Identifying and Analyzing Opportunities for Expansion and Optimization in Solar Salt Works

Salt Production

Keywords: systematic, model, production, evaluation, expansion, optimization

Abstract

Salt producers around the world desire to optimize production and increase yields, yet find it challenging to identify opportunities for expansion, determine upgrades appropriate for their facility, and ascertain economic viability. In this paper, a systematic and comprehensive approach is set forth to identify and analyze opportunities for growth by applying to salt production the same best engineering practices that are used in other industries.

The first step in identifying opportunities is obtaining a good understanding of the site. This paper discusses critical baseline data required, such as pond area, salinity, weather, and seepage, as well as methods for obtaining missing data. It describes how the baseline data can be used to develop a model of the pond system and determine theoretical yield.

Using a pond production model to compare actual yields to theoretical yields can help pinpoint areas for growth and optimization. Examples of such areas include reducing seepage, mitigating impacts from rainfall, and utilizing additional areas for concentrating ponds. This paper provides and discusses systematic approaches to identify these and other areas and provides examples of mitigation methods.

This paper describes how a potential increase to production is calculated and how it is used as the basis for analyzing each opportunity. Methods to develop a budgetary cost estimate for implementing each prospective project are identified. Various evaluation tools are discussed, as are methods for performing a simple cost-benefit analysis for each option to determine its potential return on investment. It describes how the internal rate of return is a good metric for comparing prospective projects since it reflects a rate of return based on the time over which costs were incurred and returns were realized. Other factors are also presented for consideration as part of a comprehensive evaluation, including physical and financial constraints, technical limitations, and impacts between other opportunities. This information enables decisions to be made based on a comprehensive range of long-term factors rather than only on up-front costs or near-term benefits.

Based on the determinations of the evaluation, this paper describes the basis for determining the next step in the project evaluation and development process. This includes detailed feasibility studies, preliminary design, field trials, or execution.

Introduction

A common worldwide practice at industrial facilities is optimization or expansion of production to increase profit. This practice is applied via different methods across industries including the production of solar salt. Salt producers around the world desire to optimize production and increase yields, yet find it challenging to identify opportunities for expansion, determine upgrades appropriate for their facility, and ascertain economic viability.

As industries have developed, especially those with higher value products such as oil, natural gas, and chemicals, a common approach has emerged and been generally standardized to control risk and make stepwise decisions based on specified criteria. Although variances occur between industries, companies, and even projects, this engineering method has proven effective as facilities seek to increase yields and profit, and has become an expectation for world-class operations.

Benjamin S Blanchard defined engineering as “the systematic application of physical and natural resources combined in such a manner as to create, develop, manufacture, and support a product or a process which economically provides some form of utility to man.” In general, the engineering method requires setting aside the impulse driven decision making that businesses often succumb to and instead make a series of stepwise fact based decisions. As shown in Figure 1 this method entails obtaining reliable and pertinent information, identifying opportunities, evaluating opportunities through feasibility and design, and only then implementing the project to achieve demonstrable benefits.

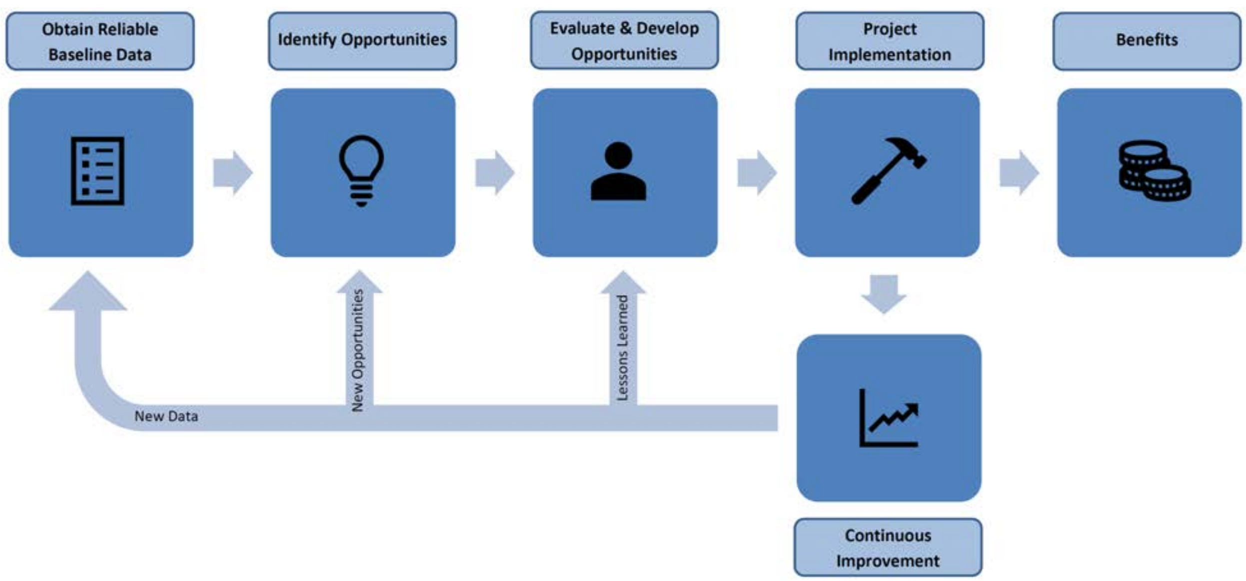

Figure 1. The Engineering Method

The use of this method ensures that the project moves in the correct direction while allowing the project team to alter course, or stop it altogether, without the point-of-no-return financial or personal investment that often accompanies less systematic approaches. The engineering method also optimizes the probability that the final design and implementation have the best chance for success and that costly changes are avoided.

In order to successfully execute the engineering method, it is important that the project team have personnel experienced in the technical aspects of the project an in applying the engineering method. Critical to the team are the Project Manager who manages the scope, schedule, and budget of the project and the Project Engineer who manages the technical aspects of the project. These two work together to balance the often-contrasting goals of the technical and financial aspects of the project. Depending on the size, structure, and complexity of the project these individuals may be a facility employee, corporate employee, or outside consultant. Other team members include engineers, designers, key stakeholders, administrative staff, consultants, and subject matter experts.

The engineering method being presented here is a *practical* approach using proven *principles*. The systematic approach need not result in an overwhelming bureaucracy. Although this approach requires discipline and it may feel unfamiliar, a balance should be maintained between the rigor required by this method and the benefit it provides. The perspective of where this balance lies is obtained via years of experience, but it usually depends on the facility, the project return on investment (ROI), and the total capital cost for the project.

Obtain Reliable Baseline Data

Reliable is defined as “consistently good in quality or performance; able to be trusted.” Baseline data in this context signifies the data required to make necessary project decisions. This baseline data includes General Baseline Data and Project Specific Data which are defined below. Due to missing historical data and/or budget and schedule restraints, it is not always possible to obtain the ideal data set. Additionally, the reliability of the data may be suspect. It is the role of the Project Engineer and Project Manager to determine the risk involved in proceeding with incomplete data and ultimately whether to put all work on hold until that data is obtained. They must define the minimum required data noting that it is likely that these requirements will increase with each successive step in the engineering process.

Without ideal data, an experienced engineer, working closely with operations, will often be capable of making educated guesses and assumptions. These assumptions should be based on written historical data, even if not perfectly applicable or complete, rather than purely anecdotal experience. Judgement is required and the scale of the potential error and its impact on project decisions should be carefully considered.

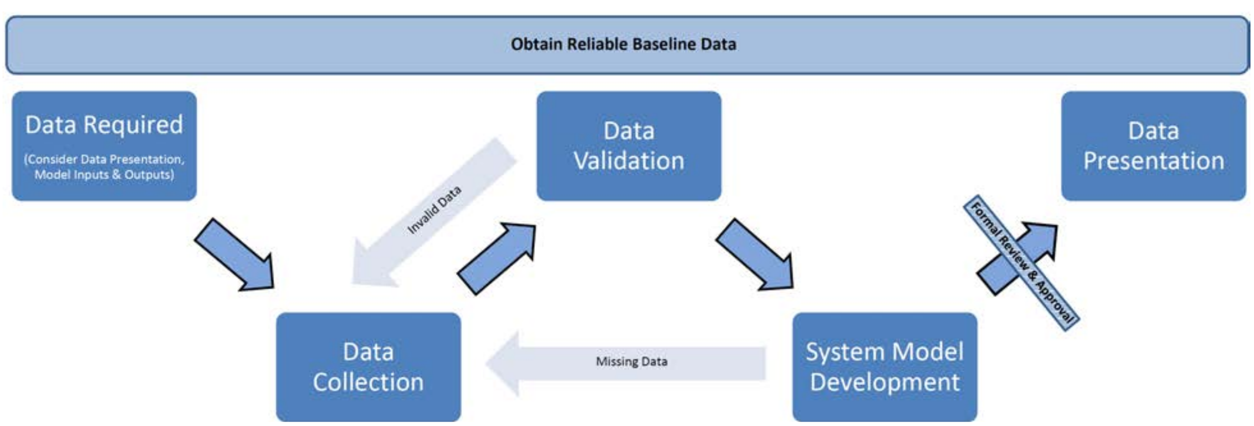

Figure 2. Detailed Workflow: Obtain Reliable Baseline Data

In practice, the process in Figure 2 is cyclical; first during the baseline data collection phase, and then later during other phases—especially the evaluation and identification of opportunities. It is the role of the project engineer to foresee data needs and minimize these data collection cycles.

Data Required

Once the project is clearly defined a set of required and desired data should become apparent. For solar salt works several categories of data exist, each with more specific sub-sets: General Site Conditions, Weather, Seepage, Pond Size & Layout, Operating Parameters (ponds, wash plant, harvesting and stockpiles), and Production Data. This data should include quantitative (numbers) and qualitative (written descriptions of conditions and procedures) data for each.

In addition to the above data, other project specific data will be required such as: financial data, maintenance and purchase records, relevant market, political, legal, and environmental data, or equipment and construction cost estimates.

Data Collection

The same rigors of scientific data gathering used across industries and disciplines also apply to solar salt operations. From observed experience a few principles are worth brief discussion.

First, ensure that data collected, especially over long periods of time, is measured in a consistent and uniform manner. Consistency can help identify suspect data in the future. This will require written procedures, personnel training and management rigor.

Second, as this data will often be used for significant extrapolation, ensure a high degree of accuracy, greater than one would need for day-to-day operations.

Finally, record all data in a legible, consistent, and usable format.

Data Validation

Through traditional analysis the collected data can be validated and any suspect data can be addressed. During validation historical data should be examined for trends, and seasonal variations should be accounted for. Totaling data can provide insight into accuracy, as can comparing gathered data against other sources (such as nearby publicly available evaporation and rainfall). Ultimately all data should go through a “gut check” to see if it conforms with experience and expected results.

System Model Development

The validated data is used to create a working pond system model consisting of, at a minimum, a mass balance of Sodium Chloride and water at each concentrating pond. This model will prove useful in almost all expansion and optimization projects, but as with all data should be validated prior to use.

The complexity of such a model can be limitless, and creating one can be overwhelming. By definition all models contain assumptions, so begin by making system simplifying assumptions that still maintain an acceptable level of accuracy. A time step of one year is a good start. As project data needs, and even operability needs, emerge a more complex model will be required. Consultants can prove very useful in creating this model as they have experience with the pitfalls and benefits of model complexities. Consultants often have a working model that can be adjusted for specific sites and needs, and thus can more easily create the original model, validate it, or upgrade it.

The basic model should output a site-based (but not pond management-based) production yield, possibly the most important single number when determining project scopes and feasibility. Further models may allow the creation of a yield curve based on yearly or seasonal rainfall.

While a functional pond system model is a major output of the baseline data gathering and validation steps, it is important to define the desired model outputs and inputs before beginning the data gathering steps so as to ensure that resources are well allocated towards obtaining the correct data in a timely manner.

Data Presentation

Once data has been obtained and validated, care should be taken to format it into documents that will be useful for the project and for unrelated projects in the future. While formatting may be useful to some extent during the gathering and validation steps, a formal review and approval of all data should occur before moving to this step.

Four types of documents are especially useful for both baseline and project data: Site Conditions, Facility Description, Layout Drawings, and Process Drawings and Descriptions.

Site Conditions consists of fundamental characteristics at a facility level such as yearly evaporation, yearly rainfall, and intake salinity (in a project sense a similar document would be referred to as a “Basis of Design”). The Facility Description would consist of a written description of the entire facility and its operation. This would include things such as product characteristics, throughputs, and operating philosophies. The Layout Drawings would detail the physical location of all properties, ponds, facilities, and equipment (such as a plot plan). Finally, the Process Drawings and Descriptions would contain things such as a Process Flow Diagrams, process descriptions, control philosophies, etc. They would represent how the process works and how flows are regulated. Together these documents should represent the fundamental aspects of the facility.

Remember that these are global documents and as such should contain only key data presented for a broad audience—usually an audience that understands basic solar salt concepts but has never worked at the site. Additional data would be maintained separately either as engineering data, equipment files, maintenance records, historical records, or project specific data.

Once created, these documents should be distributed appropriately with ongoing revision control, and be filed in a central (usually electronic) location.

Identify Opportunities

While not all projects suggested will be technically and economically viable, initially a large range of project opportunities should be considered. Often these opportunities will appear instead as problems or long-discussed improvements, but other times they will be less obvious. During this phase it is especially important to receive input from all sources, including but not limited to: operations, maintenance, management, engineering, outside consultants, and previous reports and projects.

Experience at salt works around the world indicates several areas to focus on when generating a list of project opportunities. In order of most common and highest potential impacts they are: pond management, rainwater mitigation, seepage, and utilization of unused land.

After input is received, obviously unrealistic opportunities should be discarded, but take care to not discount an opportunity due to factors such as cost. All identified opportunities should be precisely defined.

Evaluate and Develop Opportunities

Stepwise evaluation and design using the engineering method allows investment to be controlled and provides the best chance of project success. As development proceeds, factors are considered for each step in increasing detail and decreasing range.

It is important to recognize the specific challenges and advantages of each opportunity individually since it is possible to expand or simplify the steps outlined in Figure 3. However, these steps should never be skipped altogether.

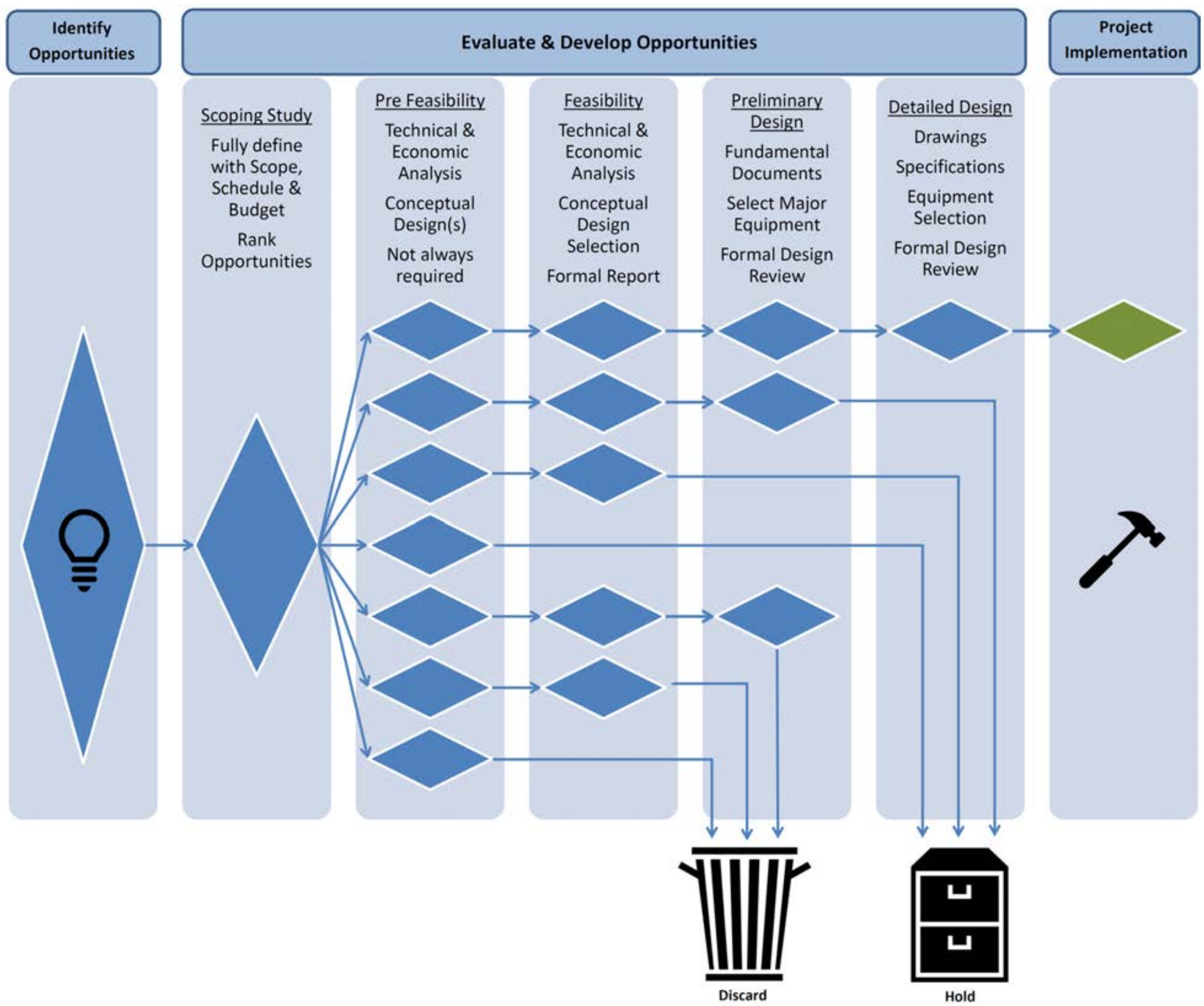

Figure 3. Detailed Workflow: Evaluate & Develop Opportunities

It may be necessary to recirculate through the different steps as different options are analyzed, starting over if one design option doesn't appear feasible or even returning to a different opportunity altogether. Experience will provide insight as to how much time and effort should be put into each step, but a good general rule of thumb is 1% of the project total installed cost should be spent in the feasibility step(s) and 10% in the design step(s). Regardless of how strictly the engineering method is followed, a scope, schedule, and budget should be defined for each step so as to not invest too much or too little into a given opportunity.

Evaluation Principles

While all factors should be considered during opportunity development, the most applicable factors will vary across projects. Additionally, the importance of certain factors will change as the opportunity is developed.

Common factors to consider include financial, environmental, social, production impact, physical restraints, risk and probability of success, technical limitations, and interactions between projects. Compiling information on all of these factors enables decisions to be based on a comprehensive range of long term factors rather than the more obvious but possibly less important factors such as upfront costs or near term benefits.

Financial factors for projects too large or too different from facility personnel experience may be challenging to determine. Good resources include construction contractors and outside consultants. Equipment vendors can also be a good resource, but remember the adage that "to a hammer, every problem looks like a nail, even when it's a screw." Once the cost and projected benefit are determined, they can be used to calculate the return on investment (ROI) or even more appropriate for a specific project, the internal rate of return (IRR).

For optimization and expansion projects the benefit can also be calculated in in terms of increased tonnage. A key tool is the system pond model discussed previously. Useful insights and project opportunities can be gained by comparing the theoretical production model against actual results at each pond and production step.

However these simplifications can be misleading and more complex methods to determine benefit may be appropriate.

Scoping Study

Typically all projects not already identified as unrealistic are considered as part of a scoping study. Simplistically this is where identified opportunities are ranked based on the evaluation tools discussed and determinations made as to which opportunity or synergistic group of opportunities should be developed as an individual project.

Feasibility Study

The first step of the project is to determine feasibility. The ultimate goal of the feasibility step is to determine whether the project is technically and economically feasible, or viable, before investing significant time and funds to design and engineering. Often to determine feasibility two to three conceptual designs are identified and all factors of each are considered. Depending on the size of the project this may warrant a pre-feasibility study be used to consider trade-offs between options followed by the full feasibility study of the selected option.

A formal report, the writing of which encourages the consideration of things that may have been missed, should address all factors discussed above and make the case for whether the project is feasible or not, and under what conditions.

Preliminary Design

Preliminary design consists of generating the fundamental documents that define the process as well as the selection of any major pieces of equipment. This step provides necessary feedback as to the feasibility of the project and may require cycling back to other options. The preliminary design should undergo a formal design review by all stakeholders before the detailed design begins so that their feedback can be considered for detailed design. Blanchard describes this review as "a coordinated activity…directed to satisfy the interests of [all stakeholders]" with the purpose to "formally and logically cover the proposed design from the total system standpoint … through a combined integrated review effort…[that] causes a reduction in the producer's risk…and often results in improvement of the producer's methods of operation."

This step may also include field trials especially when the baseline data is suspect or incomplete. If field trials are utilized care should be taken to ensure conditions are similar to the design under consideration and to avoid common scale-up concerns.

Detailed Design

The focus of the detailed design is to build the project on paper before it is built in real life. By so doing errors can be found, and corrected, more cost effectively. Drawings, specifications, and related documents should be produced and equipment selected in sufficient detail that it could be used by a contractor to be built, even if the construction will be performed by facility personnel. This ensures that communication between designers, engineers, and construction personnel is clearly understood. The detailed design step should always include a formal design review.

Project Implementation

This is the phase with which operating facilities often have the most experience. By using the stepwise phases above, even project implementation will be further improved. Once the project implementation phase is complete the project is still not finished: lessons learned should be incorporated into future projects, and continuous improvement pursued, both in design and operation. This is also the phase where the benefits of using the engineering method will begin to present themselves, often in terms of increased production, profit, efficiency, and team morale.

Conclusion

Although the engineering process used in other industries is more complex than the approach used traditionally by solar salt works, it is intuitive and simple at its core: gather and validate information into a usable format, identify and evaluate the feasibility of opportunities, and then perform engineering and design prior to implementing the project.

It is important for all levels of management to understand these principles from the onset, to understand the ultimate benefits both to cost and schedule of this stepwise approach, and commit to spending the time upfront analyzing instead of building. The engineering process requires discipline so as to not to make critical decisions without sufficient information or evaluation, and requires continuous motivation to keep project opportunities moving forward. This more systematic approach will result in cost savings when infeasible projects are cut off before being implemented, and when feasible projects are designed in a more cost effective way.

At REDD Engineering & Construction, Inc., we have found this to be the most effective and most successful way to execute any project and are confident you will find the same benefits.

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