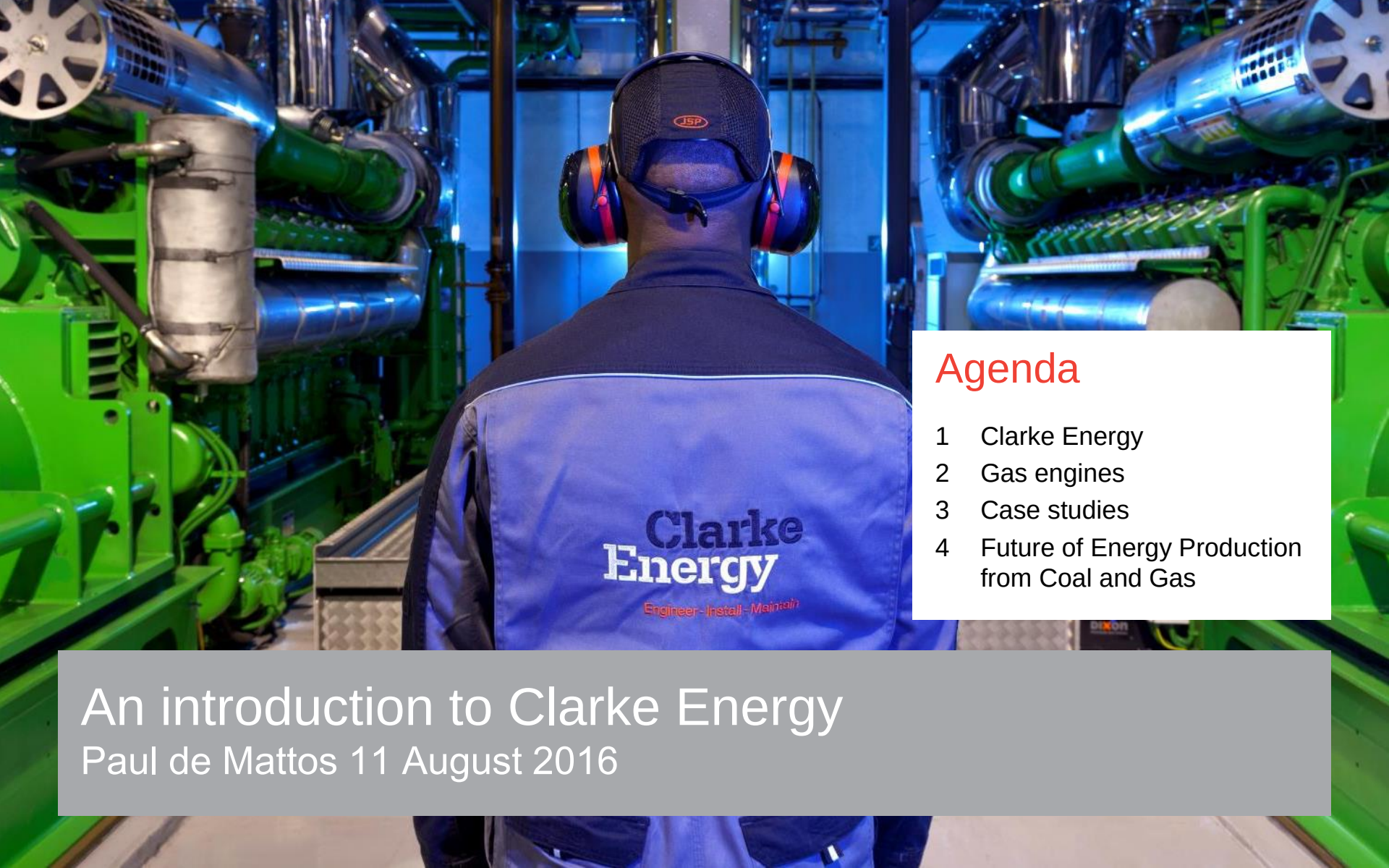
Clarke Energy®

Engineer - Install - Maintain

Distributor & Service Provider
Reciprocating engines

THE QUEEN'S AWARDS
FOR ENTERPRISE:
2014



Agenda

1. Clarke Energy
2. Gas engines
3. Case studies
4. Future of Energy Production from Coal and Gas

An introduction to Clarke Energy

Paul de Mattos 11 August 2016

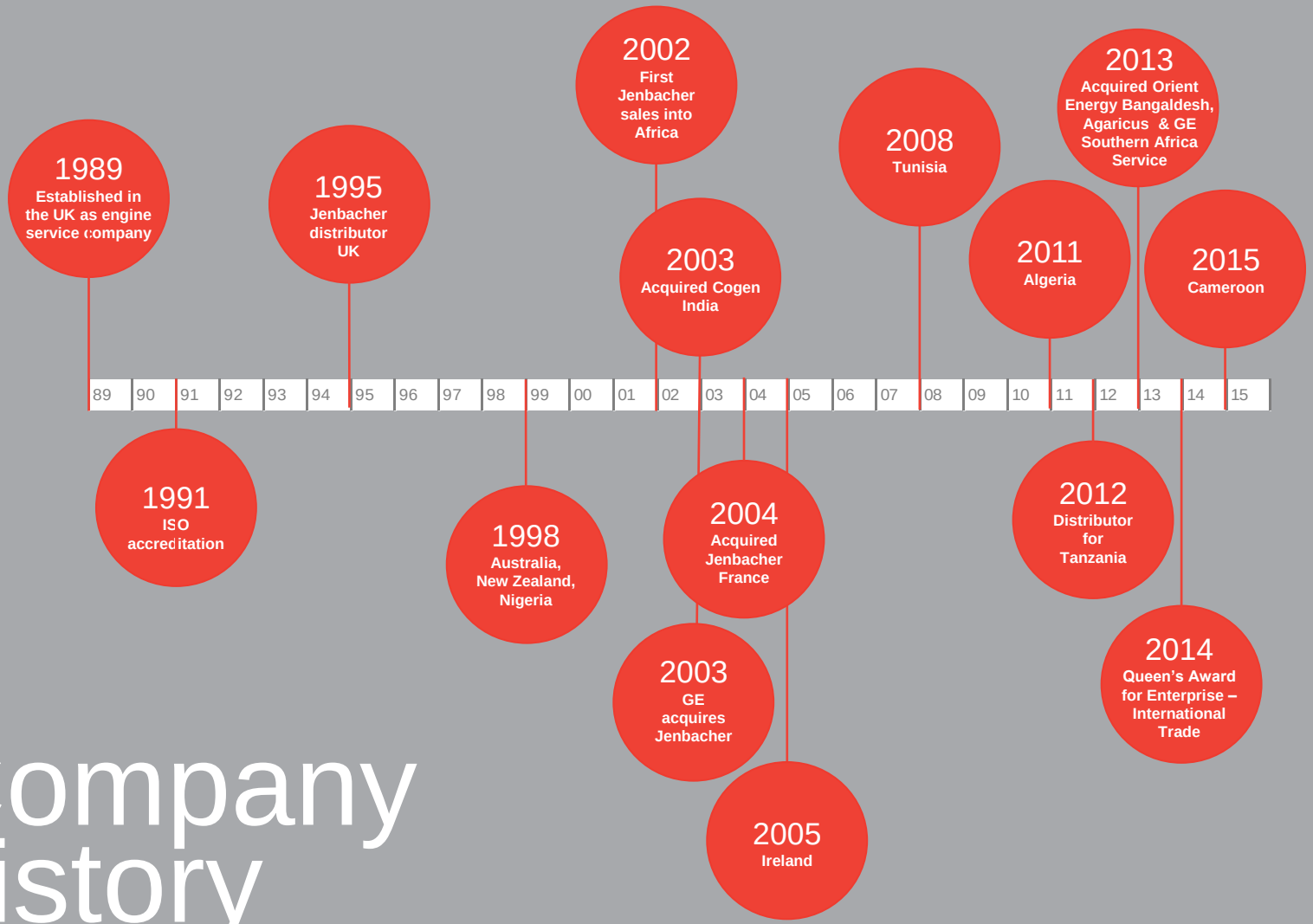
Introduction to the company

- Established 1989 in UK as a engine service company
- Turnover of £233m in 2015/16
- >1,000 employees worldwide
- ISO accreditation
  - 9001 Quality
  - 14001 Environment
  - OHSAS 18001 – Health & Safety
- Queen’s Award for International Trade 2014

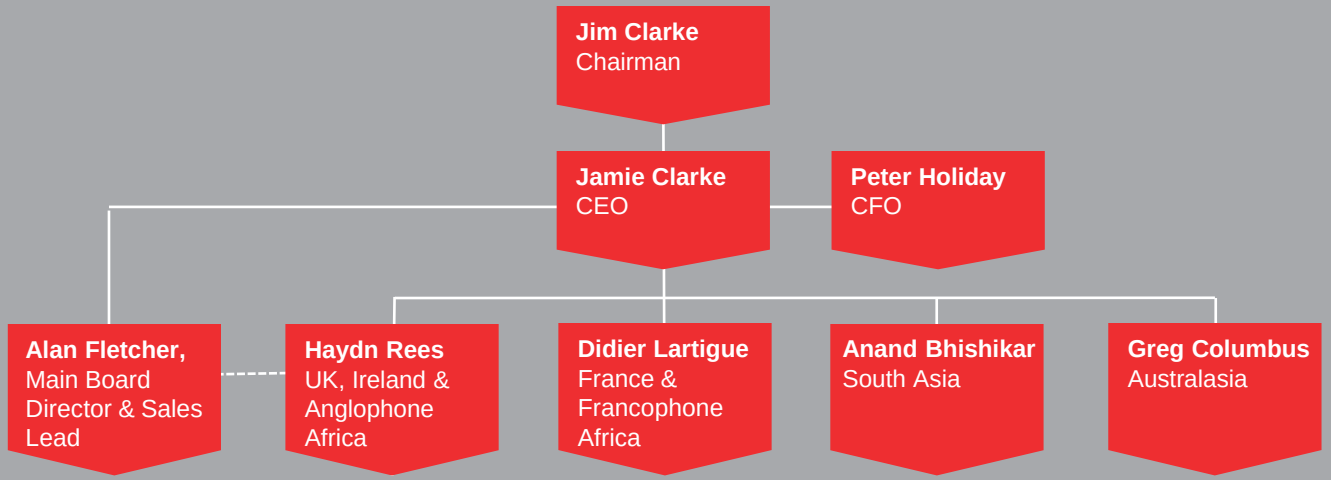
Introduction to the company

- Develops **high quality, fuel efficient** power generation installations
- Has **one focus** - GE's reciprocating engines
- GE **distributor & service provider** in 17 countries
- Over **4.8GW$_e$** of Jenbacher installed
- Turnkey **EPC contractor**
- Full **maintenance, operation and overhaul** services maximising equipment availability

Company history

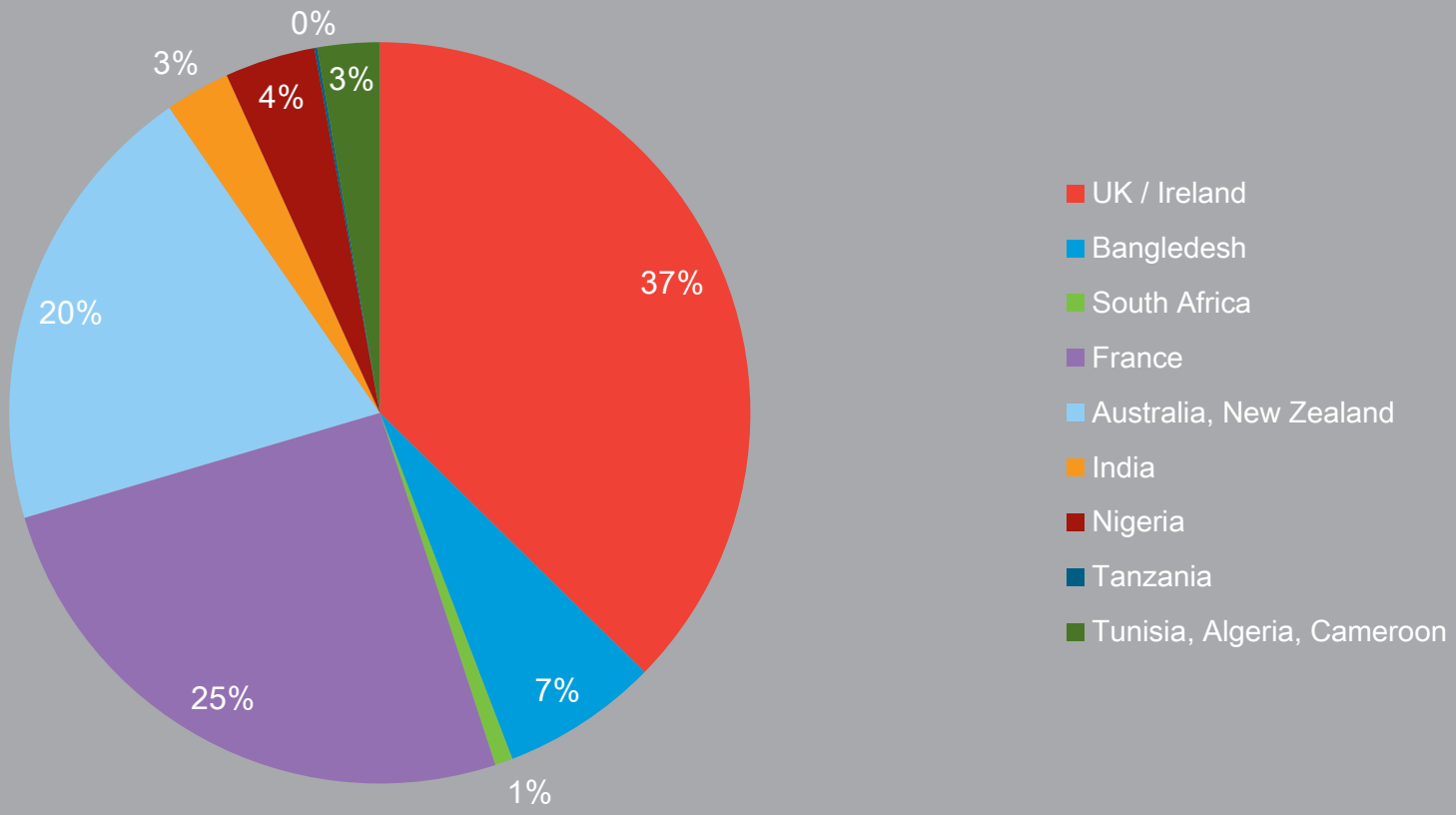


Territories & Offices



Structure

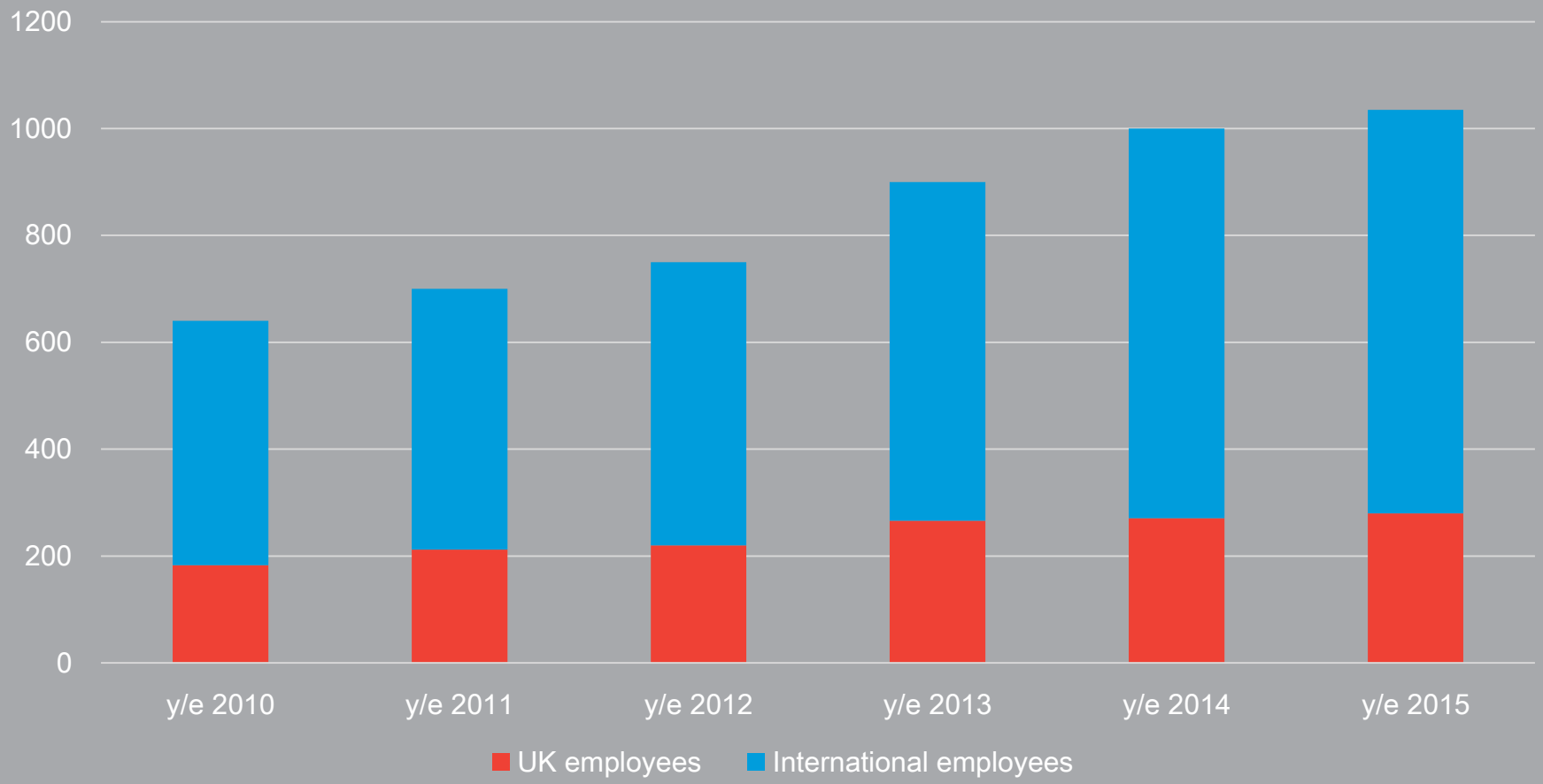
s.S.A. = sub-Saharan African territories



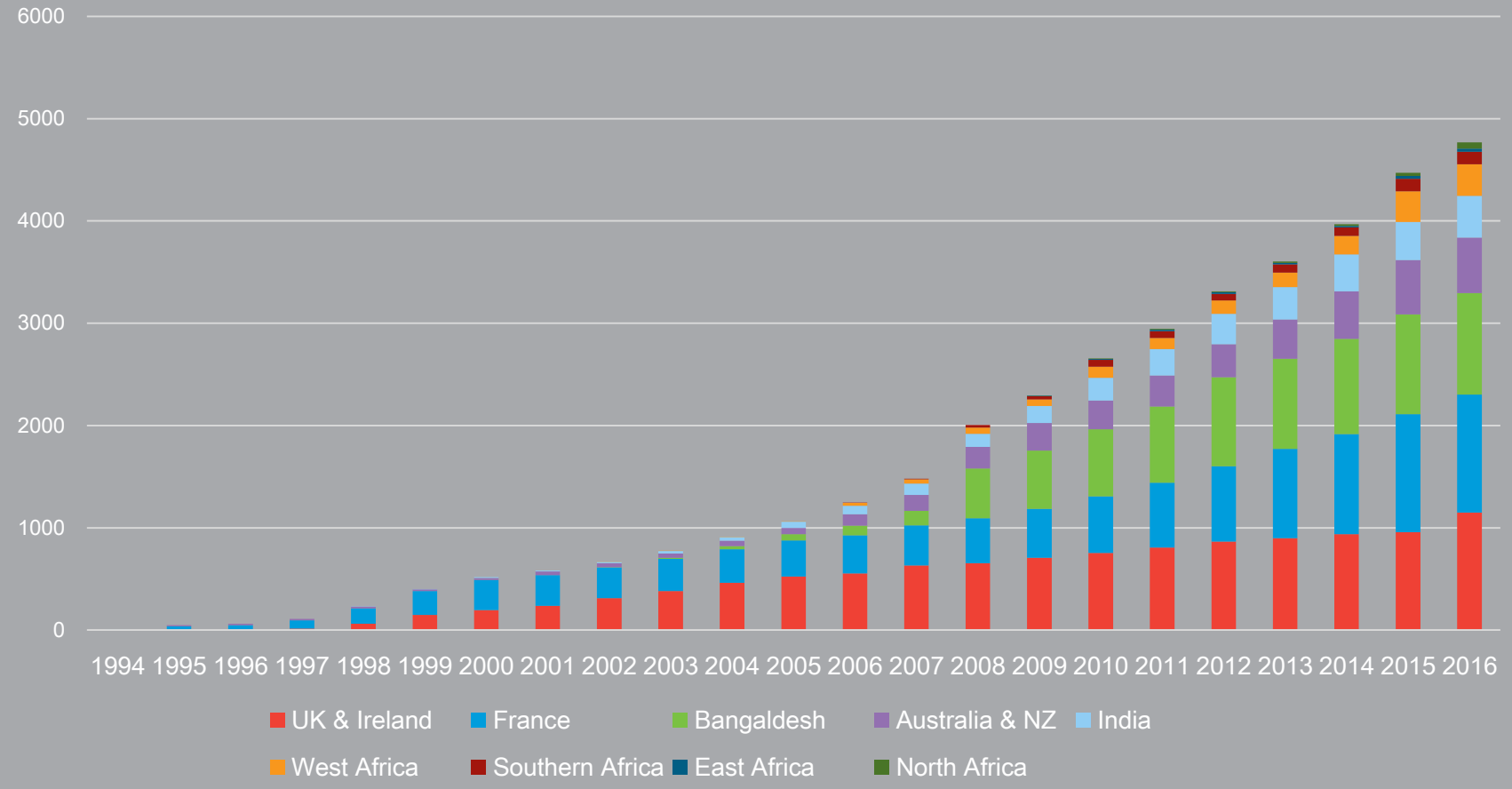
Turnover split % 2015


250
200
150
100
50
0
y/e 2010
y/e 2011
y/e 2012
y/e 2013
y/e 2014
y/e 2015
International sales £m
UK sales £m

Turnover (£m)

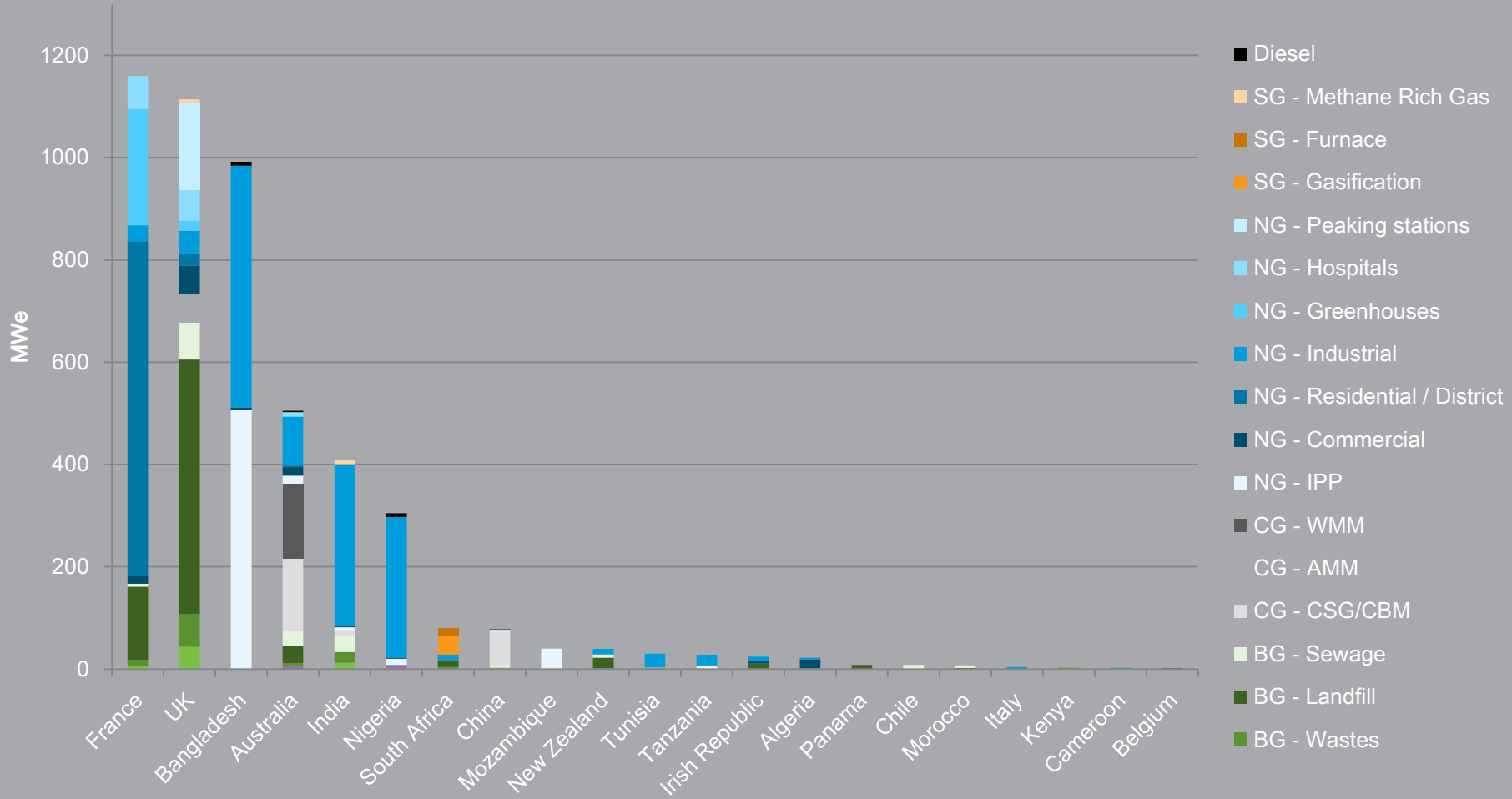

1200
1000
800
600
400
200
0
y/e 2010
y/e 2011
y/e 2012
y/e 2013
y/e 2014
y/e 2015
UK employees
International employees

Employees

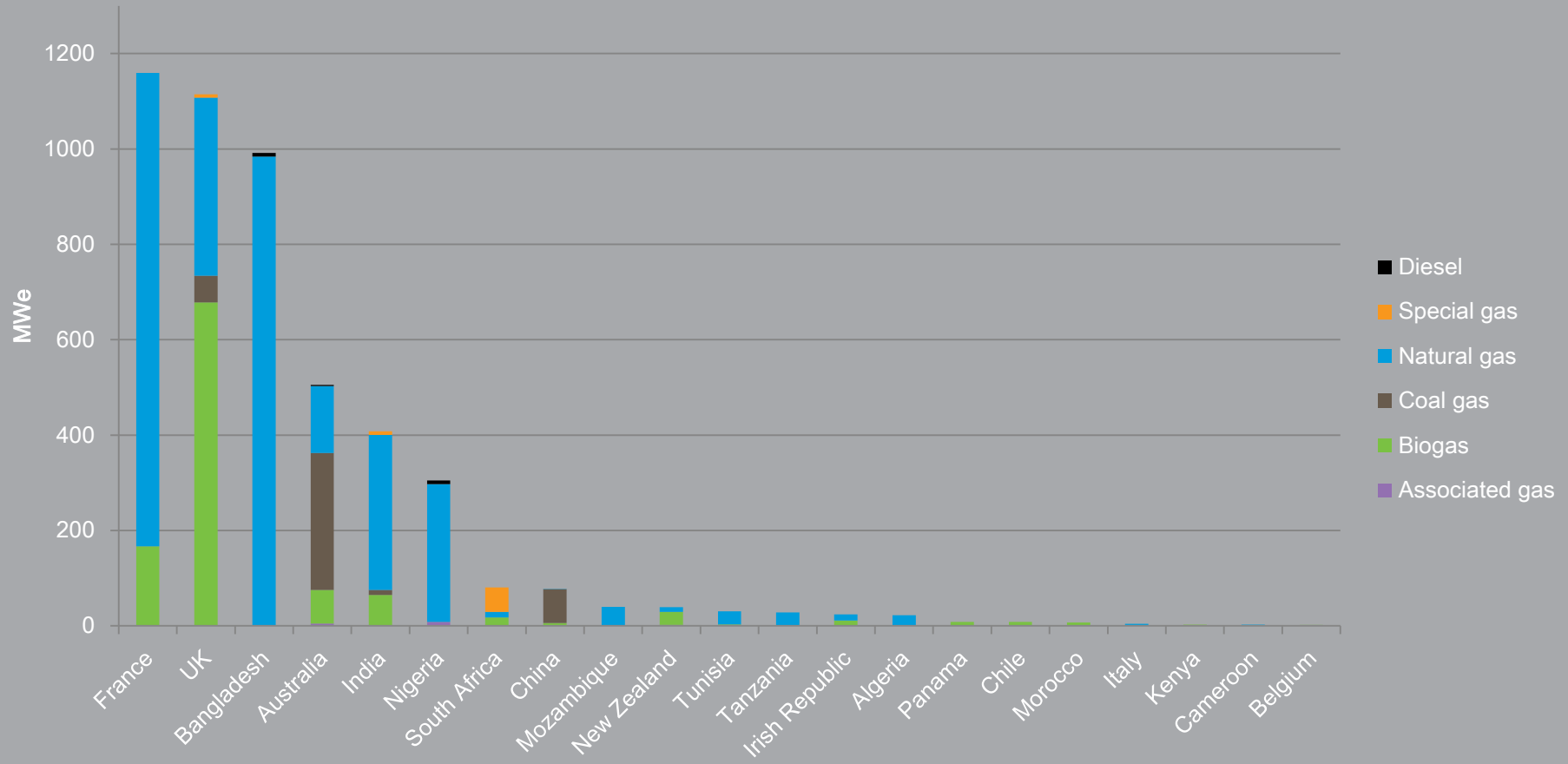


Commissioned / sold (MW)

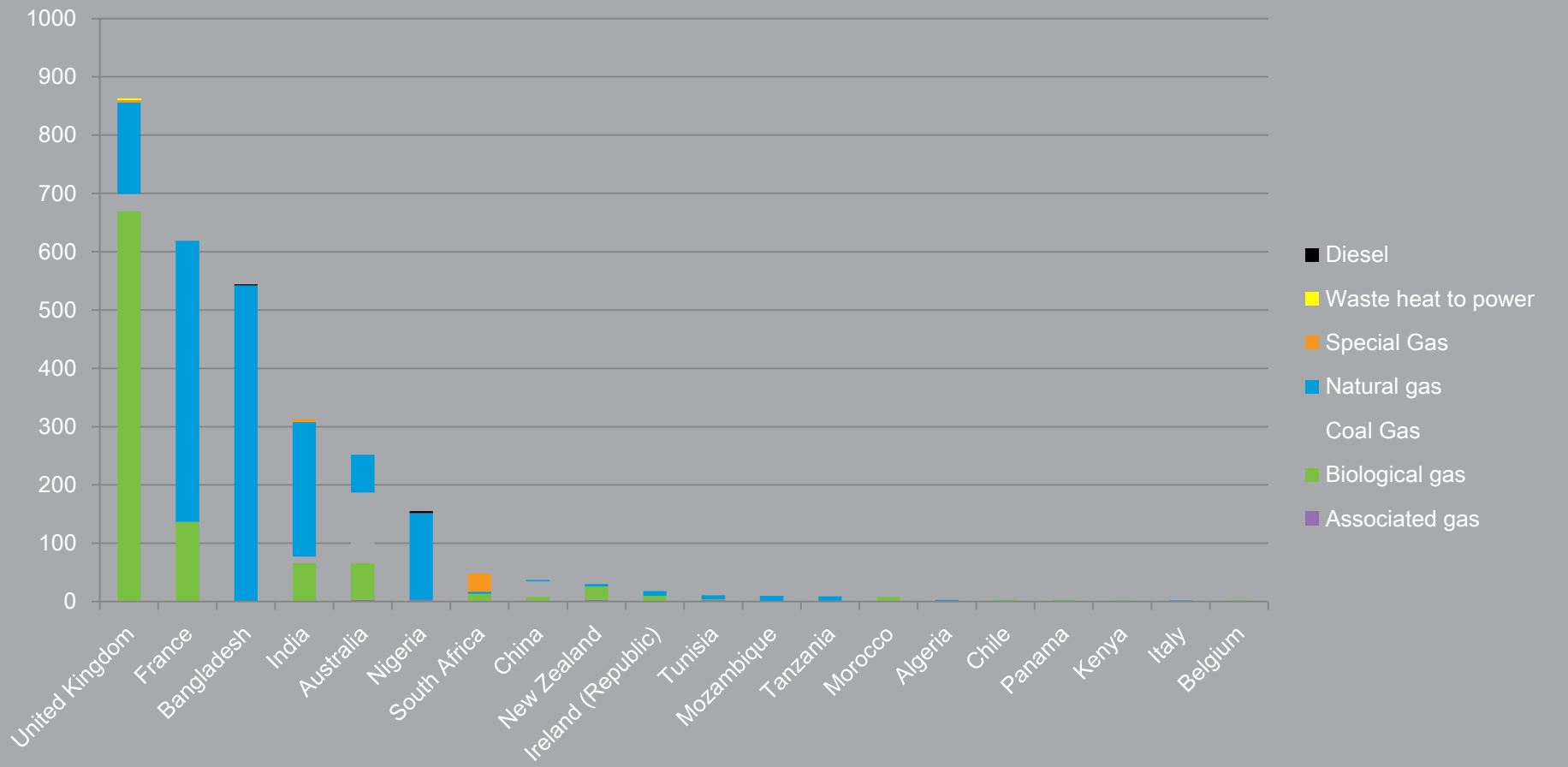
MW sold/installed



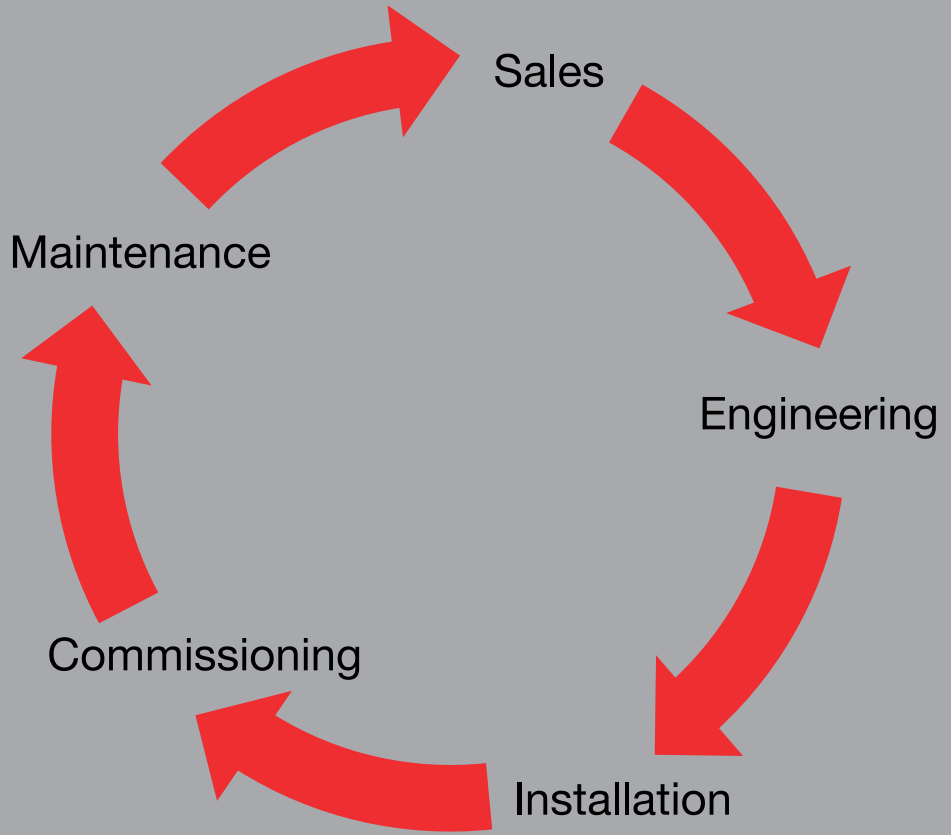
MW sold/installed



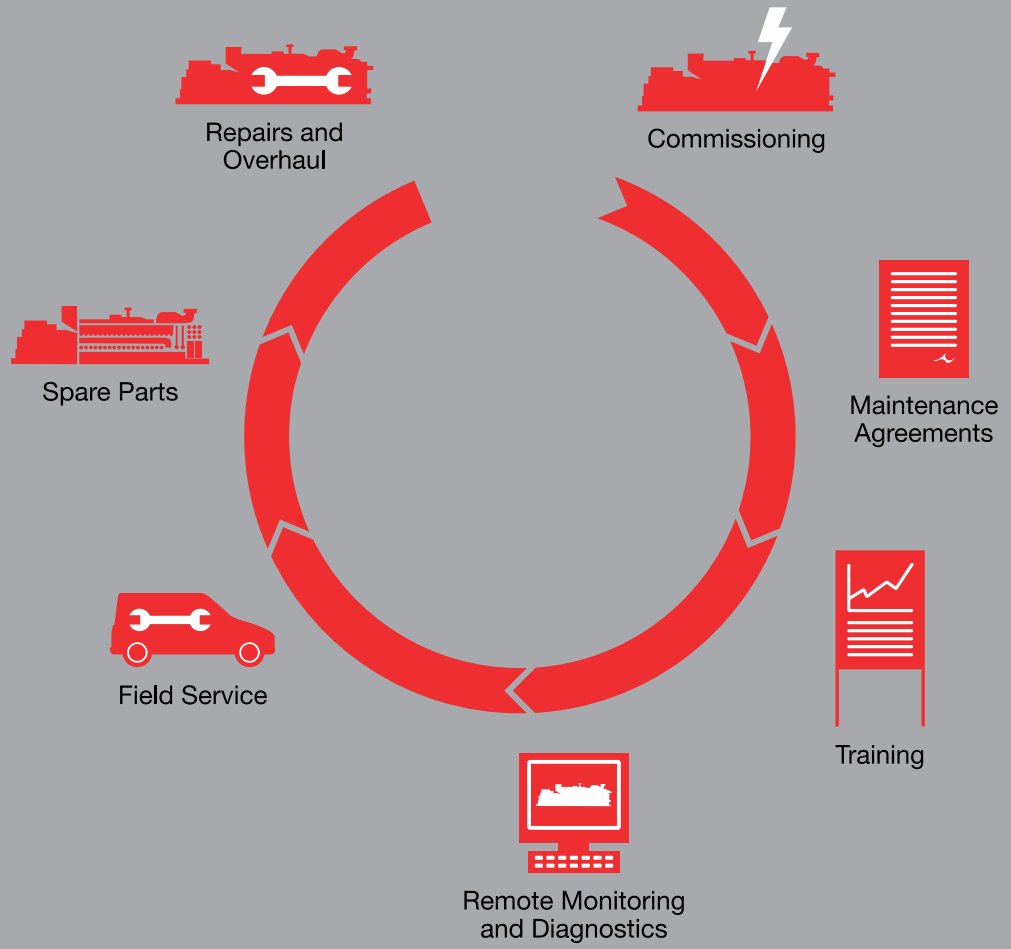
Units sold/installed



End to end service



Service lifecycle



Maximising equipment availability

- In-country commissioning support
- Maintenance agreements supported by field-service engineers
- Site-based operation and maintenance
- GE certified trainers
- Remote monitoring and diagnostics capability
- In-country GE approved spare parts inventory

Local, Equipped Field engineers

Workshop facilities

Product quality focused

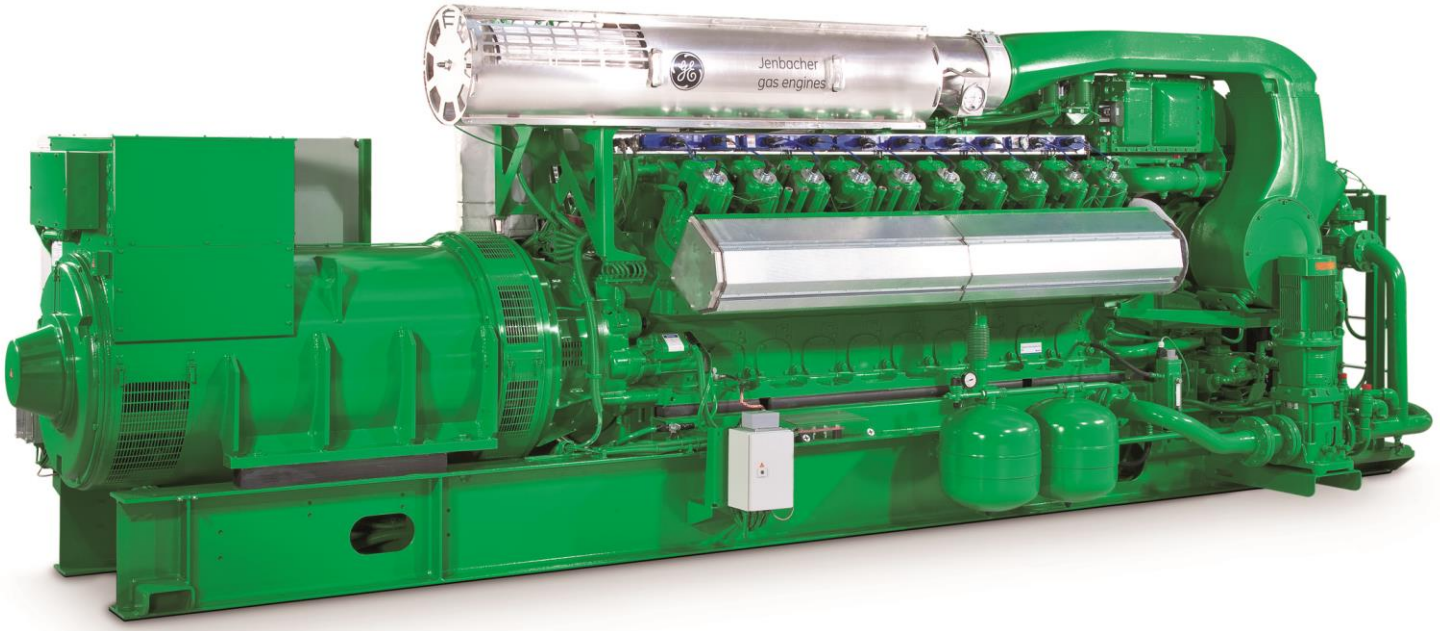
Engine design
Engine development
Engine manufacture
Parts production

Customer project focused

Installation design
Project management
Installation works
Commissioning
Maintenance
Parts stockholding

Partnership


Factory
in Jenbach,
Austria



Jenbacher Gas Engines

Designed solely for operation on various gases
Power range 0.3-9.5MWe

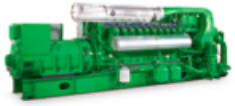
GE’s Reciprocating Engines

0.1 – 5.0 MW | 5 – 25 MW

Gas Products
Power Generation

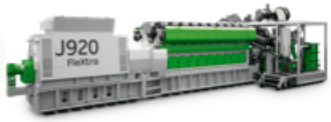
TYPE 2
250 kW – 330 kW

TYPE 3
500 kW – 1 MW



Type 4
800 kW – 1.5 MW

Type 6
1.5 MW – 4.4 MW

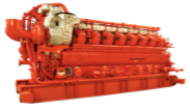


Type 9
9.5 MW

Mechanical Drives

VGF*
120 kW – 880 kW

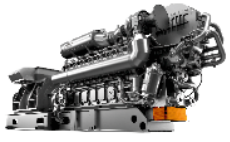
VHP*
315 kW – 1.5 MW



275GL+*
1.9 MW – 3.6 MW

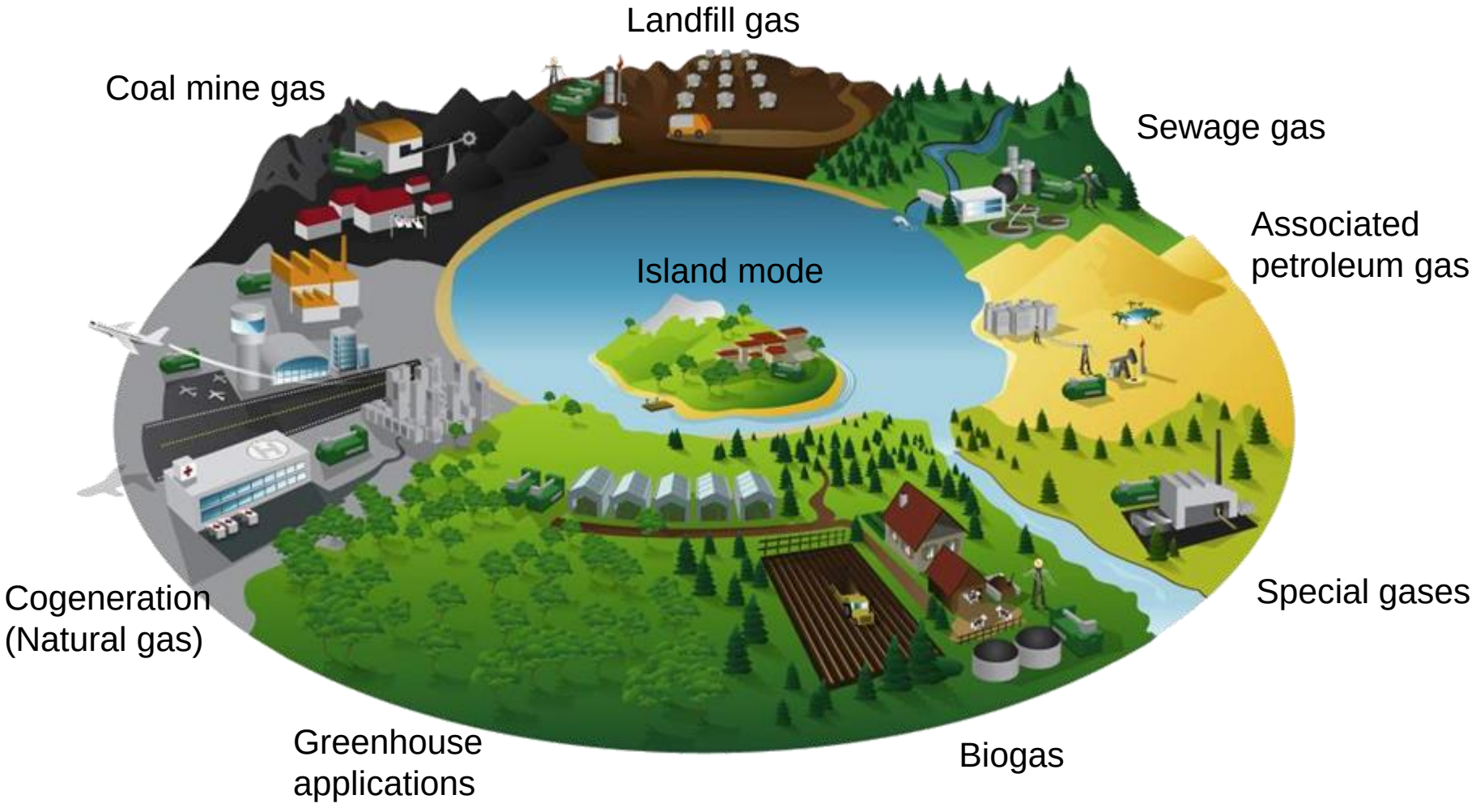
Diesel Products

228
1.5 – 3.2 MW



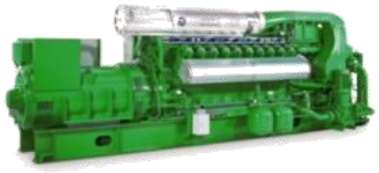
616
2.6 MW

250
1.5 – 4.5MW



Fuel Flexibility

Flexible delivery model



1. Genset
- Gas engine
- Generator
- Base frame
- Fuel gas train
- Genset control panel
- Design and Documentation
- Options

2. Power module
- Item 1 plus
- Ventilation system
- Acoustic/weatherproof enclosure
- Silencer
- Radiators
- Fire and gas detection
- Electrical and I&C
- Further options
- Co/tri-generation

3. Power plant
- Item 2 plus
- Civil work
- Gas conditioning plant
- Lube oil system
- HV/LV switch room, control room, electrical sub-stations , metering and reticulation
- Black-start diesel generators
- Storage / workshops
- Further options

Project Examples

The Shard

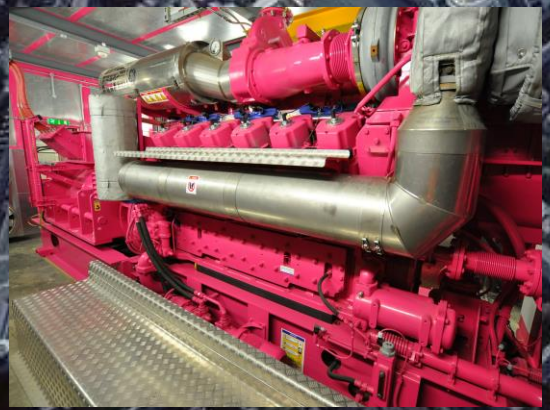
London, England, Natural gas-fuelled CHP for a commercial building, Largest residential tower block in European Union, 1 x JMS416, 1.2MW$_e$

St Thomas' Hospital

London, England, Natural gas fuelled CHP (electricity, hot water and steam), 1 x JMS620, 3MW$_e$, Saving £1m fuel costs and 5,500t CO_2 per year

Kings Cross Energy Centre

London, England, Metropolitan Kings Cross, pipeline natural gas for district energy scheme – electricity and hot water, 67 acre urban regeneration, 3 phases, 2012/14/16, 3 x JMS 612, 6MWe total (4MW installed as of 2015)



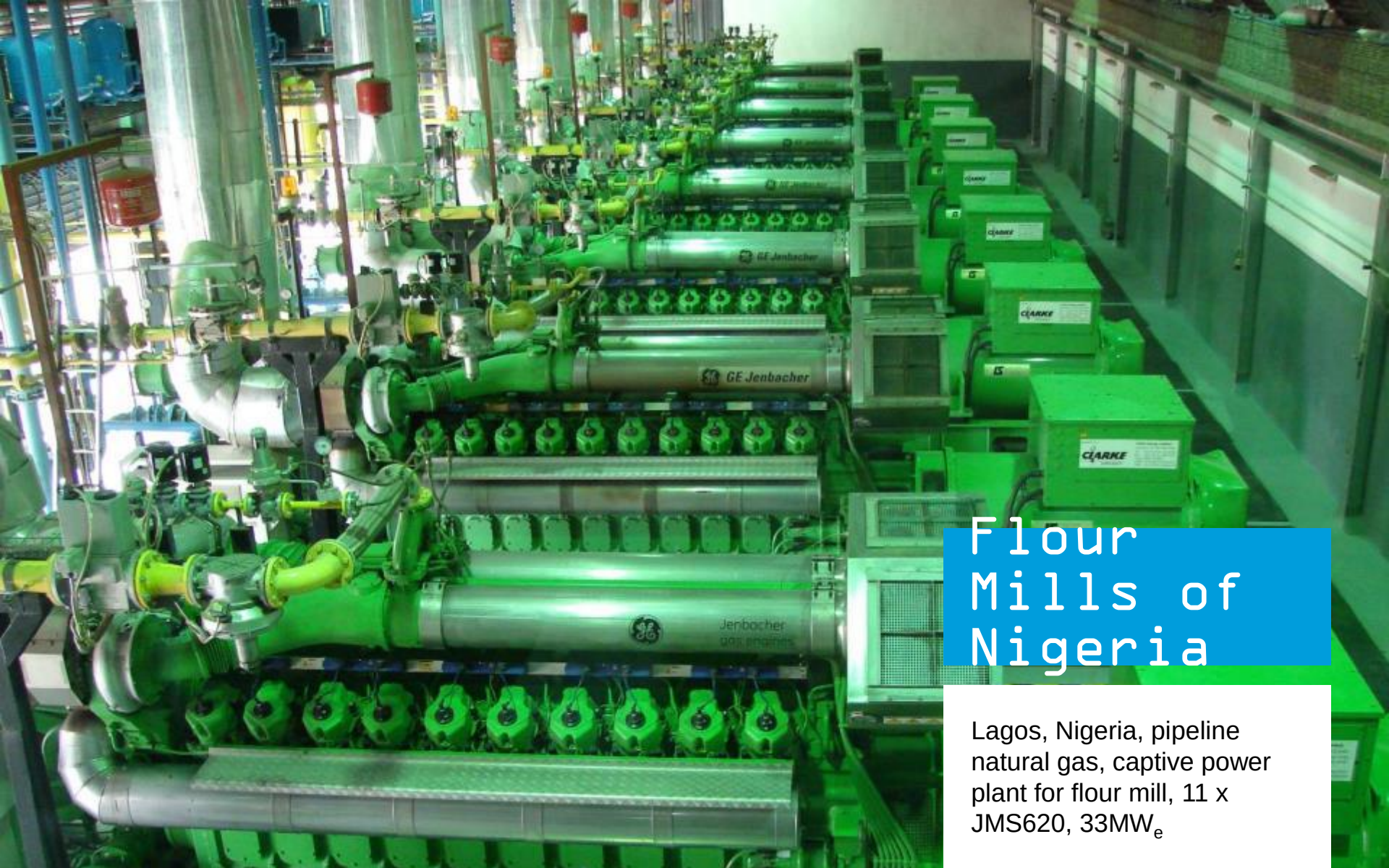
Reliance Industries Ltd.

Naroda, Gujarat, India

Pipeline natural gas

Combined heat and power plant providing steam and electricity to a textile facility

7 x JMS620, 21.3 MW_e



Flour Mills of Nigeria

Lagos, Nigeria, pipeline natural gas, captive power plant for flour mill, 11 x JMS620, 33MW$_e$

Tamar Energy

Biogas from organic wastes

5 sites in England, CHP

Farleigh, 2 x JGMC420, 3MW_e

Halstead, 2 x JMS416, 2.2MW_e

Hoddeston, 2 x JGMC420, 2.8MW_e

Holbeach Hurn 1 x JGMC420, 1.4MW_e

Retford, JGMC420, 1.5MW_e

10.9MW_e total output

Elgin Fruit

Grabouw, Western Cape, South Africa

Biogas from fruit pulp

Western Cape, South Africa

1 x JMS312, 0.5MWe

Tronox Namakwa Sands

Western Cape, South Africa
Waste furnace gases
Combined heat and power
8 x JGS620, 13.6MW$_e$

Moranbah Colliery

Queensland, Australia

Waste gas from working coal mine

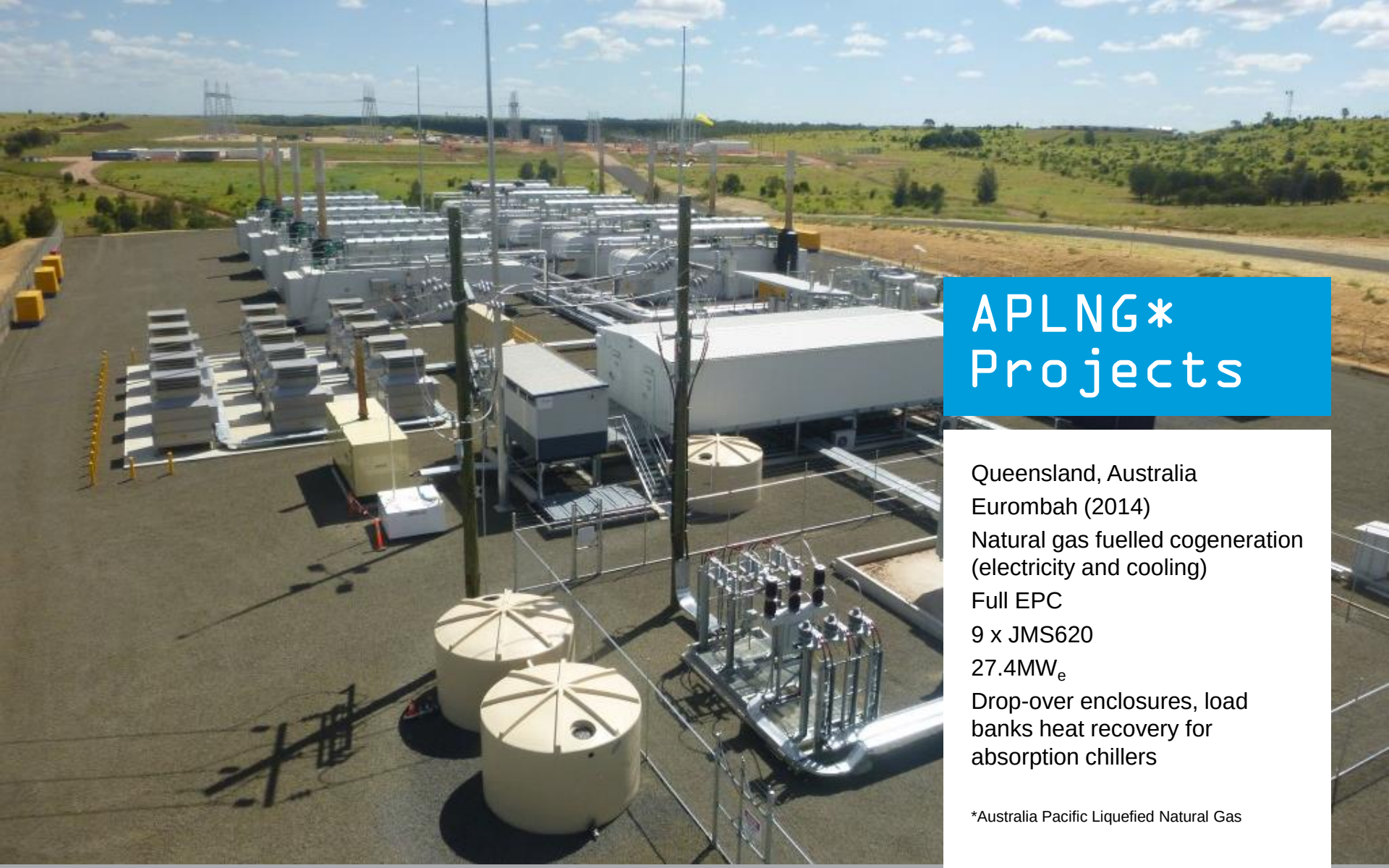
Full EPC

'Cookie Cutter' high ambient temperature enclosure

Phase 1 (2008):15 x JMS620, 45.6MW_e

Phase 2 (2014): 6 x JMS620, 18.3MW_e

Total output: 63.9MW_e



APLNG* Projects

Queensland, Australia

Eurombah (2014)

Natural gas fuelled cogeneration (electricity and cooling)

Full EPC

9 x JMS620

27.4MW$_e$

Drop-over enclosures, load banks heat recovery for absorption chillers

*Australia Pacific Liquefied Natural Gas

APLNG* Projects

Queensland, Australia
Reedy Creek
Coal seam gas
Full EPC
'Cookie Cutter' high ambient temperature enclosure
Power station 1 (2014)
10 x JMS620, 30.4MW_e
Power station 2 (2015)
10 x JMS620, 30.4MW_e

*Australia Pacific Liquefied Natural Gas

Future of Electricity Production from Coal and Gas

- Emphasis on Southern Africa
- Ever growing demand for power as economies grow.

- **Coal Conventional**
- Coal likely to around for many years to come with ~67 billion tonnes of reserves in SA alone.
- Also Botswana, Zimbabwe, Mozambique, Tanzania, Zambia and Malawi having substantial reserves.
- Likely to remain 1^{o} energy source in southern Africa for many decades.
- Mining to conventional thermal power stations in SA,

Future of Electricity Production from Coal and Gas

- Mozambique Moatize,
- Tanzania Mbeya and Mchuchuma,
- Botswana Morupule.
- Malawi Salima
- Zambia Maamba
- Both conventional and supercritical steam plant.
- SA has large discard dumps at relatively low cost that can be used in circulating fluidized bed boilers.
- Coal still the cheapest energy source in terms of R/GJ. Based on $30/te ZAR 450/te this equates to $1.15/GJ or ZAR 17/GJ. By comparison current commercial pipeline NG is ZAR105-120/GJ and CNG ZAR 180-240/GJ.
- The technology mature and robust.
- But High Carbon Foot print and environmental cost.

Future of Electricity Production from Coal and Gas

• Coal Unconventional

- Mining and thermal power stations have a high environmental impact. This cost is generally not included in energy charges to consumers. Certainly not in SA.
- Hence “clean coal”/gasification technologies particularly UCG
- Many reserves are unsuitable for either surface or underground mining for different reasons.
- Location, depth, energy value, geology etc. However these may be amenable for recovery by UCG.
- Ash and some N & S remain underground. However ground water contamination must be prevented by good site selection and management.
- UCG can be used in conventional Rankine steam cycle at lower cost with little clean up
- UCG can be used in higher efficiency gas engines/gas turbines only after substantial clean up. SA has many years experience and a large pool of experience in gas cleaning after some 60 plus years of Fischer Tropsch coal to liquid plant operation at SASOL, 1, 2 and 3.

Future of Electricity Production from Coal and Gas

- **Coal Unconventional**

- This gas cleaning/conditioning is aimed at providing:
- Steady gas pressure and flow
- Steady gas composition in terms of H_2, CO, CO_2, O_2 and N_2.
- Steady LHV
- Free from water particulates NH_3 and S compounds
- This is exactly what the Fischer-Tropsch process used by SASOL requires and there is vast experience in SA of achieving the required gas requirements for engines and turbines.
- Need removal of water, S N and particulates for use in gas engines/gas turbines. TUCG 60 MW project awaiting Gas IPP RFQ issue.
- Little or no surface impact by comparison to strip mining and ash disposal.
- Similar C footprint to coal but difficult to measure.
- Surface gasification can provide the same opportunities as UCG but with all the environmental problems of conventional coal mining and thermal power stations.

Future of Electricity Production from Coal and Gas

• CBM and CMM

- Southern African coals not particularly gassy. ~5m3/ te vs ~30m3/te in Australia and elsewhere.
- Majority of SA coal is produced from Surface mining hence ther is no CMM potential.
- Where there is underground mining it is generally shallow <100m below ground. Some methane produced in long wall mining from goaf collapse but production is too variable to be of any use.
- However potential in various areas.
- SA Volksrust, Springbok Flats, Free State, Waterberg
- Botswana Central and North East
- Zimbabwe North West Hwange Lupane, and Zambesi Valley
- Mozambique Zambesi Valley Tete, Moatize
- Zambia Maamba
- Several projects in SA and Botswana coming close to commercial production in SE Mpumalanga and W Free State. Potential likely to be in the 100's of MW not GW's

Future of Electricity Production from Coal and Gas

- **FUTURE**

- Fuel in the form of Coal, CBM/CMM and UCG is available
- Technology is available in the form of Conventional, CFB and supercritical power stations
- Gas conditioning/cleaning capability
- Boilers, Steam Turbines, Gas Engines and Gas Turbines
- Power distribution system but this requires expansion and rehabilitation.
- Interlinked Southern African Power Pool

Future of Electricity Production from Coal and Gas

- **Economics**

- Growing demand from business and domestic markets as GDP increases
- Improved tariff from an IPP point of view
- Hopeful return to increased growth in Global GDP

- **What we have**

- Slow cumbersome government controlled bidding programme
- Sometimes uneconomic tariff caps
- Current Refusal of Eskom to sign further PPA’s with IPP’s

Future of Electricity Production from Coal and Gas

- **What is Not Available**

- Clear well defined regulatory space
- Even playing field between IPP's and State Owned Utility companies which operate pretty much as a monopoly in most of Southern Africa in both generation and distribution
- Separation of generation and distribution activity
- Power Trading platform on willing buyer willing seller basis
- Fair simple generation licensing

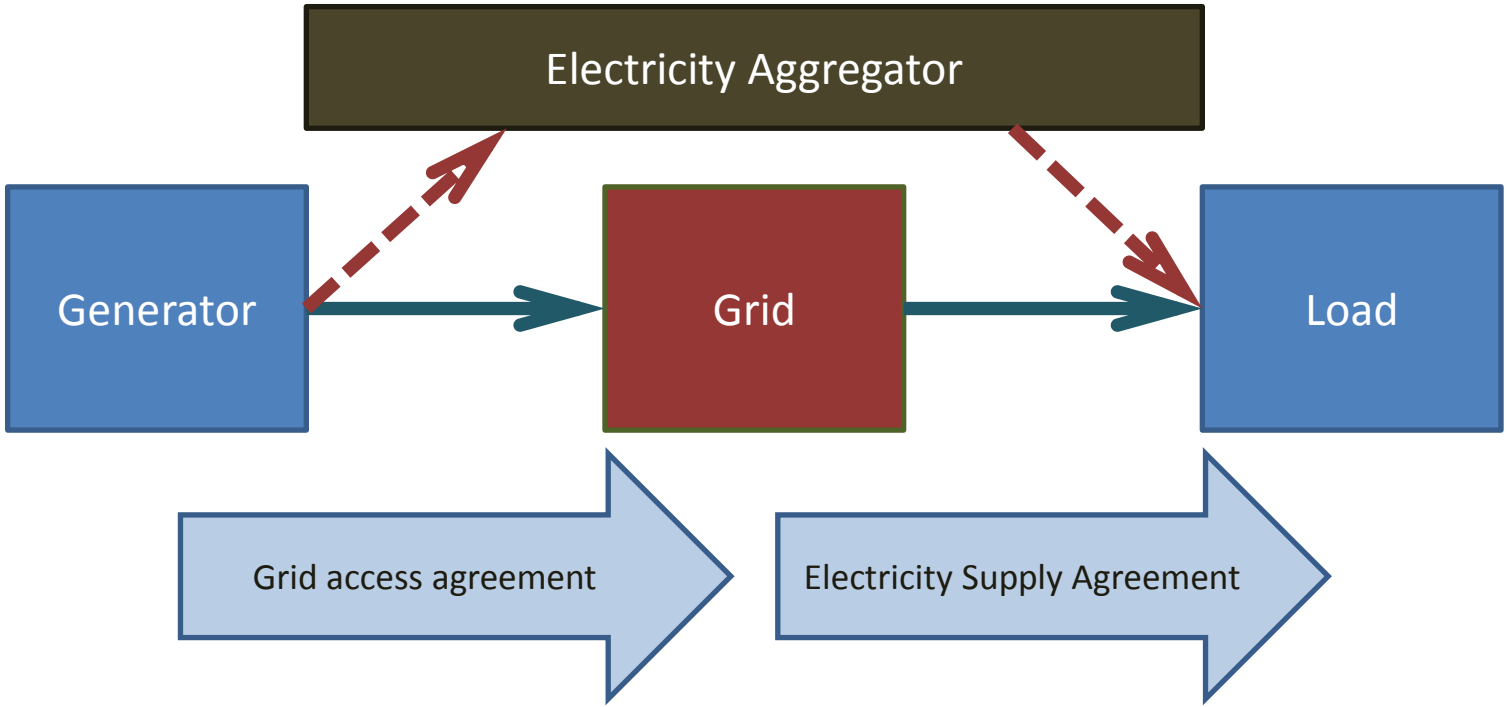
- **What do we need**

- All of the above
- Plus FDI and FDI friendly legislation

Future of Electricity Production from Coal and Gas

- **A light on the Horizon maybe**

- Current approaches to uses of power by others are
- Own consumption grid parallel
- Net metering
- Wheeling
- Island mode and across the fence
- Different approach is the Aggregator Model


Electricity Aggregator
Generator
Grid
Load
Grid access agreement
Electricity Supply Agreement

Electrcity aggregator model

- An electricity aggregator operates a “virtual power station”
- It enters into:
  - power purchase agreements with numerous generators
  - electricity supply agreements with numerous off takers
  - use-of-systems agreements with the grid
- Agreements can be long term basis or shorter term. Can trade on an exchange

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