Amec Foster Wheeler Global Power Group

Company overview

Technical Assistance project – Study Trip to Finland

22.2.2016  Espoo

Markku Kostamo
Who we are
Amec Foster Wheeler at a glance

40,000 exceptionally talented people worldwide
150+ year history operating in over 50 countries

Listed on both
- London Stock Exchange
- New York Stock Exchange

2014 pro forma Scope revenue
- £5.5bn (c. $9bn)

Employees by business units
- AMEA & SE: 23%
- NE & CIS: 29%
- GPG: 6%
- Americas: 41%

Principal office locations
Who we are
Our business structure

Markets
- Oil & Gas
- Mining
- E&I
- Clean Energy

Sectors
- Upstream
- Midstream
- Downstream
- Mining & Minerals
- Water
- Transport
- Government
- Industrial / Pharma
- Renewables / Bioprocess
- Nuclear
- Transmission & Distribution
- Conventional Power

Business units
- Asia, Middle East, Africa & Southern Europe
- Americas
- Northern Europe & CIS
- Global Power Group
Global Power Group

Business structure

Global Power Group (GPG)
Gary Nedelka

Environmental & Industrial Group (E&I)
Byron Roth

- Boiler Services
  Hampton, NJ, USA
  - Denver, CO, USA
  - McGregor, TX, USA
  - Melbourne, FL, USA

- Clean Air Technologies
  Pittsburgh, PA, USA
  - Atlanta, GA, USA
  - Tarragona, Spain

- Industrial Products & Services
  Madrid, Spain

Global Sales & Marketing (GSM)
David Parham

- Americas
- Europe/Russia/CIS
- Middle East/ Africa
- China/Asia Pacific

Power Systems & Technology Group (PS&T)
Tomas Harju-Jeanty

Global Technology Center
Varkaus, Finland

Operating Entities
- Foster Wheeler Energia Oy Group
  - Espoo, Finland
  - Varkaus, Finland
- Foster Wheeler Power Group Asia
  - Shanghai, China
  - Bangkok, Thailand
  - Hanoi, Vietnam
  - Seoul, South Korea
- Foster Wheeler Energia Polska
  - Sosnowiec, Poland
- Foster Wheeler NA Power Boilers
  - Hampton, NJ, USA

B.O.O. Power Plants
- Martinez, CA, USA
  - NGCC Cogen Project
- Talcahuano, Chile
  - PetroPower CFB Cogen Plant

Workshops
- Xinhui, China
- Sosnowiec, Poland
- Bang Chang, Thailand
# Global Power Group

## Products and services

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<th>Aftermarket services</th>
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<td>▶ Condensers</td>
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<td>▶ Coal mill service and upgrade</td>
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<td>▶ Waste heat</td>
<td>▶ Fabric Filters (FF)</td>
<td>▶ Boiler and HRSG maintenance</td>
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<td>▶ Package</td>
<td>▶ Cartridge Collectors (CC)</td>
<td>▶ Outage construction</td>
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<td>▶ HRSG</td>
<td>▶ Flue gas CFD modeling</td>
<td>▶ Performance enhancements</td>
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<td>▶ Solar</td>
<td>▶ SCR and SNCR systems</td>
<td>▶ Boiler and APC retrofits</td>
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<td>▶ Mill and classifier upgrades</td>
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<td>▶ Coal and air balancing</td>
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<td>▶ Low NOx Burners (LNB)</td>
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</table>

## Environmental products
- CFB scrubbers
- Wet FGD systems
- Dry Sorbent Injection (DSI)
- Spray Dry Absorbers (SDA)
- Dry and Wet ESPs
- Fabric Filters (FF)
- Cartridge Collectors (CC)
- Flue gas CFD modeling
- SCR and SNCR systems
- Mill and classifier upgrades
- Coal and air balancing
- Low NOx Burners (LNB)

## Aftermarket services
- Engineered and replacement pressure parts
- Weld overlay and refractory upgrades
- Replacement parts
- Cyclone burner retrofits
- Coal mill service and upgrade
- Boiler and HRSG maintenance
- Outage construction
- Performance enhancements
- Boiler and APC retrofits

## Auxiliary equipment
- Condensers
- Feedwater heaters
- Biomass gasifiers

## Plant operation and maintenance (O&M)
Global Power Group boiler references
3,853 units totaling over 234 GWe
Amec Foster Wheeler is the leading global supplier of CFB technology

We have supplied 458 Circulating Fluidised Bed (CFB) steam generators since 1975 till 2015

- Totaling 34 GWe in power capacity
  - 3 GWe Supercritical Once-Thru units
  - 31 GWe of Natural Circulation units
- Single unit capacities up to 800 MWe
- Proven by over 30 million hours of operation
- Burning a wide range of premium and waste coals, biomass, petroleum cokes, oil shale, and waste fuels

Our CFB’s utilize the most advanced technology

- Compact designs with fully cooled hot lop
- INTREX for protection of high temperature coils
- Highly efficient supercritical once-through BENSON Vertical Tube (BVT) technology
- Ultra supercritical (600 °C) steam temperatures
- Parallel gas or steam bypass reheat temperature control

World CFB market
GPG served market
Orders over 2005-2014 period

Total: 38 GWe, 363 Units

Amec Foster Wheeler 47 %
Others 53 %
World leader in Circulating Fluidized Bed combustion (CFB) technology

► First BFB boilers delivered in the 1970s, and world’s first CFB boiler supplied in 1979.
► World’s first once-through supercritical CFB boiler started operation in 2009 in Lagisza, Poland.
► Now offering Flexi-Burn® CCS CFB technology
► CFB boiler fuel flexibility provides for efficient utilization of both fossil and renewable fuels.
► CFBs can meet tough emission regulations without additional flue gas cleaning systems.

► 458 (34 GWe) units sold
  ► 460 MWe supercritical in operation
  ► 5 supercritical units in construction
► 174 BFB boilers delivered
► 11 atmospheric fluidized bed gasifiers delivered
Amec Foster Wheeler has advanced CFBs to the utility power scale
Sold 458 units (35 GWe) logging over 30 million hours of operation

Amec Foster Wheeler CFB technology evolution

- World CFB Market Orders Over 2005-2014 Period
- 1st Ultra Supercritical CFB 4 x 550 MWe
- Longest Running Supercritical CFB 1 x 460 MWe
- Longest Running Largest Pet coke CFB 2 x 300 MWe

Data Source: GRDS 22 oct 15 CFB Severed Market
Jyväskylän Energia Oy / CFB BOILER
458 MWth, 200 MWe, 160/142 kg/s, 164/43 bar(a), 560/560 °C
Polaniec CFB plant in Poland
The worlds largest CFB firing 100% biomass

Plant location: Polaniec, Poland
Customer: GDF Suez Energia Polska
Plant start-up: Fourth quarter, 2012

- Fires up to 20% high alkaline agricultural biomasses with wood-based biomasses

<table>
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<tr>
<th>Plant Electrical Output (Gross/Net)</th>
<th>205/190 MWe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Plant Efficiency (LHV/HHV)</td>
<td>36.5/31.4%</td>
</tr>
<tr>
<td>Steam Flow (SH/RH)</td>
<td>158/135 kg/s 1251/1071 kpph</td>
</tr>
<tr>
<td>Steam Pressure (SH/RH)</td>
<td>126/19 barg 1828/276 psig</td>
</tr>
<tr>
<td>Steam Temperature (SH/RH)</td>
<td>535/535°C 995/995°F</td>
</tr>
</tbody>
</table>

- In September 2012, Polaniec CFB went on-line producing 210 MWe of power from solely biomass
The Lagisza plant in Poland
PKE chose our SC CFB technology over PC

The largest and most efficient operating CFB plant in the world

► 460/440 MWe gross/net
► 43.3/41.6% (LHV/HHV) net efficiency
► Advanced vertical tube OTU SC technology
► 2.9/2.4 mpph (1298/1107 tonne/hr) of steam at 4090/734 psig (282/51 bar) and 1056/1052F (563/582C)

PKE chose CFB technology for its high value

► Achieved emission goals without FGD or SCR
► Most flexible fuel range
► Lowest installed and operating cost
► Ability to burn biomass and waste coal slurry

Successful commercial operation since June 2009
KOSPO’s Green Power Project
Samcheok, Korea

Plant will be owned and operated by Korean Southern Power Company located in Samcheok, Korea

- State-of-the-art utility CFB technology
  - Advanced ultra supercritical vertical tube steam technology
  - 4 x 550/520 MWe gross/net on 2 x 1100/1040 MWe STGs
  - 42.4/38.8% (LHV/HHV) net efficiency
  - Each CFB produces 3.4/2.8 mpph (1573/1282 tonne/hr) of steam at 3728/783 psig (257/53 bar) and 1117/1117F (603/603C)
  - Firing a wide range of import and domestic coals and biomasses
- Commercial operation expected in 2016

KOSPO selected USC CFB technology over PC
Soma Kolin 2 x 255 MWe CFB plant in Turkey
Lignite power to Turkey

Plant location: Soma, Turkey

Plant Data:
► Fuel: Local Lignite, LHV 6.7 MJ/kg (ash 43 %)

<table>
<thead>
<tr>
<th>Plant Electrical Output (Gross)</th>
<th>2 x 255 Mwe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Flow (SH/RH)</td>
<td>198.5/173 kg/s</td>
</tr>
<tr>
<td>Steam Pressure (SH/RH)</td>
<td>173/43 bar(a)</td>
</tr>
<tr>
<td>Steam Temperature (SH/RH)</td>
<td>565/555°C</td>
</tr>
</tbody>
</table>

Schedule:
► Contract Award January 2014
► Commercial Operation 3Q2018
Amec Foster Wheeler PC steam generators

We have supplied 337 utility pulverized coal (PC) steam generators since 1948

► Totaling 111 GWe in power production capacity
  ► 25 GWe Supercritical Once-Thru units
  ► 86 GWe of Natural Circulation units
► Single unit capacities up to 1000 MWe
► Proven by over 15 million hours of operation
► Burning a wide range of coals from anthracite to sub-bituminous fuels, petroleum cokes, oils, and gases

Our PC's utilize the most advanced technology

► Low NOx fuel-injection firing system
► Highly efficient supercritical once-through BENSON Vertical Tube (BVT) technology
► Ultra supercritical (600 °C) steam temperatures
► Parallel gas or steam bypass reheat temperature control

600 MWe Buk-Pyeong Ultra-Supercritical Units in South Korea
Longview advanced PC plant in Virginia, USA
770 MWe of Supercritical Vertical Tube PC technology

- Plant is located in Maidsville, West Virginia, USA built by Longview Power LLC, jointly owned by GenPower, LLC and First Reserve Corporation.
- Plant produces 770/695 gross/net MWe at full capacity with 40% Net plant efficiency (8564 Btu/kWh Heat Rate).
- PC utilizes Advanced Vertical Tube Once-Thru Supercritical Steam Technology producing 2216 tonne/hr (4.9 mpph) of Steam at 257/53 bar (3720/773 psig) and 569/567C (1056/1052F).
- Minemouth project utilizing low rank West Virginia bituminous coal from MEPCO mine.
- Commercial operation: Spring 2011.
We have a full line of air pollution control products

- Full line of air pollution control products based on proven FW, Wheelabrator and Graf-Wulff technologies
  - Hammer Rapped Rigid Electrode (HaRDE) and Variable Intensity Gravity (VIGR) rapped Dry ESPs
  - Complete portfolio of combustion upgrades and SCR for NOx reduction
  - Multi-pollutant CFB, SDA and DSI scrubbing technologies
  - High and Intermediate Pressure Pulse Jet Fabric Filters
  - Horizontal and condensing Wet ESPs

- Broad application across multiple sectors: utility power generation, iron and steel, pulp and paper, cement, mining industries, foundry, petroleum/chemical, refuse-to-energy, and cogeneration

**Acid gas and metal control**
269 Wet FGDs, CFB Scrubbers, SDA Scrubbers and DSI systems delivered

**Particulate control**
4741 Wet and Dry ESPs, Fabric Filters, and Cartridge Collectors Systems Delivered

**Low NOx control**
257 Low NOx Combustion and 132 SCR Retrofits Completed
Dry Fork Station
Design and supply of 420 MWe CFB scrubber

Amec Foster Wheeler supplied the circulating fluidized bed scrubber behind a new 420 MWe PC boiler.

Our scope included the design and supply of the absorber, pulse jet fabric filter, ash recirculation system, water injection system and lime dry hydrator.

Total flue gas flow cleaned:
  - 1,800,000 ACFM (3,060,000 m³/h)

Total electric capacity:
  - 420 MWe (500 MWe @ SL)

Plant fuel: sub-bituminous PRB coal

SO2 removal: up to 97%

SO3 removal: up to 96%

PM removal: up to 99.9%

Basin Electric Power Cooperative
Dry Fork Station
Gillette, WY, USA
2009-2011

Largest single absorber CFB scrubber in the world
### Global Power Group

**Sampling of ongoing projects, 09/15**

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<tr>
<th>Project</th>
<th>Location</th>
<th>Status</th>
<th>Description</th>
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<tr>
<td>CH2M HILL Australia, Australia</td>
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<td>Package boiler 3 x 20 MWe, completion 2014, 2016</td>
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<tr>
<td>DuPont Titanium Tech. Johnsonville, USA</td>
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<td>Package boiler 2 x 32 MWe, completion 2015</td>
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<tr>
<td>PBB, Bahia Planca, Argentina</td>
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<td>Package boiler 32 MWe, completion 2016</td>
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<td>Deven JSCo, Bulgaria</td>
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<td>CFB boiler 50 MWe, completion 2017</td>
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<td>Harbin Electric Int., Soma, Turkey</td>
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<td>CFB boiler + CFB Scrubber 2 x 255 MWe, completion 2017</td>
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<td>OGK-6, Novocherkassk, Russia</td>
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<td>Supercritical CFB boiler 330 MWe, completion 2016</td>
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<td>Fortum Heat Polska, Zabrze, Poland</td>
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<td>Coal-fired CFB boiler 75 MWe, completion 2018</td>
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<td>Elektrobudowa S.A., EC Tychy Poland</td>
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<td>Coal-fired CFB boiler 50 MWe, completion 2016</td>
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<td>Aughinish Alumina Refinery Askeaton, Ireland</td>
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<td>Package boiler 2 x 30 MWe, completion 2015</td>
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<td>North West Redwater Partnership, Canada</td>
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<td>Package boiler 3 x 35 MWe, completion 2015</td>
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<td>Al Toukhi, Hail, Saudi-Arabia</td>
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<td>HRSG 4x37 MWe, completion 2016</td>
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<td>Shanghai Marine, Pakistan</td>
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<td>Grate boiler 2 x 60 MWe, completion 2016</td>
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<td>Iberdrola, Mexico</td>
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<td>HRSG 44 MWe, completion 2016</td>
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<td>Xstrata Tech. PTY, Zambia</td>
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<td>WHB boiler 5 MWth, completion 2015</td>
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<td>Hyundae Engin. &amp; Construction Mong Duong 1, Vietnam</td>
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<td>Coal-fired CFB boiler 4 x 250 MWe, completion 2015</td>
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<tr>
<td>Hyundae Engin. &amp; Construction Cebu, Philippines</td>
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<td>Coal-fired CFB boiler 100 MWe, completion 2019</td>
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<td>Marubeni Corp., Thai Binh, Vietnam</td>
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<td>Coal-fired PC boiler 2 x 300 MWe, completion 2017, 2018</td>
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<td>DAEELIM Industrial, Philippines</td>
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<td>Coal-fired CFB boiler</td>
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<td>Hanwha Energy, South Korea</td>
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<td>CFB boiler 100 MWe, completion 2019</td>
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<td>Hanwha Energy, Kumho Yeosu South Korea</td>
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<td>CFB boiler 60 MWe, completion 2015</td>
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<td>Doosan Heavy Ind., South Korea</td>
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<td>CFB boiler 350 MWe, completion 2015</td>
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<td>GS E&amp;C, Danjing, South Korea</td>
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<td>CFB boiler 105 MWe, completion 2015</td>
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<tr>
<td>Doosan Heavy Ind., South Korea</td>
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<td>Coal-fired CFB boiler 2 x 151 MWe, completion 2016</td>
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