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Current Challenges & Opportunities in IGCC Design

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IGCC Design Challenges & Opportunities

- Better Availability
- Lower Capital Cost
- Higher Efficiency
- Reduction of Power and Efficiency loss when incorporating CCS
- Clarification of Design Basis and Emission rules for CCS

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IGCC Design Challenges & Opportunities

- Better availability
  - Improved refractory and injector life, Gas turbine availability, shorter start ups
- Lower Capital Cost
  - Larger gasifiers and gas turbines provide economies of scale.(50 Hz GT ~40% larger than 60 Hz – China is 50 Hz US 60 Hz). Lower cost ASU (e.g. ITM). Lower auxiliary power usage
- Higher Efficiency
  - Higher firing temperature gas turbines, Lower auxiliary power usage. GT air extraction. Separation process for CO_2 at higher pressure. Advanced cycles.

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Gas Turbine Current Status, Planned and Future Improvements

GT Manufacturer (OEM)	Current IGCC Application	Planned or Commercially Offered	Future Improvements
GE	7 E CoolWater 7 FA Wabash, Tampa 9 E (Saras) 6 FA Valero	7 FB Duke 9 FA 9 FB Hatfield	Hydrogen firing without derate. G or H?
Siemens	6-3000 E Dow V 94.2 Nuon V 94.2K ISAB V 94.3 Elcogas	5 -5000 F 6 -4000 F V 94 2K GreenGen	Hydrogen firing without derate. G or H?
MHI	M 701D Nakoso M 701F4 Negishi	M 701 F4 Nuon M 701G M 501 F M 501 G	M 701 J (2011?) M 501 J

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Gas Turbine Challenges in IGCC Application

- To date F GTs have lower availability than earlier E types
- China IGCC Phase 1 demonstration plants currently plan E type GTs. Need to move to higher efficiency and larger size 50 Hz GTs and incorporate CCS.
- GE 7 FB (60 Hz) to be demonstrated in IGCC at Duke Edwardsport 2012.
- Siemens 6-5000 F and 5-4000 F yet to be demonstrated in IGCC
- Both GE & Siemens need IGCC demonstration of F class 50 Hz GTs
- MHI has F class IGCC 50 Hz experience. Offers G (and later J?) GTs for IGCC. Yet to be deployed for IGCC.

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Gas Turbine Challenges in IGCC Application with CCS

- The high Hydrogen content syngas in the CCS IGCC application needs demonstration for all manufacturers. Currently it appears that the suppliers will offer guarantees for IGCC CCS (Hydrogen) applications by reducing firing temperature.
- All GT suppliers are striving for higher firing temperatures and efficiencies without the firing temperature derate. DOE has programs on this with GE & Siemens.
- The ability to extract air from the gas turbine compressor improves efficiency and reduces auxiliary power consumption (Lowers ASU Main Air compressor size). In some designs this ability is constrained by ambient conditions and elevation.

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Slurry Fed Entrained Flow Gasification Technology-Status and Potential Improvements

Gasification Technology	Current Status in IGCC Application	Planned or Commercially offered	Potential Improvements
GE (single stage downflow, single injector, refractory lined)	1800 ft^3 gasifier with Radiant Syngas Cooler (SGC) and Convective SGC 450 psig (3.2 MPa) (Tampa) ~2000 mtpd coal. Bituminous coals & Petcoke. Prefer < 20% ash. Lock hopper slag removal. 900 ft^3 Quench	1800 ft^3 Radiant SGC at 600 psig (being built at Duke Edwardsport). Offer 1800 ft^3 1000 psig (7 MPa) Quench gasifiers for China but maybe not US Power ? but US Polygen?	Longer life injectors & refractory. Extend to lower rank coals and lignite (dry feed & membrane wall ?). Scale up to larger gasifiers to match larger 50 Hz GTs. Lower cost Radiant syngas cooler. Continuous slag removal (replace lock hoppers). Higher carbon conversion.
ConocoPhillips (Two stage upflow, refractory lined. Stage 1 two opposed injectors, Stage 2 single injector)	~ 2200 mtpd at Wabash. Continuous slag removal. Pet coke, bituminous & sub-bituminous coals	Offers Higher efficiency Full Slurry quench (FSQ) design up to ~ 3000 mtpd. Modified design For CCS	Longer life injectors & refractory. Extend to lignites. Scale up to larger gasifiers to match larger 50 Hz GTs. Lower cost quench design for CCS. Non fouling SGC
ECUST OMB (single stage downflow with four horizontal opposed injectors, refractory lined)	2200 tpd, 3.8 m diameter, 6.5 MPa. No IGCC	230 MW, 2200 tpd IGCC with radiant cooler. Startup scheduled for 2010. (Huadian)	Longer life injectors & refractory Extend to low rank coals (Planned). Scale up to larger gasifiers to match larger 50 Hz GTs. Continuous slag removal.

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Dry Coal fed Entrained Flow Gasification Technology – Status and Potential Improvements

Gasification Technology	Current Status in IGCC Application	Planned or Commercially offered	Potential Improvements
Shell (Single stage upflow)	2000 mtpd coal 250 MW Nuon. 3300 mtpd (1000 MWth).China up to 35% ash. All coals. Lock hoppers for feed and slag removal.	500-800 MW Sized to match 50 Hz GTs. (Nuon, Hatfield)	Lower cost coal drying. Quench design. Scale up to larger 50 Hz GTs. Continuous coal feeder and slag removal.
Siemens (single stage downflow)	No IGCC. 200 MWth in 1980's. 500 MWth now being supplied. All coals. Lock hoppers for feed and slag removal.	500 MWth offered. 1000 MWth planned?	Lower cost coal drying.Scale up to larger 50 Hz GTs. Continuous coal feeder and slag removal.
Uhde (PSG Prenflo Steam Generation) (PDQ Prenflo Direct Quench)	PSG 2400 mtpd Puertollano. PDQ no experience. All coLock hoppers for feed and slag removal.	1000 MWth PDQ offered to match some 50 Hz GTs.	As above
MHI (Two stage upflow, enriched air)	2000 mtpd matching E type GT 240 MW. Enriched air. All coals	500-800 MW Sized to match F or G type 50 Hz GTs.	As above. More efficient design for 90% capture.
Eagle (JPower) (Two stage upflow)	150 tpd pilot.	150 MW planned at Chugoku by JPower/Chugoku) 2016	As above
TPRI (two stage upflow)	36 tpd pilot.	250 MW to match E type Siemens 50 Hz GT planned for GreenGen.Tianjin	As above

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Fluidized Bed Gasification Technology – Status and Potential Improvements

Gasification Technology	Current Status in IGCC Application	Planned or Commercially Offered	Potential Improvements
KBR Transport (Air Blown)	25 mtpd pilot. Low rank coals preferred.	560 MW Air blown with 50% capture planned. (Kemper)	Scale up to match 50 Hz GTs. Extend to higher rank coals.
HRI IDGCC (Integrated Drying GCC)	15 MWth pilot	400 MW Latrobe Valley with Harbin	As above
HTWinkler	700 mtpd operated 1980-1990. Low rank coals	?.	Uncertain Future
SES (Formerly U Gas)	None. 4 x 100 tpd gasifiers.Shanghai.	? Main market is industrial & Chemical not IGCC	Not currently considering IGCC application.
Fuel Flexible	Unknown	200 MW IGCC demonstration project Dong Guan City, Guandong	Scale up to match larger 50 Hz GTs.

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Shift & Gas Clean up for IGCC + CCS Applications- Challenges and Opportunities

Challenges/Issues

- Steam needs for Shift reduce ST output
- CO_2 pipeline and potential for venting CO_2 can require stringent CO_2 purity
- CO_2 compression has high auxiliary power
- H_2S & CO_2 separation processes currently are low temperature 40°C. Syngas then needs reheat for GT

Potential Improvements

- Shift catalyst that can use lower steam/CO ratio
- Lower cost CO_2 separation that meets purity spec..
- CO_2 separation process producing CO_2 at higher pressure. Possibly membranes?
- Warm gas clean up for H_2S & CO_2 removal at higher pressure.

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Challenge – Definition of IGCC CCS Design Basis

- Emission Regulations. In standard operation and start up. % Capture ? CO2 purity?
- Operation when either CO2 compressor, pipeline or Sequestration is not available.
  Vent CO2 ?– What purity is allowed?
  Flare CO2? Shutdown? Pay CO2 fees?
- How are CCS costs (lost power etc) to be covered?
- Degree of Integration consistent with Ownership objectives
- Separate Ownership of parts of IGCC/Polygen/CCS may influence design towards less integration

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