The Practical Implementation of Distributed Solar CHP With Thermal and EV Battery Storage for Schools

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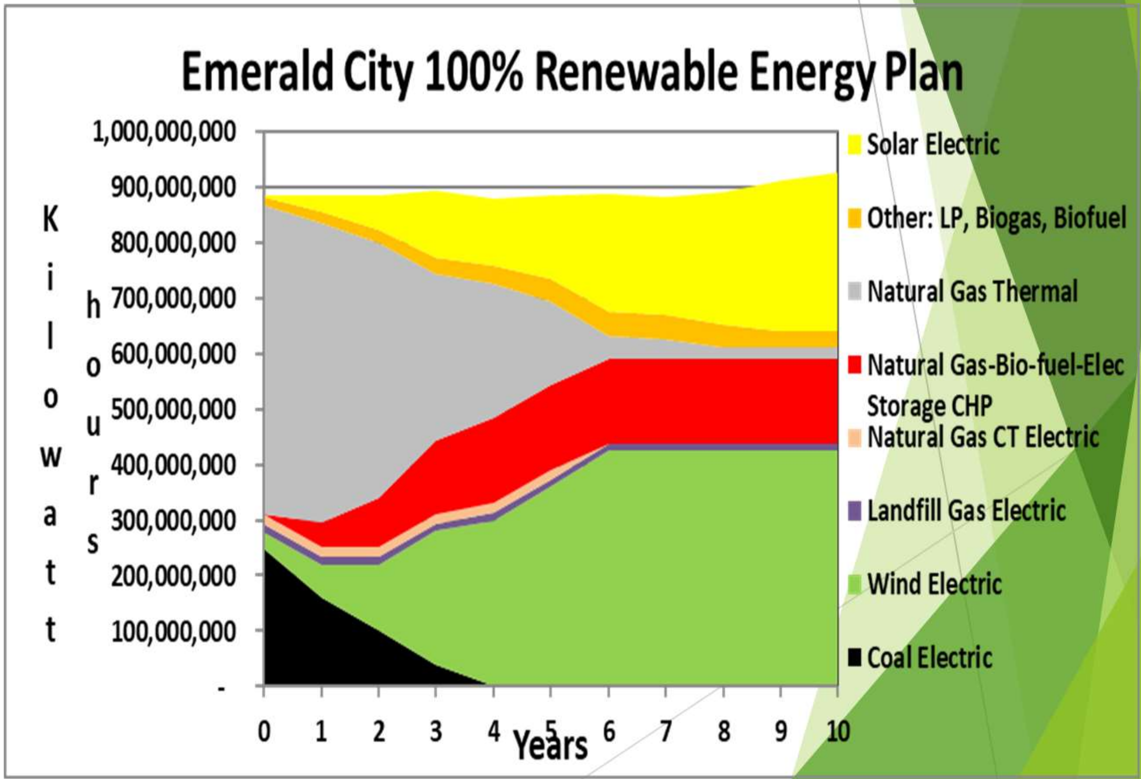
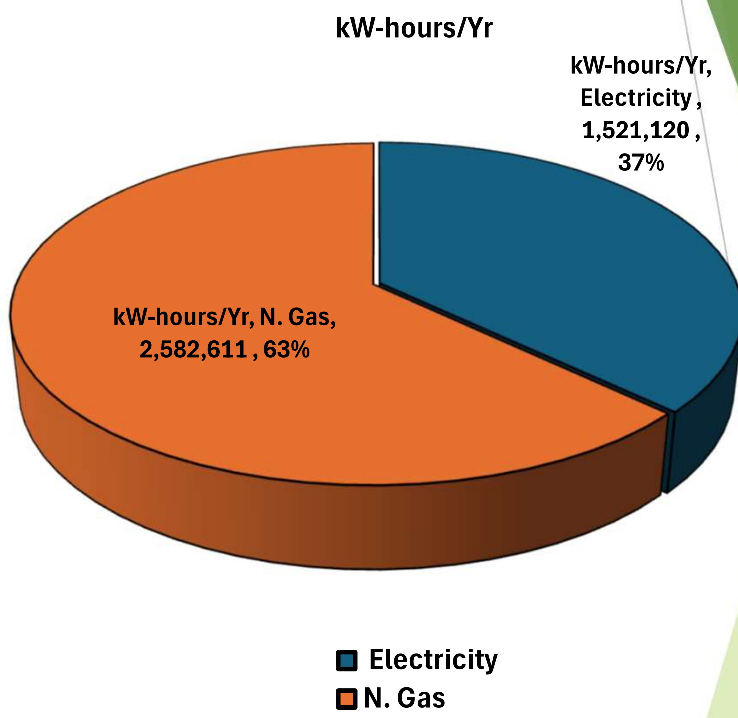
Summary and Background

- This project implementation is based on the framework developed in my ASES paper "Accelerating 100% Renewable Energy Plans" ASES Solar 2023 –that focuses on "mid-scale" community/local utility based solar PV with thermal and electrical storage inside the local electric distribution system.
- Policies and this project are also evaluated based on my conceptual plan, "Emerald City 100% Renewable Energy Plan", ASES Solar 2020 with a ten-year target to increase electric distribution from renewable energy roughly by a factor of three.



Primary Objectives

- Eliminate fossil gas GHG's
- 100% Renewable Energy – 4 million kW-hrs/yr.
- Maximize solar PV site availability
- Install solar and storage to cover both electric and thermal energy needs, displacing fossil gas and petroleum with electric kWe-hours ("electrification")
- Increase electricity distribution, in this case, 2.74 times present electric consumption
- Lower overall energy costs to school and utility
- Fit into local distribution system substation with limited electric gird upgrades – NO MISO (Mid-Continent Independent System Operator) application requirements.
- Regenerative and distributive Energy Systems (ala "Doughnut Economics")



Policies

- Public Utility / Community / cooperative solar
- Federal direct pay incentive via IRA (no Minnesota flip)
- On-bill financing
- Rebates
- Time of use (TOU) rates – high load factor rates
- Unlimited net metering – or fair value for mid-scale(1 – 10 MW) solar
- Smart grid harmony
- School bonds - green bonds
- Account for environmental / GHG / multiplier impacts
- Non-market solutions

More Advantages of Distribution System Solar CHP Generation Policies and Systems

Avoid Market Failures and Limits

- The imperfect flow of information
- Transaction costs
- The non-existence of markets for some goods
- Market power
- Externalities
- Public goods

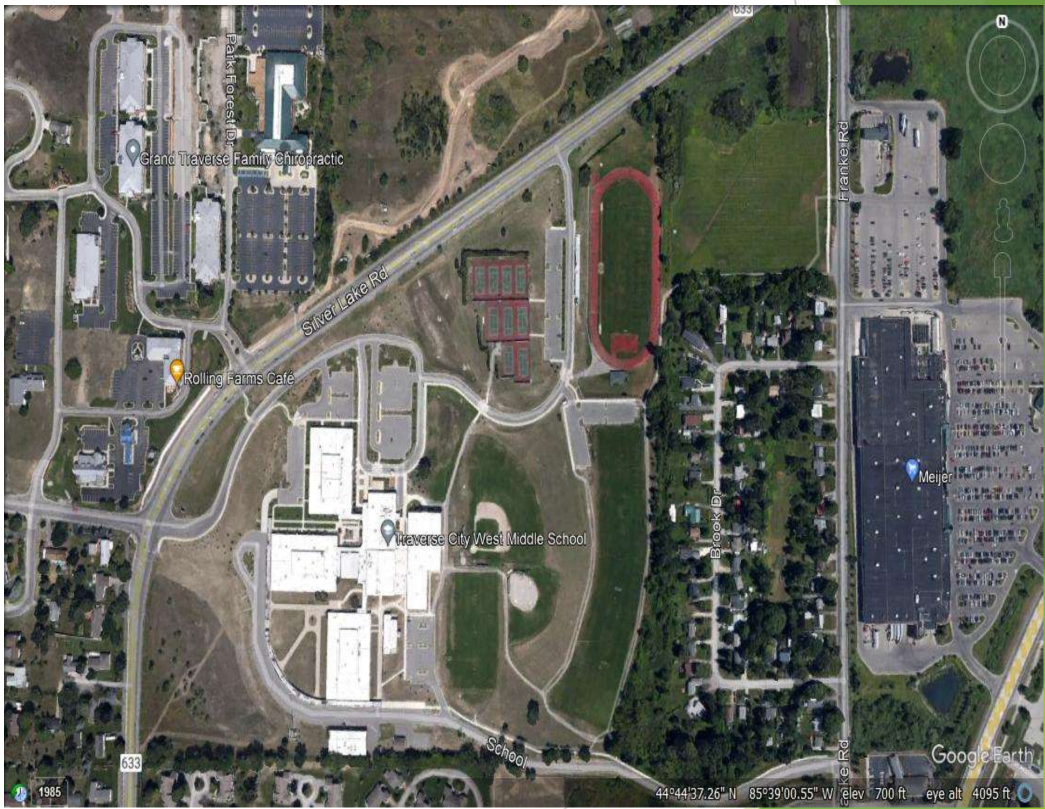
- "Make the market your slave, not your master". Frede Hvelplund, Aalborg U.
- "What if at optimal economics we are all dead?" Econ professor Dr. Jeffery Barbour

Reasons For Avoiding "Independent System Operators" MISO, PJM, etc.

- Transmission access application costs
- Long queues, studies and delays (years)
- Transmission expenses and fees
- Transmission and substation efficiency losses (2% minimum up to 10%)
- Market restrictions and bidding processes
- Loss of local control
- Potential of negative market pricing during oversupply periods, especially with increasing amounts of solar and wind generation.
- NEVER CURTAIL WIND AND SOLAR GENERATION!

Junior High School – Site and Building Characteristics

- School Campus Property: 90 acres (36 ha)
- Building Roof: 210,000 sq. ft. (19,520 m2) (5 acres or 2 ha)
- Annual Energy Expense: $284,849
- Present Annual KW-hrs – 1,521,120
- Natural gas equivalent kW-hrs – 2,582,611 (117,526 ccf)
- Total Building energy kW-hrs – 4,103,731 (100% Site target)
- Estimated Bus off-site KW-hrs/yr. 60,300
- Total kW-hrs/yr. W/Buses – 4,146,031
- Present peak kW demand 131 kW



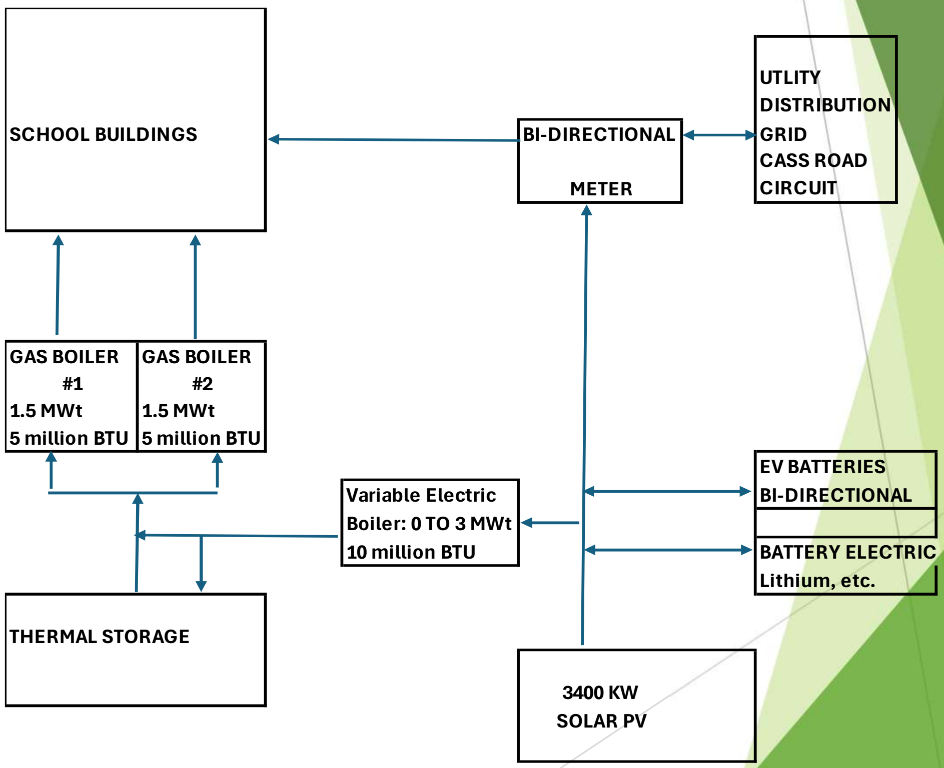
Solar PV 100% Annual kW-hours =3400 KW dc

- Solar PV coverage: 23 acres of 90-acre site. (9.2 ha of 36 ha)
- Includes:
  - Parking area
  - Roofs
  - Fields
  - Road edge

  - Photo example c/o Big Sun Solar

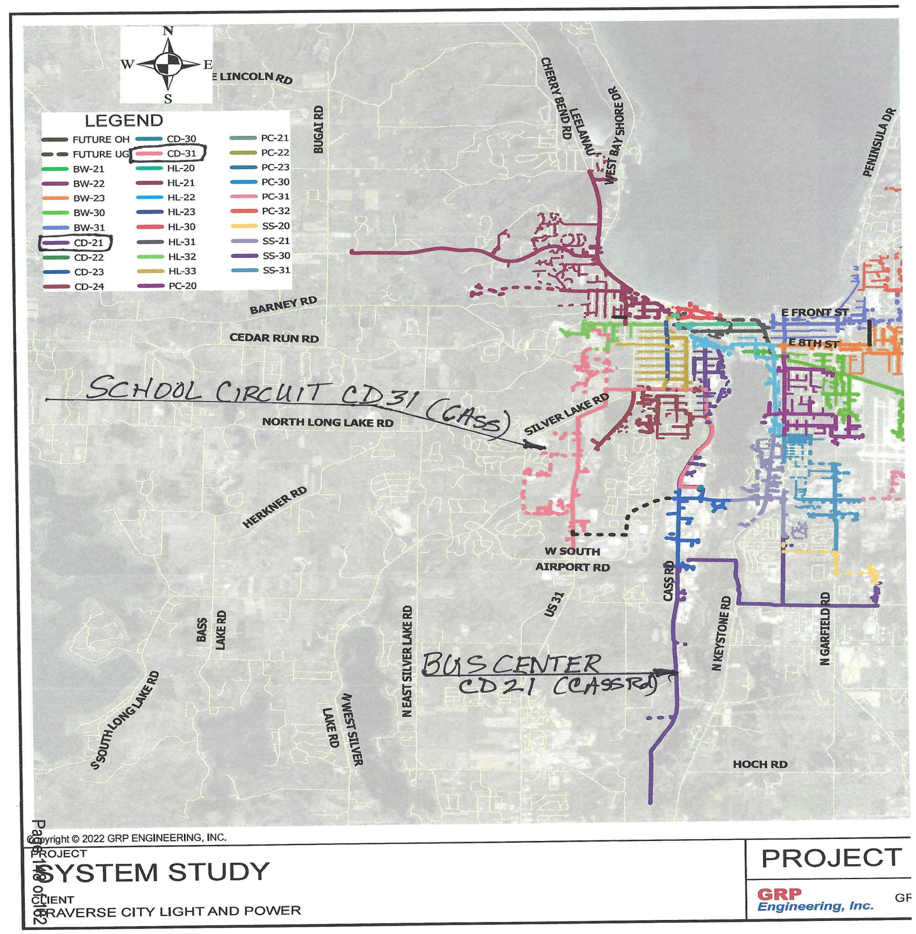
Solar CHP System

- Micro-grid controls
- Utility "smart grid" for demand management, power quality, etc.
- Fossil gas boilers remain in place, are pre-feed by electric boiler, only remain as back-up and maintenance.
- Variable electric boiler to meet demand and thermal storage as needed, and can act as utility voltage management system, etc.



Electric Distribution Grid

- School on distribution circuit CD 31 (“Cass Road” substation).
- Bus Transportation Center on distribution circuit CD 21 (“Cass Road” substation)



Electric Distribution Transformer Loads

Transformer Loading - Peak Summer and Average										
LOAD STUDY DATA FROM ENGINEERING REPORT					SMILEY EXTRAPOLATION OF DATA					
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Substation	Trans	Rating (MVA)	Summer Peak Loading (MVA)	% Max	Net of 100% (MVA)	Avg Loading at 40/70 (MVA)*	% Avg	Net of 45% Safety Factor**	45% Avg Load (MVA)	Avg Net Load at 45% (MVA)
Barlow	#1	13.4/17.9/22.4	6.95	31.0%	15.45	3.97	17.7%	27.3%	10.08	6.11
Barlow	#2	13.4/17.9/22.4	7.54	33.7%	14.86	4.31	19.2%	25.8%	10.08	5.77
Cass	#1	13.4/17.9	7.57	42.3%	10.33	4.33	24.2%	20.8%	8.055	3.73
Cass	#2	13.4/17.9/22.4	11.41	50.9%	10.99	6.52	29.1%	15.9%	10.08	3.56
Parsons	#1	13.4/17.9	7.00	39.1%	10.90	4.00	22.3%	22.7%	8.055	4.06
Parsons	#2	13.4/17.9/22.4	11.58	51.7%	10.82	6.62	29.5%	15.5%	10.08	3.46
Hall	#1	22.4/29.9/37.3	9.57	25.7%	27.73	5.47	14.7%	30.3%	16.785	11.32
Hall	#2	22.4/29.9/37.3	11.03	29.6%	26.27	6.30	16.9%	28.1%	16.785	10.48
South	#1	13.4/17.9/22.4	3.63	16.2%	18.77	2.07	9.3%	35.7%	10.08	8.01
South	#2	13.4/17.9/22.4	4.77	21.3%	17.63	2.73	12.2%	32.8%	10.08	7.35
		244.8	81.05		163.75	46.31	19.5%	25.5%	110.16	63.85

*40/70 MVA is annual averag 40 MVA compared to summer peak 70 MVA multiplied times the summer peak MVA load.

**45 percent is the recommended transformer loading factor to provide 100% backup connecting to adjacent transformers with circuit failures

965,001,600 kW-hours/year with average loading of 110 MVA at 45% substation safety factor!

This is 3 times the present annual consumpion!

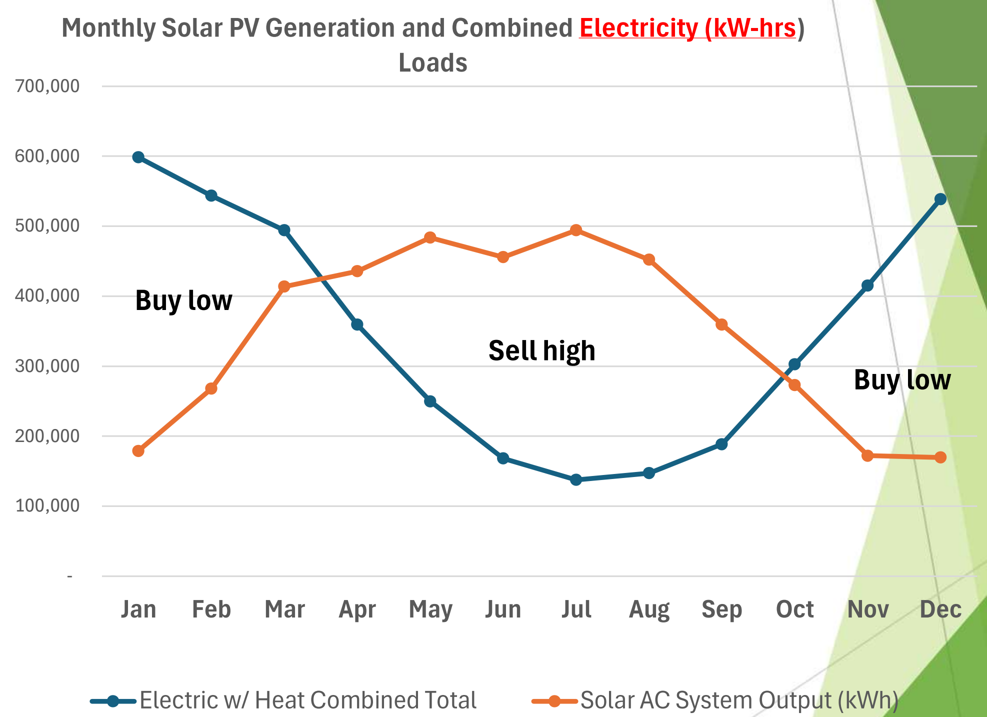
Cass # 2 and Parsons # 2 are only transformers loaded over 45% at summer peak.

The system load study analysis recommends increasing capacity at Cass and Parsons

- Cass Road Circuits are highest loaded at peak daytime summer periods—but study shows, on average, loads are <30% of transformer capacity (Column f), well below the safety load target of 45%.
- On average, over 3 MWe of(off-peak) electric heating and lighting capacity are available—from the utility.
- With a summer peak load at 50.9%, **solar PV** during summer peak can offset higher transformer loads.
- Demand management plus storage will also offset summer peak periods
- Thermal storage with variable electric heating controls (f/x Lattner Electric Boilers) can be used for power quality, voltage control, load balancing, extra “high load factor” off peak utility distribution sales.

The Solar PV Solution

- Target solar PV size to generate 100% annual kW-hours – 4,103,731
- 3,400 kW Peak Solar Array's assuming local solar resources
- Solar array's: 23 acres (9.2 ha) of 90-acre (36 ha) property, mostly parking lots and building roof area space
- Solar dispatched according to needs:
  - Peak period "peak shaving" - to eliminate demand charges (10 AM - 5 PM) 35 hours per week.
  - Peak shave and sell excess summer solar at high value demand periods—greatest energy need for utility
  - Importantly, this solar PV system peak capacity represents 10% of the entire utility average MW load, and 5% of the peak summer load!



Key Findings and Conclusions

- Implement a system to manage loads with solar PV, electric heating and storage (thermal and electric) to make the school a “high load factor” consumer (90% +/-) providing for low-cost electricity (<7 cents/kW-hour)
- Only draw high load electric heating off-peak (80% of hours)—use energy or put in storage.
- 3,400 KWe peak solar will benefit the entire distribution circuit, not just the school, while 100% of the school’s annual energy will be accounted for with solar, trading high value solar for low priced off-peak energy.
- Work inside the utility “distribution” system. Avoid ISO’s and IOU’s, independent system operators and investor-owned utilities. Avoid the many structural and institutional barriers with IOU’s and ISO’s.
- Create direct competition between cheap electric RE and natural gas IOU’s.
- Create direct competition between cheap electric RE and petroleum, gasoline, diesel, LP gas, fuel oil, etc.
- Make your own local policies; GHG fees, TOU rates, rebates, on-bill financing, net metering, etc.
- Build your own local projects, community solar, commercial wind, fuel switching, smart grid with broadband, energy efficiency, infrastructure upgrades, all with financing. Focus on local ownership versus PPA’s.
- Get involve with public power locally: Community engagement is a two-way street.

Thanks for listening
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