



STAKEHOLDER ENGAGEMENT MEETING

Electric Vehicle Charger Placement Optimization in Michigan

July 18, 2018

8:30-10:00 AM

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 18, 2018

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



- 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

This study focuses on investing in DC fast chargers for long distance (intercity) trips of EV users.



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

System Operational Assumptions

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 Performance:	70% ²	(Reduced battery capacity in Winter temperatures)
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.



¹Source: 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 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

- Major cities and interstate highways
- The focus is on intercity travel
- Travel demand around major cities is aggregated to the city center
- Travel demand within the cities were excluded
- The distance between candidate points is less than 50 miles
- Candidate points may or may not be selected for building charging stations



- 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, 50kw charger

Assumptions

EV market share: 6%

Charger power: 50kw

Results

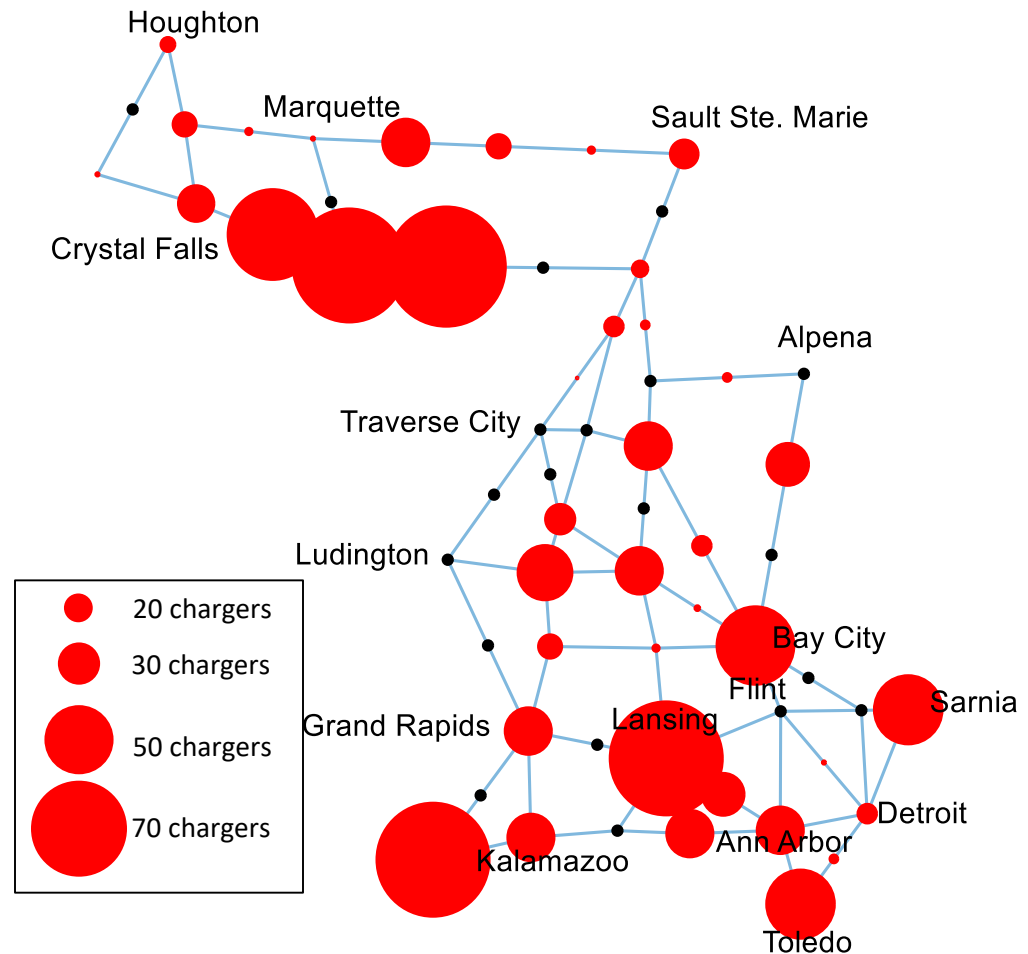
- Total Stations (number): 40
- Total Spots (number): 988

Costs

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

Time

- Average Delay (min): 47.16



Scenario 2: Rapid market growth, 150kw charger

Assumptions

EV market share: 6%
Charger power: 150kw

Results

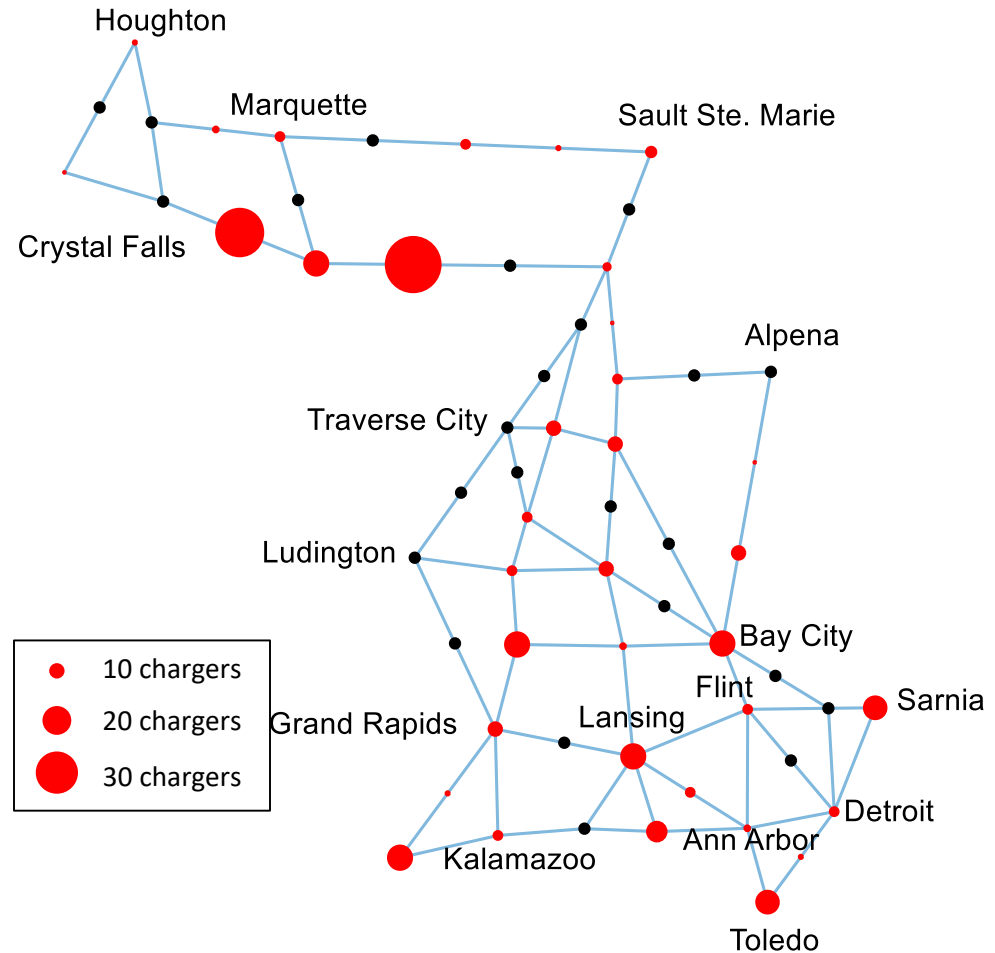
- Total Stations (number): 36
- Total Spots (number): 295

Costs

- Station Cost (ratio): 1.04
- Land Cost (ratio): 0.30
- Charger Cost (ratio): 0.83
- Total Cost (ratio): 0.85

Time

- Average Delay (min): 13.76



Scenario 3: Slow market growth, 50kw charger

Assumptions

EV market share: 3%
Charger power: 50kw

Results

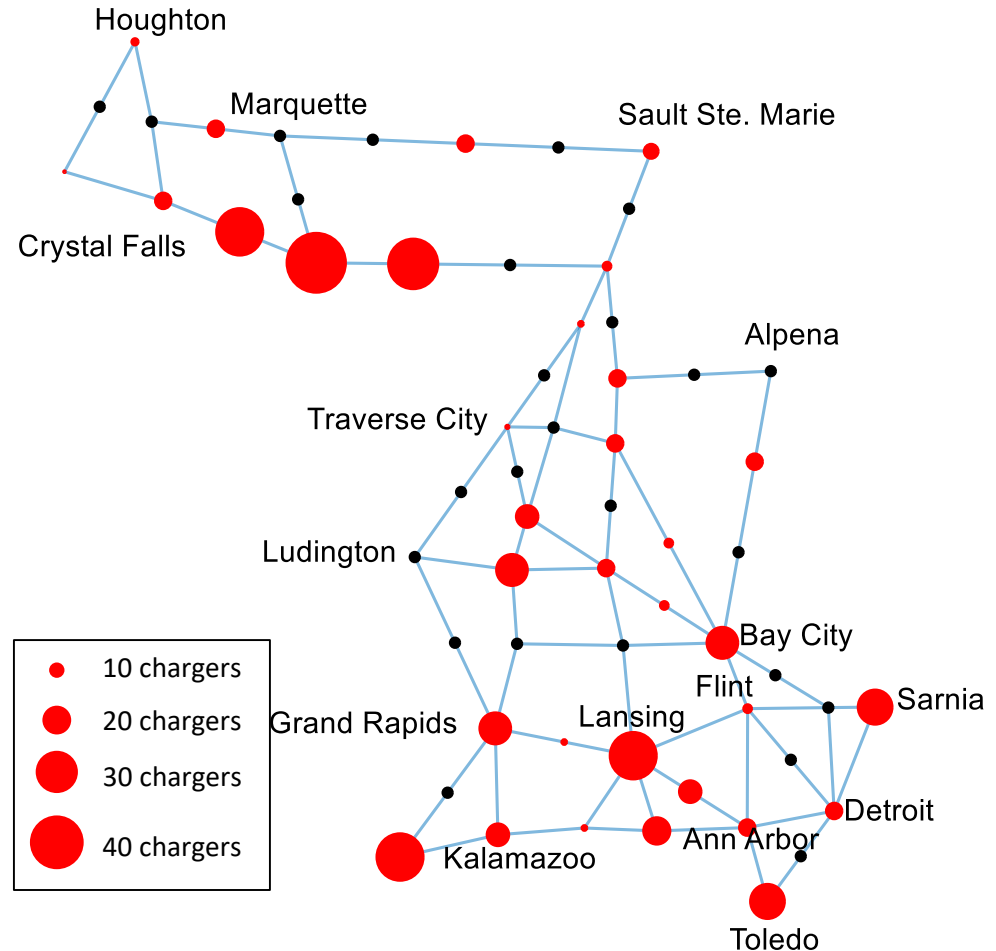
- Total Stations (number): 34
- Total Spots (number): 458

Costs

- Station Cost (ratio): 0.84
- Land Cost (ratio): 0.46
- Charger Cost (ratio): 0.46
- Total Cost (ratio): 0.53

Time

- Average Delay (min): 47.36



Scenario 4: Slow market growth, 150kw charger

Assumptions

EV market share: 3%

Charger power: 150kw

Results

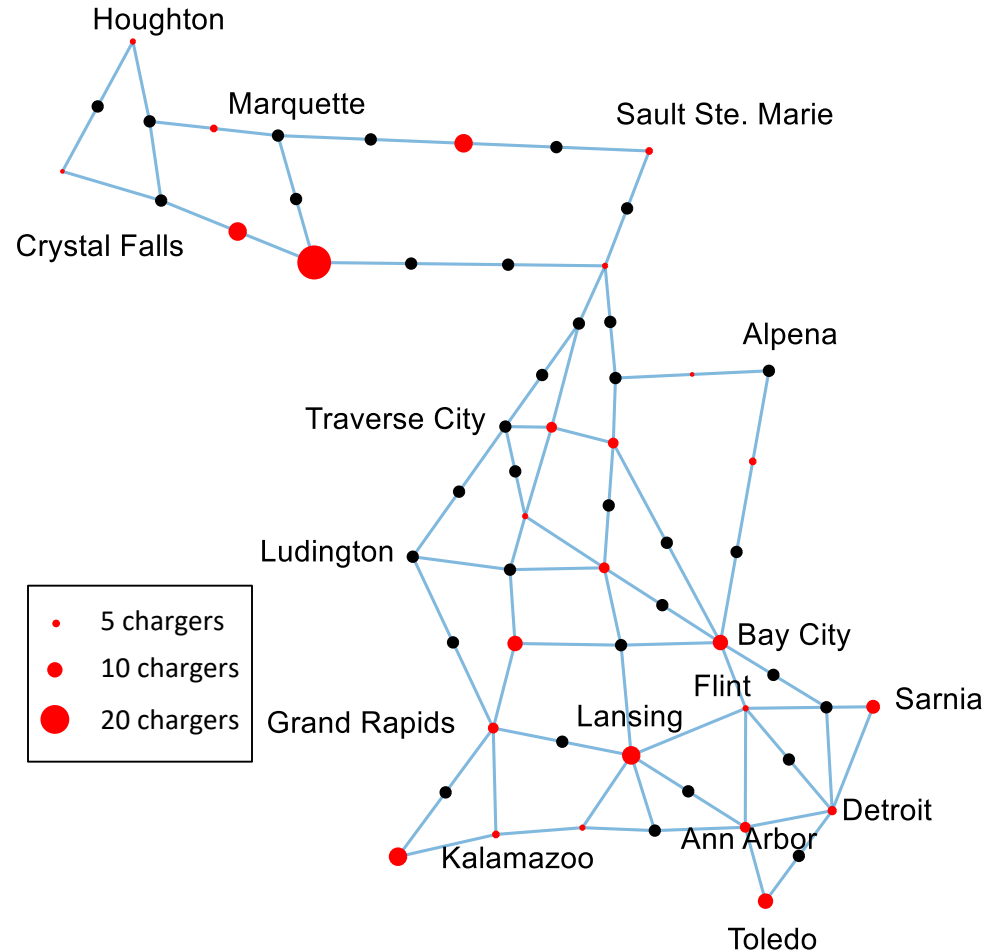
- Total Stations (number): 26
- Total Spots (number): 144

Costs

- Station Cost (ratio): 0.72
- Land Cost (ratio): 0.15
- Charger Cost (ratio): 0.41
- Total Cost (ratio): 0.45

Time

- Average Delay (min): 14.38



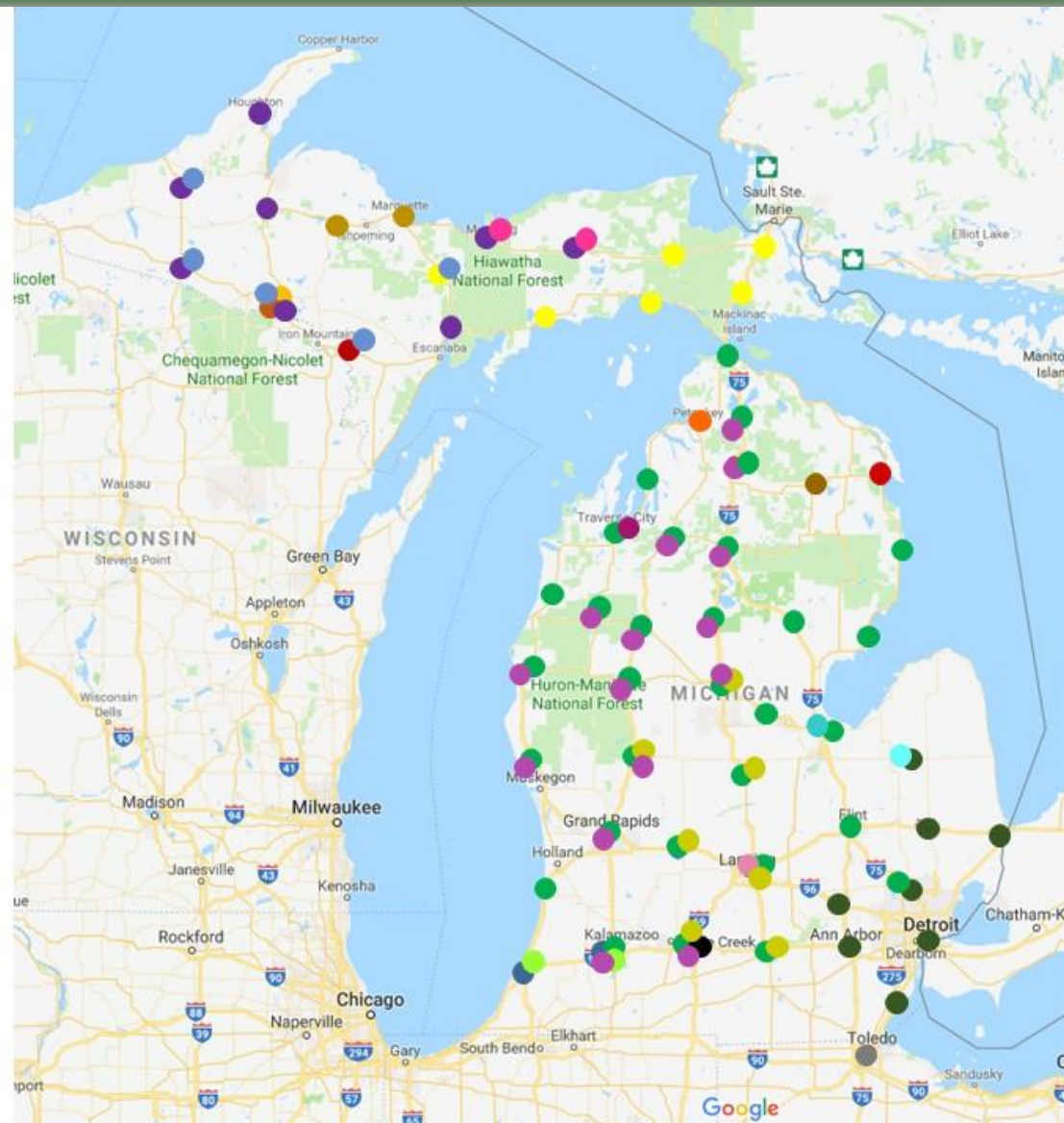
- Economic benefit assumptions
 - *Fees for charging*
- Electric vehicles market share
 - *Currently based on*
Electric Vehicle Cost-Benefit Analysis- Plug-in Electric Vehicle Cost-Benefit Analysis: Michigan
M.J. Bradley & Associates, LLC (MJB&A), July 2017
 - *Is there any other source or estimation available?*
- Grid specification data
 - *Inquire with utility companies*



- 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



Legend

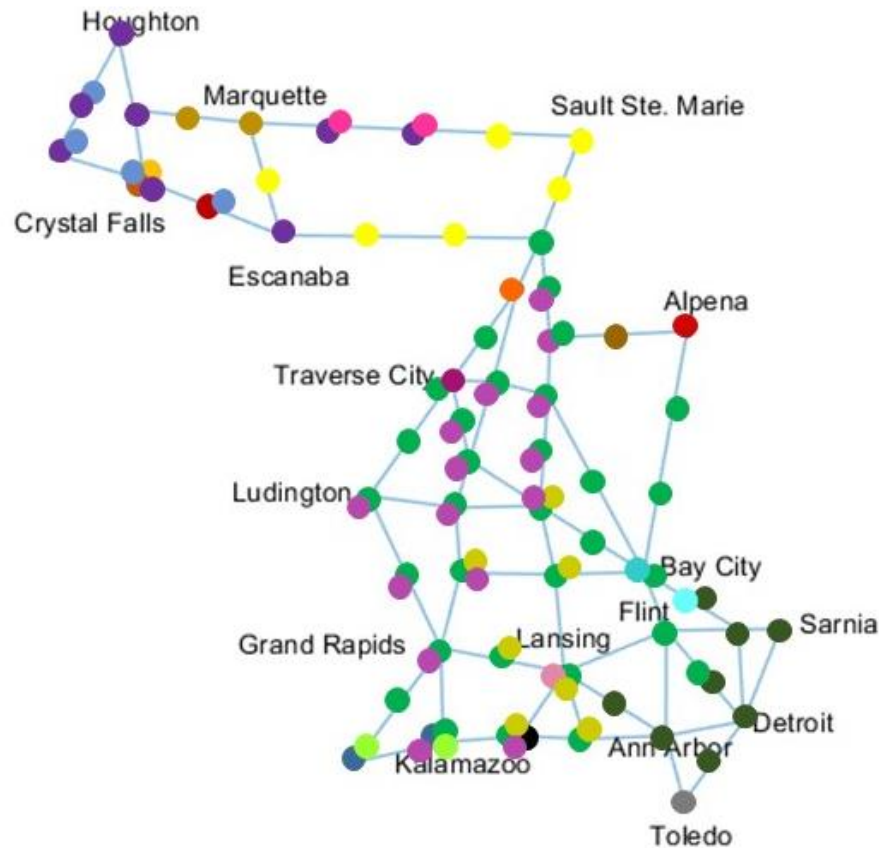
Alger Delta Cooperative
 Cloverland Electric Cooperative
 Crystal Falls Electric department
 Norway L.D.
 Upper Michigan Energy Resources Corp
 Upper Peninsula Power Company
 Marquette Board of Light and Power
 Utility billing Office
 Wisconsin Electric Power Company

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*

Project Data Requirements



Legend

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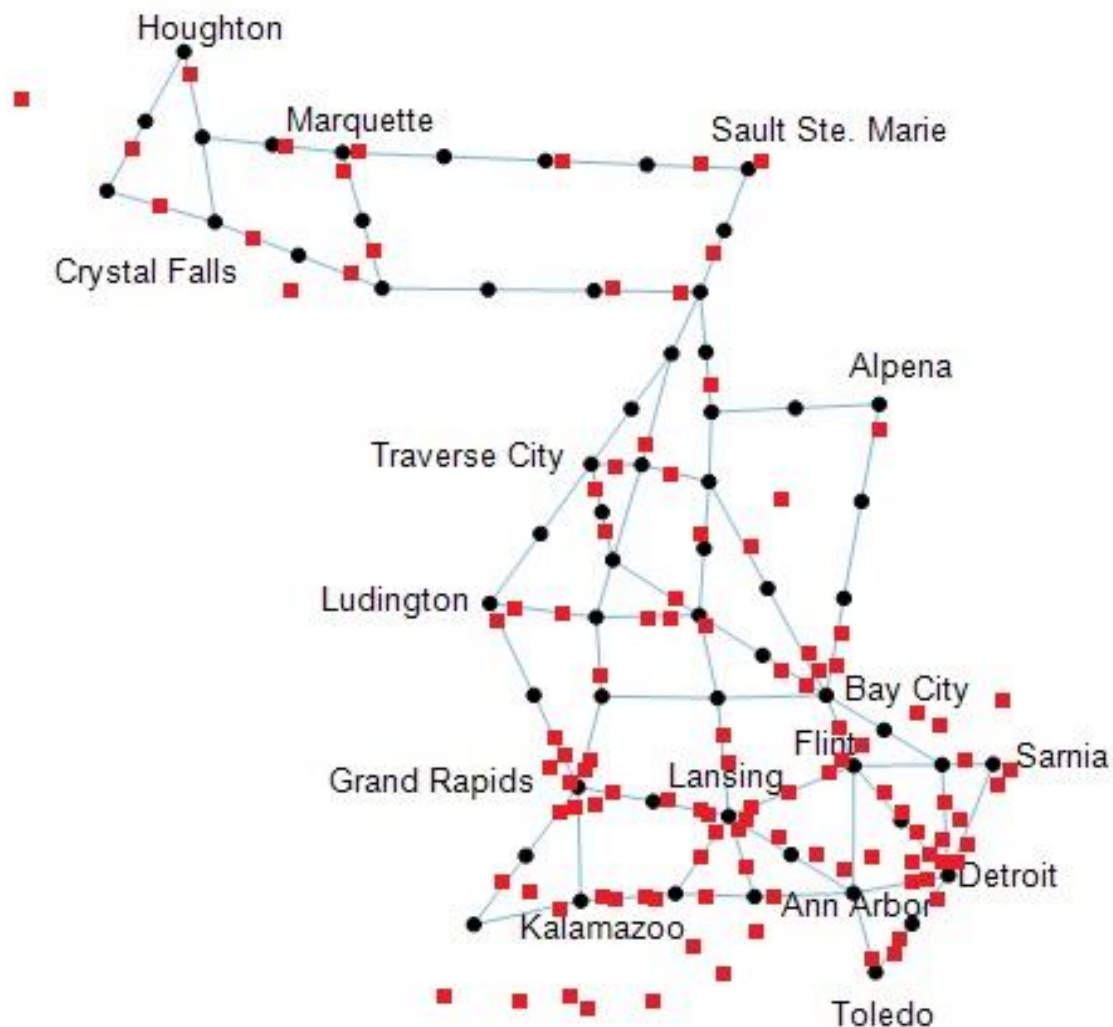
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Source: http://w1.lara.state.mi.us/cgi-bin/mpsc/mpsc/electric-gas-list.cgi?townsearch=c*

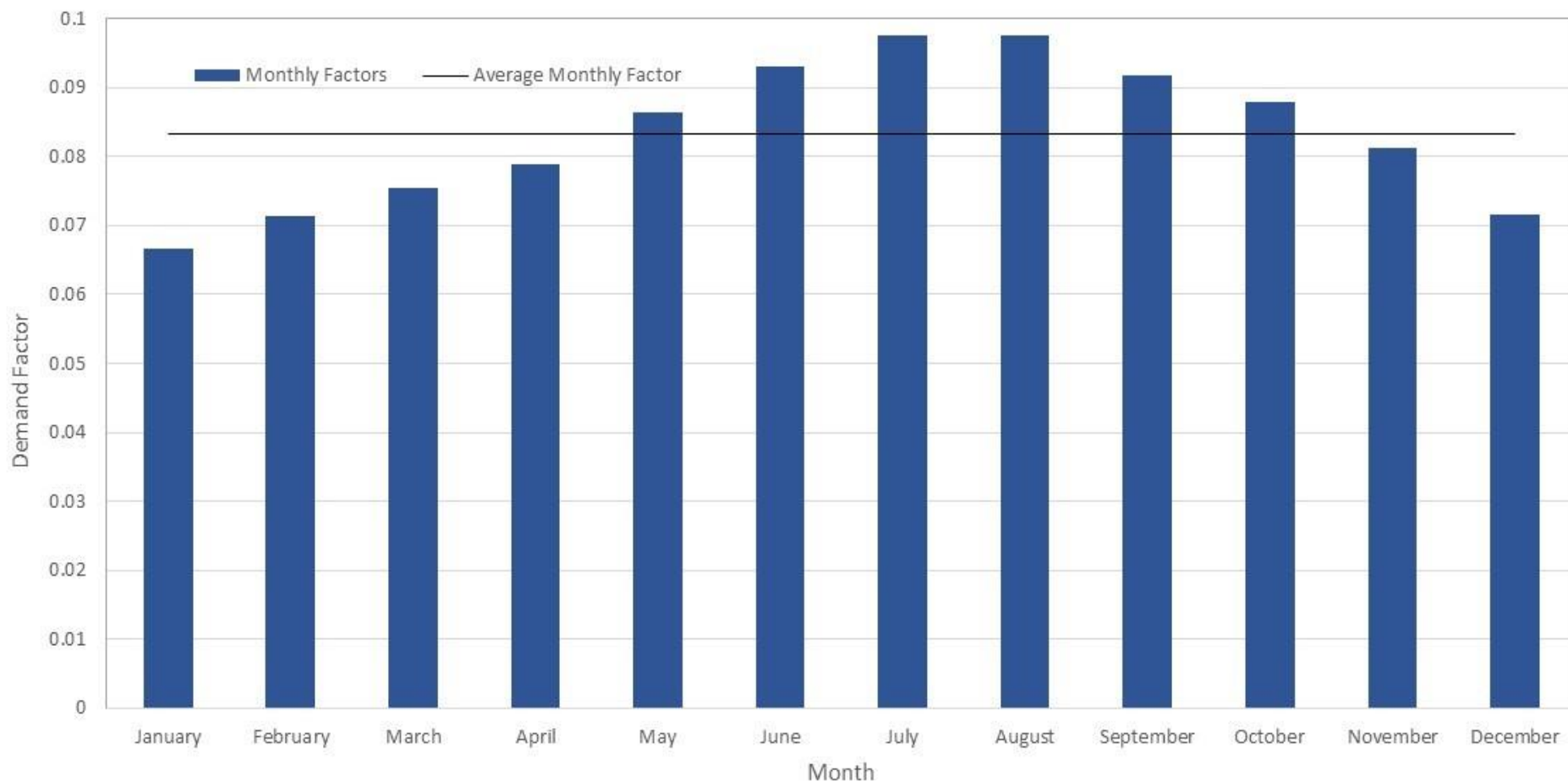
Statewide continuous counting stations

- 122 counting stations statewide
- Counting two-way traffic
- Fluctuations of demand in different months of year and different days of week



Monthly demand at counting stations

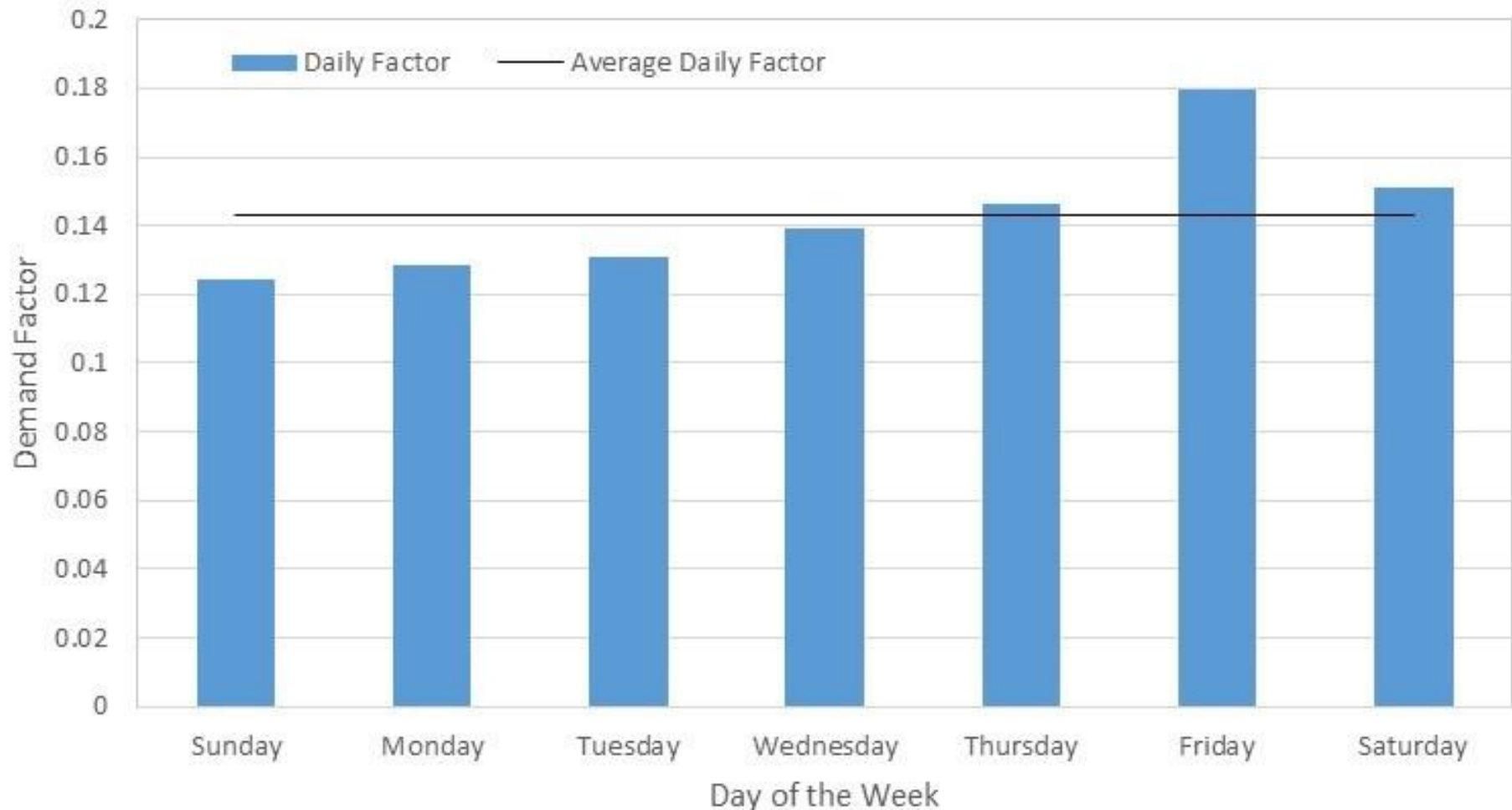
Monthly Demand Factors (Average of All Stations)



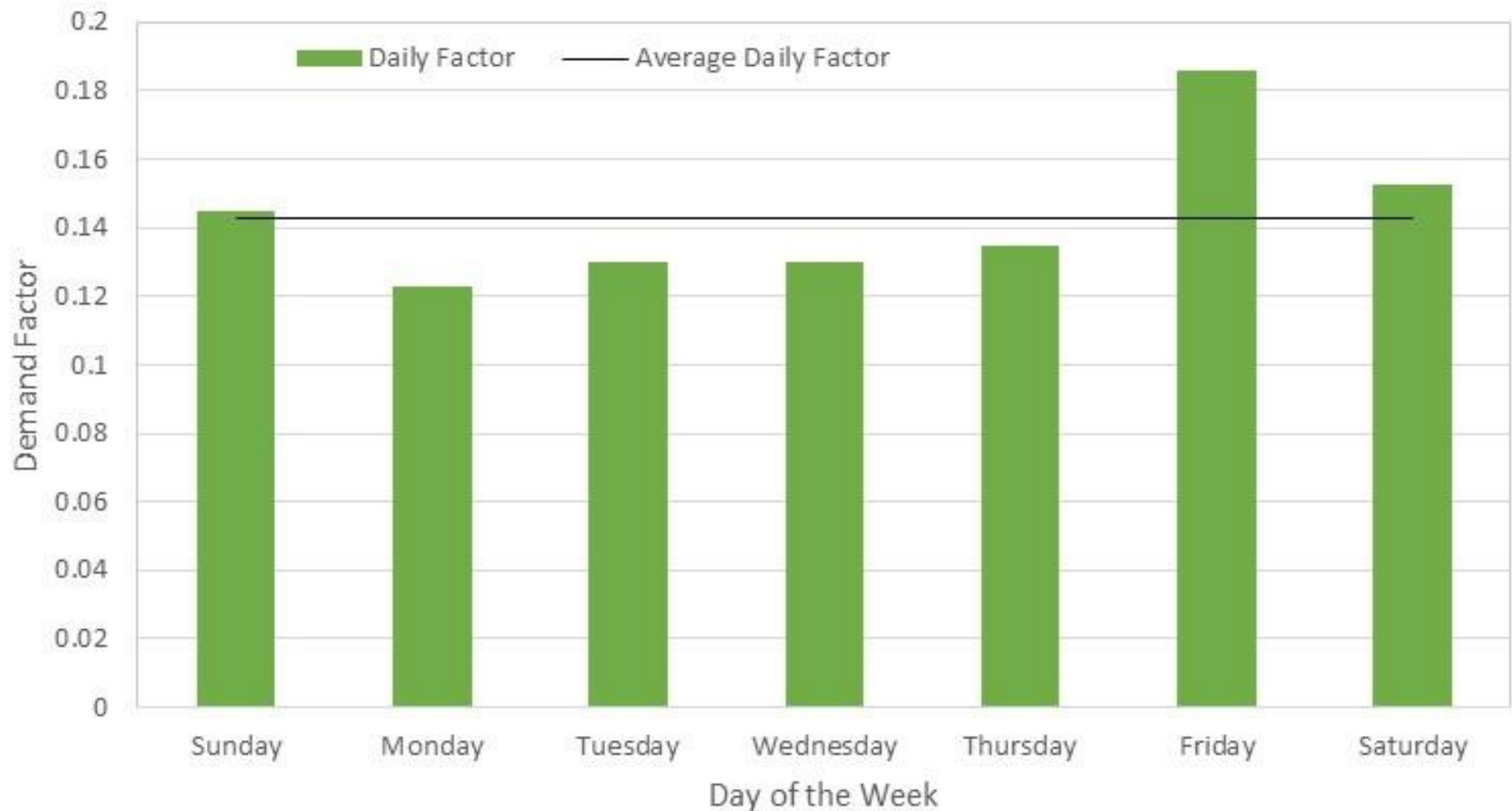
Day of week demand at counting stations

(January/February)

Day of Week Demand Factors in January (Average of All Stations)



Day of Week Demand Factors in July (Average of All Stations)

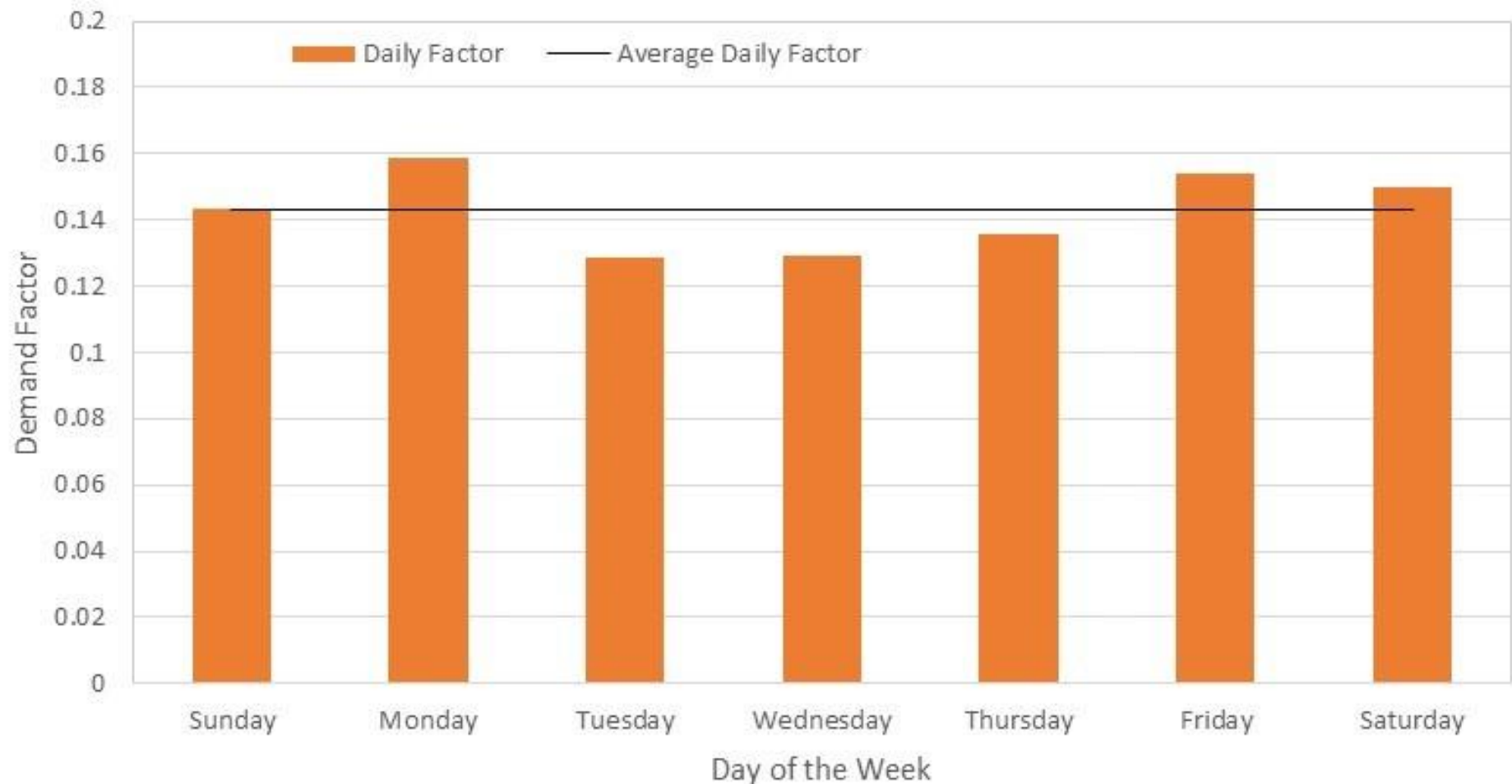


Day of week demand at counting stations

(October)

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Day of Week Demand Factors in October (Average of All Stations)



Thank you!

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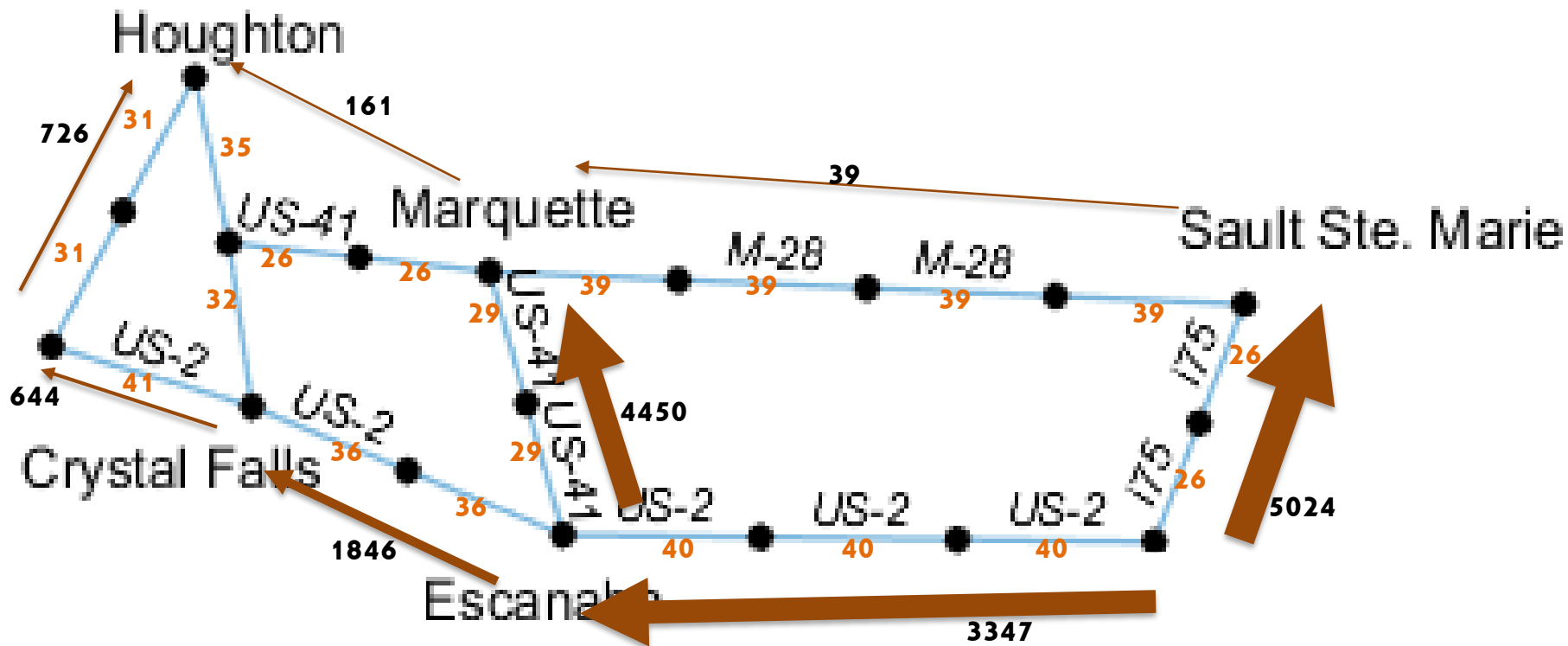
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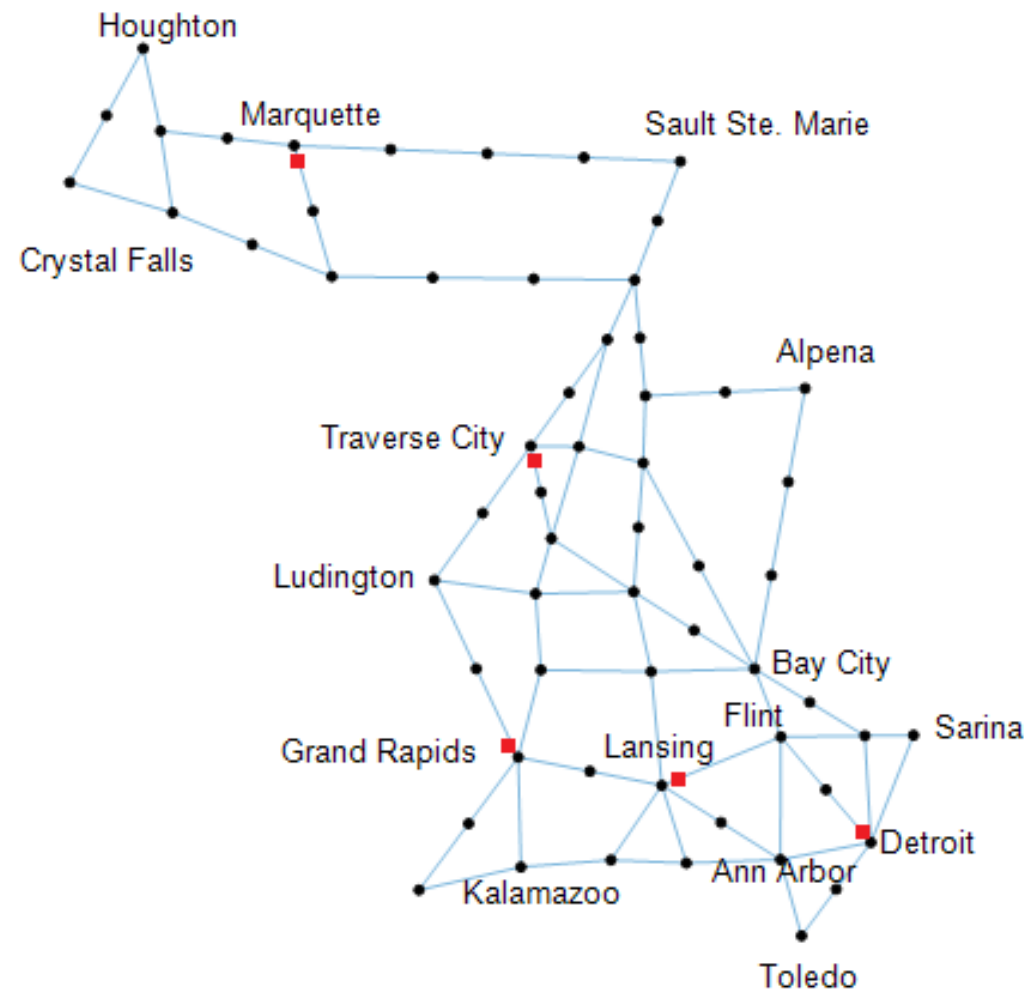


Demand and Distance in UP

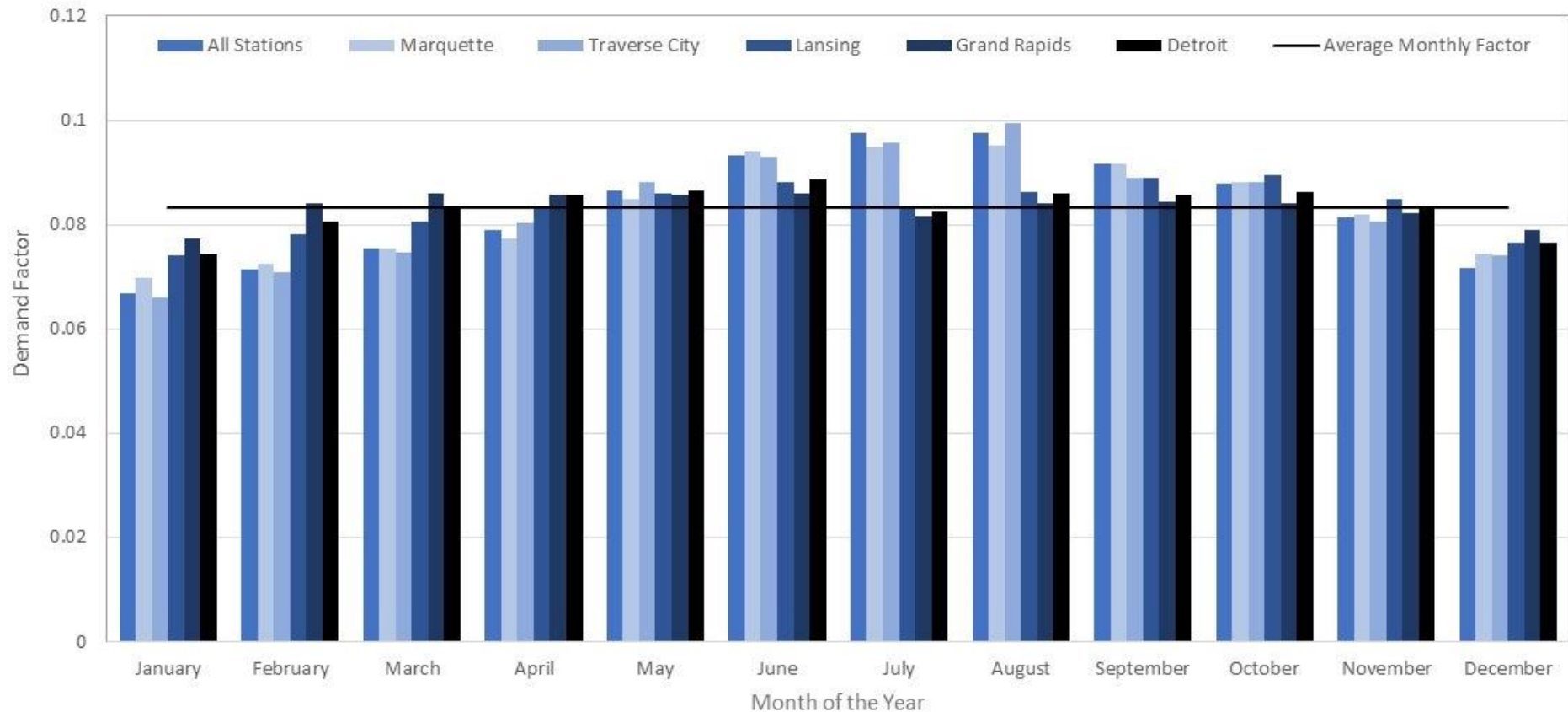


Selected continuous counting stations

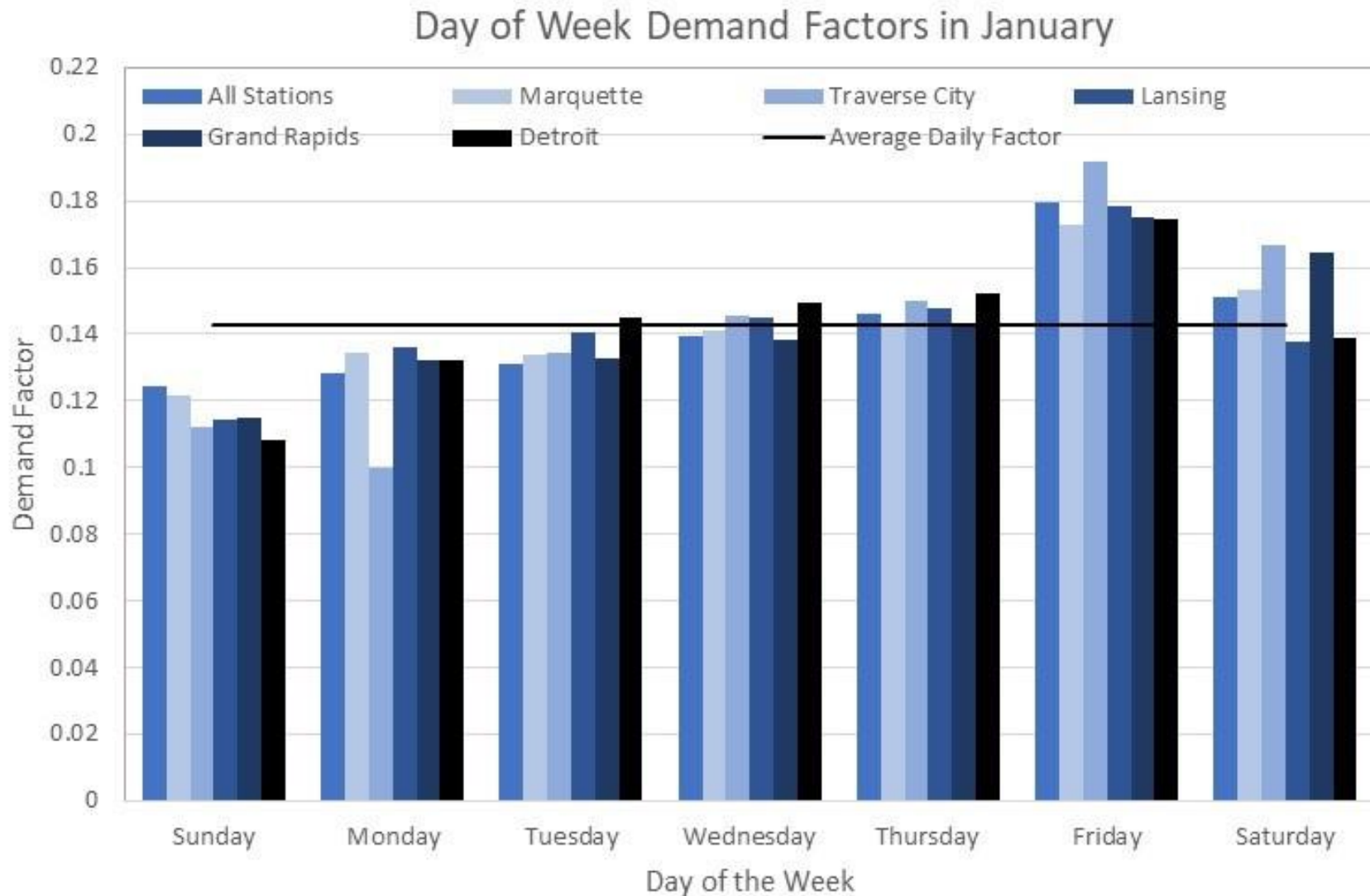
- 5 out of 122 counting stations statewide
- For demonstration and scenario selection purposes
- Distributed among major cities of the state



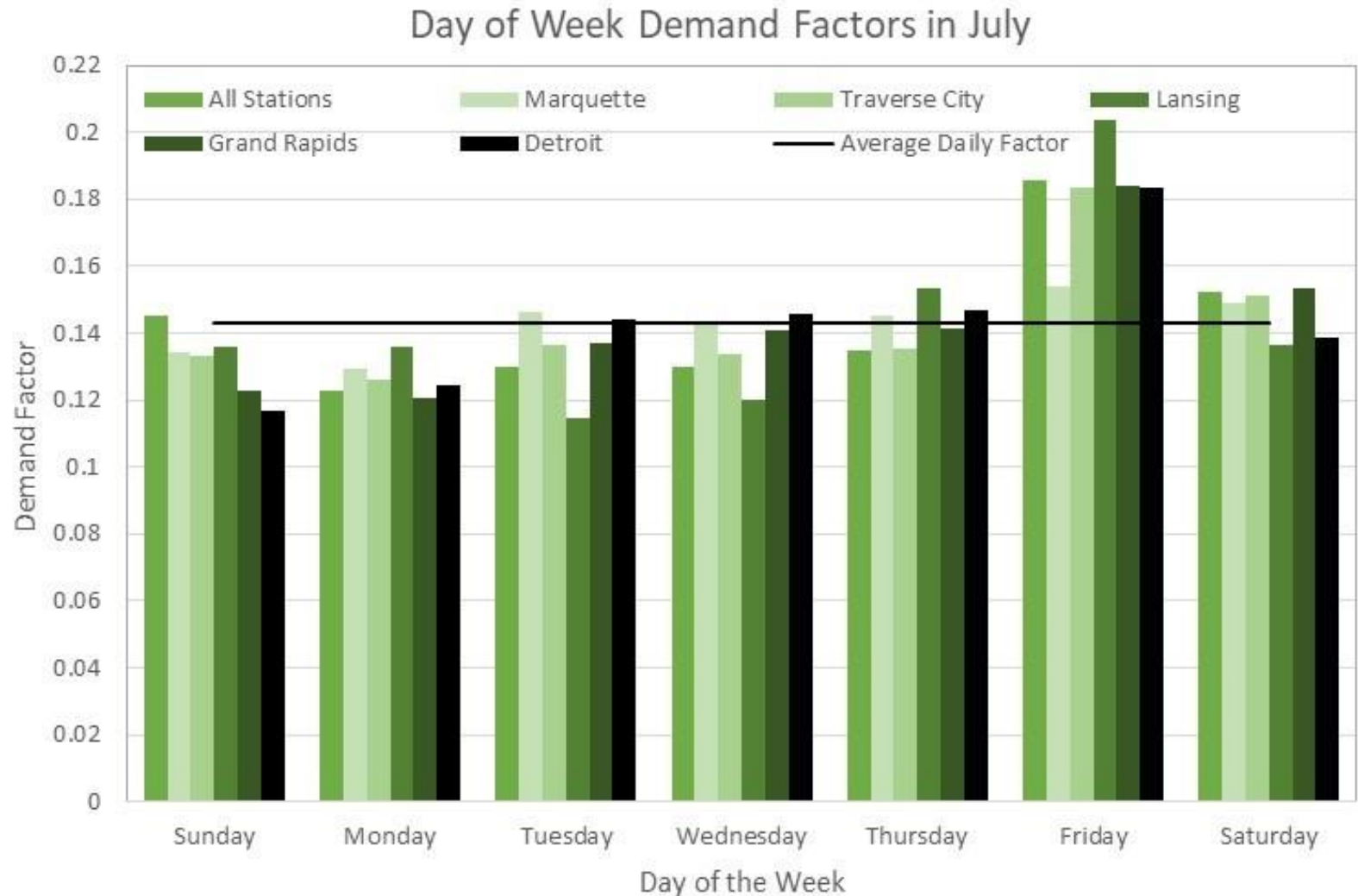
Monthly demand at counting locations



Demand at counting locations- Winter 2016



Demand at counting locations- Summer 2016



Demand at counting locations-Fall 2016

