

A COMMODITY MARKET FRAMEWORK FOR MATERIAL RECYCLING

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ABSTRACT

Successful market penetration of Department of Energy recycled decontaminated radioactive material depends on two key factors: (1) the market exchange that manages the sale and purchase of the material, and (2) the selling price the material. A national framework is proposed that effectively supports the sale and purchase of such material. An easily implemented approach is presented that can be used for efficient market pricing of decontaminated radioactive material at a best value for the taxpayers.

INTRODUCTION

The Department of Energy (DOE) has hundreds of contaminated surplus facilities that await deactivation and decommissioning in the next 25 years. Each facility contains a diverse and a large quantity of material that will either be disposed or recycled. If the material is disposed, the destination is a disposal or burial facility. If the material is recycled, it may be re-used within the DOE complex, or it may be unconditionally released to the open market. Examples include: (1) individual pieces of surplus equipment such as turbines, diffusers, or compressors; (2) building material such as transite or concrete; or, (3) metals such as nickel, copper, or iron.

There is a pressing need for a national framework that structures the environment in which sale and purchase of the recycled decontaminated radioactive material is accomplished. Furthermore, the material must be priced so that DOE can get the best value for the taxpayers when the material is sold within the DOE complex or on the open market.

The national framework must necessarily recognize that the successful sale of recycled decontaminated radioactive material implies some modification to commodity trades and pricing. Policy and guidelines for (1) risks associated with the material and (2) surveillance of market, trading, and financial activities must be implemented.

As a market driven exchange, one significant factor is the pricing mechanism for the decontaminated radioactive material. The material was, at one time, radioactively contaminated. It has been decontaminated to some standard and released for some future

use. The pricing by DOE must reflect the fact that buyers are able to purchase equivalent metals that never have been contaminated. If some residual contamination remains, restricting the manufacturing uses to which the DOE metals can be applied, the price may need to be adjusted downwards accordingly. Alternatively, the highest price the DOE metals with residual contamination will command in the market will contain a discount for the cost of further decontamination to bring the metals up to a quality acceptable for unrestricted use.

The price a buyer is willing to pay for decontaminated radioactive material is determined using a Bayesian approach to hedonic pricing. Hedonic pricing estimates the value of a multi-characteristic good (in this case, metals with residual components of either desirable or undesirable elements—good or bad alloys, in effect) by treating the traded good as a collection of characteristics (i.e., material constituents, environmental and health risks, and regulatory compliance attributes) the public would be willing to buy (Griliches, 1971 and Berndt, 1991). The statistical technique of multiple linear regression is employed to estimate the price based on these characteristics. Prices of individual characteristics (called hedonic prices) are represented by the coefficients of the regression equation. Bayesian updating of the price elasticities is employed to account for the fact that the decontaminated radioactive material market is dynamic, immature, and evolving (Raiffa and Schaliher, 1961; Kendall and Stuart, 1973; and Redus, 1994). Our pricing effort represents a first step in creating a pricing mechanism that will lead to pricing options and other derivative instruments for the sale and purchase of decontaminated radioactive material.

NATIONAL FRAMEWORK FOR IMPLEMENTATION OF A RECYCLED DECONTAMINATED RADIOACTIVE MATERIAL EXCHANGE

The national framework for implementation of a recycled decontaminated radioactive material exchange is presented in Figure 1. When coupled with our pricing approach, we can realistically account for rapid changes in the recycling market, in the technologies that are used for contaminated radioactive material disposition, and among competitors (for example, nuclear power plants) who will also supply radioactive material. The national framework is a dynamic strategy, and the goal of the strategy is adapted from the fundamentals of dynamic strategic planning (de Neufville, 1998).

DOE surplus facilities and the associated nuclear material are usually subjected to a fixed strategy and a “Master Plan” that is fundamentally inflexible to change. Unbridled optimism that decontaminated nuclear material “really will sell” is an equally dangerous shortcoming. Finally, when planning takes a life of its own in the implementation of a recycled decontaminated radioactive material exchange, resistance to change is the rule rather than the exception. These factors represent significant challenges in development and implementation of a framework that responds to changing market conditions.

The key elements of the national framework are:

- Assemble Stakeholders. Stakeholders include: Federal, State, and Tribal Nation

officials, congressional officials and staffers, prime contractors at DOE sites, public stakeholders, industry representatives, and potential buyers of recycled decontaminated radioactive material. A subset of these groups and individuals form the key decision-makers needed to implement a recycled decontaminated radioactive material exchange.

- Identify Factors Affecting Market Exchange Formation. DOE and site strategies and plans, regulatory constraints, and disposition alternatives of the radioactive material affect the structure and formation of the market exchange. Stakeholders provide the necessary perspective, lessons learned, and local networks to communicate, objectify, and structure these factors. Using this basis, a draft exchange approach is defined.
- Define Market Exchange Goals and Objectives. Stakeholders define the market exchange goals, objectives, schedules, budget requests, and the test market and its performance measures. This is accomplished by information obtained in the previous activities.
- Plan and Implement a Test Market. A test market exchange is planned and implemented at specific sites and for specific materials. Data requirements to support performance measures are defined and data collected. Access to the test market is either limited or unlimited depending on the scope of the test market.
- Collect and Evaluate Information. As part of the test market exchange implementation, pricing information, market costs, and lessons learned are collected and evaluated. This information is used for the pricing formation of the recycled decontaminated radioactive material.
- Make Market Refinements. Based on the results of the test market exchange, refinements are made, lessons learned are implemented. Using these results, the preferred recycled decontaminated radioactive material exchange is implemented.

The intent of this approach is to fully recognize that the recycled decontaminated radioactive material exchange will take time to develop, implement, and mature. This is not unreasonable considering that the Chicago Board of Exchange has existed since the mid-1800s, and improvements are still being made.

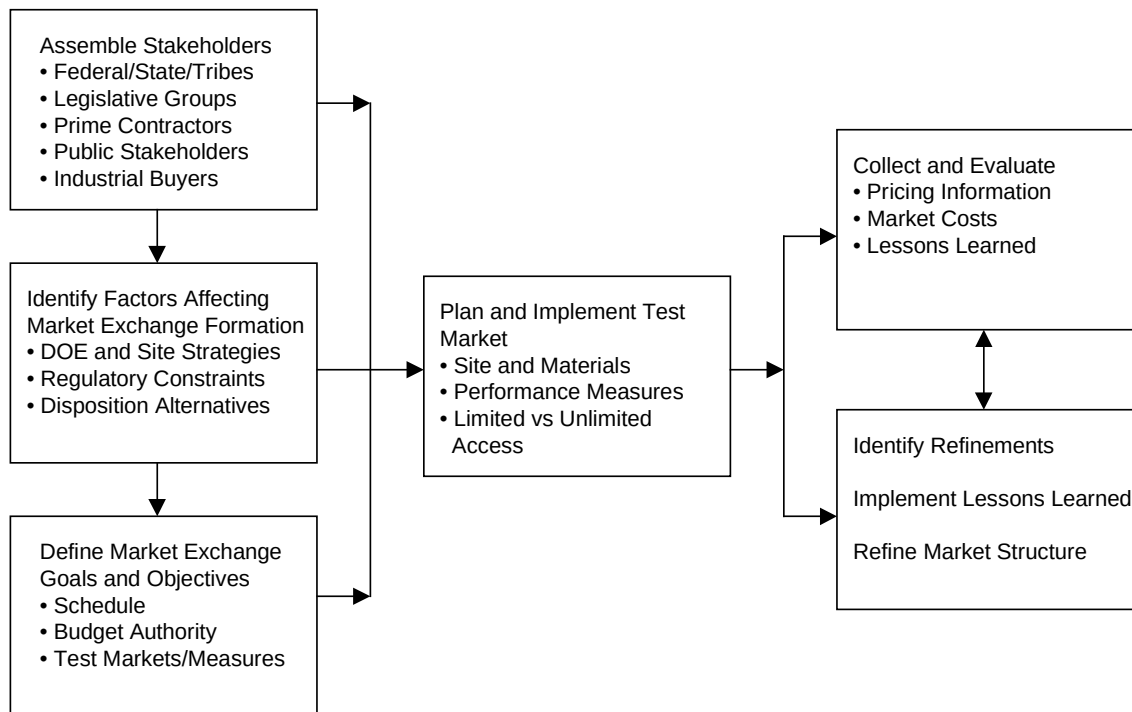


Fig. 1. National Framework for Implementation of
A Recycled Decontaminated Radioactive Material Exchange

A RECYCLED RADIOACTIVE MATERIALS COMMODITIES MARKET EXCHANGE

On the surface, it may seem that the form and structure of a recycled decontaminated radioactive material exchange must be different than that of a non-contaminated commodity exchange. This is not the case.

Success of the national framework depends, firstly, on the acceptance of the approach by the stakeholders, and secondly, on a cost-effective and socially beneficial implementation of a recycled decontaminated radioactive material exchange. Although stakeholder acceptance cannot be minimized, any exchange environment that buys and sells decontaminated radioactive material must adhere to the following operational principles:

- Protection of human health and the environment is consistently maintained by ensuring that any material that is offered for sale meets all applicable federal and state exposure and release requirements.
- Market surveillance is performed on all market participants, speculative and commercial participation is carefully analyzed, and the relationship between trading activity on the Exchange and fundamental factors in the cash market is examined.
- Financial surveillance, specially an audit capability, is performed to ensure that members continually meet all minimum capital requirements, monitoring margin collections and payments, and verifying both buyer and seller quality and capacity to

carry transactions.

- Trade Surveillance is accomplished during the physical buying and selling to ensure that accommodation trading (transactions creating the appearance of trading activity but which have no real economic effect); matching customer orders without offering them competitively, and prearranged trading are not performed.

Recall that a commodity is some physical substance, such as food, grains, and metals that is interchangeable with other products of the same type. Investors buy or sell, usually through futures contracts, the commodities. Any product that trades on a "commodity exchange" is considered a commodity. Assume that, at some point in the future, the material from contaminated surplus facilities are decontaminated and recycled. Thus, decontaminated and recycled radioactive material is a commodity.

A regulatory and market driven exchange will necessarily evolve to buy and sell recycled decontaminated radioactive materials. Coupled with the previously identified principles, five essential characteristics will be required in the exchange:

- Descriptive standards and terms must be established
- Quality must be accurately and consistently certified
- Uniform inspection, characterization, and weighing must be used
- Quality improvement incentives to both domestic and foreign buyers must be present
- Regulatory requirements must be enforced

We suggest that it is not inconceivable to imagine the recycled radioactive materials market exchange to follow almost an identical, albeit perhaps subsidized, pattern as non-radioactive commodities. There will certainly be national environmental and security regulations associated with the exchange. A social good should be considered since the materials are obtained from the nuclear weapons production complex.

Statutory requirements will be created, perhaps modeled after the Commodity Futures Trading Commission Act of 1974 in order to regulate the recycled radioactive materials futures industry. Futures contracts will evolve as sellers and buyers began to commit to future exchanges of the materials. Arbitrage (a simultaneous purchase and sale of identical or equivalent futures in order to benefit from discrepancies in price relationship) will occur.

Environmental issues such as: (1) estimates of potential sources and quantities of material available for recycling; (2) the potential normalized annual dose and normalized lifetime risk to the reasonably maximally exposed individual (RMEI) associated with the release of the material from the facilities; (3) the potential normalized collective dose and normalized collective risk to the exposed population associated with the release of the material; and, (4) surface and volumetric minimum detectable concentrations (MDC) of radionuclides must be determined.

The social and industrial acceptance of the materials must be well understood. It is not uncommon for citizen groups to harbor concerns and fears over the notion of recycling decontaminated radioactive materials into consumer products. National and foreign industries that acquire the materials must be assured that (1) risks to the health and safety of workers and the environment and (2) operating expenditures and potential losses are minimized.

THE APPROACH FOR COMPUTING THE PRICE OF RECYCLED DECONTAMINATED RADIOACTIVE MATERIAL

The mathematical approach we use to determine prices of recycled decontaminated radioactive material is hedonic pricing. Hedonic pricing consists of applying standard statistical multiple regression techniques to estimate a price function using test market data as implemented in the national strategy and information derived from subject matter experts, historical information, or recycle price models or simulations, Fig. 2.

The steps of the Bayesian updating using hedonic pricing are:

- Identify Pricing Variables for Nuclear Material. DOE and DOD experts, industry experts, and process knowledge are interviewed to determine the major pricing variables that would be applicable to creating a regression model for the price of recycled decontaminated radioactive material. The intent of this step is to use existing information to develop a pricing model that adequately reflects reality and is accepted by the user community.
- Screen Pricing Variables. Based upon the identification of the pricing variables, key drivers are identified, possible ranges of the decision variables defined, estimates of preliminary functional forms presented, and possible recycled decontaminated radioactive material disposition alternatives identified. The intent of this step is to structure the pricing modeling effort so data requirements for the test market can be defined.
- Obtain "Prior" Pricing Regression Function. The DOE and DOD experts, industry experts, and process knowledge experts are interviewed, in addition to using historical information and market penetration models, to estimate the coefficients and functional form of the price regression equation. This is often called collection of "prior" information. A price function for each type of recycled decontaminated radioactive material has the following form:

$$\text{Prior Price} = \text{Prior Constant} + \text{Prior Elasticity} * \text{Pricing Variable}$$

- Collect Market Information on Key Pricing Variables. Using DOE/DOD experience, industry sources, process testing and the test market, market information is collected.

This information is called “likelihood” information, and it is used to generate a new pricing equation of the following form:

$$\text{Likelihood Price} = \text{Likelihood Constant} + \text{Likelihood Elasticity} * \text{Pricing Variable}$$

- Combine Information Using Bayes Theorem. Bayes Theorem is used to update the elasticities and the functional form of the price equation. Furthermore, we generate confidence intervals for the elasticities. One of the weaknesses of hedonic pricing is that it requires large quantities of data to develop a meaningful regression equation. Since data is quite limited for pricing of the recycled decontaminated radioactive material, this step allows us to use all possible sources of information for realistic pricing. A pricing equation of the form is created:

$$\text{Updated Price} = \text{Updated Constant} + \text{Updated Elasticity} * \text{Pricing Variable}$$

- Compare Prices and Determine Optimal Pricing Structure. Once an updated price equation is determined, a direct comparison between the price of contaminated material and decontaminated material can be performed. Furthermore, a comparison between the elasticities of the pricing variables can be accomplished. This is extremely powerful. If elasticities are not significantly different from each other, the interpretation is that the pricing variable has no influence over the price of contaminated or decontaminated material. This also allows a clear identification of what drives the price of the recycled material, and it may indicate potential future technology or program requirements.
- Perform Sensitivities and Trade-Offs. Such actions are performed in conjunction with the preceding step. Elasticities are changed, or the functional form of the regression is changed, and the effects on price are examined to determine when indifference regions associated with the price function. Considering changes in regulatory requirements (such as allowable dose) is equivalent to defining a new operational exchange and pricing scenario; hence, trade-offs may be determined both between scenarios and between pricing variables within scenarios.

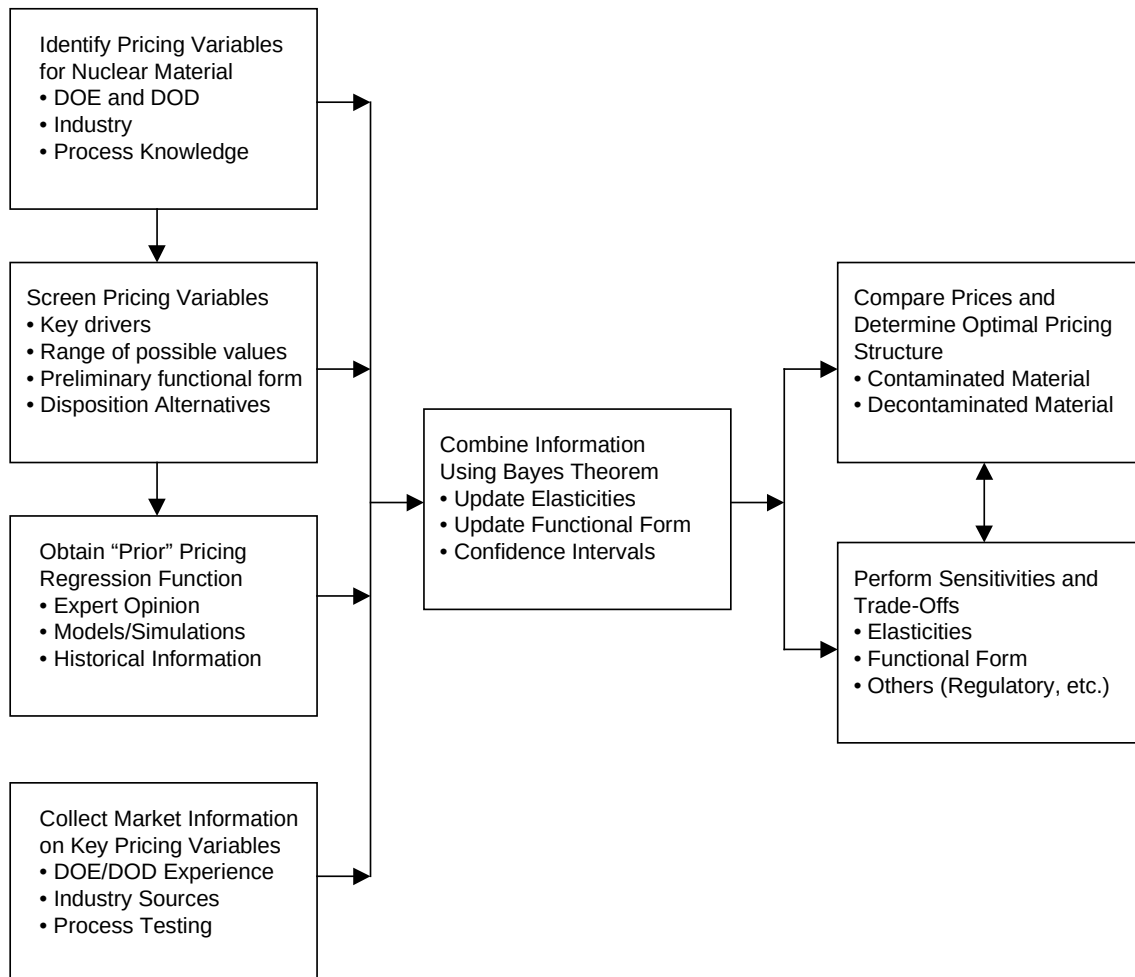
BENEFITS OF THE NATIONAL STRATEGY AND THE PRICING APPROACH

There are clear benefits to the national strategy for implementation of a recycled decontaminated radioactive material exchange and the pricing approach we have discussed in this paper:

- The national strategy is simply structured. It relies on stakeholder input. The strategy appears to be easily implemented.
- The pricing approach employs accepted techniques to account for uncertainties in the

measurement and estimation of key statistical parameters.

- The pricing approach is structured to focus on the implications, limitations, and consequences of applying optimization and decision analysis. In fact, the pricing structure is a stochastic approach designed to complement decision analysis approaches such as Life Cycle Analysis (Yuracko, 1998) or Systems Optimization (Redus and Yuracko, 1998).
- The national strategy and the pricing approach represent the first time that a market-making strategy has been coupled with the DOE's (the seller's) desire to get the best value for the taxpayers when selling recycled decontaminated radioactive material within the DOE complex or the open market. Although fine-tuning will be required for the strategy and the pricing approach, the essentials are present, and the methodology is logical and well founded.



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Fig. 2. Approach for Computing Hedonic Prices for Recycled Decontaminated
Radioactive Material.

SUMMARY

A national strategy is developed that provides the framework the sale of recycled decontaminated radioactive material either within the closed DOE market or the open recycled materials market. A pricing approach that incorporates the random behavior of prices, material supply and demand, expert opinion, and historical information is presented. Application of the national strategy supports the DOE goal of deactivating, decommissioning, and recycling surplus facilities in a cost-effective manner. Application of the pricing approach allows DOE to sell recycled decontaminated radioactive material at a best value for the taxpayers.

REFERENCES

1. Griliches, Z., "Introduction: Hedonic Price Indexes Revisited," ed. by Z. Griliches, Price Indexes and Quality Change, Harvard University Press, Cambridge, MA, pp 3 – 15, 1971.
2. Berndt, E. R., The Practice of Econometrics, Addison Wesley Publishing Company, Reading, MA, pp 110 – 130, 1991.
3. Raiffa, H. and R. Schalifer, Applied Statistical Decision Theory, MIT Press, Boston, MA, 1961.
4. Kendall, M. G., and A. Stuart, The Advanced Theory of Statistics, Vol. 2, 3rd ed., Hafner Publishing Company, New York, NY, 1973.
5. Redus, K. S., "A Bayesian Approach for Data Fusion in Waste Characterization," Proceedings of Spectrum '94, Atlanta, GA, 1994.
6. de Neufville, R., "Dynamic Strategic Planning," Course Notes, August 1998.
7. Yuracko, K. L., "A Life Cycle Analysis Approach to D&D Decision-Making," Proceedings of Spectrum '98, Denver, CO, 1998.
8. Redus, K. S. and K. L. Yuracko, "Optimal Facility and Equipment Specification to Support Cost-Effective Recycling," Proceedings of Spectrum '98, Denver, CO, 1998.

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