Technical Appendix

EPA Climate Pollution Reduction Grant Program

Central Upper Peninsula Planning and Development (CUPPAD)

Assisting Disadvantaged Northern Great Lakes Communities and Tribes with Greenhouse Gas Reduction and Clean Energy Implementation

April 1, 2024

5 Lakes Energy (5LE) prepared this analysis of the estimated GHG emissions reductions—and financial, public-health, economic, and other co-benefits—that will be delivered by Central Upper Peninsula Planning and Development's (CUPPAD's) proposed CPRG implementation project. The CUPPAD project will deploy building decarbonization strategies at 500 homes in Michigan's Upper Peninsula—homes which are owned by low- and moderate-income residents and currently heated by delivered fuels (i.e., propane). In addition to making building envelope improvements and electrical upgrades as needed, the project will install highly efficient electric space heating/cooling, water heating, and other technologies covered by the federal Home Electrification Assistance Rebate (HEAR) program. Residential solar energy systems will be installed at 170 of the homes.

A summary of 5LE's energy modeling credentials is provided at the end of this appendix. Please note that we changed the order of the technical appendix prompts, compared to how they were listed in the NOFO, to create a more linear narrative given the specifics of the project and our analytical approach.

A. GHG Reduction Estimate Method. To develop the projections described in this appendix and included in CUPPAD's proposal Work Plan, 5LE used the analytical framework or toolkit that we developed with Elevate Energy to a evaluate the net costs and benefits of proposed building electrification and renewable energy projects. Funded by a major grant from the Michigan Public Service Commission throughout its Renewable Energy and Electrification Infrastructure Enhancement and Development grant program, the toolkit helps users assess a project from the perspective of the utility customer or energy user, the corresponding utility or energy service provider, and society as a whole.

Using the toolkit and the parameters of a proposed clean energy project, 5LE models the hourly energy use of the relevant utility customer before and after the adoption of the proposed measures or investments (i.e., installation of an air source heat pump (ASHP) or solar array). In the case of CUPPAD's proposed project, those net changes will be multi-directional. Combustion of delivered fossil fuels for space and water heat will be reduced by the adoption of building envelopment improvements and installation of ASHP and heat pump water heaters (HPWHs), and other electric technologies. At the same time, the use of electricity from the grid will be both increased by the adoption of those building electrification technologies and decreased by the installation of solar arrays on 170 of the 500 homes.

5LE's modeling of the net changes in energy use for those dynamics, as well as expected changes to the generating or source profile of the electric power grid over time. As noted in the next section, the energy that newly electrified homes in the UP will use to heat their homes—and the energy that will be displaced by their residential solar energy systems—will become less carbon-intensive between now and 2050 time as policies like Michigan's new ambitious renewable and clean energy standards are implemented. That naturally impacts the results of 5LE's modeling of GHG emissions reductions and other impacts over time.

With the resulting calculation of the net change in energy use—again, electricity and delivered fuels in the case of this project—5LE's toolkit then uses various publicly available datasets and established factors (e.g, Global Warming Potentials or GWPs) to estimate the project's net GHG emissions reductions, air quality and public-health impacts, utility bill savings, job creation, and income generation. Using other publicly available data and tools, 5LE translates those impacts into their net financial and economic benefit to end-users and society, thus allowing for comparative analysis of various impacts by presenting them via a common unit of measure (i.e., dollars).

The results of this modeling are presented in a net present value (NPV) table that shows those net costs/benefits over the course of the projected lifespan of the proposed project. An annual inflation rate of 2% is applied to those values, and they are discounted each year by an established factor that accounts for how the value of the benefits change over time from the perspective of the beneficiary. Those discount factors are provided below for each type of impact that we modeled for this project. A brief layperson's explanation of NPV and the discount factors is provided in Section H.

B. Measure Implementation Assumptions. The following summarizes key assumptions related to CUPPAD's proposed CPRG implementation project that shaped 5LE's modelling and the decisions we made in conducting it.

- **Building type.** 5LE's analysis of building-related measures like CUPPAD proposes is primarily grounded in the National Renewable Energy Lab's (NREL's) ResStock dataset, which provides hourly energy profiles for different building types by geographic location, along with associated area-specific weather data. ResStock models energy use by fuel type and end use for five residential building types. Reflecting the parameters of this project, 5LE exclusively used the ResStock "single-family detached" residential building type and set the Upper Peninsula's 15 counties as the geographic area over which the ResStock data was aggregated.
- **Geographic distribution and utility providers.** As described in the Work Plan, the project expects the geographic distribution of the 500 homes that it will address to approximately reflect the relative populations of the UP's three subregions. The UP has 19 different electricity service providers, and it was not feasible for 5LE to run that many utility-specific modeling scenarios. Instead, to assign a utility to the homes in each region, we made a simplifying assumption and used the largest utility in each region as the proxy service provider for all homes there (Cloverland Electric Cooperative for the Eastern UP and UPPCO for the Central UP and Western UP). We then used the specific tariffs (rate structures) of those two utilities to calculate the average customer utility bill savings for the average home in each region, based on the energy use changes that the project is expected to yield. Those savings are averaged across the 500 homes below.
- **Timing of implementation**. Assuming a ramp-up period–as the project sets up programmatic, administrative, and financial systems for the grant, recruits households, and builds a pipeline of homes with DOE energy scores and corresponding home improvement plans–the CUPPAD team estimates that it will complete 10% of the five-year goal of 500 homes in Year 1 of its grant period (50 homes), 15% in Year 2 (75 homes), and 25% in each of the final three years of our grant period (125 homes). 5LE applied that assumed project rollout in its modeling.
- **Fuel source/switching.** In using ResStock to generate before-and-after hourly energy profiles for the homes that the project will serve, we assumed per the CUPPAD Work Plan that about 70% of the 500 homes to be addressed are currently heated by propone, 15% by wood, and 15% by fuel oil. To further refine our modelling, we assumed the following:

- ✓ Homes currently with propane space heating also use propane for water heating, cooking, clothes drying, etc.;
- ✓ Homes currently with fuel oil space heating use fuel oil for water heating and electricity for all other end uses; and
- ✓ Homes with wood space heating use electricity for water heating and all other end uses.

Again, our modeling accounted for both the decreases in the use of delivered fuels from building envelope improvements and adoption of electrification strategies, and the projected increases in electricity use from switching major energy uses to building electrification technologies.

- **Building electrification strategies.** While the proposed project will deploy electrification measures in a varied, house-by-household manner, our analysis necessarily employed simplifying assumptions to create an average or standard deployment of electrification technologies. Specifically, we assumed the installation of a cold-climate air source heat pump (ASHP) and heat pump water heater (HPWH) at each of the 500 homes. Given that electric stoves, clothes dryers, and other such equipment will also be deployed case-by-case, this approach likely underestimates the energy savings and GHG reductions that the project will deliver through electrification. In addition, our modeling assumes that the 500 homes do not currently have air conditioning, which is relatively uncommon, but far from nonexistent, in the UP given its cooler climate. By setting the baseline energy use of our 500 homes lower than reality (by not factoring air conditioning), this assumption also likely leads our analysis to underestimate the project's energy savings and GHG reductions. Equipping many UP homes with air-conditioning for the first time is a beneficial byproduct of this project, which isn't quantified in this analysis.

  NOTE: 5LE applied building electrification algorithms we independently developed in modeling the impacts of heat pumps. Those algorithms utilize the ResStock hourly profile data to account for the realities of operating that equipment in cold-weather climates like the UP. Our model computes the equipment's coefficient of performance (COP) on an hourly basis as a function of ResStock's outdoor air temperature profile for all 8,760 hours in the year. The model also simulates the additional electricity needed to run ASHPs in defrost mode when outdoor conditions are below freezing and assigns electric resistance backup heating when temperatures drop below a user-defined switchover temperature.

- **Modeling discount for equipment lifespan.** Given time and resource constraints on our modeling, 5LE applied a simple approach to accounting for the fact that the ASHPs and HPWHs—with lifespans often estimated at 15 years—will likely require replacement before the analysis period ends in 2050. Since that technology is rapidly evolving, its performance and price could change significantly in the coming decades, thus making it difficult to insert new equipment in our model with any precision. Instead, we discounted our projections as a whole by five years, running our analysis of cumulative GHG emissions reductions through 2045 (for the 2025 through 2050 figures below). While this may slightly overstate the impacts from the ASHPs and HPWHs, as some will reach end-of-life before 2045, it will understate the long-term benefits from the building envelope improvements and solar installations, which will continue to deliver energy savings through 2050 (and possibly beyond). We considered that decision a reasonable compromise and approximation.

- **Building envelope improvements.** To model the project's investments in building envelope improvements, which again will vary from home-to-home, we applied ResStock's energy-use saving shape level two scenario (EUSS2). It is the more aggressive or comprehensive building efficiency package of the two energy efficiency packages offered by ResStock. Our selection of EUSS2 was based on several factors, including:

- ✓ The efficiency-first mindset and historic building improvement approach of the CUPPAD project team; and
- ✓ The average of $13,125 in CPRG grant funds that the project has allocated per home, which should provide significant funds for building envelope investments when combined with WAP funds and utility incentives (and given the fact that electrification rebates and Solar for All funds will cover much of the cost of other project measures).

Additionally, we made conservative assumptions in modeling building electrification strategies (as described above) and, therefore, considered it appropriate to provide a counterbalance here with an assumption that is more realistically favorable to our GHG reductions estimates.

- **Solar energy systems.** Per the application's Work Plan, we modeled the installation of solar energy systems at 170 of the homes that will participate in the project. Our analysis assumed that those systems will generate sufficient power to meet about 30% of the property's projected annual load. To represent solar production, we used the NREL System Advisor Model (SAM) PV Watts model to estimate one year of hourly energy production—in other words, the amount of power from the grid that the solar arrays will displace over the course of a year based on hourly projections.
- **The electricity grid.** 5LE deployed our STEP8760 tool to characterize the source profile of the energy that participating households will use via their ASHPs and HPWHs and displace by installing residential solar energy systems. STEP8760 models the grid's resource profile at hourly intervals into the future, using a financial-optimization approach which assumes that reality will reflect the least costly available option consistent with applicable legal requirements and other dynamics. 5LE has updated STEP8760 to account for amendments adopted late in 2023 to Michigan's energy laws. Under the new laws, Michigan utilities must meet a renewable energy standard of 50% by 2030 and 60% by 2035, and a clean energy standard of 80% by 2035 and 100% by 2040 (the latter includes nuclear power and natural gas generation combined with carbon capture). Again, assuming the utilities will achieve those standards in the most cost-effective manner, STEP8760 adjusts the grid's generating profile over time in response to those requirements.
- **Income-qualification and financial braiding.** As indicated by estimates in the Work Plan, the project will invest an average of $29,125 in each participating home for needed/perquisite repairs, building envelope improvements, electrical upgrades, and installation of ASHPs, HPWHs, and other building electrification technologies. The project assumes that $16,000 of those costs will be covered by a mix of federal home electrification and efficiency rebates, weatherization assistance program funds, and utility incentives. The project has also budgeted $15,000 per home—for 170 of the 500 homes—for on-site residential solar energy systems. When that solar investment is averaged across all 500 homes, the total projected average per-home project investment sums to $34,225. On a home-by-home basis, CPRG grant funds averaging $13,125 per site will cover the portion of that $34,225 total that is not covered by other "braided" financial resources.

  Applying the income categories used by the federal Home Electrification Assistance Rebate program, the project also assumes that half of the 500 homes will be owned by low-income individuals/families, with incomes 80% or less of AMI, and the other 250 will be owned by moderate-income individuals/families, with incomes between 80% and 150% of AMI. Because they will qualify for less financial assistance, particularly from the federal electrification rebates, our project financial model calls for moderate-income families to contribute an average of $7,000 to the total project investment in their home (which, again, will average $34,225 total). With that

$7,000 homeowner contribution for moderate-income households averaged across all 500 homes, the project will average $3,500 in end-user investment per home (or $1,750,000 total).

C. Models/Tools Used. As indicated in the previous sections, 5LE used the NREL's ResStock dataset to measure the hourly net change in energy use—for both electricity and delivered fuels—that will result from CUPPAD deploying its proposed decarbonization strategies on single family homes in the UP. We used NREL's PV Watts tool to model the hourly energy production (and grid energy displacement) of the project's proposed residential solar energy systems. Our own STEP8760 model generated hourly estimates of the grid's generating profile over time (in other words, the generating source of the energy that will power the proposed ASHPs/HPWHs and be displaced by the residential solar energy systems over our analysis period). The following describes how 5LE applied the resulting net energy calculations to estimate GHG emissions reductions and other impacts (and the models/tools we used in the process).

- **GHG emissions**. GHG emissions for CO2, N2O, and CH4 were computed using emissions factors from EPA's GHG Emissions Factors Hub. As prescribed by the application guidelines, we applied the Global Warming Potentials (GWPs) in the 2013 IPCC AR5 Fifth Assessment Report. While the application guidelines suggest estimating reductions for seven different GHGs, the three on which we report—CO2, N2O, and CH4—are the only greenhouse gases that our proposed measures will reduce in significant measurable amounts. They are also the gases for which the tools described throughout this appendix provide reduction estimates for the measures.
- **Air quality and public health impacts.** Net non-GHG emission reductions were computed using emissions factors from EPA's AP-42 database by fuel type and source. Based on those calculations, the 5LE analysis used the EPA's CO–Benefits Risk Assessment (COBRA) screening model to project the health benefits that the proposed project measures will deliver by reducing on-site combustion of fossil fuels and adding electricity use. Those calculations are based on the net change that will occur in the emissions of major air pollutants: particulate matter (PM2.5), sulfur dioxide (SO2), nitrogen oxides (NOX), ammonia (NH3), and volatile organic compounds (VOCs). Using established factors that assign a dollar value to a variety of health impacts—from avoided deaths to reduced incidence of heart attacks and other ailments—COBRA estimates the benefit to society of reducing those co-pollutant emissions.

  NOTE: There is strong published evidence, some of which is summarized in the application Work Plan, of the direct occupant health benefits of reducing the on-site use and combustion of fossil fuels by replacing stoves and other equipment powered by natural gas and delivered fuels with efficient electric models. Increased incidences of certain cancers, asthma, and other respiratory ailments have been linked to use of the former. However, after consulting experts and partners in the field—and the available literature—5LE determined that sufficiently developed and vetted data is not yet available to precisely quantify the indoor air quality improvements and associated health benefits that the proposed project will achieve. Therefore, benefits related to improved indoor air quality are not included.
- **Utility savings.** As described above, we made a simplifying assumption and used the largest utility in each region as the proxy service provider for all homes in that region (Cloverland Electric Cooperative for the Eastern UP and UPPCO for the Central UP and Western UP). We then used the specific tariffs (rate structures) of those two utilities to calculate the average costumer utility bill savings for the average home in each region, based on the energy use changes that the project is expected to yield. Those savings are averaged across the 500 homes in the NPV table below. By assuming that UPPCO, which has very high residential electricity rates, is the service provider for all the homes that the project will address in the Central and Western UP, our

modeling underestimates the financial benefit to utility customers of electrifying major energy end uses, which will expand monthly electricity consumption. In reality, a significant portion of participating households in those regions are served by other power companies with lower electricity rates. They will benefit more than our model indicates from electrification strategies.

- **Net economic benefits.** Net jobs created and net income generated by the project were estimated using data and tools developed by Greenlink Analytics and supported by peer reviewed research from Georgia Tech University. Led by our partner Elevate, this analysis was conducted similarly and with the same underlying data (IMPLAN) as other widely accepted economic impact tools. Limited to the impacts in the year of the project's implementation, it considers jobs directly involved in project implementation and indirect jobs spurred by that activity, as well as net jobs lost by displacing existing energy resources. It then estimates the net income to our economy from the net jobs created.
- **Energy and capacity cost impacts.** Through its combination of efficiency-related savings, conversion to electric equipment, and installation of on-site solar generation, the proposed project will affect the amount of electricity that utilities will need to supply, and their costs associated with ensuring they have access to adequate energy capacity at peak usage times. The 5LE model computes these energy-related values as changes in utility revenue from each project customer. It computes capacity-related impacts using an algorithm which assigns a standard factor based on cost of new entry (CONE) during those hours of highest demand in the year.

D. GHG Reduction Estimate Assumptions. To summarize and consolidate relevant information provided in the previous sections, 5LE used NREL's ResStock database to model the <u>net</u> energy use—of electricity and heating fuels—that the project will deliver by implementing proposed building envelope improvements and fuel-switching/electrification strategies on 500 single-family in the UP. We used NREL's SAM tool to estimate the net electricity generated—and displaced from the grid—by deploying solar energy systems at 170 of those homes, which is assumed to cover an average of 30% of the home's electricity load. 5LE's STEP8760 tool generated the hourly source profile of the energy that the solar energy systems will displace from the grid and the ASHPs and HPWHs will use from it. To those net energy impact calculations, we applied the Global Warming Potentials (GWPs) in the 2013 IPCC AR5 Fifth Assessment Report to calculate estimated GHG emissions reductions for CO2, N2O, and CH4 from 2025 through 2030 and 2025 through 2050.

E. Reference Case Scenario. Again, summarizing and consolidating relevant information provided in the previous sections, our reference case scenario is a single-family detached home in the Upper Peninsula with the hourly energy profile and associated weather data provided by NREL's ResStock database. Of the 500 homes the project plans to address, we assumed that 70% are currently heated by propone, 15% by wood, and 15% by fuel oil. Per the application Work Plan, we assumed that solar energy systems generating enough power to cover 30% of the home's electricity load would be installed at 170 of the 500 homes. Based on these assumptions, we created and ran modeling scenarios for combinations of pre-conversion fuel types (propane, fuel oil, wood) and post-conversion properties with and without solar. Additionally, we assumed that the 500 homes will be geographically dispersed across the UP's three regions to reflect their relative populations. We treated the combination of Western and Central UP regions as separate from the Eastern UP region due to the decision to reflect different representative utility tariffs (UPPCO for Western/Central UP and Cloverland for Eastern UP).

F. GHG Emissions Reduced. As described in the application Work Plan, we assign 41.3% of the project's total GHG reductions to the investment of CPRG grant dollars, which represents that funding's share of the projected capital stack for this project (which also includes federal electrification and efficiency rebates, utility incentives, and Solar for All grants). Applying that 41.3% factor to the project totals that 5LE calculated, the estimated CPRG-grant-specific GHG emissions for this project are as follows:

- An annual average of 1,456.29 mtCO2e of GHG emissions reductions from 2025 through 2050.
- Cumulative GHG emission reductions from 2025 through 2030 of 6,569.59 mtCO2e.
- Cumulative GHG emission reductions from 2025 through 2050 of 37,863.44 mtCO2e.

Given CUPPADS's requested grant of $9,441,939, the above figures translate to $1,437.22 in CPRG grant dollars per mtCO2e reduced from 2025 to 2030 and $249.37 per mtCO2e reduced from 2025 to 2050.

GHG Emissions Reductions - For share of total project cost funded with CPRG grant (41.3%)	CUMULATIVE 2025-2030	CUMMULATIVE 2025-2050	ESTIMATED ANNUAL 2025-2050
Change in CO2 Emissions (metric tons)	6,527.52	37,625.89	1,447.15
Change in CH4 Emissions (metric tons)	0.35	2.10	0.08
Change in N2O Emissions (metric tons)	0.12	0.67	0.03
Change in CO2e Emissions (metric tons)	6,569.59	37,863.44	1,456.29
Cost Effectiveness (CPRG grant dollars/metric ton)	$ 1,437.22	$ 249.37	

When the project is considered as whole—not just the share of total project costs attributed to the proposed CPRG grant—5LE estimates the project's GHG emission reductions as follows:

- An annual average of 3,526.12 mtCO2e of GHG emissions reductions over the period from 2025 through 2050.
- 15,907.00 mtCO2e cumulatively reduced for the period from 2025 through 2030.
- 91,679,04 mtCO2e cumulatively reduced for the period from 2025 through 2050.

As our co-benefit analysis below indicates, 5LE's modeling estimates the value to society of the project's net GHG emission reductions at $10,399,717 through 2050.

GHG Emissions Reductions - Total Project /Cost	CUMULATIVE 2025-2030	CUMMULATIVE 2025-2050	ESTIMATED ANNUAL 2025-2050
Change in CO2 Emissions (metric tons)	15,805.14	91,103.86	3,503.99
Change in CH4 Emissions (metric tons)	0.84	5.08	0.20
Change in N2O Emissions (metric tons)	0.30	1.63	0.06
Change in CO2e Emissions (metric tons)	15,907.00	91,679.04	3,526.12

G. Utility customer and social co-benefits. The following tables and narrative summarize the projected co-benefits that will be generated by CUPPAD's proposed project, calculated per the methods described in Sections A-E above. These figures are NOT discounted to exclusively reflect the share of the benefits associated with CPRG grant dollars. In all cases, for ease of reading, costs are presented as negative numbers and benefits are presented as positive numbers.

- **Utility customer benefit.** The 500 households addressed by this project will enjoy a total estimated net financial benefit of $11,775,757 from 2025 through 2050, driven by $25,224,501 in savings on their delivered fuel costs and offset by $11,698,744 in increased electricity bills from adoption of ASHPs/HPWHs and their total $1,750,000 share of project capital expenses. Per those numbers, the estimated average annual net benefit per participating household is $905.83 through 2050 (that is the project total average annual net benefit of $452,914 divided by 500).

COST/BENEFIT CATEGORIES - Utility Customer	TOTAL: 2025 - 2050	ANNUAL AVERAGE: 2025 - 2050
Benefits		
Utility Customer: Utility bill BENEFIT/SAVINGS from reduced delivered fuel use (2% annual inflation; 4.0% NPV annual discount rate)	$25,224,501	$970,173
Costs		
Utility Customer: Utility Bill COST from increased electricity use (2% annual inflation; 4.0% NPV annual discount rate)	($11,698,744)	($449,952)
Utility Customer: Capital EXPENSE/COST for resident share of project costs (2% annual inflation; 4.0% NPV annual discount rate)	($1,750,000)	($67,308)
Total Benefit (Utility Customer):	**$25,224,501**	**$970,173**
Total Cost (Utility Customer):	**($13,448,744)**	**($517,259)**
Total Net Benefit (Utility Customer):	**$11,775,757**	**$452,914**
Benefit/Cost Ratio:	**1.88**	

- **Net jobs and income.** The project will create an estimated net of 150 jobs with an added net income to our economy of $8,399,764 during the five-year period in which the project will implement its proposed building decarbonization strategies.
- **Health.** The very high co-pollutant emissions factors associated with burning wood for heat drive the massive estimated health benefits in the 5LE modeling. Net the increased health costs associated with increased electricity use from the adoption of ASHPs and HPWs (and the associated combustion of fossil fuels to power the grid), the project will deliver $65,251,882 in social health benefits—in the form of avoided deaths/disease/illness and related impacts—through 2050. That is an average annual benefit of $2,509,688. These estimated health cost savings are the primary force behind the project's impressive 3.58 societal benefit-to-cost ratio.
- **Utility Company Costs.** Through a combination of building envelope improvements, fuel-switching, and new solar energy, the proposed project will affect the amount of electricity that utilities will need to purchase and the costs they will incur to ensure they have access to adequate capacity at peak usage times. Because utilities generally pass these costs/benefits on to ratepayers, we consider them a social cost or benefit. With this project creating a net increase in electricity demand (again, through adoption of ASHPs and HPWHs), the CUPPAD project will

create an added social cost of $850,540 in increased capacity costs and $1,541,104 in increased energy costs, which translates to an average annual cost to society through 2050 of $91,986.

SOCIAL COST/BENEFIT CATEGORIES	TOTAL: 2025 - 2050	ANNUAL AVERAGE: 2025 - 2050
Benefits		
Society: BENEFIT - Decrease in GHG Societal Costs/On-site Fuel Use (2% annual inflation; 2.5% NPV annual discount rate)	$11,408,192	$438,777
Society: COST - Increase in GHG Societal Costs/Grid-level combustion (2% annual inflation; 2.5% NPV annual discount rate)	($1,008,475)	($38,787)
Society: BENEFIT - Decrease in Health Costs/On-site Fuel Use (2% annual inflation; 2.5% NPV annual discount rate)	$65,760,976	$2,529,268
Society: COST - Increase in Health Costs/Grid-level combustion (2% annual inflation; 2.5% NPV annual discount rate)	($509,094)	($19,581)
Electric Utility Company: COST - Increase in Capacity Costs (2% annual inflation; 5.8% NPV annual discount rate)	($850,540)	($32,713)
Electric Utility Company: COST - Increase in Energy Costs (2% annual inflation; 5.8% NPV annual discount rate)	($1,541,104)	($59,273)
Society: BENEFIT - Increase in Net Income (2% annual inflation; 2.5% NPV annual discount rate)	$8,399,764	$323,068
Society: COST - Total Capital Expenses - CPRG grant + projected leveraged resources (2% annual inflation; 2.5% NPV annual discount rate)	($19,991,939)	($768,921)
Total Benefit (Sum of above benefits/positive #s):	**$85,568,932**	$3,291,113
Total Benefit (Sum of above costs/negative #s):	**($23,901,152)**	($919,275)
Total Net Benefits:	**$61,667,781**	$2,371,838
Benefit/Cost Ratio:	**3.58**	
Net GHG benefits	*$10,399,717*	*$399,989*
Net health benefits:	*$65,251,882*	*$2,509,688*

H. Explanation of Net Present Value (NPV). Empirically and according to economic theory, people behave as though they prefer benefits (i.e., money) sooner rather than later. A net present value (NPV) approach to projecting a return on investment considers that by decreasing the projected per-unit value of a benefit over time.

In the context of this technical appendix, the projected utility savings from an investment in clean energy projects are more valuable per dollar to the customer/applicant in the year that the project is installed than in each successive year. For example, in the case of a hypothetical project that generates annual utility savings of $50,000 for a given period, that savings may be valued at $50,000 by the customer in Year 1, $40,000 several years later, and as little as $30,000 further down the road. This “time value of money” dynamic also holds for the environmental, economic, and other social costs/benefits associated with an investment. Those benefits also decrease per unit over time, relative to today, from the perspective of the entity enjoying the benefit (or incurring the cost).

To calculate how future benefits diminish over time compared to the present (or time of the decision), an annual discount rate is applied. Generally, a small percentage of 2-10%, those rates vary by the extent to which the stakeholder (type of actor) values benefits in the present versus the future. A larger discount rate is used for actors who give less weight to the future compared to the present (and vice versa). As noted above in our NPV table, 5LE applied discount rates in this analysis that we have adopted as convention based on commonly used industry standards: 2.5% for social benefits (i.e., society's discount rate), 4.0% for utility customers, and 5.8% for the energy service providers (utilities).

I. 5LE credentials. 5 Lakes Energy is a Michigan-based policy consulting firm dedicated to mitigating climate change by accelerating clean energy deployment. Since our founding in 2010, we have helped a diverse roster of state and local governments, businesses, trade associations, and environmental and public interest nonprofits pursue clean energy, decarbonization, and climate resilience goals. Our team possesses decades of experience and deep expertise in energy systems, utility regulation, and related policy issues. Highly skilled in conducting quantitative analysis to inform public and private decision-making, the 5LE Lakes Energy team excels at identifying, organizing, and analyzing data from myriad sources, including federal agencies/laboratories, industry trade associations, state agencies and regulatory commissions, and academic experts. It also uses utility company technical, financial, and economic data in many applications, including comparing energy investment options, evaluating cost of service studies, and reviewing utility program effectiveness.

5LE deploys its modeling and data capacity in many forums, including its frequent role providing expert witness testimony in regulatory proceedings, such as those related to 20-year Integrated Resource Plans (IRP), Distribution System Plans, annual renewable energy and energy waste reduction (EWR) plans, cost allocation and rate design, voluntary green pricing (VGP) programs, and various pilots related to electric vehicle charging and other emerging technologies.

Quantitative analysis also serves as the backbone of 5LE's policy and plan development work, and the studies we produce to inform public debates. For example, 5 Lakes Energy recently joined the Michigan Energy Innovation Business Council in authoring *The Michigan Clean Energy Framework*, a comprehensive report which modelled a scenario in which Michigan adopted a suite of policies that reflects the priorities of the MI Healthy Climate Plan (MHCP) and closely resembles legislation that state lawmakers were considering at the time that the report was developed (and that they passed late in 2023). Our analysis showed that these policies would not only achieve the MHCP's short- and long-term emissions reduction targets, but also drive a myriad of other health and economic benefits, such as significant job creation, lower pollution-related mortality rates, and reduced average household energy costs. We have deployed similar modeling capabilities to support Michigan communities, including Ann Arbor, Traverse City, and Grand Haven, in developing models and pathways for achieving their ambitious clean energy goals and GHG emissions reduction targets. Our recent development of the analytic toolkit described above grew out of this work.