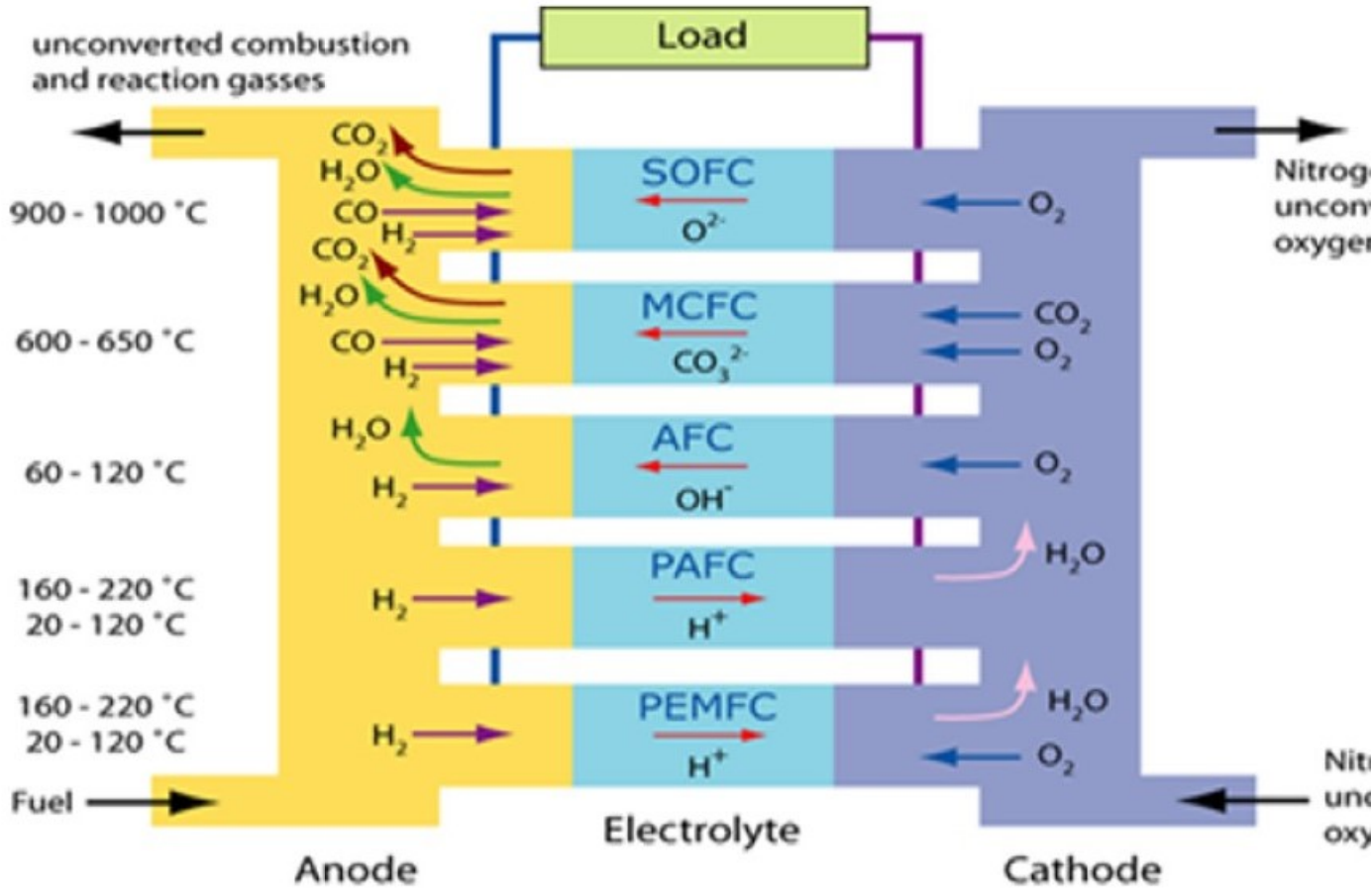


Aoki (2018)

CO_2 transp
and storac

JAPAN IS TAKING FORWARD FUEL CELLS

uel cell (FC) is an
merging technology
wards zero emission,
gh-efficiency coal
ower plants



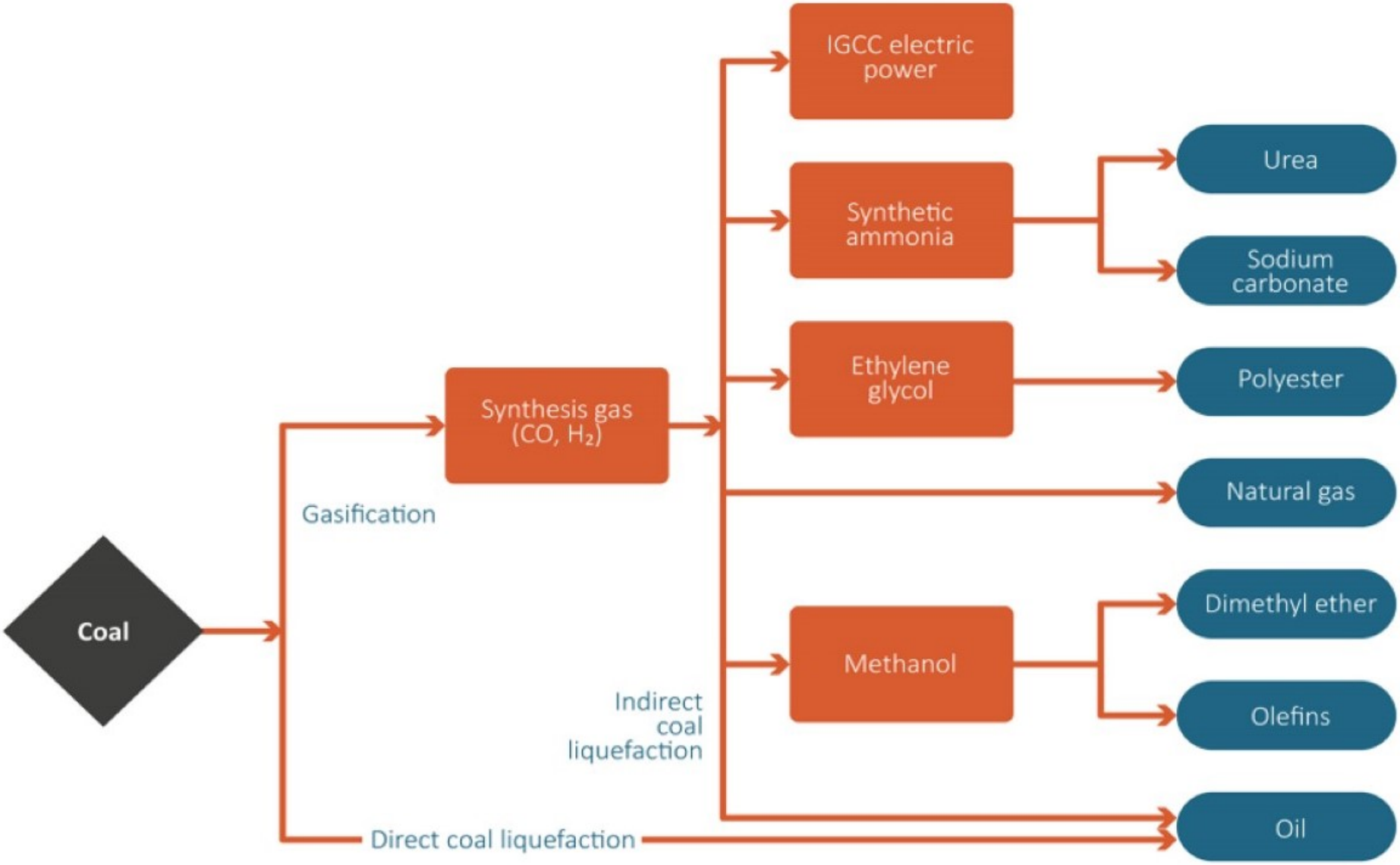
RANSFORMATION IS NOT MITED TO POWER PLANTS

- Electrification of transportation and heating
- Digitisation of electricity grids
- Flexibility
- Smart grids and virtual power plants
- Blockchain and distributed generation
- Demand side management to manage VRE
- Battery storage
- Carbon capture, utilisation and storage

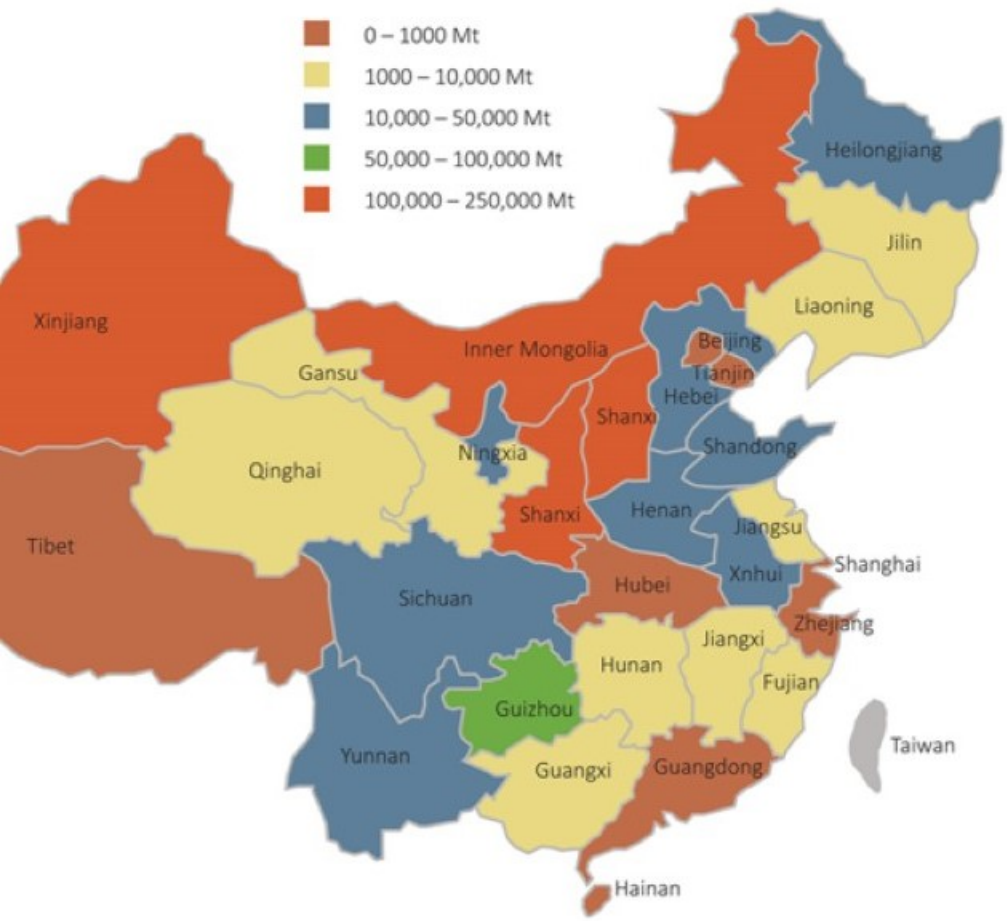
COAL GASIFICATION TO PRODUCE FUTURE FUELS IS ANOTHER OPTION

COAL AS A RESOURCE TO PROVIDE LOW CARBON END PRODUCTS

(SEEKING ALPHA, 2012)



CHINA HAS ESTABLISHED A MAJOR INDUSTRIAL SECTOR FOR CTX



- State first encouraged various coal-to chemical projects to be established, fo production of syngas as a building bloc produce ammonia, fertiliser, hydrogen methanol
- Cautious development of more compl coal-to-chemicals and coal-to-synfuel (2011-2015)
- Focus on the construction of projects commercial scale clean production, utilisation, processing and conversion calorific-value coal for coal-to-olefins to-mono-ethylene glycol, and coal-to synthetic natural gas. At the same tim plans were developed to expand the C Liquids programme to achieve comme scale capacity.

CHINA ENERGY A MAJOR TECHNOLOGY DEVELOPER

1Mty direct coal to liquids (2009-)

- 2Mty indirect coal to liquids (2017-)

CHINA'S CURRENT AND PLANNED GAS TRANSPORT INFRASTRUCTURE (PLATTS, 2014)

OTHER PROSPECTS

Tentative approach to establishing coal to methanol in India

Australia-Japan cooperation for brown coal to hydrogen project

Some work in Europe via RWE

STEP UP THE CASE FOR COAL SINCE IT WILL NEED TO REMAIN AN INTEGRAL PART OF THE GLOBAL ENERGY SUPPLY FOR A LONG TERM SUSTAINABLE FUTURE

THE IEACCC KNOWLEDGE PARTNERS NETWORK

RATIONALE

ow global solidarity
tween organisations
t have a positive
erest in sustainable
al utilisation

- Showcase the breadth of our global knowledge partners to ensure better exchange of information and encourage future collaboration

- We are also delighted t
note that there is alrea
very positive and grow
response from compar
universities and other
organisations to becom
part of this network.

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KNOWLEDGE PARTNERS

The IEA Clean Coal Centre plays an active role in an extensive network of organisations whose work is relevant to our own. This informal association of knowledge partners fa
information and results on how to reduce the environmental impact of using coal and enhance energy security in many regions where coal is readily available.

Our knowledge partners are listed below.

Sandvik
SBB Energy
SD Group
Shenergy Company Limited
Siemens
South East University
Synfuels Americas
TAURON Wytwarzanie
TE & CC (National Environmental Protection Engineering Technology Center)
The Fuel and Energy Research Forum (FER
United States Energy Association
Universidad del Valle
University of Alberta
University of Colorado
University of Kentucky
Fossil Fuel Foundation
Fuel Tech Inc
GE Steam Power
GEIDCO
Glencore
Hacettepe University of Turkey
Huaneng Clean Energy Research Institute
Huazhong University of Science and Technology
IECES (Indonesian Energy Conservation and Society
Institute for Chemical Processing of Coal
Instituto de Carboquímica
International CCS Knowledge Center
JD Energy
Lignite Energy Council
Loesche Group

8 Rivers
All-Russia Thermal Engineering Institute
Assocarboni
Bettercoal
Biomass and Fossil Fuel Research Alliance
CERTH
China Coal Processing & Utilisation
China Electricity Council
China Energy
China National Coal Association
Macquarie University
Mineral and Energy Economy Research Institute - IGSME
Minerals Council of Australia
Mitsubishi Hitachi Power Systems Europe
Mongolian coal association
NICE
ONGC Energy Centre
Peabody Coal
Penn State Energy
Polska Grupa Górnicza

JOIN OUR KNOWLEDGE PARTNERS

COUNTRIES WITH IEACCC KNOWLEDGE PARTNERS REPRESENTATIVES

AUSTRALIA (3)	BELGIUM (1)	BRAZIL (1)	CANADA (3)	CHINA (15)
COLOMBIA (1)	CZECH REPUBLIC (3)	FRANCE (1)	GERMANY (6)	GREECE (1)
HUNGARY (1)	INDIA (7)	INDONESIA (2)	ITALY (2)	JAPAN (4)
LATVIA (1)	MONGOLIA (1)	POLAND (7)	RUSSIA (1)	SLOVENIA (2)
SOUTH AFRICA (2)	SPAIN (2)	SWEDEN (1)	SWITZERLAND (3)	TURKEY (2)
UK (12)	USA (18)			
				102

KEEN TO BUILD ON OUR EXISTING CONTACTS TO BROADEN AND STRENGTHEN OUR LINKS WORLDWIDE

STRONG SUPPORT FROM OUR NATIONAL CONTRACTING PARTY MEMBERS AND OUR SPONSORS

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THANK YOU FOR LISTENING

ANY QUESTIONS?

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