ALASKA ENERGY AUTHORITY

Heat Pumps Best Practices Guide

Renewable Energy Fund Application

Introduction

The following guide contains items that are critical to the success of a Renewable Energy Fund (REF) application and project. The intent of the guide is to aid applicants in the submission of a comprehensive project proposal, and is meant to add additional details specific to heat pump projects. Smaller and simpler projects may not have to address all of the items below. Larger and more complex, systems will be expected to have a more thorough analysis of the interrelated system(s).

Since the inception of REF, the Alaska Energy Authority (AEA) has managed dozens of grants for renewable energy heat projects across the state. Over time, a number of common planning issues have been identified. Recognizing that each project is unique, this best practice guide does not prescribe a one-size-fits-all approach for project development. Instead the guide poses a series of questions and prompts to help an applicant and project developer work through the process of developing a successful application and viable project. A well planned project is more likely to be a strong proposal and benefit the community.

The guide does not follow the REF application precisely, but the application provides references to this document. The guide is organized to address these factors:

(1) Site selection,
(2) Understanding the existing system,
(3) Proposed system design and any integration consideration of any the existing primary and ancillary systems,
(4) Economic analysis & optimization,
(5) Financing and operations planning, and
(6) Common planning risks.

Project design and optimization is not generally a straight line, but an iterative process where new information will require that plans be reevaluated. An applicant is expected to have performed the data collection and analysis appropriate for all phase(s) that precede the proposed phase. The applicant should likewise use this guide to help develop the scope of work for the proposed phase(s).

Each phase of project development investigates two main questions: “Can the project be built?” and “Should the project be built?” Answering these questions requires an investigation of the technical, economic, environmental, and business aspects of the project. Every project has development risks; a thorough plan will identify these risks as early as possible, investigate possible ways to mitigate the risks, and ultimately determine if the expected benefits outweigh the risks. Where possible, the guide provides information on the detail and content for each phase (reconnaissance to construction).

1. **Reconnaissance** studies are a “desktop” study and the analysis should use resource, economic, and operational data that is readily and/or publicly available. The study should be sufficient to identify high-level flaws in the use and integration of the resource.

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2. **Feasibility and Conceptual Design** studies should include site specific data collection and analysis. The conceptual design (also called a 35% design) will not be sufficient to give to a construction company, but will be of sufficient detail that a thorough economic and feasibility analysis can be accomplished. Planning for the business and financial aspects of operating the project will be started.

3. **Final Design and Permitting** will make the project “shovel-ready.” The conceptual design will be refined and improved. The specific operational conditions and parameters will be finalized. All business, operational, and financial plans will be finalized.

4. **Construction and commissioning** activities are not specifically addressed in this document.

Contents

1 Site Selection & Assessment

A heat pump project begins with selecting and understanding a site: the available resource, the potential restrictions in accessing and controlling the site, and any environmental or other permits that may be needed for project activities.

1.1 Resource assessment

1.1.1 Data to collect & how to collect

- ☐ Other resource parameters
  - ASHP—humidity levels, Temperature of input over year (air)
  - GSHP—Temperature of input over year (groundwater), Thermal conductivity test (or flow test for open-loop systems)
  - Seawater—Temperature of input over year (seawater)

1.2 Site control

The applicant must be able to have legal right to use and access the site(s) for the heat pumps, wells, piping, etc. Applicants should identify potential issues as soon as possible. Legal and/or financial agreements may be required to resolve site control issues. Site control must be finalized before construction funds are committed. Do not underestimate the complexity of land ownership in Alaska.

- ☐ The grantee shall be responsible for resolving any land ownership disputes between state and/or federal entities, local landowners, native corporations, municipalities, boroughs and community organizations, or other entities.
- ☐ Proof of valid title to the land and/or written documentation of any private agreements is required.
- ☐ The landowner must guarantee that there are no liens or encumbrances on the property.
- ☐ Final proof of ownership shall be the certificate to plat.
- ☐ Site control for transmission or distribution power lines may be established using easements or utility right-of-ways so long as the period of the agreement meets or exceeds the intended life of the project.
- ☐ If the project expects secondary loads to be placed in non-utility facilities, ownership and access of infrastructure must be agreed to by all parties.
- ☐ If the project site is adjacent to or near an airport or runway, the grantee must research FAA permit requirements, existing or pending leases and easements, and DOT expansion or relocation plans
- ☐ Land transfers required for project development shall be recorded with the appropriate District Recording office and a copy of the recordation provided to the AEA grant manager.

1.3 Environmental and Permitting Risks

Permitting, environmental or otherwise, may stop projects or require change in size, location, or operations. It important that any potential permitting issues are identified early so that the scope of the project can be changed, mitigation measures are taken, or the project can be ended before significant funds have been spent.

In addition to understanding which permits are required, and the studies and/or modifications (either in infrastructure or operations) required for the permits, the amount of time required to do the necessary work must be included in the project plan.

Document communications and approval from US Fish & Wildlife Service, FAA, Army Corp of Engineers, DNR, local government and any other appropriate agencies.

- Contaminated sites database
- Threatened or endangered species
- Habitat issues
- Wetlands and other protected areas
- Archaeological and historical resources
- Land development constraints
- Telecommunications interference
- Aviation considerations
- Visual, aesthetics impacts
- Identify and describe other potential barriers

2 Understanding the existing system

Having a detailed understanding of the existing system (also called the base case) is key to knowing if the proposed system will be beneficial. The base case will be used both to understand the economics and the feasibility of integrating the heat pump system.

The level and type of detail required will be based on the proposed phase and the proposed system's complexity in its entirety.

This section is also a good time for the applicant to see if fixing or upgrading the current infrastructure is the best option for the community/facility. This is not required for the REF process, but is a good idea nonetheless.

The following sections are divided into *configuration* and *operation.* The configuration is the infrastructure that is currently in place. The operation is how that infrastructure is used.

2.1 Configuration of existing system

2.1.1 Heat—Info & data

- ☐ The type, design and components of the existing heating system(s) is clearly described including the operating temperature range in every proposed building/system.
- ☐ What is the design load (the maximum Btu/hr of heat needed) of building(s) and/or facility?
- ☐ Will the existing heating system(s) be removed or maintained for backup or peaking?
- ☐ Describe the existing control system(s) and if it will be useful for the proposed system—especially if there sufficient cabinet space, breakers, protection, etc. for the proposed system.
- ☐ Is the existing heating system at or near the end of its design life?
- ☐ Where are the major heat loads located in the community? Which could connect to an existing or planned heat recovery loop?
- ☐ Are there additional potential heat loads in the community that are not currently being met? Are any new heat loads being planned?

2.1.2 Power—Info & data

- ☐ Is there sufficient excess generation capacity for the proposed heat pump system? Load profile by month (peak, minimum, average) and/or 15 minute interval load profile for one year may be necessary
    - Load analysis and growth projections

- ☐ Are any upgrades needed in the building's breakers and/or distribution panels, transformers, or distribution system before the heat pump project?
- ☐ Are there opportunities for savings that are more economic than the proposal (heat recovery, diesel efficiency, etc.) that have not been implemented yet?

2.2 Operations of existing system

2.2.1 Heat—Data

- ☐ Monthly heating data is available for each proposed building (Indicate if these are actual or modeled data)
    - Pull heating fuel consumption/purchase records (minimum one year) for the buildings being considered and provide annual estimates (high/low) for each.
- ☐ What is the operational thermal efficiency (tested, manufacturer, or estimate) of the existing system?
- ☐ Describe how the heating control system(s) is used for the existing system
- ☐ If there is a heat recovery system, how are those heat loads monitored/quantified? What is the annual heating fuel purchased for each of those loads?
- ☐ Energy Efficiency improvements have been completed on the proposed buildings.
    - Air infiltration: Caulk doors & windows, rim joist, weather strip doors & windows, use foam gaskets on outlets and switches.
    - Insulation: Attic, floor, basement, walls
    - Upgrade windows
    - Install a heat recovery ventilation system

3 Proposed System Design

Designs should take into account the site-specific requirements of the energy resource, the physical environment, and the system into which it will be integrated. The design should aim to reduce costs to customers, while maintaining or improving service to customers.

The level of design required is based on the phase. A Reconnaissance project may end with a design based on a heat pump, while a Feasibility & Conceptual Design will have a design with a commercially-available heat pump, and a Final Design project will end with plans sufficient to give to a construction firm to build the project.

The proposed system design should include a description of any civil infrastructure (buildings, roads, etc.) that will be built or changed for the heating system as appropriate for the application. In all cases, designs should meet or exceed state and federal standards and regulations and be performed by people with proper credentials (such as a licensed Professional Engineer) for the design.

All appropriate building permits must be received prior to construction. What follows are a selection of common considerations that will need to be incorporated into the final design of the project prior to construction.

3.1 Proposed Heat Pump System

The proposed heating system must be described in sufficient detail consistent with the phase of development. The *configuration* of the proposed system are the specific components that will be built or installed for the project; the *operations* will explain how all of the components will be designed to work together in the system.

Some of the important questions and ideas to consider while evaluating and designing the heat pump system include:

- ☐ What is the optimally sized heat pump system, including thermal storage, needed to meet the design load of the system most economically?
  - Make/model, size (Btu/hr): How is the system sized relative to average and peak loads? Would a hybrid system improve the project economics?
- ☐ The mechanical room has ample room to access the boiler components for operations and maintenance.
- ☐ Are there non-grandfathered codes present that need to be dealt with properly?
- ☐ If piping is necessary—what type and size, where will it be routed, how will it be protected?
- ☐ Are there structural changes needed to accommodate the new infrastructure?
- ☐ Fire suppression (if needed)
- ☐ BTU meters are required for heat sales agreements and for performance reporting of total heat produced by the system.

3.1.1 Proposed Civil Infrastructure

The applicant should include a description of the civil infrastructure that will be built in support of the project. The infrastructure must be built to perform as expected for the life of the project in the particular environment of the preferred site. If the application is for a construction project, the applicant's schedule should reflect the seasonal and logistical constraints.

3.1.1.1 Designs for new or changes to existing buildings, towers, etc.

Design best practices include preparing logical, readable, and professional drawings and specifications and other documents for construction and operation and maintenance phases of the project. General goals of the design are as follows.

- ☐ That the project is designed and constructed in a safe manner that minimizes the danger to human life and harm to the environment.
- ☐ The design results in a low project cost while serving the project purpose and need for its useful life.
- ☐ The design is sufficiently detailed and adequate to minimize change orders, cost deviation, and reasonably minimizes risk of major repairs or modifications following construction.
- ☐ The design appropriately balances cost of construction with lowered operation and maintenance costs and the potential for expansion is considered.
- ☐ The design incorporates energy efficiency and arctic design best practices.

At a minimum, prior to construction the applicant should expect to have the following things:

- ☐ Project overview map(s) and general information
  - At least one map showing full project extents and a vicinity map
  - A sheet index for all drawings
- ☐ Design Criteria and information
  - Design codes and standards used along with a code analysis
  - Design loadings
    - Structural loads
    - Foundation(s)

- Geotechnical investigations and reports to design for:
  - Permafrost and other geotechnical concerns
  - Earthquake Zone/ Category Designation
- Design analysis, calculations/report
- Future maintenance and expansion

☐ Drawings showing horizontal and vertical design sufficient for layout and construction of infrastructure. Typical methods include plan and profile drawings with stationing for alignments, standard road cross sections, limits of grading, grades or slopes, and general topography, drawing scale bars and north arrows, point or dimensional data, structural sections showing embedment's, equipment layout drawings, electrical and mechanical schematics, and equipment lists, size, and locations
☐ Submittal requirements including drawings and basic design data for contractor design build items, fabrications, and procured equipment with requirement for submittal and review of the electrical switchgear engineered and shop drawings.
☐ Technical specifications for materials and methods
☐ Engineers cost estimate, updated feasibility report, owner's business development and operational plan, and schedule.
☐ Vendor signoff on contractor installed equipment if the contractor is not OEM certified, if required.
☐ Commissioning Plan Submittal by Contractor
☐ SOA DOL Boiler Registration, if psi increase

3.1.1.2 Construction requirements

Applicants should start planning for construction in the Feasibility phase—only by understanding and preparing for site specific risks and logistics can accurate costs be determined. Final Design and Permitting will end with all of the following logistics and plans must be worked out to make sure the construction is safe, cost effective, and done properly. Earlier stages of development can address the points below generally—that is identifying that a road may need to be designed to handle the load of a crane, but not specifically how the road will be built.

☐ Safety plan for construction activities
☐ Logistics for getting materials, supplies, machinery, etc. on-site
☐ Are there seasonal limitations on when materials can be delivered to the community and/or delivered to the site?
☐ General specifications governing execution of work
☐ When is labor available? Are there sufficient trained workers in the community, or will there need to be contractors brought in from other places?
☐ Are there DOL Rate requirements? Use most recent rate publications.

3.2 Proposed Operations

Planning for operations and understanding the expected outcomes should start early.

3.2.1 Operations of Proposed Heat Pump System

☐ Model proposed system with local resource, load, and control strategy
- Does the system model verify that the boiler is not oversized?
- Can the backup boiler system handle peaking requirements?
- System coefficient of performance (COP) based on input and output temperatures

- Parasitic power (pumps, etc.)
- % available
- Amount of electricity consumed on a daily, weekly, monthly, and annual basis
- Continued fuel consumption in existing generation infrastructure

☐ Are there conditions—either economic, environmental, or technical—where the project will not be feasible to operate?

4 Perform Economic Analysis & Optimization

Planning and designing a heat pump project should be an iterative process, as new information is learned the design is refined and improved, progressively more tailored to the site and system. A project that receives REF funding must be both technically possible and economically viable. A proposed system may be technically possible, but cost prohibitive—it will increase costs to customers or the costs outweigh the benefits.

AEA will perform an economic analysis for all applications. In all cases, AEA compares the proposed system against the base case (the current system configuration). The proposed costs must be outweighed by the expected savings. For heat pump projects, most of the economic savings is in displaced fossil fuels. Communities may have additional values that are important—increased local employment, decreased imported diesel, or reduced greenhouse gases.

Ideally an applicant will investigate multiple options, including improving the base case.

The economic evaluation assesses the economic viability of a project. The entire project proposal is assessed, not each individual component. If the costs for the project are greater than the expected benefits, then the project would not be economically viable. If the total benefits to all parties outweigh the costs incurred by all parties, then the project is considered to be economically viable. The economic analysis is indifferent to who receives benefits and who pays costs.

- **Benefits**: Savings to utility customers, non-utility customers, Power Cost Equalization, and others
- **Costs**: Expenses paid for by utility customers, grants from state, federal, and regional governments; non-profits, non-utility

AEA uses an Excel-based economic model to provide the underlying assumptions (such as expected fuel costs), calculations and analysis. The model is available to all applicants. While AEA encourages applicants to perform and submit an economic analysis, AEA's analysis is used in the scoring process. Ideally, applicants would use the model to maximize the project's benefits and minimize the costs.

4.1 Costs for the existing system

Before analyzing the benefits of the proposed project, it is important to understand the existing system (the base case). Any savings that can be realized by the project will come from displacing costs from the base case. Keep in mind, there may be a number of costs that will not be displaced, even with the best heat pump project.

4.1.1 Heat

- ☐ Capital costs (current depreciation/loans?)
- ☐ Operational costs
    - o Efficiencies of the existing heating systems
    - o Cost of heating oil at the proposed secondary load customers
    - o Operations and Maintenance (O&M)
    - o Repair & Replacement (R&R)

4.2 Economic optimization

Even if an applicant expects to receive grant funds for their project, the proposed project should be designed to get the best economic return on the investment. By maximizing the savings from the project and keeping the cost as low as practical, the applicant will be more likely to get an REF grant. This may mean that a proposed project may not end up displacing the maximum amount of diesel or heating oil, because the extra cost might not be worth it.

4.2.1 Develop options based on generic or common boilers

It is encouraged that applicants use industry-standard modeling programs. Just note that AEA's economic assumption may be different from the models, and the economic results may be different. AEA does not require applicants to provide an analysis of all options that were analyzed, but the applicant will need to be able to justify why the preferred alternative was chosen.

Using generic heat pumps and high-level modeling programs are sufficient for early phase development, but a more robust modeling with be needed for Final Design.

- ☐ Annual modeling including variables of demand and fuel price, financing and O&M projections, and climate projections for both the existing/alternate and proposed generation system. Note that these assumptions may differ from AEA's assumptions. Please check AEA's economic model for additional guidance.
- ☐ Investigate how the economies of scale are effected by using different types and quantities of heat pumps. How do these options vary the overall system cost?

4.2.2 Costs for the preferred alternative

Any savings that can be realized by the project will come from displacing costs from the base case. Savings are expected to be found in displacing fuel. Expect that the heat pump project will increase some costs, especially the electricity for operating the heat pumps.

4.2.3 Heat

- ☐ Capital costs (current depreciation/loans?)
    - o Estimates based on phase-appropriate cost estimates for boilers, heaters, and heating control systems, new metering, etc.
    - o Fuel storage
- ☐ Operational costs
    - o Annual O&M
    - o New account management and billing
    - o Expected R&R and/or amortized R&R
    - o Include positive or negative impacts, if any, on an existing heat recovery system
    - o Electricity
    - o Operator salaries and training

4.3 Benefit-Cost Analysis

The Renewable Energy Fund evaluation process uses the benefit-cost ratio as its primary metric for economic viability. The **benefit-cost ratio** (B/C ratio) summarizes the all of the project's benefits and costs into a single number.

The total benefits of the project are found by taking the present value of all of the annual cost savings. The cost is the present value of the project's capital costs.

B/C ratio$= \frac{\text{Project Benefits}}{\text{Capital Costs}}$

Understanding the B/C ratio

B/C ratios communicate the economic viability of a project as a single number making it ideal for communicating the benefits and costs concisely.

- A B/C ratio greater than 1 means that the benefits are greater than the capital costs. Even without grant funds, the project should be cost effective and save the utility and customers money.
- A B/C ratio of 1 means that the benefits equal the Capital costs—the project just breaks even.
- A B/C ratio less than 1 means that the costs are greater than the benefits—economically things would be worse than before the project was built. Without grant funds, the project would not be cost effective and the utility and/or customers would lose money.

Since many projects will lead to savings for utilities and customers, even projects with B/C ratios below 1, it can be confusing why AEA would use the benefit-cost ratio to rate projects. The state wants to maximize its return on investment, its "bang for the buck", and wants to promote cost effective designs.

5 Financial and Operational Planning

Planning for the eventual operation of the heat pump project is too frequently overlooked. The additional need to track and pay for the parts, maintenance, and other necessary things can stress an owner if adequate preparation is not made. With proper planning, training, and management, a heat pump project can be a long-term benefit to a community.

Below are selected aspects of a business plan that should be included in the REF application. Please see the phase appropriate business plan template for a complete version of what should be included.

5.1 Financial Management

Since grant funds cannot be used to operate the heat pump project, an applicant must know how the maintenance and operations of the infrastructure is going to be paid for over its useful life. Heat pump projects face failure without a plan for paying for needed training, personnel, contractors, materials, and supplies.

What follows is a short list of aspects that the applicant should address.

☐ How will the applicant pay costs including expected capital costs and operations and maintenance, especially electricity

- ☐ Explain how O&M activities will be tracked for required performance reporting to AEA
- ☐ Heat sales agreement(s), if applicable – required for construction
- ☐ Accounting system to track revenue and expenses

5.2 Operational Management

- ☐ The business plan should identify who will have overall responsibility for all components
- ☐ Inspections & Maintenance—include checklists for responsible personnel, estimated time to completion, parts and supplies to keep in inventory, etc.
- ☐ Employees—including a back-up operator, training

6 Common Planning Risks

- ☐ Mismatch between assumed heat loads and what fuel records indicate
- ☐ Mismatch sizing of heat pump(s) to loads
- ☐ Assume too high of a coefficient of performance (COP)
- ☐ The proposed low temperature heating system will not supply enough heat to a building designed for a high temperature heating system.
- ☐ Not following industry standards and/or not using certified designers
- ☐ Not evaluating the impact of the heat pump(s) on the community's generation system
- ☐ There is no method to understand the amount of heat produced/consumed in the new system.
- ☐ The proposed boiler system is not 3rd party certified using ASTM test methods.
- ☐ Ignoring the O&M challenges of a heat pump system – Communities who have personnel that are trained on heat pump systems to perform maintenance have a better chance at meeting the output projections of your design.
- ☐ Not having a plan should costs exceed estimates
- ☐ Not engaging agency stakeholders early-on and throughout project development
- ☐ Making major changes without consulting agency stakeholders
- ☐ Not receiving support and authorization from land owners prior to project development
- ☐ Not including all infrastructure required during economic analysis
- ☐ Proposing unproven heat pump technology to the Renewable Energy Fund – New technology falls outside of the scope of the REF.
- ☐ Not purchasing a product with OEM/warranty support.