Eaton feedback to OIRA on GHG Phase 3

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Eaton Mobility Group: $3.5M supplier of advanced technology

Solutions for emission reduction spanning ICE to BEV and Hydrogen – also charging infrastructure

Light Duty Technologies

Valves

Variable Valve Actuation (VVL/CDA)

eVaptive

Fuel Emission Controls

TVS Supercharger

Gears & shafts

Light Duty Transmissions

Differentials

Commercial Vehicle Technologies

Engine Brake

Clutches

Aftermarket

Gearing Systems

Automated Transmissions

Cylinder Deactivation (CDA)

Engine Valves

HD Hybrids

H2-ICE boosters

48V mild hybrid and low NOx

eMobility

- Power Electronics
- Distribution, safety
- Charging, Hydrogen

HV power electronics

On-board charging

Power distribution and protection

EV transmissions

Fuel Cell systems

Connectors and busbars

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AUTOMATED TRANSMISSION TECHNOLOGIES

Key Points

EPA's approach faces lower risk: 5 specific perspectives on Phase 3

Eaton supports the EPA proposal for Phase 3 GHG standards as a key mechanism for decarbonizing transportation:

- **Long-term and adequate stringency** offers certainty for our products and enabling **larger and faster technology investments.**
- **National standards** prevent multiple markets with multiple solutions that **lowers overall costs** of decarbonizing the transportation sector.
- Technology neutrality allows for multiple pathways. **New pathways already became apparent,** driving both technical innovation and **rule robustness**.
- The rule focuses other private-public investments**, increasing the impact of public funds** through DOE, DOT and EPA.

1. **Eaton invests in charging capacity:** increase usage of exiting capacity, build new capacity, and …, in place by 2027/2028.
2. Deploying components that **lower costs of EV powertrain** (~25%), as well **reducing operating costs and grid loads** (20% - 25%) for next-generation Commercial Electric vehicles.
3. Demonstrated cost-effective **Hybrid and Plug-in Hybrids that significantly lower GHG emission** (15% for tractors and up to 50% for vocational trucks) using smaller batteries and leveraging more mature Medium Duty supply chain and field service.
4. **Conventional powertrain can now realize an additional 5% GHG reduction** vs. the assumptions of Phase 2 for 2027, while complying with the new NOx standards. The solutions are cost effective and based on mature technologies
5. Zero-emissions vehicles with high energy use (> 1MWh daily, e.g., long haul tractors or high-performance vocational trucks) now have an additional paths to ZEV compliance**: H2-ICE has lower risk vs Fuel Cells and is quickly maturing** with all our OEM partners.

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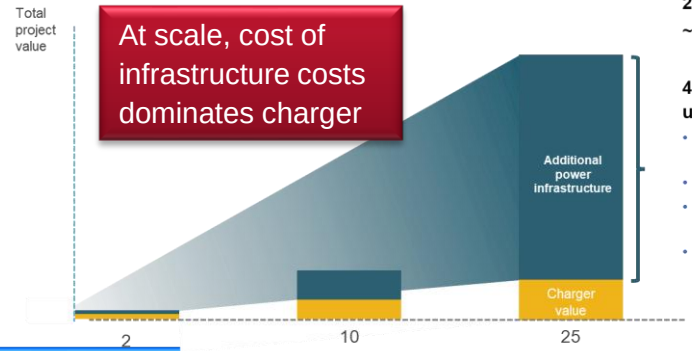
Investments to increase and speed-up EV infrastructure

Availability & time-to-deploy are significant bottlenecks to EV adoption

Current state: backlog in infrastructure

- **Transformer lead times** currently 2-3 years
- **Facility installation and certification** is not scalable
- Non-optimized solutions lead to **over-design for peak loads, driving up cost & time**

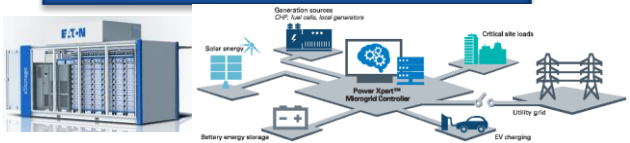
At scale, cost of infrastructure costs dominates charger



25 x 150 kW chargers
~ $750,000

4 MW infrastructure upgared
- ~ $4M grid connection hardware
- 2 year permitting
- 2-3 year transformer backlog
- Facility wiring work and costs

1. Increasing use of exiting capacity



xStorage: 2 MW battery - reduce peak power capacity & cost by ~75%

Microgrid: plug-and-play >30% usage, quick connect to DER - PV, wind, etc

Availability: immediate

2. Extending the exiting capacity

Investing nearly **$750M in North American manufacturing** to support electrification, energy transition, and digitalization. Example: **$150M capacity expansion in TX and WI** for transformers and critical grid equipment **generating 500 jobs**. In SC expanded capacity for novel EVCI. **Availability: ramp up 2023 - 2025**

3. New technology deployment

EV charging Busway: rapid installation in Commercial facilities. Today L2, expanding to 50 – 100 kW L3

Semi-mobile factory certified kit: transformer, microgrid, fast chargers with “plug-n-play” grid connect, DER, storage. **Availability: varied through 2028**

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Lower charging cost & time and reduced grid load

BEV system efficiency increases by 30%, lowering the grid load by 25%

	Charger	Battery	Inverter	Motor	Gearbox	Wheel
Current State	95%	96%	94%	93%	98%	**78.1%**
With regen						**+ 11.2%***
State-of-the-Art	98%	98%	99%	98%	98%	**91.3%**
With regen						**+ 28.2%***

	Energy at wheels [year]	Load on grid	Wasted energy	Cost of technology	Saved energy cost
Current State	24 MWh**	26.8 MWh			
State-of-the-Art	24 MWh**	20.1 MWh	**-24.1%**	**+ $5,000**	**-$678/yr**

Electrical bill savings drive **~8 years payback**

- *6.7 MWh / year = $678 cost of electricity saving*
- *Hi-Tech package ~ $4,000 - $6,000*

Eaton 4-speed EV transmission responsible for increasing system efficiency by 11% by doubling brake regeneration

Suppliers commercializing more efficient components translates to lowering energy needs by ~25%

- ***Lowers fleet energy costs and charging time*** *~$678 / year / truck*

Compounded value of efficiency due to smaller battery:

- *End user:* ***~$4,000 on a 200kWh*** *battery pack, thus* ***~1/2 year payback***
- *Battery manufacturers:* ***reduced exposure to critical supply chain***
- *Grid infrastructure:* ***reduced demand & infrastructure costs***

*35% of wheel energy is regenerated; 50% limited by motor in single speed powertrains, 5% limit with multi-speed gearbox

**1.2 kW/mile x 80 miles/day x 250 miles/year = 24 MWh/year at wheels

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HD Hybrids: robust and lower-cost pathway to low GHG

HEV and PHEV offer 15% – 50% GHG reduction at low technical risk

HD Hybrid = HD ICE powertrain + MD e-drive + small battery

Modified 12-speed: market-leading efficiency long haul freight transmission

Higher performance is key to vocational segment, and a bonus value to freight tractors

Concept Hybrids in test vehicle today

Vocation	HEV / PHEV Powertrain		BEV Powertrain		Cost %	Diesel	Cost %
	Technology	Cost w Incentives	Battery [kWh]	Cost w Incentives	[P]HEV vs BEV	Cost	[P]HEV vs Diesel
Daycab	PHEV	$ 51,000	600	$ 95,000	-46%	$ 51,000	0%
City Voc.	PHEV	$ 51,000	500	$ 75,000	-32%	$ 54,000	-6%
Perf Voc.	HEV	$ 65,000	500	$ 75,000	-13%	$ 54,000	20%
Long Haul	HEV	$ 65,000	1200	$ 215,000	-70%	$ 51,000	27%
Long Haul	PHEV	$ 51,000	1200	$ 215,000	-76%	$ 51,000	0%

Environmental and Commercial Benefits:

- 15 – 50% reduced CO2 emissions (and fuel costs)
- 30% - 75% less expensive than BEV for similar applications driven by smaller batteries
- 0% - 20% cost add vs. Diesel
- Increase performance: 50% better acceleration, 2x grade-ability, 2x startability
- Getting CO2 reductions early

Faster time-to-market and fleet acceptance

- Uses current field support and service and MD BEV infrastructure
- Lower range anxiety vs BEV – can operate with gaps in EV charging deployment
- Reduced technical risk, reuses ICE and MD BEV technology
- Advanced technology readiness: realistic 2027 production

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ICE progress: simultaneous GHG and NOx reduction

Diesel trucks set to achieve 5 –18% CO2 reduction beyond Phase II

NOx Technology				Engine & Aftertreatment	NOx for 2027 0.035 g/hp-hr	CO_2 Base: 513 g/hp-hr
CDA	LO-SCR	eHeater	Burner			
X				CDA Engine	0.056	495 (-3.6%)
	X			Production Engine	0.040 to 0.060	512 (neutral)
		X 10 kW		Production Engine	0.023	526 (+2.4%)
			X 50 kW	Production Engine	0.023	510 (-0.7%)
	X	X 7 kW		Production Engine	0.018	521 to 524 (+1.4 to 2.1%)
X			X 50/20 kW	CDA Engine	0.020	521 (+1.5%)
X	X			CDA Engine	0.018	506 (-1.5%)
X	X	X 2.4 kW		CDA Engine	0.012	505 (-1.5%)
X	X		X 50/20 kW	CDA Engine	0.012	518 (+0.9%)

Aftertreatment Aged to 430k+ miles

0.050 0.035 0.020 0.005 3% Cost Neutral

Variable Valve Actuation: reduced GHG (~10% at low load, 2% overall) in conjunction with NOx control

Exhaust Gas Recirculation pump: NOx control device that also enable improved ICE efficiency: 5% GHG reduction

48V mild hybrid and aftertreatment heater control: 1% - 2% lower CO2, incl. reducing lower NOx control needs

- Low NOx packages show lower CO2 by 1.5% (not in Phase II)
- Multiple pathways based on mature, cost-effective components that were not included in the Phase II assessments
- CO2 backstop needed: some NOx technologies do increase CO2

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Hydrogen-ICE is a new, low risk pathway to ZEV

Solutions are evolving rapidly by re-purposing existing components

An additional pathway to zero carbon

- Carbon-free by design
- Much lower technology risk vs. fuel cell: a re-purposing of Natural Gas engines, conventional Aftertreatment, boosting and

3 Major Challenges

- H2 refueling infrastructure: high risk for timing
- Cost of H2 and tanks: needs cost-out
- Inefficiency: barrier especially when H2 is expensive

Variable Valve actuation: increase combustion efficiency and makes up for engine brake lower performance

H2-ICE boosters: enable more efficient combustion and Diesel like torque and response

Re-purposing existing components:

- Increased engine efficiency from 35% to 45% → lowers H2 consumption by 22%
- Reduces technical risk vs. H2 costs and infrastructure risk
- Reduced technical risk vs. fuel cell

While not yet proven, collective EPA, DOE and all major OEMs and Suppliers are moving rapidly to ~2028 production

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Conclusions

- Since the NPRM was published, there has been enormous technology development, with clear line of sight to production in 2027-2028.
- Multiple pathways to ambitious decarbonization targets increase the robustness of achieving reduction targets.
- For progress to occur and for the rule to be robust, it is important to have one national standard that balances stakeholder group and create regulatory certainty.
- Furthermore, key OEM's and Suppliers are supporting the EPA's proposed timelines, including the proposed 2027 start day, as it allows us to more readily invest resources.
- We urge the EPA and OIRA to ensure that the impact analysis includes realistic/ updated cost assessments of the various pathways and their actual contribution to emissions standards.
- Recognizing the multitude of compliance pathways, we encourage the EPA to assess the simplification and uniformity of certification methodology, perhaps through technical amendments that ensure the certification is truly valuable in driving performance and not creating unintended barriers

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