INTRODUCTION OF THE HEAVY-DUTY VEHICLE EMISSIONS CALCULATOR (HDVEC)

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OUTLINE OF PRESENTATION

- Introduction
- Heavy-Duty Vehicle Emissions Calculator (HDVEC)
- HDVEC Tutorial - Demo #1 - Environmental Mitigation w/ Scrappage
- HDVEC Tutorial - Demo #2 - Environmental Mitigation w/ Repower
- HDVEC Tutorial - Demo #3 - Clean Vehicle Replacement

Introduction

ARGONNE HAS SUPPORTED DOE WITH TOOL DEVELOPMENT FOR 20 YEARS

- **AirCRED**
  - Air pollutants for SIPs
- **Clean Cities AOI 4 Emissions Benefit Tool**
  - GHG & air pollutant benefits for ARRA grant proposals
- **GREET Fleet Footprint Calculator**
  - Petroleum use & GHGs of HDVs & off-road equipment

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"AFLEET TOOL" TO ANALYZE AFV COSTS & BENEFITS

- **Examines light-duty & heavy-duty vehicle:**
  - Petroleum use
  - GHGs
  - Air pollutants
  - Cost of ownership

- **Contains 18 fuel/vehicle technologies**
  - Conventional
  - Hybrids
  - Plug-in electrics
  - Alternative fuels: CNG, LNG, LPG, H_2, EtOH, BD, RD
- **Includes 7 Major Vehicle Types**
  - Cost, MPG, & VMT data on 26 vocations
- **AFLEET Tool 2017 & user manual available at:**
  greet.es.anl.gov/afleet

AFLEET TOOL'S CALCULATION METHODS

- **Tool has 4 calculation methods & which to use depends on your goals**

- **Fleet Energy and Emissions Footprint Calculator**
  - Annual & remaining lifetime petroleum use, GHGs & air pollutant emissions of existing & new vehicles

- **Simple Payback Calculator**
  - Annual emissions & simple payback of purchasing new AFV vs. conventional counterpart

- **Total Cost of Ownership Calculator**
  - Lifetime emissions & NPV of costs over the years of planned ownership of a new vehicle

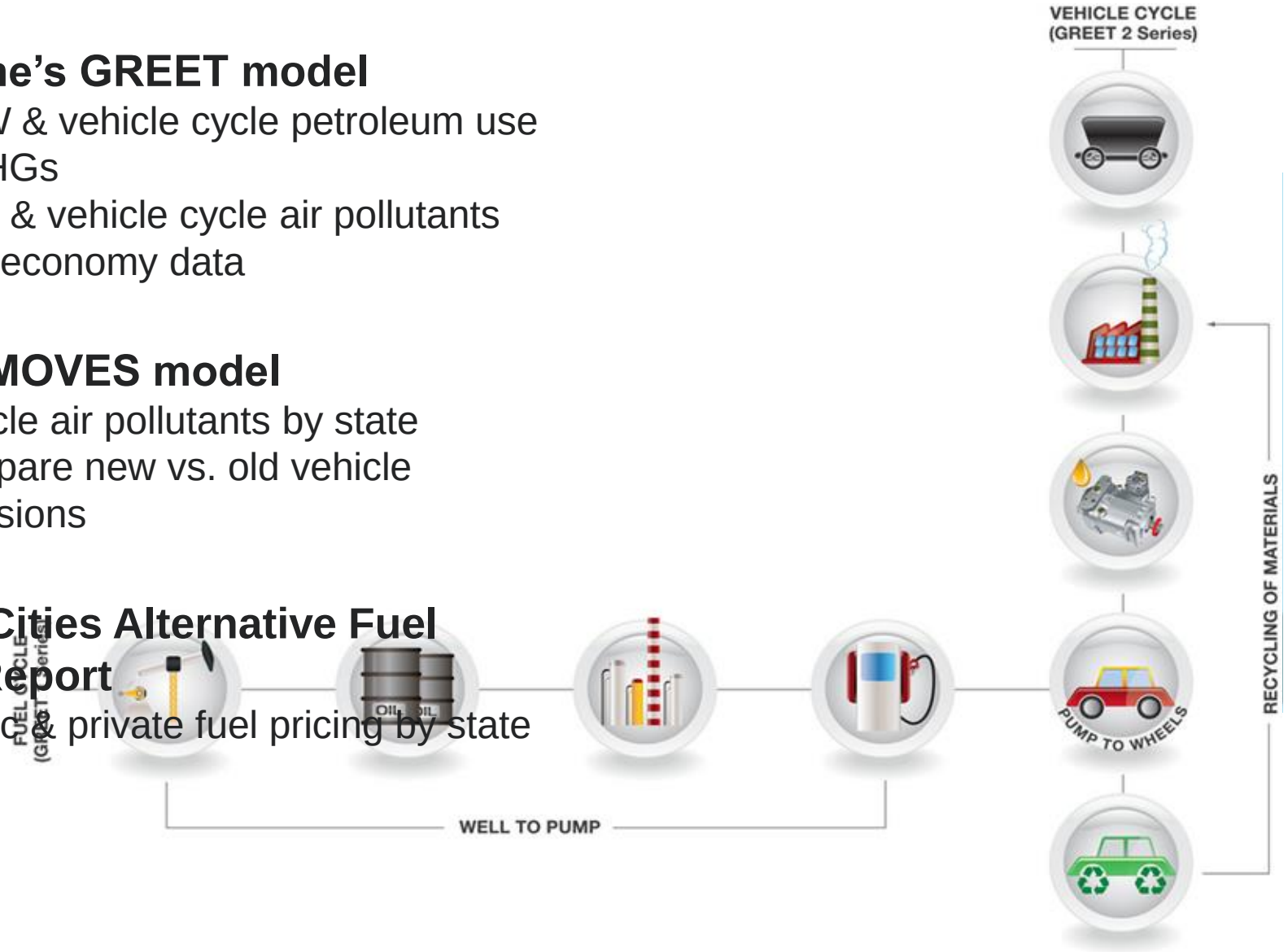
- **Idle Reduction Calculator**
  - Annual emissions & simple payback of purchasing of IR equipment vs. idling of conventional vehicles

AFLEET TOOL'S MAJOR DATA SOURCES

- **Argonne's GREET model**
  - WTW & vehicle cycle petroleum use & GHGs
  - WTP & vehicle cycle air pollutants
  - Fuel economy data

- **EPA's MOVES model**
  - Vehicle air pollutants by state
  - Compare new vs. old vehicle emissions

- **Clean Cities Alternative Fuel Price Report**
  - Public & private fuel pricing by state



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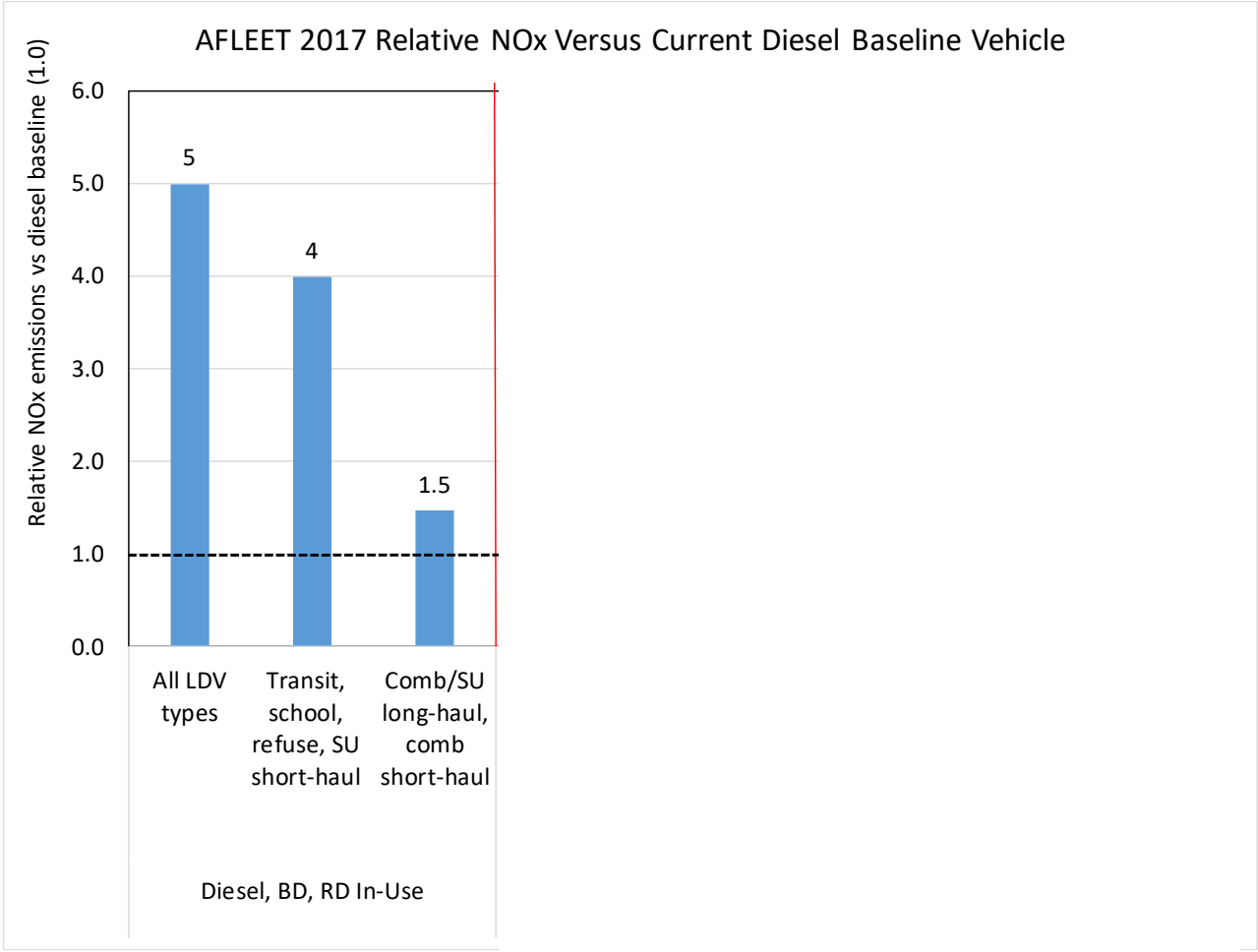
AFLEET TOOL 2017 UPDATES – DIESEL IN-USE EMISSIONS & LOW-NO_X ENGINES

- **Added feature to examine diesel in-use NOx emission estimates**
  - Factors based on Anenberg, Cai, Sandhu & MOVES
  - MOVES needs to revise diesel NOx
- **Added feature to examine HD NGV Low-NOx engines**
  - Factors based on Cai

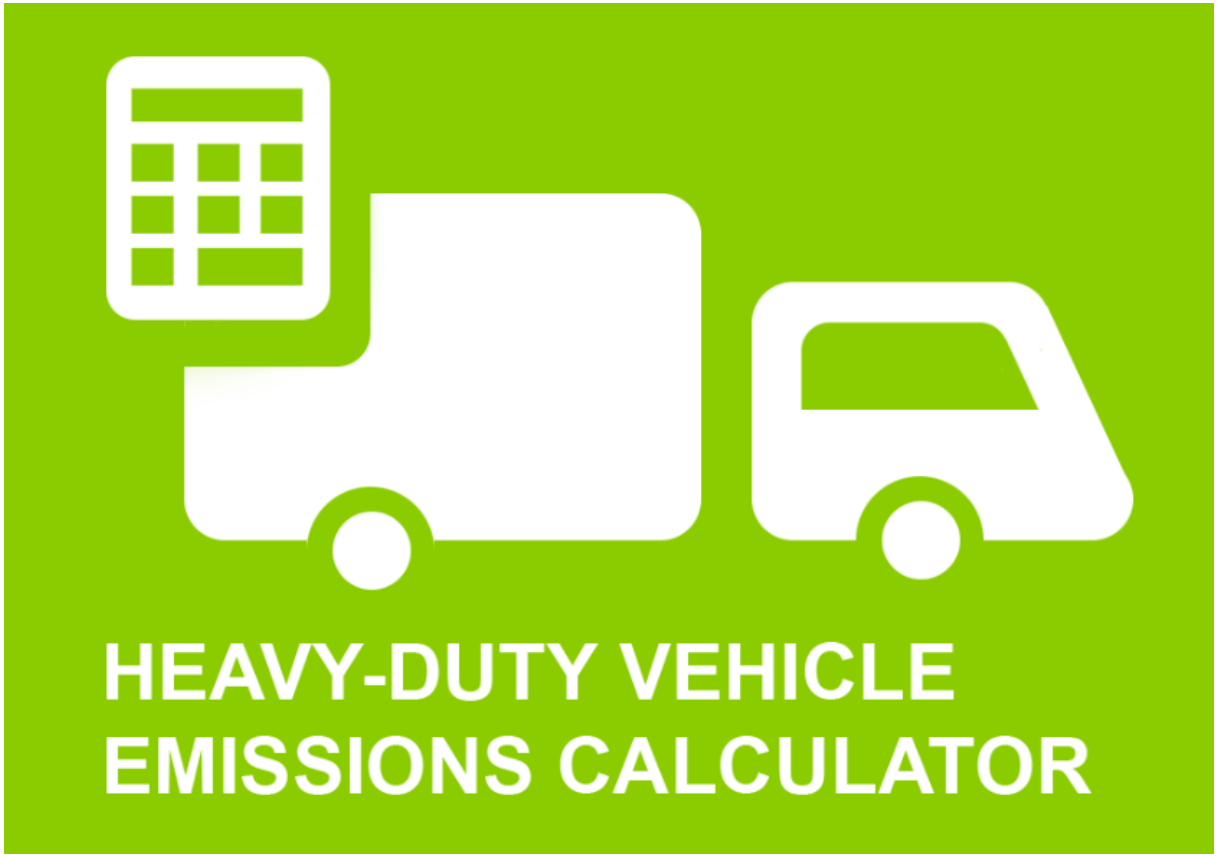


Anenberg, 2017, Impacts and mitigation of excess diesel-related NOx emissions in 11 major vehicle markets doi:10.1038/nature22086;

Cai, 2017, Wells to Wheels: Environmental Implications of Natural Gas As A Transportation Fuel

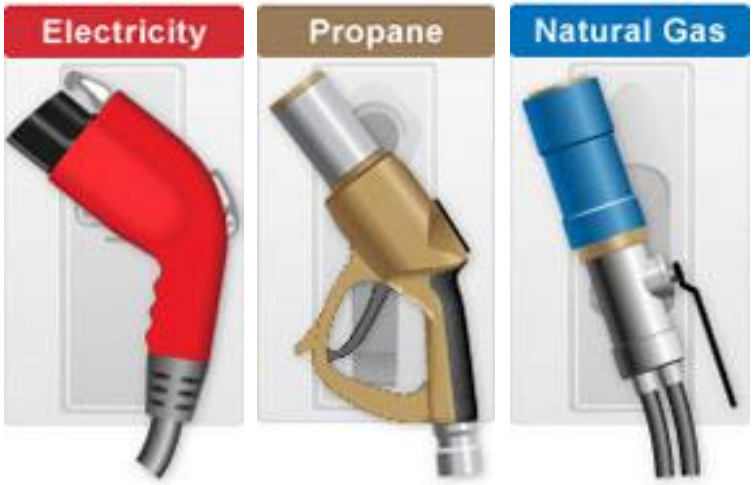
Sandhu, 2017, In-Use Emission Rates for MY 2010+ Heavy-Duty Diesel Vehicles

HDVEC Introduction



HEAVY-DUTY VEHICLE EMISSIONS CALCULATOR

- **Simple online tool based on AFLEET to help analyze AFVs for funding opportunities**
- **Examines medium-duty & heavy-duty vehicle:**
  - Vehicle operation NO_x & $PM_{2.5}$
  - WTW GHGs
  - Emission reduction cost effectiveness
- **Contains 4 fuel/vehicle technologies:**
  - Diesel
  - Electric vehicle
  - Propane
  - Natural Gas
- **HDVEC available at:** afleet-web.es.anl.gov/hdv-emissions-calculator/



HDVEC'S CALCULATION METHODS

- **Tool has 3 calculation methods & which to use depends on project type**

- **Environmental Mitigation w/ Scrappage**
  - New AFV vs. new diesel, plus additional benefit from early retirement of scrapped vehicle

- **Environmental Mitigation w/ Repower**
  - Vehicle after repower vs. diesel vehicle before repower

- **Clean Vehicle Replacement**
  - New AFV vs. new diesel

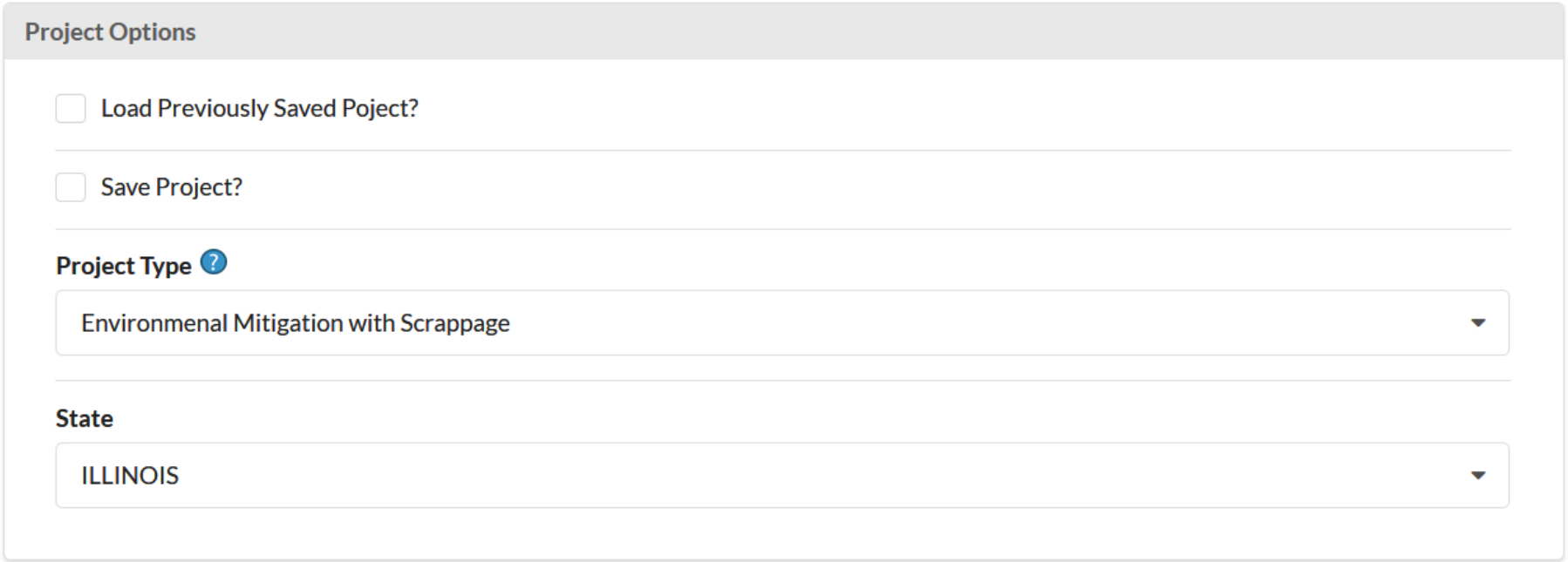
HDVEC Tutorial - Demo #1 - Environmental Mitigation w/ Scrappage

HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **3 tabs: About, Vehicle Options, & Results**

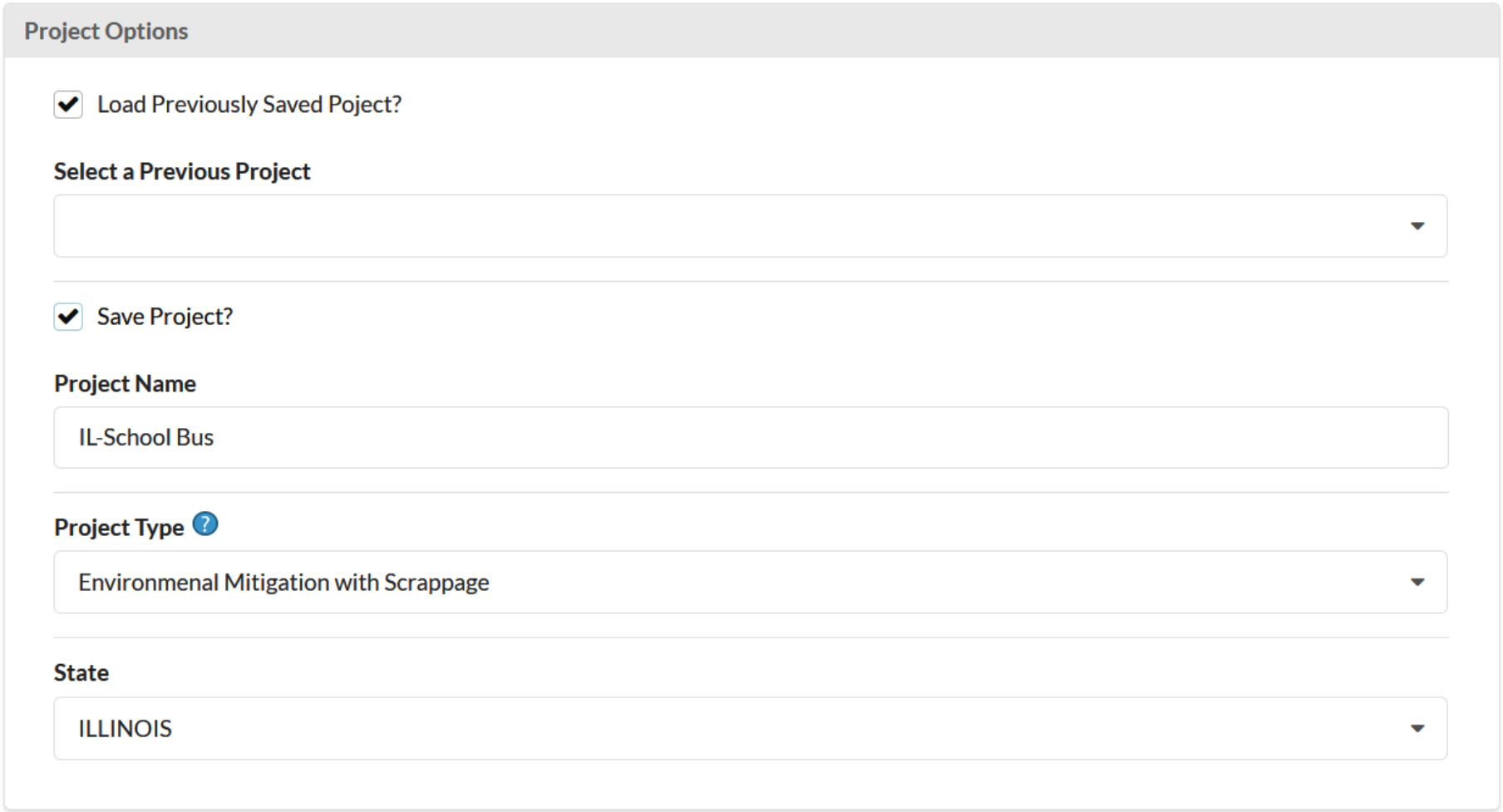
HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **1st step: on “Vehicle Options” enter project type and state**



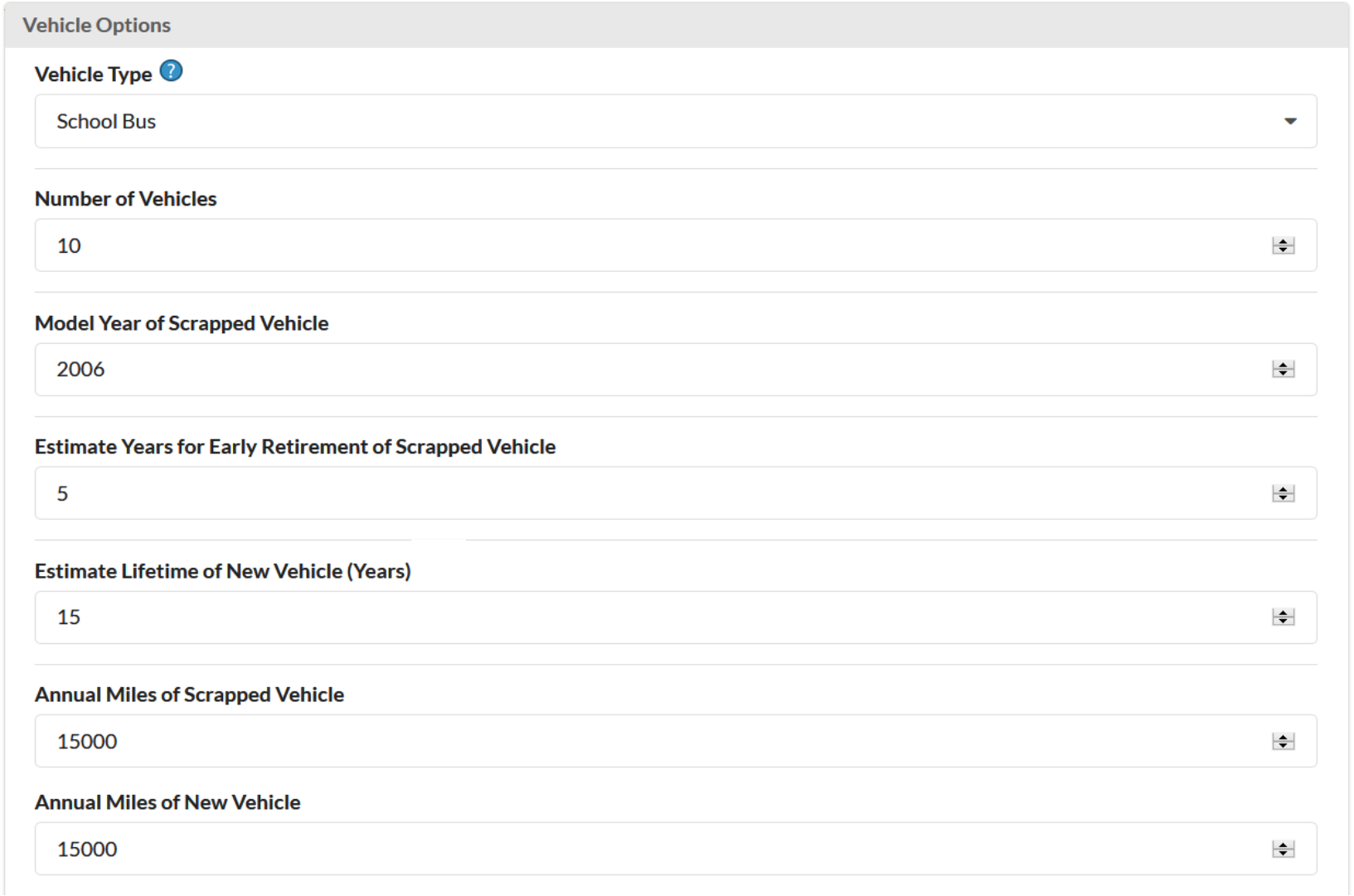
HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **Optional: load existing project or save (enter project name)**



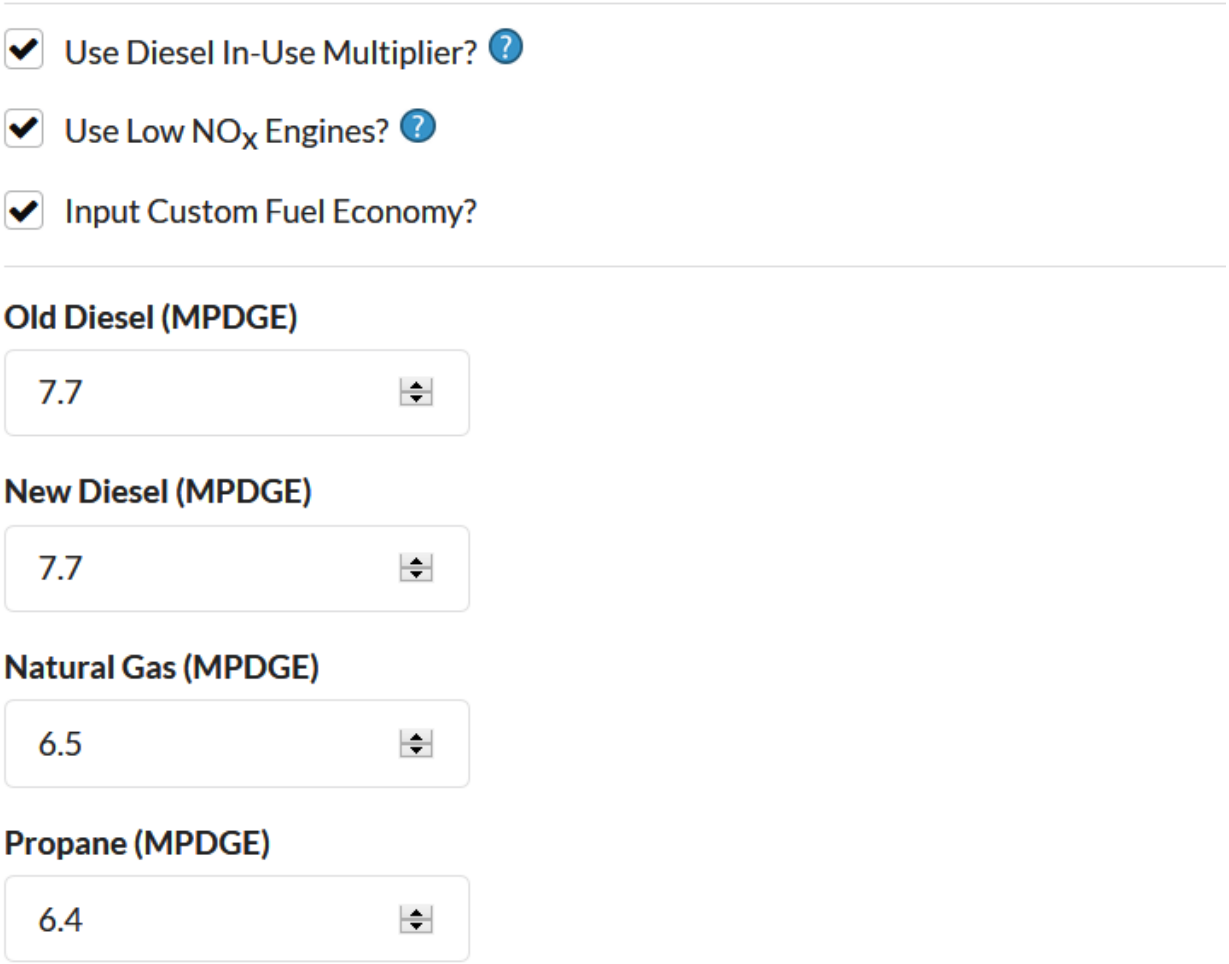
HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **2nd step: enter vehicle type, # of vehicles, MY of scrapped vehicle, yrs of early retirement, new vehicle lifetime, and VMT**



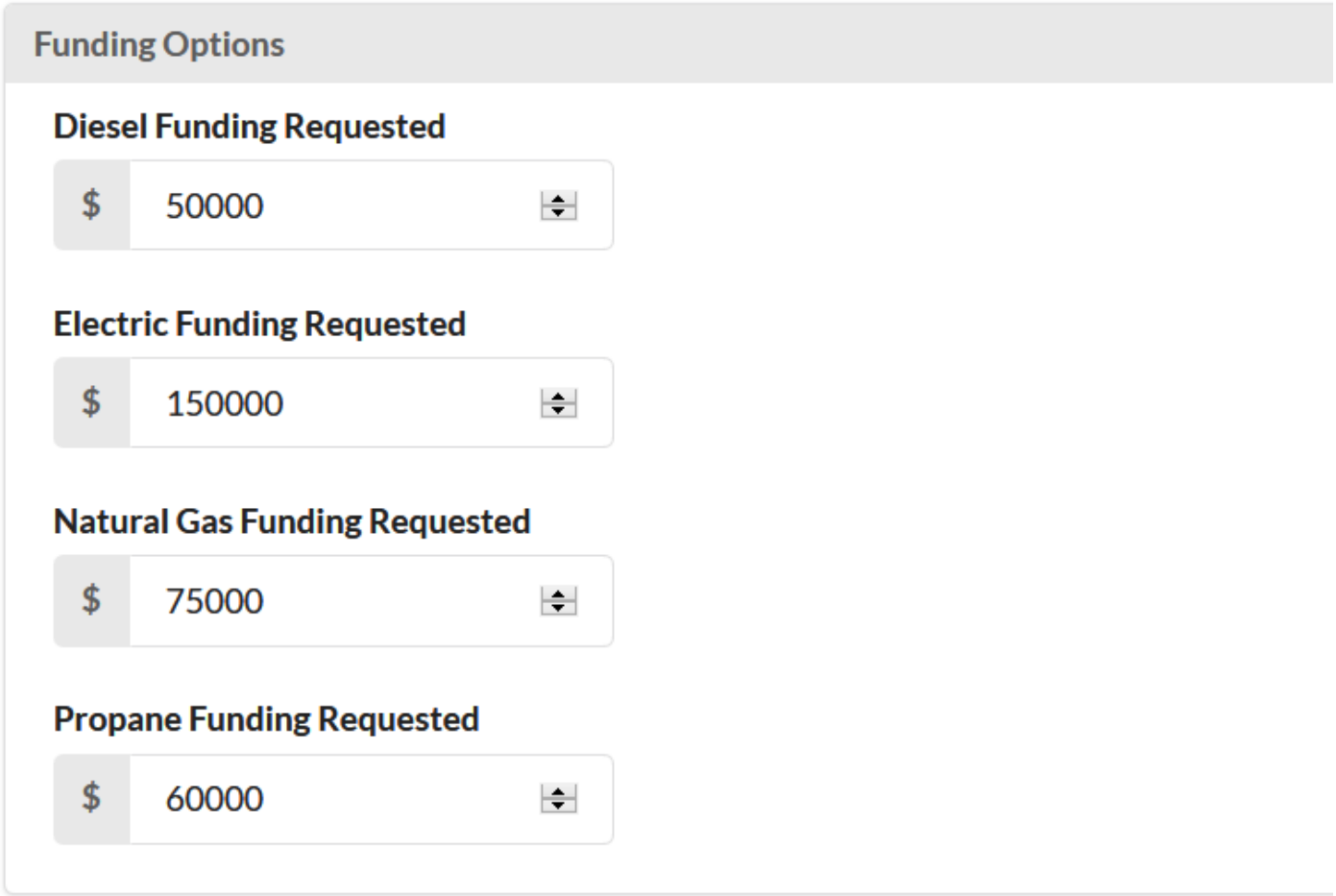
HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **Optional: use diesel in-use multiplier, low NOx engines, custom fuel economy data**



HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- 4th step: enter funding requested (for cost effectivenss)



HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **5th step: enter NG feedstock and EV source (default = state selected) and click "Calculate Results"**

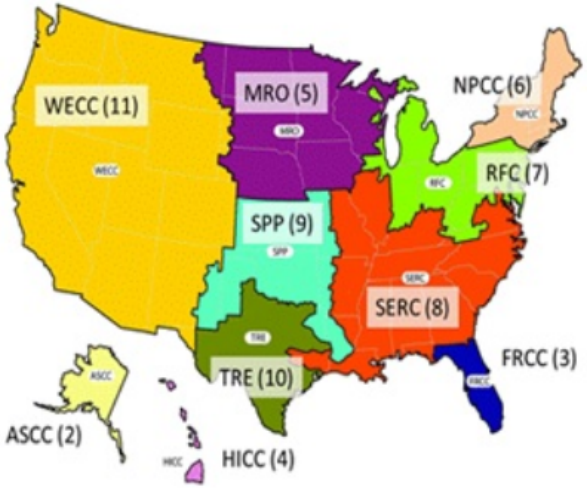
Fuel Options

Natural Gas (NG) Feedstock Source

North American NG

Source of Electricity - Electric Vehicles (EV)

RFC



Calculate Results

HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **Optional: enter custom electricity mix**

Source of Electricity - Electric Vehicles (EV)

Custom Mix

Residual Oil

% 0.6

Nautral Gas

% 31.9

Coal

% 34.3

Nuclear

% 20.4

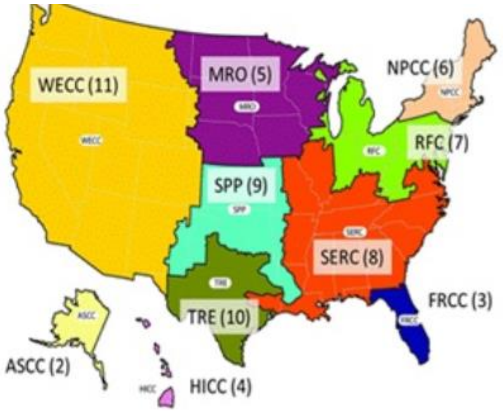
Biomass

% 0.2

Renewable (e.g. Wind, Solar)

% 12.6

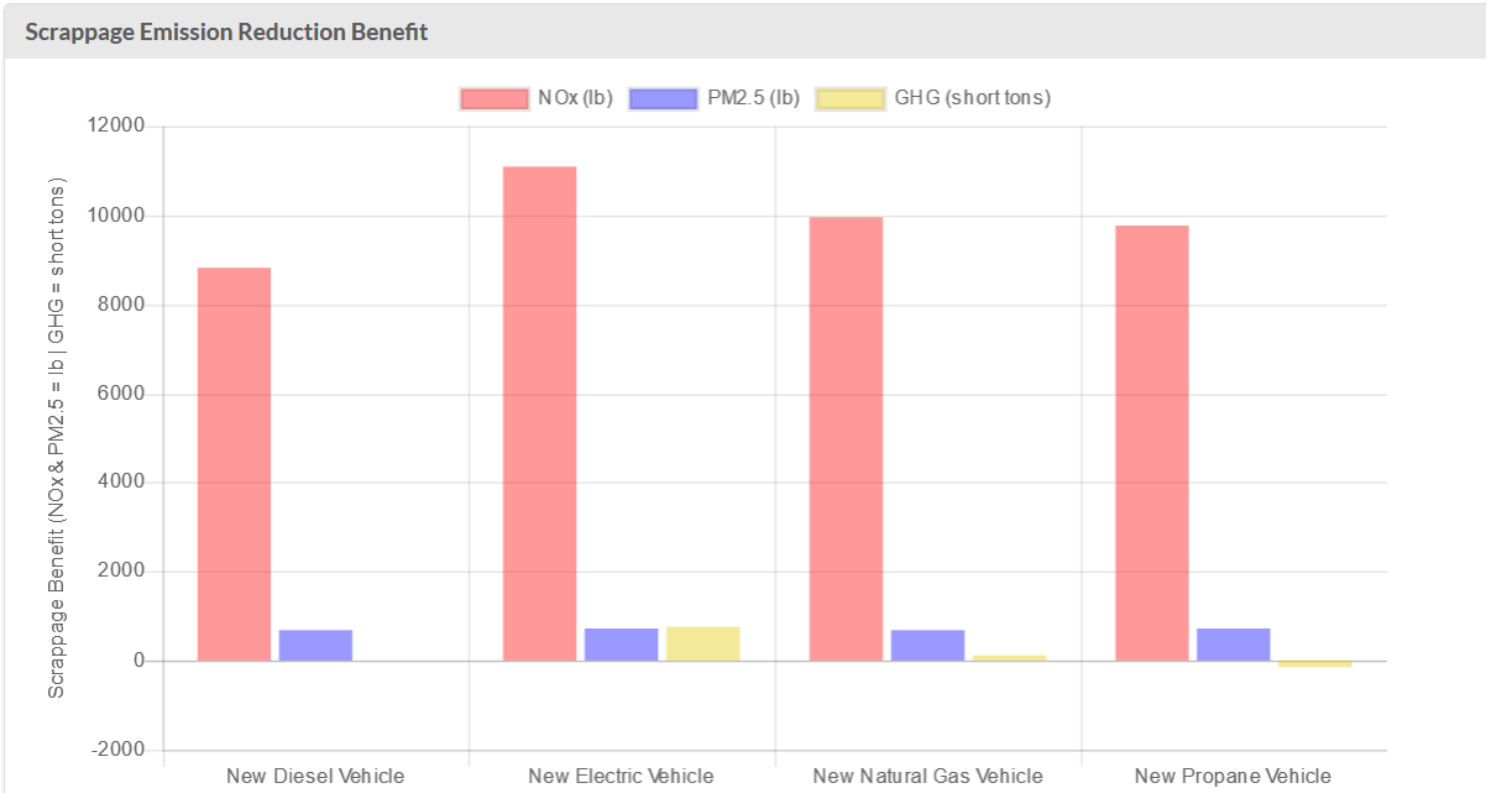
Total: 100%



Calculate Results

HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **Results: emission benefits (higher value = more reduction)**



New Vehicle Emission Benefits

Pollutant	Diesel	Electric	Natural Gas	Propane
NO_x (lb)	8,824.23	11,073.59	9,948.91	9,767.45
$PM_{2.5}$ (lb)	701.40	737.12	701.40	707.72
GHG (short tons)	0.00	755.61	105.72	-130.05

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HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **Results: cost effectiveness (lower value = more cost effective) & Optional: export results to Excel**

New Vehicle Cost Effectiveness

Pollutant	Diesel	Electric	Natural Gas	Propane
NO_X ($/lb)	$113	$271	$131	$113
$PM_{2.5}$ ($/lb)	$1,426	$4,070	$1,853	$1,554
GHG ($/ton)	N/A	$3,970	$12,297	N/A

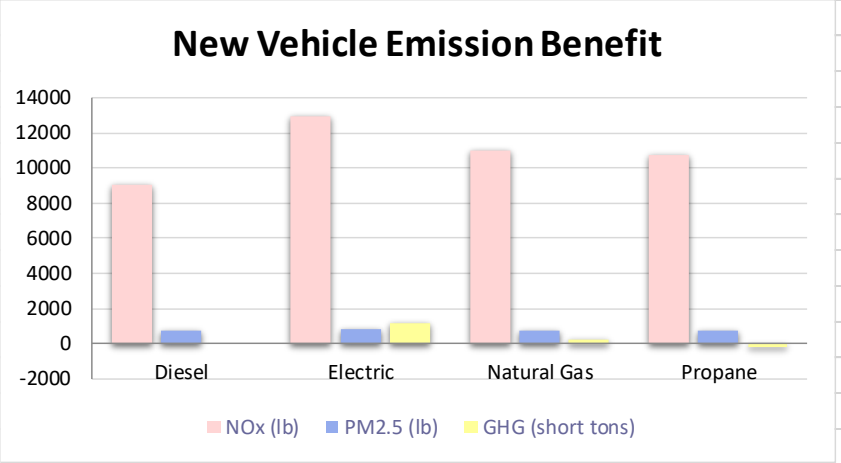
Export Results

HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **Optional: export to Excel 3 sheets Results, Inputs, Emissions**

IL-School Bus

Environmental Mitigation with Scrappage



New Vehicle Emission Benefits				
Pollutant	**Diesel**	**Electric**	**Natural Gas**	**Propane**
NOx (lb)	9053.38	12946.74	11000.06	10772.04
PM2.5 (lb)	747.7	807.88	747.7	755.56
GHG (short tons)	0	1138.8	186.04	-183.78

New Vehicle Cost Effectiveness				
Pollutant	**Diesel**	**Electric**	**Natural Gas**	**Propane**
NOx (lb)	$110	$232	$118	$102
PM2.5 (lb)	$1,337	$3,713	$1,739	$1,456
GHG (short tons)	$0	$2,634	$6,988	$0

Project Options	
State	IL
Project Type	Environmental Mitigation with Scrappage

Vehicle Options	
Type	School Bus
Number of Vehicles	10
Model Year of Scrapped Vehicle	2006
Years for Early Retirement of Scrapped Vehicle	5
Lifetime of New Vehicle (Years) After Scrappage	10
Annual Miles of Scrapped Vehicle	15000
Annual Miles of New Vehicle	15000
Use Diesel In-Use Multiplier?	No
Use Low NOx Engines?	No

Funding Options ($)	
Diesel Vehicle Funding	$1,000,000.00
Electric Vehicle Funding	$3,000,000.00
Natural Gas Vehicle Funding	$1,300,000.00
Propane Vehicle Funding	$1,100,000.00

Fuel Options	
Natural Gas (NG) Feedstock Source	North American NG
Source of Electricity	RFC

HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **Optional: export to Excel 3 sheets Results, Inputs, Emissions**

NOx Emissions				
Fuel	**Year**	**Remaining Years**	**Scrappage Years**	**Emission Rate (g/mi)**
Diesel	2006	N/A	5	6.174
Diesel	2017	N/A	5	0.69861039
Diesel	2017	10	N/A	0.828029221
Electric	2017	N/A	5	0
Electric	2017	10	N/A	0
Natural Gas	2017	N/A	5	0.349305195
Natural Gas	2017	10	N/A	0.41401461
Propane	2017	N/A	5	0.411012346
Propane	2017	10	N/A	0.45211358

PM2.5 Emissions				
Fuel	**Year**	**Remaining Years**	**Scrappage Years**	**Emission Rate (g/mi)**
Diesel	2006	N/A	5	0.463
Diesel	2017	N/A	5	0.0108
Diesel	2017	10	N/A	0.0128
Electric	2017	N/A	5	0
Electric	2017	10	N/A	0
Natural Gas	2017	N/A	5	0.0108
Natural Gas	2017	10	N/A	0.0128
Propane	2017	N/A	5	0.008888889
Propane	2017	10	N/A	0.011377778

GHG Emissions				
Fuel	**Year**	**Remaining Years**	**Scrappage Years**	**Emission Rate (g/mi)**
Diesel	2006	N/A	5	1673.965663
Diesel	2017	N/A	5	1673.965663
Diesel	2017	10	N/A	1673.965663
Electric	2017	N/A	5	1214.810242
Electric	2017	10	N/A	1214.810242
Natural Gas	2017	N/A	5	1598.955124
Natural Gas	2017	10	N/A	1598.955124
Propane	2017	N/A	5	1748.064074
Propane	2017	10	N/A	1748.064074

HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ SCRAPPAGE

- **Transit bus results: diesel in-use or low-NOx options *not selected***

New Vehicle Emission Benefits				
Pollutant	**Diesel**	**Electric**	**Natural Gas**	**Propane**
NO_X (lb)	32,521.53	44,946.50	38,734.02	N/A

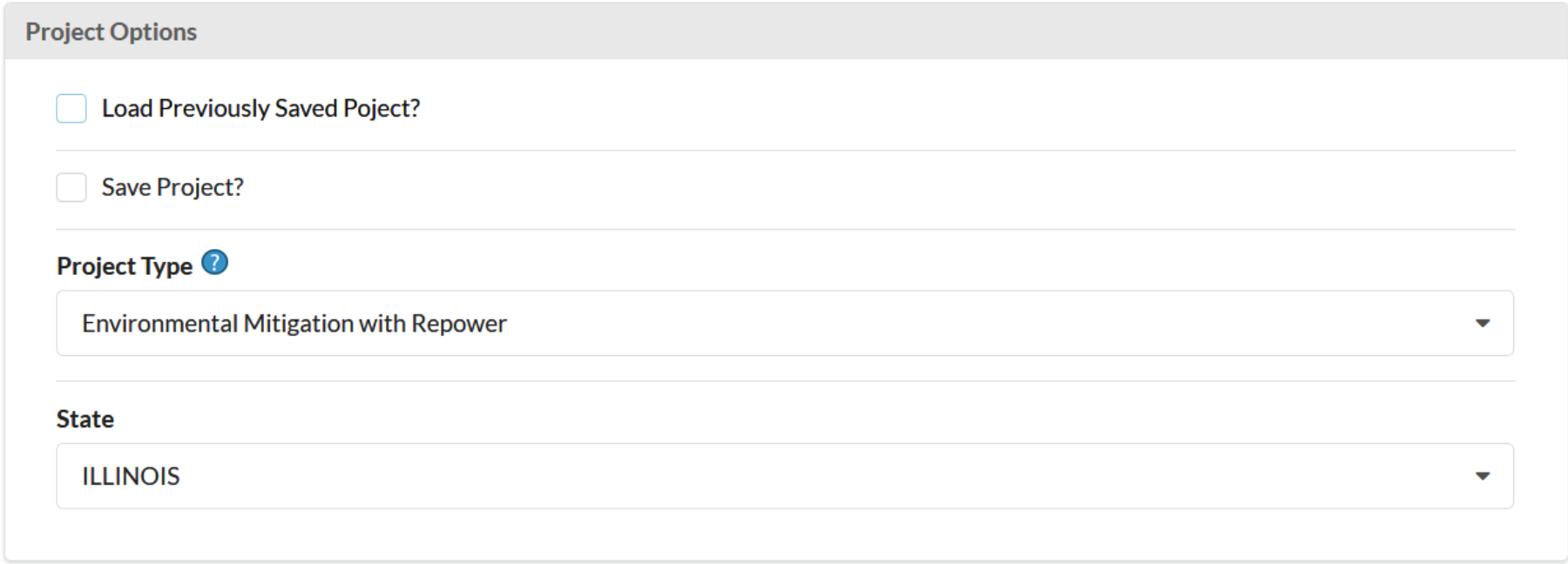
- **Transit bus results: diesel in-use or low-NOx options *selected***

New Vehicle Emission Benefits				
Pollutant	**Diesel**	**Electric**	**Natural Gas**	**Propane**
NO_X (lb)	21,195.41	70,895.28	70,274.03	N/A

HDVEC Tutorial - Demo #2 - Environmental Mitigation w/ Repower

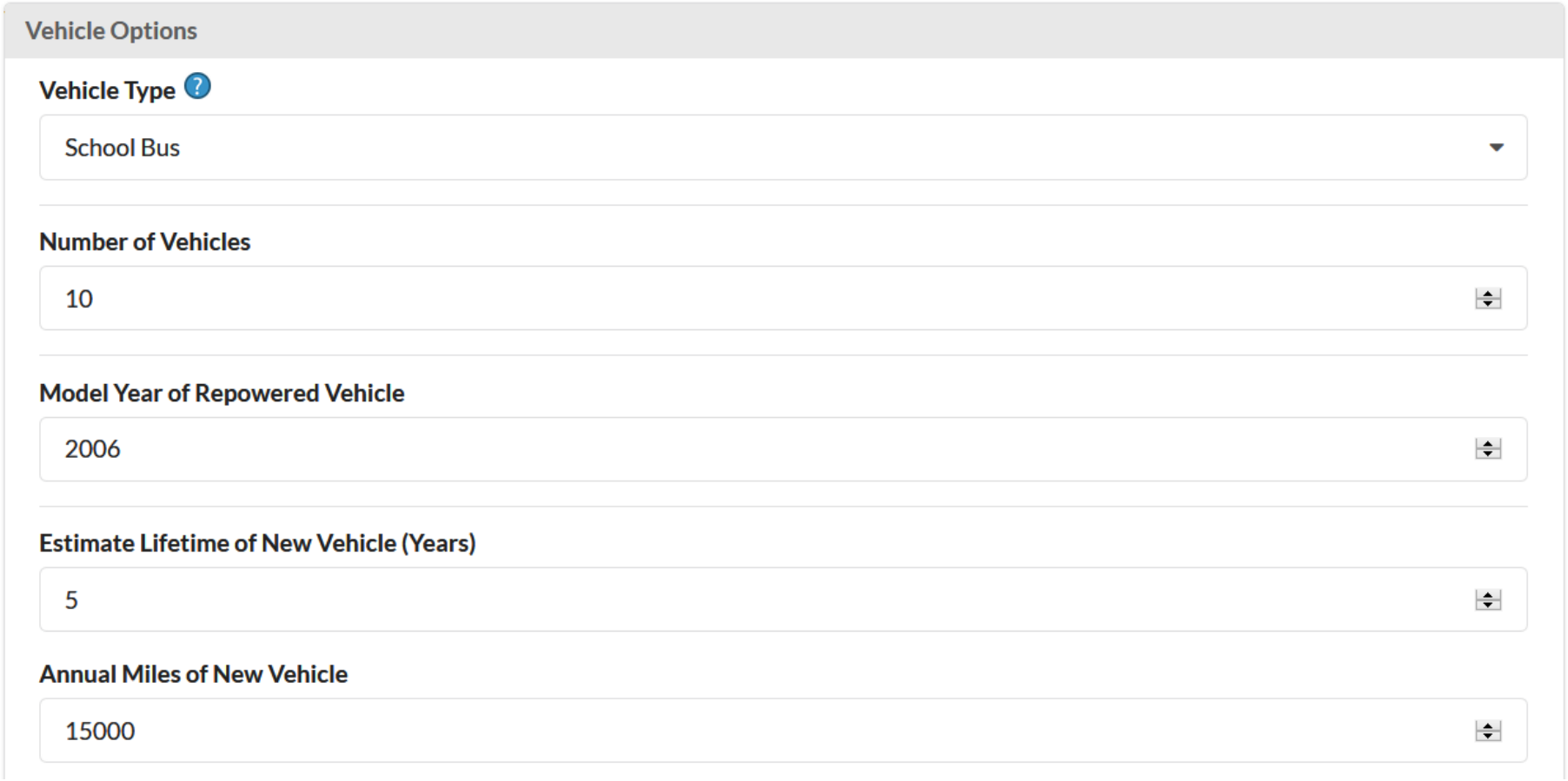
HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ REPOWER

- **1st step: on “Vehicle Options” enter project type and state**



HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ REPOWER

- **2nd step: enter vehicle type, # of vehicles, MY of repowered vehicle, new vehicle lifetime, and VMT**
  all other steps same as Scrappage option



HDVEC Tutorial - Demo #3 - Clean Vehicle Replacement

HDVEC TUTORIAL - CLEAN VEHICLE REPLACEMENT

- **1st step: on “Vehicle Options” enter project type and state**

HDVEC TUTORIAL - ENVIRONMENTAL MITIGATION W/ REPOWER

- **2nd step: enter vehicle type, # of vehicles, new vehicle lifetime, and VMT**
  all other steps same as Scrappage option

HDVEC SUMMARY

- **Argonne's HDVEC estimates NO_x, $PM_{2.5}$, and GHGs and cost effectiveness of med- & heavy-duty vehicles for funding opportunities**
  - Easy to use, online interface

- **Based on the AFLEET Tool emissions, calculations and data**
  - Includes 4 fuels: diesel, electricity, propane & NG

- **Includes 3 calculations options for different projects**
  - Environmental Mitigation w/ Scrappage
  - Environmental Mitigation w/ Repower
  - Clean Vehicle Replacement

THANK YOU!!!

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BACKUP SLIDES

HDVEC CALCULATION SUMMARY

Variables:

- A = Emissions of scrapped diesel vehicle (using scrappage years and scrappage annual miles from inputs)
- B = Emissions of new baseline diesel vehicle (using scrappage years and scrappage annual miles from inputs)
- C = Emissions of new baseline diesel vehicle (using new remaining years and new vehicle annual miles from inputs)
- D = Emissions of new AFV (using scrappage years and scrappage annual miles from inputs)
- E = Emissions of new AFV (using new remaining life years and new vehicle annual miles from inputs)

Scrappage Benefit Calculations:

Note: For scrappage projects “C” and “E” remaining years = lifetime years minus scrappage years

- New diesel vehicle w/ scrappage benefit = (A-B)
- New AFV w/ scrappage benefit = (A-D) + (C-E)

Repower Benefit Calculations:

Note: For repower projects, “A” is calculated using new lifetime years and new vehicle mileage

- Diesel repower benefit = (A-C)
- AFV repower benefit = (A-E)

Clean Vehicle Benefit Calculations:

- AFV benefit = (C-E)