The Evolution of the Off-Highway Vehicle Powertrain

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Introduction: CNH Industrial

One of the world's largest capital goods company

AGRICULTURE

Second largest manufacturer of agricultural machinery

CONSTRUCTION

A global player in construction equipment

FINANCIAL SERVICES

Global financial services player supporting customers and dealers

A BRIEF HISTORY OF AGRICULTURE AND IMPACT ON THE WORLD TODAY

What are they? And frankly, why should anyone care?

Hunter-Gatherer

Ancient Times

<1O M People

100% in Agriculture

Food Scarcity

Day to Day Living

Horse / Oxen & Plough

~4,000 BCE

<15 M People

90% in Agriculture (1800)

Development of Industry

Growth of Cities / Civilization

Early Tractors

1892 – Froelich, Iowa USA

Shown: Henry Ford 1917 (first mass produced)

1.1 B People

>50% in Agriculture (1900)
(40% in the USA)

Industrialized Nations

Global Expansion

Today

2021 – est 1.5 M produced annually

~7.9 B People

28% in Agriculture (Today)
(<1% in the USA)

Technology and Globalization

Interdependency

A Key Enabler to What World is Today!

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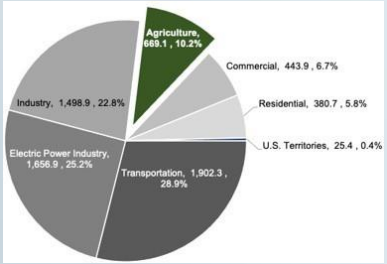
FUNDAMENTAL ROLE TO PLAY IN A SUSTAINABLE FUTURE

POPULATION	URBANIZATION	FOOD SCARCITY	CLIMATE CHANGE & BIODIVERSITY LOSS
POPULATION GROWTH: **+2B** people by 2050 **CHANGING DIETS:** **+10%** average calorie uptake	**RURAL EXODUS:** **1.5M** people move into urban areas each week **MEGACITIES:** **140** cities with > **3M** in habitants	**FIELD PRODUCTIVITY DECREASE** Soil compaction and inefficient farm management **AGRONOMIC PRACTICES** 15% yield loss from inadequate fertilizer application	**The science is clear: society must limit global warming to 1.5c by of the century**

US Emissions by Source 2019



GROWING FOOD DEMAND	GROWING INFRASTUCTURE DEMAND	GROWING YIELD DEMAND	DECARBONIZATION DEMAND

Getting more from less in a sustainable way

TECHNOLOGY ROADMAPS

ROADMAP TOWARDS FULL AUTOMATION

Optimized machine utilization and labor efficiency

MACHINE AUTOMATION
Optimize and automate the usage of our products

AUTONOMOUS VEHICLES
Autonomous driving, remote monitoring, coordinated vehicle operation and robotics

DATA MANAGEMENT AND CONNECTED VEHICLES
Leverage data (machine and agronomy) to optimize operation

ROADMAP TOWARDS ZERO EMISSION

Optimized power usage and minimized environmental impact

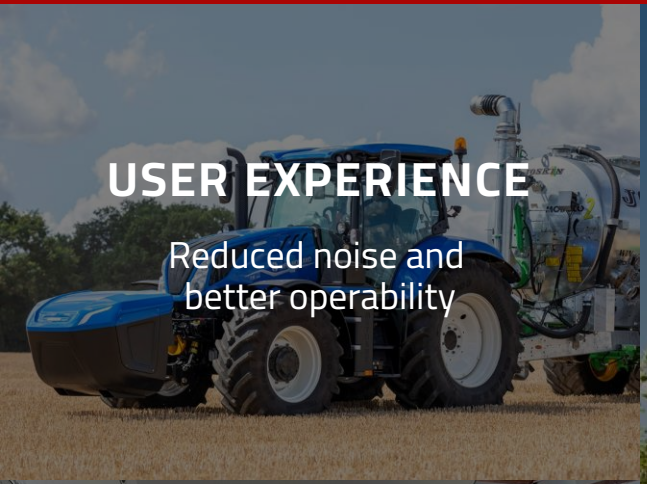
ALTERNATIVE FUELS
Reduced greenhouse gas emission

MACHINE EFFICIENCY AND PRODUCTIVITY
Optimize power usage

ELECTRIFICATION
Electric-vehicle technologies in our products

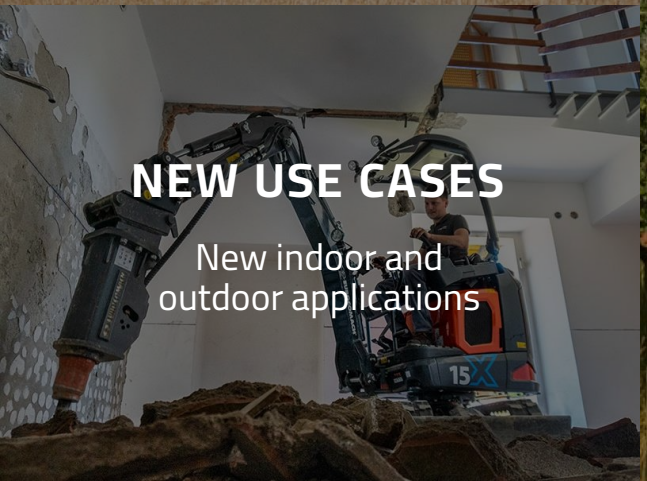
WHY ELECTRIFICATION & ALTERNATIVE FUELS MATTER

Creating value for customers



USER EXPERIENCE

Reduced noise and better operability



NEW USE CASES

New indoor and outdoor applications

SUSTAINABILITY

Accelerating net zero path along the value chain

FINANCIAL RETURN

Decreasing TCO, increasing productivity

REGULATION

Users preparing for emerging regulations

ALTERNATIVE PROPULSION

Significant improvement on emissions, operating costs and noise reduction

WORLD'S 1ST BIO-METHANE TRACTOR

80%
less pollutants

30%
lower operating costs

50%
noise reduction

Net zero
impact

WORLD'S 1ST ELECTRIC BACKHOE LOADER

up to 90%
lower operating costs

90%
noise reduction

Zero
emissions

ELECTRIFICATION BEYOND PROPULSION

Electrification improves **total vehicle efficiency**, and sets the ground for automation and autonomy

AGRICULTURE

up to 35%
fuel saving

up to 35%
CO_2 reduction

45%
noise reduction

CONSTRUCTION

1 hour
fast-charging to 80%

80cm[1] wide
Easy access through domestic doorways

90%
noise reduction

Zero
emissions

Additional benefits of electrification

- Maneuverability
- Safety
- Connectivity & data availability

Note: Noise reduction measured in decibels
1. Ca.30 inches

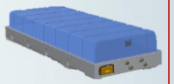
AG and CE POWERTRAIN EVOLVE WITH ELECTRIFICATION & ALTERNATIVE FUELS

ALTERNATIVE FUEL PATHS TOWARDS CO2 EMISSION REDUCTION

Comparison Vs. Diesel and Impact estimation on key Case IH machines







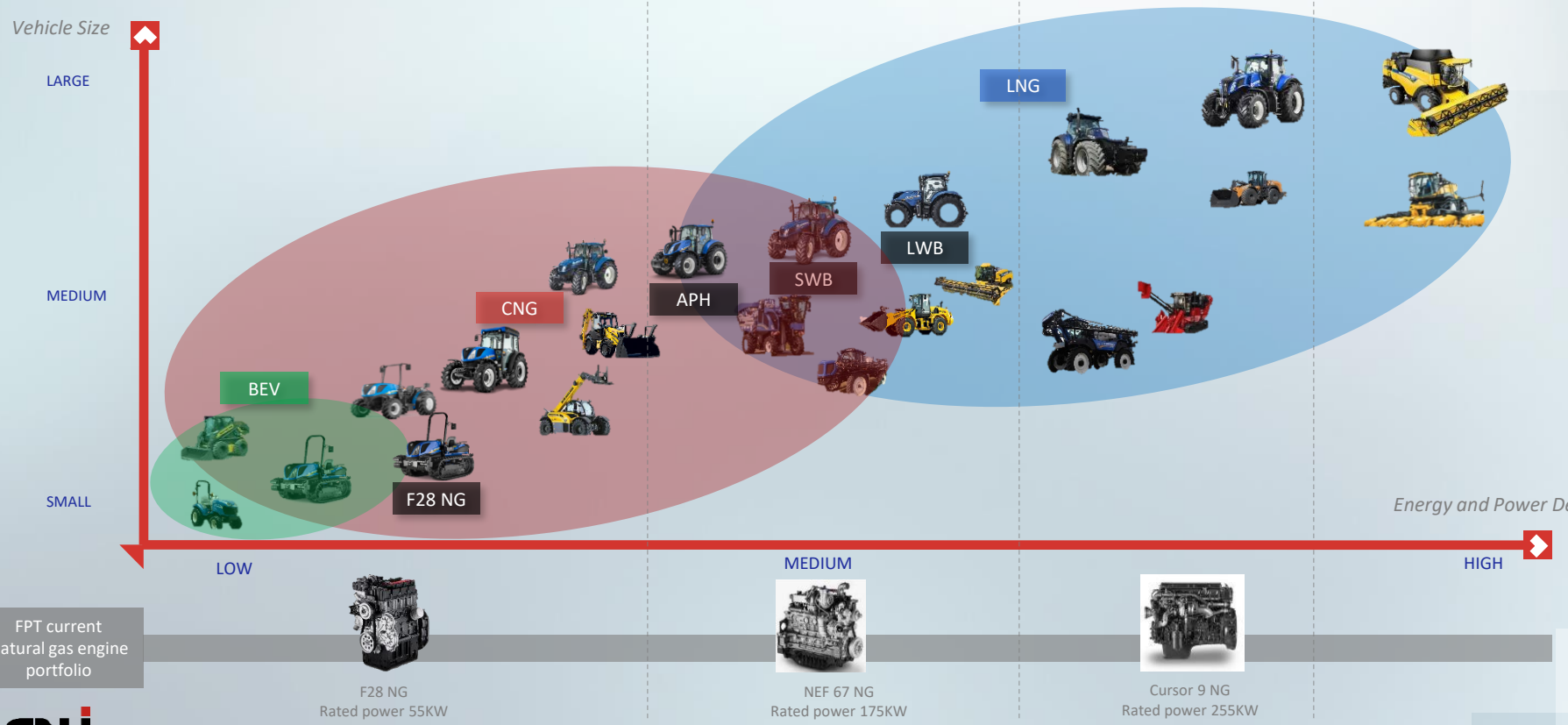
	Biodiesel (B20)	Renewable diesel (e.g., HVO, xTL)	Bio-DME	Bio-NG	Bio-Ethanol	Green Hydrogen Engine	Green Hydrogen Fuel Cell	BEV
CO_2 WTW emission*	-10%	-40%	-90%	-65%**	-70%	-96%	-97%	-100% *(if renewable)*
Volumetric power density	Same as Diesel			Slightly lower than diesel (~ -10%)			-60%	Not applicable
							To add machine electrification (e.g., e-motor)	
Autonomy with same energy storage volume	-2%	-4%	-50%	CNG -75% / LNG -50%	-50%	-90%	-85%	-95%
Energy storage volume for same autonomy	same	same	~x2	~x4,5	~x2	~x2	~x9	~x6,5	~x14
Case Study: **Magnum 380** (GVW 18/24,5 tons), **Sugar Cane** (weight 18,5 tons)								
System*** weight for same autonomy	same	same	+20%	x2 (+2 ton)	same	+10%	x3,5 (+4,5 tons)	x3,3 (+4 tons)	x8,5 (+13,2 tons)

- **Biodiesel/renewable diesels as quick win** (ready to use); **NG** as **existing technology to be adapted to Off-Road**, using LNG storage for autonomy.
- **DME and ethanol**, with comparable benefits and impacts, **to be assessed** depending on fuel strategy / production.
- **Hydrogen-powered engines** as easier-to-adapt to exploit H2 without vehicle electrification; **Fuel Cells and Battery Electric** ensures **zero emission** but with **heavier impacts on machines** (storage size and weight)

*Data from Concawe "JEC Well-to-Wheels study version 5" | ** Up to -185% if from manure (CO2 absorption from atmosphere) | *** Energy storage+engine equivalent+ATS (driveline not considered)

ELECTRIFICATION AND ALTERNATIVE FUELS MAPPING

Energy Storage Density is the key enabler!



FPT current Natural gas engine portfolio

F28 NG
Rated power 55KW

NEF 67 NG
Rated power 175KW

Cursor 9 NG
Rated power 255KW

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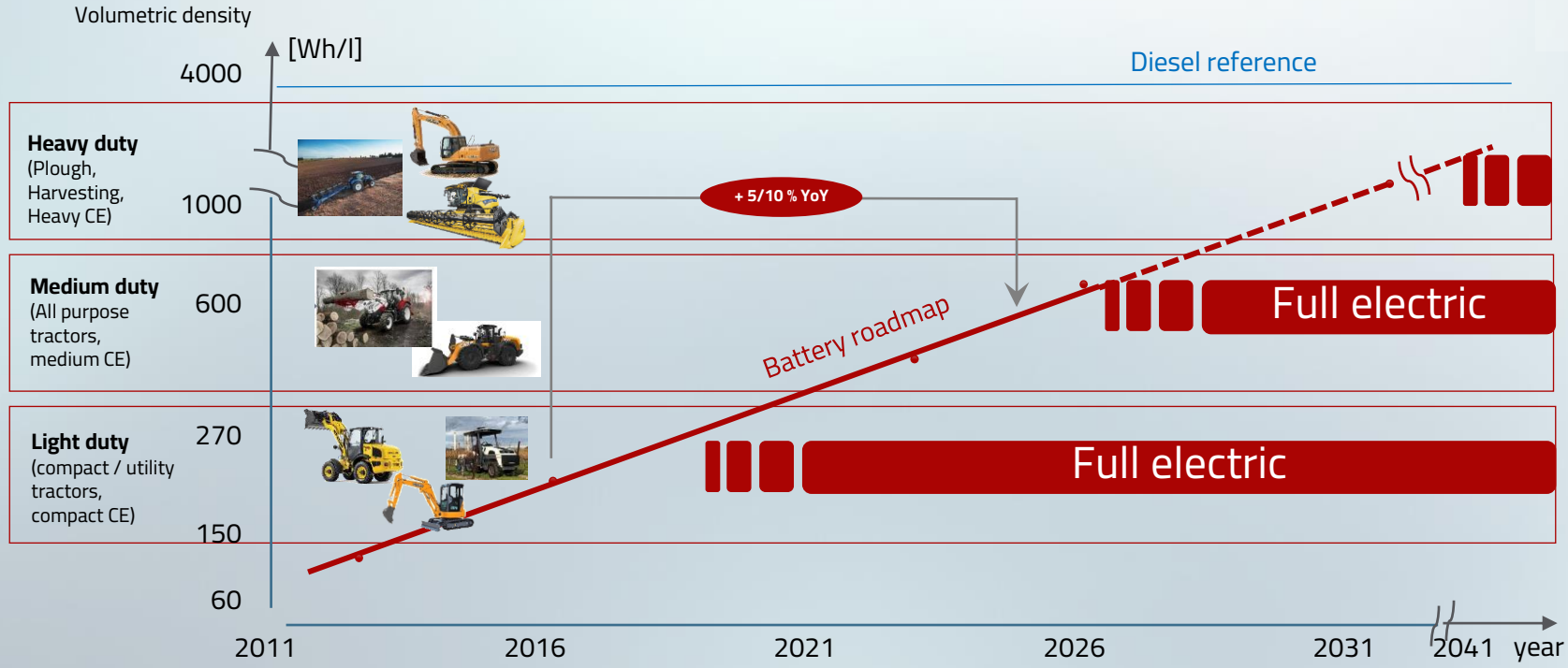
FULL ELECTRIFICATION: TECHNICAL READINESS

Battery roadmap drives the adoption curve



ELECTRIFICATION SYSTEMS IN AGRICULTURE

FULL ELECTRIFICATION

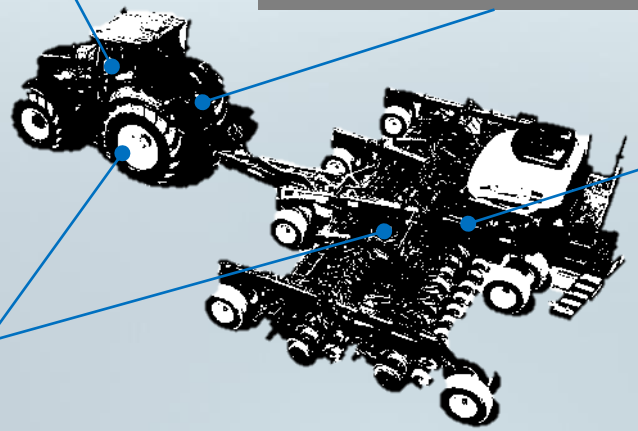
ELECTRIC VEHICLE

ZEV
1. Battery system (BEV)
2. Fuel cell (FCEV)

MEDIUM ELECTRIFICATION

ELECTRIFIED TRANSMISSION

E-Driveline
1. Parallel/Serial Hybrid
2. E-Axles
3. Traction distribution



LIGHT ELECTRIFICATION

ELECTRIC POWER UTILIZATION / E-IMPLEMENTS

E-PTO: E-Power Generation
1. PTO driven generator
2. E-generator on Implements
3. E-generator on Engine
4. E-generator on Driveline

Electrified Implements
1. Low voltage/low power implements
2. High voltage/high power implements

…AEF Interface to share Electric power from tractor to implements

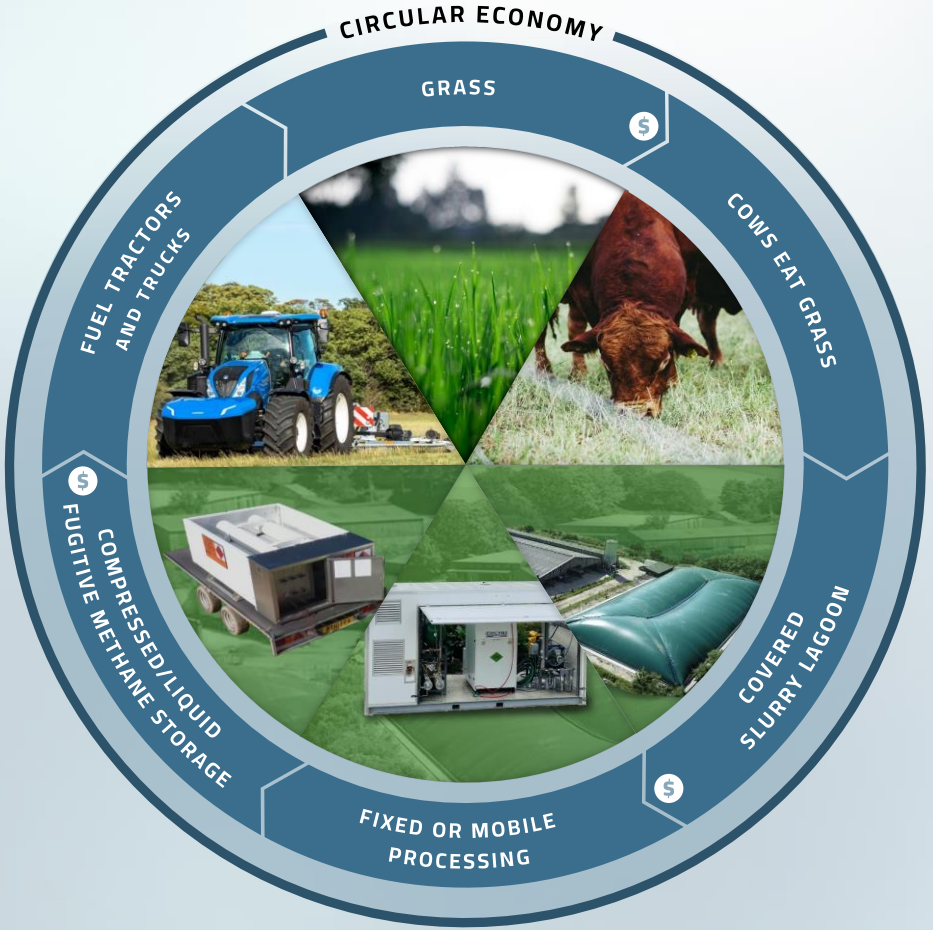
New Vehicle Architecture
(*Electrification enables new tractor layout*)

1. New vehicle category
2. Combining implements and tractor

REFUELING

- On large farms, the fuel comes to the tractor, not vice versa
- Being able to have mobile refueling as well as high runtimes between refueling is key for adoption

Enabling the circular economy in agriculture generating energy from waste



$ Emerging revenue streams

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OFF-HIGHWAY VEHICLE PATH TO ZERO CARBON

Customers' needs and sustainability

Delivering value to businesses

Urban construction as the lead

Strategic partnerships to accelerate net zero future and further innovation

Applicable to both vehicle and infrastructure

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Breaking New Ground

Innovation Sustainability Productivity