

A green John Deere tractor is positioned in the foreground on the right side of the frame, partially obscured by a green implement. The tractor is in a field of dry, brown vegetation. In the background, there are rolling hills and mountains under a cloudy sky with soft, golden light, suggesting dawn or dusk. The overall scene is a rural, agricultural landscape.

On-farm Engine Emission Reduction From New and Legacy Equipment

Cory J. Reed

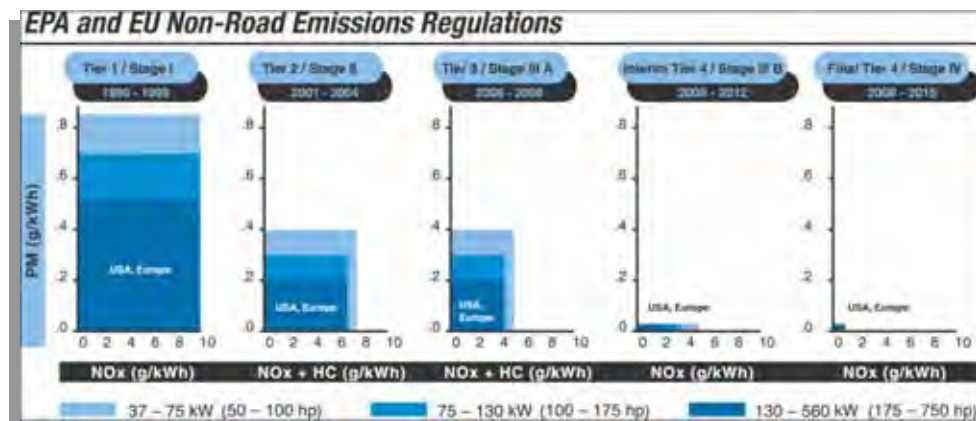
Manager, Factory Marketing – John Deere Waterloo Works

Randy S. Swanson

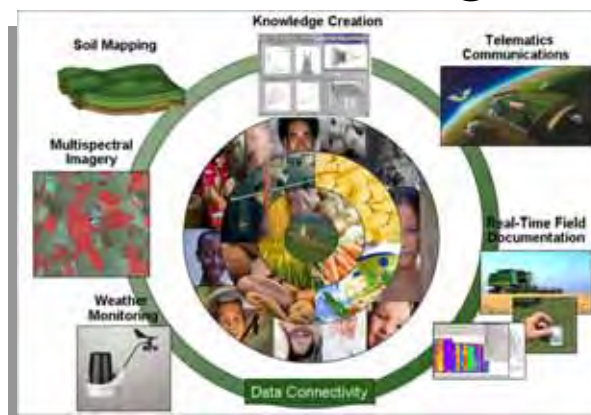
Manager, Marketing Services – John Deere Power Systems

Reducing Engine Emissions

- Reducing Exhaust Emissions Through Technology
Randy S. Swanson



- Reducing Emissions Through Production Efficiency
Cory J. Reed



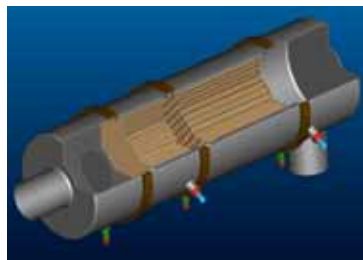
Reducing New Engine Emissions

➤ Intake Air Management

- Natural Aspiration
- Turbos: Fixed, Wastegate, Variable Geometry, Twin
- Charge Air Cooling
- 2 / 4 Valve Heads

➤ Fuel Injection Control

- Timing
- Single / Multiple Injection
- Increased Pressure



➤ Exhaust Gas Management

- Exhaust Gas Recirculation
- Aftertreatment

➤ Controls

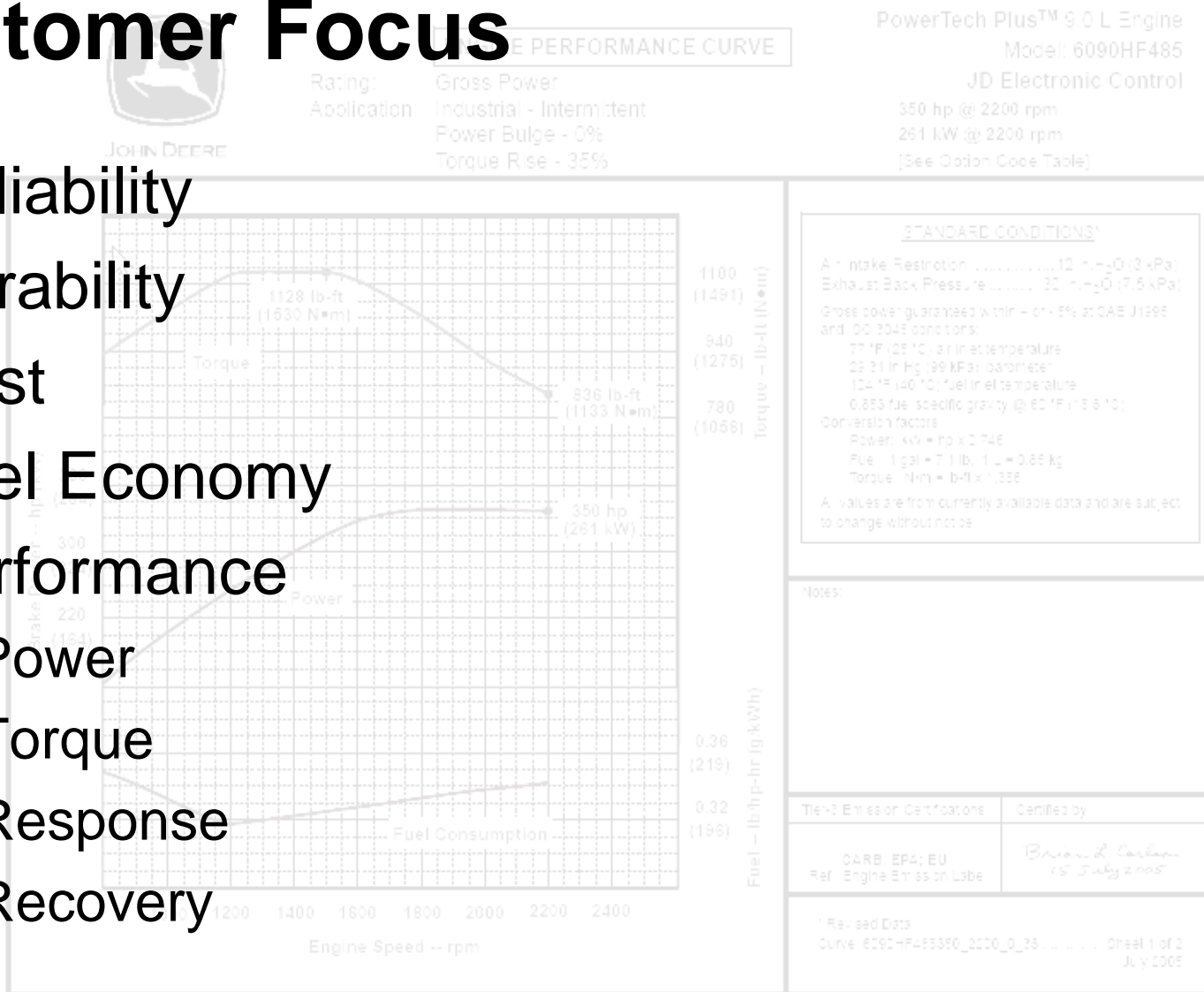
- Mechanical
- Electronic
 - Engine Only
 - Integrated w / Equipment

John Deere Engine Strategy

- Power through technology
 - PowerTech™ production started in the mid 90's
- Clean performance
 - Latest engine technologies
 - Meet or exceed regulations
 - Drive customer value

Customer Focus

- Reliability
- Durability
- Cost
- Fuel Economy
- Performance
 - Power
 - Torque
 - Response
 - Recovery



Engine Performance Curves

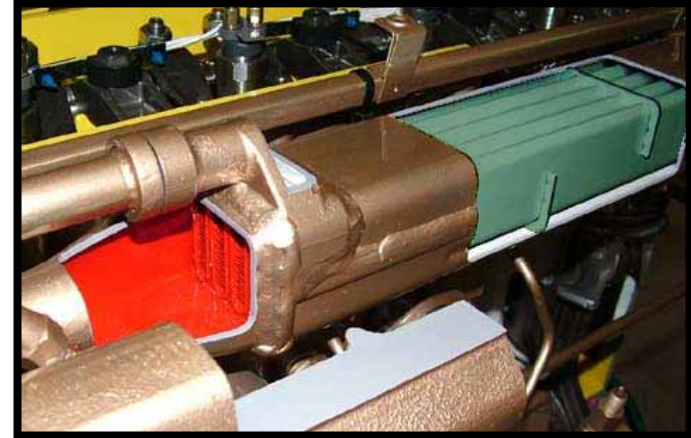
6090 - Industrial

December 2005

PowerTech Building Blocks



PowerTech M™
PowerTech E™



PowerTech Plus™

Injection	Multiple	Single
Valves	2 per cylinder	4 per cylinder
Turbo	Fixed	Variable
EGR	None	Cooled

4.5L Engines



1994

~100 hp

~315 Ft-lb Torque

~19.1 Hp-hr/gal



2006

~175 hp (+75%)

~475 Ft-lb Torque (+51%)

~19.8 Hp-hr/gal (+4%)

6.8L Engines



~175 hp

~475 Ft-lb Torque

~19.1 Hp-hr/gal



~275 hp (+57%)

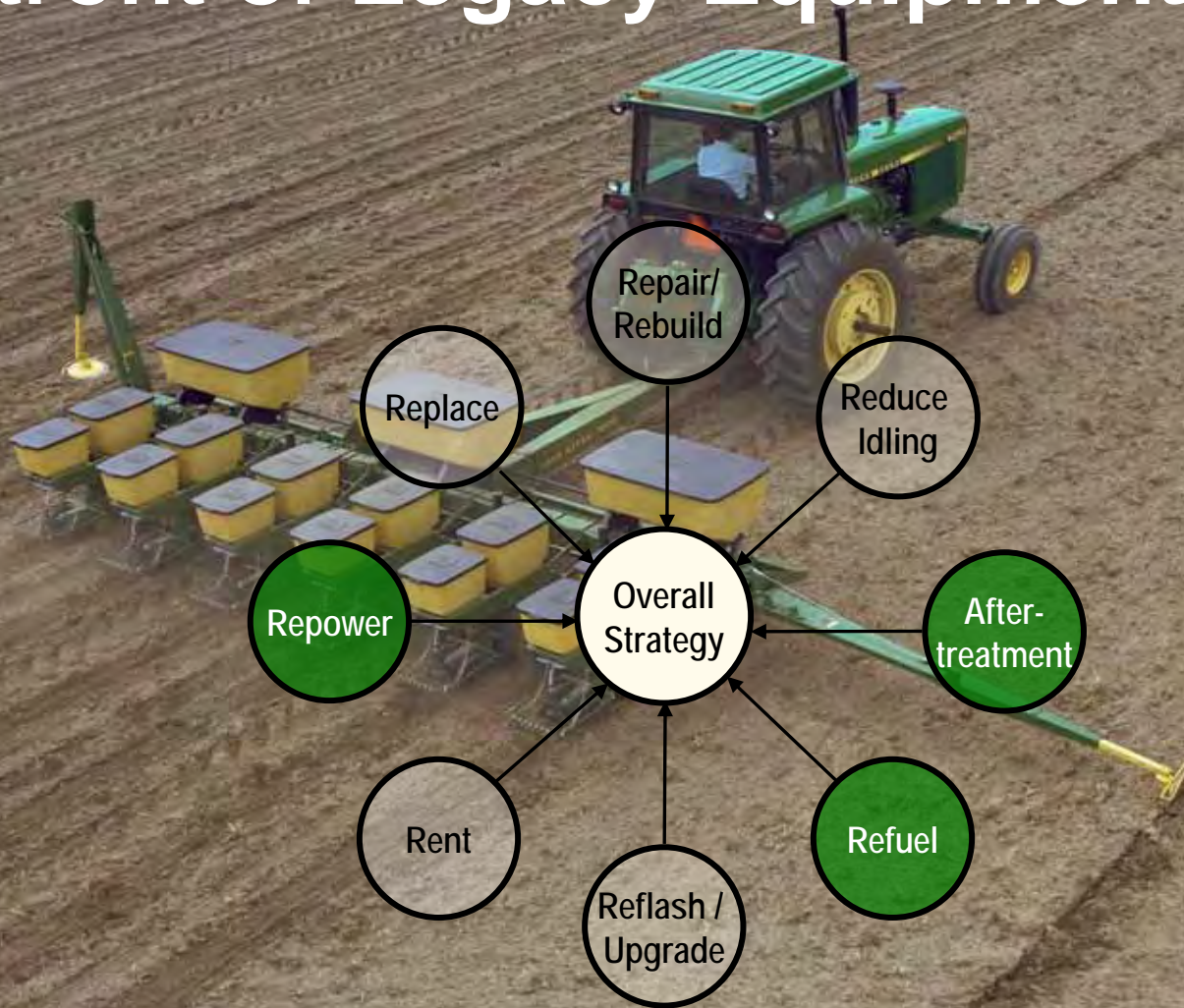
~755 Ft-lb Torque (+60%)

~20.1 Hp-hr/gal (+4%)

Reducing New Engine Emissions

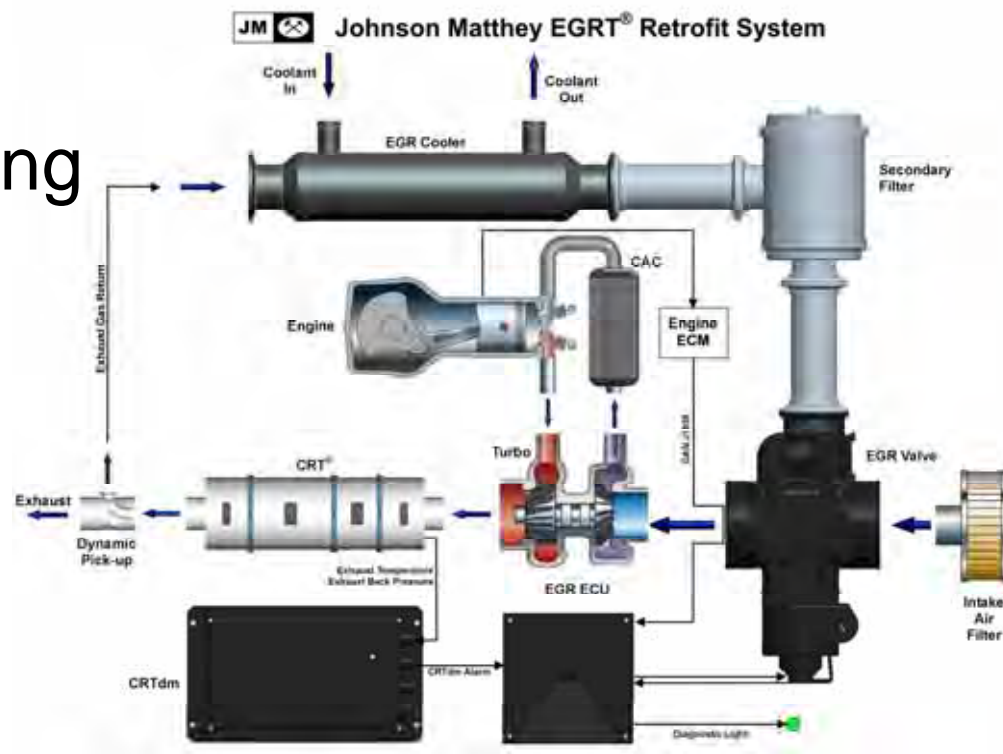
- Increased complexity and cost to meet emissions
 - Driving collaboration between component, engine and equipment manufacturers
- Strive to offset increased cost with fuel economy and performance improvement
 - Dependent on matching technology with use
- Reliable and durable solutions a must

Retrofit of Legacy Equipment



Aftertreatment & Verified Retrofit

- Exhaust Gas Recirculation (EGR)
- Diesel Particulate Filter (DPF)
- Controller
- Cooling circuit plumbing
- Brackets & hardware



Potential Aftertreatment Installation

- Technical expertise required
- Field installed by system supplier's distributor



- Will it be more cost effective than other options?

Aftertreatment Service

- Requires removal and cleaning of PM filter
 - ~2000 hours
 - Hours customer / application dependent
 - Must be serviced at certified location
 - What's financial impact of maintenance and downtime?
- Requires Ultra Low Sulfur Diesel (ULSD)
 - On-highway fuel
 - Available nationwide
 - Only fuel available in emission sensitive areas (i.e. California, large metro areas)



Refuel

- Support use of ULSD
- Biodiesel @ John Deere
 - 2% factory fill
 - 5% encouraged since 2001
- John Deere working with biodiesel industry
 - Promoting quality standards
 - Distribution guidelines
 - Handling guidelines

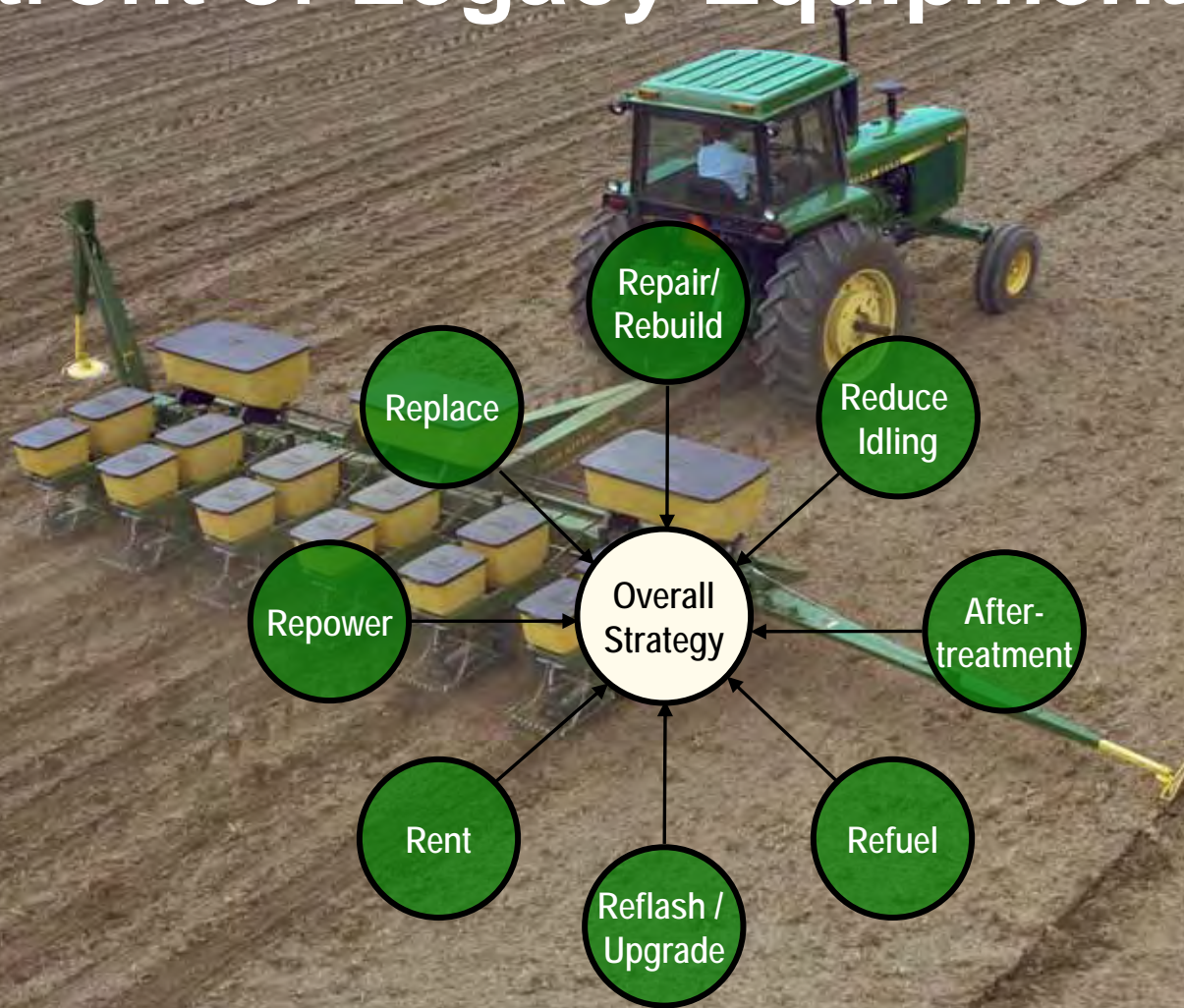


Potential Repower Program

- Highly Engineered
- National in Scope
 - One price, one design
- Support Required
 - Engine and equipment
- Unlikely to be cost effective for smaller, older, high hour or low usage equipment



Retrofit of Legacy Equipment



A John Deere tractor is shown in a field at sunset. The tractor is green and yellow, with a large rear wheel and a smaller front wheel. It is pulling a green implement, possibly a plow or harrow. The background shows a vast, flat field with some distant hills under a cloudy sky. The lighting is warm, suggesting late afternoon or early evening.

Reducing Emissions Through Production Efficiency

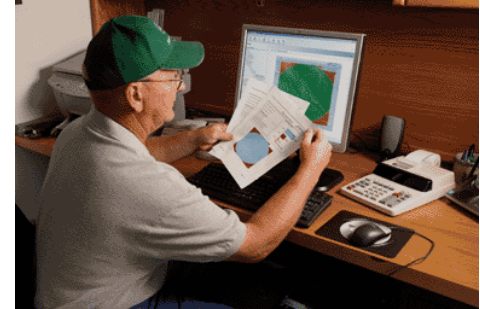
Cory J. Reed

Manager, Factory Marketing – John Deere Waterloo Works

Market Factors in Agriculture

➤ Economic Challenges

- Rising Input Costs
- Global Competition
- Food Security / Identity Preservation
- Labor



➤ Environmental Challenges

- Air Quality
- Water Quality / Source
- Climate



➤ Farm Policy



Reduced Emissions Through Platform Updates

- Four product iterations in since 1994, each update with new emissions technology
- 90% reduction in NOx and 95% reduction in PM by Tier 4
- Significant investment to maintain and improve vehicle productivity
- For retrofits, we must analyze which platforms can create the biggest impact on emissions



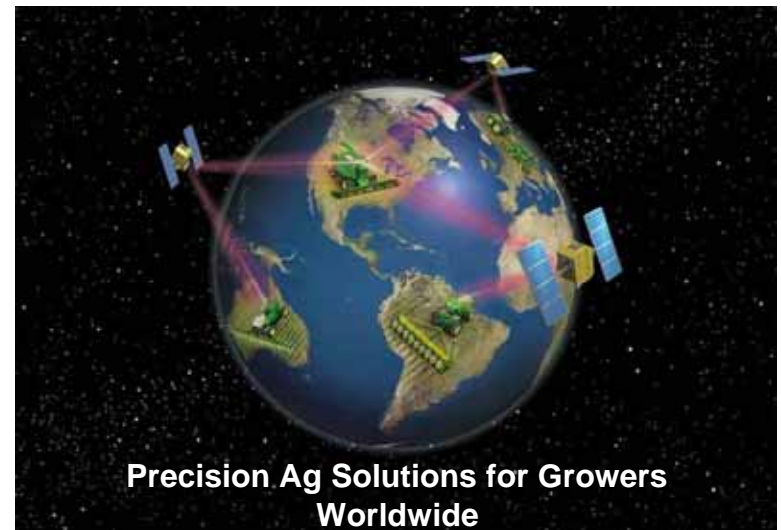
Reduced Emissions Through Production Efficiency

➤ Vehicle Efficiency

- Optimize power transfer and engine operation
- Intelligent vehicle technologies
 - Infinitely Variable Transmissions (IVT)
 - Intelligent Power Management

➤ Farming System Efficiency

- No-till / Minimum till
- Single pass farming
- Precision farming



Enabling Technologies

John Deere Ag Management Solutions

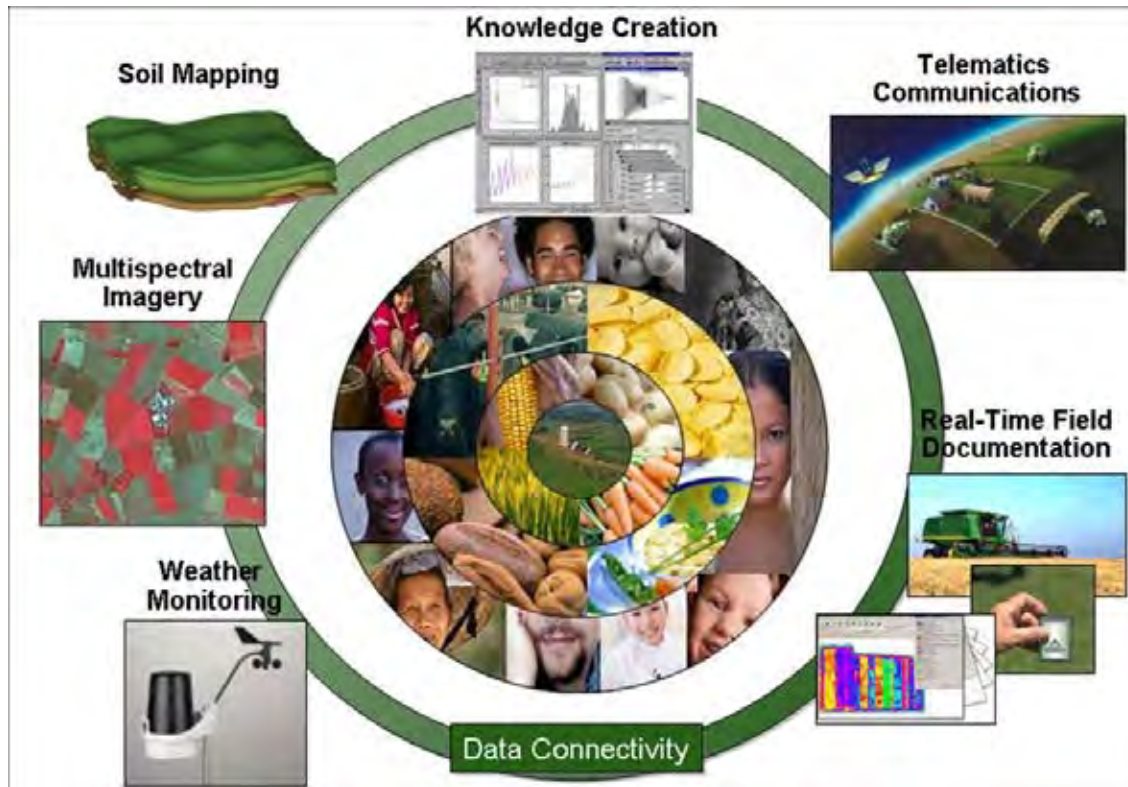
- Reduce overlap, maximize output
- Enable water management
- Precision placement of seed, chemical, fertilizer



Enabling Technologies

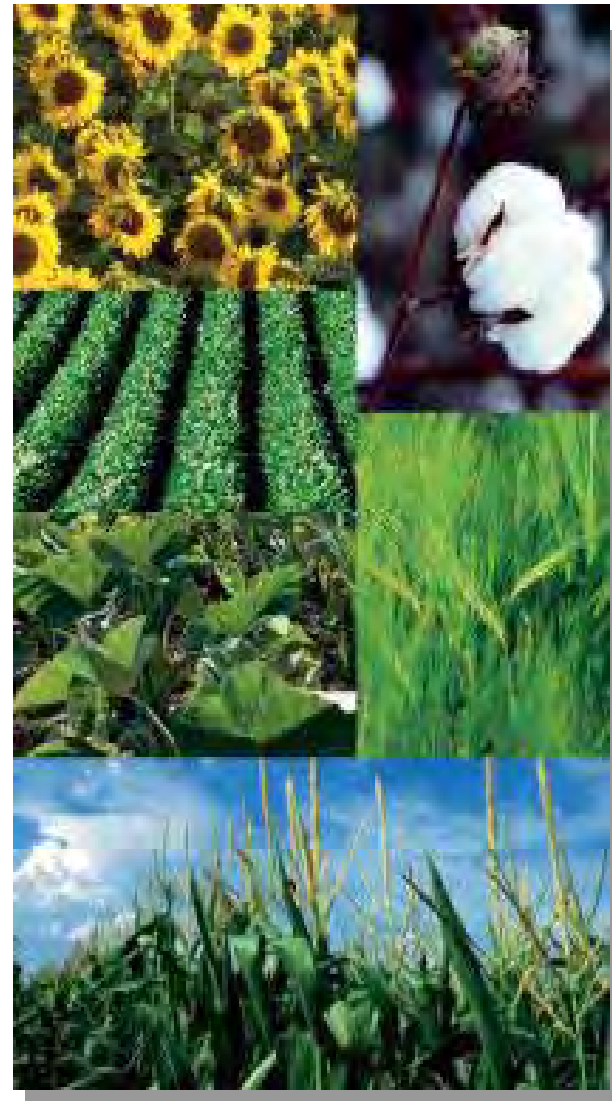
John Deere Agri Services

- Turning information and technology into insight and strategies that add value to agriculture and reduce exhaust output



Sustainable Alternative Energy

- Biomass
- Bio Fuel
- Wind Energy



Farm Engine Emissions Reduction

- Improve engine performance
 - Increase sophistication of engine technology
 - Convert remaining emissions
- Increase equipment productivity
 - Collaboration between component, engine and vehicle mfgs
 - Optimized equipment performance
 - Minimize impact of packaging
- Improve farming efficiency
 - Streamline work
 - Eliminate work
- Develop / commercialize new technologies
 - Harness the wind
 - Electric drives, fuel cells...

