ISE™

Innovative Solutions for Energy™

LEADING THE WAY

IN

GASOLINE HYBRID-ELECTRIC DRIVE SYSTEMS

ISE'S ULTRACLEAN SERIES GASOLINE HYBRID-ELECTRIC DRIVE SYSTEM

GREATER EFFICIENCY • LOWER EMISSIONS • SIMPLE EXHAUST AFTERTREATMENT

THE CLEAN, efficient TRANSPORTATION OPTION

MORE HYBRIDS ON MORE ROADS

Across the globe, transit agencies and municipalities are adding more hybrid buses to their fleets every day. These organizations are seeing positive results through reduced emissions and decreased fuel consumption. **The ISE Series Gasoline Hybrid-Electric (GHE) Drive System** answers this call with a solution specifically designed to deliver positive results in emissions output and fuel economy for transit buses.

ISE can help you meet the challenges of heavy-duty, high duty cycles that are common in transit driving. When you choose the efficient, ultraclean operation of the ISE Series GHE Drive System for your fleet, you can rely on **best-in-class exhaust emissions** ratings and ISE's proven track record of millions of miles of passenger service.

ISE SERIES GASOLINE HYBRID-ELECTRIC DRIVE SYSTEM ADVANTAGES

- Ultraclean operation with very low emissions
- Excellent low speed acceleration response and control
- Smooth and quiet operation for a satisfying passenger experience
- Greater fuel economy via regenerative braking and energy recapture/re-use
- CARB-certified alternative fuel system
- Eligible for $40,000 Hybrid Vehicle Incentive Program (HVIP) - www.californiahvip.org
- Efficient energy storage system offsets engine power dependence
- Simplified exhaust aftertreatment
- Integrates into popular bus chassis including New Flyer, ElDorado, NABI, Gillig and Wright

EFFICIENCY GAINS WITH ISE'S SERIES GHE DRIVE SYSTEM

- Reduce costs by eliminating the expense and use of additional diesel emissions fluids and supplemental fuel injection typically required for active diesel particulate filter regeneration.
- Increase maintenance simplicity by eliminating reservoirs, plumbing, pumps, and sensors needed for SCR catalyst diesel emission fluid injection.
- Streamline operations by eliminating the need to pull vehicles from service to perform periodic active regeneration especially in high idle applications.
- Save time by eliminating the many additional processes and safety requirements imposed by diesel-based hybrid systems.

PARTNERING WITH OUR TRANSIT CUSTOMERS EVERY STEP OF THE WAY

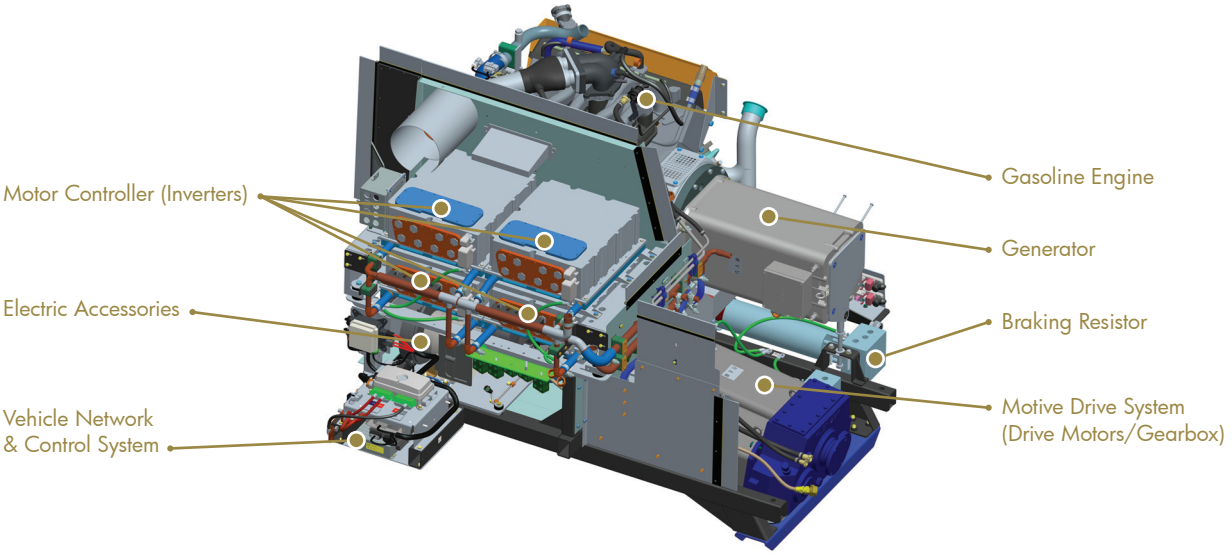
"Today, nearly half of our 40' fleet at Long Beach Transit is comprised of gasoline hybrid systems. We began partnering with ISE's engineering team in 2003 to help create a gasoline hybrid system that continues to improve in reliability."

- ROLANDO CRUZ, *Executive Director and Vice President of Maintenance and Facilities at Long Beach Transit*

FUEL-SAVING FEATURES for Increased Efficiency

ISE's Series GHE Drive System for transit bus applications is a fully integrated drive system that includes all of the necessary components to operate a vehicle using hybrid-electric technology. Our fuel-saving features include regenerative braking, all-electric accessories, proprietary energy storage systems, rooftop electronics and engine cooling, and lighter engine weight.

SPECIFICATIONS OF THE ISE SERIES GHE DRIVE SYSTEM



MOTIVE DRIVE SYSTEM

Siemens MONO Inverter	4 x 300A rms (continuous)
Rated Power	170 kW / 228 hp
Peak Power	300 kW / 402 hp
Rated Torque	1760 Nm / 1297 lb-ft
Peak Torque	4240 Nm / 3124 lb-ft
Braking Resistors	120kW (160 HP)

NO TRANSMISSION REQUIRED
4:1 Combining gearbox between drive motors & differential

ELECTRIC ACCESSORIES

ISE EDA-230	ISE's Electronically-Driven Accessories 230VAC
Air Compressor	Scroll, Oil-less, 14.7 SCFM @115PSI
Hydraulic Pump	Vane, 4 or 6 GPM, 1750 PSI
Air Conditioning	Electric

ENERGY STORAGE

Ultracapacitors	ISE Ultra-E™ (0.5 kWh or 1 kWh)

PERFORMANCE AT GVW (ALL ACCESSORIES RUNNING)

Starting Grade	~18%
Top Speed (Batteries / Ucaps)	65 mph / 55 - 60 mph
Acceleration (0-30 mph)	< 20 sec.
Range (typical, 100 gal tank)	> 300 miles
Fuel Economy (typical)	3.5 - 4.5 mpg
Emissions	CARB engine certification NOx + NHMC: 0.05 g/bhpr-hr PM: <0.01 g/bhp-hr

POWER SOURCE: ENGINE/GENERATOR

Engine Ford Triton	V10, 6.8 L
Fuel	Gasoline (87 Octane)
Generator	200 kW generator (266 HP) 145 kW option (193 HP)

VEHICLE NETWORK & CONTROL

EVCU (Electric Vehicle Control Unit)	SAE J1939 2.0b multiplexing between vehicle and hybrid drive system
RDS (Remote Diagnositc System) & GPS Automatic Vehicle Location	ISE's SAE J1939 based network monitoring, Data & Fault storage

THE HEAVY-DUTY High Duty Cycle solution

IDEAL FOR STOP-AND-GO SERVICE

Today's urban transit setting requires heavy-duty passenger vehicles to perform all day, every day in demanding stop-and-go operation. For this reason, the ISE Series GHE Drive System is ideal for the frequent stop-start, low average speed, and high operating duty cycle environments common in mass transportation.

The ISE Series GHE Drive System excels in this application by using electric motors for all vehicle propulsion. By eliminating the mechanical link between the engine and the wheels, engine dependence and usage is reduced – with no compromise in performance – and the result is: improved fuel efficiency.

Hundreds of ISE Series GHE Systems are on the roads today, effectively and efficiently meeting heavy-duty transit demands. Your organization can leverage the benefits of this technology with ISE's purpose-built alternative fuel transit solution.

ISE OFFERS YOU THESE BENEFITS:

- Best-in-class exhaust emissions ratings – 2010 CARB compliant
- Regenerative braking system recaptures/stores energy to use for the next vehicle acceleration
- Simple, safe exhaust aftertreatment
- Brake pad replacements extended by as much as 400% compared with conventional diesel systems (results may vary depending on drive cycle and retarder settings).
- Leverage mature, high-volume gasoline engine technology
- Established customer base with over 300 gasoline hybrid vehicles in service
- 13+ million mile track record in revenue service miles

TAKING HYBRID TECHNOLOGY TO THE NEXT LEVEL

"ISE's gasoline hybrid-electric drive system benefits from the tremendous investment in engine and emissions reduction technology developed for the high-volume automotive industry. By combining this advanced gasoline automotive engine technology with the ISE Series Hybrid-Electric Drive System, these emissions benefits are finally available to the heavy-duty world."

- KEVIN STONE, *Director of Applications Engineering, ISE Corp*

If these are your challenges...

ISE HAS THE SOLUTION...

How can we be sure we are meeting 2010 CARB and EPA emissions standards?

ISE gasoline hybrid-electric drive systems today exceed the new 2010 CARB and EPA heavy duty emission standards.

How can we increase our fuel efficiency?

Our fuel-saving features include regenerative braking, all-electric accessories, proprietary energy storage systems, rooftop electronics and engine cooling, and lighter engine weight. The ISE Series GHE Drive System uses regenerative braking to capture kinetic energy from the vehicle and recharge on-board energy storage systems. This recaptured energy can be used to power the vehicle, which decreases total fuel use.

Does a gasoline hybrid offer advantages over diesel in the area of maintenance cost and time?

Yes. With ISE, you eliminate both the Diesel Particulate Filter (DPF) and Selective Catalyst Reduction (SCR) filter with associated Diesel Emission Fluid (DEF) that conventional diesel systems require to meet 2010 emissions standards. The ISE gasoline hybrid solution requires only a standard muffler and catalytic converter. Less equipment means lower vehicle weight and no complicated and expensive exhaust aftertreatment systems maintenance.

Can we reduce overall maintenance costs/time and still keep reliability levels up?

ISE systems require dramatically fewer brake replacements than conventional vehicles. You can extend brake pad replacements as much as 400% compared with conventional diesel systems. This is a valuable by-product of regenerative braking, which is a critical component of ISE gasoline hybrid-electric systems.

Which technology offers the smoothest, quietest vehicle operation?

ISE can help you increase ridership with systems that offer smooth electric acceleration with absolutely no transmission shifting. The system attempts to keep engine speed and noise as low as possible under all conditions.

How can I maximize energy regeneration?

The ISE Series GHE Drive System is built using ISE's latest generation Ultra-E energy storage system, which captures up to 94% of energy. These ultracapacitor cells provide a million cycles of life and high power to support the rigorous quick charging, discharging, and acceleration requirements of transit buses.

MOVING TO CLEAN GASOLINE HYBRID TECHNOLOGY

"Our goal is to demonstrate how ISE's technology compares to existing clean diesel and diesel electric technologies. We understand how this gasoline hybrid technology works for Florida and results in improved economy and lower maintenance over existing diesel technologies."

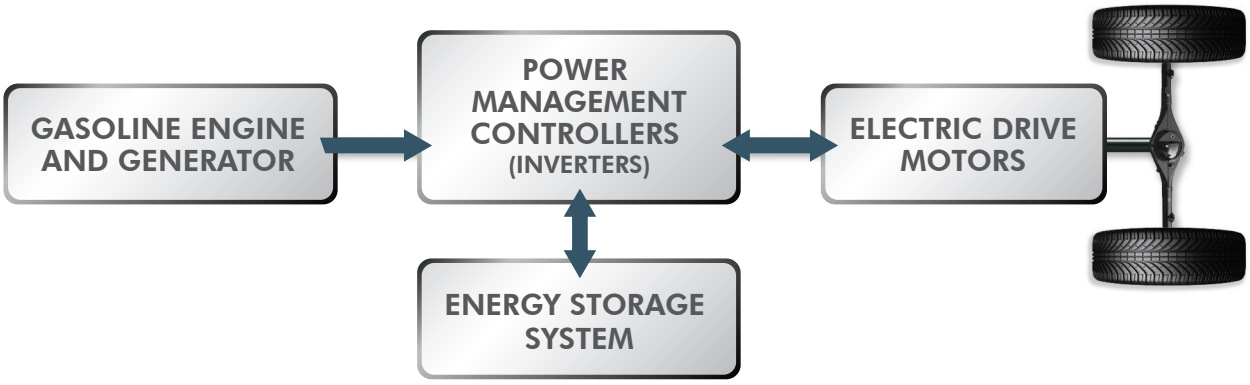
- **STEVE MYERS**, *LeeTran Director*

AMERICAN LUNG ASSOCIATION.

"A major focus of our current efforts is reducing diesel soot from trucks, buses, and ports, and we are pleased to have ISE's hybrid-electric technology supporting these efforts."

- **JANE WARNER**, *CEO, American Lung Association in California*

HOW IT WORKS



READ STEP-BY-STEP HOW ISE'S SERIES GHE DRIVE SYSTEM WORKS:

1. The gasoline engine runs a generator to produce high-voltage electric power.
2. The energy storage system captures braking energy and releases this electrical energy to help accelerate the vehicle.
3. The power management controllers meet driver demands while:
   - Maximizing energy recovered during regenerative braking (fuel savings).
   - Minimizing peak power requirements from engine/generator (more fuel savings).
4. The electric drive motors turn the vehicle's drive shaft, which connects to the vehicle's axle and wheels, making the vehicle move.

HOW DOES ISE'S SERIES GHV DRIVE SYSTEM DESIGN DELIVER MORE?

When you choose a the ISE series hybrid-electric drive system design, you receive a number of benefits in the areas of fuel economy, reduction in emissions for reduced environmental impact, improved performance and drivability, and quieter vehicle operation. Here's how the ISE Series GHE Drive System delivers these advantages:

- **Fuel-Saving Features** – Regenerative braking, all-electric accessories, proprietary energy storage systems, rooftop electronics and engine cooling, and lighter engine weight.
- **Best-in-Class Emissions** – ISE systems are CARB-certified and exceed 2010 EPA emission standards.
- **Ultra-low NOx and PM** – Our simple exhaust aftertreatment system does not require complex DPF and SCR (urea).
- **Maximum Energy Regeneration** – Our latest generation Ultra-E energy storage offers up to 94% capture of energy.
- **Lower Noise** – The energy storage dominant series drive system operates quieter to keep noise levels low. This is accomplished by eliminating the mechanical connection between the engine and wheels (versus a parallel design which couples the engine to the wheels which creates additional noise).

REDUCE PARTICULATE EMISSIONS TO NEAR-ZERO

Now, you can meet the latest emission standards with confidence. The ISE Series GHE Drive System uses the same simple three-way catalyst process used in gasoline passenger cars to reduce toxic exhaust emissions. Compared to diesel and compressed natural gas (CNG) exhaust, gasoline exhaust contains almost no particulate emissions, which makes gasoline far cleaner and lower cost to deploy than diesel or CNG.

Beyond the emission benefit, the electric drive motors in the ISE Series GHE Drive System provide the high torque required in heavy-duty applications such as mass transit buses. This system feature offers yet another incentive to organizations considering the adoption of gasoline-fueled systems for their heavy-duty applications.

LOWER WEIGHT, LESS COMPLEXITY

ISE's aftertreatment process does not require the complicated equipment and additional weight that comes with diesel aftertreatment systems. The chart below compares the aftertreatment equipment weight for each system. See our *Aftertreatment Comparison Chart* on page 11 for additional details about the differences between these two systems.

REQUIRED AFTERTREATMENT EQUIPMENT

ISE SERIES GHE DRIVE SYSTEM		DIESEL HYBRID-ELECTRIC DRIVE SYSTEM	
Required Equipment	*Weight*	*Required Equipment*	*Weight*
• Catalyst and muffler	70 lbs	• Aftertreatment ~8L Diesel (Cat, PM, Muffler)	~140 lbs
		• Urea weight in a 10 gallon tank	~90 lbs
		• Tank weight	~10 lbs
		• SCR-cat estimates	~100 lbs
Total Weight	**70 lbs***		**~340 lbs**

* Beyond the weight of the aftertreatment equipment, engine weight is an important consideration for fuel economy. ISE's system uses a gasoline engine, which can be up to 1000 pounds lighter than a conventional diesel engine.

Simple, Safe
exhaust aftertreatment

REAL-WORLD APPLICATIONS

Customers such as Long Beach Transit, Montebello Bus Lines, Gardena Transit, Norwalk Transit, Santa Monica/Big Blue Bus, LeeTran, San Diego MTS, LA-DOT, Santa Rosa, NAPA Transit, and LA Metro are enjoying the advantages of the ISE Series Gasoline Hybrid-Electric Drive System.

Reasons to Choose the ISE Series GHE DRIVE system

MEET AND EXCEED 2010 EMISSIONS REQUIREMENTS

You can meet and exceed emissions requirements for 2010 with confidence. ISE's simple three-way catalyst process applies a standard catalytic converter to manage exhaust emissions. This lets you avoid the extra maintenance required by the diesel regeneration process, which actually oxidizes exhaust particulate matter (carbon soot) to CO2, leaving other contaminants such as burned oil. This toxic residue collects inside the diesel particulate filter (DPF) and must be cleaned out every 10,000-150,000 miles depending on drive cycle.

The ISE Series Gasoline Hybrid-Electric Drive System uses the Ford Triton 6.8L V10 2-Valve gasoline engine, which exceeds 2010 emissions requirements.

	INDUSTRY STANDARD **2010 Engine Emissions Standard:**	ISE **CARB-certified 2010 Ford Triton 6.8L V10 2-Valve Engine Emissions: (A-359-0008)**
NOx:	0.2 grams*	0.05 grams*
PM:	0.01 grams*	Not Applicable
NMHC:	0.14 grams*	0.12 grams*

*Per brake horsepower hour.

DID YOU KNOW...

When you choose an ISE Series GHE Drive System instead of a conventional diesel drive system, you can reduce your greenhouse gas emissions by more than 650 metric tons over the 12-year life of the vehicle.

IMPROVED FUEL ECONOMY

- Regenerative braking captures and reuses kinetic energy from braking.
- Smaller gasoline engine operates under less load with fewer load transients and fewer friction losses.
- Accessories (i.e., power steering, braking, HVAC, etc.) are driven electrically, allowing the engine to operate at its most efficient speed regardless of accessory power load.
- Moderate speeds, repeated stop-and-go, and low average power demand result in better fuel economy than conventional diesel systems.

REDUCED MAINTENANCE

- Regenerative braking extends service brake life by as much as 4 times in urban applications.
- Gasoline engine runs at optimum speed, reducing engine wear and tear.
- Electric engine cooling is approximately 10 times more efficient than typical hydraulic systems.
- Electrically driven accessories reduce mechanical complexity and maintenance costs.

IMPROVED PERFORMANCE

- Smooth acceleration with no turbo lag or engine ramp-up requirement.
- Quieter operation as a result of the engine not being mechanically coupled to the wheels.

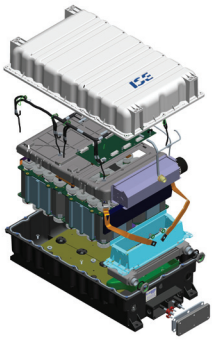
SERIES HEAVY-DUTY HYBRID VEHICLE TECHNOLOGY BENEFITS

ISE uses a series hybrid configuration, which eliminates the need for a transmission or other direct mechanical connection between the engine and the wheels. In a series hybrid, the engine drives a generator that produces electrical energy used to run electric drive motors. The drive motors provide power to the wheels of the vehicle. Excess electrical energy is stored in high density energy storage systems, where it can be drawn on for quick acceleration and uphill driving.

LEVERAGE GASOLINE ENGINE DEVELOPMENT AND MECHANIC TRAINING

Billions of dollars have been invested over decades to develop clean and efficient gasoline engines. ISE systems leverage this technology development, competition, and mass production to provide you with a hybrid drive system that is easy to maintain for mechanics familiar with gasoline engines.

THE LATEST ENERGY STORAGE TECHNOLOGY FROM ISE



The Ultra-E Energy Storage System represents ISE's newest generation of modular energy storage devices, designed specifically for heavy-duty applications in a variety of fields. This lightweight system stores energy in the gasoline hybrid-electric drive system.

COMPARISON OF AFTERTREATMENT SYSTEMS

ISE gasoline hybrids meet the EPA's 2010 vehicle emission standards without the need for expensive, complicated exhaust aftertreatment systems. The following chart compares aftertreatment requirements for ISE's Series GHE Drive System versus comparable diesel-based drive systems.

	ISE SERIES GHE Drive System	DIESEL-BASED Drive System
Approximate exhaust aftertreatment costs	~ $2,340	~$11,500 to $25,000
Urea cost	$0	~$1,800 / year @ $3.09/gal.[1] Totals $21,600 over 12-year life of vehicle.
Active Regeneration Requirements	None	• Diesel Particulate Filter (DPF) active regeneration uses ~2L fuel per regeneration and requires raw fuel exhaust system injection to "light off" filter. • Active regeneration required more for low speed cycles such as transit buses. • Approximate frequency and duration: 1 hour per day. • Estimated replacement cost for damaged DPF filter cartridge is approximately $7,500.
Temperature Parameters & Considerations	Conventional automotive exhaust requirements.	• Exhaust temperatures can reach 1450°F (800°C) during active regeneration. • Driver must avoid positioning vehicle near combustible materials. • May require exhaust temperature mitigation devices to limit risk to combustible environments.[2] DPF skin temperatures can reach 1300°F (700°C) during regeneration.
OEM Considerations	Conventional automotive exhaust requirements.	High temperatures require OEMs to position exhaust components away from vulnerable components and provide insulation as necessary.
Safety Considerations	Conventional automotive exhaust requirements.	Excessively high exhaust temperatures require additional precautions, as compared to conventional automotive exhaust system.
Additional Equipment Needs	None	OEMs may be required to provide the following: • Inhibit switch to stop or prohibit regeneration from starting if surrounding conditions are not appropriate. • Manual regeneration switch to initiate regeneration when convenient. • DPF light to indicate when regeneration is necessary. • High exhaust temperature light to warn driver of areas with combustible materials.
Additional Considerations	None	• Vehicle control system will derate until regeneration is completed if active regeneration requirements not met or if urea tank is empty or low enough. • Unexpected increases in engine idle speed will accompany automatic active regeneration cycles. • Driver training is recommended for proper implementation of DPF regeneration procedures. • Potential size increase needed on the vehicle to accommodate aftertreatment system equipment.

[1] Average cost in Europe according to Cummins. Urea consumption for trucks estimated at 2%/gallon diesel; transit estimated at 5%/gallon diesel. (Cost estimate based on 5% and 40,000 mile/year duty cycle with 3.39 MPG of diesel using Altoona conventional diesel [PTI-BT-R0704]).

[2] National Fire Protection Association standards limit exiting exhaust temperatures to 850°F (455°C).

THE CLEANER, simpler SOLUTION

ABOUT ISE CORP

COMMITTED TO CLEANER AIR

ISE Corp is a leading developer, manufacturer and distributor of heavy-duty hybrid-electric drive systems based on a core set of proprietary technologies focused on three critical subsystems: energy storage, controls software and power electronics. ISE specializes in series hybrid-electric and all-electric/zero-emission technologies, and offers industry-leading energy storage systems and hybrid system components.

Over the past 10 years, ISE has sold over 300 hybrid-electric drive systems that have demonstrated reliability and performance in over 13 million miles of fleet operation. Established in 1995, ISE is headquartered in San Diego, California. The company's history of innovation and technological leadership has resulted in the design and development of systems and components that deliver superior operating performance.

ISE's family of advanced energy products include gasoline-, CNG-, diesel-, zero-emission/fuel cell- and all-electric-based hybrid drive systems as well as a complete line of proven, heavy-duty, and modular energy storage systems.

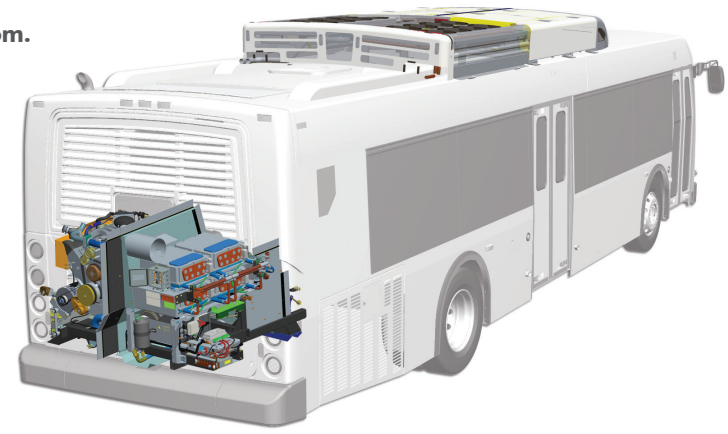
ISE Corp is a wholly owned subsidiary of ISE Limited (TSX:ISE).

LET'S MOVE FORWARD

Call us today to discuss options for your fleet.
You can also find out more at **www.isecorp.com.**

ISE Corporation

12302 Kerran Street
Poway, CA 92064
Main +1 858-413-1720
www.isecorp.com



Fully integrated series hybrid-electric drive system