Solar Microgrid Feasibility Study

City of Ann Arbor

September 12, 2017

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Introduction

- City primary objectives:
  - Resiliency of power supply to critical City infrastructure
  - Reduction of GHG emissions
    - 25% city-wide by 2025 = 568,000 Metric tonnes CO_2e/yr
- Today's presentation:
  - Potential sites for microgrids and renewable energy generation
  - Explanation of assumptions and methodology
  - Assessment of production, emissions, cost
  - Significant opportunities for renewable energy
  - Policy concerns
  - Final recommendations and ongoing work

Solar Site Selection

- Total City-owned Sites: 212
- Sites selected for further consideration: 60
- Sites selected for microgrids (solar + battery) for resiliency:
  - Fire Stations 1, 2, 3, 4
- Sites with significant solar potential:
  - Maynard Parking Structure
  - Landfill
  - Ann Arbor Public Schools
- Sites not included:
  - City Hall/Ann Arbor Police Department
  - Water Treatment Plant

Generation Technologies and Sites Not Evaluated

- Solar: Sites not selected for detailed study
  - City Hall/Ann Arbor Police Department – Low solar generation
  - Water Treatment Plant – High solar generation, but load data not available
- Other generation technologies not evaluated in detail:
  - Hydroelectric on two unpowered dams – no City assets nearby
  - Expanded hydroelectric at two powered dams
  - Wind
  - Geothermal
  - Biomass
  - Methane at Wastewater Treatment Plant – given recent renovations, assume this was addressed if viable

Important Takeaways

- Microgrids for Fire Stations
  - Opportunities to provide resiliency
  - Small emissions reductions
- Solar PV for Landfill and Schools
  - Large surface area for solar arrays provides significant opportunities to reduce city-wide emissions and meet climate goals


Pioneer


Skyline

Methods

- ArcGIS for site assessment
  - Building area footprints from City of Ann Arbor Data Catalog
- NREL PVWatts model for solar PV production ratios
  - TMY3 weather data for Ann Arbor
  - Validated with production data from operating solar projects in southeast Michigan
- NREL System Advisory Model (SAM) for battery storage
- NREL Life Cycle Analysis (LCA) values to estimate total life-cycle emissions reductions

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Assumptions

- Solar Arrays
  - 34º tilt, south-facing
  - Standard (15%) efficiency
  - Fixed Rooftop – buildings
    - 177 kWh/m^2/yr
  - Fixed Open Rack – parking lots/structures, open space
    - 179 kWh/m^2/yr
- Solar Array O&M Coverage
  - 50% Landfill & Parking
  - 62.5% Rooftop (NREL 2016) actors
- SAM
  - System sized for storage & resiliency cases, 6hr peak load
  - Li-ion battery
- System Cost
  - $1.75/Watt installed
- Battery Cost
  - $600/kWh installed (Bloomberg)
- Emissions
  - DTE 2016 Fuel Mix
  - NREL 2013 Emission Factors

Results: Fire Stations 2, 3, 4

Site	Load (MWh/yr)	Solar Generation (MWh/yr)	Avoided Electricity Cost ($/yr)	PV Cost ($)	Payback Period (yrs)
2	22.2	39.4	5,910	58,400	10
3	37.7	66.1	9,920	98,100	10
4	40.0	56.8	8,520	84,300	10

- General payback for rooftop solar PV systems: 10 years

Results: Fire Stations 2, 3, 4

Site	Load (MWh/yr)	Solar Generation (MWh/yr)	Avoided Electricity Cost ($/yr)	PV Cost ($)	Battery Size (kWh)	Total Cost ($)	Payback Period (yrs)
2	22.2	39.4	5,910	58,400	26.3	74,200	13
3	37.7	66.1	9,920	98,100	45.2	125,000	13
4	40.0	56.8	8,520	84,300	38.5	107,000	13

- General payback for systems with batteries: 13 years
- Sized for 6 hour storage
- **Total LCA emissions reductions:** 81.4 tonnes CO_2e/year

Battery Operating Scenarios

- Emergency Discharge vs. Load Leveling
  - Financially equal if purchase/sale price are equal
  - Ability to load level – benefit if purchase/sell prices diverge
    - Shorter payback period

Results: Fire Station 1

Site	Load (MWh/yr)	Solar Generation (MWh/yr)	Avoided Electricity Cost ($/yr)	PV Cost ($)	Payback Period (yrs)
1	377	186	28,000	276,000	10

- High load – large battery required
  - **Battery Size:** 628 kWh
  - **Total Cost (Battery Cost):** $653,000 ($377,000)
  - **Payback Period:** 23 years
- LCA emissions reduction: 93.4 tonnes CO_2e/year

Locations evaluated for solar potential only; i.e., no battery

- Maynard Parking Structure
- Landfill
- Ann Arbor Public Schools

Results: Maynard Parking Structure

Site	Solar Generation (MWh/yr)	LCA CO_2e Reductions (tonnes/yr)	Avoided Electricity Cost ($/yr)	PV Cost ($)	Payback Period (yrs)
Maynard	497	249	74,500	737,000	10

- Does not reduce parking capacity

Results: Landfill

Site	Solar Generation (MWh/yr)	LCA CO_2e Reductions (tonnes/yr)	Avoided Electricity Cost ($/yr)	PV Cost ($)	Payback Period (yrs)
Landfill	40,600	20,300	6,080,000	59,500,000	10

- Land footprint: 120 acres
  - Solar array area: 56 acres
- Can generate 90% of annual electricity consumption for city-owned properties with solar PV
- Potential for a pilot community solar program
- Partnership with University of Michigan

Results: Ann Arbor Public Schools

Site	Solar Generation (MWh/yr)	LCA CO_2e Reductions (tonnes/yr)	Avoided Electricity Cost ($/yr)	PV Cost ($)	Payback Period (yrs)
Huron	4,120	2,060	618,000	6,070,000	10
Pioneer	4,920	2,460	737,000	7,260,000	10
Skyline	3,940	1,980	591,000	5,810,000	10
Clague	1,250	624	187,000	1,840,000	10

- All Ann Arbor Public Schools (32 total):
  - **Total rooftop potential:** 22,800 MWh/year
  - **Total parking lot potential:** 12,400 MWh/year
  - **Total LCA emissions reductions:** 17,600 tonnes CO_2e/year

Significant Opportunities

- Solar plus storage for resiliency of some city-owned sites
- On-site natural gas generator at any site as an additional non-spinning reserve (for backup power and load leveling)
- Large-scale solar to grid for parking structures and landfill
  - **Landfill represents opportunity for large-scale solar farm**
  - Pilot Community Solar projects can be possible with further negotiation
    - Power Purchase Agreements have enabled landfill solar farms in other states
      - Examples: Rochester, NY; Brooklyn, OH
- School partnerships for community solar or microgrid sites

Policy Issues

- Generic barriers to microgrids and solar PV include:
  - Local zoning laws
  - Lack of tax incentives
  - Lack of solar access laws/easements
- Michigan/Local barriers
  - Vague or restrictive zoning laws, tax status can limit investment in PV and microgrids
  - Regulatory changes may be seen within the next year
  - No state laws directly enabling community solar
- Conclusion: behind-the-meter or utility-connected?

Conclusions

- Properties analyzed could meet the city's 2015 renewable energy goals, but not CAP carbon reduction goals
- Resiliency for Fire Stations 1, 2, 3, and 4 is possible
  - Could be combined with solar and/or wind
  - Larger microgrid with other downtown city-owned properties
- Public Schools have potential for community solar and microgrids
- Landfill is a potential site for community solar or possible partnership with U of M in cooperation with local utility

Final Recommendations for City Action

- Explore investment options for large-scale solar farms
  - Potential partnerships between Public Schools, City, and U of M
  - Enable public participation via community solar
  - Explore financing using Power Purchase Agreement
- Assess local zoning laws that may affect microgrid (electric and heat) installations, especially on new construction
- Partner with community and utility to finance microgrids for student rental properties throughout city?

Future Work

- Close the gap between CAP carbon emissions goals and identify low-emissions energy potential – more study needed:
  - Renewable generation sources in addition to solar PV
  - Resiliency for Wheeler Center and Water Treatment Plant
  - Conversion of diesel generators to natural gas (decreases CO_2e)
  - Core downtown microgrid of city-owned assets
- Working with AAPS to conduct a detailed assessment of school properties, including a robust project template for use in future assessments (U of M Fall 2017, Simon and Arnuk)

Acknowledgements

- Chuck Hookham, Consumers Energy
- Mike Bonnell, Black & Veatch
- Wayne Appleyard, Sunstructures Architects
- Laura Sherman, 5 Lakes Energy
- Dave Konkle, Great Lakes Renewable Energy Association
- Kevin Self, Schneider Electric
- Nate Geisler, City of Ann Arbor
- Emily Drennen, City of Ann Arbor
- Josh Macdonald, City of Ann Arbor
- Department of Earth and Environmental Sciences

References

- (DTE Energy 2017) DTE Jan. 2016 – Dec. 2016 Fuel Mix – https://www.newlook.dteenergy.com/wps/wcm/connect/dte-web/home/community-and-news/common/environment/fuel-mix
- (NREL 2013) LCA Harmonization Project – https://www.nrel.gov/analysis/sustain_lca_results.html
- (NREL 2016) U.S. Solar Photovoltaic System Cost Benchmark: Q1 2016 – https://www.nrel.gov/docs/fy16osti/66532.pdf?utm_source=NREL%20Report%20Shows%20U%2ES%2E%20Solar%20Photovoltaic%20Costs%20Continuing%20to%20Fall%20in%202016&utm_medium=email&utm_content=nrel&utm_campaign=NewsRelease
- (MCL 2017) Michigan Compiled Laws Complete Through PA 117 of 2017 - http://www.legislature.mi.gov/(S(2nxwwxswygpxaerhf4qehbvf))/mileg.aspx?page=MCLBasicSearch
- Ann Arbor Charter Township Code of Ordinances – https://library.municode.com/mi/ann_arbor_charter_township,_(washtenaw_co.)/codes/code_of_ordinances