



# Electric Vehicle Grid Integration for Sustainable Military Installations



NDIA Joint Service  
Power Expo

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# Agenda

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1. NREL Transportation Research
2. Net Zero Energy Installations (NZEI)
3. Fort Carson as a Case Study
  - Vehicles On-Site
  - Utility Operations
  - Vehicle Charge Management
4. Full Fleet Simulation
5. Continuing Work

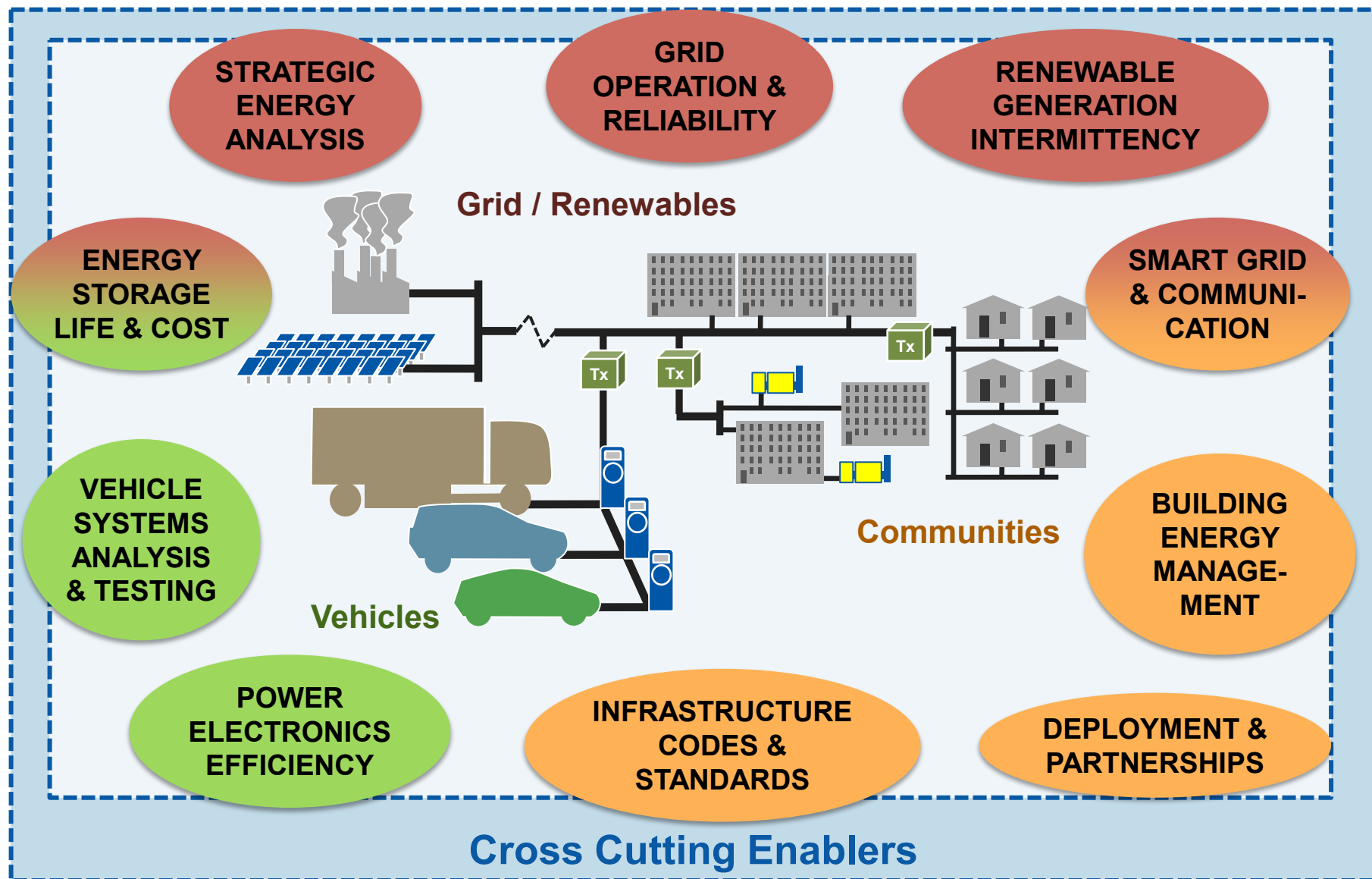
**NREL is the *only national laboratory* solely dedicated to advancing renewable energy and energy efficiency.**

**Our employees are committed to *building a cleaner, sustainable world.***

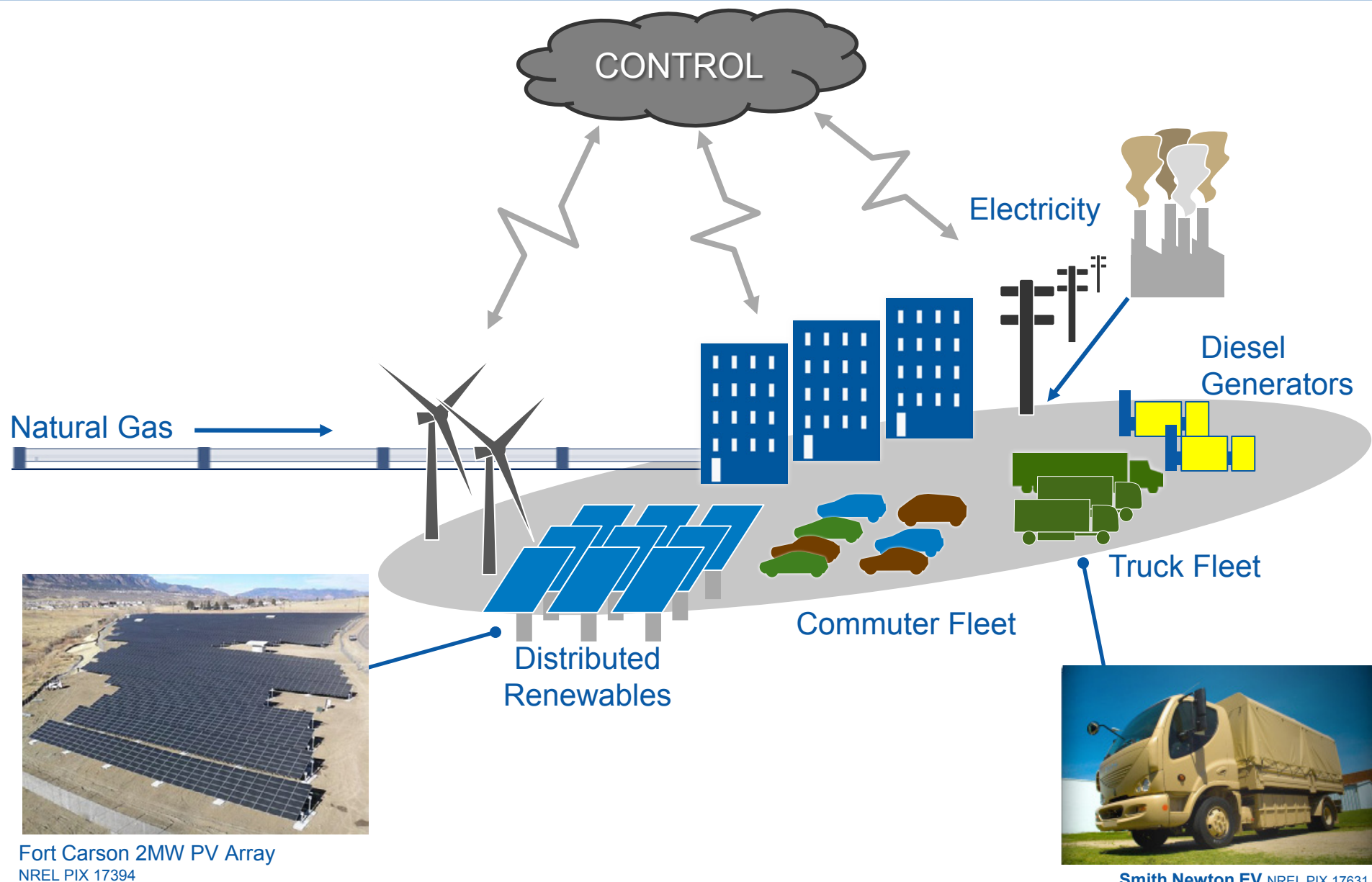


Photo Credits: NREL

# What is Electric Vehicle Grid Integration (EVGI)?



# Large multi-purpose campuses benefit from reduced energy consumption and renewable resources.



Fort Carson 2MW PV Array  
NREL PIX 17394

Smith Newton EV NREL PIX 17631



# Fort Carson Commuters

Hundreds of Thousands of Person-Miles Each Day...

Commercially available  
PEVs are here...









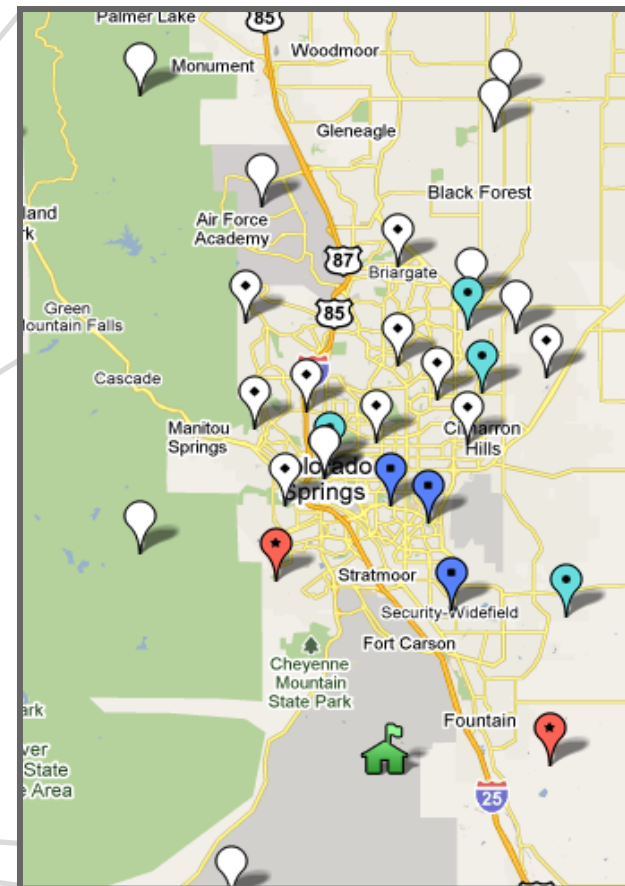
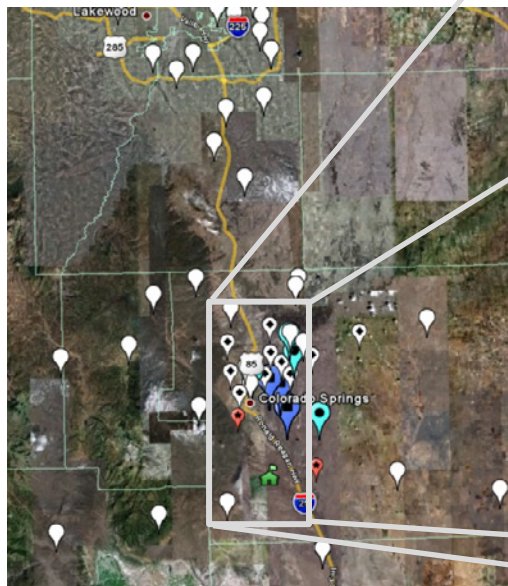
**Nissan Leaf**  
NREL PIX 18215

**Chevy Volt**  
NREL PIX 18215



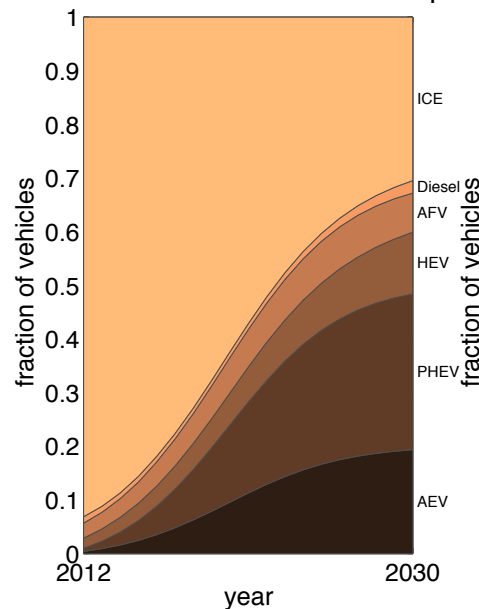
## Commuters from Local Zip Codes

-  Fort Carson
-  Over 2,000
-  1,000 to 2,000
-  500 to 1,000
-  100 to 500
-  10 to 100

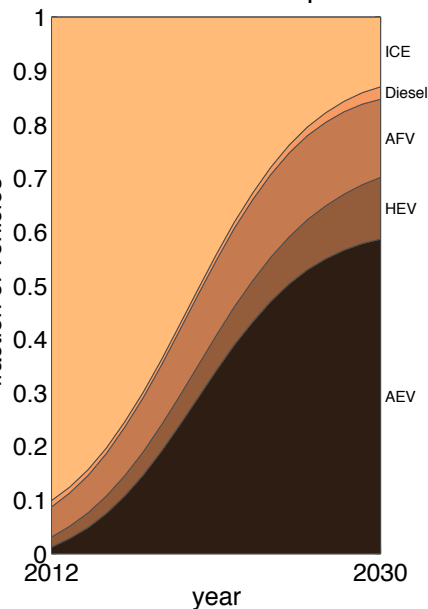


# Fleet Energy Opportunities

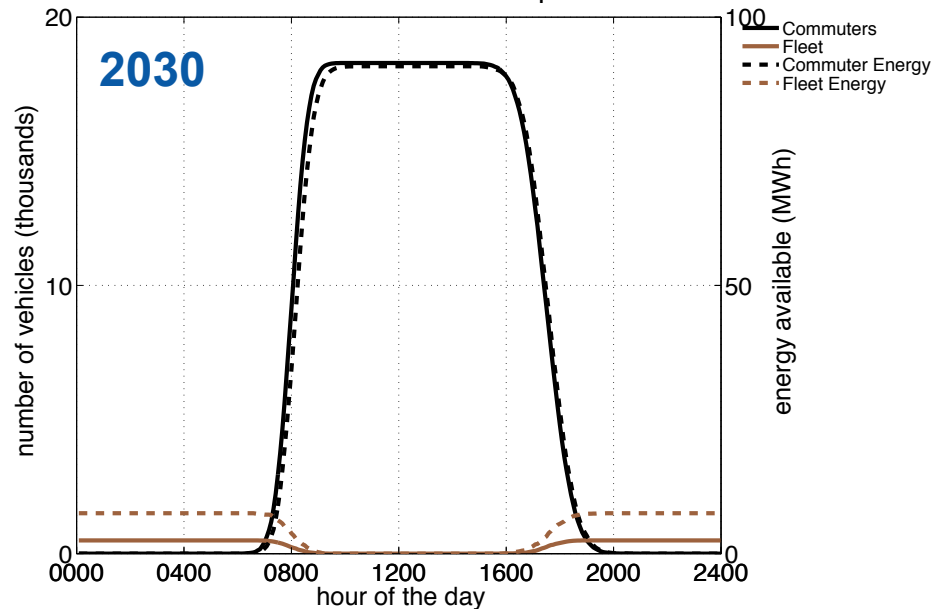
Commuter Vehicle Mix on Campus



Fleet Mix on Campus



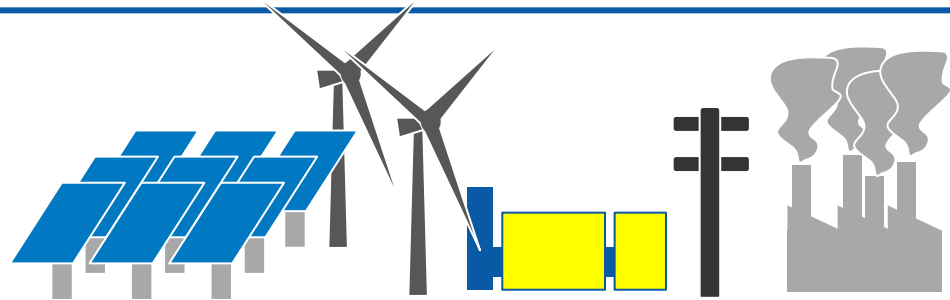
Vehicles Parked on Campus



*Dotted line is energy in PEVs only.*

GSA-Approved Vehicles	Smith Newton	Zero Truck ZT	Enova Ze
GVWR Class	4 to 6	3 to 5	3 to 4
GSA Item Number	571E.1	95E	134E.1
Maximum Range (mi)	100	75	150
Maximum Speed (mph)	50	60	65
GSA Base Price	\$167,000	\$142,100	\$109,500
Incremental Cost	\$109,548	\$119,573	\$80,309

# Example Power Exchange Scenarios



Normal Grid / Microgrid

1 Opportunity Charging



2 Managed Charging



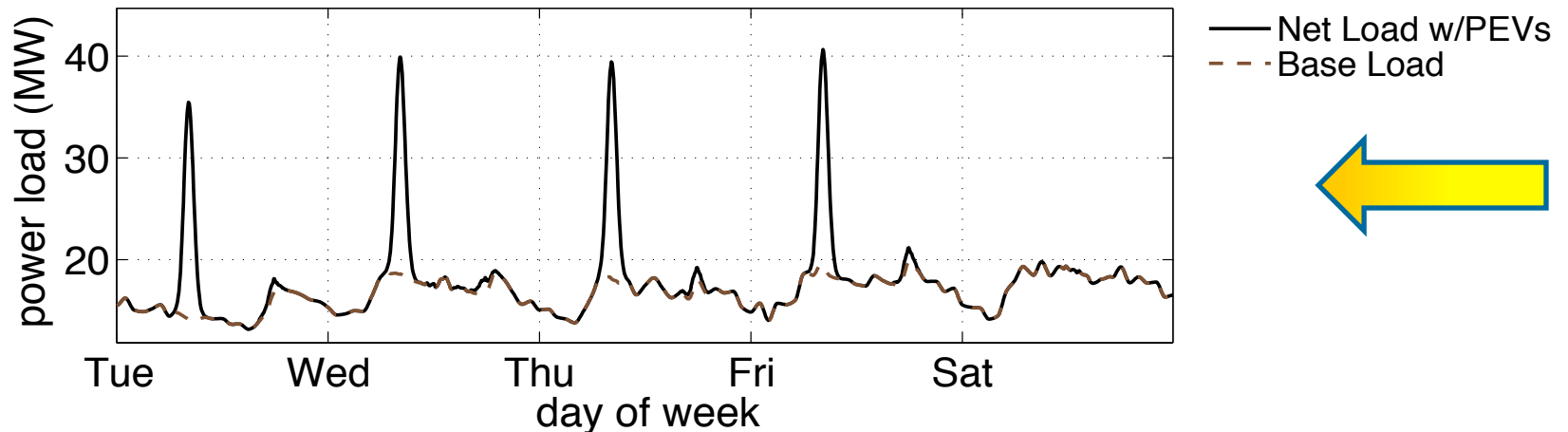
3 Managed Bi-directional Charging



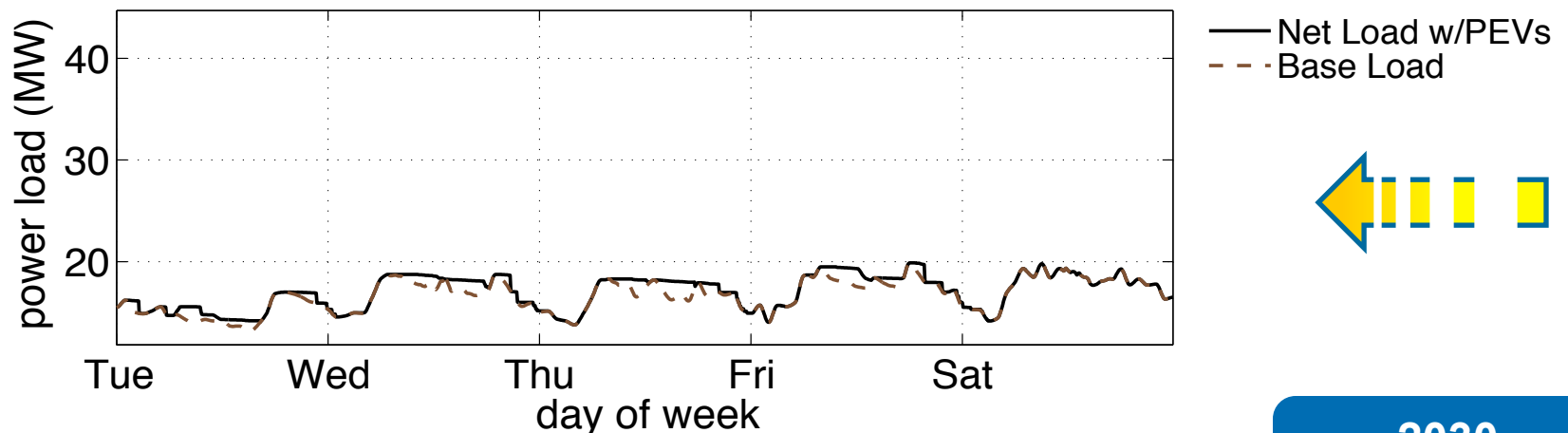


# PEV Charge Management

## Campus Base Load with Electric Vehicle Opportunity Charging

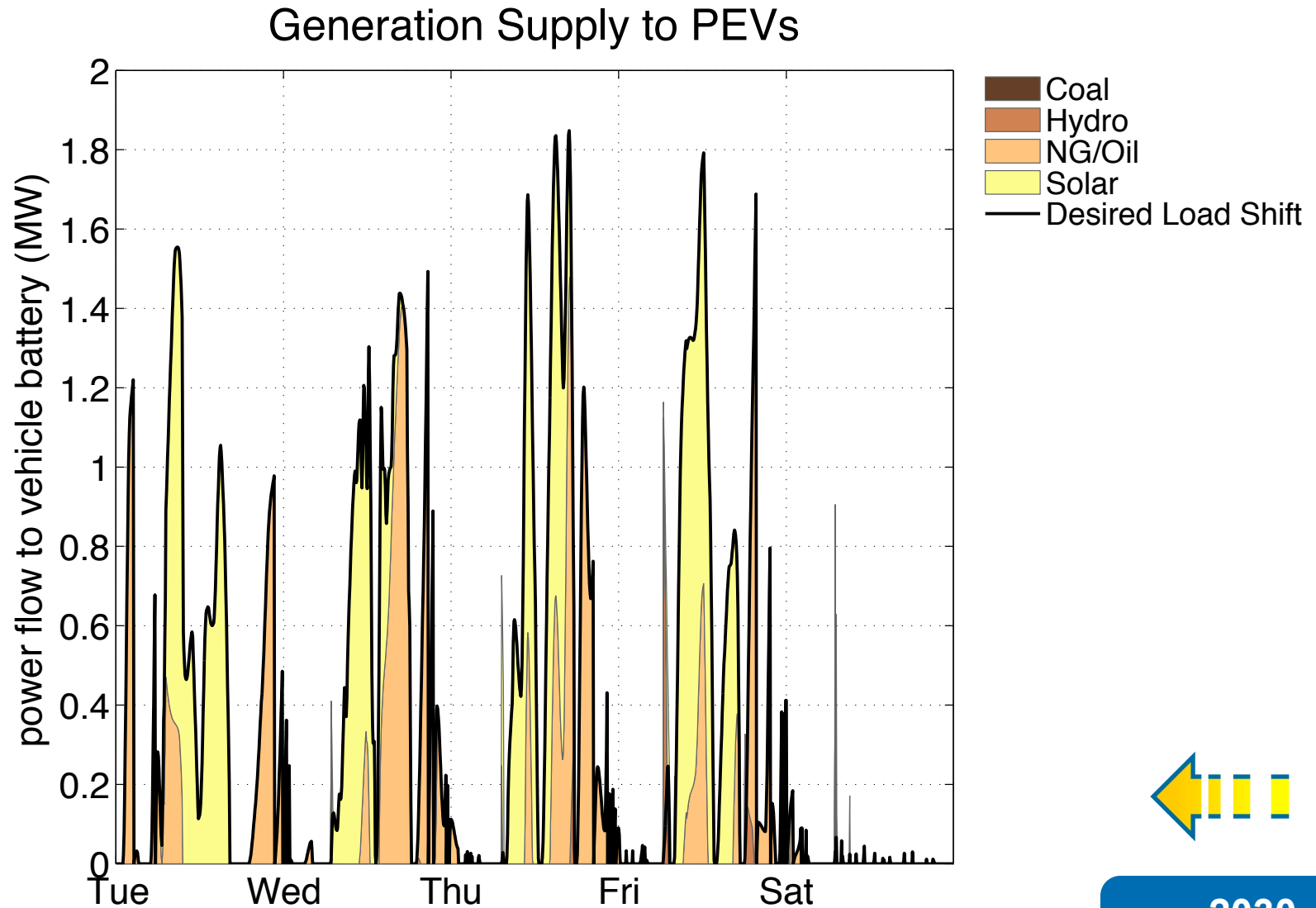


## Campus Base Load with Electric Vehicle Managed Charging



**2030  
Normal Grid**

# Enable greater resource stability



**2030  
Normal Grid**

# Load Leveling with PEVs

**Determine which vehicles are available based on day of the week** (commuters only M-F) **and situation** (fleet vehicles alternate between parked and mission driving during emergency)

## Time-step through simulation:

**Identify recent peak.**

Avoid exacerbating demand charges

**Determine which vehicles need power.**

Order vehicles by greatest difference between range remaining and range needed (commute distance)

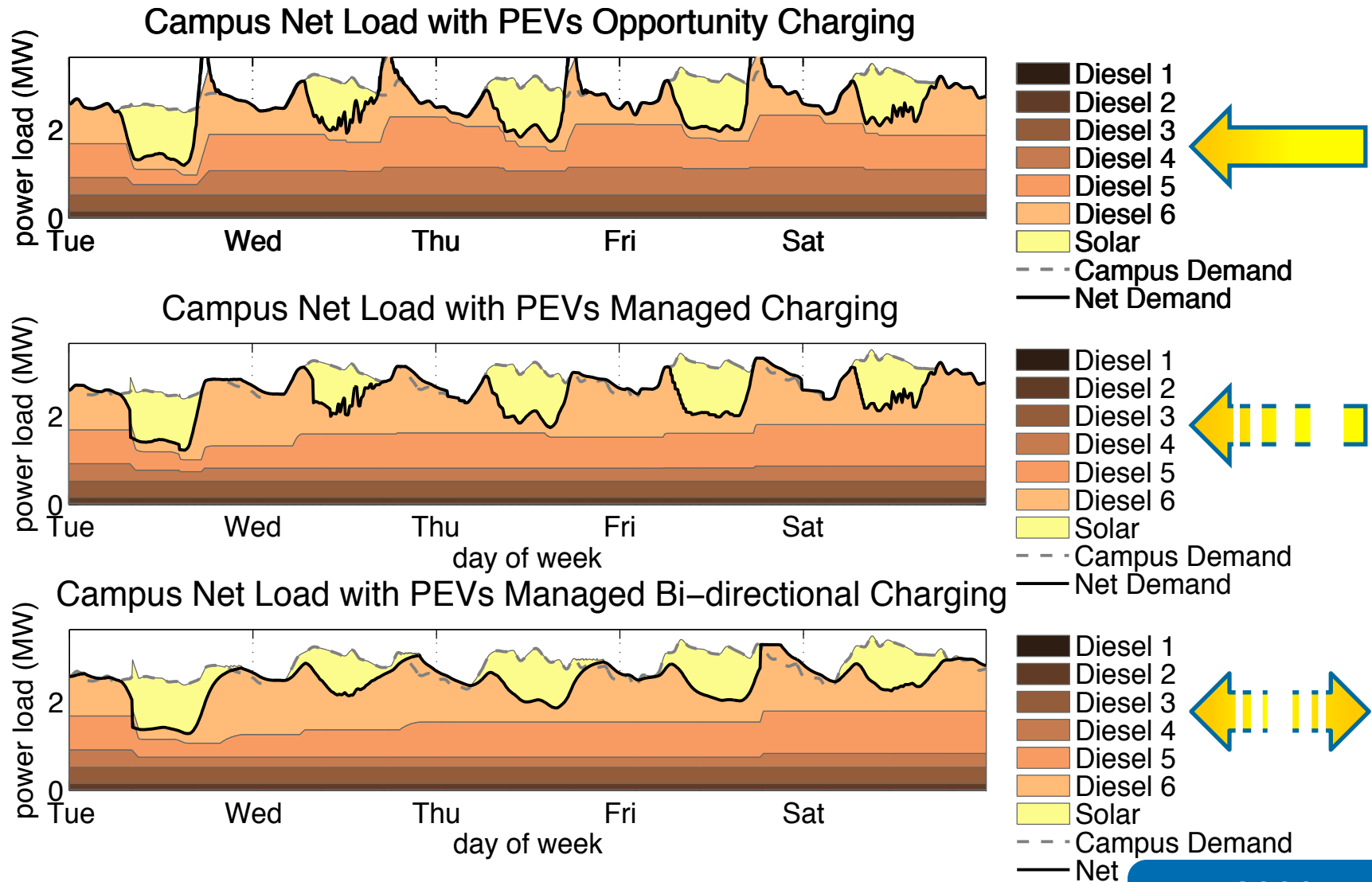
**Calculate amount to charge (+/-).** *NREL-developed Algorithm*

**Iteratively solve for vehicles that are ready to share the load.**

**Add power to total demand from those in need of charge.**

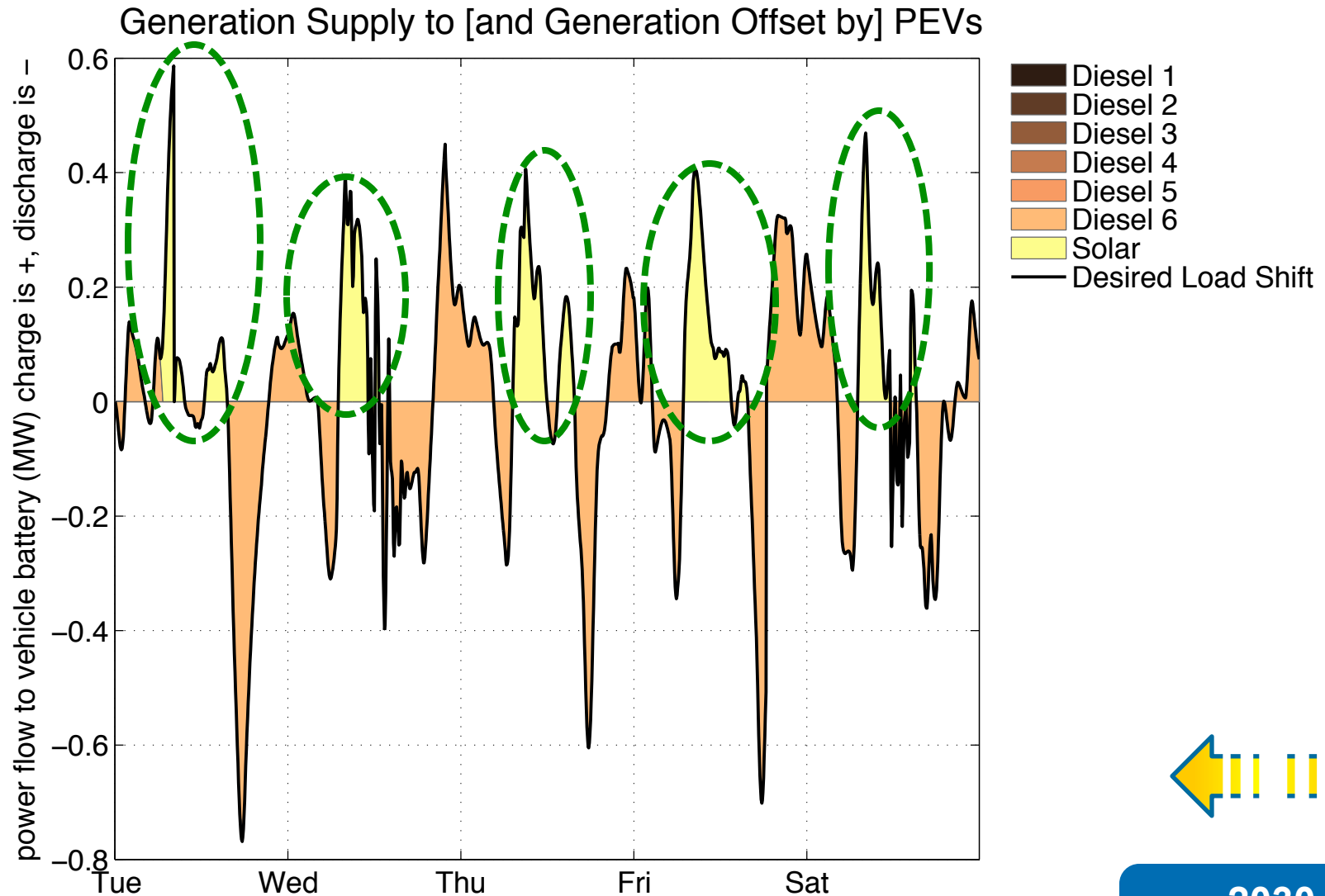
**Calculate miles remaining from SoC of each vehicle.**

# 75 electric trucks “buffer” the demand profile ...



**2030  
Microgrid**

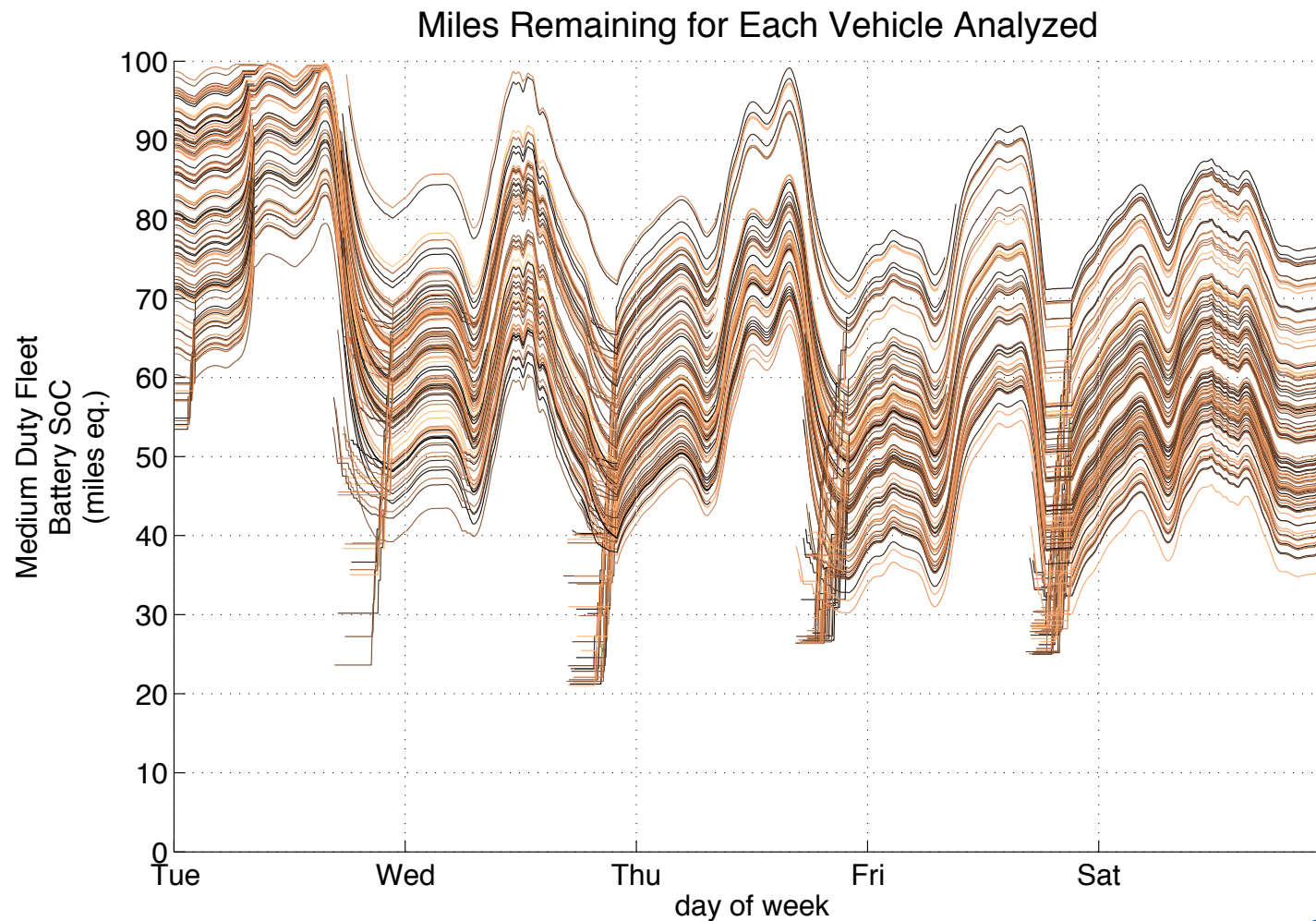
... and ensures maximum renewable energy utilization.



**2030  
Microgrid**



# Algorithms intelligently match vehicles with grid needs while ensuring mobility

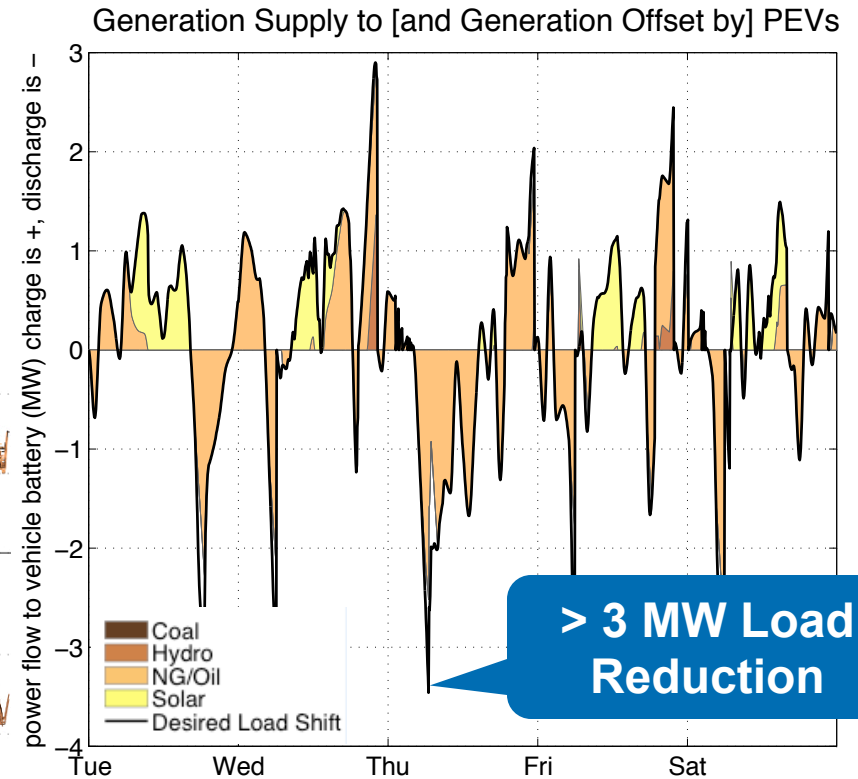
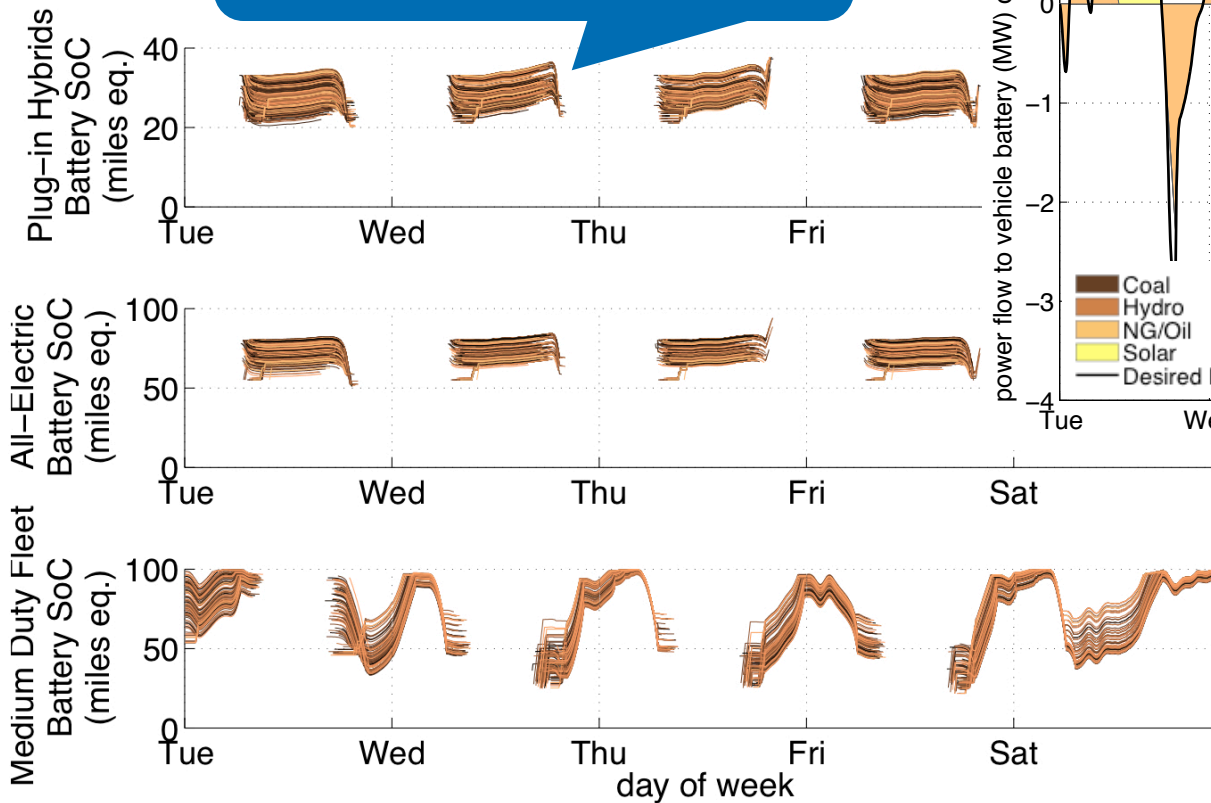


**2030  
Microgrid**

# Commuters add large benefit with little effect on each.

Frequent Solar  
Energy Uptake

< 25% SoC Window Used  
in Commuter Fleet



> 3 MW Load  
Reduction

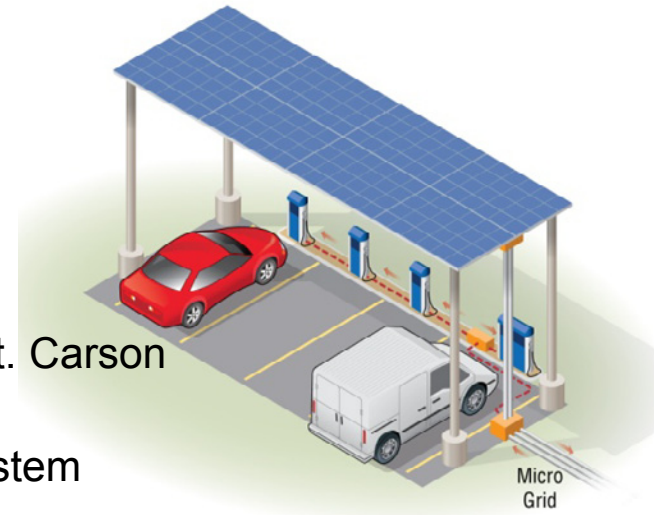


2030  
Normal Grid

# Grid-Vehicle Interface Component Requirements

## Definition Through DOD ECIP in FY11

- US Army sponsored ECIP project
  - **E**nergy **C**onservation **I**nterest **P**rogram
- Programmatic Goals:
  - Develop models, complete analysis specific to Ft. Carson for a RE and transportation microgrid node
  - Use that information to create an RFP for the system construction
- US Army Corp of Engineers collaboration
- Supports the development of parameterized models that can be used with optimization catered to each installation



**Collaboration  
on Microgrid  
Modeling**

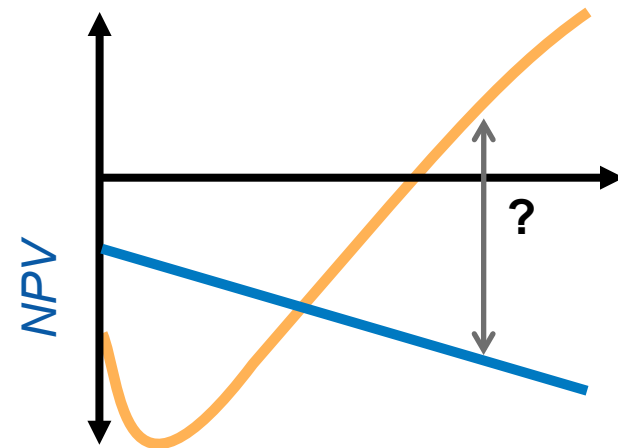
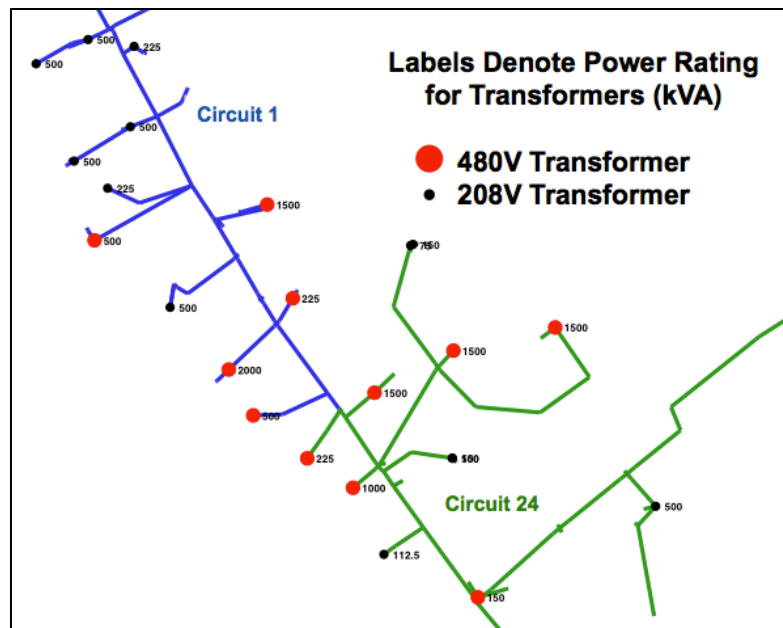
**Parameterized  
System  
Simulation**

**Design and  
Algorithm  
Optimization**

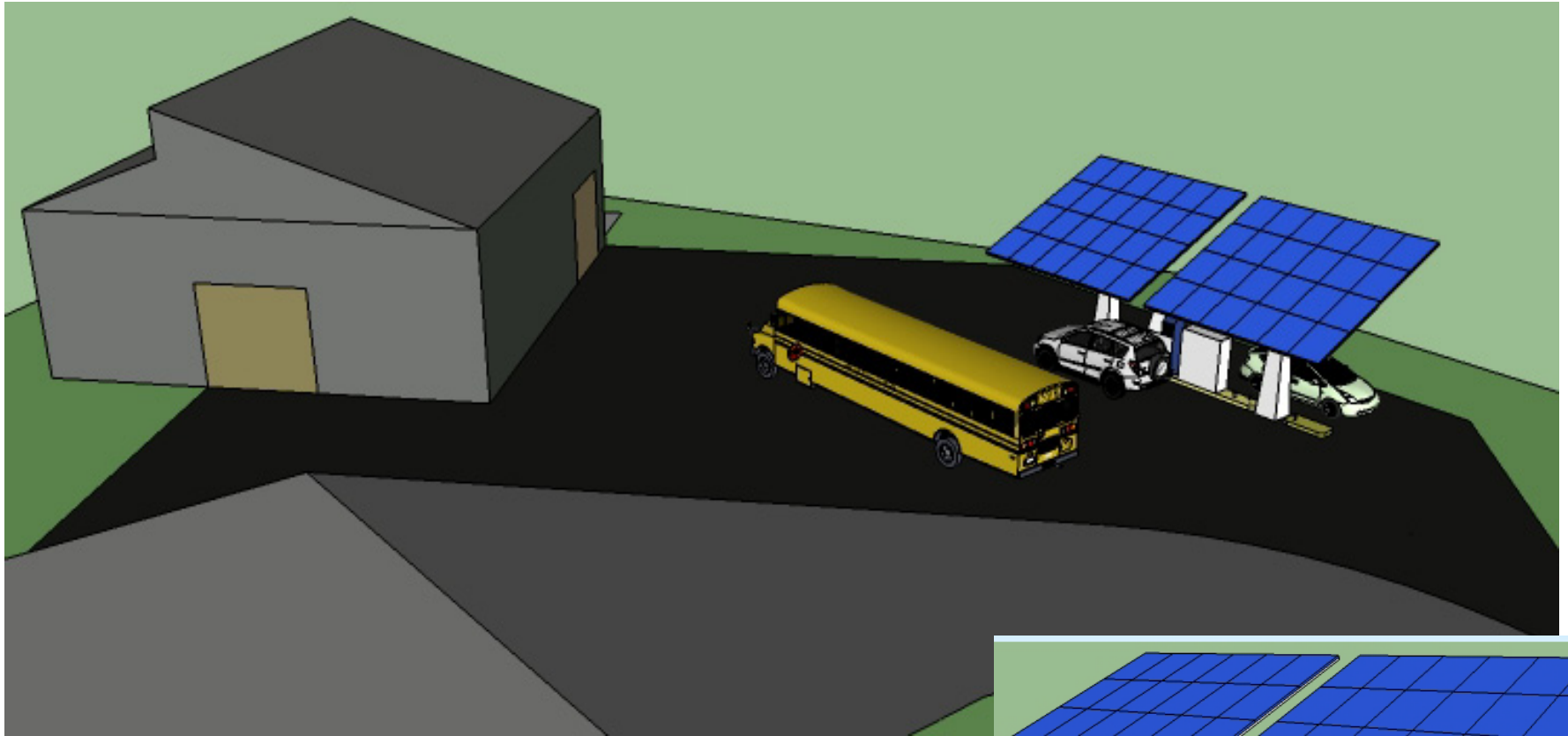
**Provide  
Advisement  
for RFP**

# ECIP: Current Status

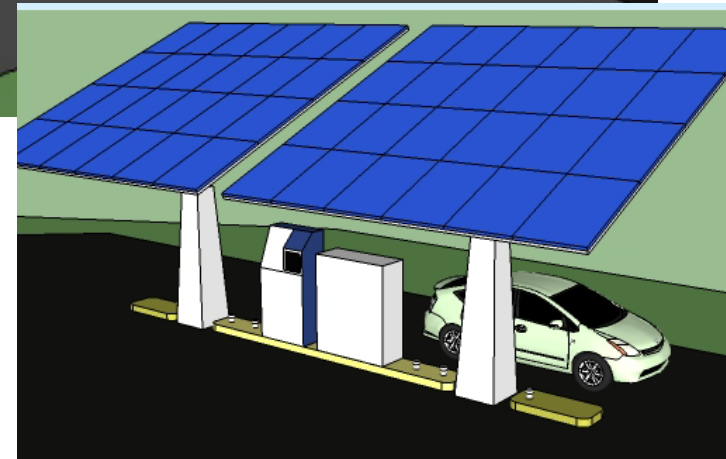
- Microgrid Model Complete
  - OpenDSS (EPRI) open source platform used
- Node component models started
- Cost model for Colorado Springs Utility initialized
- On track to integrate models and begin optimization



# RECharge Integrated Demonstration Site



Garage + Vehicle-Grid-Renewables  
Testbed at NREL Campus FY11





# Thank you.

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