Municipal Energy Assessment

Phase I: Building Heating Analysis

In support of the

Mohawk Trail Woodlands Partnership

For

Peru, Massachusetts

January 12, 2018

Prepared by

UMass Clean Energy Extension

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Executive Summary

As part of the Mohawk Trail Woodlands Partnership (MTWP), the town of Peru invited UMass Clean Energy Extension (CEE) to analyze thermal energy use in its municipal buildings with the goal of identifying opportunities to reduce municipal energy consumption, greenhouse gas emissions, and operating costs.

Using municipal building information and historical heating data, our findings and recommendations related to community energy usage are summarized as follows:

- **Total Municipal Energy Consumption** – The total energy usage in Peru in FY2017 was 1,890 MMBtu. Of this, 38% was used for heating (propane), 9% used for electricity, and 53% used for transportation (gasoline and diesel).
- **The Town Hall/Police Station:** – The Town Hall/Police Station building has the highest energy consumption and energy intensity (*energy consumption per ft^2*). Improvements to this building will have a significant impact to the municipal energy consumption. Peru should place a **high priority** for assessments on the Town Hall/Police Station building.
- **The New Town Garage** – The New Town Garage building has below average energy consumption and above average energy intensity. Due to the nature of how garage-style buildings are used, heating fuel consumption is highly dependent on building operations. These buildings should be given priority for building controls evaluation and building scheduling and operational review. Peru should place a **high priority** for assessments on the New Town Garage building.
- **The Fire station** – The Fire Station building has below average energy consumption and energy intensity. Due to the nature of how garage-style buildings are used, heating fuel consumption is highly dependent on building operations. These buildings should be given a priority for building controls evaluation and building scheduling and operational review. Peru should place a **medium priority** for assessments on the Fire station building.
- **The Library** – The Library building has lowest energy consumption and energy intensity. Improvements to this building will have a limited impact on the municipal energy consumption. Peru should place a **lower priority** for assessments on the Library building.
- **Building Heating Performance** – Our analysis shows that the buildings mentioned above have heating systems that fire at relatively moderate temperatures. Therefore, we recommend that Peru conduct a thermal energy audit that investigates building operation, heating controls (e.g., thermostat setbacks), and potential envelope improvements.
- **Transportation** –Transportation fuels account for the majority (53%)> of the town's *total* municipal energy use (including building-related, infrastructure, and transportation energy); Peru should therefore place a **high priority** on investigating strategies such as route optimization, switching to more efficient hybrid or electric vehicles, and considering transportation efficiency best-practices as described in Section 5 below.
- **Green Communities Designation** – Peru should assess whether participation in DOER's Green Communities program and access to its energy-related funding sources might help the town meet its energy goals. Further information on the Green Communities is outlined below.

As a next step, the **municipality should contact CEE to schedule an initial conference call to discuss these findings and next steps** (413-545-8510, energyextension@umass.edu)**.** This discussion may include a review the municipal energy analysis, target strategies, and support a plan for preparing Green Communities designation application, if desired. After the review call, the municipality may wish to schedule energy audits for **high priority** municipal facilities identified in this report. When soliciting potential auditors, ensure they are prepared to consider both thermal and electric opportunities.

Additionally, CEE is available to provide a **Clean Heating Screening Analysis (Phase II)** at Peru's request. A screening analysis can be completed for two to three town buildings and will provide a pre-feasibility evaluation of the investment cost, available incentives, and lifecycle economic savings of technologies such as air- or ground-source heat pumps, solar thermal, and modern wood heating systems.

1. Introduction

1.1 Purpose of this Report

UMass Clean Energy Extension (CEE) has been engaged by the state Department of Energy Resources (DOER) to support the Mohawk Trail Woodlands Partnership (MTWP), a planning and public outreach process exploring interest in a new partnership with State and Federal agencies for 21 municipalities in northwestern Massachusetts. Working in Collaboration with Franklin Regional Council of Governments (FRCOG) and Berkshire Regional Planning Council (BRPC), CEE is providing technical and analytical support to municipalities related to their heating fuel and overall energy consumption. The purposes of this report are to:

- Identify the heating energy usage characteristics for the municipality (described in **Section 2**);
- Provide building specific analyses to indicate performance metrics (described in **Section 3**);
- Introduce Peru to a range of technologies and strategies to manage energy consumption, including clean heating technologies, and energy efficiency best practice (described in **Section 4**);
- Assist in prioritizing targets for municipal energy reduction opportunities (described in **Section 5**); and
- Provide additional detailed building analyses to support further engineering studies and/or the solicitation of contractor quotes (described in **Appendices**).

1.2 Green Communities Designation and Grant Program

Peru is not currently a designated Green Community within DOER's Green Communities Designation and Grant Program. More than half of the cities and towns in Massachusetts are designated as Green Communities, and have received grants toward clean energy projects. This report lays the groundwork for Peru should it decide to pursue Green Communities designation and its associated funding for energy-saving measures. For more information on the Green Communities program, contact CEE or your Green Communities regional coordinator (http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/).

2. Energy Accounts and Analysis

2.1 MassEnergyInsight & Accounts Overview

Data used in this analysis was provided directly to CEE by Peru officials or sourced from Peru's MassEnergyInsight (MEI) account. MEI is a web-based tool provided by DOER at no cost to all cities and towns in the state, and enables cities and towns to develop an energy-use baseline, track and analyze energy use and costs, prioritize energy projects, and communicate about energy use and greenhouse gas emissions. Data from electric accounts are automatically uploaded to the town's MEI account. Delivered fuels (e.g., propane, gasoline) data is gathered from town municipal records or vendors and entered manually into MEI. CEE has ensured that the town's MEI platform is accurate and current to the best of its abilities.

The data included in this report has been organized in alignment with the Massachusetts Fiscal year (July 1st to June 30th).

2.2 Energy Consumption

The following graphs (1) outline the town's total energy consumption in FY2017 and (2) provide a comparison of the town's individual accounts and facilities. The town's energy consumption by fuel type is shown in **Figure 1** below. Heating accounts for 38% of the town's total energy consumption, suggesting that heated buildings may be an important focus area for future energy efficiency efforts. Transportation fuels account for 53% of Peru's total energy consumption. Additional figures, displaying Peru's energy consumption, are provided in **Appendix D**.

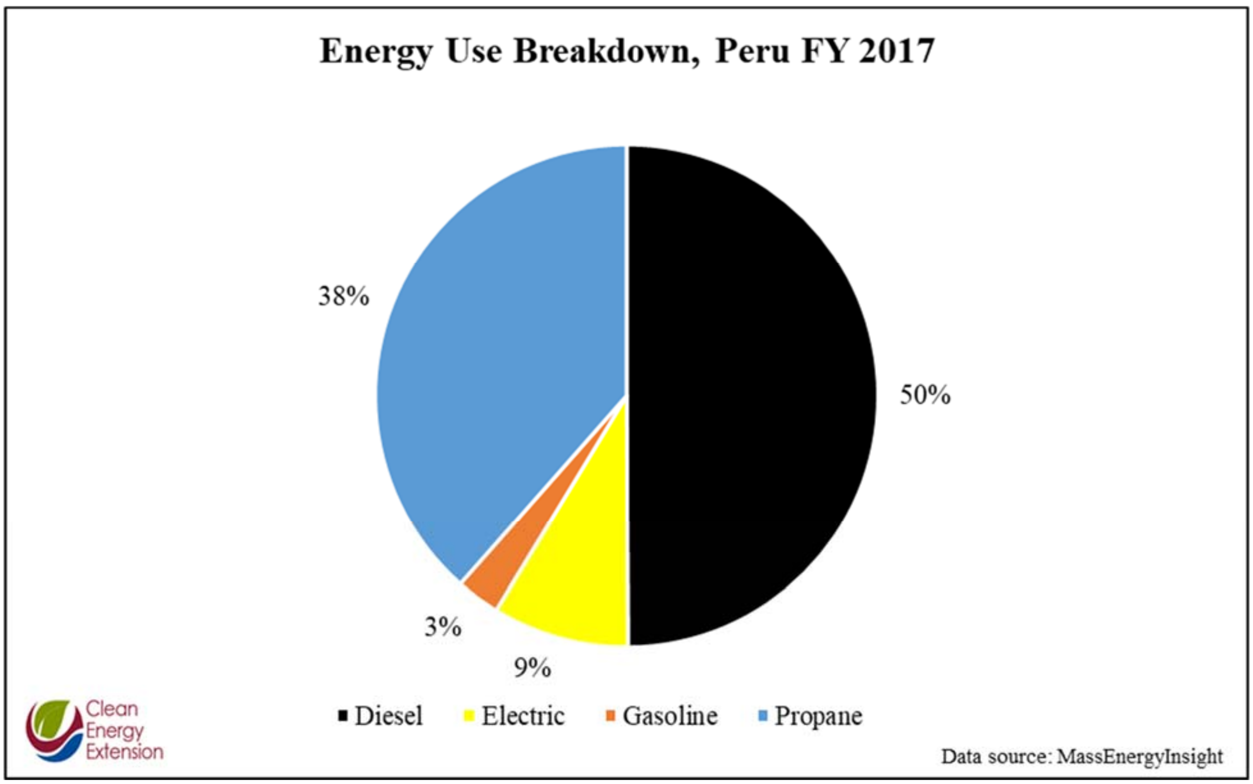

Figure 1: Total consumption of each energy type as percentage of the town's total energy consumption

3. Building Energy Analysis

3.1 Building Inventory

Before reviewing building energy analysis and recommendations, it is important to understand how improvements to each municipal facility might influence the town's overall energy consumption. In other words, buildings that use more energy have a greater potential to reduce the town's overall energy usage if efficiency improvements are made. A complete list of Peru's municipal buildings and their total energy consumption is shown in **Table 1**. This inventory and the analyses that follow provide the basis for recommendations found in **Section 5**.

Table 1: Municipal building energy consumption inventory

Building Name	Building Area (ft^2)	Electric (MMBtu)	Propane (MMBtu)	Total (MMBtu)	% of Total Municipal Building Energy Usage
Town Hall/Police Station	9,629	81	379	460	51.7%
New Town Garage	3,964	19	167	186	20.9%
Fire station	4,140	43	132	175	19.7%
Library	1,472	4	50	54	6.1%
Old Town Garage	1,800	15	-	15	1.7%

*Blank cells indicate no data, or inadequate data.

3.2 Analysis Tools

Building performance as it relates to energy-related operations can be understood through the application of a number of analytical tools developed by CEE for this report. Tools used in this analysis include:

- **Weather Normalized Energy Consumption** – To account for annual variations in weather conditions, CEE has calculated the typical heating energy consumption for key buildings, given the weather conditions for the selected year compared to the average weather conditions (from 1991 and 2005). This provides the town and auditors with an understanding a facility's typical annual energy consumption.
- **Weather Normalized Energy Usage Intensity** – Energy use intensity (EUI) expresses a building's energy use as a function of its size, in terms of energy per square foot per year. It is calculated by dividing the total energy consumed by the building in one year (measured in kBtu) by the floor area of the building. Generally, a low EUI signifies good energy performance. EUI is a valuable metric to evaluate and compare energy performance regardless of building size. However, some building types are more energy intensive than others. Buildings that have longer operating hours or require specific energy-intensive equipment will typically have a higher EUI than other buildings. The heating fuel portion of each building's EUI has been adjusted to account for varied annual weather conditions following the same protocol defined previously. Considering energy consumption in conjunction with weather normalized EUI can help identify buildings that will have a significant impact on the town's total energy consumption should energy efficiency measures be implemented.
- **Heating Performance Analysis & Balance Point** – The pattern of fuel consumption was compared with weather data (outdoor temperature) to identify the "balance point" for each selected building. The balance point is the outdoor temperature at which internal systems turn on to heat the building. A building

with a balance point that is higher than 60°F is a good candidate for operational (e.g., keeping overhead garage doors closed) or structural changes (e.g., adding Insulation) that would decrease the building's heat loss through the envelope.

3.3 Summary of Key Building Performance Metrics

To better understand building operation and make informed decisions regarding energy investments, the tools discussed in **Section 3.2** were applied to key buildings and shown in **Table 2**. Key buildings are defined as having a high overall energy consumption relative to the other municipal buildings within Peru. These buildings comprise approximately 80-90% of the total municipal building energy use, therefore are critical to achieving energy reduction goals. The full background analysis is shown in **Appendix C**.

Table 2: Summary of key building energy consumption and performance metrics

<table>
<tr><th>Building Name</th><th>Energy Consumption * (MMBtu)</th><th>Energy Use Intensity* (MMBtu)</th><th>Heating Performance (Balance Point °F)</th></tr>
<tr><td>Town Hall/Police Station</td><td>410</td><td>43</td><td>65</td></tr>
<tr><td colspan="4">Key interpretations: The Town Hall/Police Station building has the highest energy consumption and energy intensity (energy consumption per ft^2). Improvements to this building will have a significant impact to the municipal energy consumption. Peru should place a high priority for assessments on the Town Hall/Police Station building.</td></tr>
<tr><td>New Town Garage</td><td>164</td><td>41</td><td>65</td></tr>
<tr><td colspan="4">Key interpretations: The New Town Garage building has below average energy consumption and above average energy intensity. Due to the nature of how garage-style buildings are used, heating fuel consumption is highly dependent on building operations. These buildings should be given priority for building controls evaluation and building scheduling and operational review. Peru should place a high priority for assessments on the New Town Garage building.</td></tr>
<tr><td>Fire station</td><td>157</td><td>38</td><td>65</td></tr>
<tr><td colspan="4">Key interpretations: The Fire station building has below average energy consumption and energy intensity. Due to the nature of how garage-style buildings are used, heating fuel consumption is highly dependent on building operations. These buildings should be given a priority for building controls evaluation and building scheduling and operational review. Peru should place a medium priority for assessments on the Fire station building.</td></tr>
<tr><td>Library</td><td>47</td><td>32</td><td>65</td></tr>
<tr><td colspan="4">Key interpretations: The Library building has lowest energy consumption and energy intensity. Improvements to this building will have a limited impact on the municipal energy consumption. Peru should place a lower priority for assessments on the Library building.</td></tr>
</table>

3.4 Graphical Representation of Key Building Characteristics

The following provides additional graphical representation of Peru's energy consumption for the most recent complete fiscal year (2017). The top municipal buildings are displayed and ordered in terms of total heating fuel consumption (**Figure 2**) and EUI (**Figure 3**).These graphs give a visual comparison of the Peru's buildings and heating fuel accounts.

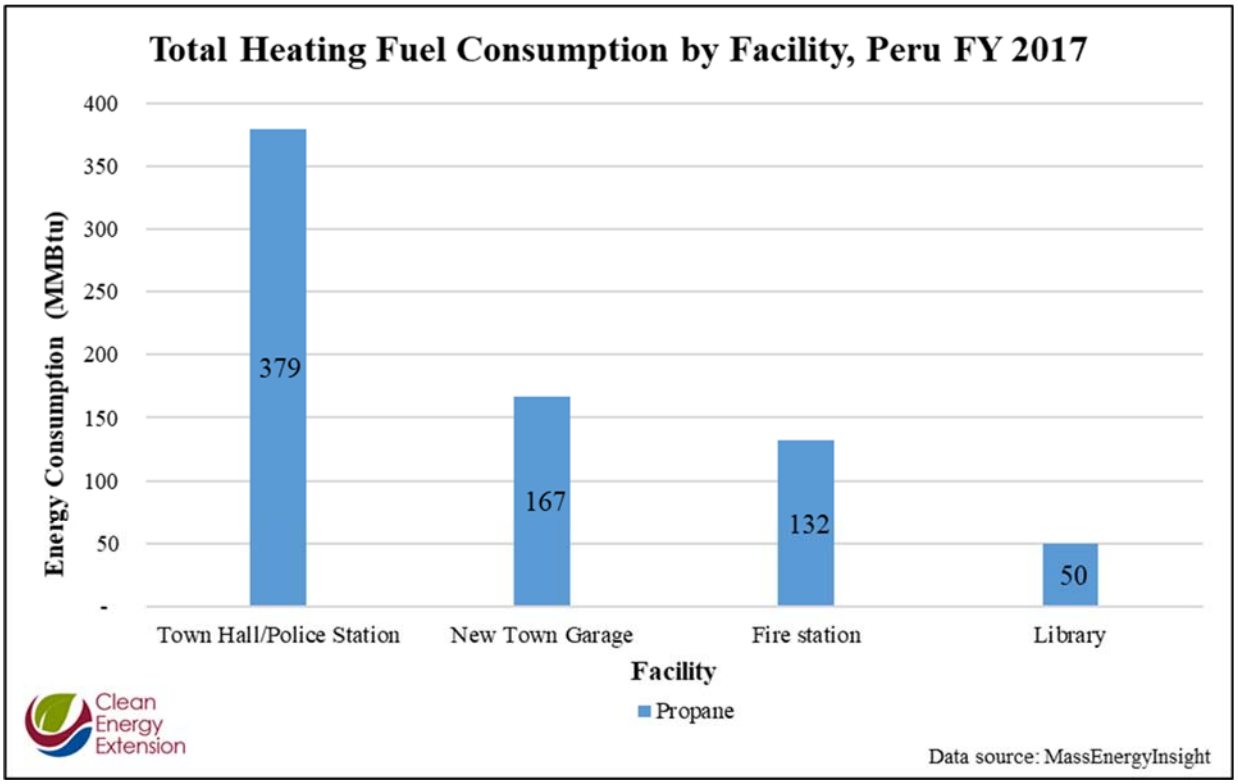

Figure 2: Municipal heating fuel consumption by facility

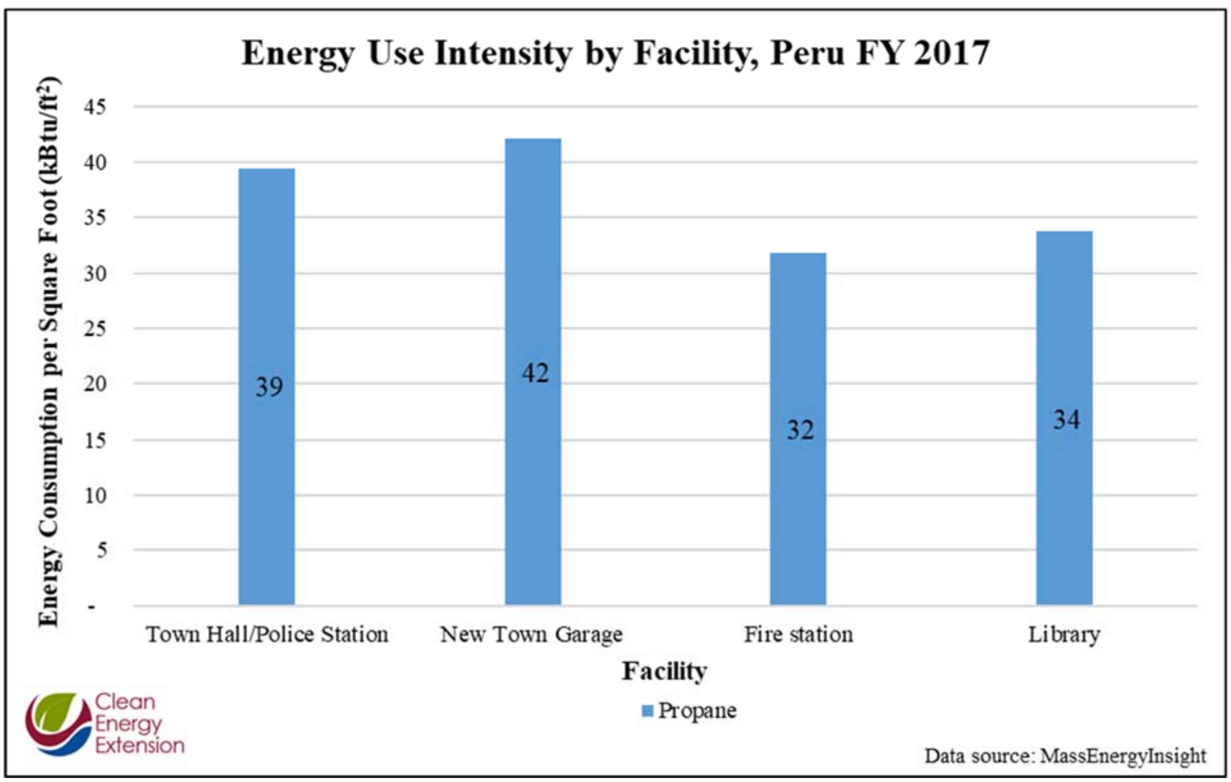

Figure 3: Municipal heating Energy Use Intensity in $kBtu/ft^2$

4. Clean Energy Technologies and Best Practices

Understanding the baseline energy conditions described earlier in this report provides a strong foundation to identify and implement energy improvements. This section provides an overview of energy efficiency opportunities and clean heating and cooling technologies, with more detail provided in the appendices.

This information will help to familiarize the town with potential options to reduce its energy consumption, operating costs and environmental impact. CEE staff is available to discuss these options and how they apply to the town's facilities and operations.

4.1 Efficiency in Building Operations

Opportunities to improve energy efficiency may include equipment upgrades, building envelope improvements, maintenance practices, behavioral or operational changes, or the use of automated controls. The effort and cost required to implement energy efficiency improvements ranges from little or no-cost modifications of existing equipment or behaviors to major investment projects.

Cities and towns that have earned Green Communities designation from the Massachusetts Department of Energy Resources (DOER) are eligible for grants to help fund energy efficiency projects. For more information, see http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/. Also consult with your utility company to find out about eligibility for Mass Save incentives or rebates.

See **Appendix A** for information on energy efficiency best practices.

4.2 Clean Heating and Cooling

Clean heating and cooling, or renewable thermal, technologies can be used to substantially reduce or eliminate consumption of traditional fossil fuels in municipal buildings. Established technologies include air-source heat pumps, ground-source heat pumps, solar thermal heating, and modern wood heating.

The Massachusetts Clean Energy Center's (MassCEC) Clean Heating and Cooling programs offer rebates to support the installation of renewable heating, hot water, and cooling technologies at facilities across the Commonwealth. These technologies are generally more cost-effective to operate than traditional fossil-fuel systems and can reduce greenhouse gas emissions, while maintaining a high level of comfort, automatic operations, and reliability. MassCEC provides substantial rebates toward implementation of clean heating and cooling systems. Find more information on the programs and technologies at http://www.masscec.com/government-non-profit/clean-heating-and-cooling, as well as in **Appendix B**.

DOER is currently finalizing its Alternative Portfolio Standard regulation, which will provide additional incentives for the operation of clean heating technologies. Grants received through the Green Communities program may also be applied to clean heating and cooling systems upon review with DOER.

Additionally, if some municipal buildings are clustered together, there may be an opportunity for a district heating system where centralized heating equipment serves multiple buildings, which may reduce the capital and operational costs for new clean heating equipment. Other technologies such as combined heat and power can be used with district heating for increased efficiency and reliability.

See **Appendix B** for additional information on clean heating and cooling technologies.

4.3 Solar Power Generation

Generating electrical power onsite can often provide environmental and financial benefits to a community. Solar electric systems, also known as solar photovoltaics or solar PV, convert sunlight into electrical energy through an array of solar panels that connect to a building's electrical system or directly to the electrical grid.

With federal and state incentives, solar electricity is often a cost-effective way for municipalities to reduce their energy costs for the long run, while also reducing their environmental impact. A robust solar industry in Massachusetts is eager to work with municipalities to develop, host, or serve as net metering off-takers for solar electricity.

Additional information relating to solar photovoltaic systems can be found on the MassCEC website: http://www.masscec.com/solar-electricity. The Department of Energy Resources is launching its new SMART program (http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/rps-aps/development-of-the-next-solar-incentive.html) in 2018 to continue to advance the solar PV market in Massachusetts.

4.4 Vehicle Operations

Vehicle fuel accounts for as much as a quarter of total energy consumption for many Massachusetts municipalities, but it may be overlooked during efficiency assessments. There are several other ways to reduce vehicle fuel use:

- Right-size vehicles for their tasks
- Optimize vehicle routes
- Regularly check and maintain air pressure in tires
- Educate employees on vehicle idling
- Evaluate hybrid, electric or more efficient models vehicles to replace the vehicles that currently use the most fuel
- Consider fuel efficiency and alternative fuel vehicles in all new vehicle purchases, including those that are exempt from Green Communities criterion 4 mandatory efficiency improvement requirements
- Alternative snow plow configurations (e.g., Hydraulic “down-pressure” attachments may reduce vehicle fuel consumption by reducing the required number of passes and tire spinning from lost traction. This attachment may also reduce the force on front axle decreasing maintenance costs)

5. Considerations for Energy Project Prioritization

Following are facility-specific key findings and recommendations from CEE's analysis of Peru's energy data. These can help to prioritize future energy assessments and energy efficiency efforts:

- **The Town Hall/Police Station:** – The Town Hall/Police Station building has the highest energy consumption and energy intensity (*energy consumption per ft^2*). Improvements to this building will have a significant impact to the municipal energy consumption. Peru should place a **high priority** for assessments on the Town Hall/Police Station building.
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6. Next Steps

As a next step, the **municipality should contact CEE to schedule an initial conference call to discuss these findings and next steps.** This discussion may include a review the municipal energy analysis, target strategies, and support a plan for preparing Green Communities designation application, if desired. After the review call, the municipality may wish to schedule energy audits for **high priority** municipal facilities identified in this report. When soliciting potential auditors, ensure they are prepared to consider both thermal and electric opportunities.

Additionally**,** CEE is available to provide a **Clean Heating Screening Analysis (Phase II)** at Peru's request. A screening analysis can be completed for two to three town buildings. The screening analysis will provide a pre-feasibility evaluation of the investment cost, available incentives, and lifecycle economic savings of technologies such as air- or ground-source heat pumps, solar thermal, and modern wood heating systems**.**

CEE is grateful for the opportunity to serve the Town of Peru, and for the support of Peru's officials in developing this analysis. We are available to assist the town with the above next steps and to discuss other energy-related suggestions/ideas the town may have. Please do not hesitate to contact us with any additional questions or comments regarding this analysis (413.545.8510, energyextension@umass.edu).

Appendix A – Municipal Energy Efficiency Best Practices

The UMass Clean Energy Extension recommends that municipalities consider the following energy efficiency best practices. Financial support for these efforts may be available through Green Communities grants or Mass Save incentives or rebates. For more information, see http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/ and consult your utility company representative.

Optimize Building Controls

Many buildings have building/energy management systems or programmable thermostats that are not operating to their full potential. These control systems need to be properly programmed and maintained in order to be effective in optimizing building operation and energy use. Energy efficiency opportunities may be identified by periodically retrocommissioning these systems or reviewing temperature setpoints and schedules, comparing to building occupancy, making any necessary adjustments, and testing to make sure that the related equipment is operating as intended.

Control systems may record environmental conditions and operational parameters, and review of this data can be very helpful in maximizing the value of the system and identifying any performance problems with HVAC equipment.

For selected buildings, utility companies may be able to provide electrical billing data in 15-minute intervals, which can also be very useful in understanding electricity use patterns throughout the day/week and identifying opportunities to optimize building operation.

Several Green Communities have seen great benefits from these practices, some with the assistance of fault detection and diagnostic software or circuit-level monitoring by consulting companies. Utility pay-for-performance programs may provide incentives based on the achieved savings.

Install/Upgrade HVAC controls

Advanced controls can improve the efficiency of some HVAC systems without the substantial investments required to replace major equipment. These technologies include:

- Energy recovery ventilators or heat recovery ventilators use a heat exchanger to preheat or precool incoming fresh air by reclaiming energy from the outgoing exhaust air.
- Demand control ventilation automatically adjusts the amount of outside air let into the building to optimize energy use while providing occupants with the right amount of fresh air.

Integrate Energy Efficiency into Purchasing Decisions

Efficiency ranges widely for many types of energy-consuming equipment. Incremental costs range depending on the product type, but sometimes there is sometimes little to no added cost for high efficiency models of new equipment, and in other cases the long term energy savings can justify a higher purchase price for an efficient model. Information about efficiency of many types of products – including appliances, commercial kitchen equipment, electronics, HVAC equipment, office equipment and more – is available from the ENERGY STAR program at http://energystar.gov/products and http://energystar.gov/purchasing.

Use Power Management Software on Computers

The ENERGY STAR program offers free support on computer power management to reduce electricity consumption when computers are not in use, detailed at http://energystar.gov/powermanagement.

Implement an Energy Engagement Program

Some Green Communities have had success with programs that educate municipal employees, students and other building occupants about their energy reduction goals and encourage simple behavioral actions such as turning off lights, computers and other equipment when not in use.

Investigate Energy Efficiency Opportunities in Water and Wastewater Treatment Plants

Water and wastewater treatment plants are often among the highest energy consuming facilities in cities and towns. Support for projects in these facilities may include the following programs, where applicable:

- The **UMass Center for Energy Efficiency and Renewable Energy**, CEE's partner organization, offers free, in-depth assessments of plants with annual energy costs of at least $100,000. The Center conducts a site visit with a thorough review of equipment and processes, then provides a detailed report with recommended energy efficiency opportunities, including estimates for energy and cost savings and implementation costs. More information is available at http://ceere.org/iac/

- The **Massachusetts Department of Environmental Protection** (MassDEP), with funding assistance from the Massachusetts Department of Energy Resources, is planning to award grants to municipal water and wastewater treatment plants in support of clean energy and increased efficiency in our water infrastructure. The agency is planning to make grant applications available in the fall of 2017. For more information, see http://www.mass.gov/eea/agencies/massdep/climate-energy/energy/ or contact MassDEP: Michael DiBara, (508-767-2885, michael.dibara@state.ma.us), James Doucett (617-292-5868, James.Doucett@state.ma.us), or Ann Lowery (617-292-5846, ann.lowery@state.ma.us).

- **MassCEC** is offering up to $150,000 in funding for the piloting of innovative technologies at publicly-owned wastewater treatment facilities across the Commonwealth. This program focuses on innovative technologies aimed at one the three focus areas: (1) increasing energy efficiency, (2) recovering resources for reuse, or (3) removing nutrients including nitrogen and phosphorous. Additional information can be found on the MassCEC website: http://www.masscec.com/innovation-wastewater-treatment-plants.

- **Mass Rural Water Association** (MassRWA) provides free on-site technical assistance to small and rural wastewater treatment and collection systems through the Wastewater Technical Assistance Program and the Wastewater Training and Technical Assistance Program both funded by the U.S. Department of Agriculture's Rural Utilities Service. These programs provide hands-on assistance and training to wastewater systems in areas such as operator certification, treatment, biological process control, laboratory procedures, collection systems, smoke testing, and maintenance. The emphasis of the technical assistance is promoting low cost, long-term solutions. Learn more at http://massrwa.org/ or contact Dave Kaczenski (dkaczenski@massrwa.org) for assistance or information about MassRWA's Wastewater Programs.

- The **Water Innovation Network for Sustainable Small Systems** (WINSSS) at UMass develops research opportunities, conducts piloting projects, and provides technical assistance at small-scale wastewater and drinking water systems. Learn more at http://www.umass.edu/winsss/ or contact Patrick Wittbold (pwittbold@gmail.com) for more information.

Appendix B – Clean Heating Technologies

Clean heating and cooling, or renewable thermal, technologies can be used to substantially reduce or eliminate consumption of traditional fossil fuels in municipal buildings. The following are descriptions of these technologies from the Massachusetts Clean Energy Center website. See more information at http://www.masscec.com/government-non-profit/clean-heating-and-cooling.

Air-Source Heat Pumps

Air-source heat pumps (ASHPs) can provide cost-effective and energy-efficient heating and cooling for your building's space. While traditional systems burn fuel to create heat, a heat pump instead works by moving heat into or out of a space. Though they require electricity to operate, efficient ASHPs use 40-70 percent less electricity than traditional electric-resistance heating. Rebates of up to $210,000 are available.

Key points:

- Easy to install in existing buildings and compatible with any type of existing heating system
- Often installed to supplement existing heating systems
- Provide both heating and cooling in a single, efficient unit without the need to install ductwork
- Lowest up-front cost of any clean heating and cooling technology, and can be more cost effective to operate than traditional oil, propane, or electric heat

Modern Wood Heating

Modern wood heating systems use wood chips or wood pellets to produce heat, much in the same way traditional boilers or furnaces use oil, propane, or natural gas. Biomass heating systems can often integrate into existing heating systems, and can fulfill all of a building's heating and hot water needs. Systems are typically fully-automated, and require limited maintenance. Wood chip and pellet delivery is available in most parts of the Commonwealth. Rebates of up to $250,000 are available for commercial-scale systems and $27,000 for small-scale systems.

Key points:

- Typically installed in buildings with baseboard hot water heating, but furnace options are also available for buildings with forced air heating
- Can be more cost-effective than heating with traditional oil, propane, or electric heat

Ground-Source Heat Pumps

Ground-source heat pumps (GSHPs) can provide cost-effective, energy-efficient space heating and cooling, hot water and process heat by utilizing the nearly constant temperature underground to transfer heat between the ground and your facility. GSHPs are typically the most efficient type of heat pump. Though they require electricity to operate, efficient GSHPs can provide the same amount of heating for substantially less than traditional electric heating. Grants of up to $250,000 are available for commercial-scale systems and $25,000 for small-scale systems.

Key points:

- Great option for new construction, but can also replace existing forced air or hydronic heating systems

- High installation costs are offset by long-term energy cost savings compared with electric heat, oil, propane, or even natural gas heating plus highly efficient cooling

Solar Hot Water

Solar hot water systems use the energy of the sun to heat water for use in your home's hot water system. Solar hot water systems reduce the usage of traditional water heating fuels (such as oil, electricity or natural gas) and thereby reduce the amount you spend purchasing these fuels. Rebates of up to $100,000 are available.

Key points:

- Great option for both existing buildings and new construction
- Can reduce water heating costs and greenhouse gas emissions at your facility
- Especially cost-effective for buildings currently heating water with oil, propane or electricity

Appendix C – Extended Building Analysis

Weather Normalized Heating Fuel Consumption

Comparing year-to-year total heating fuel consumptions will help distinguish any trends or anomalies **(Figure C.1)**. These trends may be representative of abnormally cold or mild winters, or could be caused by alterations to the building. To parse out these effects, the data was adjusted to account for variation in weather, or weather normalized **(Figure C.2)**. Weather normalization allows us to determine if trends in the total heating fuel consumption are due to building operation or infrastructure alterations or to weather related effects.

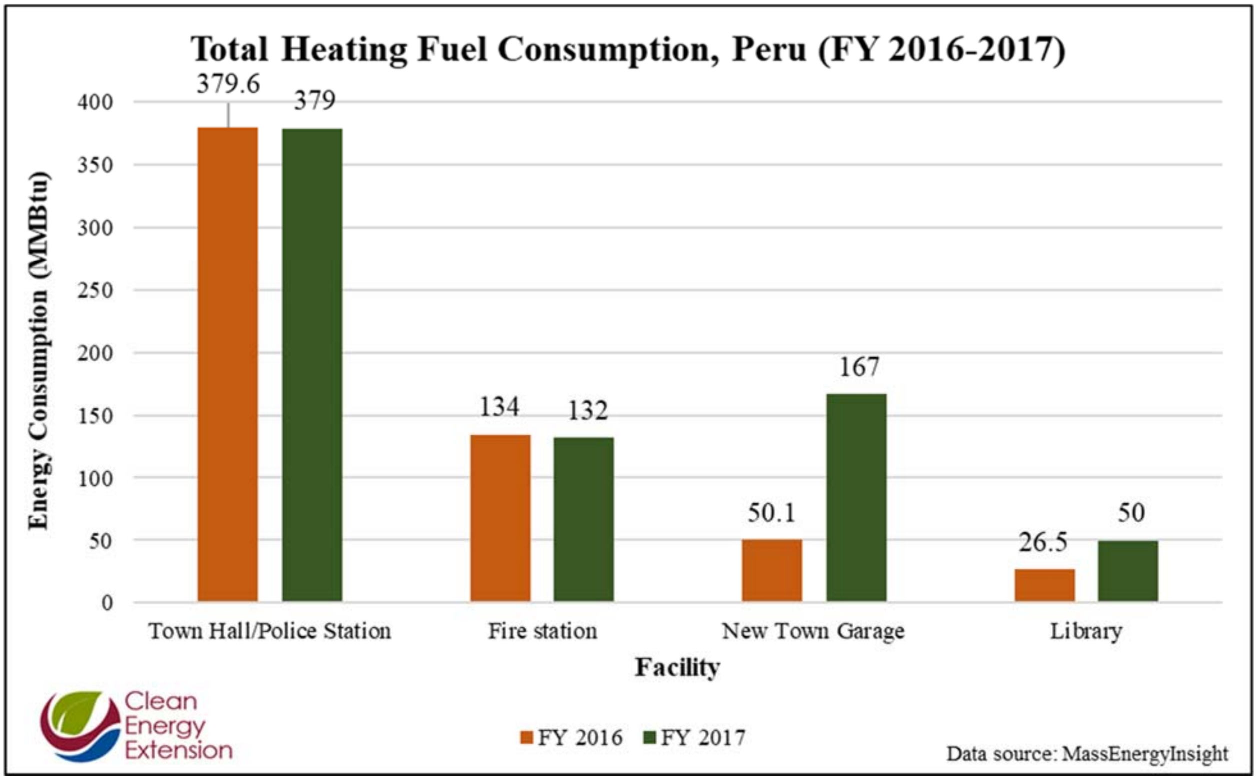

Figure C.1: Annual heating fuel yearly comparison

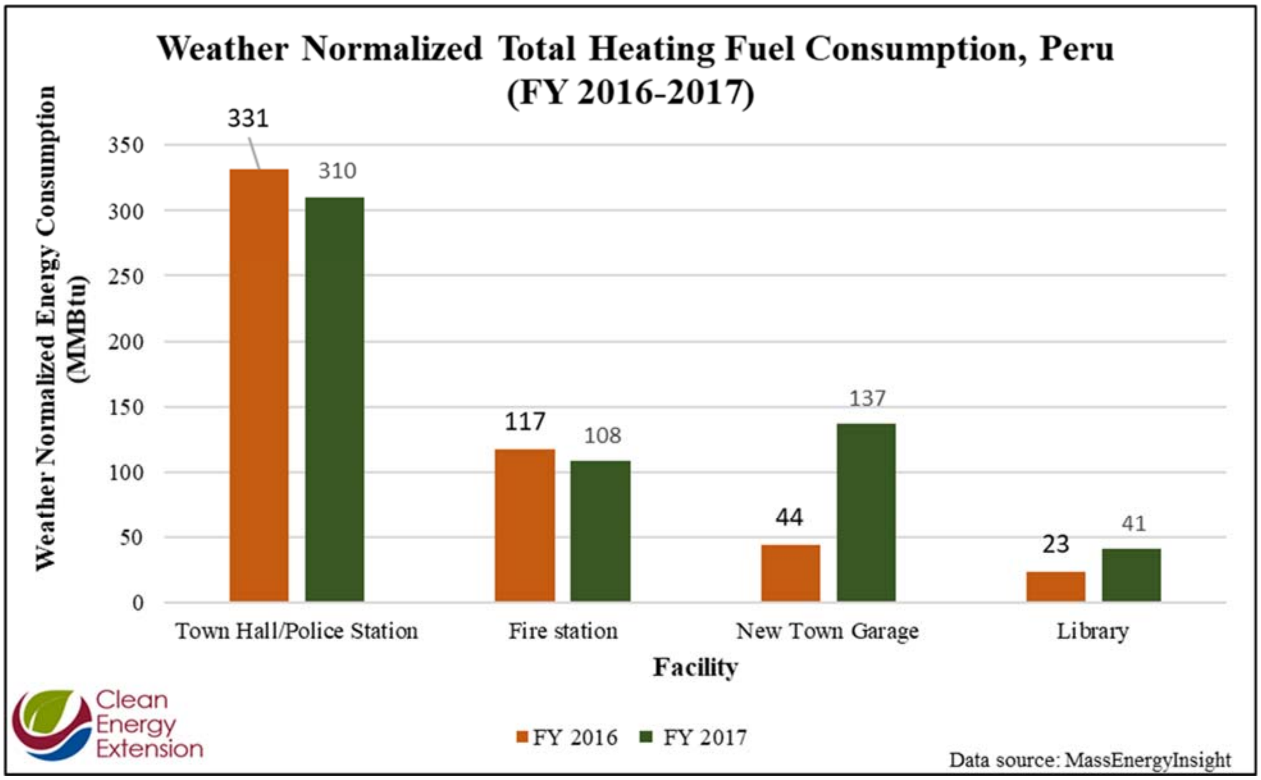

Figure C.2: Weather normalized heating fuel yearly comparison

Thermal Performance Analysis

Historical energy consumption is compared to historical weather conditions to determine the relationship between energy consumption and weather. From this comparison, the balance point can be calculated. The balance point is the outdoor temperature at which internal systems turn on to heat the building. For internally dominated buildings (e.g. office buildings) a typical balance point is 50°F. For envelope dominated buildings (e.g. traditional house) the typical balance point is 60°F. A building with a balance point that is higher than 60°F is a good candidate for lifestyle or structural changes that would decrease the buildings heat loss through the envelope. This analysis is useful to quickly identify buildings that would benefit from retrofits that could reduce the buildings energy usage per Heating Degree Day (e.g. Increased insulation, improved air barrier).

The regression analysis, utilizing fuel delivery data from MEI for the buildings along with local temperature data, are shown on the following pages.

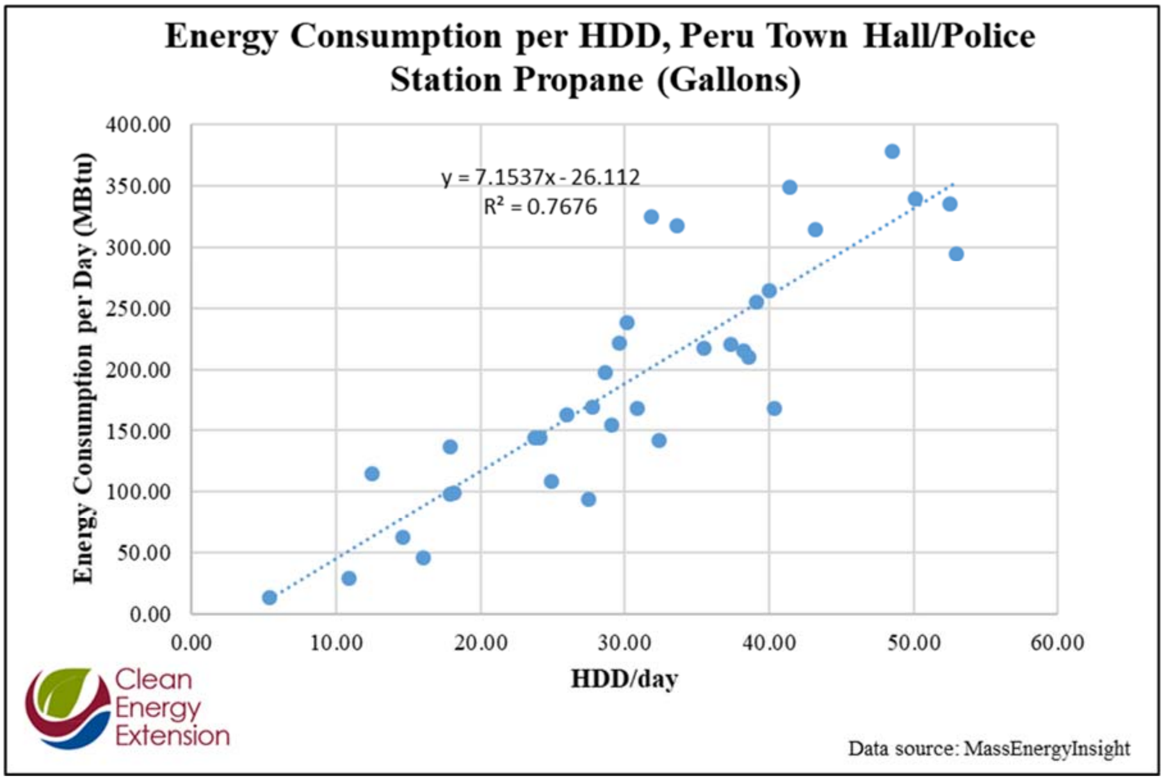

Figure C.3: Regression plot of total energy consumption per heating degree day.

Table C.1: The baseload, balance point, correlation and heating sizing of the building

Baseload, Peru Town Hall/Police Station Propane (Gallons)	
Intercept	**15th Percentile**
-26.11	10.81
Correlation	
R^2	**Pearson**
0.768	0.876
Slope (energy unit/°F)/intercept (energy unit)	7.15
Balance Point (°F)	64.73
Heating Sizing (MBtuh)	5,331.51

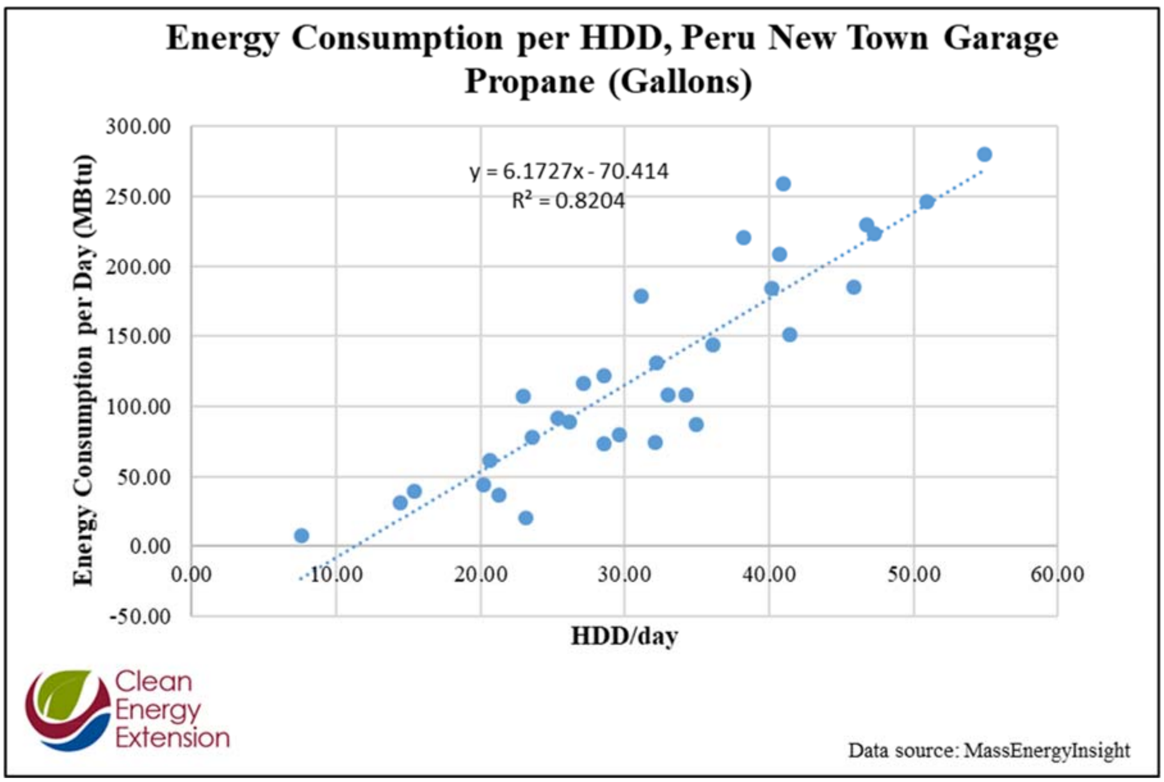

Figure C.4: Regression plot of total energy consumption per heating degree day.

Table C.2: The baseload, balance point, correlation and heating sizing of the building

Baseload, Peru New Town Garage Propane (Gallons)	
Intercept	**15th Percentile**
-70.41	4.69
Correlation	
R^2	**Pearson**
0.820	0.906
Slope (energy unit/°F)/intercept (energy unit)	6.17
Balance Point (°F)	64.91
Heating Sizing (MBtuh)	4,600.35

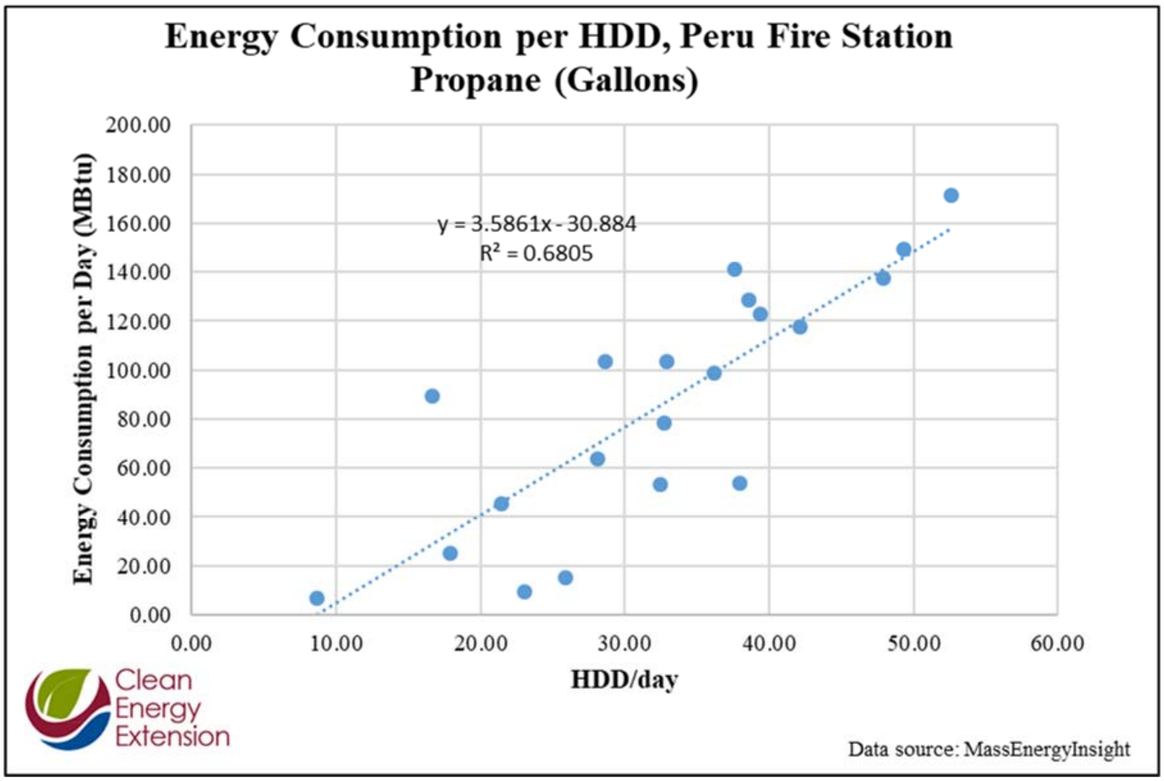

Figure C.5: Regression plot of total energy consumption per heating degree day.

Table C.3: The baseload, balance point, correlation and heating sizing of the building

Baseload, Peru Fire Station Propane (Gallons)	
Intercept	**15th Percentile**
-30.88	2.56
Correlation	
R^2	**Pearson**
0.681	0.825
Slope (energy unit/°F)/intercept (energy unit)	3.59
Balance Point (°F)	64.88
Heating Sizing (MBtuh)	2,672.61

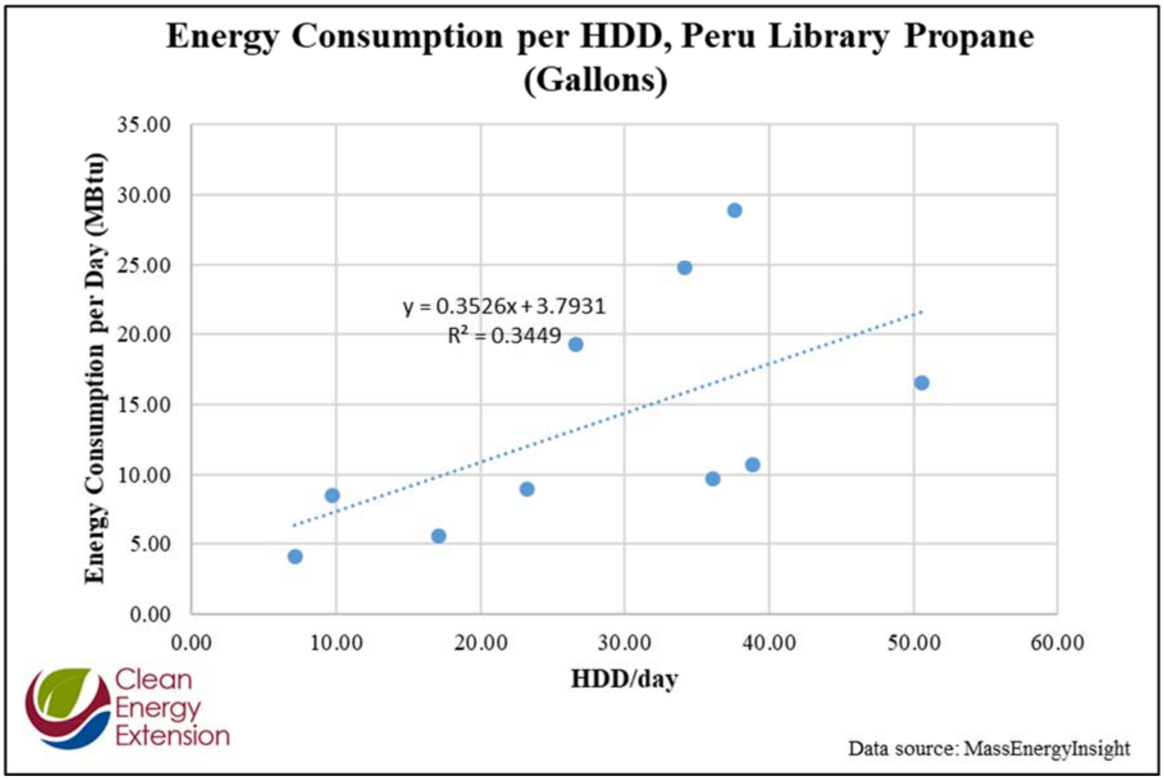

Figure C.6: Regression plot of total energy consumption per heating degree day.

Table C.4: The baseload, balance point, correlation and heating sizing of the building

Baseload, Peru Library Propane (Gallons)	
Intercept	**15th Percentile**
3.79	0.72
Correlation	
R^2	**Pearson**
0.345	0.587
Slope (energy unit/°F)/intercept (energy unit)	0.35
Balance Point (°F)	65.09
Heating Sizing (MBtuh)	262.78

Appendix D – Additional Energy Consumption Charts

Peru's ten accounts of any fuel type with the highest energy consumption in FY2017 are shown in ranked order in **Figure D.1** below. These accounts comprise between 80 and 90% of the municipality's total annual energy consumption, thus Peru should consider prioritizing these top accounts for further energy studies and subsequent energy efficiency projects.

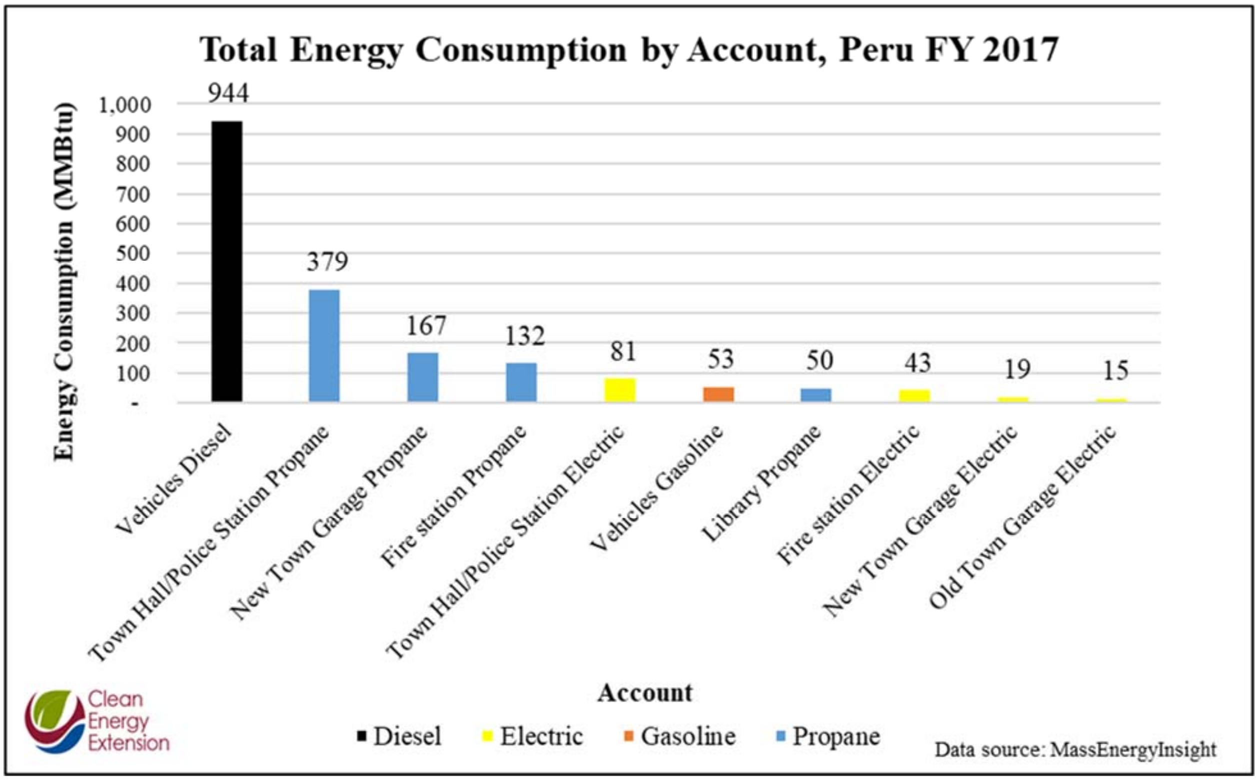

Figure D.1: Top ten energy accounts

Peru's top municipal electric accounts in FY2017 are shown in ranked order of usage in **Figure D.2** below.

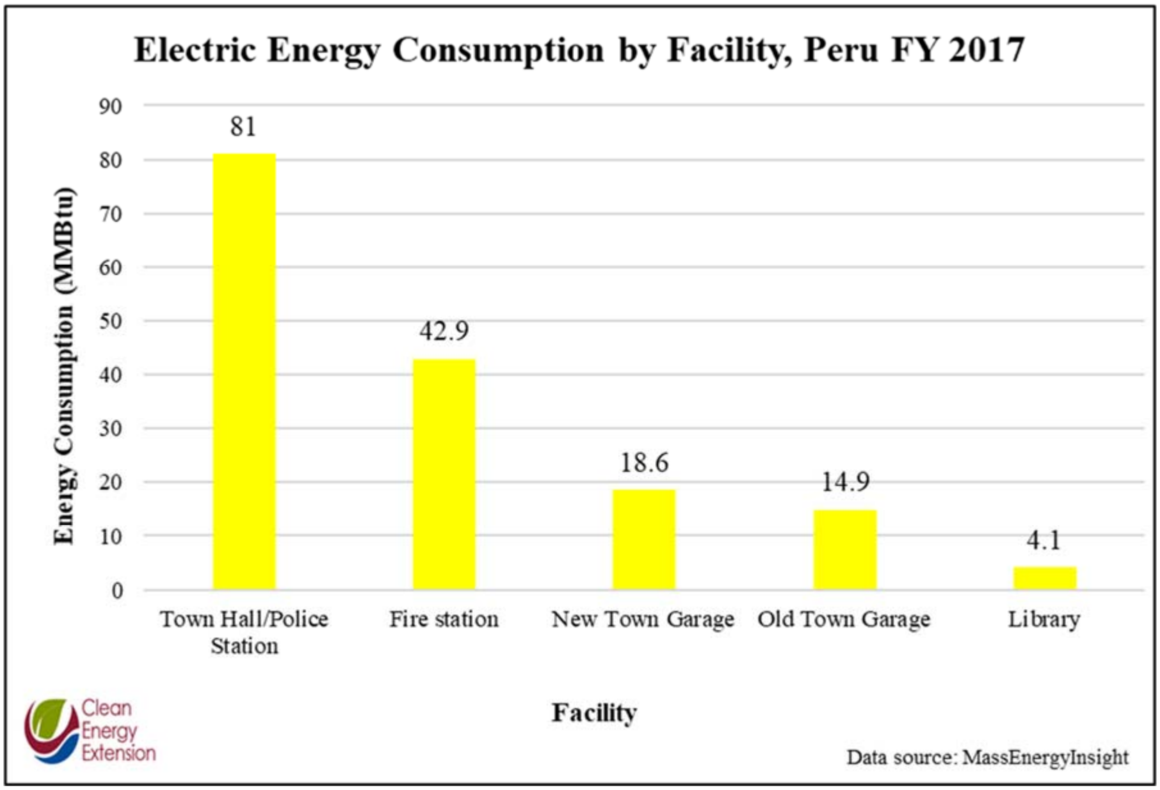

Figure D.2: Top municipal electric accounts ranked by consumption