

# REVOLUTION

ZERO EMISSION IN THE SCHOOL ZONE



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# REVOLUTION

## ZERO EMISSION IN THE SCHOOL ZONE



## Improve School Zone Air Quality

The **US Environmental Protection Agency (EPA)** maintains the Integrated Risk Information System (IRIS), an electronic database that contains information on human health effects from exposure to various substances in the environment. **The EPA classifies diesel exhaust as “likely to be carcinogenic to humans.”**

School bus riders are "often exposed to a high level of diesel exhaust," says Dr. Edward Naureckas, assistant professor at the University of Chicago, and a board member of the **American Lung Association** of Metropolitan Chicago. "Diesel fumes are known to be harmful to humans and are probably carcinogenic, so **we need to do everything we can to reduce the amount of diesel emissions inhaled by children.**"

### Article from the American Cancer Society:

[www.cancer.org/cancer/cancercauses/othercarcinogens/pollution/diesel-exhaust](http://www.cancer.org/cancer/cancercauses/othercarcinogens/pollution/diesel-exhaust)

Another important program is **Clean School Bus USA**. **Children can be exposed** to diesel exhaust during school bus travel or when **standing near running school buses outside of school**. Clean School Bus USA brings together partners from business, education, transportation, and public-health organizations to reduce children's exposure to bus-related air pollutants.

The **International Agency for Research on Cancer (IARC)** is part of the **World Health Organization (WHO)**. Its major goal is to identify causes of cancer. IARC classifies diesel engine exhaust as **“carcinogenic to humans,”** based on sufficient evidence that it is linked to an increased risk of lung cancer. IARC also notes that there is **“some evidence of a positive association” between diesel exhaust and bladder cancer.**



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## School Bus Idling Facts

- Average school zone wait time for pupil loading and unloading is 20-30 minutes, occurring twice per day.
- A school bus idling at high idle consumes 1.5+ gallons per hour, to power belt-driven AC compressors. High idling 1 hour per day @ \$2.50 per gallon, wastes more than \$675.00 per year in fuel alone. Idling also increases maintenance costs.
- Drivers idle for many reasons, but primarily for cabin temperature comfort.
- Local idle reduction ordinances and federal IDEA (Individuals with Disabilities Education Act) policies can conflict when Special Needs Pupils require cabin temperatures to be maintained in the no-idle school zone.
- No-idle regulations in school zones have been enacted in most states, they have helped improve air quality and save fuel. School districts are now looking for new technology that will provide even greater improvement for emission reductions.

Vanner has introduced **REVOLUTION**. Affordable technology that eliminates school zone idling, improves pupil air quality, and lowers fuel and maintenance costs.



# REVOLUTION

## ZERO EMISSION IN THE SCHOOL ZONE



## System Design Features

### Power Generator      9.0kW output capacity

- Ample energy at idle for air conditioning and accessories.
- OEM 12V alternator, starter, and battery are not modified. Starting batteries are recharged by Revolution.
- Under 60VDC components – Safe technology can be maintained at the bus fleet's facility.

### Air Conditioning System

- 220V/3 Ph scroll compressor is more efficient and reliable than under-hood / belt driven compressors, with a longer life.
- Scroll compressor is hermetically sealed, maintenance-free, and does not require additional oil. 12 year design life.
- All refrigerant lines are removed from the high heat under-hood environment. Reduces leaks and maintenance.

### Power Module (VPM)

- Designed to power the air conditioning system and 12V accessory loads.
- Allows the A/C to operate at maximum capacity at low idle, reducing fuel consumption
- Provides feedback on auxiliary battery conditions through the Control Panel status LED.
- Solid-state power conversion technology. 12 year design life.

### Auxiliary Battery Module (VBM)

- 48VDC      40Ah / 2000Whr
- Self-contained / Maintenance-free auxiliary battery and monitoring system.
- Provides ~30 minute engine-off operation of air conditioning and 12V accessories.
- Florida and Texas specification testing has resulted in 35+ minutes of engine-off AC operation.
- In future revisions, longer engine-off operation may be obtained with an additional battery module.



### Designed for Safety

- Does not affect or draw power from the OEM starting and charging system.
- In the unlikely event of an inoperable Revolution system, the bus can still be operated and complete its route.
- In the event of an engine breakdown, pupils can remain on the bus with air conditioning for 30+ minutes, until help arrives.

## ***Pupil Benefits***

### **Zero Emission in School Zone**

- Clean and healthy environment during pupil pick-up and drop-off.

### **Engine-Off Operation**

- Proper temperature is maintained for special needs pupils.
- Full use of wheel chair lifts and all 12V accessories.
- Safer - Quiet operation assures driver's instructions are heard.



## ***Driver Benefits***

**Full use of air conditioning and all 12V accessories with engine-on or engine-off.**

**Simple one-button operation for air conditioning operation, control, and status.**

## ***Operation and Maintenance Benefits***

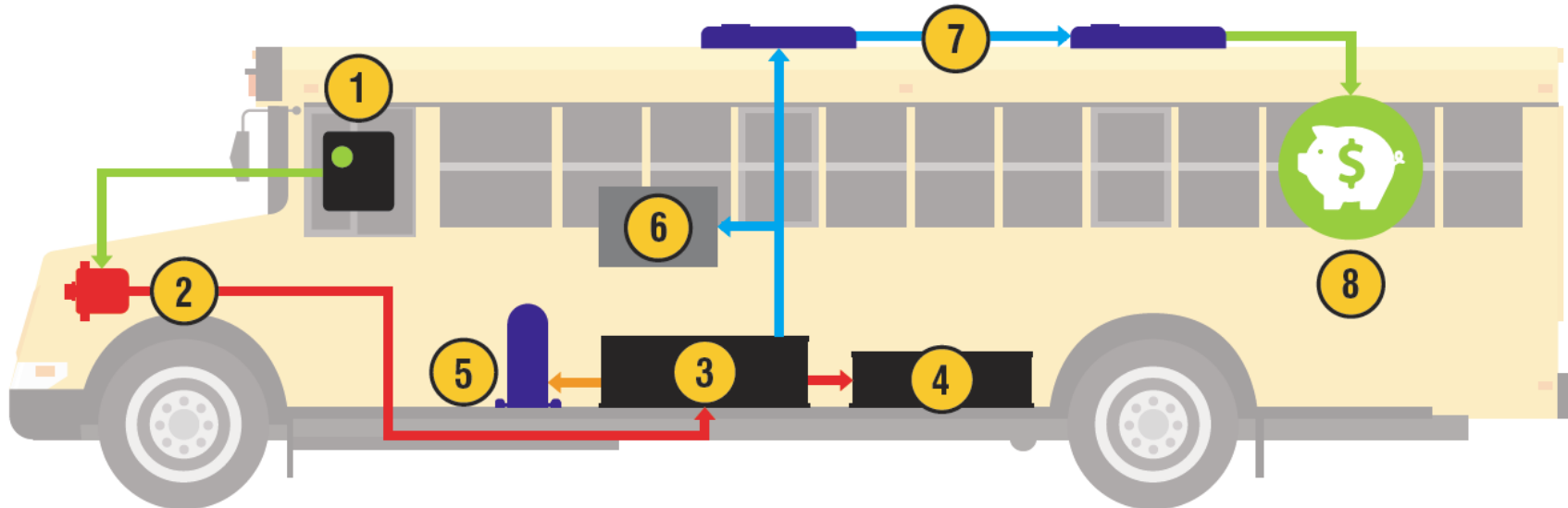
### **Lower Fuel and Maintenance Costs**

- 12 Year Component Design Life - Maintenance-free Scroll AC Compressor, Power Conversion, and Auxiliary Battery.
- Refrigerant lines are removed from the high heat under hood environment. Significantly reduces system leaks and recharging.
- Typical engine mounted compressors require replacement every 2-3 years. Revolution compressor has a 12+ year design life.
- Engine-off operation saves fuel, reduces engine hours, and extends maintenance intervals, reducing operating cost.

### **Fuel Neutral Diesel, Gasoline, and Alternate Fuel Systems (LNG, LP, CNG)**

- Provides a "Zero Emission" capability to diesel propane powered buses.
- Future systems will include Gasoline and Alternate Fuel Systems.
- Combine with alternate fuels for additional fuel savings and federal/state funding qualification.

**No special facility infrastructure is required for charging high-voltage batteries.**



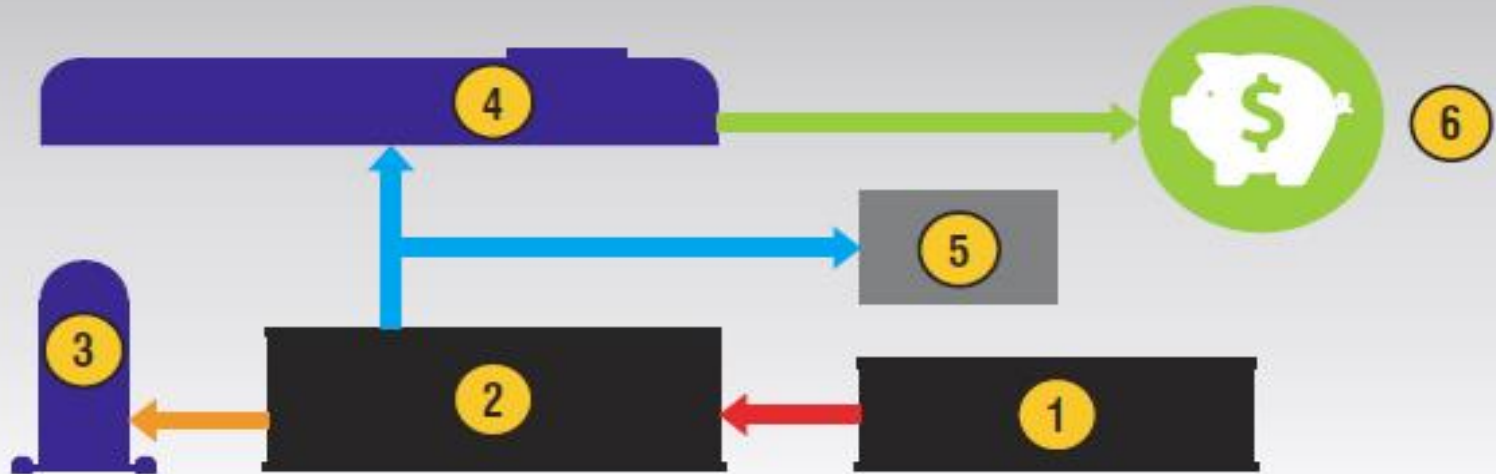
Patent # US 9,868,409 B2

## REVOLUTION SYSTEM COMPONENTS AND SOLID-STATE POWER FLOW

- |                                                                 |                                                                                          |
|-----------------------------------------------------------------|------------------------------------------------------------------------------------------|
| 1 SIMPLE ONE-BUTTON OPERATION                                   | 6 BUS ACCESSORIES ARE POWERED WITH 12 Vdc WITH ENGINE ON OR ENGINE OFF                   |
| 2 9KW / 48VDC BRUSHLESS GENERATOR                               | 7 AIR CONDITIONING COMPONENTS ARE POWERED WITH 12 Vdc WITH ENGINE ON OR ENGINE OFF       |
| 3 VANNER POWER MODULE (VPM) CONVERTS 48 V TO 220 Vac AND 12 Vdc | 8 <b>REDUCES SCHOOL ZONE EMISSIONS AND MAINTENANCE COSTS WHILE SAVING FUEL AND MONEY</b> |
| 4 48V LI-ION PHOSPHATE BATTERY FOR SAFETY                       |                                                                                          |
| 5 SCROLL HERMETIC ELECTRIC COMPRESSOR POWERED BY 220 Vac        |                                                                                          |

**“Driver has full use of air conditioning and all accessories with the engine off”**

## ENGINE-OFF MODE



- 1 48 Vdc POWER IS DRAWN FROM THE VANNER BATTERY MODULE (VBM)
- 2 VANNER POWER MODULE (VPM) CONVERTS 48 Vdc POWER TO 220 Vac AND 12 Vdc
- 3 SCROLL ELECTRIC COMPRESSOR IS POWERED BY 220 Vac FROM THE VPM
- 4 AIR CONDITIONING COMPONENTS ARE POWERED WITH 12 Vdc
- 5 BUS ACCESSORIES ARE POWERED WITH 12 Vdc
- 6 ZERO EMISSION IN THE SCHOOL ZONE SAVES FUEL AND MONEY

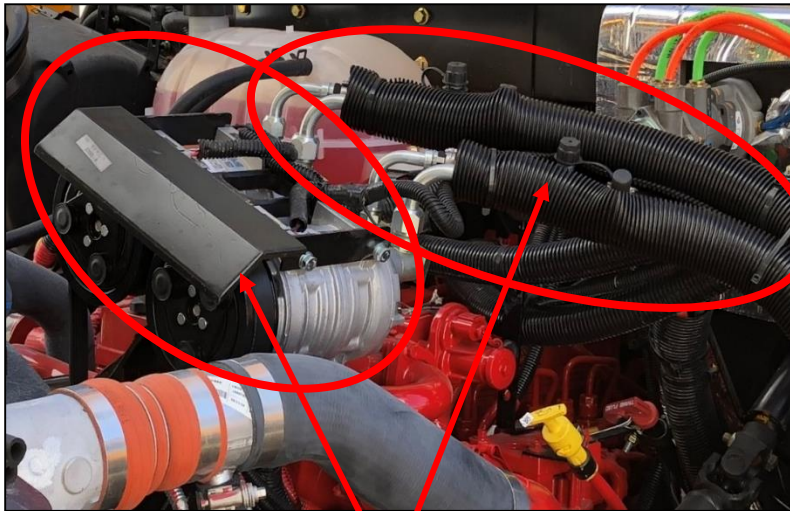
## Eliminates Dual Under Hood Compressors

### Swash Plate Engine Mounted AC Compressors

- Inefficient design, built to be lowest cost.
- Engine must run to operate AC system.
- Engine must operate at high RPM, wasting fuel.
- Compressors are replaced 3-4 times over 12 year life.
- Seals leak refrigerant oil necessary for lubrication.
- Highest maintenance item on AC buses.
- Multiple connections that leak over time.

### Compressors are removed from severe under-hood Environment

- High Temperatures
  - Make compressors work harder and less efficient.
  - Cause refrigerant lines to crack and leak.
- Extreme heat ages all components faster.



**Removed from Under Hood**

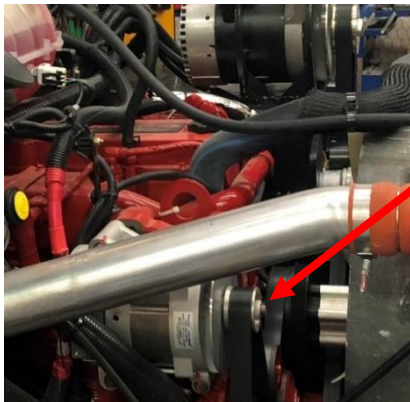
## Revolution generator is designed for under-hood environment

### Built to Military Standards

- Power at idle and low RPM
- Power in extreme heat
- Available nationwide



OEM coolant circulation pump can be used to provide engine-off cabin heat from vehicle's engine coolant system.



### OEM 12V Alternator, Battery, and Starter are not removed or modified

- Assures starting reliability.
- Peace-of-mind... Eliminates risk of on-road break downs.
- Revolution charges the OEM Battery and supports 12V accessory loads.

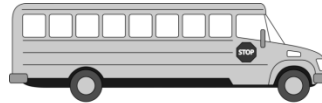
## “The New Electric School Bus”



**1950's  
Gasoline  
Production**



**1980's  
Diesel  
Production**



**2000's  
Propane  
Production**



**2015  
Battery Electric  
Prototypes**



**2019  
Revolution  
Production**

- **Zero Emission in the School Zone**
- **Eliminates Range Anxiety**
- **Eliminates High Voltage Charging Systems**
- **No Additional Infrastructure Costs**
- **Zero Emission Enhances Propane Fuel Benefits**
- **Affordable Without Incentives / 2019 Production**



# **REVOLUTION**

**ZERO EMISSION IN THE SCHOOL ZONE**



## **Summary**

- Zero Emission in school zone, improves air quality.**
- Full use of air conditioning and 12V accessories with engine off.**
- 30 minutes of engine-off system operation.**
- Easy one-button system activation and LED status.**
- No expensive infrastructure costs or high voltage charging required.**
- Maintenance-free components. 12-Year Design Life.**
- Combine with Gasoline / Propane for Zero Emission and fuel cost reduction.**
- Affordable Zero Emission technology / <4 Year ROI**

**Zero Emission technology for today's school buses**