ESTABLISHING A FAIR PRICE FOR STEAM FROM A RESOURCE RECOVERY FACILITY

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ABSTRACT

The economic feasibility of resource recovery projects depends largely on the amount of revenue that can be obtained from the recovered energy products. The revenue that can be obtained from steam is dependent on the type of steam market available. The type of steam market in turn affects the design of the resource recovery facility and its capital cost. This paper discusses how the proposed steam use affects the design of the facility and how the revenues from the sale of steam can be optimized to obtain a minimum tipping fee for the processing and disposal of the solid wastes.

INTRODUCTION

The basic economics of resource recovery are simple. In order for a resource recovery project to be financially feasible, the project must generate sufficient revenues to cover all costs associated with the project. If the project involves the use of private funds, it must generate a return on the investment or a profit as well.

There are two types of costs associated with a resource recovery project. The first type are the capital costs; these are costs incurred to create the facility before it is operational and producing revenues. The second type are the operating costs; these are costs incurred during the useful life of the facility in order to keep it in operation. Generally, the capital costs are distributed over the useful life of the facility by borrowing the capital funds and paying debt service during the project life.

There are also two sources of revenue for a resource recovery project. The first source is the disposal charge or tipping fee paid by the municipalities or private collectors who use the facility to dispose of their wastes. The second source is the revenue obtained from the sale of recovered energy and materials.

In order for a project to be financially feasible, the projected tipping fees, obtained by subtracting the potential revenues from the estimated total costs including capital charges, must be less than the costs of any available alternate method of disposing of solid wastes. Thus the municipality or other agency sponsoring the resource recovery project is vitally interested in maximizing the potential revenues from the sale of the recovered energy and materials in order to minimize the tipping fee. The anticipated energy revenues generally hold the key to the financial feasibility of a proposed project.

In this paper, we will assume a resource recovery facility that processes solid wastes by means of incineration and produces as its major product steam for sale to a district heating system or to an industrial user. The specifics of the process used to produce steam or of the size and location of the facility are not relevant to this discussion. The discussion will consider how the requirements of the steam user can affect the costs of the resource recovery facility, and how the resource recovery system operator and the potential steam customer...
can arrive at an agreement on the price of and conditions for delivering steam that will yield maximum benefits to both parties.

**ECONOMICS OF RESOURCE RECOVERY**

Resource recovery plants are capital intensive facilities. This means that the annual charges resulting from the initial outlays of capital used to create the facility constitute a major portion of the total annual costs. These obligations remain essentially fixed over the life of the project and must be met regardless of the amount of solid waste processed at the plant. It follows that the unit costs for processing solid waste (the tipping fee) will be minimized if sufficient waste material is available to operate the facility at or near the maximum possible throughput rate, which is the design capacity. One means by which the resource recovery system operator attempts to ensure sufficient revenue is to have “put-or-pay” contracts for the supply of solid waste, so that the tipping fee revenue is assured even if the actual deliveries are less than the minimum required to meet the fixed costs.

The problem of the minimum assured revenue also applies to the sale of steam. If the revenue from the sale of steam is to be considered available to meet debt service, contracts for the sale of steam must have been executed at the time the project financing is finalized. These contracts must also contain “take-or-pay” clauses, that is, the steam customer must obligate himself to take the steam whenever it is produced at the resource recovery facility. Frequently, for a potential steam customer to agree to a take-or-pay contract, he will insist that the resource recovery operator commit himself also to a minimum rate of steam delivery, regardless of whether he has solid wastes to burn or not.

This is an aspect of the minimum rate of solid waste processing that is often overlooked in the economic analysis. If there is an interruption or a shortfall in the deliveries of solid waste, the loss is not confined to the loss of the tipping fee revenue, but there will also be a corresponding shortfall in the revenue from the sale of the recovered energy products. In addition, the resource recovery system may be forced to burn fossil fuel just to meet its obligations under its energy contracts.

There is therefore a direct relationship between the tipping fee and the contractual arrangements for supplying solid waste to the resource recovery facility and marketing the recovered resources. If the committed or available tonnage of solid waste is less than the tonnage the recovery system can handle, the tipping fee must be raised to insure sufficient revenues to cover costs. If the commitment to purchase the energy products does not cover all of the energy available when it is produced, the assured revenues from energy sales will be less than the maximum potential revenues and the tipping fee must increase to cover the lost revenue.

This creates a hierarchy of users for the recovered energy. The most desirable steam customer is one who can commit himself to purchase all the steam the resource recovery plant can produce and at the same time does not require any minimum delivery or impose a penalty when no steam is produced. While this type of customer normally will pay only for steam at the fuel replacement cost, the fact that he is willing to pay for all steam produced whenever it is produced and requires the least capital investment at the resource recovery plant generally results in the lowest possible tipping fee.

Next in line are seasonal users of steam such as district heating systems. For these users, some other use may have to be found for the steam when they, the primary customer, don’t need it. Usually the only other use is to generate electricity. This requires the installation of turbine generators and electrical interconnections, with additional capital cost for the resource recovery facility.

Generally, the least desirable end use of the recovered energy is to generate electricity. This is true because the generation of electricity is a thermodynamically less efficient use of the energy (at least two-thirds of the energy is lost to the environment). Also, in many parts of the United States, although there is a continuous market for electric power, the price that can be obtained from selling to the utility grid is depressed by having to compete with the fuel costs of nuclear power plants.

**COSTS ASSOCIATED WITH STEAM PRODUCTION**

If steam is used only as a medium for dissipating the heat produced by the incineration of solid waste, it does not matter whether the steam production is efficient. All of the components of the steam system can then be designed for minimum cost. However, once the resource recovery facility
operator enters into a contractual relationship to sell steam, the steam system must be designed to fulfill the contractual obligations. The terms of the steam contract will then affect both the design and the cost of the resource recovery facility.

The terms that will affect the design and the cost of the facility include the relationship of the steam demand to steam production, the steam system reliability required by the potential steam customer, the steam quality requirements, and the feasibility of returning condensate after use of the steam. These factors are discussed in following paragraphs.

STEAM DEMANDS VS PRODUCTION

The most desirable steam customer for a resource recovery facility is one who can always take whatever steam the resource recovery facility can deliver, but who has enough steam generating capability so that he can supply all of his needs on his own. The proposed New York City project at the Brooklyn Navy Yard is of this type. Steam produced by the resource recovery plant would be delivered into Manhattan's downtown steam supply system. Although the plant may produce as much as 750,000 lb per hour (340,000 kg/h) of steam, the minimum demand of the Manhattan steam loop is 2,000,000 lb per hr (907,000 kg/h).

Another type of desirable steam customer is an industry that has a continuous use for process steam. Typical examples of this type of steam user are pulp and paper mills, pharmaceutical plants, breweries, food processors, and petrochemical plants. These plants have continuous requirements for large quantities of low pressure steam. Many of these plants are operating cogeneration systems, that is, they produce their steam requirements at higher than needed pressures and generate a portion of their electric power requirements with the steam they produce. They are also most affected by the rising costs of fossil fuel and are therefore prime candidates for long term steam contracts which would stabilize their energy costs.

STEAM QUALITY

Boilers used with incinerators can be designed to produce steam at pressure/temperature conditions of up to 900 psi (6.2 MPa) and 1,050 F (565 C). However, at temperatures exceeding 800 F (425 C), the superheater tubes are subject to rapid corrosion, and current practice seems to be design the boiler for conditions not exceeding 600 psi (4.14 MPa) and 750 F (400 C).

Steamp users seldom require high pressure steam. If the steam is used for industrial process or district heating, 150 psi (1.03 MPa) is usually sufficient. Some industries make use of the thermodynamic efficiency of cogeneration to produce steam at higher temperature/pressure conditions than required for process purposes, generate electricity from the pressure differential, and then use the steam as it leaves the turbine in their process.

This type of potential steam customer presents several options for the design of the resource recovery facility. One option is to offer to supply steam at the turbine inlet pressure and let the customer continue to operate his turbines in the cogeneration mode. A second option would be for the resource recovery facility to install its own turbines, and supply the user with steam for his process requirements only.

The economic analysis of these options can become quite complex. Additional capital investments are required if the resource recovery facility must include electric generating facilities. On the other hand, the potential users electric generating facilities may be old and inefficient, and new turbines and generators may be able to make more efficient use of the steam produced.

For example, a backpressure or an extraction turbine can generate about 25 kWh from every 1,000 lb (450 kg) of steam produced at 600 psi (4.14 MPa) and 750 F (400 C) and delivered to the user at 150 psi (1.03 MPa) and 360 F (182 C). Sold to the utility grid, this electricity might be worth at bulk rates, about $0.03 per kWh or $0.75 per 1,000 lb (450 kg) of steam produced. However, if the resource recovery plant has to purchase electricity at retail rates, it might be worth as much as $0.08/kWh or $2.00/1000 lb (450 kg) of steam produced. What premium the steam customer might be willing to pay for the higher pressure steam depends on his own steam system requirements.

On the other hand, the cost of the turbines and generators must be offset against the potential additional revenues from the sale of electricity, or the potential savings from not having to purchase outside electric power. Here again the question of reliability must be considered, since the charges by utilities for stand-by electric service are a significant portion of the electric bill.
STEAM SYSTEM RELIABILITY

The degree of steam system reliability desired by the user can affect the design and the cost of the resource recovery facility. Several levels of reliability can be provided, but there must be early agreement between the resource recovery system operator and the steam users as to the level of service to be provided.

At the minimum level, the resource recovery system sells steam on an “as available” basis, with no minimum guarantees by either side. This type of arrangement will be suitable when the user has his own steam production facilities and his requirements always exceed the output of the resource recovery plant. The user continues to operate his boilers. The only tangible benefit to the user is a savings in fuel. The price for the steam will generally be pegged to the price of fuel oil, with some sharing of the benefits between system operator and steam user.

At the next level, the resource recovery system agrees to meet certain minimum steam delivery rates, regardless of availability of solid waste. This would entail installation of fossil fuel burners in at least one of the furnaces or provision of a separate fossil fuel fired boiler. Under this arrangement, the resource recovery system incurs some additional costs to insure the reliability of the steam supply, and the user does not have to continue to operate his boilers, thus saving labor and potential replacement costs. The price for steam would tend to reflect these costs and benefits.

One method of insuring greater reliability is to provide additional lines of process equipment. Thus the reliability of steam from a 1200 ton/day (1,090 t/d) plant consisting of two 600 ton/day (545 t/d) lines is not as great as if the plant consisted of three 400 ton/day (360 t/d) lines. However, the capital costs of a three line plant are greater than those of a two line plant for the same capacity, so that the incremental costs have to be evaluated against the potentially greater revenues from a three-line plant.

CONDENSATE RETURN

In a power plant, steam is condensed in the turbine and the condensate returned to the boiler. Similarly, in industrial processes, steam is often condensed as part of the process and the condensate recycled. District heating systems may or may not provide for the return of condensate.

If the proposed use of the steam is such that the condensate can be recovered, it is usually economically desirable to return it to the resource recovery facility in spite of the need for additional pumps and piping. If the boiler feedwater consists of 100 percent makeup, the cost of chemical treatment is increased. There is also a thermal loss represented by the difference in the temperature of the condensate and the feedwater supply. If condensate is returned at 200 F (93 C) and the makeup supply is at 60 F (16 C), the energy required for heating the feedwater can be as much as 10-25 percent of the energy available for sale.

If condensate return is part of the system, the steam contract must specify both how much condensate is expected to be returned and at what temperature, and must provide a formula for adjusting the steam price if the thermal value of the condensate differs from the value specified.

VALUE OF STEAM TO CUSTOMER

The price that a potential steam customer is willing to pay is a function of his current costs of producing steam, his estimates of the future cost of steam, and his conception of the risks associated with becoming dependent on the resource recovery facility as a source of steam.

Many steam users do not keep detailed records of what it costs to produce steam. This is particularly true of industries that use steam to generate a portion of their electric power and for process purposes. Industries do have depreciation accounts, but these are seldom broken down so that the depreciation applicable to a specific function can be determined. Similarly, operating and maintenance costs applicable to steam production are seldom segregated from the general operating and maintenance costs. The only cost element that can usually be identified is the cost of fuel.

If there is generation of electricity with the production of steam, the costs applicable to the power plant as a whole must be further allocated to electricity and steam. One method of allocation described in a study prepared for the Office of Solid Waste, Region I, U.S.E.P.A. [1] consists of determining what percentage of the total energy delivered by the boiler is contained in the exported steam and what percentage is applied to electricity production. An alternative approach is to estimate what the electricity bill would have been without cogeneration and to deduct the savings in electricity costs from the total power plant costs to
arrive at the steam costs. Another alternative is to develop hypothetical boiler system performance data and calculate the costs of a system that would only supply steam. Regardless of the method used, it is evident that some arbitrary judgement cannot be avoided.

Whatever estimates of the current costs of steam production may turn out to be, the real value of the steam to a potential customer is what he perceives his future steam costs to be. This involves not only his estimate of the future cost of fuel, but also his estimate of his future steam needs and the ability of his facilities to meet those needs. If these facilities are fairly new and are operating satisfactorily, the only benefits from purchasing steam are the savings in fuel costs. If, however, the facilities are old and in need of early replacement, there may be much more of an inducement to enter into a steam purchase contract. Also, the public relations and environmental regulation aspects may be significant inducement to become involved in a resource recovery project.

A major attraction of purchasing steam from a resource recovery system under a long-term contract is that it offers protection against further escalation in fossil fuel costs. Since a large proportion of the costs of resource recovery are fixed costs, these are not subject to escalation. Thus the increases of the steam unit price should not only be less than the increases of fuel costs, but should even be less than the increases in the Consumer Price Index. One recent proposal suggests an escalation factor based on 50 percent of the increase in the Consumer Price Index. Another proposal pegs escalation at 90 percent of the Consumer Price Index for the labor component of the operating costs only.

With No. 6 fuel oil currently being quoted at $28-30 per bbl ($0.67-0.71/gal or $0.176-$0.189/1), the fuel replacement value of steam, based on an 85 percent boiler efficiency, is $5.34/million Btu (or 1000 lb) ($5.06/GJ). This figure does not include any operating costs other than fuel or any capital charges, all of which are highly variable and dependent on local conditions. Assuming further that it is possible to produce 5000 lbs of steam (2270 kg) from every ton of solid waste, the potential value of the steam is $26.70/ton ($29.43/t) of waste processed.

**CONTRACTUAL PROVISIONS**

**LENGTH OF CONTRACT TERM**

Resource recovery plants are generally financed by the issuance of revenue bonds. The number of years over which the bonds are amortized determines the annual debt service charges and therefore the unit costs. Ideally, the terms of the contract for the sale of steam should be concurrent with the term of the bonds issued to finance construction of the project.

If the steam customer does not want to commit himself over the full term of the bonds, provision has to be made for other revenues in case the steam contract is not renewed at expiration. This could take the form of a reserve fund to finance construction of additional facilities to make beneficial use of the steam.

**ESCALATION**

Provision should be made in the steam contract for automatic annual modification of the unit price in accordance with changes in the general price levels.

One method is to tie the price of the steam directly to the price of the fuel replaced, that is No. 6 fuel oil, or some other published cost index for fossil fuel. Under that formula the price of steam will be set at a fixed percentage of the price of a certain type of fuel oil on an equivalent Btu basis. This method has the advantage of simplicity. It also shifts the risks and the potential benefits of any future increases in fossil fuel costs from the user to the resource recovery facility operator. As far as the user is concerned, it assures him a saving of a certain percentage of his fuel bill at a minimum risk.

A second method relates the unit price to the cost of producing steam. One study attempts to identify separate escalation factors for each cost element, that is, labor, industrial equipment, fuel oil, natural gas, boiler water chemicals, and local water rates. This does not seem to be worth the effort. Certain cost elements such as debt service (or depreciation) are fixed at the time the facility is built and do not increase throughout the life of the project. Other costs such as labor and utilities do vary over the life of the project. It is believed that a single escalation factor, such as the Consumer Price Index, applied only to the variable portion of the operating costs of the facility, is a reasonable approach to accounting for inflation.

The use of such a factor to escalate the unit price for steam will have the effect of shifting some of the risk and some of the benefits of future
fuel price increases from the system operator to the steam user. If energy costs continue to escalate at a higher rate than the general price levels, the purchaser of the steam would receive the benefits of having an energy source with a relatively stable cost. This could be a significant inducement to an industry to sign a long term contract with a resource recovery facility operator.

**QUANTITY DISCOUNT**

Some pricing formulas for energy products contain a quantity discount. The customer commits himself to buy a certain number of units at a certain price. If actual purchases exceed a specified minimum, the unit price is reduced. This concept is valid only to the extent that the resource recovery facility has access to a sufficient quantity of solid waste and sufficient capacity to deliver more than the minimum contracted amount. There is no point in encouraging additional steam purchases if either the plant is unable to obtain the additional solid waste, or is already operating at full capacity.

From the customer's point of view, his steam requirements are generally fixed by production schedules and ambient temperatures. They are not likely to be subject to control, or affected by, the promise of reduced rates for increased consumption. Therefore, nothing is gained by introducing quantity discounts. However, if the customer proposes a major change in steam usage, the unit price can be renegotiated to reflect the new conditions.

**SUMMARY AND CONCLUSIONS**

In a resource recovery facility, the cost of producing steam can never be entirely separated from the cost of solid waste disposal. It is in the interest of the system operator to obtain as much net revenue as possible from the sale of steam. The interest of the steam customer is to have his energy requirements met at the lowest possible cost. The contract between the system operator and the steam user must reflect both of these interests.

The most significant part of the steam contract is the unit price, expressed in terms of the amount of steam delivered at a certain point and under specified service conditions. The price itself is a function of the conditions of service. Steam at higher pressures will be priced higher than low pressure steam. Steam delivered on demand will be more expensive than steam delivered when available. A guaranteed steam supply is more valuable than a steam supply that is interrupted when the resource recovery plant is not in operation.

For the system operator, a minimum charge is a highly desirable provision. A steam contract covering the same period as the life of the bonds and committing the steam customer to accept a minimum amount of steam each month is ideal from the system operator's point of view. If the customer is willing and able to make this type of commitment, the system operator is likely to agree to a minimum unit price. If the steam customer attaches conditions to his acceptance of steam, the price will rise, not only because the conditions of delivery are likely to involve additional costs for the systems operator, but also because the amount of steam sold will be less.

The unit price can be made subject to adjustments for failure of either party to meet the conditions of the contract. Typical items that may be causes for adjustments to the basic unit price are failure to supply steam within specified pressure and temperature limits and failure on the part of the user to return condensate.

The unit price would also be subject to escalation in accordance with an agreed-upon formula. The escalation formula should be kept simple and should take into account that the portion of the steam production cost which is due to capital charges does not change during the term of the bonds used to finance the project construction. The value of the steam to the user, however, will continue to escalate with the increase in energy costs.

The term of the contract for steam sales should ideally be equal to the term of the bonds. If it is shorter, provision must be made for a reserve fund representing the unamortized value of the steam production facilities at the end of the contract term.

The provisions of the steam purchase contract will affect both the design and the cost of the resource recovery facility. Agreement on the major provisions of this contract must be reached before the design and financing of the facility are finalized. A suitable steam market served by a mutually beneficial contract for steam can be a major factor to reduce tipping fees and establish the economic feasibility of resource recovery.
REFERENCE

Key Words
Boiler
Burning
Combustion
Contract
Economics
Market
Planning