IGCC – The Current State

Dr. Aaron Avagliano
Technology Manager, Gasification & IGCC
GE Energy

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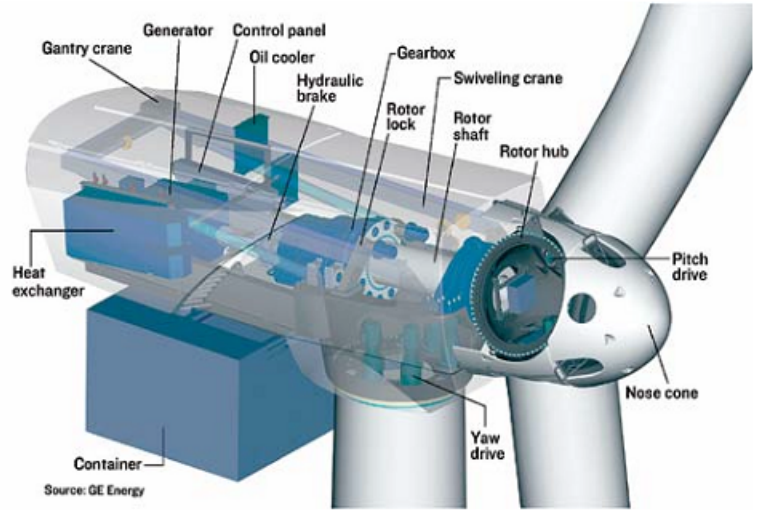
GE 1.5MW Wind Turbine

30% COE reduction '02 → '08



GE 1.5MW	'02	'08
Rotor Size (m)	77	82.5
Reliability (%)	85	97 +13 Pts
Cap Fact. (%)	39	48 +9 Pts

Installed Base	1,000	10,000+

Breakthrough improvements in performance & reliability

- Design technology- pitch system, blades, gearboxes
- Technology … improved component models
  - Fluid structural loading
  - Acoustics
  - Stress & structural reliability
  - Integrated system models

XLE Design

- Load following design, lower root stress
- Better blade performance, fluid to load, acoustics

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Current IGCC plant progresses Tampa
从坦帕电厂到新一代IGCC

Integration: technology + execution

系统整合：技术 + 项目执行

- ✓Time to maturity （项目）的成熟时间
- ✓Performance 性能
- ✓Cost 费用
- ✓Operability 可操作性

"Tampa x 2"

2倍的坦帕生产能力

Improvements + system integration

改进+系统整合

Current (Duke)

目前 （杜克）

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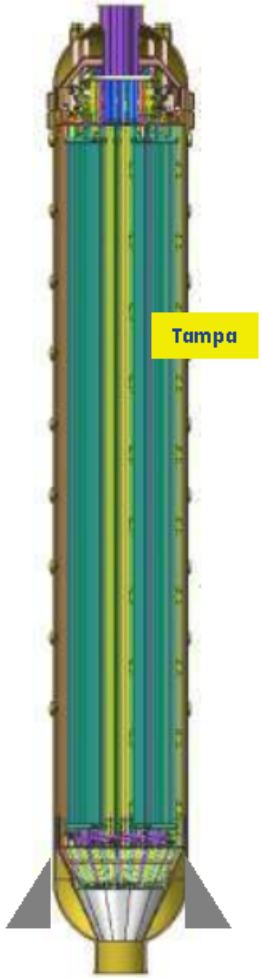
Radiant Syngas Cooler
↓ *cost* + ↑ *reliability*

辐射合成气冷却器
↓费用＋ ↑可靠性



Tampa Soot blower Deposits
坦帕灰吹扫处理

Tampa Tube Cage Leak RCA
坦帕管笼泄漏的故障根源分析

Inlet Fouling – Coating sample clean入口垢?

Soot-blowers – Removed from new configuration
除灰器－－新装置上去除了

Performance – 30% increase in steam production through surface enhancements & increased steam & hot gas pressure
性能－通过增加换热，增加蒸汽和热气压力提高30%的蒸汽产能

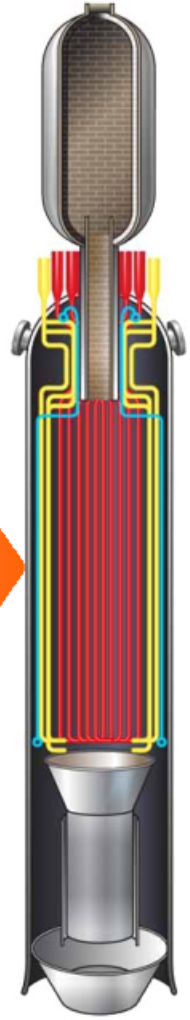
Size – 9 ft longer, same weight, and 2ft smaller diameter
尺寸－加长了9英尺，相同的重量和直径缩小2英尺

Seal/N2 Purge - Enhanced for robust operation and RAM
密封/N2吹扫-增加了操作性及可靠性，可用性及可维护性

Convective Cooler - Removed to increase availability
取消了对流冷却器增加可用性

Internal Quench – experience based configuration, favorable for sealing
内部激冷－基于经验的配置，有利于密封

Experience Based Improvements在经验基础上的改进



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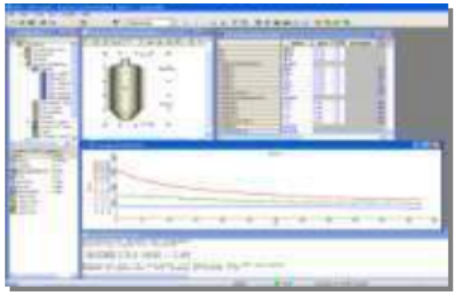
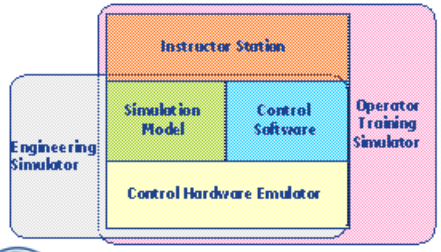
Control systems
控制系统



- Physics-based models for dynamic plant control
  机理模型用于工厂动态控制

- Plant simulator for optimization & operator training
  工厂模拟器用来优化和操作员培训



- Combined hardware + software testing & deployment
  整合硬件＋软件测试和调度

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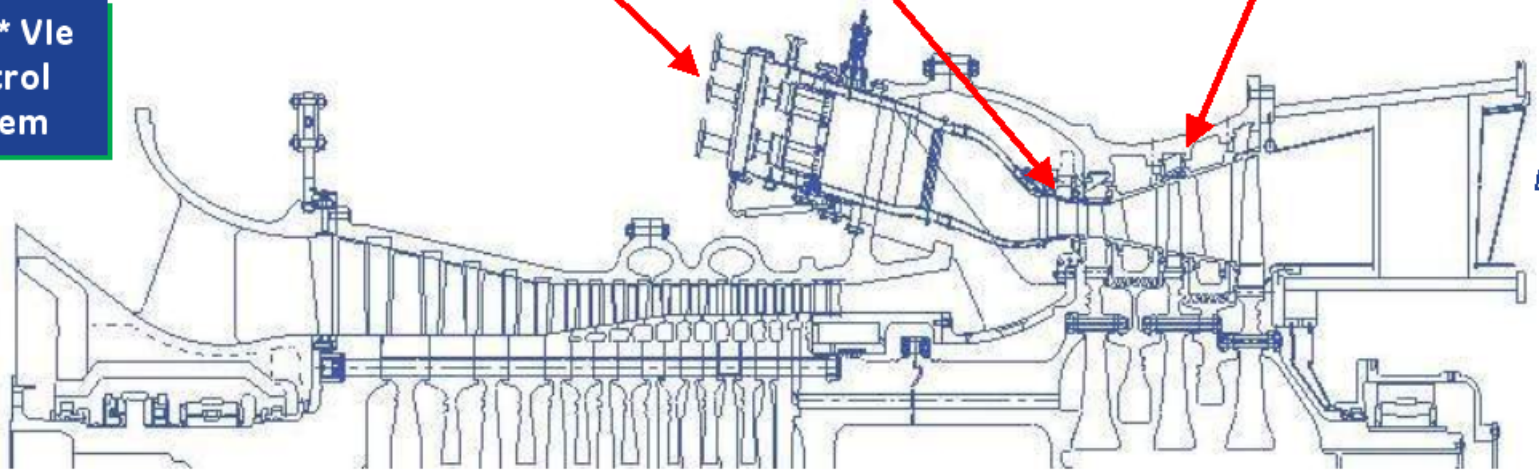
9F Syngas

Combustion System: Proven IGCC MNQC

Enhanced Increased Area S1N

9FA+e HGP (Mtls Proven in Syngas Service)

Mark * VIe Control System



"F" product line experience & technology advancements

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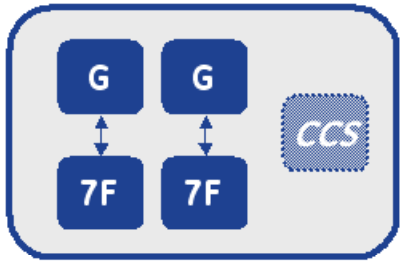
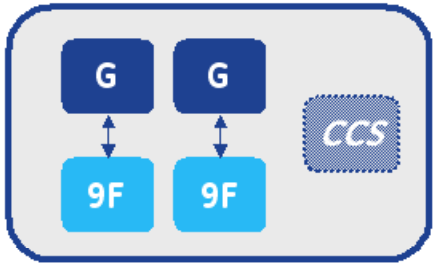
IGCC in China … ready today
IGCC在中国 … 准备就绪

Duke → COD 2012
杜克 –> 2012年竣工



- 630MW, "Carbon ready"
  63万千瓦，可碳捕集
- Improved Tampa config
  改进坦帕配置
- GE integration + controls
  GE总体设计+控制
- Under construction
  建设中

China IGCC → ready to execute
中国IGCC –> 可开始实施



- ~800MW, "Carbon ready"
  ~80万千瓦，易于碳捕集
- Std components + 9F
  标准部件+9F 燃气轮机
- GE integration + controls
  GE总体设计+控制
- Capability for 40%+ LHV
  40%＋的低位热值能力

Standard components
标准部件

Modified component
改进部件

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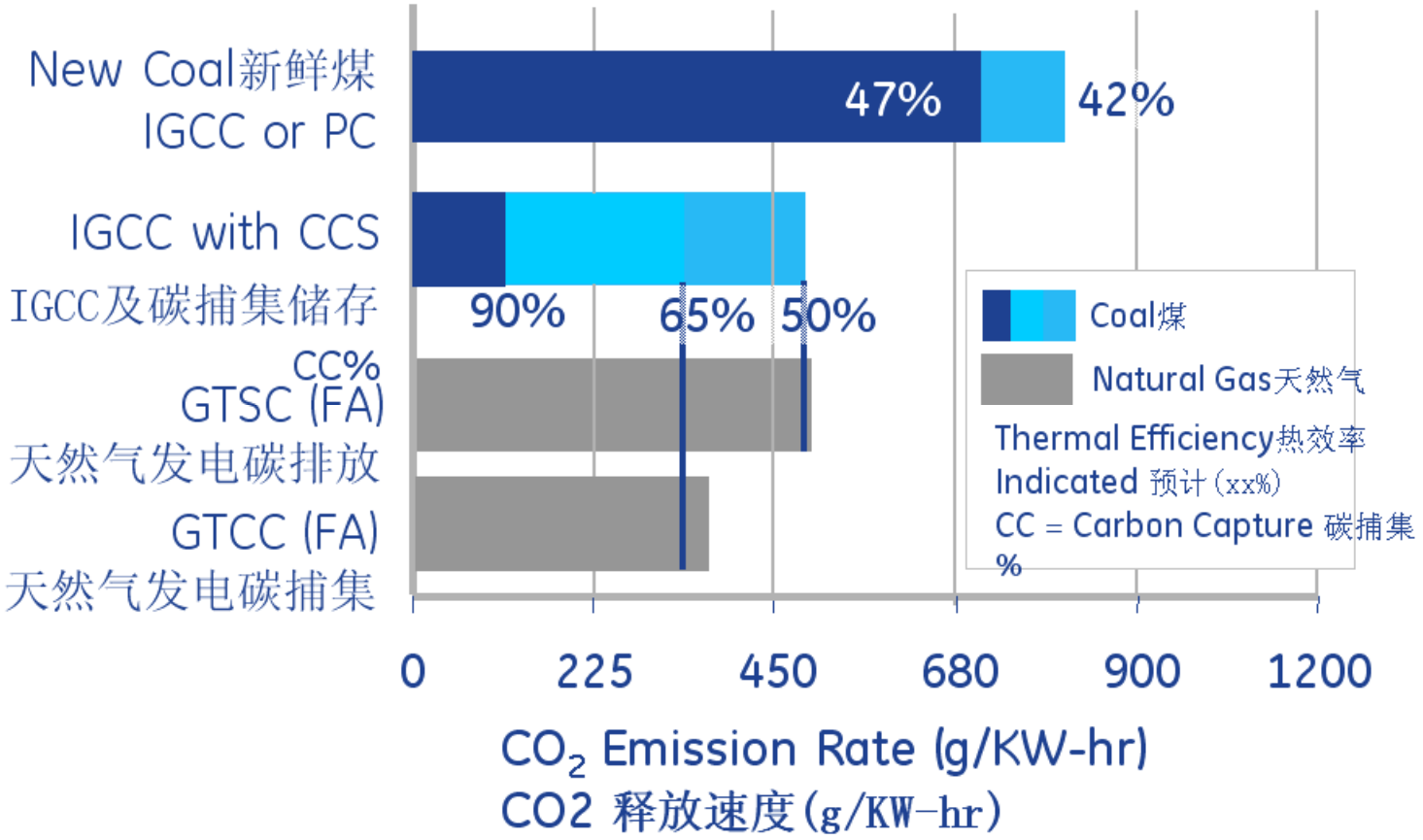
Carbon impact of fossil power 化石能源中碳的影响



References: DOE NETL; EIA; IEA and GE Internal Data

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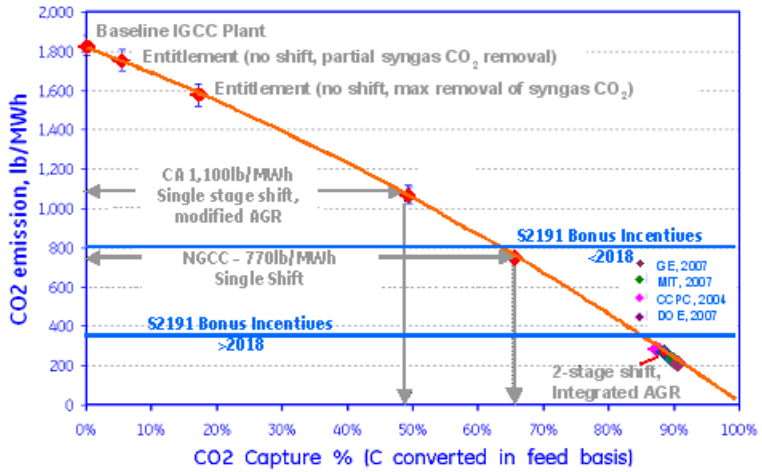
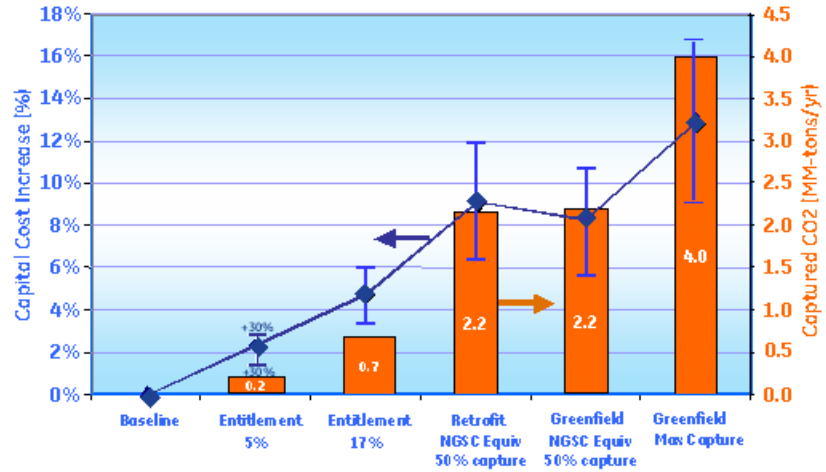
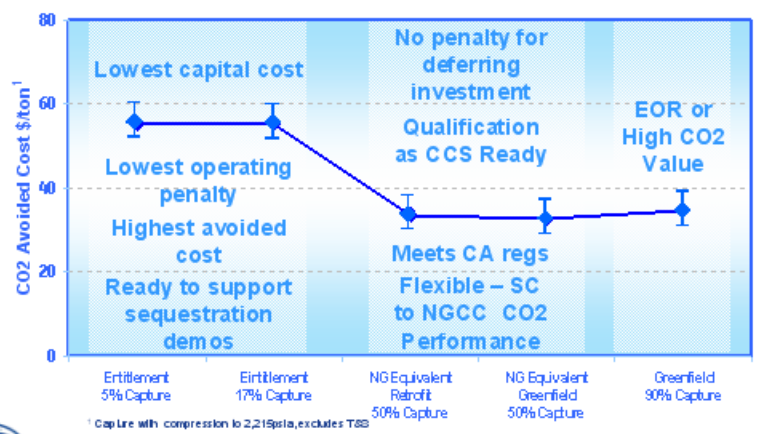
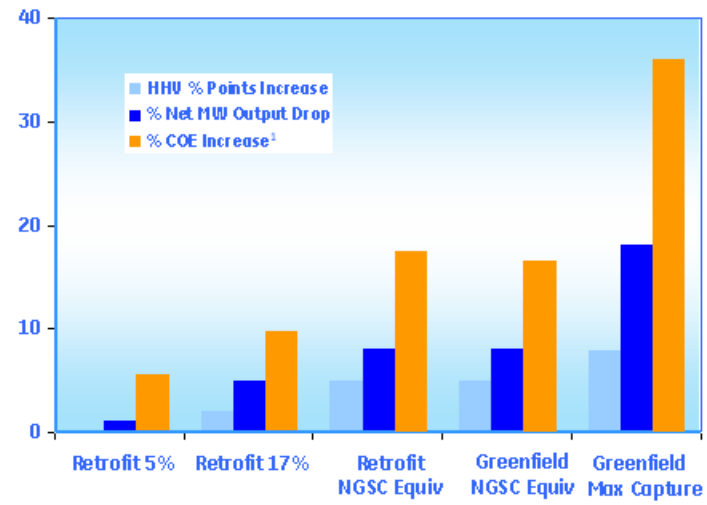
GE study shows NG-level emissions as best first step









[1] Excludes T&S

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IGCC is carbon "capture ready"

IGCC 为碳捕集做好了准备

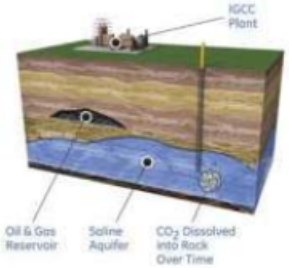
Multiple levels of carbon capture
多层次的碳捕集

1. **AGR Entitlement (~17%) - 酸气脱除的能力(~17%)**
   Remove the most CO2 from syngas by maximizing Acid Gas Removal (AGR) performance without shift.
   变换前的酸气脱除工段尽可能脱除合成气中的CO2

2. **NG Equivalency (~50-65%)-天然气发电当量（~50-65%）**
   Remove the majority of CO2 from syngas with a single-stage shift and CO2 separation.
   在单程变换和CO2分离阶段脱除合成气中大部分的CO2。

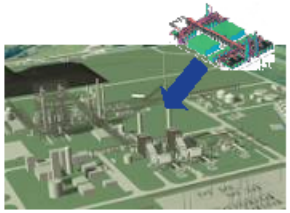
3. **Maximum Removal (~90%) -最大除碳**
   Remove the most CO2 with dual (or more) shift stages and CO2 separation.
   在双（或多）程变换和CO2分离阶段脱除大部分的CO2

A potential roadmap to CCS
潜在碳捕集封存路线图



Phase I (Now-2015)第一阶段

- **Build IGCC CC-Ready**
  IGCC为碳捕集做好准备
- **Build IGCC CCS demos**
  碳封存示范IGCC
- **Validate CO2 storage**
  验证CO2存储



Phase II (2015-2020)

- **Retrofit installed base to NG Eq. CO2 footprint**
  改造已建设施使CO2排放量可与天然气发电等同
- **Commercial CCS**
  商业运营的碳捕集储存

- **Phase III (2020-2030)**
- **Greenfield NG CO2 footprint coal build**
  以煤为原料达到绿色的天然气发电的CO2排放

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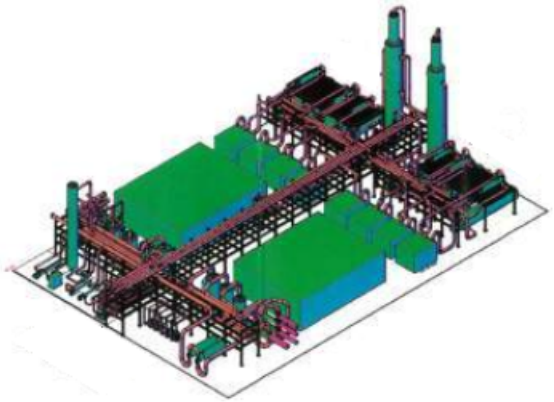
Carbon Island™ potential performance
碳岛潜在的性能



- ~$100-200MM total installed cost

约1－2亿美元的总装置费用

- ~700-740 MW output (from ~800 MW)

700－740MW输出（以后可达800MW）

- ~30-35% efficiency 效率约30－35％ (from 38-40%+ capability)
- Tie-ins matched GT outages
与燃气轮机停车时间相匹配

(Minimum plant downtime缩短工厂检修时间)

NG Eq. CO_2 Footprint

等同天然气发电的C02排放

- Simple Cycle: 单程循环
50% carbon capture
50％碳被捕集(~1,100 lb/MWh)
- Combined Cycle:联合循环
65% carbon capture
65％ 碳被捕集(~770 lb/MWh)

Note: Example only; China thermal coal, performance impacts scaled from US experience...Performance and CAPEX are coal-dependent. Cost scaled based on China industrial gasification experience ... assumes imported CO2 compression equipment.

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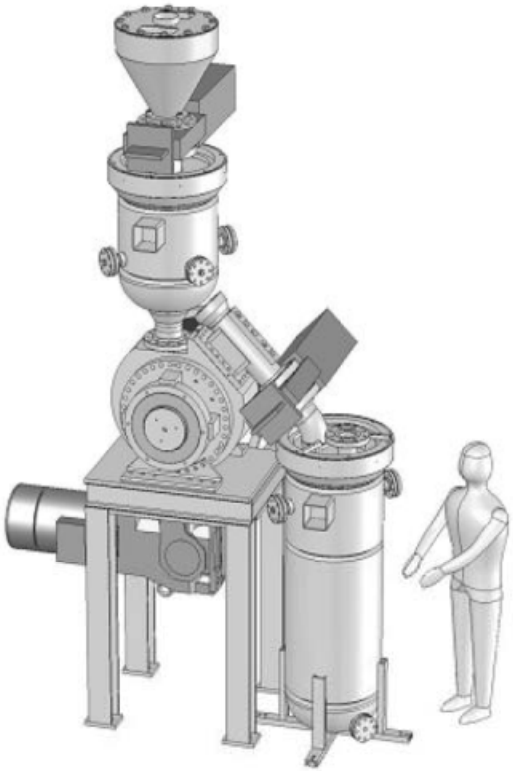
Advanced Technology Options
GE干粉泵

15 June 2007

GE Energy Advances Its Cleaner Coal Solutions for Low Rank Coals

ATLANTA--GE Energy (NYSE: GE) announced today it has acquired high-pressure feeder pump technology from Stamet Inc.—an investment that is expected to accelerate GE's offering of a cleaner coal solution using sub-bituminous coals, such as Powder River Basin (PRB) coal.



GE SIGNS LETTER OF INTENT WITH UNIVERSITY OF WYOMING TO DEVELOP NEW COAL GASIFICATION ADVANCED TECHNOLOGY CENTER

ATLANTA, GA.—February 13, 2008—GE Energy has signed a letter of intent with the University of Wyoming, countersigned by Wyoming Governor Dave Freudenthal, for the development of an advanced gasification research and technology center to be located in Wyoming.

2007年6月15号

GE推出针对低品质煤的洁净煤解决方案

亚特兰大—GE能源宣布：GE从Stamet公司获得高压粉煤给料泵技术。该项投资被认为将会加速GE能源推出针对次烟煤的清洁煤解决方案。

GE和WYOMING（怀俄明）大学签署意向书建立新的煤气化先进技术中心。

2008年2月13号，亚特兰大

怀俄明州长Dave Freudenthal 为该意向书署名

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Supporting Material

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Tampa Electric Company
Polk Power Station #1
坦帕电力公司Polk1号电站

- **250MW** 250兆瓦
- **Coal & Petroleum Coke**
  -煤及石油焦
- **Lowest variable cost plant**
  -最低的工厂可变费用

Duke Energy Edwardsport IGCC 杜克能源Edwardsport IGCC

60Hz Reference Plant launch customer 60Hz 参考厂项目发布给客户

- 630MW on Indiana #5 coal 使用印地安那#5煤 发电能力63万千瓦
- NTP in 2007, COD in 2012 2007年项目开始 2012年竣工
- Detailed engineering near completion 详细设计近尾声
- Construction on-track 厂建按计划进行
- Syngas cooler ships in 2009 合成气冷却器2009年发运
- 7F Syngas turbines ship in 2010 7F燃气轮机2010年发运

Duke Energy
Edwardsport site construction, January 2009

Successful siting & permitting 厂址选定获得批准

- Sited & permitted next to aging PC facility 建于现存的粉煤厂附近

" We have an opportunity to make history with the Edwardsport plant. The facility could very well be one of the cleanest coal-fired power plants in the world. It will produce nearly 10 times as much energy as the existing Edwardsport plant with much less environmental impact." - Jim Turner, President & COO, U.S. Franchised Electric and Gas-Duke Energy "我们有机会让Edwardsport工厂创造历史，新的工厂将是世界上最清洁的燃煤发电厂。新工厂将生产10倍于老厂的电力，但却对环境有更小的影响。"— —Jim Turner，总裁及 COO，美国杜克能源电力和燃气公司Duke Energy press release, Jan. 25, 2008

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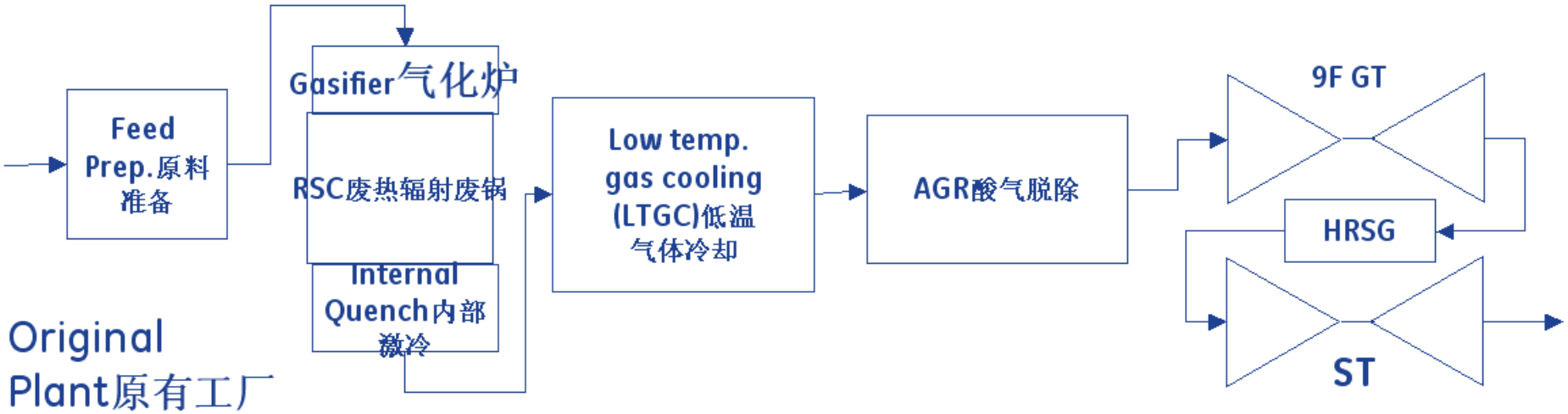
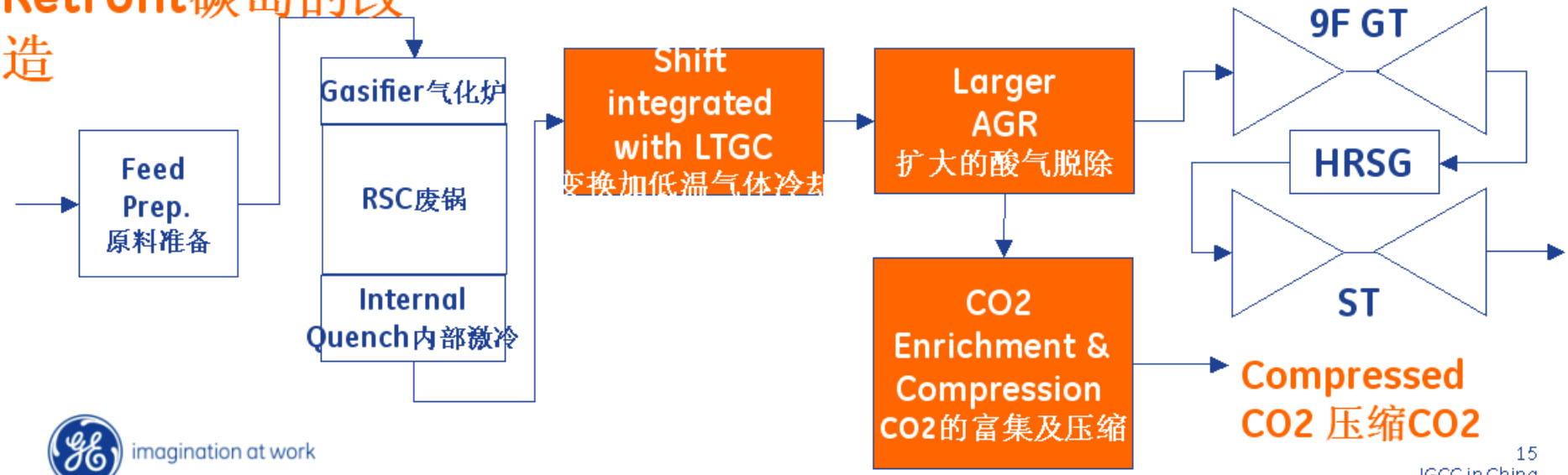
Plant modifications for retrofit 工厂的改造



Original Plant原有工厂

Carbon Island™ Retrofit碳岛的改造



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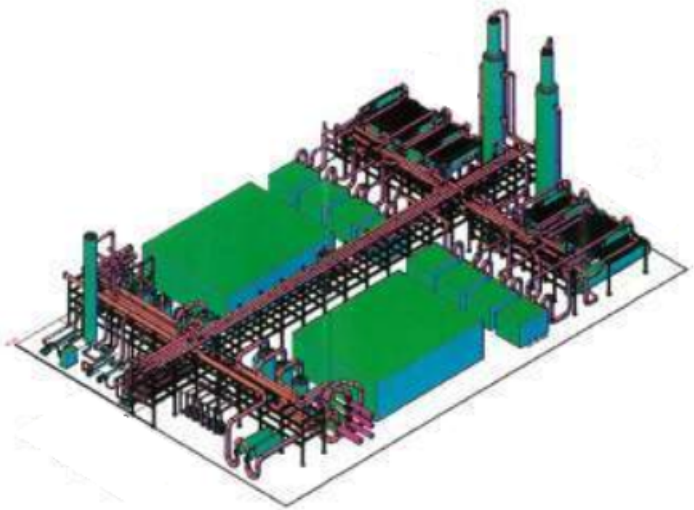
GE's Carbon Island™ GE的碳岛



IGCC carbon solution … new build or retrofit

IGCC碳解决方案…新建和改造工厂

- Option to GE's IGCC plant design
  GE的IGCC工厂设计选项
- Fits in allocated plot space 装配完成并能与指定位置相匹配
- Integrated with existing AGR整合现有的酸气脱除
- Commercially proven technologies经商业运行验证的技术
  - Shift and low-temp gas cooling变换和低温气体冷却
  - Supplementary AGR附加的酸气脱除
  - CO2 enrichment CO2浓缩
  - CO2 compression CO2压缩
- Multiple capture options (0%, 50-65%, 90%)
- 多种捕集选项（0%，50－65%，90%）

→50-65% = NGCC equivalent carbon footprint

50－65%＝天然气联合循环的CO2排放量

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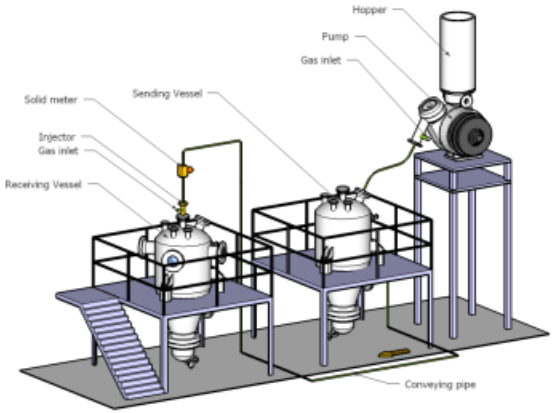
High pressure dry-feed test facility
高压干粉进料测试装置



Stamet Posimetric® pump

- ✓Reduces drying req, efficiency+;
  减少干燥的需要，效率+
- ✓Part of High Efficiency Feed Sys
  高效率的给料系统

Coal Dry-Feed Test Rig干粉给料测试平台

- ✓Integrate system, pump, conveyance & injector
  系统整合，泵，输送与烧嘴
- ✓Validate controls & instrumentation
  验证控制与仪表
- ✓ Operational testing
  运行测试

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