# 04 Integrated gasification combined cycle (IGCC) plants


## Summary

1 Japanese utilities saw renewed interest in advanced coal technologies such as IGCCs, particularly with the start-up of the first commercial IGCC plant in Japan. However, there is little certainty that IGCC can deliver on its financial and climate promises.

2 IGCC has a chequered past, which saw frequent cost blowouts. This has led to cancellations of many planned projects globally. For the projects that went ahead, capital costs often ballooned to double the anticipated outlay.

3 High upfront cost, with significant risk of cost overruns, reduces the financial attractiveness of IGCC plants. Looking into the future, the cost reduction potential for IGCC is also not obvious. IGCC plants face challenges in scaling up installed capacity, with projects seeing the capital cost per unit of installed capacity rise instead of fall, as installed capacity increases.

4 Unless coupled with CCS, IGCC plants do not meaningfully reduce carbon emissions. There are no existing CCS-equipped IGCC plants, pointing to significant financial and technical hurdles to realising the low-carbon potential of IGCC.

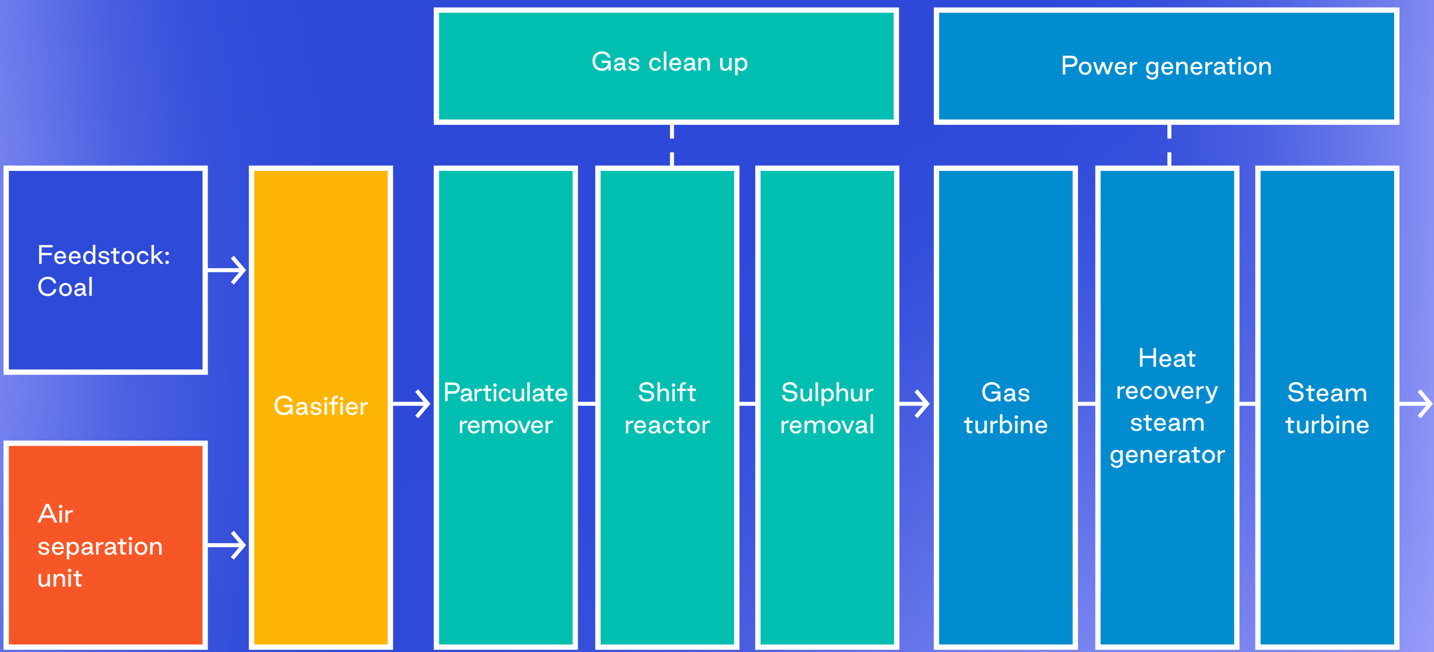
5 Retrofitting IGCC with CCS is technically infeasible, so investing in IGCC means new coal plants, which is inconsistent with Japan's net-zero ambitions, and may lead to stranded assets in the future.

6 IGCCs also face significant technical and operational challenges during the operational phase, among other challenges.

## Background

Integrated gasification combined cycle (IGCC) plants convert feedstock into synthesis gas, which is cleaned before burning in gas turbines to generate electricity. Potential feedstocks for IGCC plants include coal, biomass, refinery bottom residues (such as petroleum coke, asphalt, tar, etc.), and municipal waste. A simplified IGCC system comprises three major "systems"—gasification, gas cleanup, and power units (Figure 3.1).

### Figure 3.1 Basic set up of an IGCC plant




*Source: TransitionZero*

Coal-based IGCC plants have several advantages compared to coal plants, including: reduced air pollution, higher thermal efficiency, greater coal quality flexibility and cheaper/easier to integrate with pre-combustion CCS. Although the first IGCC plant was built in Germany in the 1970s, IGCC only gained commercial interest in the 1990s as a potential technology to keep the pollutant-emitting coal plants alive. At that point, IGCC was part of the coal industry's response to the dirty image of coal plants as heavy emitters of harmful pollutants such as sulfur dioxide, nitrogen oxide, mercury, and particulate matter, all of which contributed to localised air pollution. However, due to technological complexities and high costs compared with back-end clean-up alternatives, the technology never really took off. As climate change concerns gained traction in the early 2010s, interest in the technology revived due to its compatibility with pre-combustion CCS. Since then, several new projects have been deployed.

## Box 3.1 Global development of IGCC: a series of failed experiments

In the 1990s, a series of IGCC projects were proposed and built across Europe and the US. The rush to IGCC was prompted by air pollution concerns from coal plants. In the US, with the support of the Clean Coal Program through the Department of Energy, three IGCC plants were built: the Wabash River Project, the Polk County IGCC and the Pine IGCC. All three projects ran into operational challenges and failed to achieve their desired outcomes of proving the technical and commercial viability of coal gasification[46]. IGCC was considered a failed experiment.

### US:
### Edwardsport IGCC (2013)

Duke Energy first proposed the Edwardsport IGCC in 2006, with a projected cost of just under US$2 billion for the 618 MW plant. By the time the plant completed construction, the price tag had ballooned to US$3.5 billion, a cost overrun of over 80%. Problems persisted in the operational stage. Plant operations were far from being stable and reliable, as expected of traditional thermal plants. Edwardsport had more than three times the unplanned plant outages compared to a typical gas-fired plant, while also being one of the most expensive plants to run in the US.

### China:
### GreenGen IGCC (2011)

GreenGen IGCC is China's first commercial scale IGCC project. The project was first initiated by China Huaneng Group in 2004. After almost five years of preparatory work, the project finally broke ground in 2009. The initial project plan consisted of three stages:

1 the construction of a 250 MW IGCC plant

2 a demonstration test for carbon capture and

3 the construction of a 450 MW IGCC plant equipped with pre-combustion carbon capture[47].

In 2011, the first phase of the GreenGen project was brought online. However, while phase 2 of the project began in June 2016, the final phase of the project, which was to be the operation of a fully built CCS-equipped IGCC plant, was never completed due to technical and financial challenges.

### South Korea:
### Taean IGCC (2016)

South Korea began its own IGCC experiment in 2006 with support from the Ministry of Knowledge Economy. After years of research and development, a 300 MW demonstration plant within Korea Western Power Co's existing 4 GW Taean power plant was proposed in 2011. During that time, interest in IGCC was growing in South Korea. Due to the purported environmental benefits, IGCC plants were welcomed in South Korea, with ambitious plans to build 15 coal gasification plants producing 10 GW within the decade. However, when the demonstration plant was brought online in 2016, it was grossly over budget and underperformed both on its efficiency and environmental claims. The failure of this demonstration plant significantly slowed down the momentum for IGCC plants in South Korea and there have been no new developments since then.

### US: Kemper County
### IGCC (2017)

The Kemper County IGCC is often referred to as one of the most infamous IGCC failures. The 824 MW project was initially planned to start operating in 2014, at a cost of about US$2.9 billion. However, operational issues with the gasifier system continued to add costs and delay plant commissioning. By 2017, the capital cost of the plant was up to US$7.5 billion, and the decision was made to abandon coal gasification altogether. The facility is now operating as a natural gas plant instead.

46 Pine IGCC failed to achieve stable production, clocking only 128 cumulative hours over the three-year start-up period. Polk IGCC switched to using petroleum coke as feedstock after the five year demonstration period, while the Wabash River project faced significant challenges addressing reliability issues in the early years of operation.

47 Phillips, Booras and Marasigan (2017)

Japan's experience with IGCC in power generation can be divided into two distinct technological tracks: oxygen-blown IGCC and air-blown IGCC. Air-blown IGCCs are known to achieve a thermal efficiency advantage of 2-3% against an oxygen-blown IGCC; the latter requires an additional air separation unit, which consumes high amounts of auxiliary power, incurring high energy penalties for the plant. Existing commercial plants, such as the Nakoso IGCC plant in Japan, operate in the air-blown mode.

In recent years, interest in oxygen-blown IGCC has increased, due to its compatibility with cost-effective pre-combustion carbon capture. Initial studies have indicated that due to the high cost associated with capturing carbon downstream, oxygen-blown IGCC equipped with pre-combustion capture is expected to be commercially attractive going forward. As they had done with other technologies, the Japanese government provided significant seed funding to kick start the technological development of IGCCs in Japan. R&D for IGCC plants first started in 1983 in Japan, followed by a pilot plant test that ran from 1991 to 1996, funded primarily through government subsidies. A summary of Japan's IGCC projects are detailed below.

### Air-blown: Nakoso Unit #10 IGCC demonstration plant

In September 2007, Japan conducted demonstration tests for air-blown IGCC at Nakoso Power Station. The capacity of the demonstration plant was 250 MW, half the size of a commercial plant. The 5 year trial proved commercially successful, achieving a net thermal efficiency of 42% and over-achieving on various operational and environmental parameters. The success of the demonstration plant allowed it to continue its operation as a commercial plant from 2013.

### Air-blown: Nakoso/Hirono IGCC Power

Following from the success of the Nakoso IGCC demonstration-turned-commercial plant, a further 2x543 MW IGCC facility was built at the same site of the demonstration plant. The Nakoso IGCC plant began operations on April 16, 2021. The power plant claims to be 10% to 15% more efficient than a 600C–class ultra supercritical (USC) coal-fired unit, and targets emissions of 650g carbon/kWh[48].

### Oxygen-blown: Energy Application for Gas, Liquid, and Electricity (EAGLE) project

The EAGLE project was an initial research proposal, funded by Electric Power Development Company of Japan (J-Power), in collaboration with NEDO, a testbed for oxygen-blown coal gasification launched in 2002. Demonstration tests started in 2002, centring on IGCC operations. Since then, CCS related tests were also conducted between 2007-2013.

### Oxygen-blown: Osaki CoolGen project

Following the EAGLE project, the Osaki CoolGen Project was conceptualised to scale up demonstration tests, and included new elements such as CCS and the production of hydrogen to support the creation of a hydrogen economy. The Osaki CoolGen project consists of the design, manufacturing and operation of a 166 MW oxygen-blown IGCC plant, which will be conducted in three stages.

- Phase 1 (2016-2018): Demonstration tests for the commercialisation of oxygen-blown IGCC
- Phase 2 (2019-2020): Demonstration tests for oxygen-blown IGCC coupled with CCS
- Phase 3 (2021-2022): Demonstration tests for integrated coal gasification fuel cell combined cycle (IGFC) technology

48 Power Magazine (2021)

## Cost of IGCC
## Chequered past

### Table 3.1 Capital cost estimates for IGCC plants

| Sources | Original unit | Original value | US$(2021)/kW | Description |
|---|---|---|---|---|
| Wang and Stiegel (2015) | $/kW (2011 US) | 3,339 | 3,910 | |
| Wang and Stiegel (2015) | $/kW (2011 US) | 3,461 | 4,053 | |
| Wang and Stiegel (2015) | $/kW (2011 US) | 3,820 | 4,474 | |
| NREL (2019) | $/kW (2017 US) | 3,893 | 4,184 | |
| Pichardo et al (2019) | $/kW | 5,999 | 6,182 | |
| Pichardo et al (2019) | $/kW | 7,140 | 7,358 | |
| Xia et al (2020) | $/kW | 2,133 | 2,292 | |
| Xia et al (2020) | $/kW (2017 US) | 3,540 | 3,805 | Based on Taean IGCC, South Korea |
| Rosner et al (2020) | $/kW | 5,136 | 5,228 | |
| Xia et al (2020) | $/kW (2017 US) | 5,663 | 6,086 | |
| Kim (2021) | $/kW (2017 US) | 4,820 | 5,180 | Based on actual project: Edward-sport, US |
| Szima et al (2021) | Euro/kW | 2,245 | 2,657 | |
| Adnan et al (2021) | $/kW (2011 US) | 4,872 | 5,706 | |

*Source: TransitionZero, and the various literature quoted in the table*[49]
*Note: If the study did not specifically cite the base year for cost estimates, we have assumed that the costs are indexed to the year of publication.*

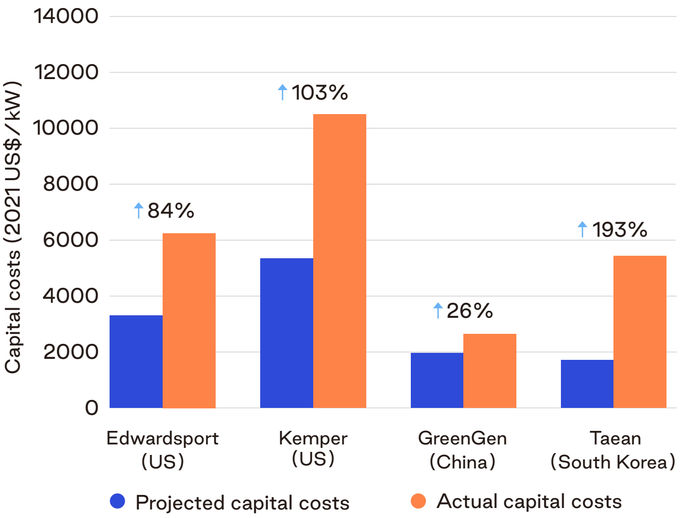
Aside from the high capital costs, the risk of cost blowouts is also significant for commercialising IGCC plants. Due to the technical complexity of IGCC plants, several well-known IGCC plants faced significant budget overruns as the final design specifications are fleshed out, due to factors such as repeated modifications and increased complexity of plant design. The technical complexity for IGCC plants can be largely attributed to the intricacy of individual "systems" and processes, and the need to ensure integration across the multiple systems.

The performance and economic viability of gasifier units are key measures of commercial success of an IGCC plant. However, gasifiers have also been a key problem area for IGCC projects, being the root cause of various well-known IGCC failures. While we refer to a gasifier as one simple unit, there are multiple underlying design parameters that make each gasifier unique. Design considerations such as the choice of technology (i.e. fixed bed gasifier, moving bed gasifier, or circulating fluidised bed), the coal feeding conditions (slurry or dry feed), by oxidising agent (air-blown or oxygen-blown), and many other factors, make each gasifier customised for each plant.

In addition, the need to integrate across multiple systems further enhances the technical challenges associated with IGCC plants. To achieve higher efficiency and ensure smooth plant operations, a high degree of synchronisation is required between the three main subsystems. However, this level of coordination can be challenging to accomplish. If unsolved for, the design flaws may also lead to increased maintenance, reduced availability and degraded reliability for the plant. Such risks should also be considered when evaluating investments into IGCC plants at an early stage. Compared to conventional coal plants, which have achieved a level of technological sophistication to enable simpler plug-and-play project development, a typical IGCC plant will have to undergo rounds of technical design, and even then, face a lead time for synchronisation before stable plant operations.

49 Xia et al (2020); Szima et al (2021); Wang and Stiegel (2016); NREL (2019); Kim (2021); Rosner et al (2019); Adnan et al (2021); Pichardo et al (2019)

## Figure 3.2 Cost blow-outs for select IGCC projects




*Source: TransitionZero*
*Note: Kemper IGCC has higher capital costs due to its integration with CCS. GreenGen IGCC claimed to achieve lower capital costs due to the use of self-developed gasifiers instead of importing existing commercially available gasifiers. Thus, the result is hard to replicate. Despite GreenGen being touted as a success story, China did not build any new IGCC plants thereafter, possibly indicating that the technology has fallen out of favour.*

Cost-overruns due to technical complexities of IGCC plants are one of the main contributors that led to the series of high-profile failures of IGCC plants. Aside from Kemper IGCC, several now infamous projects, including the US FutureGen project, and Australia's ZeroGen project, were suspended due to unmanageable and escalating costs. Out of the 25 coal-gasification projects that were proposed in the US in early 2000s, only two projects were brought to completion (Edwardsport and Kemper County), and at significantly higher costs (Table 3.2)[50], without ultimately incorporating carbon capture. Most of the projects were suspended, citing challenges due to high costs, significant project lead times and technological challenges. South Korea saw history repeat itself as the ambitious scale-up goals lost momentum after challenges revealed by Taean IGCC.

> Out of the 25 coal-gasification projects that were proposed in the US in early 2000s, only two projects were brought to completion

Poor air quality in Seoul, South Korea is regularly blamed on coal. However, Japan seldom faces similar issues due to strict emissions standards at coal power plants.

## Table 3.2 Select cancelled IGCC projects

| Cancelled IGCC projects | Cancelled year | Country | Size (MW) | Technology |
|---|---|---|---|---|
| Ashtabula IGCC | 2006 | US | 830 | IGCC |
| Polk Power Station Unit 6 | 2007 | US | 630 | IGCC |
| Southern Illinois Clean Energy Center | 2007 | US | 600 | IGCC |
| PacifiCorp Sweetwater Project | 2007 | US | 450 | IGCC |
| Stanton Energy Center | 2007 | US | 285 | IGCC |
| Nueces IGCC Plant | 2007 | US | 600 | IGCC |
| Bowie IGCC | 2007 | US | 600 | IGCC |
| Huntley Generating Station | 2008 | US | 680 | IGCC |
| Buffalo Energy Project | 2008 | US | 1100 | IGCC |
| Future Gen | 2008 | US | 200 | IGCC/pre-combustion capture |
| Kwinana Power Station | 2008 | Australia | 500 | IGCC/pre-combustion capture |
| Great Bend IGCC | 2009 | US | 629 | IGCC |
| Hebei Chaohua IGCC | 2010 | China | 800 | IGCC |
| Goldenbergwerk IGCC | 2010 | Germany | 450 | IGCC/pre-combustion capture |
| Mesaba Energy Project | 2011 | US | 603 | IGCC |
| ZeroGen | 2011 | Australia | 500 | IGCC/pre-combustion capture |
| Magnum IGCC | 2011 | Netherlands | 1311 | IGCC |
| Mountaineer IGCC | 2011 | US | 629 | IGCC/pre-combustion capture |
| Taylorville Energy Center | 2013 | US | 770 | IGCC/co-production |
| Lianyungang IGCC | 2014 | China | 1300 | IGCC/pre-combustion capture |
| Teesside IGCC | 2015 | United Kingdom | 850 | IGCC/pre-combustion capture |
| Texas Clean Energy Project | 2017 | US | 400 | IGCC/pre-combustion capture |
| North Killingholme IGCC | 2017 | United Kingdom | 470 | IGCC/pre-combustion capture |
| Lima Energy IGCC | 2018 | US | 600 | IGCC |

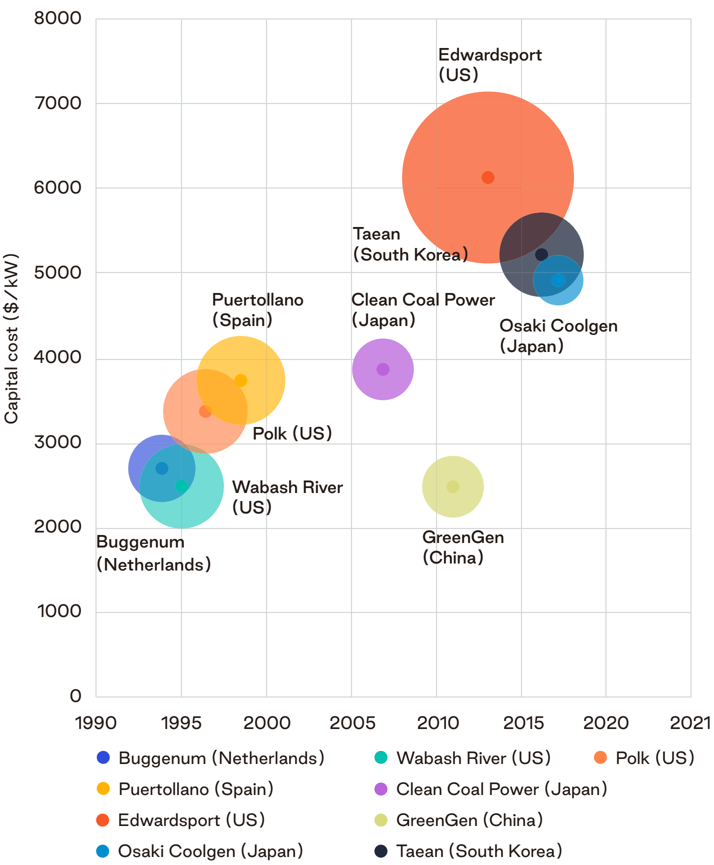
*Source: TransitionZero*

## LCOE assessment

Looking into the future, the cost reduction potential for IGCC is not obvious. With only a handful of existing projects, a robust analysis on the cost reduction potential for IGCC plants is not possible for this report. However, based on the consolidated project costs of commercial IGCC plants, the cost reduction potential for IGCC plants appears limited (Figure 3.3). In fact, from 1990 to 2020, the overall trend for IGCC capital costs seems to be increasing. This is not surprising, due to the technical complexities and bespoke nature of each IGCC project.

In addition, the capital cost estimates of past projects seem to point to another trend: as larger projects are installed over the years, the capital cost per unit of installed capacity does not fall, but actually rises. This poses a significant challenge for large-scale deployment of IGCC plants in the future. Most existing IGCC plants are between 200 MW to 300 MW, significantly smaller than typical coal and gas plant units. The largest IGCC to date is the Edwardsport IGCC project, at 618 MW. It is also the most expensive IGCC plant on a per kW installed capacity basis[51]. The need to ensure seamless integration across various individual systems, discussed earlier, may have contributed to the difficulty in scaling up IGCC operations.

### Figure 3.3 Capital costs of IGCC plants




*Source: TransitionZero*
*Note: The size of the bubble illustrates the size of the IGCC project. Kemper County IGCC is removed from this project list as it does not run as an IGCC plant and runs exclusively on gas.*

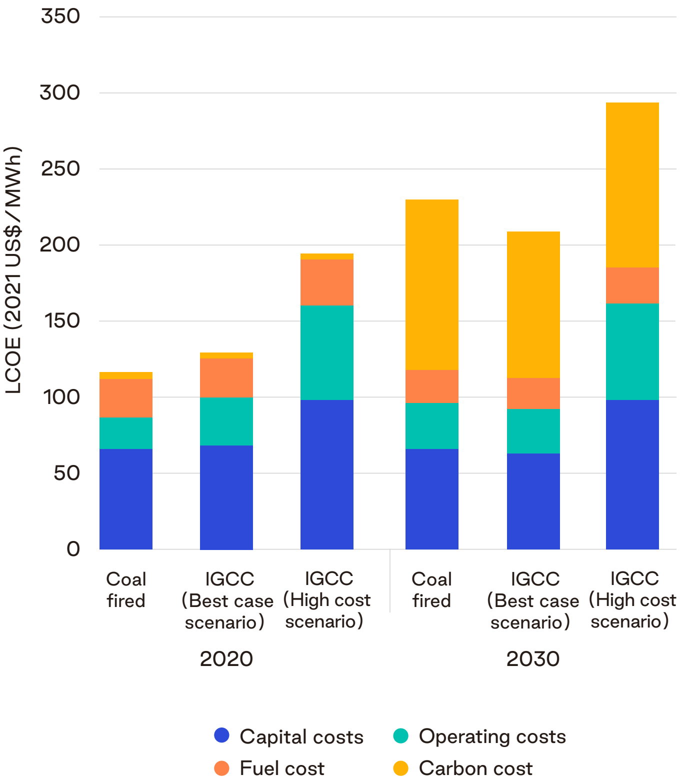
Anecdotal evidence from the ill-fated Edwardsport and Kemper County IGCC plants may also help uncover some of the reasons behind the flat learning curve. Both plants are attempts to scale up from existing prototypes, Edwardsport being a 2:1 scale up of Polk County IGCC and Kemper of a similar demonstration plant in the US. Both projects aimed to gain some learning experience from previous prototypes, including recycling previous project design parameters. However, it was not long before both projects ran into significant design flaws when they realised that significant modifications to the original design was required, leading to additional costs to correct those errors during the construction stage[52]. Developers of both Edwardsport and Kemper County IGCC severely underestimated the complexity of the technology, resulting in both plants failing to reach their design performance. In fact, Kemper County IGCC never ran on coal gasification.

What the Edwardsport and Kemper County IGCC experience illustrates is the lack of transferability across different projects for IGCC plants. This leads to a rather flat learning curve for the technology, meaning that cost reductions are likely to remain low despite additional deployments. That being said, some lessons and cost reductions can be achieved on the operational level. According to research by the IEA Clean Coal Centre, several lessons, specifically on the plant management front, can be drawn from existing commercial IGCC plants, which could help to create operational savings[53]. However, the case study above has proven that project developers and investors, alike, should be cautious not to overestimate cost savings from learning curves for IGCC plants.

51 The next largest IGCC plant will be Japan's 540 MW Nakoso IGCC plant. Cost estimates for Nakoso IGCC are not included in this analysis as TransitionZero cannot confirm the actual capital cost, although preliminary estimates place the figure at JPY 150 billion (US$1.3 billion).

52 Xia et al (2020)
53 Barnes (2013)

## Figure 3.4 Cost breakdown for IGCC power plants

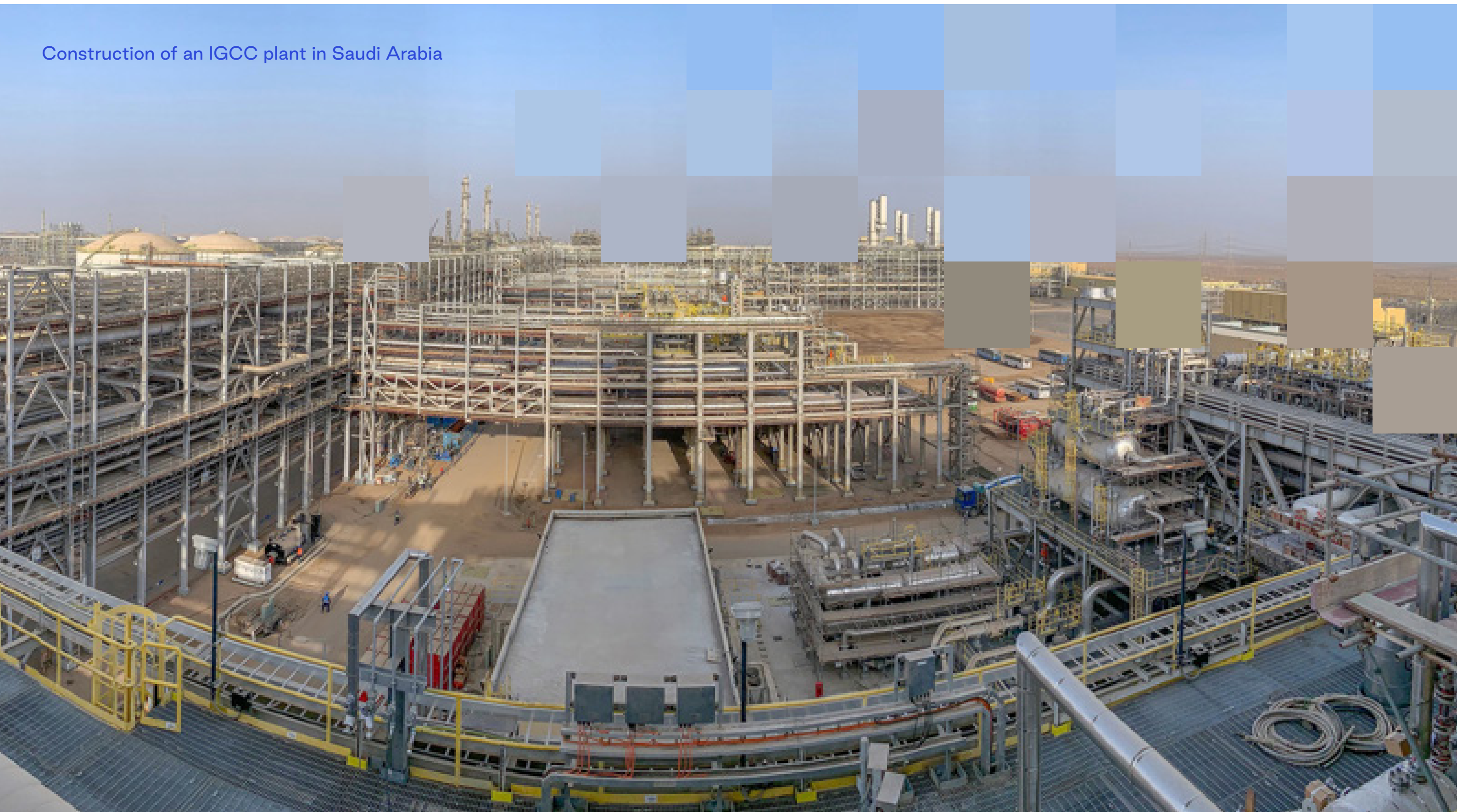



*Source: TransitionZero*
*Note: The carbon cost refers to the carbon costs associated with power generation in Japan, which stands at US$5/ $tCO_2$ and US$130/ $tCO_2$ in 2020 and 2030 respectively. The assumed 2030 carbon price is in line with IEA's NZE scenario.*

Although commonly overlooked, operating costs hold significant sway over LCOE for IGCC plants. Operating costs make up 24–31% of total LCOE for coal gasification plants, compared to coal plants at 17%. The increased operating costs are the direct result of increased monitoring requirements, particularly from the gasifier and turbine units, which are prone to breakdowns. Such equipment breakdowns lead to plant outages, which drags down plant availability and financial returns on the plant. To counteract these issues, significant investment into monitoring and control systems are required.

Under the best-case scenario, with costs aligned with the lower end of cost estimates, IGCC plants are marginally more expensive than traditional coal-fired power plants. However, for this scenario to occur, there is little margin of error for project development, requiring immaculate plant design, cooperation among engineering, procurement, and construction (EPC) contractors and smooth operations throughout the lifetime of the plant. The likelihood of this is low due to a poor track record, drawn from experience.

When considering a more realistic high-cost scenario, which aligns with the cost estimates of existing plants, the LCOE will skyrocket to above US $190/MWh, which is more than the average 2021 electricity price in Japan, currently standing at US $134/MWh. Compared to the best-case scenario, capital cost premiums are likely to arise from increased equipment costs, EPC contractor risk premiums, as well as other finance and related charges. Realistically, the cost of IGCC plants in Japan is likely to fall somewhere between the best-case scenario and the high-cost scenario.

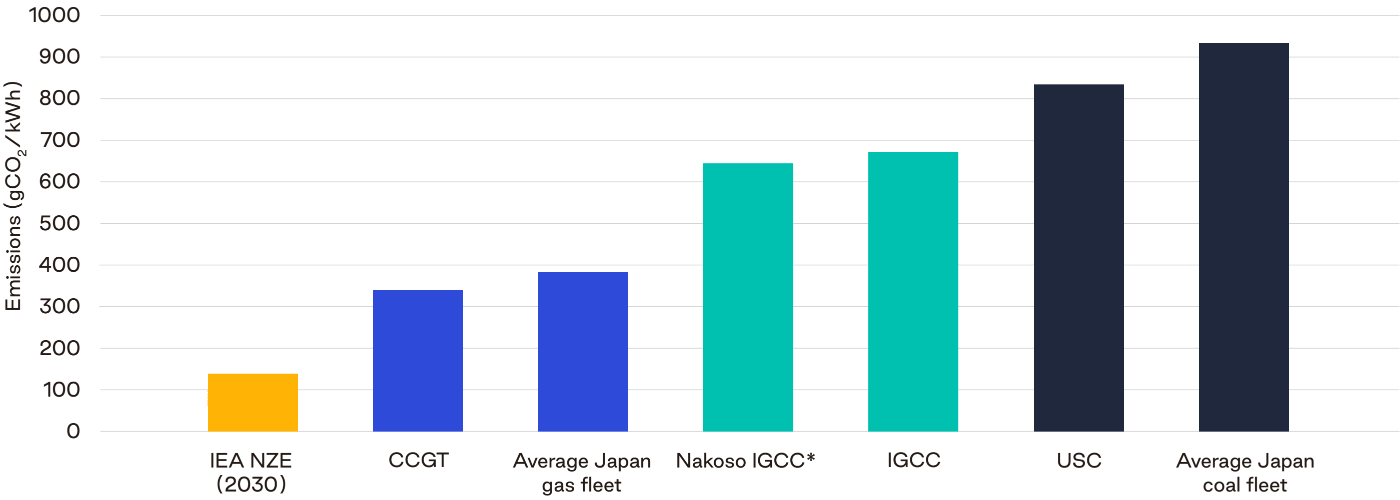


Construction of an IGCC plant in Saudi Arabia

## Carbon reduction potential of IGCC

Per the IEA's NZE scenario, unabated coal generation is phased out in advanced countries, such as Japan, by 2030 and globally by 2040. According to existing literature, IGCC plants emit about 670 $gCO_2$/kWh, or a 22% reduction compared to ultra-supercritical (USC) coal plants. IGCC's abatement potential stems from its higher thermal efficiency, which reduces the coal consumption at coal plants. Compared to the average USC thermal efficiency of 42% at a low heating value (LHV) basis, IGCCs can achieve an efficiency of 46%-50%[54]. This will mean less coal is burned for the same power output, thus reducing the emissions per unit of power generated. Despite potential emissions-cutting benefits, as detailed in Figure 3.5, the emissions of IGCC plants still stand at almost double that of gas-fired power plants and deviate significantly from a net-zero aligned pathway, as envisioned by the IEA NZE scenario. Thus, without pre-combustion CCS, IGCC does not belong on a list of options for decarbonising the power sector.

### Figure 3.5 Emissions performance of IGCC plants




*Source: TransitionZero*
*Note: Nakoso IGCC refers to the emissions factor that Nakoso IGCC plant in Japan claims to have achieved, which is lower than industry estimates of a typical IGCC plant. To date, there is no confirmation whether this has been achieved since the plant only started commercial operations in April 2021. CCGT refers to the emissions factor of combined cycle gas turbines. USC refers to the emissions factor of ultra-supercritical coal plants. USC plants are considered to be the most efficient of coal-fired power plants*

More critically, existing coal fleets cannot be retrofitted with IGCC technologies. Unlike ammonia co-firing, which can be enabled through the existing coal fleet, retrofitting existing coal plants into IGCC is prohibitively expensive. This means that any additional investment into IGCC will directly translate into new-build coal plants in Japan. This will not only contradict Japan's overall climate ambitions and do nothing to reduce grid emissions to put Japan on a net-zero trajectory, but also result in significant stranded asset risk in the future. The stranded asset risk is best illustrated when considering the cost of generation of new build IGCC plants in 2030. Assuming a carbon price of US$130/$tCO_2$, consistent with the IEA NZE scenario, the LCOE of IGCC plants lies between U$200-300/MWh (Figure 3.4), which is close to double the electricity prices in Japan.

The lifecycle impact of IGCC raises even more alarm bells. One of the key benefits of coal gasification lies in its ability to use a variety of coal grades, particularly the lower grade lignite and subbituminous coal. Lignite is largely regarded as the world's most pollutive and energy inefficient fuel. Moreover, lignite also creates concerns around a range of other environmental externalities, including localised air pollution, soil quality concerns near mining sites, upstream methane slippages, among many others. In recent years, with the climate movement gaining momentum, demand for the fuel is declining as end-users seek cleaner alternatives. However, should coal gasification gain mainstream status in the power sector, it could breathe new life into this industry, raising more concerns about emissions across the lignite value chain, a move that would be detrimental to the global climate movement.

54 Estimates place the thermal efficiency of oxygen-blown IGCC at 46%, while air-blown IGCCs can achieve 48%-50% thermal efficiency. The Osaki Coolgen demonstration plant which utilized oxygen-blown technology recorded an efficiency of 42.5% (LHV), while the Nakoso Unit 10 demonstration plant, which employs air-blown IGCC, achieved an efficiency of 42% (LHV). This indicates that there is, in effect, no emissions reduction compared to USC coal plants. The argument is that these demonstration plants see efficiency penalties due to their reduced scale. In fact, Nakoso IGCC claim that their commercial scale oxygen-blown IGCC was able to achieve 48% efficiency at a LHV basis.

## Other IGCC challenges

Historically, coal gasification IGCC plants required three to five years to reach a stable level of availability. The prolonged start-up period is required as a "debugging" phase to synchronise power plant parameters before reaching stable operations. During the start-up of the GreenGen project in 2011, the project faced various operational stability issues, which required plant operators to cooperate with equipment suppliers to undergo significant fine-tuning. The issue was resolved after repeated adjustments to the plant system, but it still took three years to reach optimal conditions. While newer plants have been able to reduce the fine-tuning phase to about one to three years, this is still considered long compared to other power generation technologies.

Beyond slow ramp up, IGCC plants also face issues with reliability. The operational challenges with Edwardsport are not unique to the plant. In fact, various other IGCC plants have experienced similar challenges with reliability. As one of the second generation IGCC plants, the Wabash River IGCC faced repeated plant outages due to gasifier problems, while integration issues have weighed down operations at Buggenum IGCC in the Netherlands. Plant outages have a direct impact on the costs of electricity as interruption of electricity generation, as well as high plant repair and maintenance costs, contribute to increased costs of the IGCC projects.

While operational failures at each IGCC plant are unique, some commonalities can be drawn. Equipment failures are common in the gasifier and turbine set-ups. With limited commercial applications of gasifiers globally, the technology has yet to achieve the maturity required for mass deployment. Due to different combustion characteristics of natural gas and syngas, gas turbine manufacturers also have some way to go to ensure stable operations of syngas turbines. To improve availability, some plants have burned natural gas as a backup fuel, or installed additional gasifiers. These additional mechanisms will only serve to prop up costs of IGCC. The addition of new equipment, such as new gasifiers or air separation units, will also increase the own energy consumption of a plant, further reducing plant profitability.

## Conclusion

Coal gasification IGCC, despite being around for decades, has yet to establish a proven track record. In its five decades of existence, the IGCC technologies received waves of interest, first in the 1990s for its pollutant control potential, and again in the 2000s, for its emissions reduction pollution potential. However, coal gasification never gained mainstream attention. This is emblematic of the various technical and financial challenges surrounding the technology, highlighted in our discussions in this paper. IGCC is not a new technology. The industry has already given up on the technology, twice. Japan's confidence in pushing forth an outdated technology that did not pass the commercialisation test, twice, is indeed worrisome. Furthermore, stand-alone IGCC only performs marginally better in terms of emissions than coal plants, limiting any meaningful contribution to climate goals. Without an obvious advantage over other power generation facilities, IGCC is unable to compete effectively in Japan's power sector. This will leave IGCC plants technologically obsolete in the face of cost-competitive zero-carbon alternatives, such as wind and solar PV.

# 10 Reference


IGCC

Adnan et al (2021). Thermo-economic evaluation of integrated gasification combined cycle co-geneartion system with carbon capture: a Pakistan's perspective. Available.

Barnes (2013). Recent operating experience and improvement of commercial IGCC. Available.

IEA (2012). Technology Roadmap - High-Efficiency, Low-Emissions Coal-Fired Power Generation. Available.

IEEFA (2017). Using coal gasification to generate electricity: a multibillion-dollar failure. Available.

Kim (2011). Overview of IGCC R&D project in Korea in Gasification Technologies

NREL (2019). 2019 Annual Technology Baseline: Electricity — coal. Available.

Phillips, Booras and Marasigan (2017). The history of integrated gasification combined-cycle power plants. Available.

Pichardo et al (2019). Technical Economic Analysis of an Intensified Integrated Gasification Combined Cycle. Available.

Power Magazine (2021). Japan Ushers in New Era for IGCC Coal Power. Available.

Rosner et al (2019). Thermo-economic analyses of IGCC Power plants employing warm gas carbon separation technology. Available.

Szima et al (2021). Techno-economic assessment of IGCC power plants using gas switching technology to minimize the energy penalty of carbon capture. Available.

Wang and Stiegel (2016). Integrated Gasification combined cycle (IGCC) technologies. Available.

Xia et al (2020); Prospect of near-zero-emission IGCC power plants to decarbonize coal-fired power generation in China: Implications from the GreenGen project. Available.

TransitionZero

Jacqueline Tao
Jacqueline@transitionzero.org
transitionzero.org
+44(0)71234567