MI Energy
Michigan Agency for Energy
Michigan Energy Office

STAKEHOLDER ENGAGEMENT MEETING
Electric Vehicle Charger Placement Optimization in Michigan

July 16, 2018
1:00-2:15 PM

Agenda

- Welcome
- Opening Remarks (Michigan Energy Office)
- MSU Project Team Presentation
- Discussion
- Questions

Electric Vehicle Charger Placement Optimization Project

Dr. Mehrnaz Ghamami
Dr. Ali Zockaie
Dr. Steven Miller

MICHIGAN STATE UNIVERSITY

July 16, 2018

Acknowledgement

This study is commissioned and funded by the Michigan Energy Office.

Problem Statement

MICHIGAN STATE UNIVERSITY

- Find the optimal infrastructure investment to support electric vehicle travel:
  - **Where** to deploy charging stations?
  - **How many** charging outlets must be built at each station?

- The modeling framework considers:
  - EV trip feasibility
  - Minimizing charging station investment cost
  - Minimizing travelers delay including:
    - Charging time
    - Queuing delay time
    - Detour time

NOTE: The results presented here do not include tourism and seasonal variation results. Those are the next steps of this study.

System Operational Assumptions

MICHIGAN STATE UNIVERSITY

Battery size: 100 kWh (Average of all EVs in the market)

Confident range: 0.8 [1] (Travelers would recharge when the battery is depleted 80% of its capacity.)

Charging efficiency: 1.3 [1] (Converting energy/power ratio to charging time accounts for waste of energy while charging)

Reduced battery Capacity in Winter Temperatures

Performance: 70% [2]

Value of time: $18/h [1] (Based on users' willingness to pay)

Battery charge limit: 0.8 [1] (Users charge their vehicle up to 80 percent of capacity as charging speed decreases significantly after this point)

Charger power: 50 kW [3] (Current average power in fast charging facilities)

Total demand: 2,979,998 [4] (Number of intercity trips between major cities in the state of Michigan per day)

Definition: Major city - *Any city which has a population more than 50,000.*

[1]Source: Ghamami, M., Zockaie, A., & Nie, Y. M. (2016). A general corridor model for designing plug-in electric vehicle charging infrastructure to support intercity travel. Transportation Research Part C, 68, 389-402
[2] Source: https://www.energy.gov/eere/electricvehicles/maximizing-electric-cars-range-extreme-temperatures
[3] Source: Discussion with stakeholders.
[4] Source: Michigan Department of Transportation origin-destination travel data .

Economic Benefit Assumptions

MICHIGAN STATE UNIVERSITY

- Economic benefits are measured in the value of transactions captured at the charging station over a 10-year period (All estimates in 2018 dollars)
  - Fees for charging
    - $0.15 per kWh for DC Fast charging – about $5.40 per connection
  - Expected ancillary expenditures while charging
    - Increasing in-store "dwell time" by 1% equates to a 1.3% increase in expenditures
    - Impacts arise from unplanned (new) stops generated by the DC Fast charger station
    - Average unplanned stop generates about $12.48 in sales (may vary significantly depending on shopping options)
  - Economic Impacts
    - Economic impacts accounts for all direct and secondary transactions (multiplier effects)
    - Ancillary expenditures broken out into retail and food service (50/50)
    - Net values of retail transactions attributed to impacts (only accounts for margins earned)
    - IMPLAN for Michigan used to calculate multipliers (secondary transactions)

Reference Road Network

- A sketch road network for the state of Michigan.
- Major cities and interstate highways

Four Scenarios Analyzed

MICHIGAN STATE UNIVERSITY

- Scenarios:
  - Focus on 2030 EV market penetration for Michigan
  - Four scenarios focusing on:
    - Two rates of market growth
      - Slow growth: 3%
      - Rapid growth: 6%
    - Two DC fast charger options
      - 50 kW charger
      - 150 kW charger
- Cost data cannot be currently shared because of nondisclosure agreements
  - Instead, scenario cost comparisons are presented as ratios of the base scenario
    - Base scenario is rapid market growth and 50kW charger

Scenario 1: Rapid market growth and 50kw charger

MICHIGAN STATE UNIVERSITY

Assumptions

EV market share:	6%
EV trips:	178,784 (per day)
Charger power:	50kw

Results

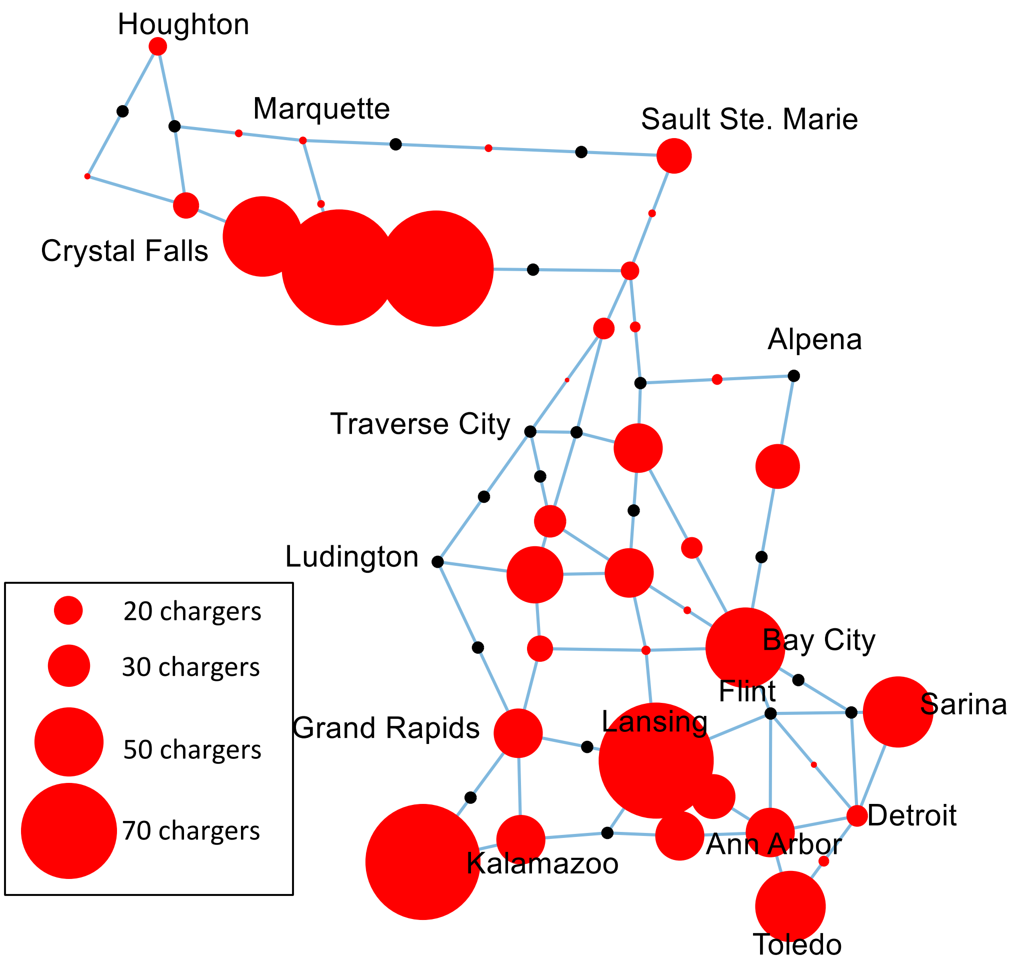
- Total Stations (number): 39
- Total Spots (number): 917

Costs

- Station Cost (ratio): base value
- Land Cost (ratio): base value
- Charger Cost (ratio): base value
- Total Cost (ratio): base value

Time

- Total Refueling Time (hr): 5665.63
- Total Queuing Time (hr): 0
- Average Delay (min): 46.14



Scenario 2: Rapid market growth and 150kw charger

MICHIGAN STATE UNIVERSITY

Assumptions

EV market share:	6%
EV trips:	178,784 (per day)
Charger power:	150kw

Results

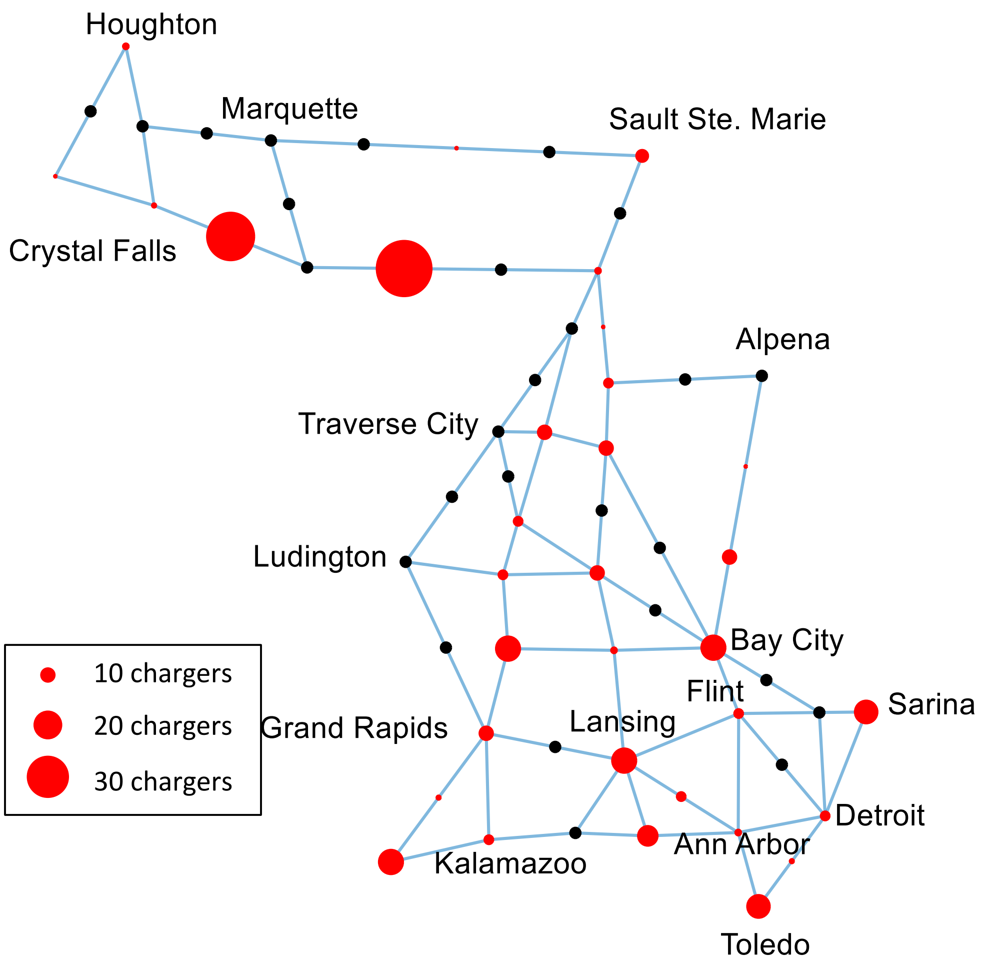
- Total Stations (number): 33
- Total Spots (number): 269

Costs

- Station Cost (ratio): 0.99
- Land Cost (ratio): 0.29
- Charger Cost (ratio): 0.82
- Total Cost (ratio): 0.83

Time

- Total Refueling Time (hr): 1877.34
- Total Queuing Time (hr): 8.28
- Average Delay (min): 13.81



Scenario 3: Slow market growth and 50kw charger

MICHIGAN STATE UNIVERSITY

Assumptions

EV market share:	3%
EV trips:	89,392 (per day)
Charger power:	50kw

Results

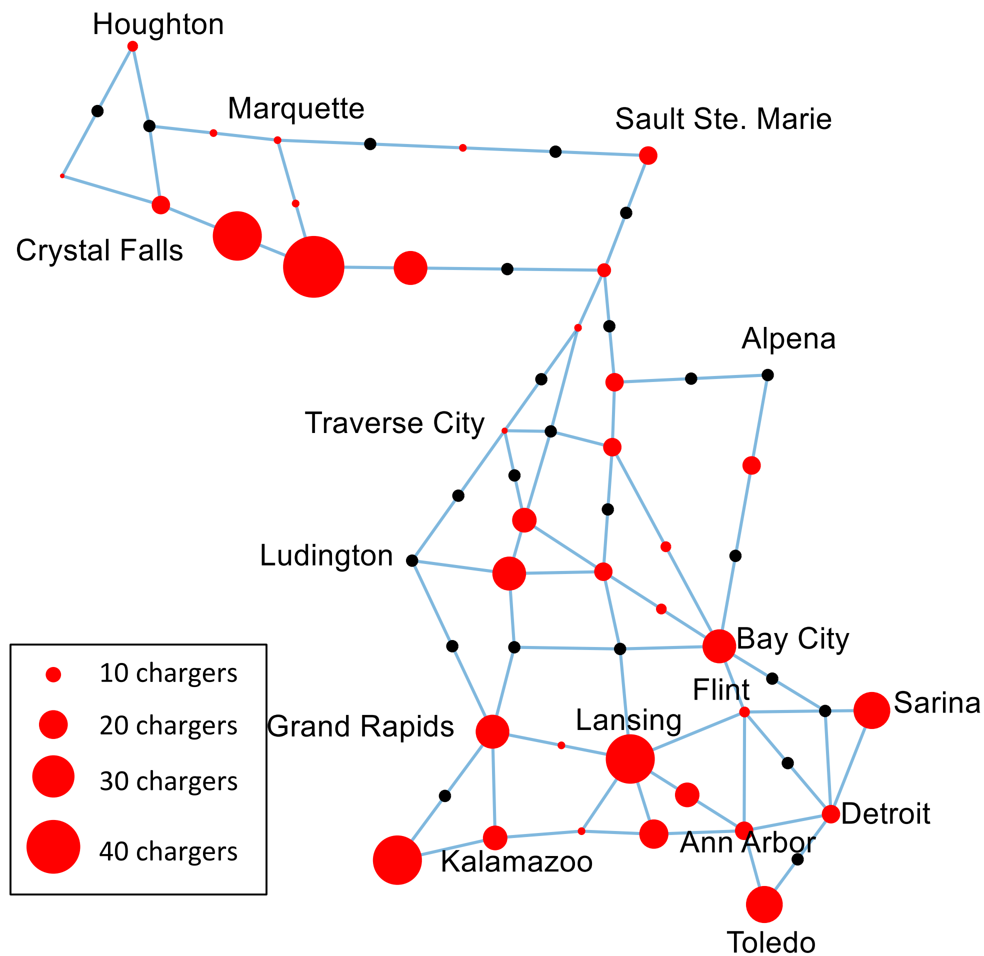
- Total Stations (number): 36
- Total Spots (number): 442

Costs

- Station Cost (ratio): 0.91
- Land Cost (ratio): 0.48
- Charger Cost (ratio): 0.48
- Total Cost (ratio): 0.56

Time

- Total Refueling Time (hr): 2803
- Total Queuing Time (hr): 0
- Average Delay (min): 45.53



Scenario 4: Slow market growth and 150kw charger

MICHIGAN STATE UNIVERSITY

Assumptions

EV market share:	3%
EV trips:	89,392 (per day)
Charger power:	150kw

Results

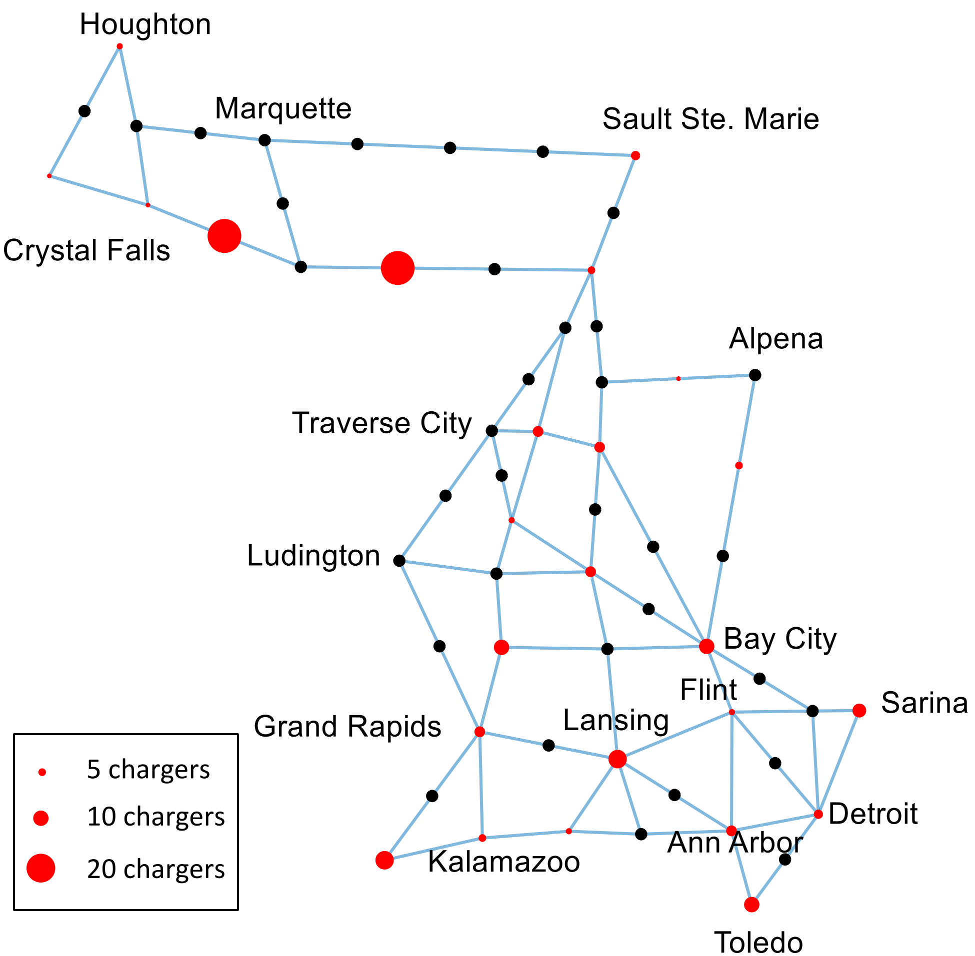
- Total Stations (number): 25
- Total Spots (number): 144

Costs

- Station Cost (ratio): 0.71
- Land Cost (ratio): 0.16
- Charger Cost (ratio): 0.44
- Total Cost (ratio): 0.47

Time

- Total Refueling Time (hr): 985.2
- Total Queuing Time (hr): 1.3
- Average Delay (min): 14.1



Project Data Requirements & Questions

- Economic benefit assumptions
  - *Fees for charging*

- Electric vehicles market share
  - *Currently based on*

    Electric Vehicle Cost-Benefit Analysis- Plug-in Electric Vehicle Cost-Benefit Analysis: Michigan
    M.J. Bradley & Associates, LLC (MJB&A), July 2017
  - *Is there any other source or estimation available?*

- Grid specification data
  - *Inquire with utility companies*

Project Data Requirements & Questions, cont.

MICHIGAN STATE UNIVERSITY

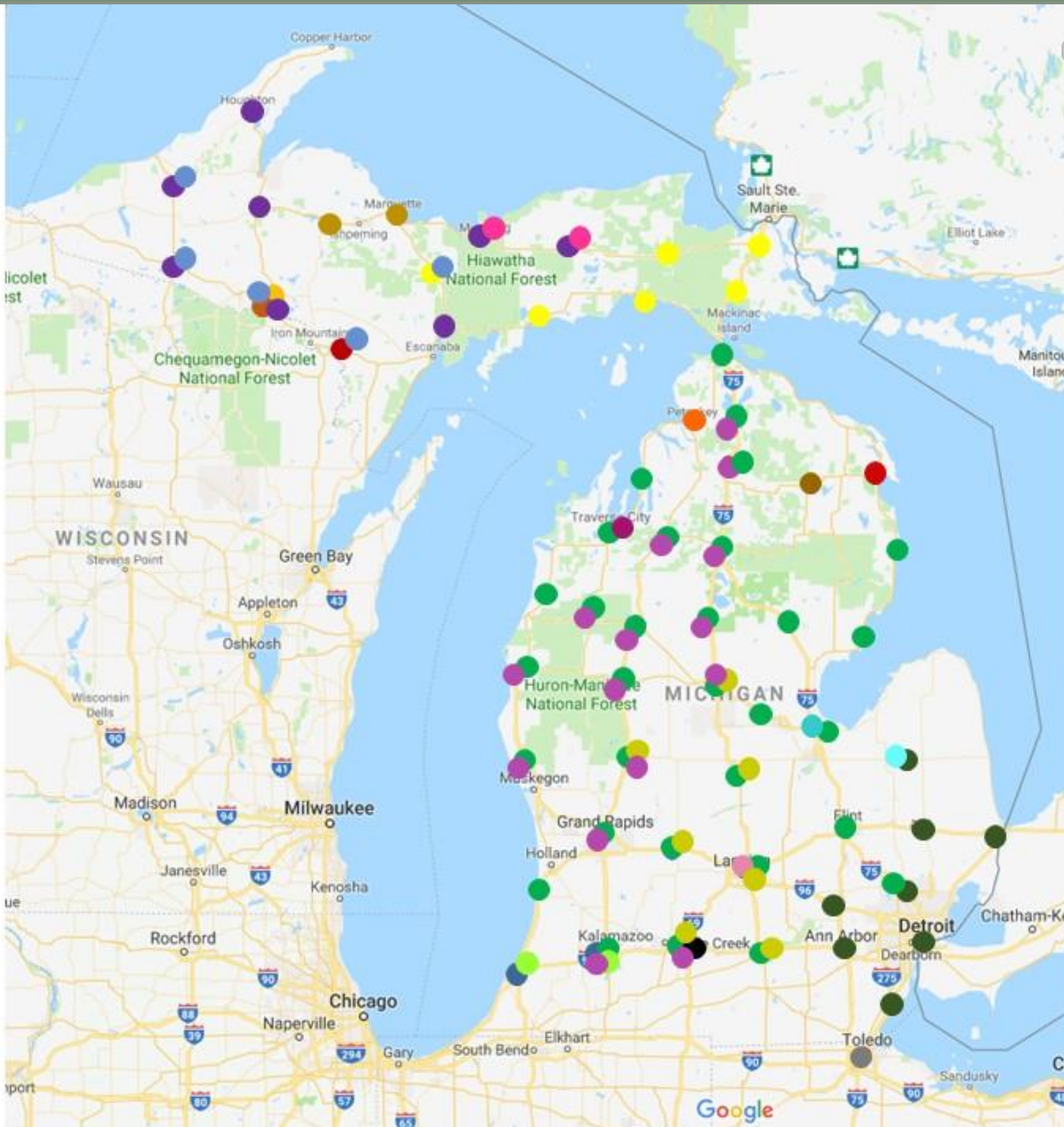
- What EV charging station investments are going to be made in your service territory through pilots, demonstrations, or other opportunities?

- What are your actual or anticipated demand charges for EV charging?

- Is the current model for 2030 sufficient or should we look at five year projections (e.g. 2020, 2025, 2030)?

Project Data Requirements

MICHIGAN STATE UNIVERSITY

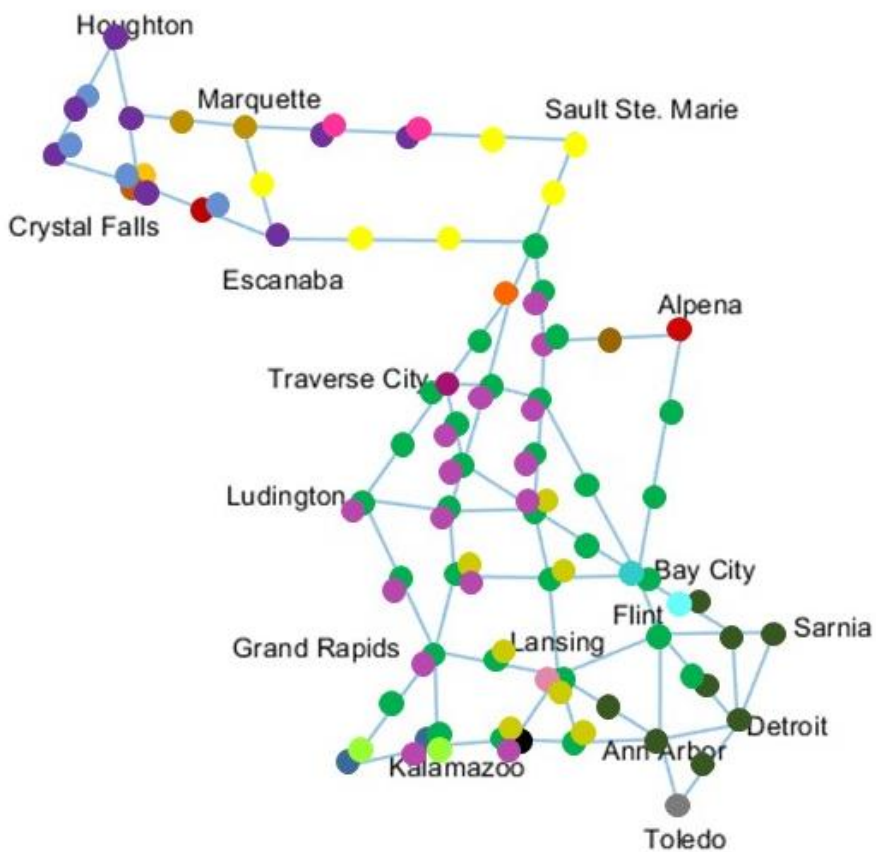


Legend	
Alger Delta Cooperative	pink
Cloverland Electric Cooperative	yellow
Crystal Falls Electric department	orange-yellow
Norway L.D.	red
Upper Michigan Energy Resources Corp	light blue
Upper Peninsula Power Company	purple
Marquette Board of Light and Power	gold
Utility billing Office	grey
Wisconsin Electric Power Company	brown-orange
Alpena Power Company	red
Bay City utility department	turquoise
Indiana Michigan Power Company	dark blue
Cherryland Electric Cooperative	magenta
Consumers Energy	green
Detroit Edison company (DTE)	dark green
Great Lakes energy cooperative	violet
Lansing Board of water and light	light pink
Marshall C.W & E.W.	black
Midwest Energy Cooperative	light green
Petoskey E.D.	orange
Presque Isle electric and Gas Co-op	brown
Thumb Electric Cooperative	cyan
Tri-county Electric Cooperative	olive yellow

Source: https://www.michigan.gov/images/mpsc/serviceareaUPDATE20110120_599009_7.gif
*Source: http://w1.lara.state.mi.us/cgi-bin-mpsc/mpsc/electric-gas-list.cgi?townsearch=c**

Project Data Requirements

MICHIGAN STATE UNIVERSITY



Legend

- Alger Delta Cooperative
- Cloverland Electric Cooperative
- Crystal Falls Electric department
- Norway L.D.
- Upper Michigan Energy Resources Corp
- Upper Peninsula Power Company
- Marquette Board of Light and Power
- Utility billing Office
- Wisconsin Electric Power Company

- Alpena Power Company
- Bay City utility department
- Indiana Michigan Power Company
- Cherryland Electric Cooperative
- Consumers Energy
- Detroit Edison company (DTE)
- Great Lakes energy cooperative
- Lansing Board of water and light
- Marshall C.W & E.W.
- Midwest Energy Cooperative
- Petoskey E.D.
- Presque Isle electric and Gas Co-op
- Thumb Electric Cooperative
- Tri-county Electric Cooperative

Source: https://www.michigan.gov/images/mpsc/serviceareaUPDATE20110120_599009_7.gif
Source: http://w1.lara.state.mi.us/cgi-bin-mpsc/mpsc/electric-gas-list.cgi?townsearch=c*

MICHIGAN STATE UNIVERSITY

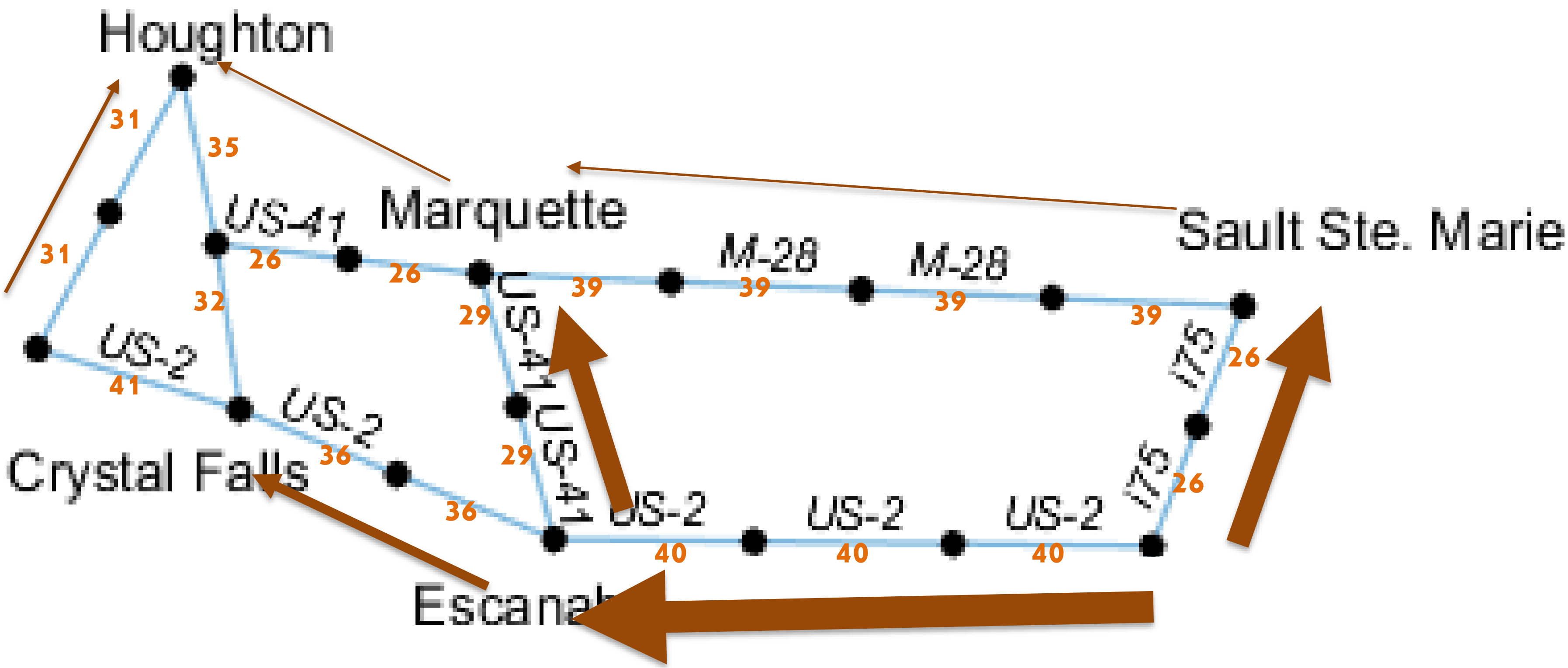
Thank you!

Mehrnaz Ghamami
Email: ghamamim@egr.msu.edu
Phone: (517) 355-1288

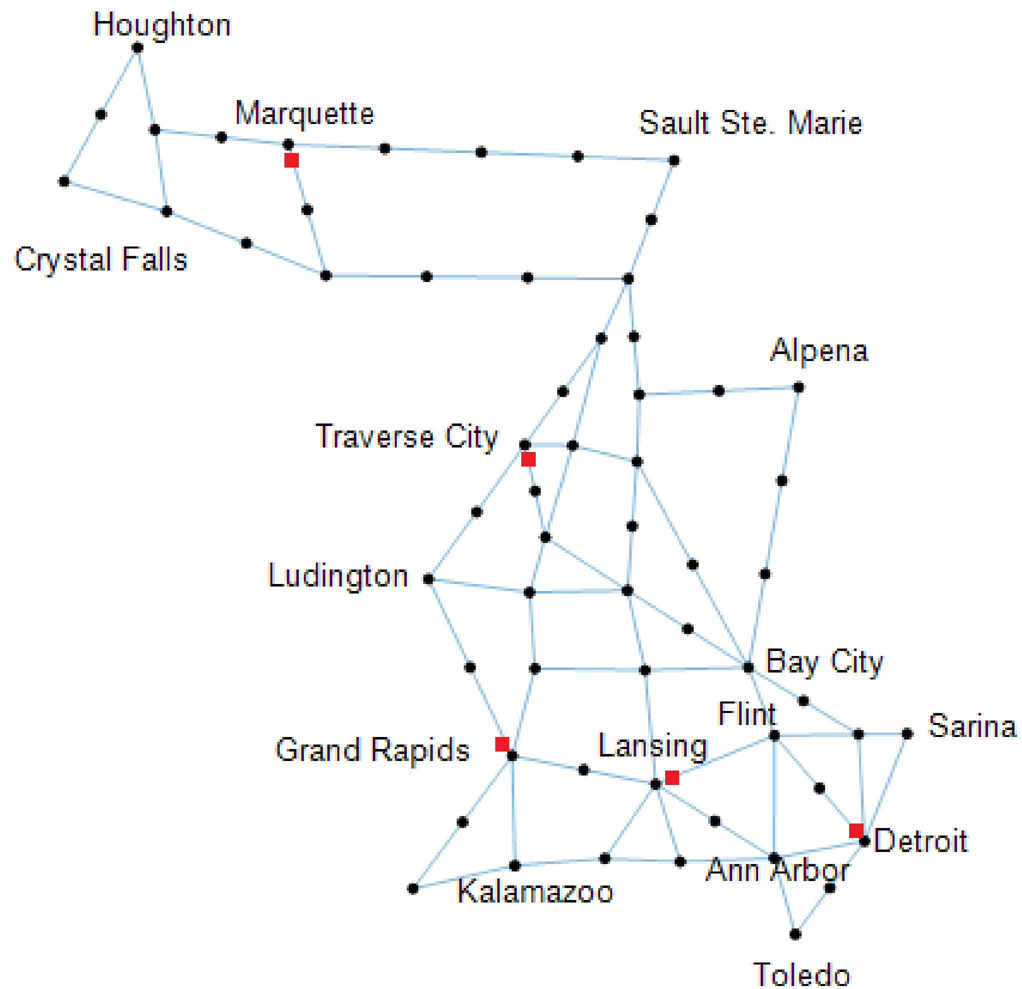
Ali Zockaie
Email: zockaiea@egr.msu.edu
Phone: (517) 355-8422

Steven Miller
Email: mill1707@anr.msu.edu
Phone: (517) 355-2153

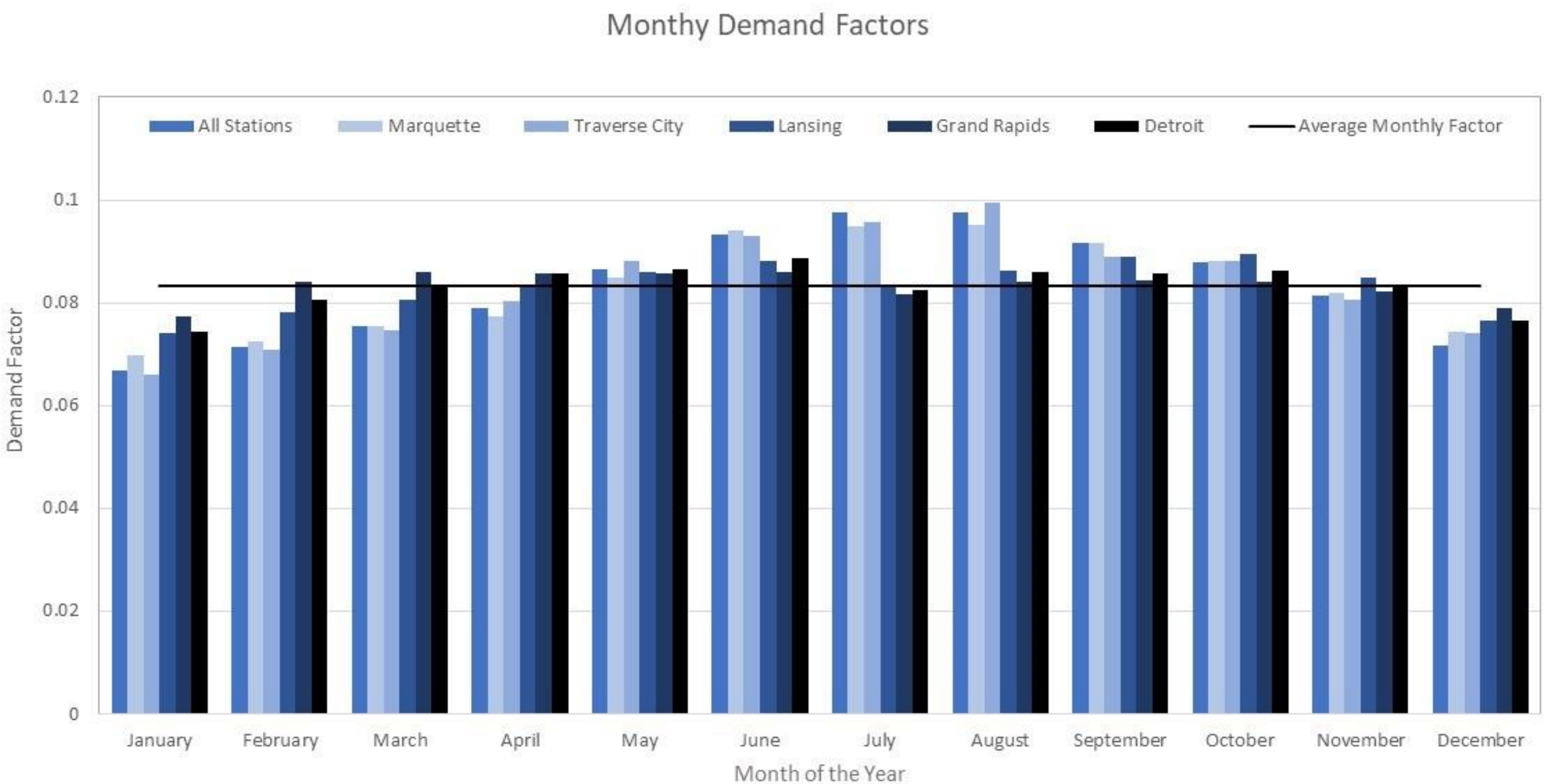
Demand and Distance in UP



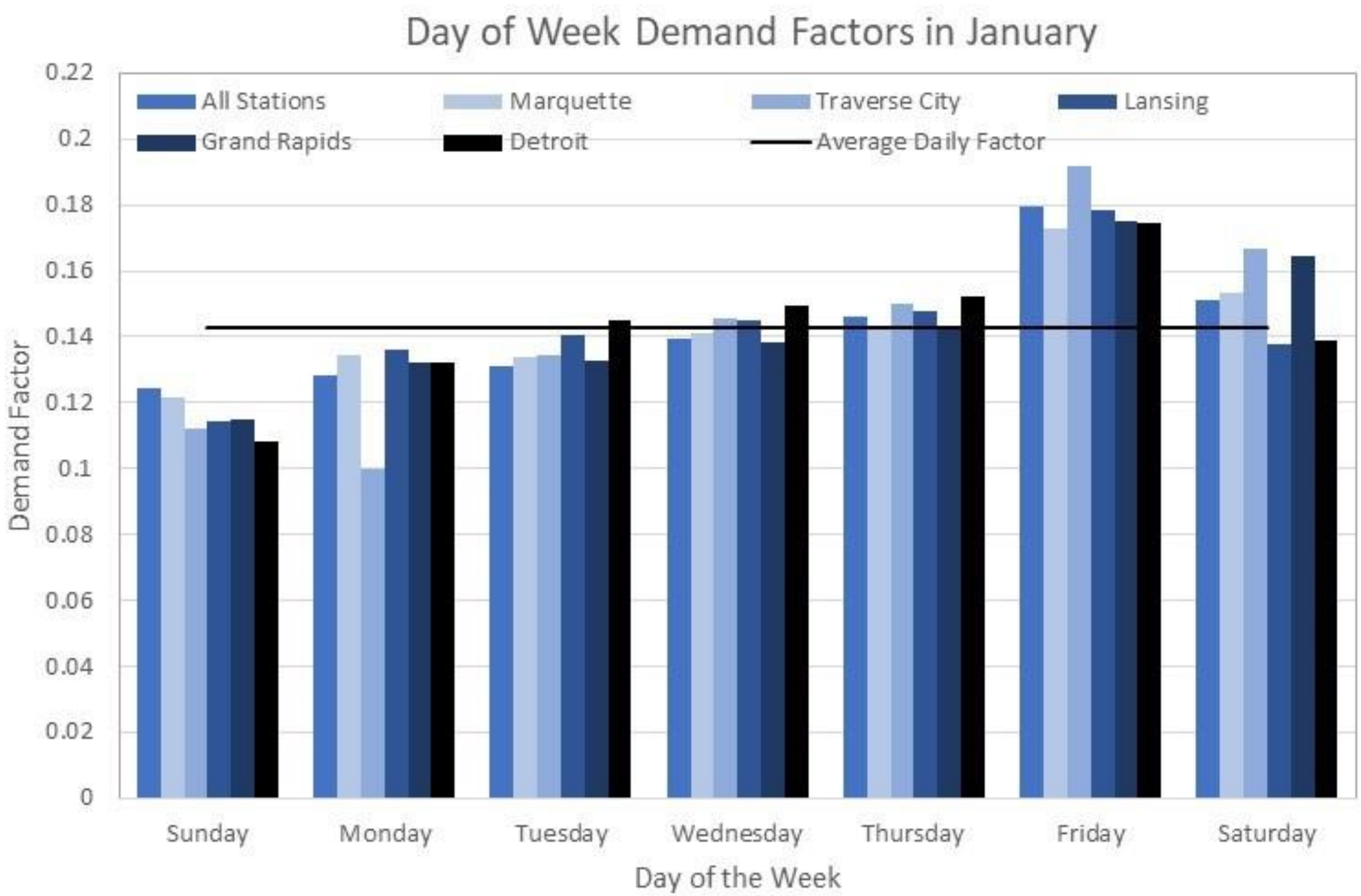
Selected counting stations



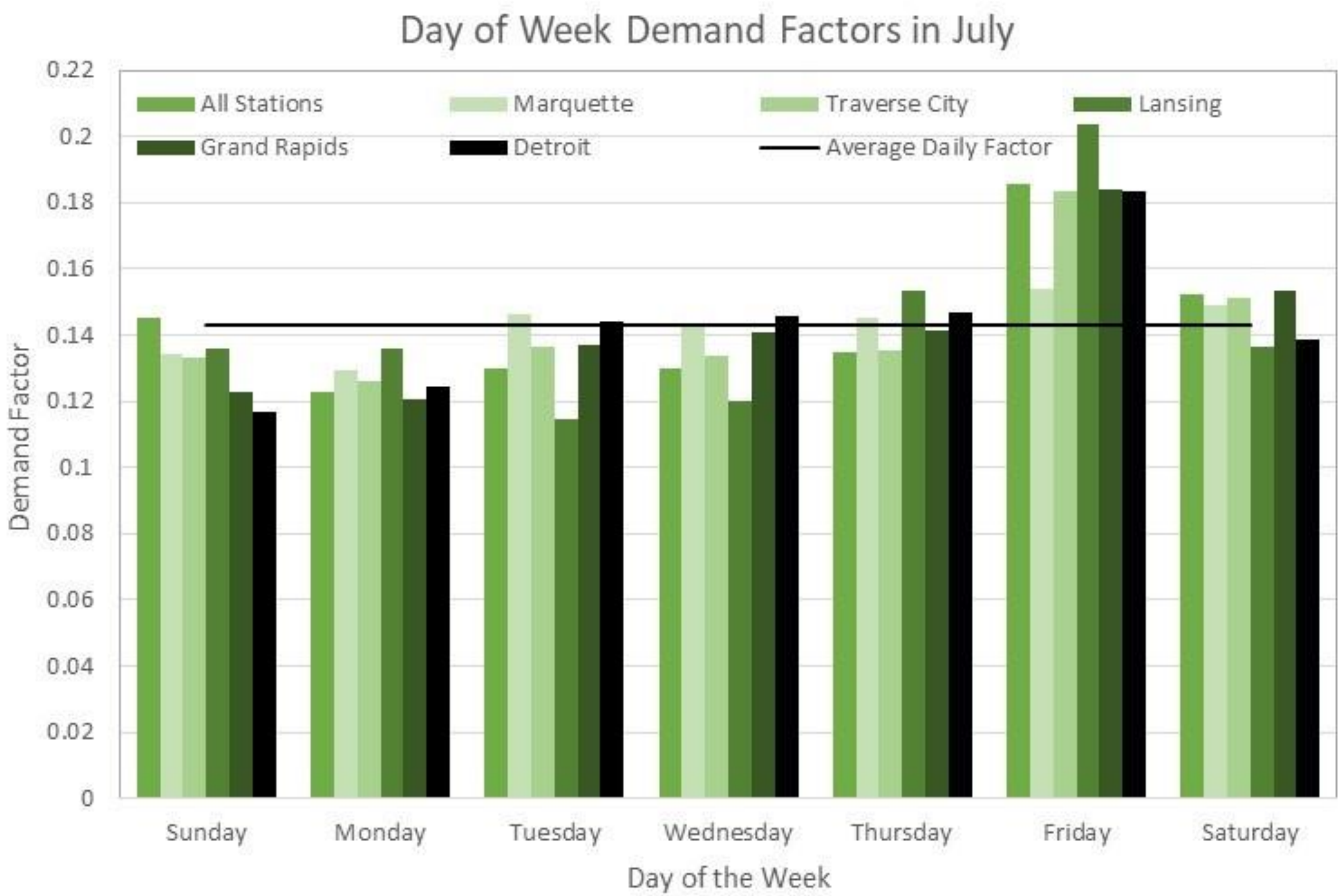
Monthly demand at counting locations



Demand at counting locations- Winter 2016



Demand at counting locations- Summer 2016



MICHIGAN STATE UNIVERSITY

Demand at counting locations-Fall 2016