Cautionary Statement

This presentation contains forward looking statements that are subject to risk factors associated with, amongst other things, the economic and business circumstances occurring from time to time in the countries and sectors in which Johnson Matthey operates. It is believed that the expectations reflected in these statements are reasonable but they may be affected by a wide range of variables which could cause actual results to differ materially from those currently anticipated.
Introduction and Welcome

Neil Carson
Chief Executive
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<td>Introduction and Welcome</td>
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<td>New Business Development. Q&amp;A and coffee break after this session</td>
<td>Nick Garner, Roanna Doe, Martin Green</td>
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<td>Opportunities in Emission Control Technologies. Q&amp;A after this session</td>
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Purpose of the Day

Provide
an overview of our new business development activities

Outline
our progress in four new business areas: air purification, advanced packaging, water purification and battery technology

Update
on the drivers and opportunities in JM’s Emission Control Technologies business

Explain
How we continue to add value through R&D and technology to leverage future growth opportunities
Introduction

- A world leading technology company
- Success founded on continued investment in R&D and product development
- Differentiation through technology
- Proven strategy in place to develop new business areas
- Well positioned in growth markets
- Delivers value
Strategy and New Business Development

Nick Garner
Group Director, Corporate and Strategic Development
Introduction to Johnson Matthey New Business Development

Update on New Business Development progress

Insight into the New Business Development process

Explain key growth opportunities

Details of our work on:
Air Purification,
Advanced Packaging,
Water Purification and Battery Technology
Strategic Direction to 2020

- **New Business Development Objectives:**
  - Create new divisions with sales of more than £200m in 10 years
  - Looking at areas peripheral to main operating business focus
  - Building on core competences of JM but will involve development/acquisition of some key elements
  - Further improve the generation and commercialisation of new products in JM

**Our Strategic Intent**
- Delivering superior long term growth through technology leadership

**Our Strategy**
- Focus on leading edge catalysis
- Differentiation through technology
- Strong position in platinum group metals
- Organic growth
- New business development

**Supported by**
- Global drivers
- Sustainability
- R&D
- Manufacturing Excellence
- Our people and culture
Global Drivers Impacting the Chemical Industry

Change provides opportunity
JM Technology Competences

Designing advanced materials at the atomic scale to deliver real life solutions

- Sustainable, high technology, high margin businesses need clever solutions
New Business Development Process

Market focused research in promising areas to identify opportunities that would allow JM to build on core competences and other capabilities

- Prioritise and scope out opportunities into JM-specific business propositions
- Product / market development through R&D, prototyping and commercial launch

**Phase 1**
- Market research
- Technology roadmaps
- Business proposition

**Phase 2**
- Opportunity development
- Initial investment case

**Phase 3**
- Business team established
- Further opportunity development
- Updated investment case

**Phase 4**
- Prototype
- Piloting
- Scale up and commercialisation
- Further investment case

**Phase 5**
- Expansion and establishing long term structure

**Sales growth**

**Ongoing cost £6m p.a. to support the current levels of activities in market research and product development across a portfolio of opportunities**
Developing a Portfolio of Opportunities

Aim is develop high tech, high margin, high growth businesses in developing niche markets

- Market research led process filters down a large number of opportunities to specific business propositions

- **Current** examples include:

  - Air Purification
  - Advanced Packaging
  - Water Purification
  - Battery Technology

- Potential businesses have a range of risk profiles but all have potential to be substantial business in 2020 timeframe
Opportunities in Air Purification, Advanced Packaging and Water Purification

Roanna Doe
Group Corporate Development Director
Opportunities in Air Purification

The Opportunity:
- Extension of JM’s existing air purification activities
- Driven by:
  - Increasing air quality concerns
  - Greater energy efficiency demands

The Market:
- Current technologies £1bn in sales
- Consumer driven, increasing regulation
- Immediate focus in Asia

Annual and Projected Sales of Air Purifiers in China
Opportunities in Air Purification

The Offering:
- Current technologies focus on trapping particles
- Demand for:
  - gaseous pollutant removal
  - reliability and durability
  - energy and price efficiency
- Potential for advanced solutions

Phase 2
- Business to business approach
- Ongoing market research
- Establishing commercial links
- Research and development teams in place
- Ambient conditions and advanced adsorbents
Advanced Food Packaging

The Opportunity:
- Extension of JM’s existing activities in this area
- Driven by:
  - Consumer demand
  - Need to minimise food loss levels
  - Desire to reduce use of chemicals
  - International transport – longer life required

The Market:
- Ecosystem control
- Active packaging worth £1.5bn in 2010
- Evidence of demand for advanced technologies

Decay microorganisms
Nutritional value reduced

Respiration

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H₂O

N₂O

CO₂

heat
Advanced Food Packaging

The Offering:

- Technologies to manage gas levels
- Integrated solutions
- Regulation compliance
- Extended range of technologies, applications and market links

Phase 2

- Business to business approach
- Developing our market and applications knowledge
- Expanding our market links
- Technology workstreams established
- Focus on applications engineering, ambient conditions
Water Purification

The Opportunity:
- Removal of **problematic pollutants** from water
- **Regulators** supportive of proven, cost effective technologies

The Market:
- Most of £250bn+ total spend not of interest to JM
- **Niche** advanced materials and specialised process sector ~£1bn
- Specific addressable demand worth **£200m today**
Water Purification

Initial focus

Toxic Metals:

• Remove to lower levels from wider range of sources
• Potential for JM to add value
  • Collect in non-hazardous form
  • Support regulatory requirements
• Adapt JM’s existing scavenging technologies

Organic Chemical Pollutants:

• Limits to current technology applications
  • Space restrictions
  • Operating conditions
  • Cost effectiveness
• Develop JM’s catalytic and electrochemical technologies
Water Purification

The Offering:

- **Advanced material solutions** for difficult to remove pollutants
- Initially adapt existing JM technologies
  - Supports **high margins**
  - No significant medium term capex required
- Short, medium and long term opportunities

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**Phase 3**

- **Business to business** approach, focus on industry
- Business and technical teams in place
- Specific **commercial links** being established
- **Trials under way** on three continents
- Acquisition opportunities being assessed
Opportunities in Battery Technology

Martin Green
Group Strategic Development Director
Batteries

• **Electrification** of vehicle powertrains a growing trend
  • Supported by major global drivers
  • Electrification places new demands on the vehicle system:
    • Energy efficiency
    • Heat utilisation
    • **On-board energy storage**

• A key challenge – substantial improvements to current battery technology required

![Projected Annual Light Duty Vehicle Sales by Technology Type](source: IEA Energy futures, BLUE Map scenario)
Battery Materials

- **Many types of EV** from start / stop hybrid to fully electric vehicles
  - Each with different energy requirements
- Rapidly growing market for EVs
  - Expected to reach **10 - 15 million** vehicles by 2022\(^{(1)}\)
- Opportunities in automotive and other **high performance** applications
- Current battery technology **cannot deliver** the performance required

![Electric Vehicle Battery Requirements](image)

- Opportunity to apply **JM approach** to solving these problems

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(1) Source: Electric Vehicles 2012 – 2022, ID Tech Ex Ltd

(2) Adapted from Peter Lamp, BMW, AABC 2010
What is Johnson Matthey Doing?

- **Battery Technologies** group formed in 2012
  - Focus on **advanced materials** and **applications engineering** for high performance battery systems
- Building a new business grouping, through internal R&D and acquisitions
  - Acquisition of the **Axeon** Group in October 2012
  - Expanded internal **R&D programme** underway
- Excellent match with JM technology competences

- **Target £300m** revenue from Battery Technologies group in 2020

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**Relative Energy Storage Capacities**

- **Practical (Wh/kg)**
- **Theoretical (Wh/kg)**

![Graph showing energy storage capacities for various battery types](graph.png)
Acquisition of Axeon

- Leading developer of **battery systems** for high performance applications
  - Application analysis and design
  - Cell selection and pack engineering
  - Assembly and supply
- **Cell agnostic** strategy, working with many different cell chemistries and vendors
- Revenue of ~£60m p.a., manufacturing in UK and Poland
  - Strong position in **portable power**
  - Developing position in **automotive**

- Over a million vehicle miles driven since 2007 = 20MWh of batteries shipped
Translating Vehicle Requirements into System Design

OEM Customer

Validate Specification

Detailed Cell Testing

Safety Design

System Integration

Battery Management System

Control Software
Axeon Integration

- Initial integration programme complete
- Continuing to deliver on growth plan
  - Automotive and portable power
- Synergies already showing
  - Technology exchanges
  - JM materials characterisation capability
- Investment to support growth of the business
- Establishing materials testing and cell prototyping capability

Battery Systems Value Chain

Cell Materials → Cell Manufacturer → System Design → OEM Customer

Axeon is already accessing JM’s world leading characterisation capabilities
Battery Technology Summary

**Axeon has delivered:**
- Existing revenue stream and good growth prospects in automotive
- Window on Li-ion technology landscape
- Deep understanding of battery applications engineering
- Strong synergies from JM characterisation and analysis capability

**Next steps:**
- Refine and developing the broader JM materials plan for batteries
- Improved Li-ion technology
- Next generation batteries
- Evaluation of further acquisitions underway
Strategy and New Business Development

Nick Garner
Group Director, Corporate and Strategic Development
Developing a Portfolio of Opportunities

Aim is to develop high tech, high margin, high growth businesses in developing niche markets

- Market research led process filters down a large number of opportunities to specific business propositions. Examples discussed:

  - **Air Purification**
    - Total Market 2020: £1bn
  - **Advanced Packaging**
    - Total Market 2020: £3bn
  - **Water Purification**
    - Total Market 2020: £0.5bn
  - **Battery Technology**
    - Total Market 2020: £3bn

- Potential businesses have a range of risk profiles but all have potential to be substantial business in 2020 timeframe
- M&A is key to delivery
Johnson Matthey
Opportunities in Emission Control Technologies

John Walker
Division Director, Emission Control Technologies
Agenda

01 Overview and Strategy  
John Walker

02 Introduction to Emission Control Technologies (ECT)

03 Recap of Global Drivers for the Chemical Industry

04 The Light Duty Catalyst Market
   i. Vehicle Production
   ii. Legislation
   iii. Technology and Revenue Implications
   iv. Powertrain Trends
   v. Market Position
   vi. Market Growth

05 The Heavy Duty and Non-road Catalyst Market
   i. Vehicle Production
   ii. Legislation
   iii. Technology and Revenue Implications
   iv. Market Position
   v. Market Growth

06 Light Duty Aftertreatment Technology  
Dr Chris Morgan

07 Emissions Control for Heavy Duty Vehicles  
Dr Andy Walker

08 Summary and Key Messages  
John Walker
Overview

Showcase
the exciting **growth opportunities** in emission control catalysts

Detail
the market, legislative and technology **drivers** of the business

Highlight
the **expected growth** in our markets over the next **decade**

Explain
how R&D and strong **customer relationships** will drive our **future growth**
Emission Control Technologies’ Strategy

Maintain differentiation through technology by investing in R&D
- High performance catalysts
- Materials science and manufacturing

A deep understanding of our markets and customers

Manufacturing Excellence
- Optimum efficiency
- High quality products

Deliver superior growth
- Markets driven by global trends and regulation
- Rates above industry baselines
Overview of ECT

- Global **leader** in emission control
- Extensive operations across the globe
- Sales growth of **187%** over 10 years to £1.5 billion (**11% CAGR**)  
- **HDD business now 33% of sales**
- Legislation drives **value growth** with more new opportunities
ECT’s Global Network
Global Drivers Impacting the Chemical Industry

Global drivers support growth in ECT
The Light Duty Catalyst Market

- **Market Growth Drivers**
  - i. Vehicle Production
  - ii. Legislation
  - iii. Technology and Revenue Implications
  - iv. Powertrain Trends

- **Market Position**
- **Market Growth**
Light Duty Vehicle Production to Grow – Shift to Asia

Global megatrends support increasing vehicle production

- Recovery 2010 to 2012, steady growth to 2020
- Weakness in 2013, recovery from 2014 expected
- China slows but still fastest growing region
- JM growth expected at a few % ahead of market

Source: LMC (December 2012)
## New and Tighter Regulations Across the World

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### Notes:
- **Tier II**: LEV II
- ** LEV III**:
- **Euro 5 – brought CSF**:
- **Euro 6b – brings NOx control**: Euro 6c – drives GPFs
- **Japan 2009**:
- **Euro 5 (exact date uncertain)**:
- **BS II**:
- **BS III**:
- **BS IV**:
- **BS V**:
- **Euro 5**:
- **Euro 6**:
- **Euro 4**:
Revenue Implications of New Legislation and Technologies

**LD Diesel**
**Euro 5 → Euro 6b**
- Passenger cars September 2014
- LCV < 1305kg, September 2014
- LCV > 1305kg September 2015
- Dates apply to new models
- Existing models are one year later

**LD Gasoline DI Engines**
**Euro 5 → Euro 6c**
- Passenger cars September 2017
- LCV < 1305kg, September 2017
- LCV > 1305kg September 2018
- Dates apply to new models
- Existing models are one year later

• Europe offers the most **growth in revenue** per vehicle
Trends in Powertrain Mix in the Medium Term

Diesel maintains high market share in Europe, ZEV share remains small

- Diesel remains a **European** phenomenon
  - Slight decline in diesel share as efficient small gasoline engines become more popular

- Alternative powertrains gain ground but **slowly**
  - Global penetration remaining below 1%

- Penetration of alternative powertrains **not sufficient** to reverse global growth in internal combustion engine sales

- Mix remains **positive** for ECT technologies
- Hybrids **require catalysts**
JM Global Market Position

JM global share of supply stable at circa 30%

• #1 position in **highest value** European market
• #1 in **China** – 47% of forecast global growth over next five years
• #1 in **new growth areas** inc. SE Asia and Russia
• Weaker in Japan and Korea – **competitor JVs** and **Cataler**
Strong Sales Growth Continues in Light Duty

- Market size $6bn by 2015 and $8bn by 2020
- European diesel remains the main value driver
- Euro 6 and GPFs provide opportunities in Europe
- Asian car sales growth adds further opportunity

- Light duty market continues to offer significant growth potential
- JM sales growth expected at 2 to 3% ahead of growth in global vehicle production
The Heavy Duty and Non-road Catalyst Market

• **Market Growth Drivers**
  i. Vehicle Production
  ii. Legislation
  iii. Technology and Revenue Implications

• **Market Position**

• **Market Growth**
Heavy Duty Vehicle **Regulated** Engines

Volatile, sensitive to global economy. Asian regulations imminent

![Graph showing heavy duty vehicle regulated engines growth](image)

- **North America**: CAGR 3.1%
  - Pent up demand drives growth in next few years

- **Total Europe**: CAGR 6.7%
  - Good growth expected from 2014

- **Asia and South America**: CAGR 24.3%
  - Emerging markets become regulated

- **Global**: CAGR 13.9%
  - Good growth with JM maintaining very strong market position

Source: LMC (December 2012); JM estimates for proportion regulated
**Heavy Duty Diesel: Global Regulatory Introductions**

*New and tighter regulations will continue to drive catalyst demand*

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<td>Brazil</td>
<td>Tier 3a</td>
<td>Tier 3b</td>
<td>Tier 4a?</td>
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Increased Value with Tightening Regulations

Engine management and emission control trade-offs

Alternative choices but increasing catalyst value per vehicle

<table>
<thead>
<tr>
<th>DOE</th>
<th>SCR</th>
<th>CRT®/CCRT®</th>
<th>SCRT®</th>
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<td>US 04</td>
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<td>US 07</td>
<td>US 2010</td>
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<td>Emerging Markets</td>
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<td>Tier 4b</td>
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<td>£</td>
<td>2-3x £</td>
<td>5x £</td>
<td>10x £</td>
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Emerging Markets £ 2-3x £

£ 5x £
JM Global Market Position

Expect >50% share of global supply (inc. China and India) to be maintained

- **Clear #1** position in North America and Europe
- **Japan** and **Korea** dominated by competitor JVs
- Significant *share won* in India

- China more closely fought with *local catalyst makers* – may change as systems become more complex
- **Leading position** carried over into non-road
A $2.1bn Market by 2015, Growing to $3.0bn by 2020

- **Euro VI** major contributor
- Growth in **China** as more vehicles become regulated
- **Non-road** sector adds value

- JM prior estimate revised:
  - Reduction in European truck sales
  - 18 month delay in Chinese legislation

- Heavy duty market continues to offer **significant growth** potential

Source: JD Power and JM estimates
Key Takeaways...

- **Growth in all our markets**
- **Legislative tightening continues to deliver value**
- **Many opportunities develop and derive value from innovative technologies**
- **JM continues to invest ahead of growth opportunities. ECT’s capex reduces to around 1x**

- **Strong position in HDD to be maintained**
- **Margins stable to growing**
- **Double digit growth on average for the foreseeable future**
Light Duty Aftertreatment Technology

Dr Chris Morgan
Technology Director, Emission Control Technologies, Europe
Agenda

**Light Duty Aftertreatment Technology**

01 Opportunities for New Technology

02 Diesel
   i. Selective Catalytic Reduction (SCR)
   ii. NOx Adsorber Catalysts (NAC)
   iii. SCR on a Filter (SCRF®)

03 Gasoline
   i. Gasoline Particulate Filters (GPF)
   ii. LEV III

04 CO₂ Regulations

05 Real World Emissions
Key Legislation Changes in Light Duty

- **Lower Diesel NOx limit for Euro 6 (2014/15)**
  - Reduces from 180 to 80mg/km
- **Gasoline Particulate Number Control for Euro 6**
  - Limit reduces from $6 \times 10^{12}$ to $6 \times 10^{11}$/km in 2017/18
- **Real World Driving Emissions (RDE)**
  - Proposed to reduce off-cycle emissions in Europe
  - Details being finalised: portable emissions measurement system (PEMS) or random drive cycle?
- **LEV III forces lower fleet average emissions**
  - More vehicles to be certified as SULEV 20 and SULEV 30
- **Tightening rules in emerging markets e.g. China, Indonesia**

- Plays to ECT’s **global** footprint
New Product Opportunities

**Diesel NOx control**
- Widespread adoption of SCR and NAC
- Integration onto particulate filter – SCRF®
- Multifunctional filters – ammonia (NH₃) slip, hydrogen sulfide (H₂S) attenuation

**Gasoline particulate number**
- Introduction of coated gasoline particulate filters
  – Three Way Filters (TWFT™)

**More robust catalyst systems for real world emissions control**
- Increased thermal durability
- Emissions control at low temperatures
- Emissions control at high speed / high exhaust gas flow
Diesel NOx Control

**Selective Catalytic Reduction (SCR)**
- Metal-zeolite based catalyst
- Low pgm loading (slip catalyst only)
- Requires urea injection system, with tank, doser and injector systems
- Favoured on larger vehicles

**NOx Adsorber Catalysts (NAC)**
- Pgm based catalyst
- Requires fuel addition, hence penalty on fuel consumption
- Favoured on smaller vehicles

- JM well positioned with both technologies
- Trend moving to SCR for all engine sizes
Integration of SCR and Soot Filter – The SCRF®

The next step for diesel NOx control

- SCRF® allows improved thermal management of catalyst on vehicle
- Technically very demanding system
- May require additional SCR / ammonia slip catalyst (ASC) to maximise NOx conversion

- Delivers performance improvements and cost benefits to customer

Higher technology product adds value
Gasoline Particulate Filters

• Alignment of Euro 6 particulate number legislation for gasoline and diesel
  • Expected introduction with Euro 6c in 2017/18
  • Not expected outside Europe until post 2020

• Ultrafine particles can penetrate deep into the lungs

• JM’s Three Way Filter (TWF™) technology can reduce particle number by 50 - 90% on gasoline direct injection engines

• Development partnerships with major European OEMs

• GPF doubles catalyst value for JM
Key Legislation Changes Outside Europe

In US LEV III forces lower fleet average emissions
- More vehicles to be certified as SULEV 20 and SULEV 30
- Little change to catalyst system in next five years

US ‘Clean Diesel’ is an opportunity for growth
- Especially due to close partnerships with key European OEMs

Main growth effect in Asia is vehicle sales rather than legislation
- Carry over of existing Euro 4/5 gasoline products from Europe
CO₂ Regulations Provide Further Opportunities

- **CO₂ – indicative of fuel efficiency**
  - EU: 130g CO₂/km by 2012; 95g CO₂/km by 2020
  - USA 233g CO₂/mi by 2012; 131g CO₂/mi by 2025

- A product of combustion

- Cannot be catalytically transformed

- Can be reduced by:
  - Consumer decisions – smaller powered engines
  - Powertrain development

<table>
<thead>
<tr>
<th>Powertrain Development</th>
<th>Additional Catalyst Value</th>
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<tbody>
<tr>
<td>Smaller powered engines</td>
<td>✗</td>
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<tr>
<td>Hybrid</td>
<td>✓</td>
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<tr>
<td>Direct injection</td>
<td>✓</td>
</tr>
<tr>
<td>Lower operating temps</td>
<td>✓</td>
</tr>
<tr>
<td>Battery electric vehicles</td>
<td>✗</td>
</tr>
</tbody>
</table>

- Will require **emission control** modifications
- Will **maintain** or **grow** margins
Real World Emissions

• **Confirmation of European legislation expected in 2013**
  • Will require more **robust catalyst systems** to ensure emissions compliance over wider window of operation

**Key challenges:**
• High speed diesel NOx control
  • Passive SCR behind NOx adsorber catalyst?
• Low speed emissions
  • Cold Start Catalysts, hydrocarbon (HC) traps
• More **thermally durable** gasoline systems
Further Improvement of Current Technologies

Key to continue development of existing TWC and DOC technologies

- Increased durability
- Reduced light-off temperatures
- Reduced pgm content and optimised pgm ratios
- Reduced rare earth content

Enables JM to supply better value products to OEMs

- Protecting margin and market position
Emissions Control for Light Duty Vehicles

• Vehicle production continues to grow particularly in Asia
• Tighter legislation will necessitate advanced and more complex catalyst systems
  • In particular in Europe and USA
• Penetration of diesel in Asia
• CO₂ / fuel efficiency requirements and control of new pollutants:
  • Additional challenges and opportunity for new catalyst technologies

• Exciting opportunities in diesel NOx control
  • SCR, NAC and SCRF®
• Exciting opportunities in gasoline particulate control with TWF™
• Real world driving emissions testing
  • Demand for new technologies
• New and improved technologies

• Continuing growth opportunities underpinned by vehicle growth, legislation and new technologies
Emissions Control for Heavy Duty Vehicles

Dr Andy Walker
Technology Director, HDD
Agenda

Emissions Control for Heavy Duty Vehicles

01 Heavy Duty Diesel (HDD) Technology Trend

02 Key Legislative Changes and Implications

03 CO$_2$ and Fuel Economy Regulations

04 Potential Future Regulations

05 New Product Opportunities

06 Other Powertrains
HDD Technology Trend: Multifunctional Systems

Complex systems with multiple catalyst components required to meet advanced legislation

■ **DOC** – Diesel Oxidation Catalyst
  - Removes CO and HC
  - Oxidises fuel to drive active filter regeneration
  - Converts some NO into NO₂

■ **CSF** – Catalysed Soot Filter
  - Traps particulate matter (carbon)
    - For subsequent removal by NO₂ and / or O₂
  - Enables particle number (PN) compliance

■ **SCR** – Selective Catalytic Reduction
  - Removes NOx via reaction with NH₃

■ **ASC** – Ammonia Slip Catalyst
  - Removes any ammonia (NH₃) slip and converts it to (predominantly) nitrogen (N₂)
Key Legislative Changes and Implications

On road

- 80% reduction in NOx limit + introduction of particle number legislation for Euro VI (2014)

- Introduction of GHG-based regulation in North America (2014) requires higher NOx conversion systems

- Japanese Energy Saving Law (2015) and lower NOx limit (JP 16) require increased NOx conversion

- Brazil Euro V (2012), China Euro IV (2013), India Euro IV (2014/15) drive

- Brazil Euro VI (circa 2018) drives
Key Legislative Changes and Implications

Non-road

- Aligned standards in Europe, North America and Japan
- **80%** reduction in NOx limit for Tier 4b (2014)
  - Optimised **SCR systems** required
- No particle number limit
- Filters **not required** to meet the non-road Tier 4b regulations
- **SCR** is required; typical systems:
  - 🟢 SCR + 🟢 ASC
  - 🟢 DOC + 🟢 SCR + 🟢 ASC
  - 🟢 DOC + 🟢 CSF + 🟢 SCR + 🟢 ASC
**CO₂ and Fuel Economy Regulations**

- Japan **tax incentives** for fuel efficient vehicles
- North America’s EPA recently announced **GHG and fuel economy** regulations
  - Introduces CO₂, CH₄ and N₂O regulations for the first time – targeting global warming
- Active discussions on **CO₂ regulation** for HDD in Europe
- Major **future focus** will be on GHG and fuel efficiency

- **Catalyst systems** will play a major role in enabling fuel efficiency improvements and GHG reductions

Source (top image): University Corporation for Atmospheric Research
Potential Future Regulations

- Potential introduction of \( \text{N}_2\text{O} \) and \( \text{CH}_4 \) regulations outside North America
- Potential introduction of \( \text{NO}_2 \) regulations
  - Major focus in urban areas to improve urban air quality
- Expected introduction of particle number regulations
  - In non-road Stage V European regulations around 2019/20
  - Would drive filter fitment on all non-road engines
- Increased focus on Black Carbon emissions
  - Major contributor to GHG emissions (40% of current warming)
  - Short lived in atmosphere – can achieve immediate benefits

- Should drive filter fitment on non-road vehicles
Current R&D Priorities and Focus

New product opportunities

Extruded catalysts for optimised low temperature performance
- Enables performance increase and/or volume reduction

Cold Start Catalysts (CSC)
- Engine-out emissions exceed cycle limit in 80 seconds
- CSC gives extra time to get SCR catalyst hot enough to convert NOx
Other Powertrains

**Natural gas and hybrids**

- Potential of natural gas (NG) powered HDD vehicles, especially in North America
  - NG currently lower cost than diesel
  - Potential concerns include higher truck prices, future pricing of NG, methane losses leading to GHG concerns
- NG powered vehicles **require catalysts** to meet regulations
- Hybrids offer fuel economy advantages for in-city stop-go driving
- Hybrids use the **same catalyst systems** as diesel trucks

Top image courtesy of Clean Energy
Bottom image source: Digital Trends, Inc.
Emissions Control for Heavy Duty Vehicles

- **Vehicle** and **engine production** continues to grow worldwide

- **Tightening legislation** in the developed markets (Europe, North America, Japan) moves all on road and non-road engines to **complex catalyst systems**

- Incoming **legislation** in very large Chinese and Indian markets
  - Will **require emissions control** on HDD vehicles for the first time

- **CO₂ / fuel efficiency requirements and control of new pollutants**
  - Offers additional challenges and opportunities for continued **development and innovation**

- Continuing growth opportunities underpinned by **vehicle growth, legislation** and new **technologies**
Opportunities in Emission Control Technologies

John Walker
Division Director, Emission Control Technologies
Key Takeaways...

- Growth in all our markets
- Legislative tightening continues to deliver value
- Many opportunities develop and derive value from innovative technologies
- JM continues to invest ahead of growth opportunities. ECT’s capex reduces to around 1x

- Strong position in HDD to be maintained
- Margins stable to growing
- Double digit growth on average for the foreseeable future
Tour of the Royston Facility

Dr David Prest
Managing Director, Emission Control Technologies, Europe
ECT Royston Operations

**Plant Location:**
- Royston, Hertfordshire, England

**Operating Region:**
- European

**Start of Operations:**
- April 2001

**Accreditations:**
- ISO/TS 16949 / ISO 14001

**Site Capacity:**
- CSF + flowthrough catalysts
Site Overview
The Structure of an Autocatalyst

**Washcoat**
Chemical solution adhering to the substrate walls and providing high surface area to pgm

**Active components**
Platinum group metals (pgms)

Coated substrate
Process Overview

Raw Materials

- Oxide powders
- Pgm salts
- Base metal salts
- Substrate

Washcoat Preparation

+ water
milling

Washcoat slurry

Coating Process

Substrate Catalyst coating

PROCESS 1

Drying
Firing
Inspection
labelling / boxing

PROCESS 2
Technology Centre

Product Development

Catalyst Assessment

Catalyst Characterisation

Vehicle Testing

Engine Testing
Plant Tour

Safety instructions

To ensure your safety please stay on the green routes when touring the factory.

If the fire alarm rings continuously please follow your guide to the FIRE ASSEMBLY POINT.

Security

Request that phones and other recording devices are left in the conference room.
Closing Remarks

Neil Carson
Chief Executive
Summary

A world leading technology company

Success founded on continued investment in R&D and product development

Differentiation through technology

Proven strategy in place to develop new business areas

Well positioned in growth markets

Delivers value
Conclusions

Well positioned for future growth

New Business Development

• Developing a portfolio of opportunities
• Good fit with JM technology competences, supported by global drivers
• Targeting high tech, high margin, high growth businesses in developing niche markets
• Potential to create new divisions with sales >£200m

Emission Control Technologies

• Good growth opportunities in all our markets
• Legislation and technology continues to drive business around the world
• Continued investment to support growth
• Double digit growth on average for foreseeable future
JM Executive Board

Neil Carson
Chief Executive

Robert MacLeod
Group Finance Director

Larry Pentz
Executive Director
Environmental Technologies

Bill Sandford
Executive Director
Precious Metal Products
Presentation Team

**Nick Garner**  
Group Director  
Corporate and Strategic Development

**Roanna Doe**  
Group Corporate Development Director

**Martin Green**  
Group Strategic Development Director

**John Walker**  
Division Director  
Emission Control Technologies

**Dr Chris Morgan**  
Technology Director  
Emission Control Technologies Europe

**Dr Andy Walker**  
Global Technology Director  
Heavy Duty Diesel
## Other Senior Management

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<tr>
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<tr>
<td>Lawrence Berns</td>
<td>Managing Director</td>
<td>Axeon</td>
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<tr>
<td>Simon Christley</td>
<td>Division Finance Director</td>
<td>Environmental Technologies</td>
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<tr>
<td>David Clark</td>
<td>Business Development Director</td>
<td>Emission Control Technologies</td>
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<tr>
<td>Kevin Donegan</td>
<td>Commercial Director</td>
<td>Light Duty</td>
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<td>Alan Myers</td>
<td>President</td>
<td>Emission Control Technologies</td>
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<tr>
<td>Dr Allan Paterson</td>
<td>Senior Electrochemist</td>
<td>Axeon</td>
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<td>Dr David Prest</td>
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<td>John Zubrickas</td>
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<td>Ian Godwin</td>
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<td>Investor Relations</td>
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<td>Dr Sally Jones</td>
<td>Group Corporate Communications Manager</td>
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<td>Don Newton</td>
<td>Global Technology Director</td>
<td>Axeon</td>
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# Glossary

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<th>API</th>
<th>Active pharmaceutical ingredient</th>
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<td>ASC</td>
<td>Ammonia slip catalyst</td>
<td>EV</td>
<td>Electric vehicle (HEV, PHEV or BEV)</td>
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<td>BEV</td>
<td>Battery electric vehicle</td>
<td>GHG</td>
<td>Greenhouse gas</td>
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<td>C₂H₄</td>
<td>Ethylene</td>
<td>GPF</td>
<td>Gasoline particulate filter</td>
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<td>CAGR</td>
<td>Compound annual growth rate</td>
<td>H₂</td>
<td>Hydrogen</td>
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<td>CARB</td>
<td>California Air Resources Board</td>
<td>H₂O</td>
<td>Water</td>
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<td>CCRT®</td>
<td>Catalysed continuously regenerating trap</td>
<td>H₂S</td>
<td>Hydrogen sulfide</td>
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<td>CCS</td>
<td>Carbon capture and storage</td>
<td>HC</td>
<td>Hydrocarbon</td>
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<td>CNG</td>
<td>Compressed natural gas</td>
<td>HDD</td>
<td>Heavy duty diesel</td>
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<tr>
<td>CH₄</td>
<td>Methane, natural gas</td>
<td>HEV</td>
<td>Hybrid electric vehicle</td>
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<td>CO</td>
<td>Carbon monoxide</td>
<td>JM</td>
<td>Johnson Matthey</td>
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<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
<td>JV</td>
<td>Joint venture</td>
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<td>CRT®</td>
<td>Continuously regenerating trap</td>
<td>LCV</td>
<td>Light commercial vehicle</td>
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<td>CSC</td>
<td>Cold start catalyst</td>
<td>LD</td>
<td>Light duty</td>
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<td>CSF</td>
<td>Catalysed soot filter</td>
<td>Li-Air</td>
<td>Lithium-Air, a type of battery cell chemistry</td>
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<td>DOC</td>
<td>Diesel oxidation catalyst</td>
<td>Li-ion</td>
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<td>ECT</td>
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<td>Li-S</td>
<td>Lithium-sulfur, a type of battery cell chemistry</td>
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<td>EPA</td>
<td>US Environmental Protection Agency</td>
<td>LPG</td>
<td>Liquefied petroleum gas</td>
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## Glossary

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<tr>
<th>Abbreviation</th>
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<td>( N_2 )</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>( N_2O )</td>
<td>Nitrous oxide</td>
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<tr>
<td>NAC</td>
<td>NOx adsorber catalyst</td>
</tr>
<tr>
<td>NG</td>
<td>Natural gas</td>
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<tr>
<td>( NH_3 )</td>
<td>Ammonia</td>
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<tr>
<td>Ni-Cd</td>
<td>Nickel-cadmium, a type of battery cell chemistry</td>
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<tr>
<td>Ni-MH</td>
<td>Nickel-metal hydride, a type of battery cell chemistry</td>
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<tr>
<td>NO</td>
<td>Nitrogen monoxide</td>
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<td>( NO_2 )</td>
<td>Nitrogen dioxide</td>
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<tr>
<td>NOx</td>
<td>Nitrogen oxides</td>
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<td>( O_2 )</td>
<td>Oxygen</td>
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<td>OEM</td>
<td>Original equipment manufacturer</td>
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<tr>
<td>p.a.</td>
<td>Per annum</td>
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<td>PEMS</td>
<td>Portable emissions measurement system</td>
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<tr>
<td>Pgm</td>
<td>Platinum group metal</td>
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<td>PHEV</td>
<td>Plug-in hybrid electric vehicle</td>
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<td>Pms</td>
<td>Precious metals</td>
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<td>Particle number</td>
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<td>R&amp;D</td>
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<td>RDE</td>
<td>Real world driving emissions</td>
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<td>ROW</td>
<td>Rest of the world</td>
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<td>RSA</td>
<td>Republic of South Africa</td>
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<td>SCR</td>
<td>Selective catalytic reduction</td>
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<td>SCRF®</td>
<td>Selective catalytic reduction on a soot filter</td>
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Johnson Matthey