

Andrea Barreto, Justin Williams, Jose Castillo, Jonathan Guillen  
Industrial Engineering

## PROBLEM STATEMENT

As the availability of electric vehicles grows over the next couple of decades, so does the energy required to provide dependable charging for the fleet. The state of Texas needs to implement reliable, clean, and cost-effective charging infrastructure to conveniently power the growing EV fleet.

## PROJECT PURPOSE

- Plan the first-ever, easy-access statewide EV charging network.
- The integration of wind or solar microgrid technology.
- Achieve energy independence and low carbon infrastructure operations with solar and wind energy (future work)

## PROJECT OBJECTIVES



Forecast future size & growth of EV fleet in Texas by 2040

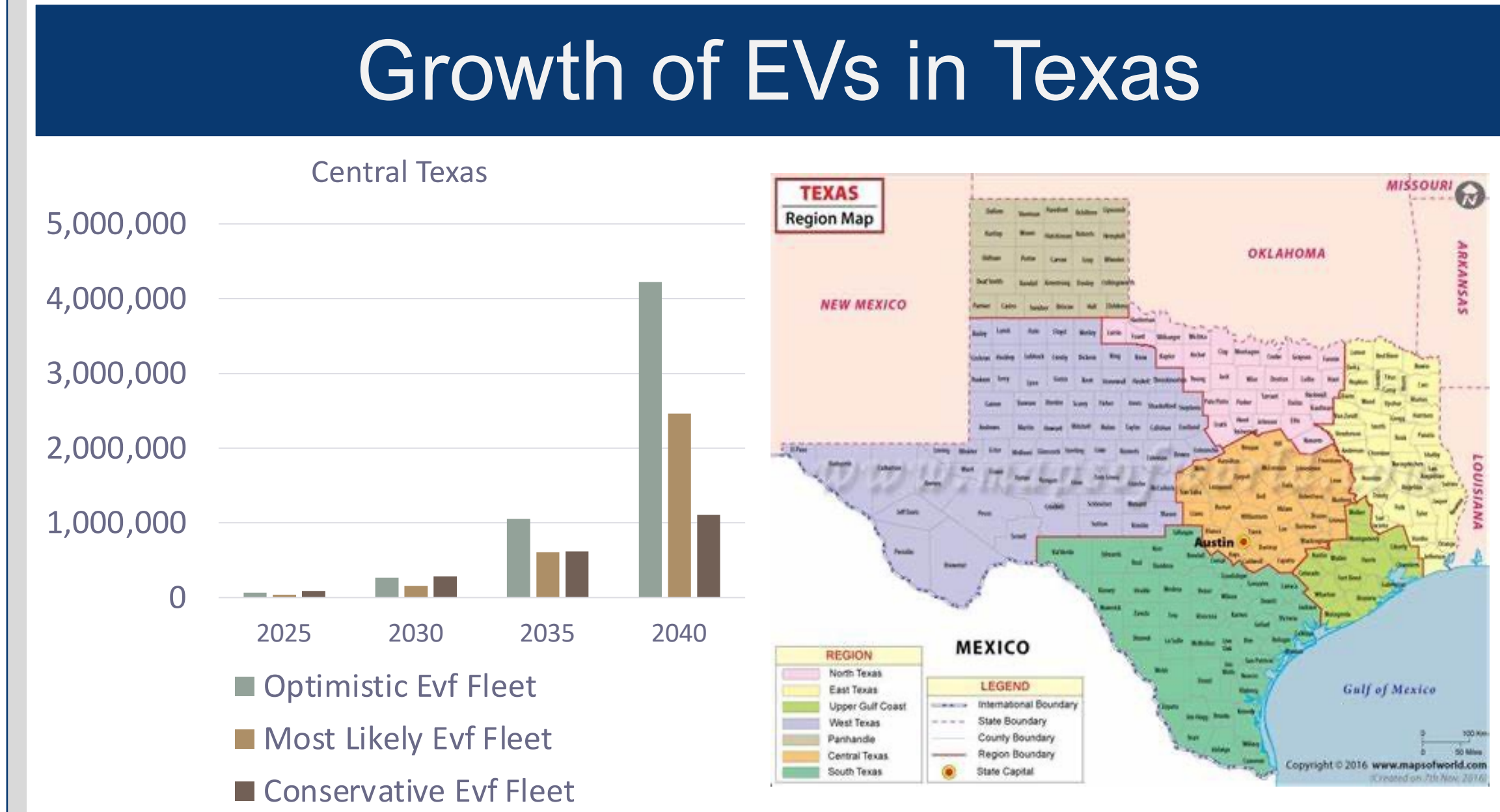


Design the charging infrastructure for Electric Vehicles in Texas that will efficiently sustain the power needs of EVs in Texas



Charging stations operate independently economically and ensure the return-on-investment of the state-wide charging infrastructure

## GRAPHS



### EV Fleet by 2040

Region	Optimistic	Most Likely	Conservative
Upper Gulf Coast	24,054,135	14,413,381	2,035,301
West Texas	6,572,942	3,640,644	503,352
South Texas	16,282,851	9,019,209	1,256,316
Panhandle	1,111,129	615,396	84,178
North Texas	28,883,042	15,999,713	2,255,102
Central Texas	14,098,194	7,810,105	1,110,864
East Texas	4,961,880	2,748,142	376,308

### The Number of Chargers Needed

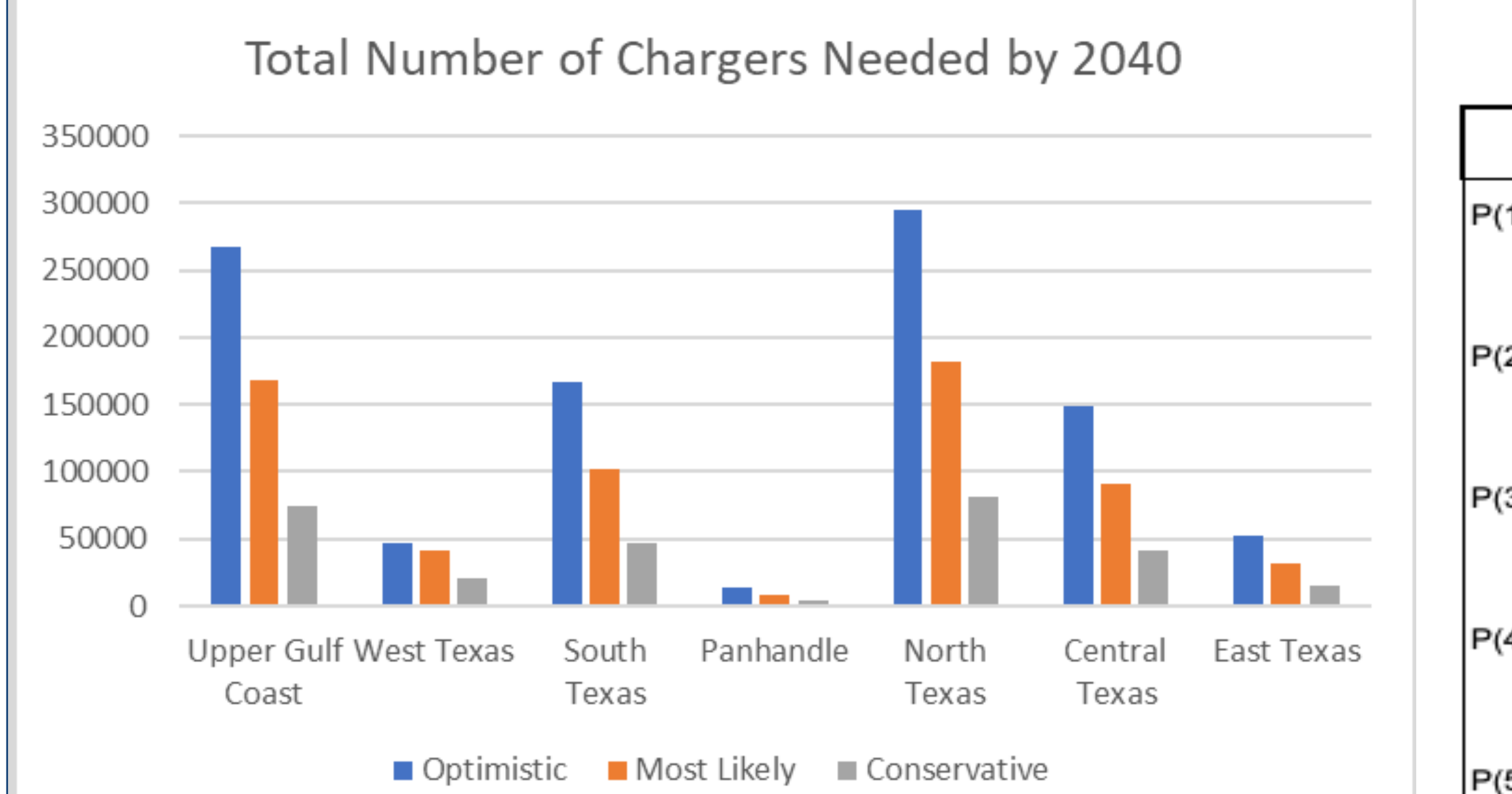
#### Your Results

In the Austin area, to support 40,000 plug-in electric vehicles you would need:

- 846** Workplace Level 2 Charging Plugs
- 526** Public Level 2 Charging Plugs  
*There are currently 1,028 plugs with an average of 2.1 plugs per charging station per the Department of Energy's Alternative Fuels Data Center Station Locator.*
- 98** Public DC Fast Charging Plugs  
*There are currently 204 plugs with an average of 4.2 plugs per charging station per the Department of Energy's Alternative Fuels Data Center Station Locator.*

#### Where Do I Start?

Planners may want to prioritize installation of fast charging infrastructure above Level 2 charging.



### Achieving a Net-Zero Carbon Output

#### System Parameters

- 120 Total Chargers
- 1 EV arrives every 30 sec
- 30-minute charge time

#### Renewable Energy

- Solar Generates 1.71 kWh/day
- Cost per PV: \$712.50
- Cost per WT: \$1.75 M
- 77,760 kWh/day needed

#### Assumptions Wind (WT)

WT Capacity Factor:	25%
2MW Turbine Power Output:	12,000 kWh/day
Cost per kW:	\$875

#### Assumptions Solar (PV)

Avg. EV Battery Capacity:	27 kWh
60 Cell Solar Panel Power Output:	285 W
Cost per Watt:	\$2.50
Peak Sunlight Hours:	6 hours

#### Decision Variables:

X1 = # of PV needed  
X2 = # of WT needed

#### Objective Function:

Minimize Cost = \$712.50X1 + \$1,750,000X2

#### Subject to:

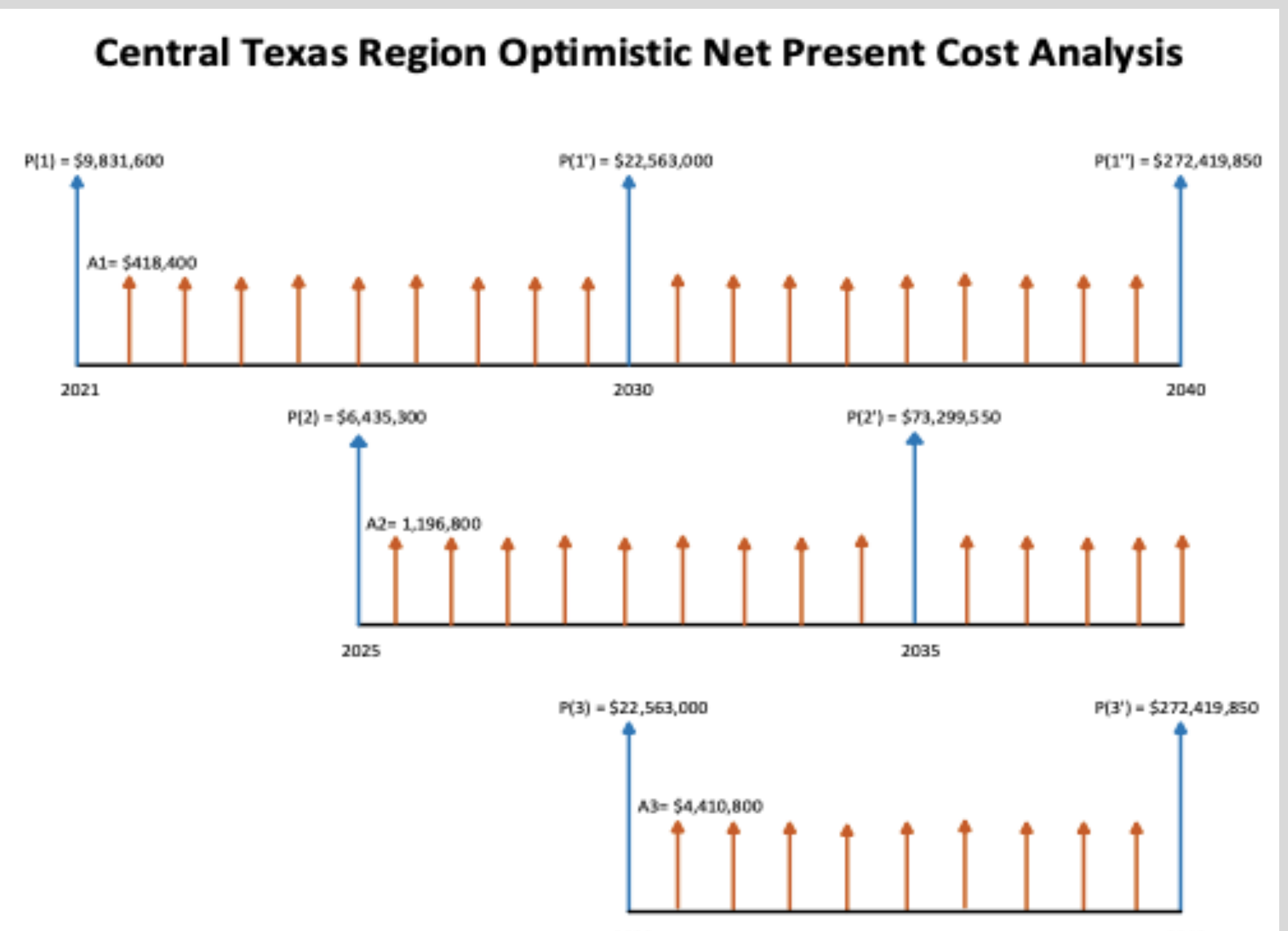
1.71X1 + 12,000X2 >= 77,760  
{X1, X2} = integer

#### Results

# of PV:	0
# of WT:	7
Total Cost:	\$12,250,000.00
Power:	84,000 kWh

#### Results (PV only)

# of PV:	46042
# of WT:	-
Total Cost:	\$32,805,000.00
Power:	78,732 kWh



#### Formulas

$$P(1) = P_1 + (P/A, 5\%, 20) + P_1 \cdot (P/F, 5\%, 10) + P_1 \cdot (P/F, 5\%, 20)$$

$$P(2) = P_2 \cdot (P/F, 5\%, 5) + P_2 \cdot (P/F, 5\%, 15) + (P/A, 5\%, 15) \cdot (P/F, 5\%, 5)$$

$$P(3) = P_3 \cdot (P/F, 5\%, 10) + P_3 \cdot (P/F, 5\%, 20) + (P/A, 5\%, 10) \cdot (P/F, 5\%, 10)$$

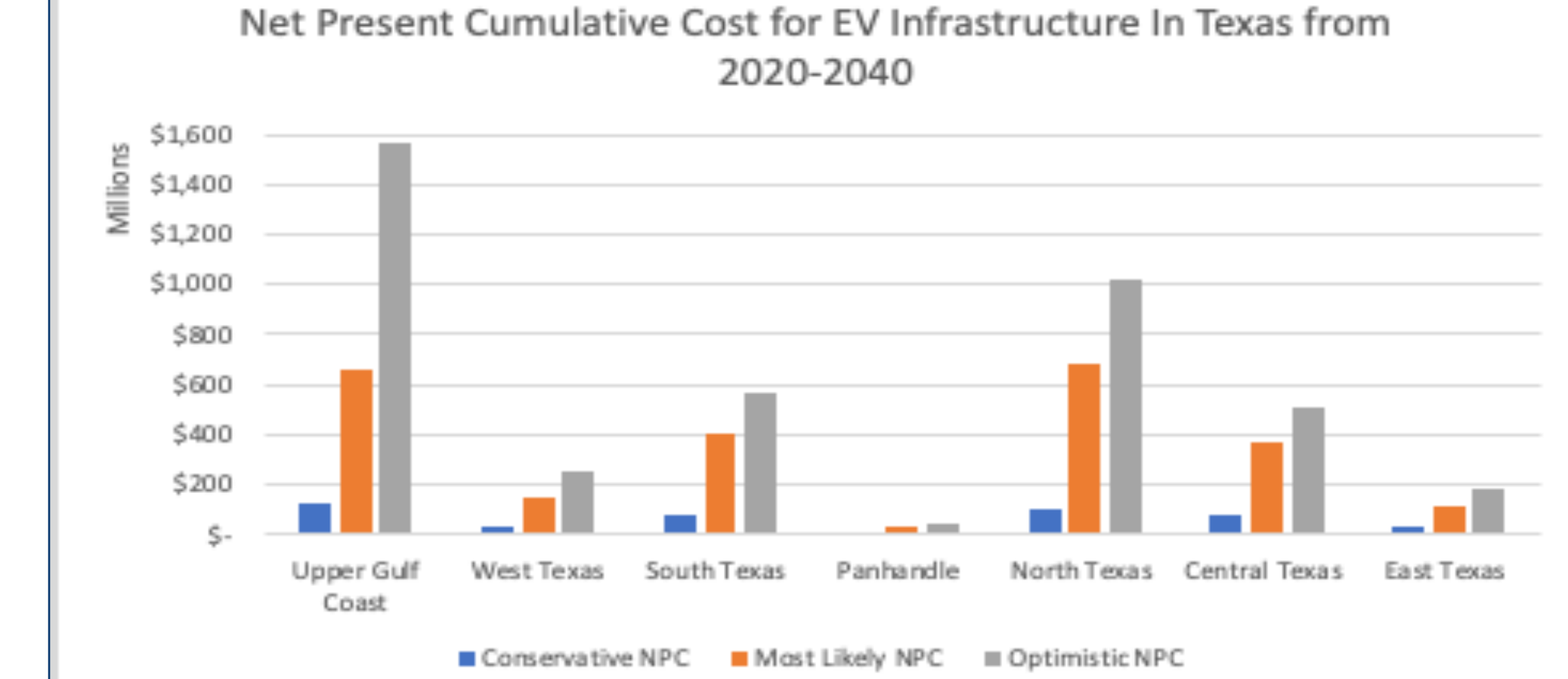
$$P(4) = P_4 \cdot (P/F, 5\%, 15) + (P/A, 5\%, 5) \cdot (P/F, 5\%, 15)$$

$$P(5) = P_5 \cdot (P/F, 5\%, 20)$$

## COST ANALYSIS

- Net present cost analysis is conducted to find total cost of the electric vehicle charging stations for each region, scenario and year period.
- Average costs for each charging station, installation costs, & maintenance costs were taken to estimate the total cost.
- Every 5 years new chargers are installed, & an annual maintenance cost will be added for each charger with an interest rate of 5%.

Region	Conservative NPC	Most Likely NPC	Optimistic NPC
Upper Gulf Coast	\$ 129,646,315.77	\$ 664,904,701.25	\$ 1,563,139,424.22
West Texas	\$ 37,701,497.52	\$ 148,239,811.53	\$ 247,902,302.99
South Texas	\$ 83,146,442.82	\$ 401,257,898.79	\$ 568,667,510.34
Panhandle	\$ 7,351,450.35	\$ 30,253,045.45	\$ 48,379,354.96
North Texas	\$ 106,678,418.57	\$ 681,604,577.21	\$ 1,020,888,087.96
Central Texas	\$ 74,878,477.06	\$ 364,103,436.15	\$ 510,251,158.86
East Texas	\$ 29,461,238.75	\$ 112,952,964.27	\$ 187,021,305.53
<b>Total</b>	<b>\$ 468,863,840.83</b>	<b>\$ 2,403,316,434.65</b>	<b>\$ 4,146,249,144.86</b>



## ACKNOWLEDGEMENTS

- Dr. Tongdan Jin (Sponsor)
- Dr. Michelle Londa (Instructor)
- Dr. Tao Ma (Technical Advisor)
- EPRI For Funding

## TEAM



From left to right: Jonathan Guillen, Jose Castillo, Andrea Barreto, & Justin Williams