RE-Energizing Emerald City: 100% Solar Renewables

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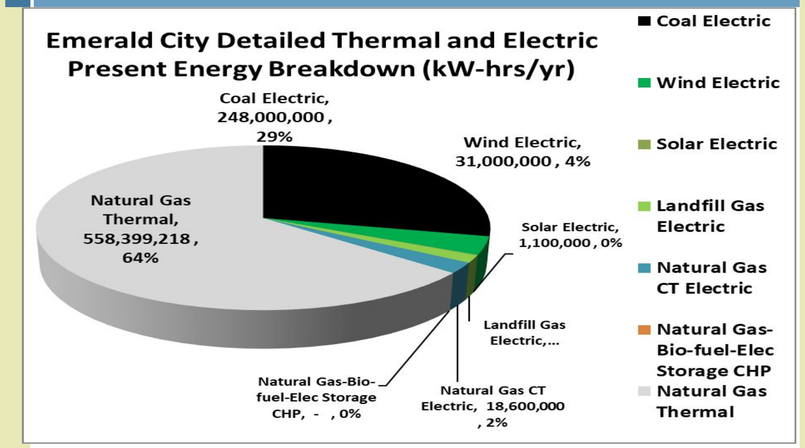
ABSTRACT

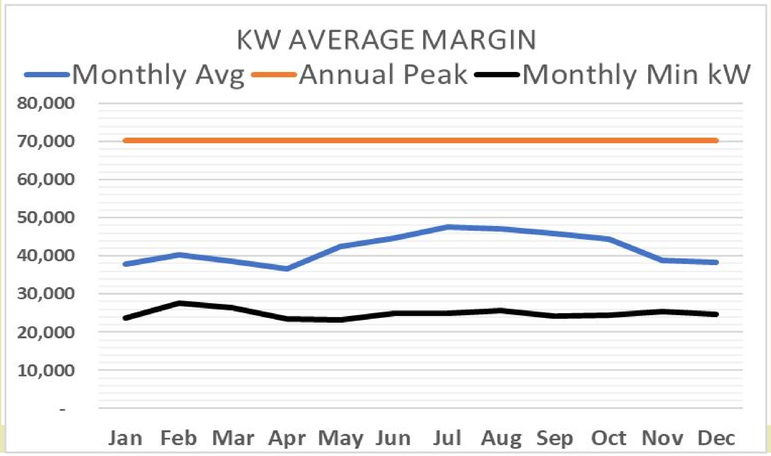
This is a "how to" plan for making "Emerald City" 100% renewable energy heated and powered, including mobility, within ten years. "Emerald City" is based on the geographic, economic and energy characteristics of Traverse City, Michigan with a population of 15,000, covering 8.7 square miles, in a humid continental climate with 7,794 heating degree days and 458 cooling degree days. The solar resource is 1,350 kW-hrs/m2/year and the wind resource is IEC Class IIIA on surrounding higher ground. This study includes solar, wind and combined heat and power (CHP) transitioning from natural gas to electric heat and power, (heat pump assisted), electric thermal storage and bio-fuels in conjunction with small CHP distributed district heat systems.

With an annual energy expense of $55 million, with electric consumption of 310 million kW-hours (310,000 MW/hrs), a summer peak of 70,000 kW (70 MW's) a base load of 25,000 kW (25 MW's) and 560 million kW-hours/year (560,000 MW-hours) of natural gas thermal use, the present energy profile (without transport), is 63% natural gas thermal, 28% coal, 2% natural gas CT, 3.5% wind, 1% landfill gas, and 1% solar electric. This plan will result in a clean energy profile of 46% wind (124 MW), 31% (191 MW) solar, 17% CHP (35 MW) transitioning to electric and thermal storage, and 5% other. The distributed energy systems will be connected on the public utility distribution side of the local sub-stations, avoiding, whenever possible, the system operator MISO market limitations and restrictions. At a capital cost of $600 million over ten years the investment will fix long-term wholesale electric prices at rates competitive with natural gas, averaging less than $0.05/kW-hr.

PRESENT ENERGY PROFILE



ELECTRIC LOAD PROFILE



PROJECTS: SOLAR, WIND, CHP

SOLAR ELECTRIC	Acres	Installed KW	Capacity Factor	Energy (kWh/yr)	kW on Cloudy day	Est. Capital Cost ($million)
Airport / Aero Park Drive Area	125	25,000	0.15	32,850,000	2,500	$ 38
Solar PV - NMC/CHS/Civic Center	10	2,000	0.15	2,628,000	200	$ 3
GT Commons Solar PV	10	2,000	0.15	2,628,000	200	$ 3
South Hwy 31 Solar PV - West JR High/Meijer/...	250	50,000	0.15	65,700,000	5,000	$ 75
Sub-station based Solar PV w/ Electric Storage (TWP FARMS)	500	100,000	0.15	131,400,000	10,000	$ 150
M72 V44 Wind Site Solar PV - 3 MW +	15	3,000	0.15	3,942,000	300	$ 5
Distributed "Community Solar PV" (with established policy)	50	10,000	0.15	13,140,000	1,000	$ 15
Distributed net metering residential/commercial/institutional	100	20,000	0.15	26,280,000	2,000	$ 30
Schools: T Heights, G Loomis, CGS, EE, etc	6	1,200	0.15	1,576,800	120	$ 2
West Bay Solar Pier	0.25	140	0.15	183,960	14	$ 0
Industrial Sites; trackers and single axis large net metering	15	3,000	0.15	3,942,000	300	$ 5
SOLAR TOTAL	**957**	**191,340**		**284,270,760**	**19,134**	**$ 287**

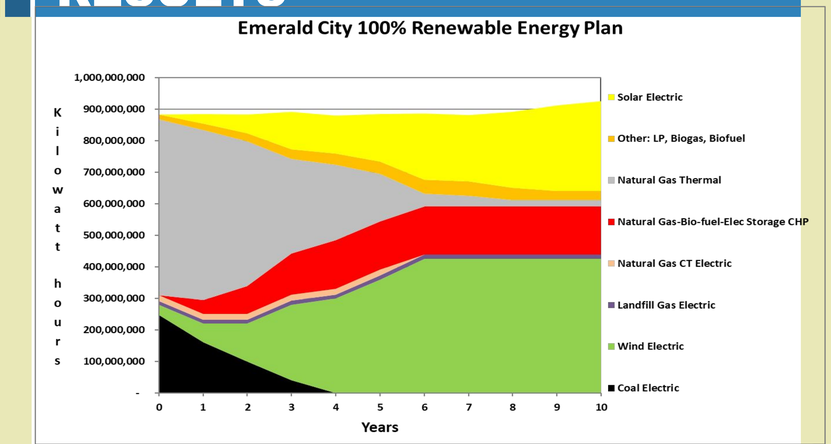
COMMERCIAL WIND	Number	Installed KW	Capacity Factor	Energy (kWhr/yr)	kW on Low Wind Day	Est. Capital Cost ($million)
Existing Heritage 10 MW	5	10,000	0.3	26,280,000	500	$ 18
City Distributed Wind Projects	2	6,000	0.4	21,024,000	300	$ 11
Garfield Twp Wind	4	12,000	0.4	42,048,000	600	$ 22
Elmwood Township	6	18,000	0.4	63,072,000	900	$ 32
Long Lake Township	2	6,000	0.4	21,024,000	300	$ 11
East Bay Township	2	6,000	0.4	21,024,000	300	$ 11
Acme Township	10	30,000	0.4	105,120,000	1,500	$ 54
Peninsula Township	2	6,000	0.4	21,024,000	300	$ 11
Blair Township	10	30,000	0.4	105,120,000	1,500	$ 54
WIND TOTAL	**43**	**124,000**		**425,736,000**	**6,200**	**$ 223**

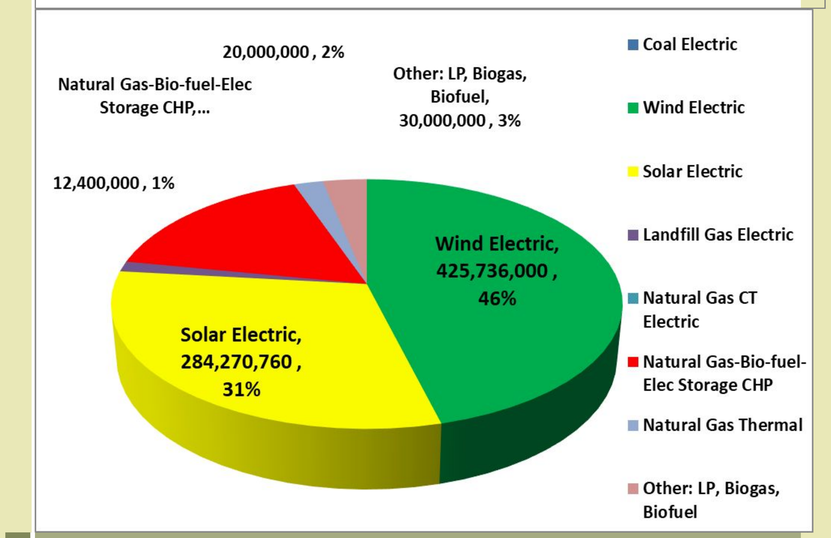
COMBINED HEAT AND POWER (CHP) NG-Bio Fuel-Elec Storage	Installed KW	Capacity Factor	Energy (kWh/Yr)	Est. Capital Cost ($million)
College/Schools/CHS/EE/CC/MC Hospital/District heat	1	5,000	0.5	21,900,000	$ 5
Aero Park /Coast Guard/ District heat	2	10,000	0.5	43,800,000	$ 10
Hillshire Foods/BATA/District Heat	1	5,000	0.5	21,900,000	$ 5
GT Commons/Munson Hosp/W Jr High/Meijer/ District Heat	1	5,000	0.5	21,900,000	$ 5
Public Works/Library/Waste Water Plant/District heat	1	5,000	0.5	21,900,000	$ 5
Cone Drive/Oryana/Govt Center/Downtown/District Heat	1	5,000	0.5	21,900,000	$ 5
TOTAL	**7**	**35,000**		**153,300,000**	**$ 35**

POLICY

- Time of day pricing for off-peak thermal, electric storage & EV charging
- Wind, solar and CHP dispatching, optimizing and integrating generation
- Full solar net-metering w/o upper limits
- On-bill utility financing at low interest for solar and energy efficiency
- On-bill financing for electric thermal storage, especially large commercial (100 kW – 3 MW)
- On-bill financing for electric storage
- Virtual net metering
- Community solar projects
- Demand response controls and management
- Optimize wind with thermal storage (thermal storage on when windy)
- Mini-bonds
- Zoning modifications
- Targeted Rebates

RESULTS





FINDINGS/CONCLUSIONS

- Issuance of $600 MM municipal bond will provide the financial foundation the transition.
- Back by bond and on-bill utility financing, the capital bottleneck will be removed releasing the tremendous "latent" demand by local citizens for clean energy.
- In displacing natural gas with local solar and wind, up to $20 million/year will be retained in the community with additional economic multiplier benefits.
- Grid modernization (in the budget),and an approximate 100 MV renewable energy distribution sub-station, will aid in managing large wind and solar generation in the out-lying areas. On average only 2 – 3 wind turbines per surrounding township will be needed
- During peak solar and wind generation periods, when storage systems are full, excess energy can be sold into the regional grid, avoiding curtailment.
- Large thermal storage associated with CHP/district heat will transition to wind and solar with electric battery and electric powered thermal storage in the 3 – 5 MW range per system. 1,000's of electric hot water thermal storage units will be integrated into the system and managed.
- CHP quick response gas engines (enough to run the city on average) can remain in place as back-up in the event of grid failures. City-wide individual emergency back-up generation can be phased out (amazingly it accounts for over 50% of the city electric load, a large waste of money and electric capacity).
- EV's will be phased in with low-cost TOU charging supplied by roughly 30 million kW-hrs/year of solar and wind dedicated to electric mobility.
- Energy costs will be lower than present, and fixed indefinitely.