Baseline Energy Analysis for Sherman

Laying out a Path to 100% Clean, Renewable Energy

Prepared by People's Action for Clean Energy (PACE)
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SHERMAN
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Highlights

Using publicly available sources, PACE has estimated Sherman's total annual energy usage, including residents, businesses and municipal operations. We estimate this usage under two scenarios: current conditions and in a 100% clean energy economy. Based on this analysis, we observe that the town currently:

- spends $17.6 million each year on energy, or $4,821 per resident,
- has roughly 43 residential solar installations with total capacity of 0.4 megawatts (MW), providing 2.2% of the town's electricity usage
- has 17 electric vehicles (EVs), or 0.45% of vehicles in town and
- has 16 heat pumps, representing 0.8% of buildings in town

In a 100% clean, renewable economy, Sherman would:

- use 57% less energy,
- produce 33% of its energy needs locally, with the remainder coming from regional sources, over time,
- spend 29% less on energy and create local jobs, keep energy expenditures and ownership local, enhance resiliency and improve air quality.

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Overview

People's Action for Clean Energy (PACE) has carried out this baseline energy analysis for Sherman, CT. The goals of this analysis are:

- to estimate and understand the town's current energy usage,
- to determine what this energy usage would be in a 100% clean energy economy,
- to identify what steps are needed to transition to such an economy.

Figure 1 below provides an overview of this analysis. The blue bars on the left show the cumulative build-up of types of energy, including electricity, heating (i.e., gas, oil, electric and other) and transportation. Next, the red bars demonstrate the significant reductions in energy usage achievable through efficiency and electrification of heating and transportation. The green bars show the energy load in a 100% clean energy economy, split between local and regional sources.

Figure 1: Current and Potential Future Energy Usage

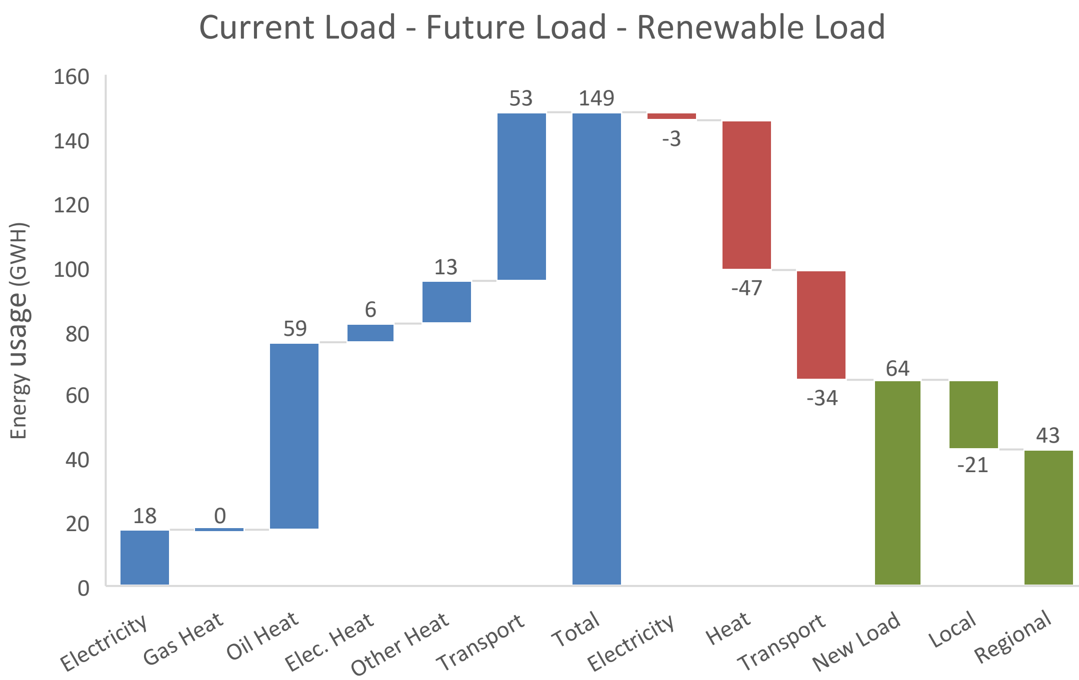
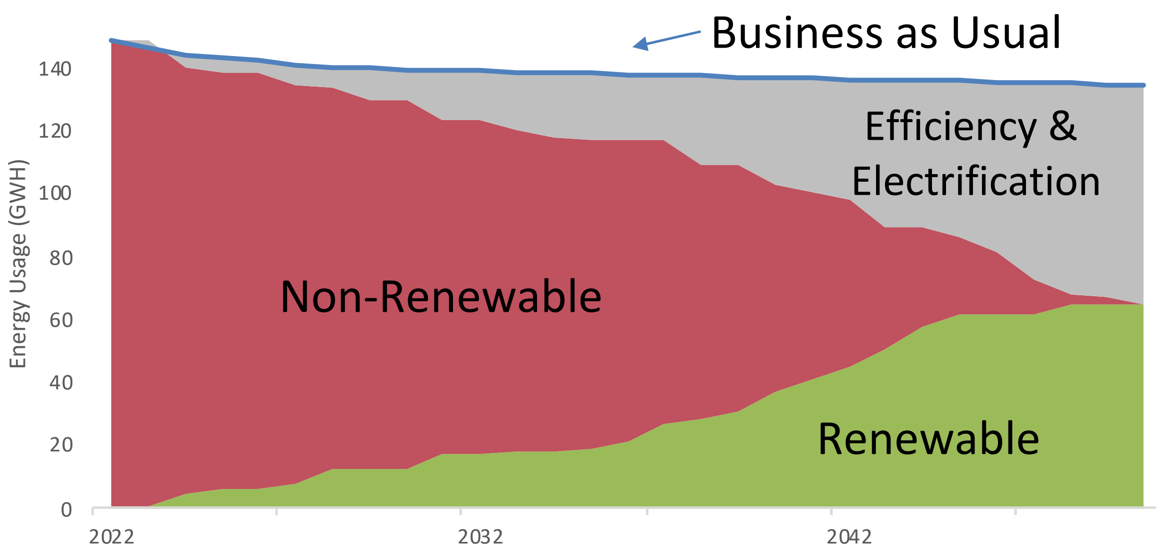


Figure 2 below gives an alternate view of this path to clean energy, showing the town's progress over time. On the left side of the graph, we see that nearly all energy is derived from non-renewable sources. The blue line showing the "Business as Usual" scenario suggest that energy usage will decline slightly over time due to general improvements in technology. The grey wedge labeled "Efficiency & Electrification" indicates the potential energy reductions possible through these means. The green portion labeled "Renewable" shows the deployment over time of renewable energy, both locally and regionally. The "Non-Renewable" wedge is therefore reduced to zero over time, from above through efficiency and electrification and from below through renewables.

Figure 2: Transition to 100%



Figures 1 and 2 both suggest that dramatic reductions in energy usage are possible through Efficiency and Electrification. Significant efficiency gains are possible due to the level of wasted energy that could be avoided with existing technology (e.g., weatherization). Electrification gains arise from the higher efficiency of electric vehicles and heat pumps. These reductions are discussed in greater detail below.

Current Energy Usage

Using publicly available sources, we have estimated the total annual energy usage for Sherman. This estimate comprises the entire town, including residents, businesses and the municipality. It includes electricity, heating and transportation. The primary data sources are:

- annual electricity and natural gas usage, provided by the respective utilities,
- town grand lists for buildings in town and vehicles registered in town.

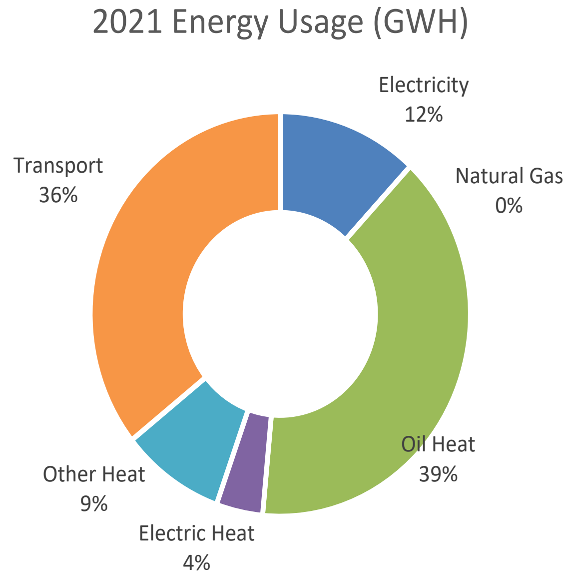
Table 1 below shows the total estimated annual energy usage for Sherman. Figures for electricity and gas heat are provided directly by the utilities. Figures for heating and transportation are based on our analysis of, respectively, the building and vehicle Grand Lists, and are described below.

Table 1: Current Annual Energy Usage

	Unit	Original Units	Gigawatt-hours (GWh)	Cost ($ millions)	GHG Emissions (Tons CO2)
Electricity	kWh	17,832,057	18	$3.7	5,209
Natural Gas	CCF	0	0	0.0	0
Oil Heat	Gallons	1,447,985	59	5.3	16,217
Electric Heat	kWh	5,898,453	6	1.2	1,723
Other Heat	Gallons	323,427	13	1.2	3,622
Transport	Gallons	1,590,964	53	6.1	15,591
Total			149	$17.6	42,363
Per Resident				$4,821	11.6

Note, the town spends roughly $17.6 million each year on energy, or $4,821 per resident. The town emits 42,363 tons of greenhouse gas (GHG) equivalents annually, or roughly 11.6 tons per person. By converting energy usage amounts into common units (i.e., gigawatt-hours, or GWh,) we are able to view the relative contribution of each energy source, as seen in the Figure 3 below. As shown in this chart, roughly 36% of usage is attributable to transportation and 52% is from heating.

Figure 3: Current Energy Usage Mix



Current Heating Energy Usage

We estimate the amount of annual heating energy the town uses, separately for residential and commercial buildings, using the town's building Grand List. This list, which towns typically use as a basis for levying property taxes, contains a wealth of information on buildings in town. Some of this information, when it is well-populated, is helpful in estimating annual heating energy. Tables 2 and 3 below shows these calculations, respectively, for residential and commercial buildings in town.

Table 2: Current Residential Building Energy Usage

				Current Heating Energy				
	Number of	Total		Units	Annual Energy Usage			GWh
Source	Buildings	Area (SF)	Units	Per SF	(Orig. Units)	GWh	% of Total	Per Bldg
Heat Pump	15	40,899	MWh	0.004	149	0.1	0.2%	0.0099
Gas	0	0	CCF	**0.000**	**0**	0.0	0.0%	0.0000
Oil Heat	1,381	3,416,443	Gallons	0.394	1,347,152	54.7	82.1%	0.0396
Electric Heat	263	431,365	MWh	0.013	5,523	5.5	8.3%	0.0210
Other Heat	173	392,422	Gallons	0.394	154,738	6.3	9.4%	0.0363
Total	1,832	4,281,129				66.6	100.0%	

Table 3: Current Commercial Building Energy Usage

				Current Heating Energy				
	Number of	Total		Units	Annual Energy Usage			GWh
Source	Buildings	Area (SF)	Units	Per SF	(Orig. Units)	GWh	% of Total	Per Bldg
Heat Pump	1	11,355	MWh	0.004	41	0.0	0.4%	0.0413
Gas	**0**	**0**	**CCF**	**0.000**	**0**	**0.0**	**0.0%**	0.0000
Oil Heat	28	255,718	Gallons	0.394	100,833	4.1	36.0%	0.1451
Electric Heat	5	29,298	MWh	0.013	375	0.4	3.3%	0.0816
Other Heat	31	427,806	Gallons	0.394	168,690	6.8	60.3%	0.2245
Total	64	724,176				11.4	100.0%	

In Tables 2 and 3 above, our heating energy estimates are based on our analysis of the relative fuel usage per square foot for various heating fuels across multiple towns. The results of our analysis are shown in Table 4 below. (These assumptions are used for both residential and commercial buildings.)

Table 4: Heating Energy Usage per Square Foot

	Energy Usage per Square Foot		
		Original	
Source	Units	Units	(kWH)
Heat Pump	MWh	0.004	3.6
Gas Heat	CCF	0.500	14.7
Oil Heat	Gallons	0.394	16.0
Electric Heat	MWh	0.013	12.8
Other Heat	Gallons	0.394	11.6

Current Transportation Energy Usage

We estimate the amount of transportation energy the town uses annually, separately for private and commercial vehicles, using the town's vehicle Grand List. This list contains extensive information on vehicles registered in town, including the class of use and vehicle identification number (VIN). From the VIN, we can determine whether the vehicle is an:

- internal combustion engine vehicle (ICEV)
- battery electric vehicle (BEV) or
- plug-in hybrid vehicles (PHEV)

Table 5 below summarizes the town's current vehicle stock and transportation energy usage, measured in both gallons of gasoline and equivalent gigawatt-hours (GWh).

Table 5: Annual Transportation Energy Usage

	# of Vehicles			Annual Fuel Usage (Gallons)			Total Energy Usage	
	ICEV	BEV	PHEV	ICEV	BEV	PHEV	Gallons	GWh
Private	3,300	13	4	1,272,947	2,185	1,172	1,276,305	43
Commercial	431	0	0	314,659	0	0	314,659	11
Total	3,731	13	4	1,587,607	2,185	1,172	1,276,305	53

The underlying assumptions used in these calculations are shown in Table 5 below. Using industry sources, we apply annual fuel usage assumptions, separately by detailed vehicle class. These assumptions are shown below.

Table 5: Annual Transportation Energy Usage by Vehicle Class

Vehicle Type	Vehicle-Miles Traveled (VMT)	Miles per Gallon (MPG)	Annual Fuel Usage (Gallons)
Car	11,244	23.4	480
Motorcycle	2,423	43.5	56
Light-Duty Vehicle	11,346	21.6	524
Light Truck	11,712	17.2	683
Police	15,160	10.7	1,423
School Bus	12,000	6.3	1,896
Delivery Truck	13,116	6.6	1,974
Taxi	65,862	23.4	2,813
Para. Shuttle	23,576	7.7	3,065
Refuse Truck	25,000	2.5	9,877
Transit Bus	34,053	3.3	10,440
Class 8 Truck	68,155	5.3	12,889
Other - Zero	0	0.0	0
Other - Low	4,682	23.4	200
Other - High	20,920	10.5	2,000

Potential Energy Usage Reduction

Under a 100% clean, renewable energy economy, Sherman will use significantly less energy. This reduction is possible through:

- electrification of heating
- electrification of transportation
- reduced electric plug loads and
- building efficiency improvements.

Each of these sources is described below.

Potential Reduction in Heating Energy Usage

The transition to a clean energy economy entails switching heating fuels from fossil-based to electric heat pumps. Modern air source heat pumps are three to four times more efficient than alternative technologies, including natural gas furnaces, oil burners and electric resistance. Ground source heat pumps (aka "geothermal") is even more efficient.

For example, suppose that a given 2,000 square foot home in Connecticut needs roughly 100 thousand British Thermal Units (MBTUs) annually for heating.[1] A natural gas furnace with efficiency of 85% would use roughly 1,144 CCF of natural gas each year to heat this home, which equates to 33.5 megawatt-hours (MWH) of electricity. To produce the same amount of heat energy, a modern heat pump[2] requires roughly 8.3 MWH per year, or roughly 75% less than the natural gas furnace. Our analysis uses the more conservative assumption of 60% reduction. Table 5 below summarizes the reduction in heating energy load for each fuel type.

[1] Based on an average annual heating load of 50 MBTUs per square foot (Source: https://inspectapedia.com/heat/Heating-Cooling-Climate-Zone-BTU-Requirements.php - HeatingBTUs)
[2] Based on a Heat Seasonal Performance Factor (HSPF) of 12 (i.e., a Coefficient of Performance (COP) of 3.5)

Table 5: Reduction in Heating Energy Usage

Current Source	Residential Heating Usage (GWh) Current	Residential New Paradigm	Residential Percent Reduction	Commercial Heating Usage (GWh) Current	Commercial New Paradigm	Commercial Percent Reduction
Heat Pump	0.1	0.1	0%	0.0	0.0	0%
Gas Heat	0.0	0.0	0%	0.0	0.0	0%
Oil Heat	54.7	21.9	60%	4.1	1.6	60%
Electric Heat	5.5	2.2	60%	0.4	0.2	60%
Other Heat	6.3	2.5	60%	6.8	2.7	60%
Total	66.6	26.7	60%	11.4	4.6	60%

Potential Reduction in Transportation Energy Usage

The transition to a clean energy economy also entails switching most transportation from internal combustion engine (ICE) vehicles to electric vehicles (EV). For the purposes of our analysis, the term "electric vehicles" comprises both battery electric vehicles (BEV) and plug-in hybrid vehicles (PHEV).

EVs are substantially more efficient than ICE vehicles. For ICE vehicles, only 17 to 20 percent of the energy in the fuel is used to move the vehicle, whereas for EVs, 64 to 89 percent of the energy powers the wheels.[3] Our analysis therefore assumes that energy usage for an EV is 65% lower than that for ICE vehicles. Table 6 below summarizes the potential reduction in transportation energy possible through electrification.

Table 6: Potential Reduction in Transportation Energy Usage

	Current Energy Usage Gallons	Current Energy Usage GWh	Future Usage GWh
Private	1,276,305	43	15
Commercial	314,659	11	4
Total	1,276,305	53	19

[3] Mark Z. Jacobson, 100% Clean, Renewable Energy and Storage for Everything, 2021, p.253.

Potential Reduction in Electric Plug Loads

Electricity services a wide range of needs in Sherman, including lighting, appliances and miscellaneous loads. Our model currently assumes that, over time, these electric loads will reduce by **20.0%** due to the replacement of older, less efficient devices with modern, efficient ones.

Solar Siting Analysis

An important step in any town's path to 100% clean energy is to review how much solar energy can be responsibly sited in town. We encourage towns to engage in an open, proactive and inclusive conversation about specific locations in town that are suitable for solar and which should remain off-limits.[4]

Our analysis conducts a high-level estimate of how much solar could be sited in Sherman. Our estimate comprises several potential locations, including rooftops, (both residential and commercial), solar canopies and other land areas. Table 7 below summarizes the results of this analysis. It shows both the *capacity*, measured in megawatts (MW) representing the maximum instantaneous power output and the *annual production*, measured in gigawatt-hours (GWH) representing the amount of electricity produced over one year.

Table 7: Total Solar Potential

Source	Capacity (MW)	Annual Production (GWH)
Rooftop	4.3	5.5
Carports	0.6	0.8
Other	10.0	15.1
Total	14.9	21.4

Note, these estimates are intended as a placeholder for a more robust estimate created by the town, based on a more thorough and inclusive review.

Rooftop Solar Potential

For rooftops, we perform rudimentary calculations of the potential for solar on existing buildings, then we compare the results to those from the Google Project Sunroof Data Explorer.

- For residential rooftops, we assume that 20% of the 1,832 households in town could support a 7.0 kilowatt (kW) solar array, resulting in a total of 2.6 megawatts (MW).

[4] For a discussion of local solar siting considerations and how to engage the community, see the June 2020 PACE webinar presentations at https://youtube.com/playlist?list=PLl8ApCpEzsBdASUbHvMp3qLA1gPWYidMI

- For commercial rooftops, we assume that 20% of the 0.6 million square feet of roof space is suitable for solar, which we estimate could hold 1.7 MW in total (assuming 15.0 watts per square foot.)
- Together, our rudimentary estimate of the town's rooftop solar potential is 4.3 MW.

Potential for Solar Canopies

Increasingly, solar is being installed on canopies over parking lots and other surfaces. Solar canopies represent a significant solar resource in the state and yield several benefits, including:

- Reduced pressure on farmland and forests
- Location in and near population centers
- Co-benefits such as covered parking, integration with EV charging and paired storage
- Reduced urban heat island effect

We have estimated the potential for solar canopies across the state. For Sherman, we have identified 3 potential canopy sites (representing parking lots of 100 or more spaces). We estimate that these sites could host 1.7 MW of solar, which could generate enough electricity to meet 7.1% of the town's current usage. For the purposes of this analysis, we have selected a total canopy potential of 0.6 MW.

PACE would be pleased to share further information on our Solar Canopies work and its implications for Sherman.

Potential Other Solar Locations

As noted above, we suggest that a town engage the community in a conversation about appropriate locations in town and also about inappropriate ones. Through such a process, the town might discover land parcels suitable for solar, including landfills, rights-of-way, non-prime farmland and forests and others. For the purposes of this analysis, we include a placeholder of 10.0 MW.

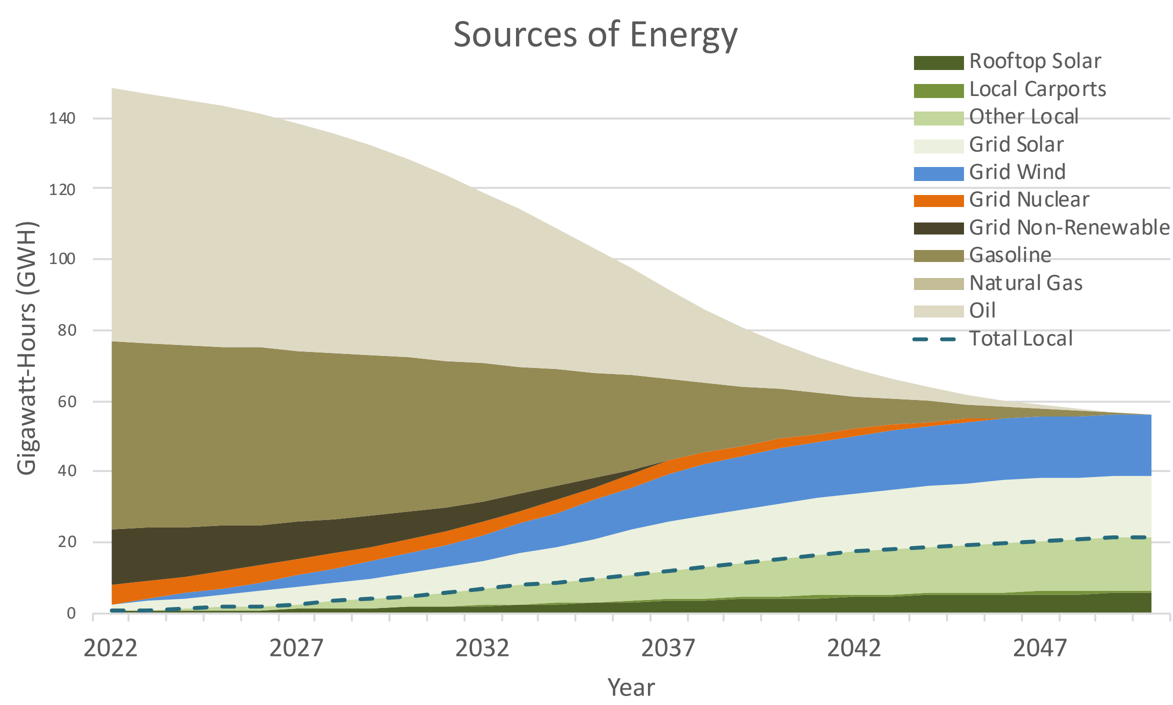
Economic Analysis

In this analysis, we estimate the cost of transitioning to a 100% clean energy economy. To do this, we project Sherman's energy usage out to the year 2050. This projection makes assumptions about a wide range of variables, including:

- The rate at which residents transition to EVs and heat pumps,
- the rate at which the town deploys solar within its borders,
- the rate at which the regional grid transitions to clean energy and
- current and projected future costs of building solar and wind generation, both locally and at grid scale.

Figure 4 below shows the sources of energy for the town, projected out to the year 2050.

Figure 4: Change in Energy Sources Over Time

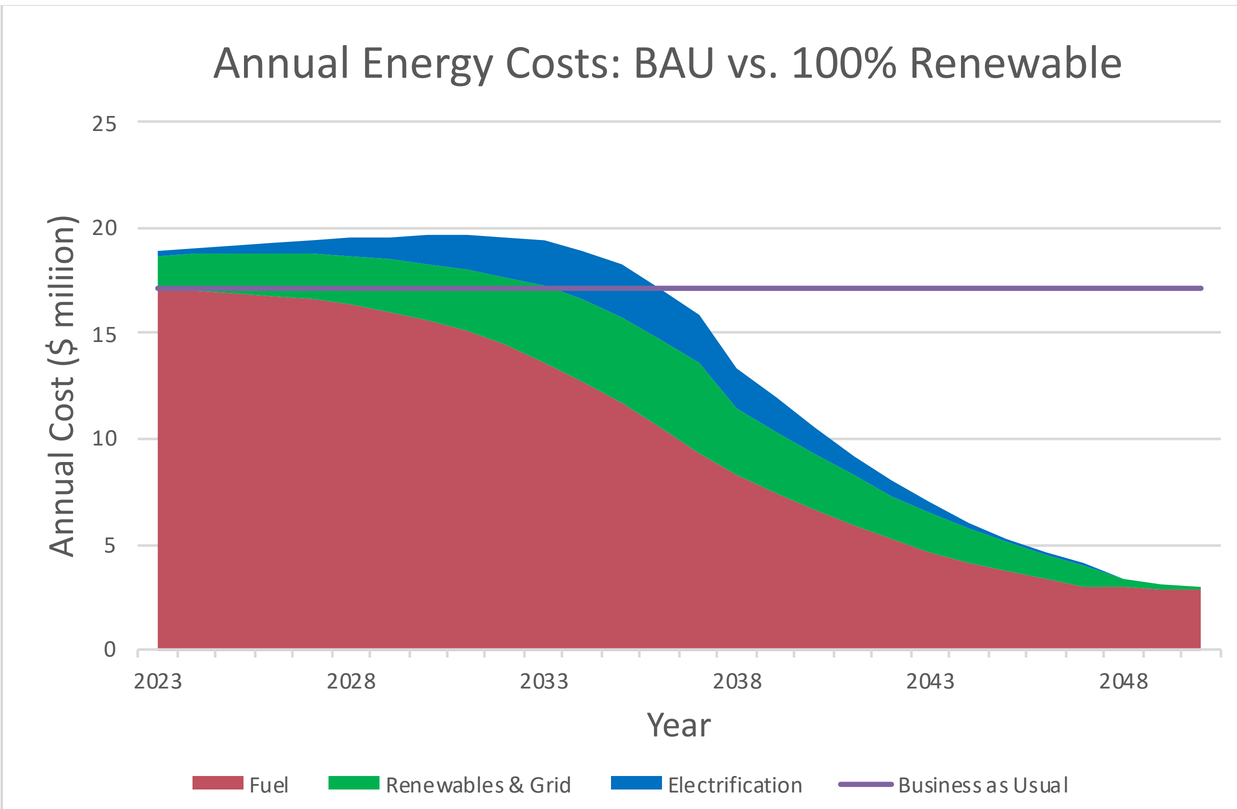


Over time, the total amount of energy Sherman uses declines significantly due to efficiency measures and the electrification of transportation and heating. The town burns less non-renewable energy sources such as gasoline, oil, natural gas and nuclear and relies increasingly on renewables, both local and grid-scale. The dotted line in the above graph indicates the share of the energy load that will be generated locally, with the remainder coming from regional sources.

By projecting these costs into the future, we are able to compare the cost, over time, of the transition to a clean energy economy to the cost of the status quo, or "business as usual" scenario. Figure 5 below shows the results of this analysis. It compares two scenarios:

- Business as Usual (BAU), or continuing to pay $12.5 million each year in fuel costs[5] and
- the Path to 100% scenario, showing higher costs in early years due to investments in electrification, renewables and the grid, offset by gradually reducing fuel costs.

Figure 5: Comparison of Annual Energy Costs: BAU vs. 100% Renewable



This analysis suggests that the transition to a 100% renewable economy will require higher costs in the early years as the economy invests in efficiency and electrification. Over time, declining fuel expenditures bring total costs well below current levels.

For all years combined, we estimate that the transition to a 100% clean renewable economy will yield economic savings of 29%.

[5] The model currently assumes no growth or inflation.

Conclusions and Next Steps

Sherman currently spends $17.6 million on energy, including residents, businesses and the town. Spread across all residents, this amounts to $4,821 per resident! Roughly 52% of this energy us used for heating and 36% for transportation. Electrification and efficiency can reduce this energy usage by 57%. Based on our rudimentary calculations, Sherman could generate 33% locally, with the remainder coming from regional sources.While this energy transition will require initial investments in renewables, efficiency, electrification and the grid, over time, it will reduce energy costs by 29%.

This energy report is intended to document the methods, assumptions and conclusions of the PACE Energy Model. PACE welcomes the chance to discuss the implications of these findings and plan next steps. For further information, download the Path to 100%, A Practical Handbook for Transitioning Connecticut Communities to 100 Clean, Renewable Energy.

Reliances and Limitations

Our baseline energy analysis is intended to facilitate and inform discussion of Sherman's energy usage, both currently and under a 100% clean, renewable scenario. These calculations are based on publicly available sources with limited discussion with town staff or volunteers. This underlying data should be reviewed for completeness and accuracy before placing reliance on the analysis. This report is intended to document the methods and assumptions of our energy analysis. PACE is pleased to provide further details on all of these data, methods and assumptions.

Our primary data sources include:

- the town Grand List of buildings in town
- the town Grand List of vehicles registered in town
- data on aggregate electricity and natural gas usage from the utilities
- a history of residential solar installations in town from the CT Green Bank

We rely on the building Grand List for information on the number and size of buildings, separately by heating fuel. This list indicates, for example, that Sherman currently has 11 residential buildings and 0 commercial ones with heat pumps. We urge readers to work with the town Assessor's office to ensure that this data is captured completely and on a timely basis going forward, as it will be helpful in tracking progress toward the electrification of heating.

Similarly, we rely on the vehicle Grand List for information on vehicles registered in town. We use a vehicle information number (VIN) decoder maintained by Atlas EV Hub[6] to identify the fuel source for each vehicle (e.g., battery electric, plug-in-hybrid, internal combustion engine.) We urge readers to confirm that this list includes vehicles owned and operated by the town. Municipal vehicles are not typically subject to local property taxes, and therefore may be excluded from the Grand List. If this is the case, we suggest judgmentally increasing our transportation energy estimates to reflect these vehicles.

[6] https://www.atlasevhub.com/materials/state-ev-registration-data/