

Technical Appendix

Alabama Community College System I-CARE Initiative

An EPA Climate Pollution Reduction Grant Project

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1. GHG Reduction Estimate Method(s)

The following methods were used to arrive at the measure-related activity data and other outputs and the GHG emission reduction estimates as indicated by the specific reduction measure.

A. Transportation

In determining the GHG emission reductions for the replacement of gasoline vehicles with electric vehicles and hybrid vehicles, the information and graph was used from the US Department of Energy regarding Alternative Fuels Data Center. In the State of Alabama, it shows that annual emissions for a gasoline powered vehicle average at 12,594 pounds of CO₂e. All electric vehicles had annual emissions of 2,559 pounds of CO₂e. Hybrid vehicles had annual emissions of 6,898 pounds of CO₂e. The difference between a gasoline powered vehicle and all electric vehicle was 10,035 pounds of CO₂e which is the figure used as our basis for GHG emissions reduction for electric vehicles. This is equal to 4.55 metric tons of CO₂e. The difference between a gasoline powered vehicle and a hybrid vehicle was 5,696 pounds of CO₂e which is the figure used as our basis for GHG emissions reduction for hybrid vehicles. This is equal to 2.58 metric tons of CO₂e.

B. Buildings

The mechanical and building renovations GHG emission reduction figures were derived from charts from the Commercial Buildings Energy Consumption Survey of 2018 found on the Energy Information Administration (EIA) website. From these charts, it was determined that the average electrical consumption in kilowatt-hours (kWh) per square foot for a college building was 12.6 kWh. The average natural gas consumption per cubic foot (cf) per square foot for a college building was 24.8 cf. An energy conversion calculator from NRG Energy helped determine that 24.8 cf is equal to 7.26 kWh. Our total building energy consumption per square foot is then calculated as $12.6 + 7.26 = 19.86$ kWh. For energy efficient equipment and materials, it was determined that the renovation improvements would result in a reduction of lighting energy consumption by 7%, reduction of HVAC energy consumption by 18%, and an energy reduction of 5% for the better-insulated windows and exterior doors. This leads to a goal of 30% reduction in energy consumption from the mechanical and building renovations.

C. Electric Power

The solar microgrid will consist of a ground-mounted solar array of 160 kW and a roof-mounted solar array of 200 kW. The expected energy generation of both is calculated as

497,139 kWh per year. Any excess energy produced that is more than the college needs to use will be stored in the integrated energy battery storage system, or if capacity is reached, returned to the commercial grid.

2. Model/Tools Used (as applicable)

The following are the Sources used for the models and tools used to estimate the calculations regarding the Greenhouse Gas Emissions reductions.

EPA – Greenhouse Gas Equivalencies Calculator - <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

EPA – Greenhouse Gas Inventory Data Explorer - <https://cfpub.epa.gov/ghgdata/inventoryexplorer/>

FEMP (Federal Energy Management Program) – Search for Energy Efficient Products - <https://www.energy.gov/femp/search-energy-efficient-products>

EPA – Emission Factors for Greenhouse Gas Inventories - https://www.epa.gov/system/files/documents/2023-03/ghg_emission_factors_hub.pdf

EIA – Electricity Consumption Totals - <https://www.eia.gov/consumption/commercial/data/2018/ce/pdf/c22.pdf>

EIA – Natural Gas Consumption Totals - <https://www.eia.gov/consumption/commercial/data/2018/ce/pdf/c32.pdf>

IPCC (Intergovernmental Panel on Climate Change) – Global Warming Potentials for Greenhouse Gases - https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

EPA – Avoided Emissions and Generation Tool (AVERT) - <https://www.epa.gov/avert>

NRG – Energy Conversion Calculator - <https://www.nrg.com/resources/energy-tools/energy-conversion-calculator.html>

US Department of Energy – Alternative Fuels Data Center - https://afdc.energy.gov/vehicles/electric_emissions.html

EIA – Energy Usage in Commercial Buildings - <https://www.eia.gov/energyexplained/use-of-energy/commercial-buildings.php>

3. Measure Implementation Assumptions

In general, the assumption is that the funding would be available at the beginning of Q4 of 2024 and that design and implementation schedule can proceed without delay. The cost estimates

are also based on current average capital cost and renovation prices. The following provides specific assumptions for each GHG reduction measure.

A. Transportation

The assumption was made that each of the internal-combustion engine vehicles being replaced by electric and hybrid vehicles would have the same GHG emissions. This assumption does not consider the type of vehicle, how old the vehicle is and the number of miles that the vehicle was being driven. In addition, the way a vehicle is driven can affect the emissions rate too. With the many variables, some of which would be hard to measure, it was decided to use an average per vehicle.

B. Buildings

In the calculation regarding the buildings, it was assumed that each building had similar infrastructure during the specific period. For example, just because a building built in 1988 has asbestos and needs to be accounted for in a renovation, does not necessarily mean the building on the other side of the state built in 1988 has asbestos as well. This is just one small example of the different complexities of buildings that could create different estimates.

The assumption was also made that systematic preventive maintenance would be performed on the new energy efficient equipment in the buildings and would keep the efficiency at its best throughout the 25 years.

C. Electric Power

It is assumed that a 3rd party, or our equally trained staff, will be doing the maintenance on the solar grid so that it can be maintained at optimal efficiency.

4. GHG Reduction Assumptions

The following assumptions were used as part of the methodology for estimating GHG emissions reductions by measure:

A. Transportation

It was assumed that the formula for converting 4.55 MT (metric tons) of CO₂e to 6,513 kWh to determine emission rates is the following:

$$4.55 \text{ MT of CO}_2\text{e} * (2,204.6 \text{ lbs of CO}_2\text{e}/1 \text{ MT of CO}_2\text{e}) * (1 \text{ MWh}/1,540.1 \text{ lbs of CO}_2\text{e}) * (1000 \text{ kWh}/1 \text{ MWh}) = 6,513 \text{ kWh}$$

It was assumed that the formula for converting 2.58 MT (metric tons) of CO₂e to 3,693 kWh to determine emission rates is the following:

$2.58 \text{ MT of CO}_2\text{e} * (2,204.6 \text{ lbs of CO}_2\text{e}/1 \text{ MT of CO}_2\text{e}) * (1 \text{ MWh}/1,540.1 \text{ lbs of CO}_2\text{e}) * (1000 \text{ kWh}/1 \text{ MWh}) = 3,693 \text{ kWh}$

B. Buildings

To convert kWh to metric tons of CO₂e, it was assumed that the following formula is accurate:

$1,540.1 \text{ lbs of CO}_2\text{e}/1 \text{ MWh} * (1 \text{ MT of CO}_2\text{e}/2,204.6 \text{ lbs of CO}_2\text{e}) * (0.001 \text{ MWh}/1 \text{ kWh}) = 0.000699 \text{ MT of CO}_2\text{e per kWh}$

C. Electric Power

Assumed that the same formula used for the Buildings measure is correct:

$1,540.1 \text{ lbs of CO}_2\text{e}/1 \text{ MWh} * (1 \text{ MT of CO}_2\text{e}/2,204.6 \text{ lbs of CO}_2\text{e}) * (0.001 \text{ MWh}/1 \text{ kWh}) = 0.000699 \text{ MT of CO}_2\text{e per kWh}$

5. Reference Case Scenario

The following reference case scenarios were used to quantify GHG reductions per measure:

A. Transportation

For a reference point in calculating the GHG emissions reductions for electric and hybrid vehicles, the factors were different depending on the State chosen due to the diverse types of energy produced in that specific State. Alabama was chosen for the State and when looking at other comparable charts, most of the time it was necessary to select the South region or Southeast Region to correctly account for the different weather and energy factors in this climate.

B. Buildings

In the Southeast, Alabama to be specific, HVAC is a large contributor to energy consumption in the buildings. Whereas states in the north might use up more energy on heating, in the South it is all about the air conditioning. The energy reduction is considerable when accounting for the most energy efficient chillers, air handlers, condensing units, and other air conditioning equipment. The effort was made to be modest in our assumptions that HVAC energy would be reduced by 18%. There were many studies found with that number being closer to 30%.

C. Electric Power

For the solar microgrid to produce enough energy to supplement the entire campus is an assumption that this campus will continue, business as usual. If different workforce programs are brought into this campus, like welding, which would increase the energy demand, then the solar grid in itself may not be adequate. Looking out 25 years, it is unlikely

that the dynamics of this campus will stay the same as they are today, but by then, the college may have had the means and opportunity to expand the microgrid installation.

6. Measure-Specific Activity Data

The following provides relevant activity data that is used for estimating GHG emission reductions for each measure.

A. Transportation

An electric vehicle replacing a gasoline powered vehicle has an annual reduction of 10,035 pounds of CO₂e or 4.55 metric tons of CO₂e or 6,513 kWh.

A hybrid vehicle replacing a gasoline powered vehicle has an annual reduction of 5,696 pounds of CO₂e or 2.58 metric tons of CO₂e or 3,693 kWh.

B. Buildings

Energy consumption of a commercial, educational building is 12.6 kWh of electricity per square foot and 24.8 cubic feet of natural gas per square foot or 7.26 kWh per square foot. That is a grand total of 19.86 kWh per square foot of energy consumption.

For a commercial, educational building, lighting consists of 10% of the total energy consumption, HVAC consists of 43% of the total energy consumption and windows/exterior doors consists of 10% of the total energy consumption. When energy efficient equipment and systems are installed and better insulated windows and exterior doors, the anticipated reduction of energy consumed was measured to be:

Lighting 10% reduced to 3% of total energy consumption (7% energy reduction)

HVAC 43% reduced to 25% of total energy consumption (18% energy reduction)

Windows/Exterior Doors 10% reduced to 5% of total energy consumption (5% energy reduction)

Total energy reduction of 30% after mechanical and building renovation.

C. Electric Power

Solar system energy generation from proposed microgrid over 25 years was calculated as 12,428,487 kWh. That averages 497,139 kWh of energy generating each year.

7. GHG Emissions Reduced

The chart on the following page provides the measure-specific estimated annual GHG emission reductions and cumulative GHG emission reductions for the periods 2025-2030 and 2025-2050.

ANNUAL GHG EMISSIONS REDUCTIONS YEAR BY YEAR				
Year	Transportation (MT of CO ₂ e)	Building (MT of CO ₂ e)	Electric Power (MT of CO ₂ e)	TOTAL (MT of CO ₂ e)
2025	324	465	0	789
2026	981	676	0	1,657
2027	981	766	174	1,921
2028	981	856	347	2,184
2029	981	905	347	2,233
5-Year Sub-Total 2025-2030				8,783
2030	981	905	347	2,233
2031	981	905	347	2,233
2032	981	905	347	2,233
2033	981	905	347	2,233
2034	981	905	347	2,233
2035	981	905	347	2,233
2036	981	905	347	2,233
2037	981	905	347	2,233
2038	981	905	347	2,233
2039	981	905	347	2,233
2040	981	905	347	2,233
2041	981	905	347	2,233
2042	981	905	347	2,233
2043	981	905	347	2,233
2044	981	905	347	2,233
2045	981	905	347	2,233
2046	981	905	347	2,233
2047	981	905	347	2,233
2048	981	905	347	2,233
2049	981	905	347	2,233
TOTAL	23,868	21,765	7,814	53,447

8. Uncertainties with the estimated GHG emission reduction estimates and assumptions

A. Transportation

Each vehicle being replaced with an electric or hybrid vehicle is not the same, therefore, there is uncertainty if the proposed emissions reduction will be calculated accordingly. In addition, various parts of the State of Alabama have differing energy sector sources that would provide differing consumption numbers. The hope is that these differences are minimal and would average out to produce essentially the same figures that have been used in these calculations.

B. Buildings

It is uncertain if the assumed energy reduction figures are accurate regarding Lighting, HVAC, and Windows/Exterior Doors. These figures are compiled from surveys of similar buildings, but it cannot be certain that these are a complete reflection of the building renovations proposed in this grant application. Having looked at a few sources regarding energy reduction from such buildings and mechanical renovations, the figures used for GHG reduction estimates were just that, estimates.

C. Electric Power

At this time, it is uncertain that the college campus that will be housing the proposed solar microgrid will exceed the energy demand of the estimated energy generation from the solar grid. If that be the case, then the emissions reduction will not be accurate. If by chance the energy demand is less than what the solar grid can generate, then that energy will be stored. However, less energy used by the campus also does not accurately depict the GHG emissions reductions achieved by that campus. The microgrid will have the capability of discharging power back to the grid, which reduces the energy that the local utility company must provide to other consumers, which we believe would result in full calculated emission reductions at some point.

9. Additional Reference Tables: The tables on the following pages are also found elsewhere in the application but are provided here as additional reference for a more complete understanding of the calculations of GHG emission reductions and our technical approach to those calculations.

GHG REDUCTIONS FROM 2025 THROUGH 2030				
Measure	College/Dept	Building	Project	GHG Emissions Reductions from 2025-2030 (MT of CO ₂ e)
Transportation	ACCS/Colleges	Campus	Replace vehicles with Electric Vehicles	4,058
	ACCS	ACCS	Replace vehicles with Hybrid Vehicles	190
	TOTAL			4,248
Building	Bishop State	Delchamps - Student Life	Mechanical, lighting, windows, ext doors	740
	Drake State	Bldg 300	Mechanical, lighting, windows, ext doors	81
	Drake State	Bldg 100 (Nursing Bldg)	Mechanical, lighting, windows, ext doors	139
	Gadsden State	Prater Hall	Mechanical, lighting, windows, ext doors	432
	Gadsden State	LRC	Mechanical, lighting, windows, ext doors	70
	Lawson State	Bldg F - Kennedy Student Ctr	Mechanical, lighting, windows, ext doors	368
	Lawson State	Building D - Library	Mechanical, lighting, windows, ext doors	276
	Wallace Selma	Byrd Arts & Sciences Bldg	Mechanical, lighting, windows, ext doors	325
	Wallace Selma	Classroom Bldg	Mechanical, lighting, windows, ext doors	331
	Chattahoochee Valley	Wallace Hall	Mechanical, lighting, windows, ext doors	247
	Reid State	900 Admin Bldg	Mechanical, lighting, windows, ext doors	149
	Trenholm State	Bldg E	Mechanical, lighting, windows, ext doors	343
	Shelton State	Bldg 300	Lighting, windows, ext doors	63
	Shelton State	Bldg 500	Lighting, windows, ext doors	51
	Shelton State	Bldg 700	Lighting, windows, ext doors	53
	TOTAL			3,668
Electric Power	Bevill State	Energy Infrastructure Training Center	Install renewable microgrid system	868
	TOTAL			868
All Measures	GRAND TOTAL			8,784

GHG REDUCTIONS FROM 2025 THROUGH 2050				
Measure	College/Dept	Building	Project	GHG Emissions Reductions from 2025-2050 (MT of CO ₂ e)
Transportation	ACCS/Colleges	Campus	Replace vehicles with Electric Vehicles	22,804
	ACCS	ACCS	Replace vehicles with Hybrid Vehicles	1,067
	TOTAL			23,871
Building	Bishop State	Delchamps - Student Life	Mechanical, lighting, windows, ext doors	4,438
	Drake State	Bldg 300	Mechanical, lighting, windows, ext doors	488
	Drake State	Bldg 100 (Nursing Bldg)	Mechanical, lighting, windows, ext doors	831
	Gadsden State	Prater Hall	Mechanical, lighting, windows, ext doors	2,591
	Gadsden State	LRC	Mechanical, lighting, windows, ext doors	422
	Lawson State	Bldg F - Kennedy Student Ctr	Mechanical, lighting, windows, ext doors	2,208
	Lawson State	Building D - Library	Mechanical, lighting, windows, ext doors	1,654
	Wallace Selma	Byrd Arts & Sciences Bldg	Mechanical, lighting, windows, ext doors	1,952
	Wallace Selma	Classroom Bldg	Mechanical, lighting, windows, ext doors	1,986
	Chattahoochee Valley	Wallace Hall	Mechanical, lighting, windows, ext doors	1,400
	Reid State	900 Admin Bldg	Mechanical, lighting, windows, ext doors	847
	Trenholm State	Bldg E	Mechanical, lighting, windows, ext doors	1,946
	Shelton State	Bldg 300	Lighting, windows, ext doors	377
	Shelton State	Bldg 500	Lighting, windows, ext doors	305
	Shelton State	Bldg 700	Lighting, windows, ext doors	319
	TOTAL			21,765
Electric Power	Bevill State	Energy Infrastructure Training Center	Install renewable microgrid system	7,814
	TOTAL			7,814
All Measures	GRAND TOTAL			53,450