

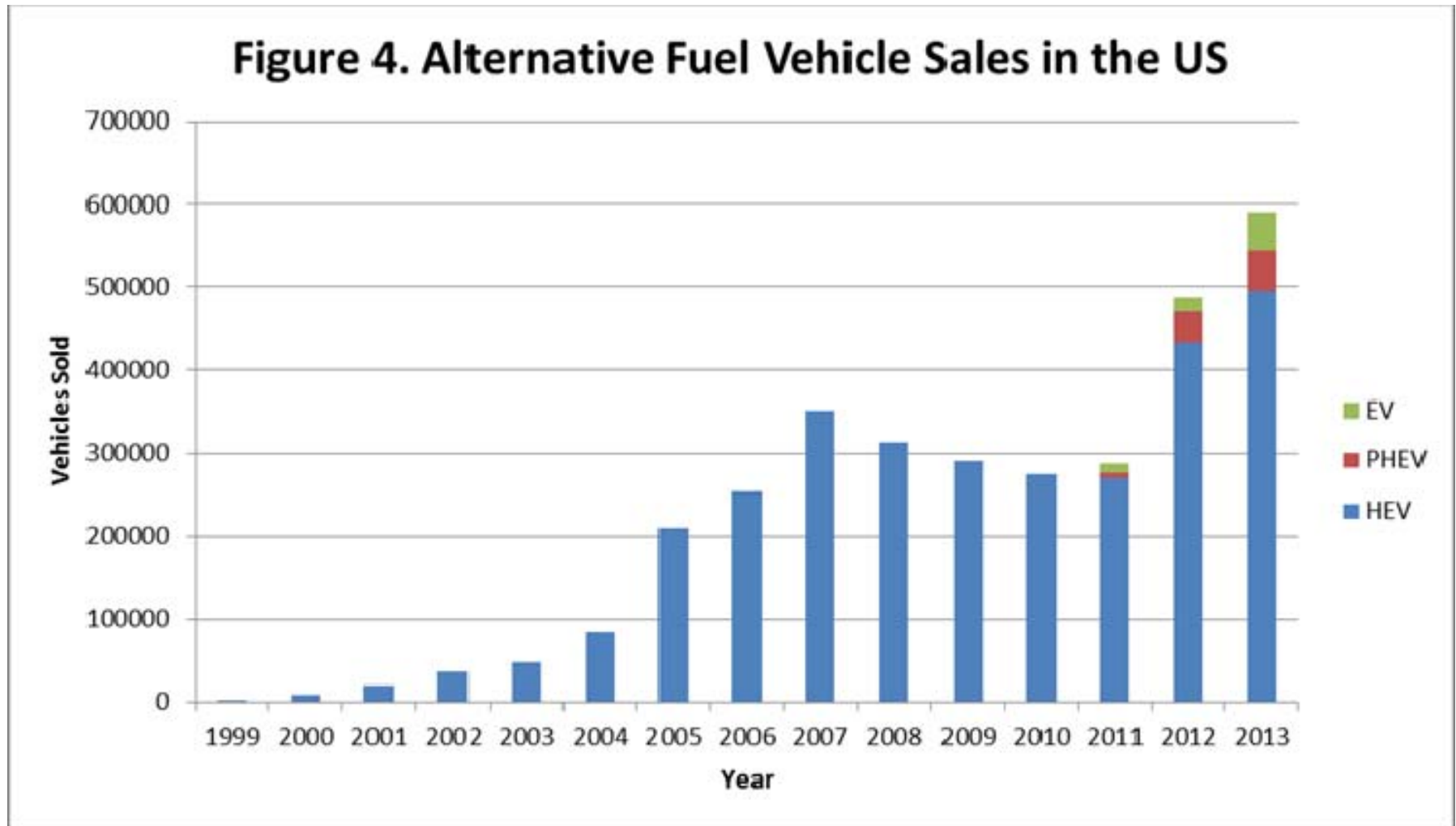
# Greenhouse Gas Emissions Associated with Electric Vehicles in Minnesota

Legislative Energy Commission, Minnesota State  
Legislature

July 29, 2015

Matthew Prorok

# Growing Number of EVs Sold in US



Source: U.S. Department of Energy Alternative Fuels Data Center, 2014

# Why Your Electric Vehicle Might Not Be as Green as You Think



## Coal Makes Electric Cars Bad? No, Plug-Ins Show Coal As Bad



## Cleaner than what?

Why an electric car may be much dirtier than a petrol one

Dec 20th 2014 | From the print edition



## Coal-Powered Electric Cars Out-Pollute Fossil Fuels



## All-electric cars: Not so eco-friendly

ENERGY 7/21/2013 @ 1:56AM | 51,725 views

## Are Electric Cars Really That Polluting?



+ Comment Now + Follow Comments

# What are the GHG emissions from EV charging in MN?



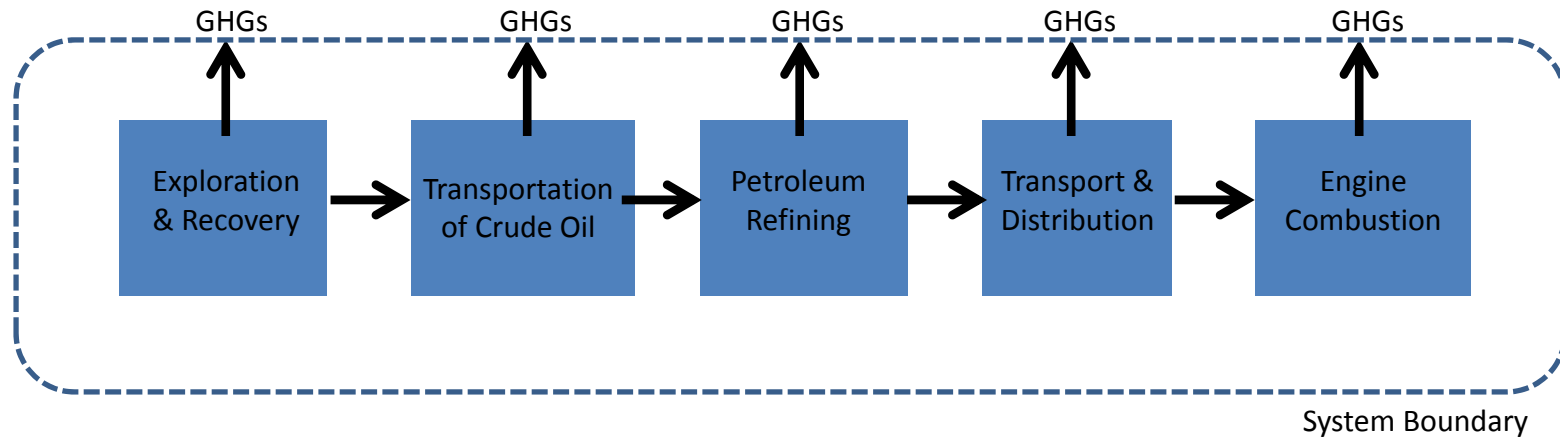
Laura Taylor, NCSU



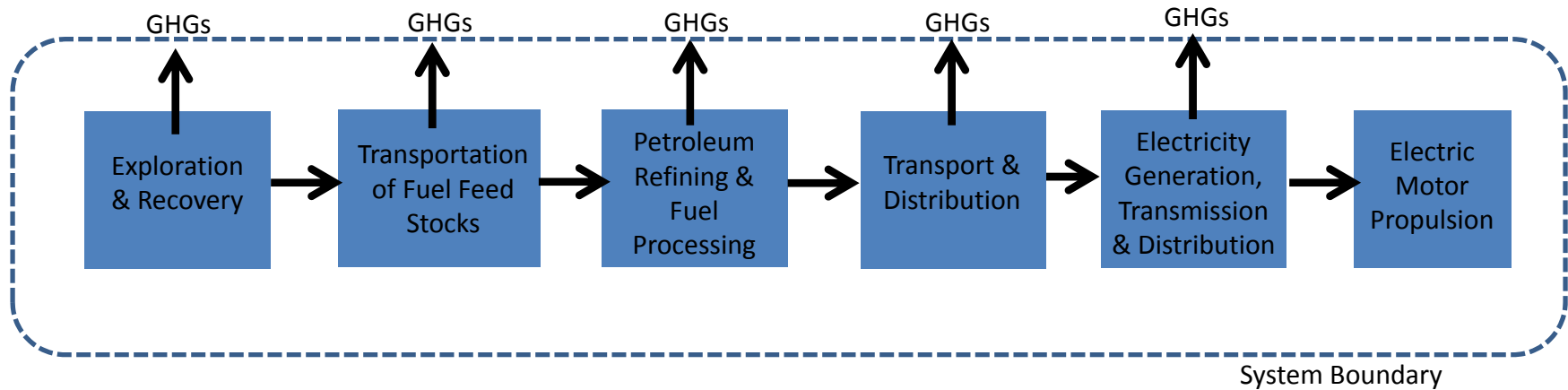
Elizabeth Wilson, HHH

# Use Phase Life Cycle Analysis

## Conventional Vehicles



## Electric Vehicles



Source: Adapted from Argonne National Laboratory's GREET Model

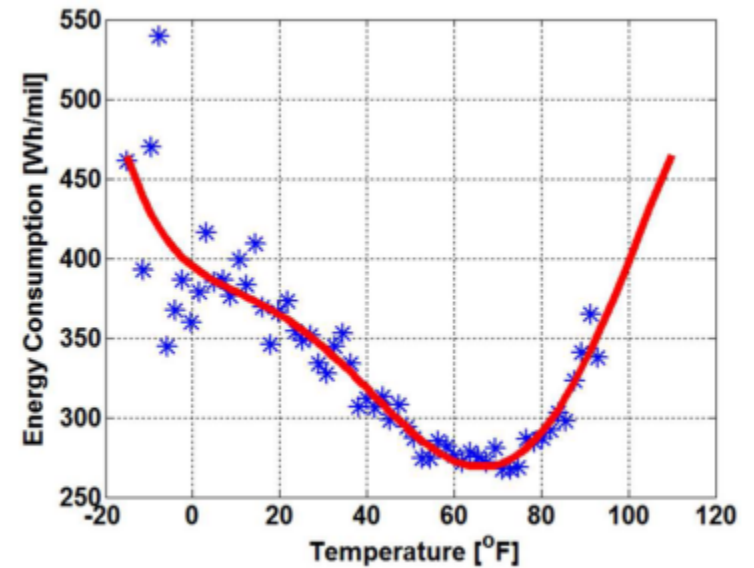
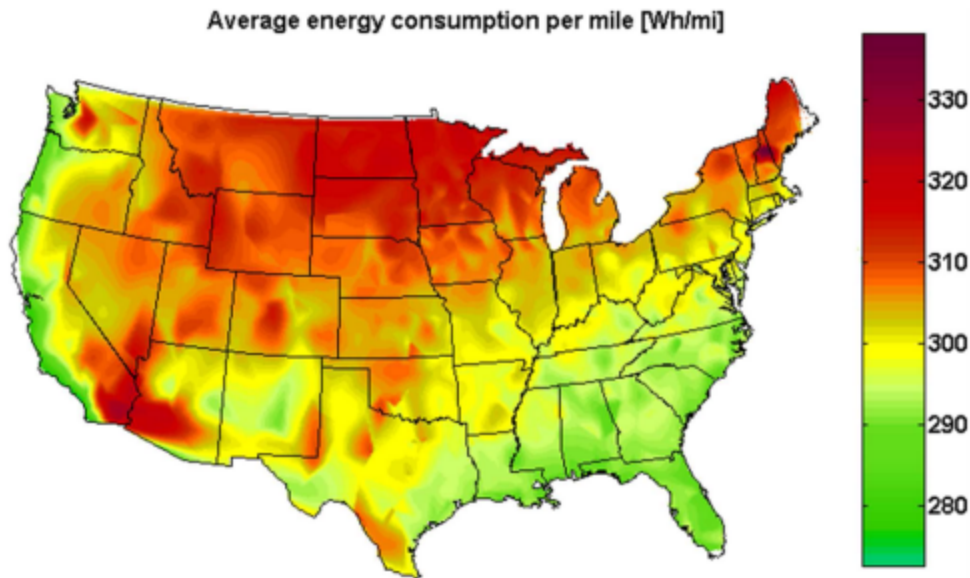
Ambient temperature matters for GHG emissions from EV charging

The electricity grid is the main driver of emissions for EV charging

A growing EV market means balancing trade-offs

# EV Efficiency in Extreme Weather Conditions

15% increase in energy intensity for Upper Midwest



(Yuksel & Michalek, 2015)



# Grid's Emissions Intensity Varies Throughout the Day and Year



**Coal:**  
1.15 kg CO<sub>2</sub>e/kWh  
0.003 kg PM/kWh  
6.8E-6 kg SO<sub>2</sub>/kWh

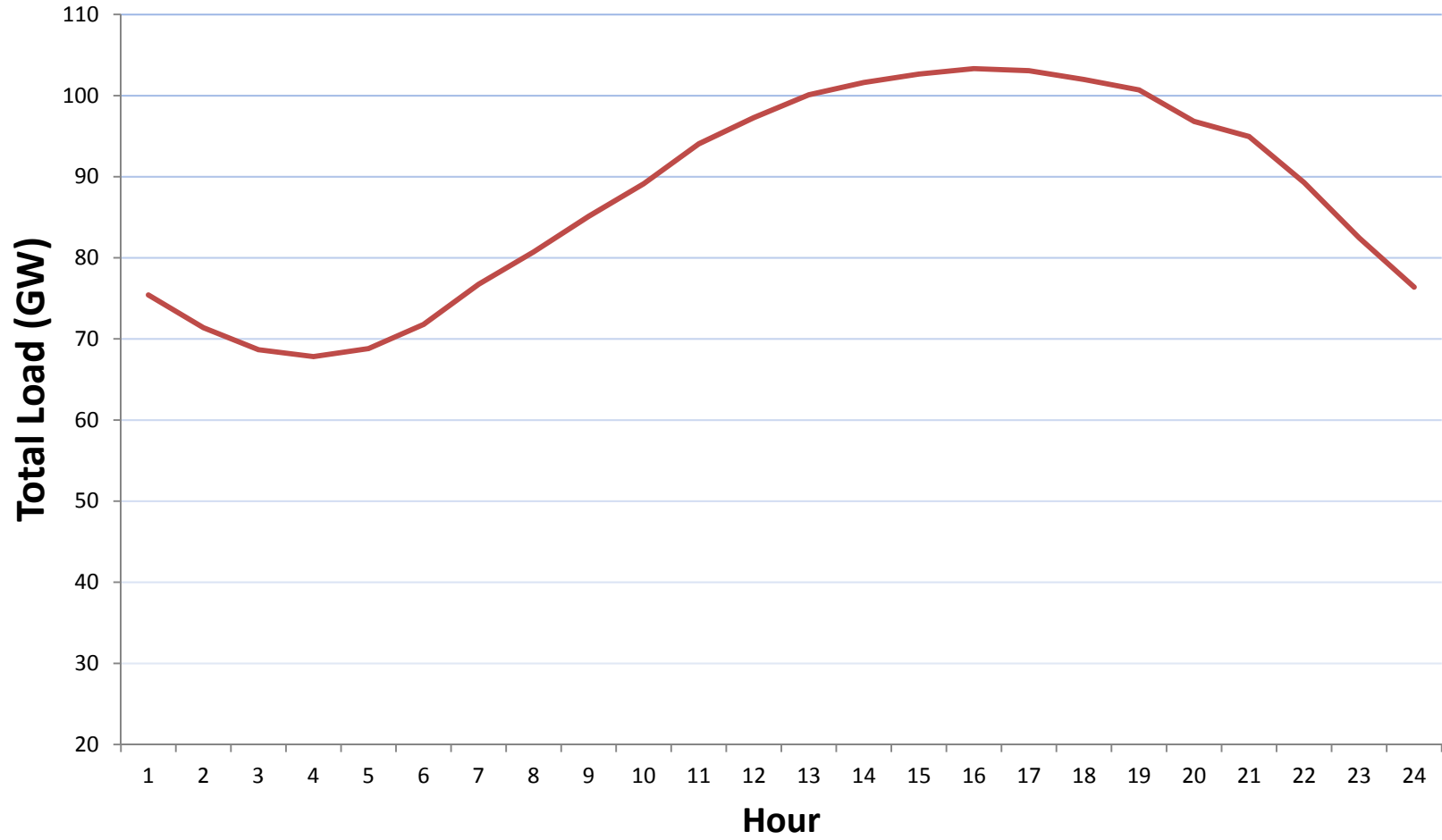
(Cleantechies.com)

**NG:**  
0.54 kg CO<sub>2</sub>e/kWh  
1.0E-5 kg PM/kWh  
5.3E-6 kg SO<sub>2</sub>/kWh

(Pictures from Wikimedia Commons)

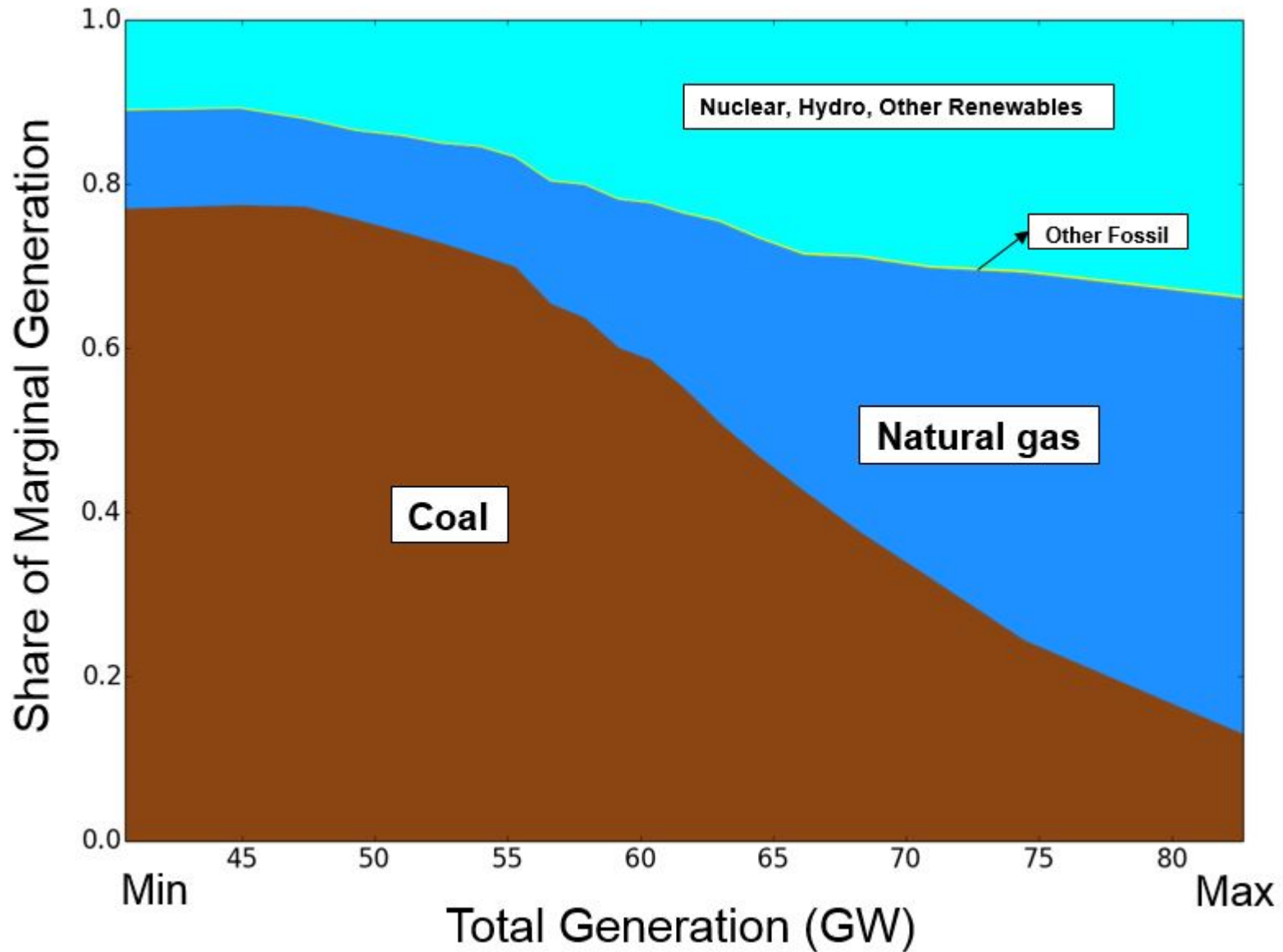


## Daily MISO Total Load Curve, July 21 2015



Source: MISO Data Library

# MISO Marginal Generation Mix as a Function of Total Generation

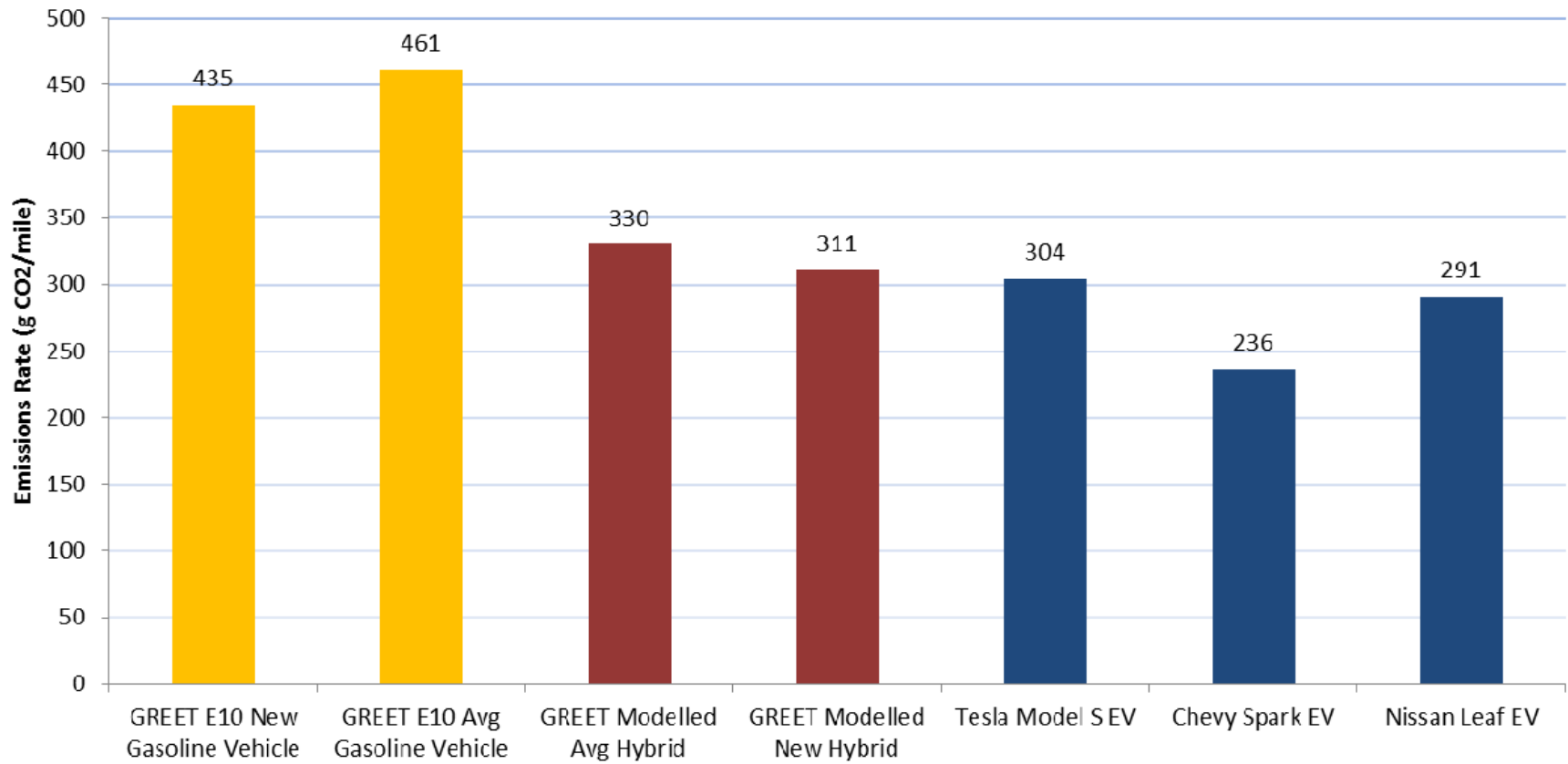


Source: *Maninder Thind*, Department of Civil, Environmental, and Geo-Engineering, University of Minnesota

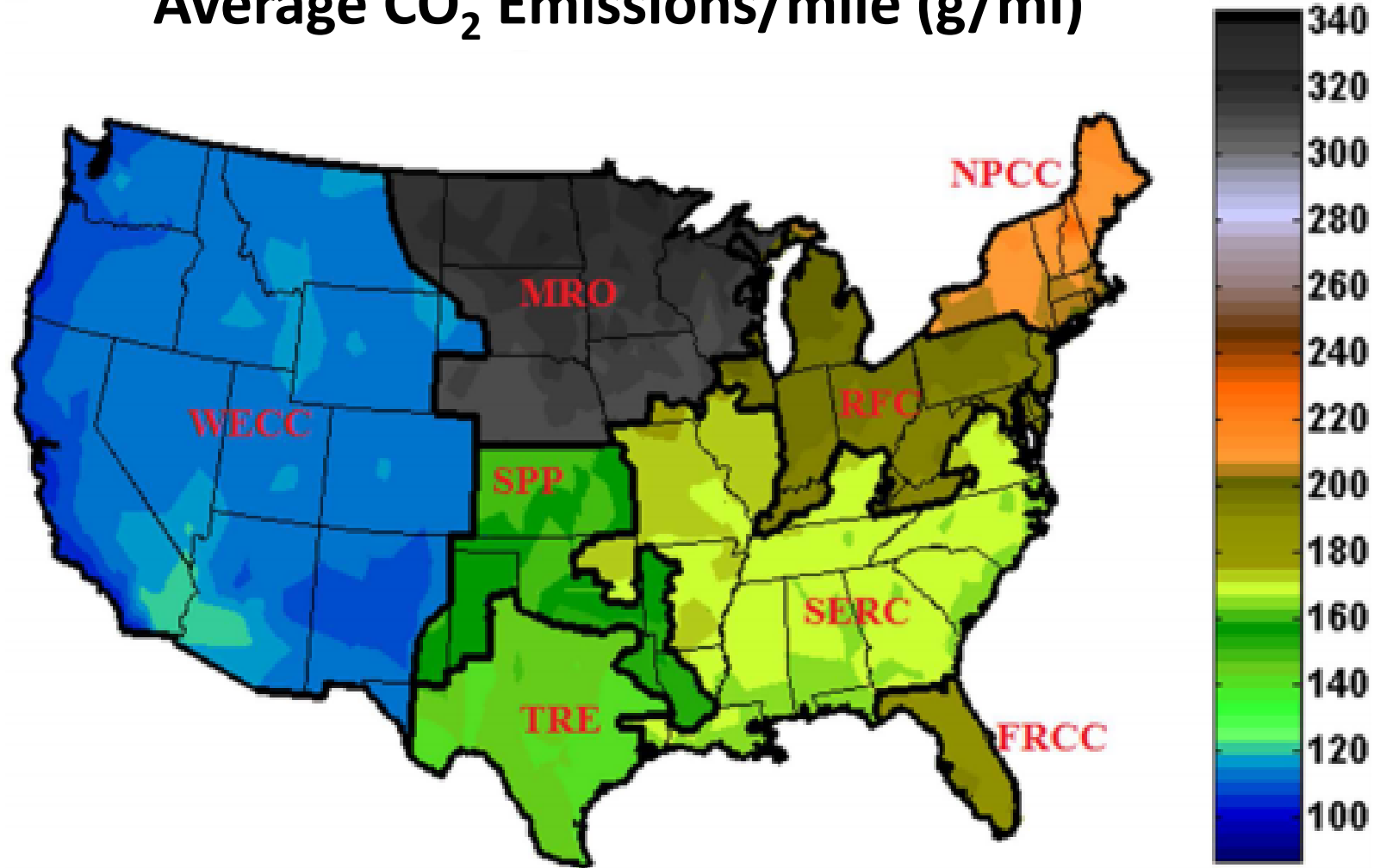
# All Renewable Charging Option under Minn Stat 216B.1614

- Investor Owned Utilities must offer customers an option to purchase renewable energy to meet part or all of their EV charging electricity demand
- Utilities will meet this requirement via existing wind energy programs but the PUC has asked them to propose a framework for the design of an all-renewable rate specifically for their EV tariff

## Life-Cycle Vehicle Emissions Rate Comparison



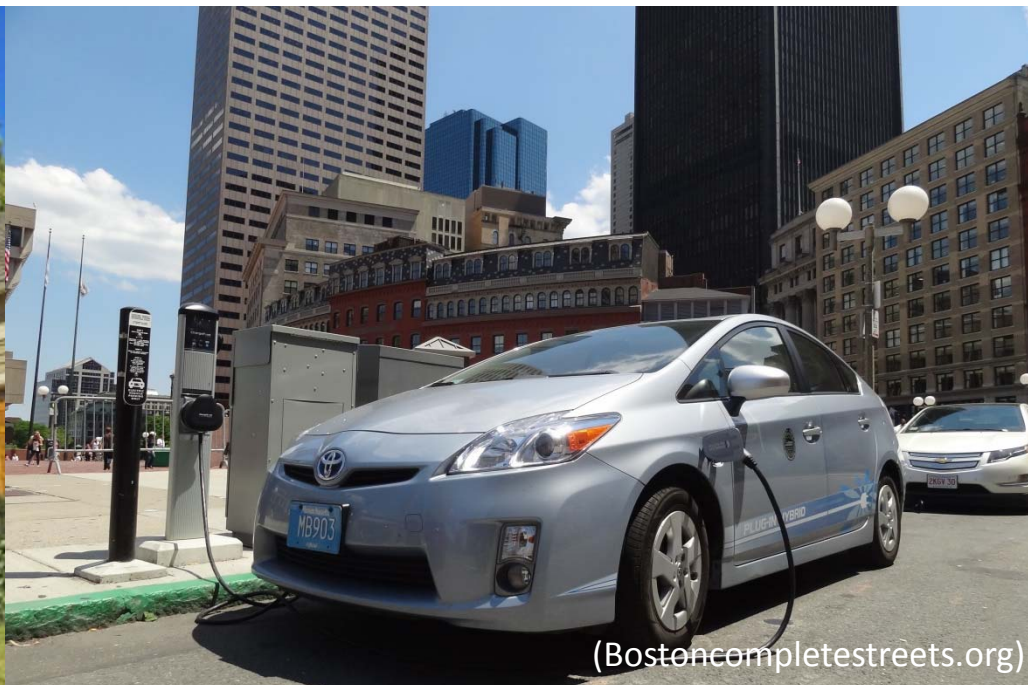
## Average CO<sub>2</sub> Emissions/mile (g/mi)



(Yuksel & Michalek, 2015)

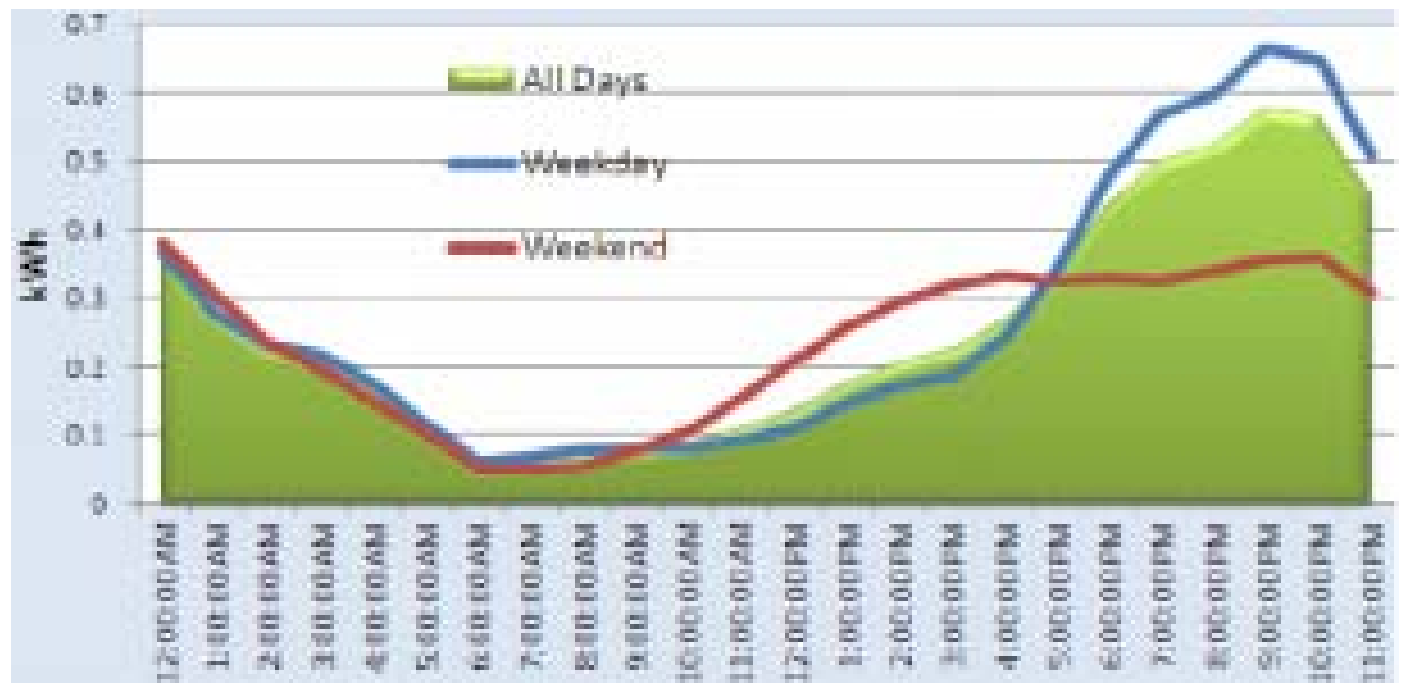
# Managing Tradeoffs

- GHG emissions vs. grid impacts & cost
- Managed load vs. consumer demand for convenient charging





## Residential Charging Stations



## Public Charging Stations



# Key Takeaways

Minnesota's extreme climate makes EVs more energy intensive than more temperate regions of the U.S.

The electricity grid is becoming less emissions intensive, meaning EVs will continue to get cleaner

Policies to manage EV charging create trade-offs for emissions and grid impacts.

# Thank You

Matthew Prorok  
matthew.prorok@lec.leg.mn