

# Cambridge Clean Fleet Initiative

## Technical assistance for selected special applications of Clean Fleet technologies

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**City of Cambridge, Massachusetts**

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## Takeaways

Key takeaways from this analysis and three possible next steps for Cambridge include:

- Consider tackling cold-weather idling with anti-idling technologies
  - May be able to eliminate 1/3 or more of total idling time and associated fuel usage
  - Look at anti-idling technologies that provide heating service and ideally also electrical service
- Prioritize Ford F-350s for opportunities to reduce both plowing-related and idling emissions
  - Consider potential to downsize F-350 to F-150 for certain plowing applications, or to F-250 HEV/PHEV conversion
  - Reduce the 373 idling hours per vehicle per year with a cabin heating anti-idling solution
- Discuss with dealers and consider specifying transmission technologies to reduce idling and PTO emissions on all new packers: neutral at stop (idle reduction) combined with either power on demand or pack-at-idle (for PTO) could reduce fuel usage by 3-6% and 8-15%, respectively

## Summary

Volpe researched current usage and potential solutions for three special applications identified as important to address as part of Clean Fleet Plan implementation: plowing, power take-off, and idling. Volpe analyzed data on 117 active vehicles in the Department of Public Works, analyzed available telematics data from 56 of those vehicles, and interviewed municipal fleets, snow plow companies, and Clean Cities Coalitions across the U.S. for applicable best practices.

The plowing and idling analyses both indicate that Class 3 trucks, specifically Ford F-350s, are of special interest: they are the most common plowing vehicle as well as the leading contributor to engine idling among the telematics-equipped DPW vehicles.

Since pickup truck engine power and efficiency have both increased over the past decade, one strategy for reducing plowing fuel consumption may be to reduce future model year engine displacements to match older in-service vehicles (such as 2008 models). At least one snow plow option is now available for F-150s with a V-6 engine, for example, and the manufacturer advises that sufficient electrical power

is more critical than horsepower or torque. The City of Denver uses F-150s for plowing bike/walking paths, similar to how Cambridge already uses a Chevy Colorado for bike lanes. Plug-in hybrid conversion of F-150s/250s may be another strategy and would provide ample electrical power.

The main applicable PTO solution appears to be engine-off operation of bucket truck booms, several of which are mostly found in the City's Electrical Department (plus one in DPW). These electric-PTO systems, available from multiple vendors, are reported to have reduced fuel consumption by 40 percent on a local landscaping company's bucket trucks. Two hydraulic PTO strategies, with estimated 8-15% fuel savings each, are *power on demand*, which uses variable load-sensing control; and *pack-at-idle* or *operate-in-gear-at-idle*. Both features are available on McNeilus/Heil packers. At least pack-at-idle can be implemented on the City's current packer specifications, according to Heil.

Analysis of a full year of telematics data shows that wintertime idling is about double summertime idling, which means that operators are using the engine to heat the vehicle cab. From November to April, telematics-equipped vehicles totaled about 200 hours of idling per week, whereas from May to October, they totaled about 100 hours per week. Among all vehicles analyzed, the 18 Ford F-350s idle the most by a large margin—about 373 hours per vehicle per year—making them prime candidates for an anti-idling solution that includes heating services. Volpe filtered the Argonne National Laboratory idling reduction equipment database for this application, yielding 16 best-match products to research further, downselect and potentially implement.

## Introduction

Advanced technology solutions underpin the 2030 Target for the Clean Fleet Initiative, based on expectations that these technologies will be implementable in a wide range of City vehicles. Within the target vehicle population, a number of special applications have been identified that need additional research to anticipate and mitigate potential implementation challenges.

In consultation with Cambridge, Volpe has solicited input from fleets and technical organizations with implementation experience related to three special application areas. These areas are important to address in the course of attaining the 2030 Target or Stretch Target reduction levels:

- Plow, water, and other pick-up truck requirements in terms of power and payload, and whether or not lower power and torque can fulfill those requirements
- Idling activity: What idle reduction device can provide air conditioning, heat, and power radio and possibly other power needs? What idle reduction technologies can address various departments' specific operational needs?
- Power Take-Off – what technologies can address PTO loads and how significant are the loads?

Additionally, Volpe received vehicle idling data collected by the AAT and Samsara telematics systems on City vehicles. Analysis of this data may indicate why idling is occurring, on which types of vehicles, and which technology solutions may be effective in addressing this idling behavior.

## Current special application vehicles

The City led a data call with DPW fleet staff and compiled a spreadsheet with 119 DPW vehicles, providing this information to Volpe about vehicles used for snow plowing, vehicles with a PTO load, and whether or not vehicles are in year-round operation.

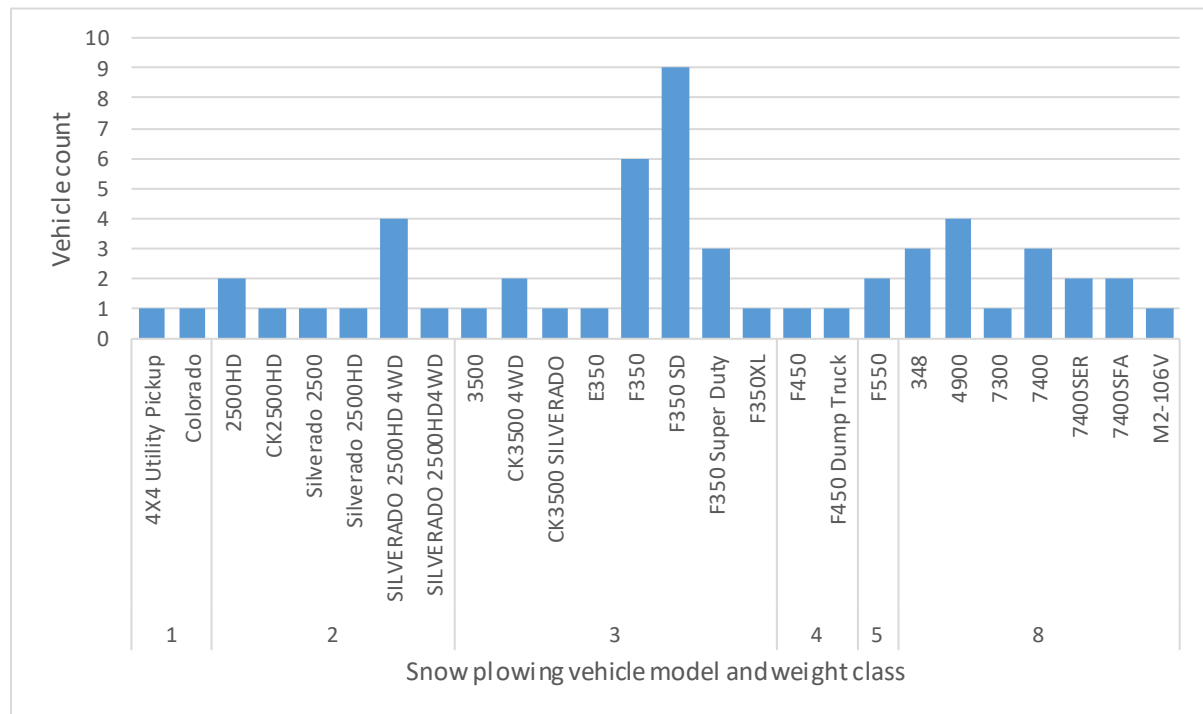
Among the 117 active DPW vehicles in the table provided to Volpe:

- 56 vehicles perform snow plowing, and all of them are used year-round.
  - The largest number of these are Class 3 (such as F-350), followed by Class 8 (Peterbilt, International, Freightliner), then by Class 2 (Chevy Silverado 2500)
- 41 vehicles have PTO, all but two of which are heavy-duty vehicles
  - The two exceptions being the Grumman step van and an F-350
  - Per fleet manager John Keeter, there are several Electrical Department bucket trucks and one in DPW. There are also 17 packers (DPW vehicle numbers 20 – 36).

## Plowing

The following shows the breakdown of plowing vehicles by weight class and vehicle model.

Current Plowing Vehicles			
<b>1</b>		F350 SD	9
4X4 Utility Pickup		F350 Super Duty	3
Colorado		F350XL	1
<b>2</b>		<b>4</b>	
2500HD		F450	1
CK2500HD		F450 Dump Truck	1
Silverado 2500		<b>5</b>	
Silverado 2500HD		F550	2
SILVERADO 2500HD 4WD		<b>8</b>	
SILVERADO 2500HD4WD		348	3
<b>3</b>		4900	4
3500		7300	1
CK3500 4WD		7400	3
CK3500 SILVERADO		7400SER	2
E350		7400SFA	2
F350		M2-106V	1
		<b>Grand Total</b>	<b>56</b>



The horsepower and torque specifications of three current plowing vehicles' engines, both their actual model years (2003, 2008) and the corresponding 2019 model years are shown below.<sup>1</sup> Light truck manufacturers have been steadily increasing engine horsepower over the past decade.<sup>2</sup> For example, a 2008 gasoline 4x4 F-350 included a 300 horsepower engine, whereas a 2019 model includes a 385 horsepower engine—an increase of 28 percent. This is also true of the F-250. If plowing operations have not changed, it may be possible to reduce the current model year engine and vehicle size without loss of performance over some of the older in-service vehicles.

The following are three in-service plow vehicle engine specifications:

	2008 Ford F-350 XL 4x4 SD	2003 Chevrolet Silverado 2500HD LS 4x4	2019 Chevrolet Colorado WT 4x4
Engine	5.4L V-8	6.0L V-8	2.5L I-4
Horsepower	<b>300 @ 5,000 Rpm</b>	<b>300 @ 4,400 Rpm</b>	<b>200 @ 6,300 Rpm</b>
Torque	365 @ 3,750 Rpm	360 @ 4,000 Rpm	191 @ 4,400 Rpm

Here is the equivalent 2019 model engine specifications, which are 20-28% higher powered:

	2019 Ford F-350 XL 4x4 SD	2019 Chevrolet Silverado 2500HD LS 4x4
Engine	6.2L V-8	6.0L V-8
Horsepower	<b>385 @ 5,750 Rpm</b>	<b>360 @ 5,400 Rpm</b>
Torque	<b>430 @ 3,800 Rpm</b>	<b>380 @ 4,200 Rpm</b>

<sup>1</sup> <https://www.autoblog.com/cars-compare/details/?v1=USB80FOT132A0&v2=USB30CHT306B0&v3=USB80CHT354A0&u=1>

<sup>2</sup> <https://www.epa.gov/automotive-trends/highlights-automotive-trends-report>



Potential downsized 2019 model options have the following specs. The F-250 and Silverado 1500 have the same engines (or nearly the same) as the F-350 and 2500 and would not significantly reduce GHG emissions. However, the 2019 F-150 provides similar power to the 2008 F-350 with a smaller displacement engine, and more power than the in-service 2019 Chevrolet Colorado.

There is no EPA-reported fuel economy rating for medium-duty pickups, but users of the Fuelly fuel-tracking website report that an F-350 with 6.2L engine achieves about 11 mpg,<sup>3</sup> while the F-150 with 3.3L engine achieves about 19 mpg.<sup>4</sup> Cambridge's mileage will vary, but the mpg ratio suggests significant fuel reduction potential if F-150 (1/2-ton pickup truck) plowing were an option.

	2019 Ford F-150 XL 4x4	2019 Chevrolet Silverado 1500LD WT 4x4	2019 Ford F-250 XL 4x4 SD
Engine	3.3L V-6	5.3L V-8	6.2L V-8
Horsepower	<b>290 @ 6,500 Rpm</b>	<b>355 @ 5,600 Rpm</b>	<b>385 @ 5,750 Rpm</b>
Torque	<b>265 @ 4,000 Rpm</b>	<b>383 @ 4,100 Rpm</b>	<b>430 @ 3,800 Rpm</b>

The F-150 minimum required equipment for snowplowing is 4x4 and the Snowplow Prep Package (68P) from Ford.<sup>5</sup> Although a 5.0L V8 engine may be required<sup>6</sup>, according to Sno-Way, the 3.3L V6 model can be used with a 7' 6" Snowway 26 Series straight plow without exceeding the front axle rating.<sup>7</sup> Based on discussion with Sno-Way, **electrical power for operating the plow is more of a limiting factor than engine power**, and they recommend putting in a larger/second battery or larger alternator. As noted below, Denver currently operates Ford F-150s for plowing bike and walking paths. The City's Chevy Colorado is similarly used to plow bike lanes.

While this analysis considered potential engine/vehicle downsizing, another strategy may be PHEV conversion. XL Hybrid's "XLP F-250" conversion was scheduled for release in late 2019 for the **F-250 with 6.2L, 4x4 driveline**.<sup>8</sup> The product sheet states that it "is projected to provide up to a 50% improvement

<sup>3</sup> [http://www.fuelly.com/car/ford/f-350\\_super\\_duty/2019?engineconfig\\_id=299&bodytype\\_id=&submodel\\_id=](http://www.fuelly.com/car/ford/f-350_super_duty/2019?engineconfig_id=299&bodytype_id=&submodel_id=)

<sup>4</sup> [http://www.fuelly.com/car/ford/f-150?engineconfig\\_id=127&bodytype\\_id=&submodel\\_id=](http://www.fuelly.com/car/ford/f-150?engineconfig_id=127&bodytype_id=&submodel_id=)

<sup>5</sup> <https://www.trailer-bodybuilders.com/equipment-parts/snow-ice/article/21742331/snowplowmounting-guidelines-for-2018>

<sup>6</sup> <http://www.arcticsnowplows.com/sites/default/files/53651-hop-r01.pdf>

<sup>7</sup> <https://www.snowway.com/what-plow-fits-my-truck/>

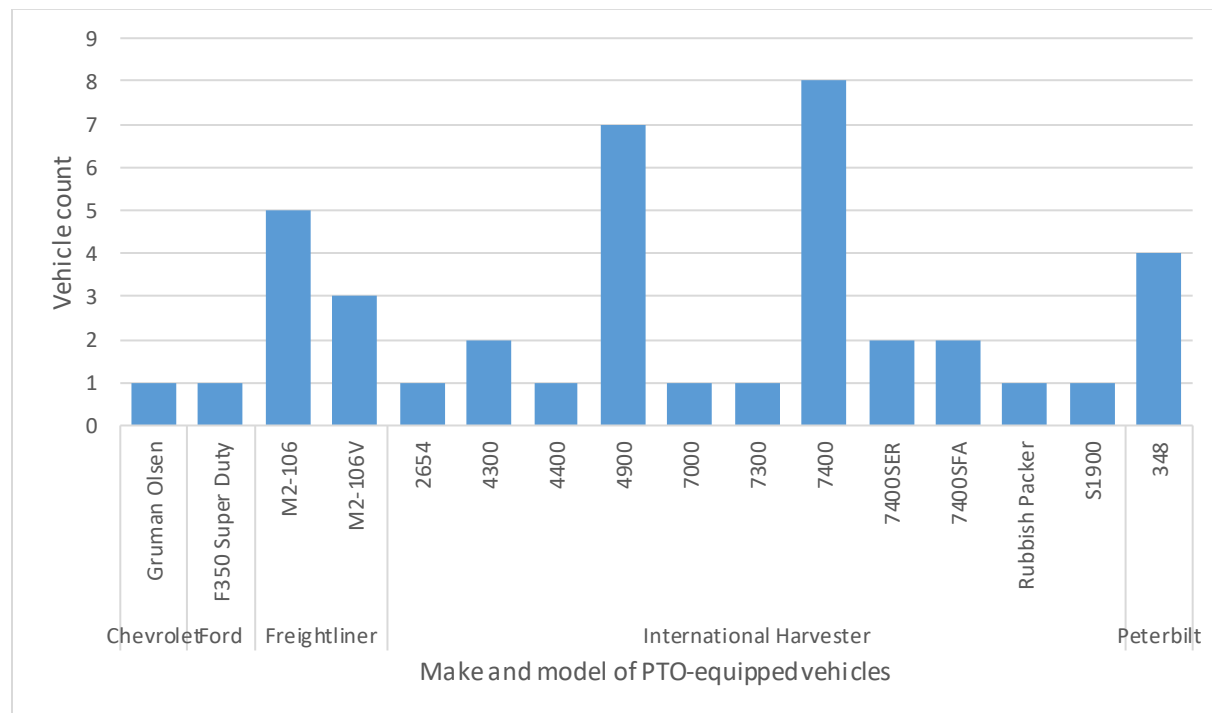
<sup>8</sup> <https://www.xlfleet.com/content/assets/Uploads/XL-XLP-F250-Flyer-8.5x11-LR.pdf>; Volpe has inquired with the company about any schedule updates.

in miles driven per gallon over conventional units, while reducing greenhouse gas emissions by 33% during normal operation.”

## PTO

The PTO vehicles by make and model are as follows. Most are International or Freightliner trucks:

Current PTO Vehicles			
<b>Chevrolet</b>			
Gruman Olsen	1	4400	1
<b>Ford</b>		4900	7
F350 Super Duty	1	7000	1
<b>Freightliner</b>		7300	1
M2-106	5	7400	8
M2-106V	3	7400SER	2
<b>International Harvester</b>		7400SFA	2
2654	1	Rubbish Packer	1
4300	2	S1900	1
		<b>Peterbilt</b>	
		348	4
		<b>Grand Total</b>	<b>41</b>



Seventeen of the 41 vehicles are packers (generally 20 cubic yards), and one is a cherry picker. **Electrified booms** for the cherry pickers (two options are Altec<sup>9</sup> and Terex<sup>10</sup>) are worth considering, as the most widely electrified type of work-truck PTO; however the largest opportunity for PTO emissions reduction appears to be packers.

Volpe's discussion with DSNY suggests that **Power on Demand (POD)**, which uses variable load-sensing control and is available from packer body manufacturers McNeilus and Heil may be an option to consider for new Cambridge packers to reduce fuel usage by up to 15 percent. However, this has not yet been confirmed by Heil or McNeilus, and Heil indicates that POD may be challenging to implement together with another feature, pack-at-idle.<sup>11</sup>

Based on discussion with Heil, **pack-at-idle** (which Heil calls "**operate-in-gear-at-idle**") is available as an option on all rear loaders. This feature does not come standard, and most rear-load packers are not ordered this way due to the \$6,000-\$7,000 upcharge.<sup>12</sup> The feature reduces both noise and fuel consumption: 12-15% or more fuel savings, according to Heil (8-9% according to DSNY). It requires a tandem pump instead of a single pump to provide flow to run the hydraulic system without racing the engine. No particular chassis or engine requirements apply, according to Heil, which indicates that for example Freightliner M2-106s with 20 cubic yard bodies can implement this feature. There are two tandem pump variants: front engine (FEPTO), likely used by the City's packers, and the typically heavier-duty transmission-mounted PTO. According to Heil, FEPTO operate-in-gear-at-idle can probably be retrofitted to the City's existing packers at higher cost (perhaps \$10,000 for the new pump, shaft, coils, etc.) versus the \$6,000-7,000 upcharge for a new truck.

Heil notes that there can be a need to train drivers to not rev the engine when this feature is installed, because most drivers are used to higher engine RPM providing more hydraulic flow.

## Idling analysis

### Data collection

Weekly idling time data was collected for 35 available vehicles via Samsara, and daily idling event data was collected for 25 available vehicles via AAT. Cross-referencing the fleet inventory from prior analysis, Volpe was able to match makes and models for all 35 Samsara vehicles and 21 of the AAT vehicles, for a total dataset of 56 vehicles from a Ford Escape Hybrid up to Class 8 trucks. The combined dataset spanned 365 days from November 15, 2018 through November 15, 2019 and therefore included all seasons.

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<sup>9</sup> <https://www.altec.com/products/green-fleet/>

<sup>10</sup> <https://www.terex.com/utilities/en/products/green-solutions>

<sup>11</sup> Email from Dan Cowher (Heil), February 12, 2020.

<sup>12</sup> According to phone call with Dan Cowher (Heil), 978-809-9799, on January 24, 2020. Few rear loaders are ordered with tandem pumps (for pack-at-idle) because rear loaders are older technology in the industry and there is not a lot of investment in them as industry transitions to automated and front loaders.

## Approach

Volpe assembled the AAT and Samsara data (daily and weekly, respectively, total idle times and percentages of engine run time) and the official average daily/weekly temperature for KBOS, the National Weather Service weather station at Logan Airport over the same period into a combined fleet-level table:

Week End	Avg Weekly Temp	AAT_Avg_Idle_Pct	Sam_Ave_Idle_Pct	FLEET_Avg_Idle_Pct	AAT_Total_Weekly_Idle_hrs	Sam_Total Idle Hrs	FLEET_Total_Idle_hrs
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Additionally, a vehicle-group-level table was created:

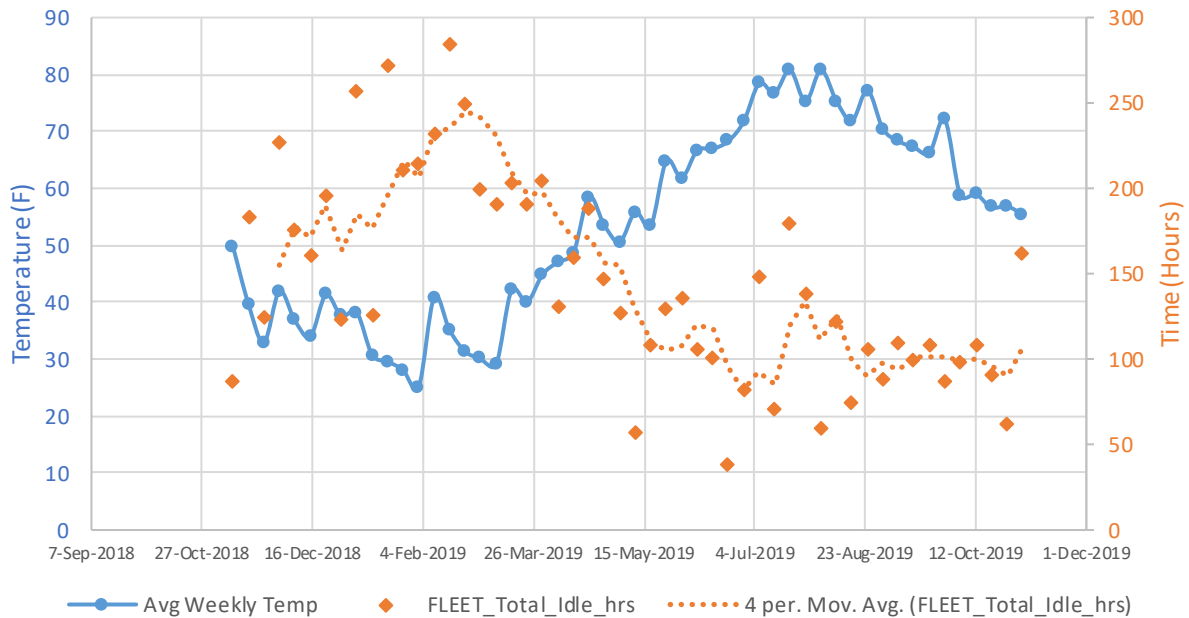
Vehicle Group	Vehicle Make/Model	Vehicle Avg Idle %	Total Vehicle Idle Hours	Vehicle Count	Total Annual Idle Hours	Avg Annual Idle Hours	Avg Annual Idle %
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Idling and idling-temperature plots were produced based on these tables and based on vehicle make and model.

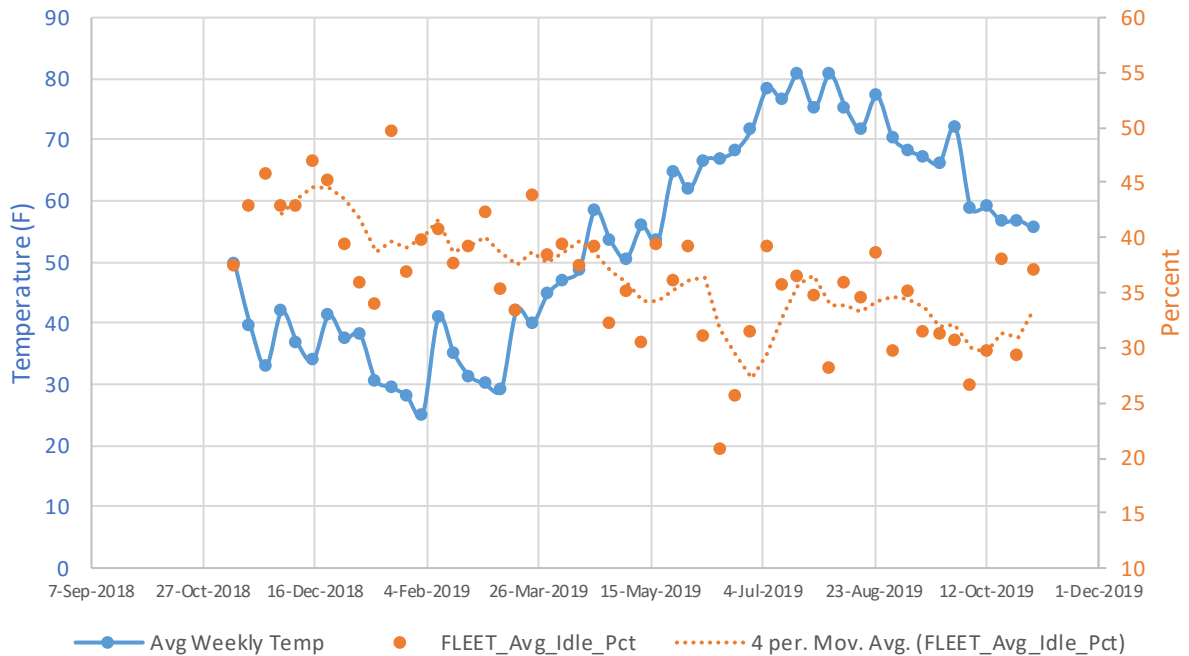
## Findings

On a weekly timescale, the large daily variability of idling activity (including between weekdays and weekends) smooths out enough to reveal a strong inverse relationship between the weekly average temperature and the total hours of fleet-wide idling. This is evident in both the total idling hours per week and in the idling percentage of engine-on time. At the fleet level, wintertime idling is about double the amount of summertime idling, indicating that extra idling is probably used by operators to heat the vehicle cab. From November to April, all the telematics-equipped vehicles totaled about 200 hours of idling per week, while from May to October, they totaled about 100 hours per week. With idling higher in the colder months, high-idle vehicles are prime candidates for an anti-idling solution that provides heating services.

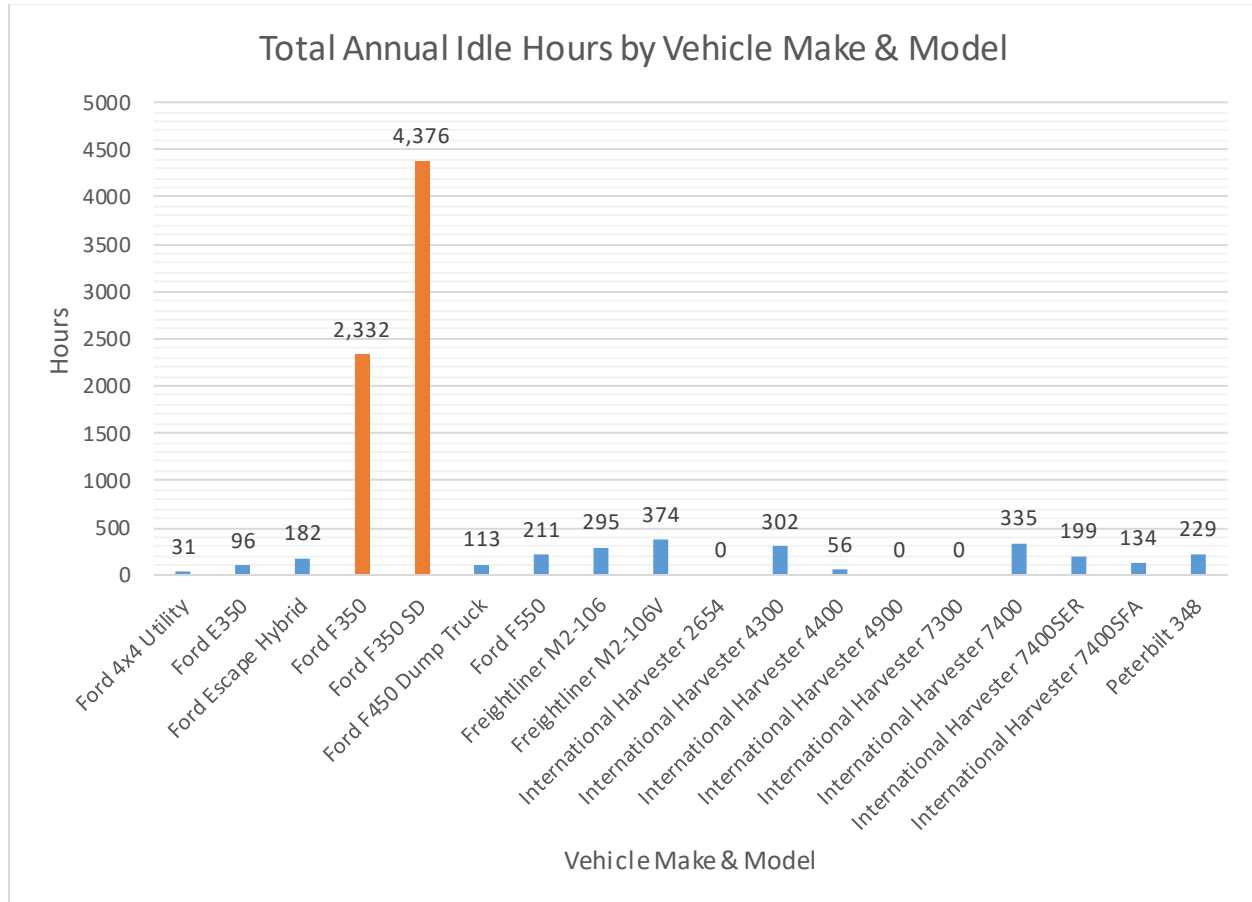
## Weekly Temperature and Fleet-wide Time Idle Nov. 15th 2018 - Nov. 15th 2019



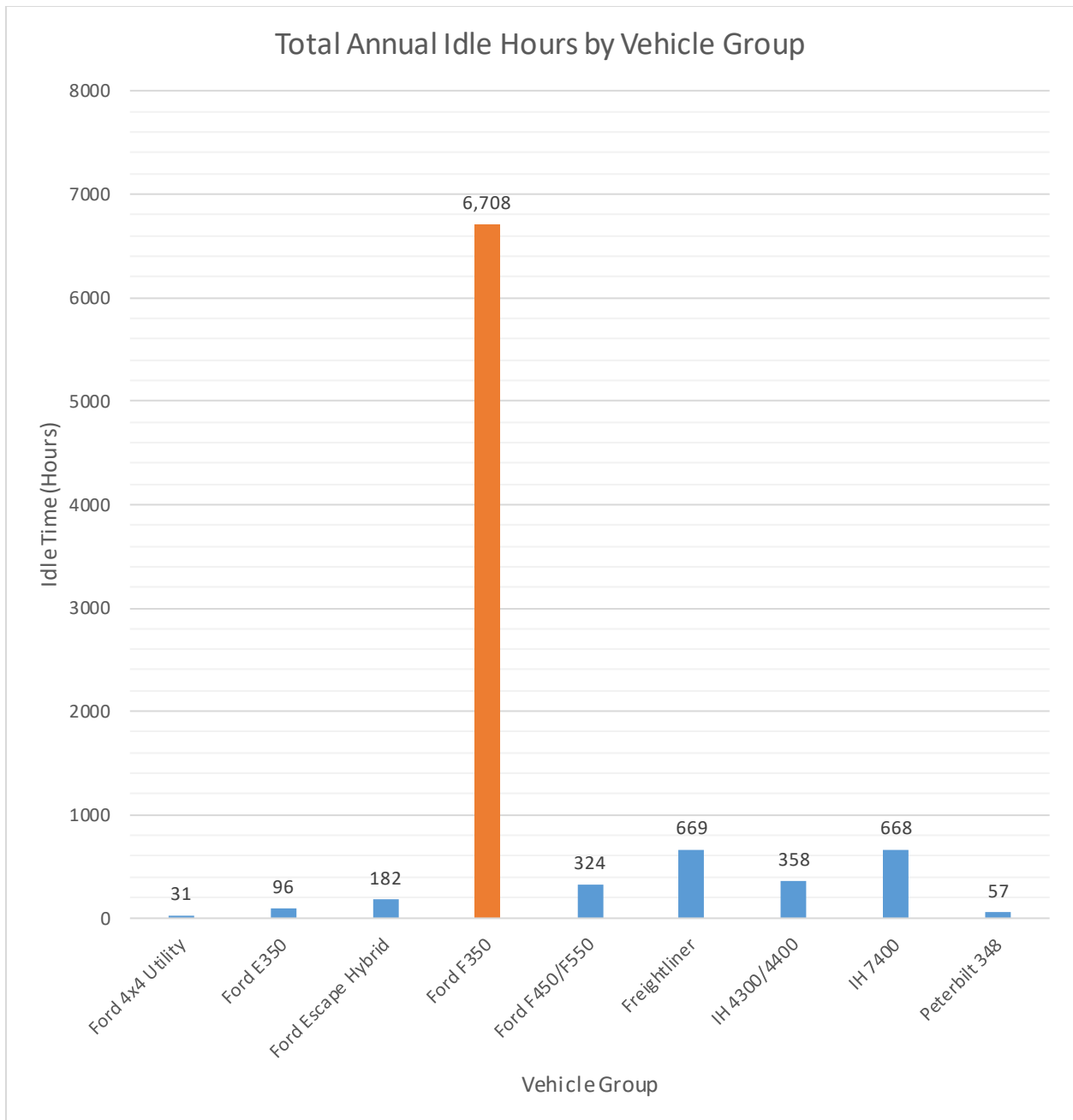
## Weekly Temperature and Fleet-wide % Time Idle Nov. 15th 2018 - Nov. 15th 2019



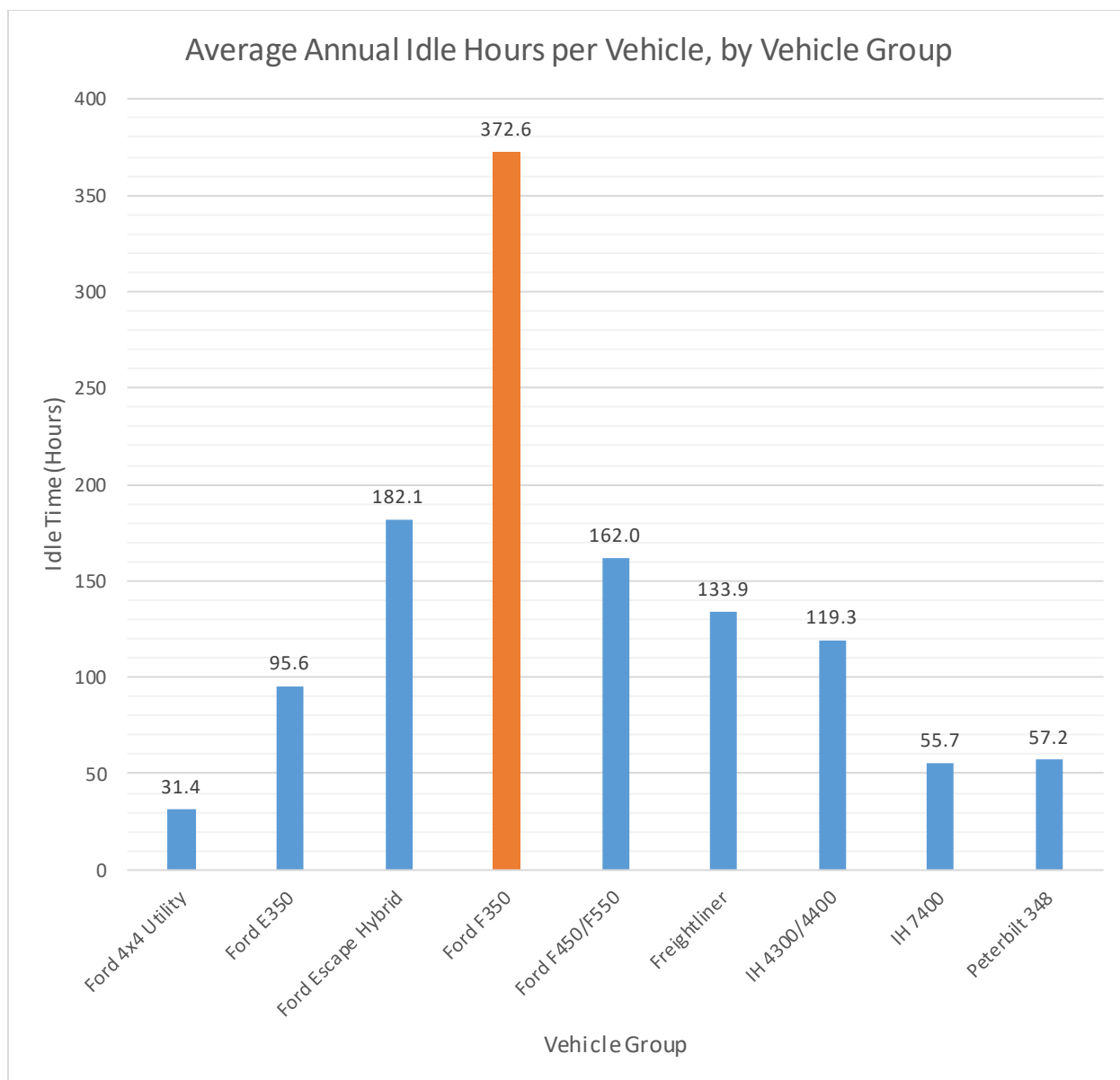
Because it is possible that certain vehicle makes and models are responsible for a disproportionate amount of idling, and these should be targeted first for the best potential payback, Volpe plotted their total annual idle hours. Ford F-350s and F-350SDs logged the largest total number of idling hours among telematics-equipped fleet vehicles.



For clarity, Volpe also combined the 18 makes and models into nine groups based on weight class and vehicle type (e.g., van, pickup, Class 6, Class 8).



Not only do the 18 Ford F-350s idle more in total than the other vehicle groups, but they also idle more per vehicle. This can be seen in the following graph of annual per-vehicle idle hours.



Volpe could further analyze the dependence of idling on temperature for each individual vehicle group. However, even without this analysis, given:

1. The apparent cold-weather driver of idling in the fleet, and
2. F-350s experience the largest number of idling hours per vehicle,

A cabin heating solution should be considered on the F-350s to reduce idling fuel consumption. Best-match candidates for the Medium-Duty Vehicle Class vehicle class, according to the Argonne National Laboratory idling reduction equipment database, are as follows. This table represents a menu of preliminary proposed solutions that can be further refined to downselect to one or two technologies.



Company	Product	Estimated Fuel Use gal/hr (Mfr. Estimate)	Estimated Cost (low end)	Estimated Cost (high end)	Website
Autotherm	No-Idle Cab Heating System (T2500 and T2524)				<a href="http://www.autothermusa.com/index.html">http://www.autothermusa.com/index.html</a>
Canadian Extreme Climate Systems Ltd	GRIP Idle Management		\$2,000	\$10,000	<a href="https://www.gripidlemanagement.com/">https://www.gripidlemanagement.com/</a>
Eberspaecher	Airtronic Heater (D2)	0.02-0.07	\$900	\$900	<a href="https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/air-heaters.html">https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/air-heaters.html</a>
Eberspaecher	Airtronic Heater (D4)	0.03-0.13	\$900	\$900	<a href="https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/air-heaters.html">https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/air-heaters.html</a>
Eberspaecher	Airtronic Heater (D5)	0.04-0.17	\$900	\$900	<a href="https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/air-heaters.html">https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/air-heaters.html</a>
Eberspaecher	Hydronic Coolant Heater (D5)	0.07-0.16	\$1,250	\$1,250	<a href="https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/coolant-heaters.html">https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/coolant-heaters.html</a>
Eberspaecher	Hydronic S3 E coolant heater	0.15-0.17	\$900	\$1,500	<a href="https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/coolant-heaters/hydronic-s3.html">https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/coolant-heaters/hydronic-s3.html</a>
Idle Smart LLC	Idle Smart		\$1,500	\$2,500	<a href="http://idlesmart.com/#home">http://idlesmart.com/#home</a>
InterMotive Vehicle Controls	Eco-Star™	0.6	\$800	\$900	<a href="http://www.intermotive.net/Brochures/EcoStar_brochure.pdf">http://www.intermotive.net/Brochures/EcoStar_brochure.pdf</a>
InterMotive Vehicle Controls	EcoLock	0.6	\$630	\$630	<a href="http://www.intermotive.net/Installation%20Instructions/Eco%20Lock/ECL554-A-061517.pdf">http://www.intermotive.net/Installation%20Instructions/Eco%20Lock/ECL554-A-061517.pdf</a>
Smart Power Solutions	Stealth Power	0.60- 2.5	\$4,295	\$19,995	<a href="http://www.idlereduction.com/">http://www.idlereduction.com/</a>
Temp-a-Start	Temp-a-Start System		\$1,750	\$2,500	<a href="http://www.temp-a-start.com/">http://www.temp-a-start.com/</a>
Vanner	IdleWatch		\$1,588	\$1,588	<a href="http://www.vanner.com/idlewatch-for-engine-off-acdc-power-for-work-trucks/">http://www.vanner.com/idlewatch-for-engine-off-acdc-power-for-work-trucks/</a>
Webasto	Thermo Top C	0.08-0.16	\$1,415	\$1,415	<a href="https://www.webasto.com/gb/markets-products/truck/heating-systems/products/thermo-top-c/">https://www.webasto.com/gb/markets-products/truck/heating-systems/products/thermo-top-c/</a>
Webasto	DBW 2010	0.4	\$3,315	\$3,315	<a href="https://www.webasto.com/us/markets-products/heavy-duty-truck/heating-systems/products/dbw-2010/">https://www.webasto.com/us/markets-products/heavy-duty-truck/heating-systems/products/dbw-2010/</a>
Webasto	Air Top 2000 ST	0.03-.06	\$1,800	\$1,800	<a href="https://www.webasto.com/us/markets-products/heavy-duty-truck/heating-systems/products/air-top-2000-st/">https://www.webasto.com/us/markets-products/heavy-duty-truck/heating-systems/products/air-top-2000-st/</a>

Beyond the F-350s, a second opportunity is reduction of packer truck idling fuel consumption during red light stops and trash stops. Volpe’s research suggests that **neutral at stop** is a promising option to consider for new Cambridge packers to reduce fuel usage by up to six percent. Neutral at stop is part of the Allison transmission FuelSense 2.0 Plus package. While it cannot be retrofitted on existing transmissions in Massachusetts<sup>13</sup> (and a number of other states), it is available on truck makes and models currently used in the Cambridge packer fleet:

<sup>13</sup> Phone call with Kim at Allison Transmission, 800-524-2303, January 22, 2020.

- Neutral at stop has been available since 2014 on Freightliner M2-106 with Allison 1000/2000/3000/4000 series transmissions.<sup>14</sup>
- Neutral at stop becomes standard in 2020 on International MV medium-duty trucks, successor to the International 4000-series, another model used by current Cambridge packers.<sup>15</sup>

FuelSense 2.0 is available on Allison transmissions across most, if not all, heavy truck and bus types, as detailed in the transmission manufacturer's [Vocational Model Guide](#). Other trucks such as dump trucks could also be equipped with neutral at stop, but the fuel efficiency benefit would likely not be as large as for packers, which make the most frequent stops.

## Findings from other fleets

The following is a summary of Department of Energy local Clean Cities Coalition and other fleet feedback that Volpe has compiled, organized by the three special application areas. More detailed inputs are compiled in the appendix.

### Plowing

Volpe's research uncovered limited examples of **electric or hybrid** plow vehicles:

- Since 2013, a Minneapolis apartment complex operates an all-electric Polaris Ranger side-by-side snow plow.<sup>16</sup>
- In early 2020, an all-electric Mack LR demonstration garbage truck (not commercially sold yet) in will be put into service by NYC Sanitation; expected to perform plowing
- Northern Colorado Clean Cities indicated that hybrid plows are in use in that region (but had no details).

### Minimum plow vehicle specifications

Feedback from Northern Colorado Clean Cities is that overall the engine range is between 300-600 HP with 700-1200 lbs. of torque, with 300 HP as a general standard. In NYC, the Parks department runs over 100 diesel F-250s and F-350s (but not F-450s or 550s) to clear one-lane streets with 400 HP and 800 pound-feet of torque.

Denver DPW typically purchases Ford Rangers and F-150's for light duty application, F-350's for heavy duty application, and F-550's for severe heavy duty application. Rarely, if ever, do they purchase F-250's or F-450's. They state: "The F-350 and F-550 are roughly \$1000 more in cost than the F250/F450 so the increase in weight/hauling/towing capacities make them much more practical in our application."

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<sup>14</sup> <https://www.government-fleet.com/116862/freightliner-adopts-allison-s-fuelsense-for-fuel-efficiency>; <https://www.todaystrucking.com/allison-boosts-fuel-savings-with-software/>

<sup>15</sup> <https://www.marketwatch.com/press-release/international-truck-to-feature-allison-neutral-at-stop-as-standard-equipment-on-the-2020-international-mvtm-series-2019-10-16>

<sup>16</sup> <https://ranger.polaris.com/en-us/ranger-ev/>

As mentioned in the previous section, the electrical power for operating the plow (determined by battery and alternator) is more of a limiting factor than engine power for pickup trucks.<sup>17</sup> Sno-Way advises that if the Chevrolet Colorado works for Cambridge plowing today, a Ford F-150 engine should work as well for similar plowing duty.

## PTO

Volpe research points to widely available PTO emissions reduction solutions for bucket trucks and cherry pickers. The utility and landscape business has used hybrid systems since at least 2008<sup>18</sup> that has a battery that will allow the operator to use the bucket without idling the engine. Altec<sup>19</sup> and Terex<sup>20</sup> are two of the upfitters that offer **electric PTO on bucket trucks**. About ten years ago, the technology may have had reliability issues: in 2011, NYC Parks bought six Kenworth chassis with Eaton e-PTO bucket trucks (no longer made<sup>21</sup>), but their out of service rates were so high that they were removed. Locally, Cambridge Landscape Company has several hybrid bucket trucks that they report are saving them 40% in fuel usage.<sup>22</sup> On City vehicles, there are several bucket trucks in the Electrical Department, but only one in DPW. Anecdotally, NYC states that bucket trucks are among their top idlers due to the PTO.<sup>23</sup>

For the 17 packers in Cambridge's fleet packers, there are possible future routes to electrifying PTO, such as the all-electric Mack LR being tested by NYC Sanitation.<sup>24</sup> However, in the near-term, there is at least one non-electric PTO reduction option for City of Cambridge. Currently used by NYC Sanitation, **power on demand** uses variable load-sensing control for PTO instead of a gear pump. Packer body manufacturers Heil and McNeilus both offer this option, which yields 10-15% savings, but compatibility with Cambridge's packer spec has not been confirmed. The upcharge is not known because it has been spec'ed in when NYC Sanitation purchases vehicles.<sup>25</sup> According to Spiro Kattan, Power-on-Demand

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<sup>17</sup> Per call with Kevin Kuechler, 262-673-7200, and per email with Jeff Hess, Sno-Way: "The Sno-Way Series 26, 26R, and 26V plows are specifically designed for ½ ton (F-150 / Series 1500) trucks, including F-150 EcoBoost models. These same mentioned Sno-Way plows are also the only brand of snowplows that are compatible with the 2011 – 2014 F-150 truck models in that Sno-Way's patented EIS Electrical System is the only snowplow system that draws so little power from the vehicle's electrical system. The 2011 – 2014 F-150 trucks would automatically shut down power steering and computers with all other snowplow brands. A snowplow prep package refers to a vehicle that has a larger capacity alternator, larger capacity radiator, and larger capacity battery (or two batteries). The vast majority of modern vehicle and truck production meets or exceeds the original requirements of snowplow prep packages. Engine size is not a consideration of a snowplow prep package."

<sup>18</sup> <https://www.utilityproducts.com/articles/print/volume-5/issue-12/product-focus/vehicles-accessories/hybrid-bucket-trucks-gaining-traction133.html>

<sup>19</sup> <https://www.altec.com/products/green-fleet/>

<sup>20</sup> <https://www.terex.com/utilities/en/products/green-solutions>

<sup>21</sup> <https://www.worktruckonline.com/125215/eaton-discontinues-diesel-electric-hybrid-trucks>

<sup>22</sup> <https://www.cambridgelandscape.com/organics-and-sustainability>

<sup>23</sup> As Cambridge is already aware, Samsara and AAT have the capacity to collect PTO runtime data. The City does not currently have this feature connected to track PTO, but as future vehicles with PTO are equipped with telematics/GPS, this data may start to become tracked.

<sup>24</sup> <https://www.macktrucks.com/trucks/lr-series/lr-electric/>

<sup>25</sup> "Hydraulic flow is only delivered to the body when a body function is requested and all interlocks have been satisfied. When pump flow is not needed the pump goes to minimum displacement reducing the load on the engine." <http://www.bidnet.com/bneattachments/?/429084266.pdf>

(POD) is another feature from Heil and McNeilus (other than Pack@Idle) which can further reduce parasitic losses when the hydraulic system is NOT under load. The POD utilizes an electronically controlled variable displacement load-sensing hydraulic pump.

### Idle reduction

Volpe research points to a number of promising solutions for reducing idling that Cambridge could consider. Separate from hybridization (by Odyne, Lightning, LX Hybrid, etc.), two Clean Cities Coalitions independently recommended **Grip**, an anti-idling platform that can fit many vehicle classes and address a range of loads.<sup>26</sup>

Low hanging fruit for idle reduction on medium- and heavy-duty vehicles can include **neutral at stop**. This is an Allison FuelSense 2.0 transmission option that reduces or eliminates the load on the engine (by releasing the clutch entirely) while the vehicle is stopped with service brakes engaged—for example, at red lights or during trash stops—reducing fuel usage and emissions.<sup>27</sup> According to NYC Sanitation, neutral at stop produces 3-4% fuel savings. (Allison claims savings of 6% for packers.)<sup>28</sup> NYC Sanitation is unsure of the upcharge but states that neutral at stop does not cost very much.<sup>29</sup>

NYC installed **fuel-fired cabin heaters** on 90 salt spreaders around 2011 that proved to have high maintenance, but they believe “the technology has definitely improved since then.” They recommend fuel fire heaters as a “great application for spreaders that idle in place before a snow storm.”

Less ready for Cambridge but worth watching: NYC Sanitation is piloting **Effenco aftermarket auto-stop-start** for heavy-duty diesel engines, apparently the only such solution on the market.<sup>30</sup> There is a 10% measured savings, and a portfolio of chassis that Effenco has designed for. It is a \$40k upcharge, so payback seems unlikely at this price, according to NYC. But there may be more options in the future with EPA Phase 2 GHG standards. Allison is reportedly working on a similar system, for example.

## Appendices

### Plowing

Generally, the feedback is that larger plowing vehicles may be good candidates for CNG, and medium duty vehicles for propane. (Biodiesel blends can also work well as long as the fuel is properly conditioned for winter.)

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<sup>26</sup> <https://gripidlemanagement.com/>

<sup>27</sup> <https://www.allisontransmission.com/why-allison/fuelsense>

<sup>28</sup> <https://www.fleetowner.com/equipment/article/21695614/allison-unveils-fuelsense-20-software-upgrade>

<sup>29</sup> Allison 4500RDS transmission is specified in NYC Sanitation trucks.

<http://www.bidnet.com/bneattachments?/429084266.pdf>

<sup>30</sup> <https://www.effenco.com/>

## Technical Response Service

### Multi-Unit Dwelling Procurement Case Study: Green Rock Apartments

(<https://afdc.energy.gov/case/3081>)

- The Green Rock Apartments installed electric vehicle supply equipment to charge tenant vehicles and the building's all-electric snow plow, a Polaris Ranger side-by-side.<sup>31</sup>

Colorado Leads in Alternative Fuel Use and Public Transit Efficiency (<https://afdc.energy.gov/case/1223>; <https://afdc.energy.gov/case/1223?text>)

- The City of Fort Collins' fleet includes alternative fuel vehicles, including compressed natural gas (CNG) snow plows. (<http://www.northerncleancities.org/>)

Wisconsin Reduces Emissions With Natural Gas Trucks (<https://afdc.energy.gov/case/163>; <https://afdc.energy.gov/case/163?text>)

- The City of Milwaukee's fleet includes CNG sanitation trucks that are used for snow plowing. (<http://www.wicleancities.org/>)

## Northern Colorado Clean Cities

In Northern Colorado there are some differences between the fleets, but **overall the range is between 300-600 HP with 700-1200 lbs. of torque**. A lot of Internationals are being used, and some use Natural Gas, Propane and **even hybrids**. 300 HP would absolutely be the standard (not that there aren't smaller they just aren't common) as typically I have seen fleets go big and use a 400 HP for a 48" plow.

## Clean Fuels Ohio

Vehicles used to plow snow can vary in size. Generally larger vehicles may be good candidates for CNG and medium duty for propane. EVs are not as likely to pencil out well. Biodiesel blends can work well as long as the fuel is properly conditioned for winter. I don't personally know of hybrid or EV snow plows but we could make some inquiries. The issue with snow plows for any fuel type is whether they are high enough mileage applications to pencil out. It depends on how else the vehicles are used during the rest of the year.

## City and County of Denver<sup>32</sup>

Equipment spec's/purchases depend on our customer's needs, how the vehicle will be used and obviously the budget amount assigned to the replacement vehicle. I typically purchase F-150's for light duty application, F-350's for heavy duty application, and F-550's for severe heavy duty application. Rarely, if ever, do I purchase F-250's or F-450's. The F-350 and F-550 are roughly \$1000 more in cost than the F250/F450 so the increase in weight/hauling/towing capacities make them much more practical in our application. Please see attached plow spec. This particular spec includes a gas power plant but normally we spec Lt. Duty trucks that are intended to push snow with a diesel.

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<sup>31</sup> <https://ranger.polaris.com/en-us/ranger-ev/>

<sup>32</sup> Gary Bales | Operations Manager | Fleet Management | Public Works | City and County of Denver  
720.337.1197 Office | 303.513.6044 Cell | [Gary.Bales@denvergov.org](mailto:Gary.Bales@denvergov.org)

### Utah Clean Cities

We are in the process of adding some snow plows to our state fleets and a large city. There is an excellent example in Colorado that I believe is listed here.

### South Shore Clean Cities

City of Hobart Indiana has been replacing their end-dumps with CNG. Same with City of Southbend Indiana, both have reported NO ISSUES and continue to expand their fleets as replacement schedules allow.

### MA Clean Cities

The City of Boston fleet has added a propane upfit to several of their pickup trucks. Three are F 350s that they use for plowing. Propane could work for Cambridge as it is a fuel they that has availability. They can be dual fuel or dedicated. The Larger Plow trucks could operate on CNG (compressed Natural Gas) but there is no fuel supply close enough to them to work.<sup>33</sup> There are two companies that do the propane upfits – ICOM and Roush. The city of Boston installs the propane equipment themselves. They have used both but like the ICOM set up. <https://www.icomnorthamerica.com/>  
<https://www.roushperformance.com/>

### NYC Fleet

Jon Ells, NYC Fleet: No focus or discussion on downsizing plow vehicles--too political. Parks department ran over 100 diesel F-250s and F-350s (but not F-450 or 550) to clear one-lane streets with 400 hp and 800 pound-feet of torque (now Ford is doing 900 lb-ft). All of them had salt spreader and plow package (8-foot Western straight plow). Forward and reverse operating alarms for driving through park space.

Spiro Kattan, DSNY: Electric Mack LR kickoff in January—will be a demonstration vehicle, not for sale. 72,000 GVW. Plan to put into service Q1 2020. 92 Level 2 chargers now at DSNY, will build a Level 3 DC Fast chargers for electric LR to service 300 kWh battery. Valuable lesson is that power feeds to the shops can limit Level 3 installation.

## PTO

### Technical Response Service

Utility Products case study (<https://www.utilityproducts.com/articles/print/volume-5/issue-12/product-focus/vehicles-accessories/hybrid-bucket-trucks-gaining-traction133.html>) on hybrid bucket trucks states the following:

“In certain aspects of what [the Orlando Utilities Commission does]—whether on the operations side or the street light maintenance side—[HEVs] have an advantage for us,’ Chase said. ‘The hybrids would be more than adequate for short duration trouble response calls because they could run off the battery the entire time.’”

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<sup>33</sup> Steve Russell via email correspondence.

That said, if the task requires longer operation of the utility vehicle equipment, the hybrid battery alone may not be sufficient. The U.S. Department of Energy's fact sheet on work truck idling reduction ([https://afdc.energy.gov/files/u/publication/work\\_truck\\_idling\\_reduction.pdf](https://afdc.energy.gov/files/u/publication/work_truck_idling_reduction.pdf)) provides some information about idle reduction technologies for these situations, such as auxiliary power units.

#### Clean Fuels Ohio

I'm less familiar with electrified power take off systems but I know there are several options.

#### MA Clean Cities

The utility and landscape business have used a hybrid system for several years that has a battery that will allow the operator to use the bucket without idling the engine. Provider is Altec:

<https://www.altec.com/products/green-fleet/>

Cambridge Landscape Company has several hybrid bucket trucks that are saving them 40% in fuel usage: <https://www.cambridgelandscape.com/organics-and-sustainability>

#### NYC Fleet

Jon Ellis, NYC DCAS: Around 2011, NYC Parks bought six Kenworth chassis with Eaton e-PTO bucket trucks, but their out of service rates were so high that they were removed. The tech was not ready. Bucket trucks do idle about as much as ambulances, but this poor experience led NYC Fleet to not try other ePTO technologies since then.

Sanitation is working with a Canadian company named Effenco on idle reduction, but not sure that the ROI is going to be great. Samsara does have the capacity to collect PTO runtime—NYC requested this feature, and Samsara incorporated it, but it may require additional monitoring devices. Ask Samsara for details. (NYC Fleet did not end up using Samsara, but rather Geotab.)

In addition to the electric Mack LR heavy-duty packer, there is also a Lion Electric Class 8 garbage truck in development.

Spiro Kattan, DSNY:

- **Power on demand** for PTO: instead of a gear pump, uses variable load-sensing control. Both Heil and McNeilus offer this. 10-15% savings. Upcharge not known.
- **Pack-at-idle**: RPMs don't increase to 1,500 while packing but stay at idle rpm—8-9%. Requires larger pump assembly.

NYC Sanitation also notes that diesel engines can be programmed to shut off after 5 minutes, as long as the PTO is off.

## South Shore Clean Cities

I know we have been approached by a few folks but many of them I believe either have been sold or out of business.<sup>34</sup>

### Idle reduction

#### Technical Response Service

The Medium-Duty Vehicle Idle Reduction Strategies page

([https://afdc.energy.gov/conserve/idle\\_reduction\\_medium.html](https://afdc.energy.gov/conserve/idle_reduction_medium.html)) recommends the following for vehicles requiring power take-off (PTO):

*“For medium-duty trucks that require PTO throughout the day, **a secondary power plant, storage battery, or hydraulic storage system can be an excellent solution.** In the case of a battery, it can be mounted in the back of the truck and charged overnight and recharged if needed during the day. In the case of an auxiliary power unit, it can have a small diesel engine like a generator, which uses less fuel and produces fewer emissions than an idling vehicle's main engine would.”*

The U.S. Department of Energy's *Work Truck Idling Reduction* publication

([https://afdc.energy.gov/files/u/publication/work\\_truck\\_idling\\_reduction.pdf](https://afdc.energy.gov/files/u/publication/work_truck_idling_reduction.pdf)) offers the following guidance:

*“Companies can **purchase a new hybrid truck or retrofit an existing truck with an auxiliary battery system** to power electric or hydraulic equipment and provide climate control for the crew compartment.”*

The following manufacturers offer hybrid electric vehicle (HEV) and plug-in hybrid electric vehicle (PHEV) conversions:

- XL Hybrids (<https://www.xlfleet.com/content/vehicles/#xlh-section>)
  - XL Hybrids offers both HEV and PHEV conversion systems.
- Odyne (<https://www.odyne.com/>)
  - Odyne offers PHEV conversion systems.
- Enginer (<http://www.engineer.us/>)
  - Enginer offers PEHV conversion systems.

## Clean Fuels Ohio

There are many options for anti-idling. I'd consult the tools AFDC has developed such as Idle Box. Argonne lab has some good anti-idling resources and success stories. I'm most familiar with Grip. I think the Grip system can fit many vehicle classes.

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<sup>34</sup> Carl Lisek, Executive Director, South Shore Clean Cities, Inc.



## MA Clean Cities

ENow is a company in Rhode Island that makes an anti idling unit that is designed to handle all the auxiliary needs that require idling. They use solar panels and a battery. <https://enowenergy.com/> Also hybrid: <https://www.xlfleet.com/>

## Utah Clean Cities

We did a small paper on APUs we can send this week. I have cc'd Emily Paskett here to help us communicate.

## NYC Fleet

For high-idle vehicles, NYC has had success with 300 ambulances using **Stealth Power** and (more recently) **ZeroRPM**, which use a large battery that is installed in the ambulance and can be charged off board or from the engine.<sup>35</sup> In most cases it is charged from the engine, which results in the engine running about 10 minutes an hour. It is expensive at \$20K a unit, but NYC reports an ROI based on extended engine life from saving 4 hours of ambulance idling a day on average. The Fire Department reportedly couldn't keep up with required maintenance of these expensive ambulance diesel engines, and idling represented many of those hours.

Jon Ells, NYC DCAS: ZeroRPM is a new second vendor providing anti-idle competition to Stealth, which has been around for years. Had trouble getting telematics data, just like with Canceivers a few years ago. Now getting monthly reporting. Saving 4 hours of idling a day on average on the ambulances (the range is about 2-6 hours). Wear and tear was actually the biggest driver of savings because of expensive ambulance diesel engines—Fire Department just couldn't keep up with required maintenance of engines every X miles, with idling representing a lot of those hours. About 300 ambulances are equipped out of 500 ambulances and all turnovers going future.

Spiro Kattan, DSNY: Can program HD engines to shut off after 5 minutes as long as PTO is off.

Low hanging fruit on heavy-duty vehicles is reducing parasitic losses: park-at-idle, neutral at idle, power-on-demand for PTO.

- **Neutral at stop** with Allison transmissions reduces parasitic loss with torque at clutch when foot is on brake—3-4% savings. Part of an Allison package called "Allison FuelSense 2.0." Not sure of upcharge, believe does not cost very much.

There were some early **fuel-fired cabin heaters** on 90 salt spreaders that were abandoned because of high maintenance, about 8-9 years ago. Great application for spreaders that idled in place before a snow storm. But the technology has definitely improved since then.

Don't know of electric APUs for HD, but DSNY is piloting **Effenco aftermarket auto-stop-start** for HD diesel. They've been around ~10 years. Adds a PTO to the transmission, electric motor behind PTO, then this motor starts the engine. Ultracapacitor based—see flyer; POC is Simon Poulin. There is a

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<sup>35</sup> <https://www.idlereduction.com/smart-power-solutions/ems/>

portfolio of chassis that they've designed for. \$40k upcharge, so payback is unlikely at this price! But there will probably be more options in the future with EPA Phase 2 GHG standards. Allison working on a similar system, for example. Measured 10% savings.

#### South Shore Clean Cities

We have had much success with the GRIP Technology <https://gripidlemanagement.com/> Contact would be Mr. Lynn Stafford, Government and Commercial Sales, 317-696-1085.

#### Other interview notes

Spiro Kattan, DSNY: opportunities to replace older diesel engines with 2014 or 2017, which provide emissions reduction. The MP7 diesel engine used on 2,400 Mack LR garbage truck fleet that DSNY operates. NYC planning to go from current B20 to renewable diesel on all diesel municipal vehicles.

Low hanging fruit for municipal fleet was passenger vehicles, specifically hybridizing and electrifying since 50—no pilots or customization needed. Over 90% of light-duty converted to HEV or EV.

Global Environmental **first commercial all-electric street sweeper** in NYC starting Q1 2020 (\$734k versus \$230k). Federal grants helped pay for it.

#### Example Denver plow truck specifications

- Denver, CO residential plows: 2019 F-350 4x4 regular cab, 6.2L V-8 gas plant or 6.7L diesel, 9' 2" V-plow kit (PDF of purchase order available)
- Denver, CO path plows: 2019 F-150 4x4, 3.3L V-6 gas (up-spec'ed to 5.0L V-8 gas) plant, 6' 8" straight plow kit (Excel of purchase order available)

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