The Appraisal of Liquid Fuel Refineries

Liquid fuel refineries (petroleum oil, ethanol, and biodiesel) present interesting appraisal problems. Their various technologies and the individual plants differ as much as the vehicles that use the refined fuel. Liquid fuel refineries can range in value from billions of dollars to being substantial liabilities. Their markets are peculiar: being dependent on several volatile commodity prices, subject to a mix of market and regulated affairs, impacted by international markets, and even contingent upon the weather. In this article, the issues, methodologies, and practice of appraisal of liquid fuel refineries will be examined.

The Economic Nature of Liquid Fuel Refineries

It is an understatement that the modern economy requires liquid fuels. Liquid fuels have an unmatched energy density that even the best electric and natural gas vehicles cannot currently match. For over a century, those liquid fuels have been gasoline, diesel, aviation fuel, heating oil and heavy fuel oils. Recently, ethanol and biodiesel have gained a small market share as transportation fuel.

Economically, liquid fuel refineries convert commodities into other commodities and earn a profit when the spread between the two is advantageous. The technologies convert one form of chemical energy (crude petroleum oil, corn or vegetable oil) into another, namely gasoline, diesel, ethanol, or biodiesel. Numerous other co-products are also produced, and these can be substantial sources of revenue.

Main Sources of Gross Revenue for Fuel Refineries

Petroleum Refineries	Ethanol Refineries	Biodiesel Refineries
Gasolines	Ethanol	Biodiesel
Diesels	Distillers Grains	Sustainable Aviation Fuels
Aviation Fuels	Corn Oil	Glycerin
Heating Oils	CO2	RINs
Kerosene	RINs	Tax Credits
Lubricants	Tax Credits	
Aromatics		
Heavy Distillates		
Propane		
Butanes		
Naptha		
Asphalt		
Petroleum Coke		
Numerous Others		

The chemical conversion is completed by using large, expensive, and complex plants. Petroleum refineries are highly engineered. They frequently have values ranging from $100's million to billions of dollars. In the United States, the national fleet of approximately 130 petroleum refineries has a wide range of technologies and effective ages; thus, it is difficult to compare one to another. The national fleet of approximately 225 ethanol refineries is also highly engineered.

They frequently have values ranging from $10's to $100's millions. Interestingly, many of the recently constructed ethanol refineries in the United States are of similar designs and technology; thus, ethanol refineries can be more mechanically similar. Biodiesel refineries have substantially simpler engineering and are smaller in scale, frequently having values ranging from $0.1 to $10's million, with designs that are usually of custom, one-off plants. Currently, there are several very large biodiesel plants in development or recently completed that have values in $100's millions.

There are other types of plants, such as breweries and alcohol refineries for human consumption, methanol plants, pharmaceutical fermentation plants, distillation plants, and others, that have similar major components and processes. While these won't be covered specifically in this article, their valuation process is similar.

The Spread

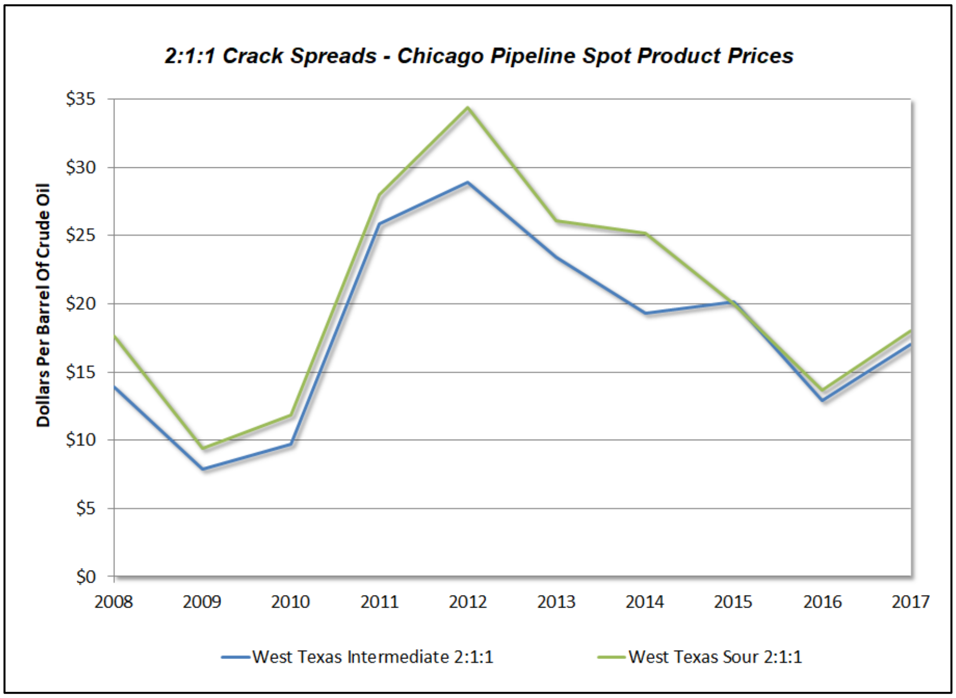
As mentioned, fuel refineries profit when the spread in prices between their feedstocks and products is sufficiently positive. For example, the ethanol refining market pays close attention to the spread in prices between ethanol, their main product and corn, their main feedstock. This spread at ethanol plants and biodiesel plants is called the "crush spread". For petroleum refineries, it is called a "crack spread". Spreads can be thought of as a form of arbitrage. When the price of ethanol decreases and the price of corn increases, then the crush spread declines. Fuel refineries likewise often work on narrow margins; the price of their main feed stock is relatively close to the price of their main products. Thus, small swings in spreads occasionally wipe out all profit in the short term. If today, corn prices rise and ethanol prices do not, profit could be temporarily wiped out. Conversely, if the spread increases, profits could increase dramatically.

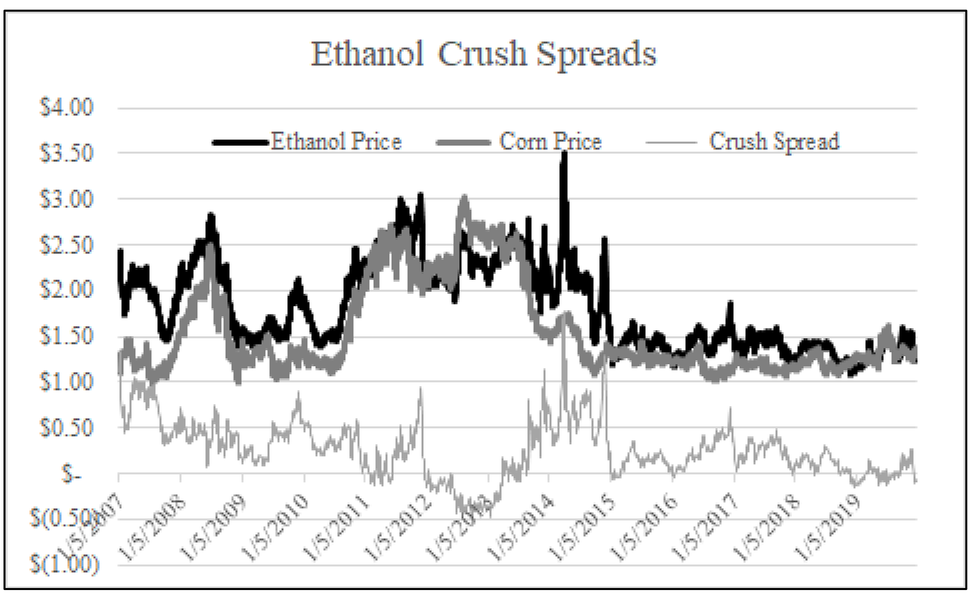
When feed stock prices are sufficiently lower than the price of refined products, it is financially feasible to operate the plant. It should be noted that the spread must be sufficient to cover all other fixed and variable expenses, capital expenses, interest, taxes, and profit, and after consideration of other plant related incomes. Given that the other incomes and expenses are frequently less volatile, and frequently represent a relatively small portion of the income or expenses, prudent management focuses on the larger, harder to forecast ones, namely the main feedstock and product commodities. Thus, the industry focus is on spreads.

The prices of commodities are highly volatile. As commodities, crude oil, corn and vegetable oil, and fuel prices can change daily, and frequently do so, dramatically. While an insufficient spread is undesirable, it is a regular condition of the fuel refining market. It is a primary challenge for refinery appraisals to forecast these commodities into the short, intermediate, and long terms in order to forecast the spreads. It must be determined if the spreads will be negative in the long term, or whether profitability and value will be positive in the long term. If the net present value of the incomes (losses) from the periods with insufficient spreads is less than net present value in periods with sufficient spreads, then a refinery has positive value and is financially feasible to continue to operate. Of course, a substantially higher NPV is required to be financially feasible to construct. Regularly, refineries find that their spreads cannot support their construction debt but can support continued operations. This causes obsolescence.

Exhibit 1 - Historical Spreads

Petroleum Refineries





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Decisions to operate, or not to operate, a fuel refinery must be made as commodity prices change. Refinery management complete their spread analyses sometimes daily. Unlike most general real estate, where it is extremely rare for prudent management to withhold renting space for temporary periods due to low market rents, fuel refineries sometimes prudently withhold production due to low spreads. In effect, at those times the highest and best use analysis for these plants fails the test for financial feasibility, hopefully only temporarily; however, this may indicate economic or functional obsolescence. Some financial infeasibility periods are to be expected at some refineries and fall within the range of long-term economically feasible and functional plants. In marginal cases, a refinery may accept a spread that's merely sufficient to minimize losses, until the long term-expected healthy spread returns. Since the decision to operate or not operate is an option, some refinery managers and appraisals conduct option valuations, such as Monte Carlo simulations to aid in decisions to accept short term losses in favor of longer-term larger profits.

The Units of Comparison

Given that fuel refinery operations and capacities range over several magnitudes, values and incomes may be denominated in $ millions to $ billions. Rates of value may be expressed as dollars or cents. For example: $/day, $/year, ¢/lb, $/ton, ¢/gal and others. There is a constant risk of miscommunication, that data between sources is not on the same basis when being considered by appraisers. The most discussed units of rating, comparison, and value for fuel refineries are usually expressed as volumes and weights (barrels, gallons, bushels, or tons, e.g., $/ barrel, barrels per day, $/gallon, gallons per year, tons/year, $/ton). But given the numerous components of these technologies within these complex plants, there are other possibilities, such as BTUs, cubic feet, and watts.

Petroleum refineries are usually described as barrels/day of throughput or production. Ethanol and biodiesel refineries are usually described as million gallons/year. These rating figures are often found on the nameplates of major refinery elements, but also importantly, may be officially reported to or even measured by government agencies. These capacities sometimes change over time.

The Process of Fuel Refining

The various technologies for fuel refining have vastly different processes. Additionally, experimental technologies are regularly arising or in development, such as cellulosic ethanol. In a basic sense, however, refineries chemically alter compounds.

Fundamentally, petroleum refineries conduct distillation, cracking, and catalytic processes. Petroleum refineries take the long-chain chemical compounds in crude oil, fracture it into smaller compounds, combine smaller compounds into preferred larger compounds, sometimes add other chemicals, and separate them into various products. Since crude oil is such a complex mixture of compounds, petroleum refineries regularly generate dozens of grades and products. Each petroleum refinery is specifically designed to first, process certain qualities of crude, and secondly, produce a certain array of products. When it comes to processing, there are three main types of petroleum refineries; topping, cracking, and coking, which represents a spectrum of capabilities to divide the crude into more and higher value products. The higher value products are typically gasoline, diesel, and aviation fuels depending on the market area. Asphalt is typically a less valuable product, but in most markets there is demand for some amount of asphalt. The first table in this article, Main Sources of Gross Revenue, lists products in loose order of value to a refinery. The challenge is to position the refinery to meet the market demand for each product. However, since building the units and components necessary to make a refined product can cost anywhere from $10 to $100 million and years to plan and build, missing the market can create significant obsolescence.

There are a variety of types of crude oil in the world. Of course, there is an expense to transporting it and many plants are generally designed to process crude geographically closer to the extent that it is profitable. Plants often blend different crude feedstocks in order to meet environmental standards and work around their plant's limitations. Some petroleum refineries process more heavy sour crude (higher density crude with more sulfur and other undesirable or problematic elements and compounds). Other petroleum refineries are capable of only processing limited sour crude and must process light sweet crude (crude with less sulfur and undesirables). West Texas Intermediate (WTI) is a light sweet crude. WTI is a common benchmark price. The challenge is that while heavy sour crude is cheaper, heavy sour crude refining is more expensive and capital intensive. The expense comes from the need to enhance plant construction, complexity, environment controls, and higher operating costs.

Ethanol refineries have a two-stage process, a biological and then a chemical stage. In the United States, fuel ethanol is typically produced by first processing corn into starch and then into sugar. The process continues with a biological process, fermentation, as is done with wine or beer where yeast converts the sugar into alcohol. Ethanol and alcohol are the same, except for the flavorings. Wine and beer are about 90% to 95% water, 10% to 5% ethanol, respectively, and with trace amounts of flavoring chemicals. After the fermentation stage, the alcohol is separated from the water largely by distillation. This is the same process that is used to make whiskey and moonshine, except that many whiskeys are distilled to only about 50% alcohol. If a still or refinery succeeds in removing most of the flavorings when at about 50% alcohol, the product would taste like a good vodka or grain alcohol. Fuel ethanol is distilled and further processed to almost 100% alcohol. In one of the last steps in preparing fuel ethanol, the product is denatured as required by federal law, typically by adding naphtha gasoline, in order to prevent the illegal sale of fuel ethanol for alcohol consumption.

Biodiesel refineries are substantially less complex and often have no or few high pressure or high temperature systems. Basically, a vegetable oil is mixed with methanol and the solution sits until the diesel separates by the forces of gravity from the other main product, glycerin. In the United States, the main feedstock for biodiesel is soybean oil, but any other vegetable oil can be used, and many small processors and hobbyists use old French fry oil from restaurants. Biodiesel refineries often require little to no exotic designs or materials.

Regulation

Fuel refining is not a regulated utility industry, unlike natural gas or electricity distribution utilities; however, many aspects of fuel refining are highly monitored for national strategic economic, security, safety and environmental reasons. Petroleum plant owners must report production and consumption activities to federal agencies. National fuel and consumption standards apply. Ethanol and biodiesel producers often receive incentives, while petroleum refiners often pay these incentives.

Cost Approach

The size of liquid fuel refineries ranges over several orders of magnitude, with small biodiesel plants in the 10,000 gallons per year capacity range, modern ethanol plants in the 100,000,000 gallons per year, and petroleum refineries average in the 100,000 barrel per day range. Refineries benefit from economies of scale, where concepts like cost-to-capacity[1] and the rule of six-tenths factor[2] can be generally applicable to the costs to build and to the operating incomes and expenses.

Still "bigger is better" has limits. For example, corn ethanol and biodiesel plants have been known to consume so much feedstock within their drive-time radius/market area, that they have caused feedstock prices to inflate so high as to destroy their crush spreads. Nationally, between 2001 and 2009, a large number of new ethanol plants were built, and the new demand for corn caused large price spikes (see graph below). This caused severe economic obsolescence for a

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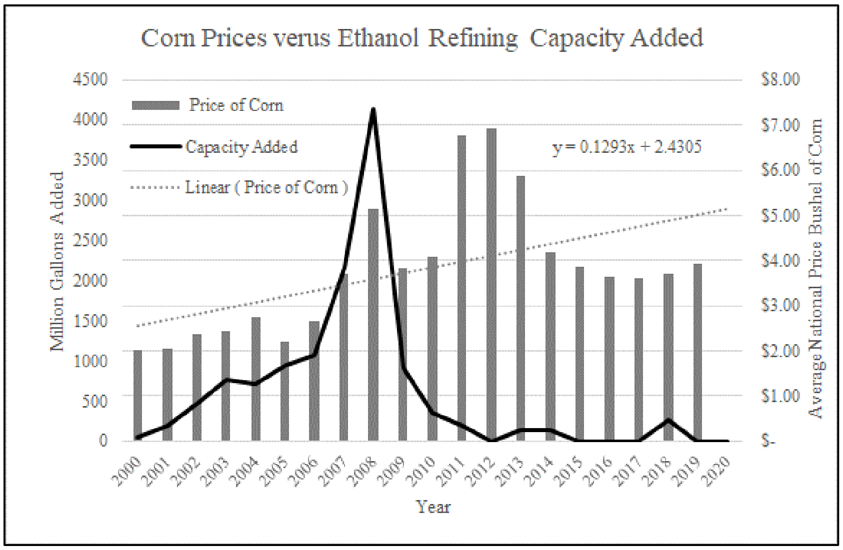
[1] Valuing Machinery and Equipment: The Fundamentals of Appraising Machinery and Technical Assets, Third Edition by Machinery and Technical Specialties Committee of the American Society of Appraisers, Pages 51-52.
The costs of similar plants or pieces of equipment of different sizes vary, along a curved line, with the size raised to some power; $Cost_B = Cost_A * (Size_B / Size_A) ^ X$, where $Cost_B$ equals the approximate cost of item having $Size_B$, $Cost_A$ equals the known cost of item having corresponding $Size_A$.

[2] The rule of six-tenths factor: $Cost_B = Cost_A * (Size_B / Size_A) ^ 0.6$. The factor of 0.6, six-tenths, is so commonly utilized in budgeting and valuation, within the cost to capacity formula, that it has been given its own name.

period, which resulted in bankruptcy at some plants. The under-supply has since declined somewhat as farmers grew more corn to meet the new demand.

Exhibit 2



Each technology has its own economic life cycle. The components at fuel refineries are more like automobiles than general commercial real estate in that they usually have shorter, finite physical and economic lives. The major components often wear out within decades. Typically, these components are replaced or upgraded and the refinery continues to operate.

A good number of the petroleum refineries in the United State are between 50 and 125 years old, albeit with many new or renovated components. Sometimes, when major components wear out, it can render the balance of the plant fully depreciated, because the efficiency of new components at other plants make any old still-operable components financially uncompetitive even with some new components; its economically prudent to close the old refinery down. In 1980, there were over 300 petroleum refineries in the United States. Today there are about 130 operable petroleum refineries in the United States. The last fully new full capability petroleum refinery built in the United States was in 1977; however, interestingly, the total United States capacity has increased significantly in the last 20 years, as new capacity has been added to existing plants and outpaced the loss due to shut down capacity.

Most of the large ethanol refineries in the United States are of recent vintages. Ninety percent of current capacity has been built since 2000. Further, the recent technology is incomparably superior to the old. This leaves little long-term history on which an appraiser can base a life cycle opinion upon.

For these reasons, depreciation is preferably not estimated on the basis of the whole plant life, but instead on expected lives of each of the various components; however, this technique is only possible when data on the various components is available to the appraiser.

Petroleum refineries take 3 to 7 years to build. While no new fully capable grass-root plants have been built in decades in the United States, new petroleum refineries have been built internationally. Ethanol refineries take around 1.5 to 3 years to build. Biodiesel refineries take around 0.5 to 1.5 years, depending on whether existing finished general-purpose industrial buildings are utilized.

Cost-Value Relationship and Disconnect

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The basic concern surrounding the cost approach for fuel refineries is that typically the cost of construction of a new plant does not equal value. When applicable, the cost approach reflects market thinking by recognizing that market participants sometimes judge the value of a refinery by considering the cost to build the improvements; however, due to issues surrounding the cycle of the market, the age, condition, and legal status of the plant, simple, unadjusted cost is unlikely to equal market value. Unless the appraiser fully reflects all forms of depreciation (physical, functional, and external), then the cost estimate will diverge from market value. To make matters more difficult, the job of estimating each of the various forms of depreciation at fuel refineries is often problematic and sometimes practically impossible. Unlike general real estate, where a property frequently will continue to function if it is adequately maintained, even well-maintained fuel refineries may suffer critical economic and functional obsolescence. Common types of obsolescence include obsolete engineering designs and inefficiencies, operating cost inefficiencies (excessive operating costs, usually from new better technologies entering the market), obsolete environmental designs (legal/regulatory), original cost overruns, low spreads, and physical aging on a limited life span. Still the cost approach can be a viable approach to value, as the appraisal axiom suggests, because refineries are special purpose/built properties, but challengingly when significant depreciation and obsolescence is present or is difficult to quantify.

Typical Overnight[3] Construction Costs

Petroleum	$25,000/Barrel
Ethanol	$2.10/Gallon

[3] Overnight costs do not include financing costs, entrepreneurial costs and other costs associated with the time to construct.

Biodiesel	$1.50/Gallon

Parts versus the Whole

Fuel refineries are complex combinations of real property, personal property, and sometimes business intangibles[4] (as example, feedstock and fuel supply contracts or offtake agreements). A refinery is sometimes referred to as a business enterprise[5], or a business combination[6]. The integrated combination of the total assets in the business creates the business enterprise. The market value of the total assets of the business (MVTAB)[7] is the value of the refinery as a whole, as an integrated combination. The components, such as real property (land, building), personal property, and business intangibles, are sometimes referred to as asset classes. The degree that a refinery consists of real property, personal property, or business intangibles is dependent on the definitions applicable in the appraisal context. It may be prescribed in law or regulation, but different circumstances will entail different law or regulations, and thus different definitions. For example, boilers or tanks may be considered to be real property in one state for ad valorem taxation, and personal property in another. They may also be classified as shorter- or longer-lived items for depreciation under state and federal law, investor reporting, or income tax reporting.

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[4] **Intangible Assets -** Non-physical assets such as franchises, trademarks, patents, copyrights, goodwill, equities, mineral rights, securities and contracts (as distinguished from physical assets) that grant rights and privileges, and have value for the owner. The Dictionary of Real Estate Appraisal, Sixth Ed., Chicago, Appraisal Institute, Page 119.

[5] **Business Enterprise -** A firm or individual producing goods and services. An entity pursuing an economic activity. The Dictionary of Real Estate Appraisal, Sixth Ed., Chicago, Appraisal Institute, Page 28.

[6] **Business Combination** – Accounting Standards Codification (ASC) 805, Financial Accounting Standards Board (FASB). This standard directs the reporting of values for various classes and categories of property owned by business, tangible and intangible. The notion is that business is comprised of a combination of different assets and the value of important categories ought to be separately reported.

[7] **The Market Value of the Total Assets of the Business (MVTAB)**, The market value of all of the tangible and intangible assets of a business as if sold in aggregate as a going concern. The Dictionary of Real Estate Appraisal, Sixth Ed., Chicago, Appraisal Institute, Page 143.

Despite these complexities, the refined product revenues are largely earned from all the assets equally as a business combination, because the various classes function best as one economic unit.

Depending on the use of the appraisal, there are occasions when the value of some real and personal property and business intangibles must be reported separately from each other and from the MVTAB. Many purposes require separate real and personal property values. For property tax appraisal purposes, the value of any tax-exempt property must be removed. For IRS and SEC reporting, the value of existing contracts might be separately reported from the rest. A residual technique is often the best method to isolate the value of the target assets from MVTAB. In real estate appraisal, a land residual is where the overall real estate value (Vl&b) minus building value (Vb) equals land value (Vl). In refinery appraisals, the residual formula is MVTAB ($V_{refinery}$) minus value of assets that are not the subject of appraisal (Vns) equals the value of the balance of the plant (Vbal), which is the appraisal target value of the subject property (Vs).

The appraiser must exercise care to report which type of value is concluded as of each point in the appraisal. If the purpose of the appraisal is to report the value of something other than the MVTAB, as indicated by the income or sales approaches, then some further analysis beyond the MVTAB from the income or sales approaches will be necessary. The cost approach may or may not have been completed in a manner to indicate directly the target value to be appraised. If a unit in place cost approach was developed, then business intangibles were likely excluded, but real and personal property may still be intermingled, requiring further analysis. If a trended original cost approach was employed, it may have reported the value of real and personal property separately. Typically, the further analysis will include the use of various allocation[8] techniques. When used in conjunction with the sales and income approaches, the cost approach affords one of the best appraisal techniques to allocate MVTAB to the market value of the refinery's parts. Extraction[9] techniques are not typically utilized due to the lack of detail usually available in the market data.

While sometimes problematic for estimating MVTAB, due do difficulties estimating all forms of depreciation, the cost approach is especially useful for appraising the different components of the refinery and for allocating value to the components of the refinery. The income and sales approaches on fuel refineries usually indicate MVTAB of the refinery rather than purely real estate or personal property values. MVTAB intrinsically reflects all forms of depreciation. Any residual or allocation using cost techniques, of MVTAB based on an income or sales approach for the refinery, will intrinsically reflect all forms of depreciation. For this reason, many refinery appraisers prefer to find value of components of a refinery via a residual or allocation of MVTAB, (a top-down approach), rather than building up a value via a cost approach (a bottom-up approach). Simply put, if an appraiser is to find a real and/or personal property value, it is often substantially easier to find MVTAB first and then complete a residual or allocation, than to complete a cost approach where there is great difficulty estimating all forms of depreciation.

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[8] Allocation – A method of estimating land value in which sales of improved properties are analyzed to establish a typical ratio of land value to total property value and this ratio is applied to the property being appraised... The Dictionary of Real Estate Appraisal, Sixth Ed., Chicago, Appraisal Institute, Page 7. While written using land and building as examples, the underlying principle can be applied to parts of a business combination. Many appraisals for IRS and SEC reporting concerning purchase prices are completed using this concept, Purchase Price Allocations.

[9] Extraction – A method of estimating land value in which the depreciated cost of the improvements on the improved property is calculated and deducted from the total sale price to arrive at an estimated sale price for the land. The Dictionary of Real Estate Appraisal, Sixth Ed., Chicago, Appraisal Institute, Page 83. While written using land and building as examples, the underlying principle can be applied to parts of a business combination.

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Commonly, for property tax appraisal, excludable property may include inventory, pollution control improvements, contracts for feedstock supply, offtake agreements, specialized or proprietary documents (including policies and procedures, manuals, computer software, and drawings), and working capital accounts. As discussed earlier, the cost approach is usually the best method to estimate the value of the excludable tangible property. The value of inventory, specialized, or proprietary documents are usually estimated via cost techniques. Contracts are usually appraised via a comparison of the plant income streams with and without the contracts, in the same way that a leasehold analysis compares fee simple income streams to leased fee income streams.

Reproduction vs. Replacement Approaches

Both of the two main cost methods, reproduction cost and replacement cost, are regularly applied to fuel refineries.

Trended Original Cost Method

Although rarely utilized to value general real estate, the trended original cost method (TOC), a type of reproduction approach, is frequently utilized for complex special-purpose heavy industrial assets, like refineries. Historical cost information, even if decades old, is sometimes available on fuel refineries. In a TOC, the reproduction cost new (RCN) is computed by trending the original (historical) construction costs to the date of appraisal. The usefulness of the TOC method is contingent on the accuracy and completeness of the historical cost information. The costs by date of expenditure must be reliable and available for each class of asset within the entire plant, and must also include capital expenditures made since original construction, and include data on component retirements made through history.

Various widely accepted cost trend references provide the basis for the trending of refinery construction costs. The indices do not give prices for specific cost items in either the historical period or the current period. Rather they provide the change in cost, the delta, between the different dates. Appraisers apply that delta to the actual original cost at the subject plant to get an RCN as of the appraisal date. The proper indices can be applied to specific cost items, such as bricks, tanks, or pumps, or to whole categories of refinery items, such as a boiler or distillation system.

Cost per Capacity Method

The cost per capacity method, a replacement cost approach, is estimated by multiplying unit cost, usually $/barrel or $/gallon of capacity, by the number of units at the subject plant. The unit cost can be developed from a variety of sources including research publications, government estimates, contractor estimates, manufacturer estimates, owner estimates, or the comparative-unit method.

The cost per capacity method is relatively practical and is utilized by market participants because of its simplicity and availability; however, the apparent simplicity of the cost per capacity method can be misleading. This method is often less precise than others. It is sometimes difficult to reconcile the vast differences between the various cost sources and the subject plant, and between this cost approach and the other approaches. Few new refineries have been built recently, on which to base a cost per capacity estimate. At petroleum and biodiesel refineries, the plants are frequently of unique designs.

Physical Depreciation

Typical depreciation techniques can be as simple as a single age-over-life ratio, or as complicated as the breakdown of the subject's assets into their various components for individual consideration. Models based on the economic age-life method are commonly utilized. For petroleum refineries, provided the scope of appraisal work allows, the age-life method is applied to plant components, and not a refinery-wide technique. Physical deterioration can be estimated by the straight-line method, and by the age-life method, using mortality dispersion techniques. Often the effective age plus the remaining useful life is equivalent to the service life. Accounting and bookkeeping lives are not appropriate for appraisal purposes for fuel refineries. Physical life may be longer than the average service life, but it may not accurately represent the usefulness of the service of an asset due to economic or legal reasons. The effective age should reflect the conditions of the plant, which often are not the chronological (actual or historical) age. It should also be recognized that the expected remaining service life of a plant might change during its life for economic or legal reasons. This blurs the distinction between physical depreciation, and functional and economic obsolescence.

With this said, these plants and their components are more like automobiles, which after so many proverbial miles get worn out. Many of the country's large ethanol and biodiesel plants are only about 10 years old. We have little historical record of full life cycles with these newer vintage technologies. Consequently, appraisers frequently approximate life and depreciation based on engineered design life.

Conversely, some of the country's petroleum refineries are approaching 100 years of age, where major additions and replacements subsume the remaining original parts with the current plant bearing little resemblance to the original plant.

Functional Obsolescence

Functional obsolescence is common at petroleum fuel refineries and is often easily spotted. It usually arises as a result of the ad hoc additions and renovations to the plants over their many decades. Functional obsolescence is less common at the new ethanol and biodiesel plants, as they often represent state of the art designs, built at the same time in an integrated fashion. Petroleum refinery managers and engineers will be aware of the limitations and are usually quick to accurately report the issues. The types of functional obsolescence commonly found include deficiencies requiring an addition, deficiencies requiring a modification, deficiencies requiring additional operating costs, and super-adequacies. Often these deficiencies are incurable, in both the short and long term, but deferred maintenance can also be present Appraisers will expend considerable effort on determining the value lost to functional obsolescence. A common technique for the appraiser is an income and expense analysis, with and without the dysfunctional issue. Despite this, this approach may be problematic if it causes a circular argument between the cost and income approaches, leaving the cost approach as not fully independent from the income approach.

Economic Obsolescence

Economic obsolescence within fuel refinery industry occurs regularly. Changes in federal or state law, the economy, and/or any operational constraints external to the asset can cause economic obsolescence at fuel refineries. One cause of economic obsolescence is unfavorable spreads in commodity prices or unfavorable crack or crush spreads. Usually, the impact on value can be measured by capitalizing the expected losses in earnings over the period that the condition is expected to persist. If the economic obsolescence is not permanent, still the appraiser must determine if the net present value of future positive spreads nets out to something financially feasible against the cost of maintaining the plant until spreads recover. For example, historically several ethanol and biodiesel plants closed permanently in the late 2000's because at that time, spreads were not expected to support financial activities for a period of years and the cost of maintaining the plant in the interim was too high to justify waiting for the future value of the recovered market years later. Some of those refineries were liquidated as parts and scrap.

Common techniques used for estimating functional and economic obsolescence include the capitalization of excess operating costs and the capitalization of income shortfalls. In both, income capitalization techniques are employed to evaluate the loss in value from specific operating or capital costs, or from an inability to earn income. While not adequate to measure the value of the obsolescence, the existence of functional and economic obsolescence is often easily discovered by comparing MVTAB from the income and sales approaches to the replacement cost new less physical depreciation (RCNLD). Any difference can be attributed to either functional or economic obsolescence or both. While this comparison proves the existence of the obsolescence, this direct comparison of values from income and sales approaches to value from the cost approach is a circular measurement of the amount of obsolescence. Such a circular determination could spoil a cost approach as an independent approach from the sales or income approaches, and is not acceptable in many courts.

Half of the petroleum refineries in the United States have been retired since 1980. These retired facilities were judged to be financially infeasible for physical, functional, and economic reasons. At this time, there is little expectation that the remaining petroleum refineries will be retired soon though history shows it is common to have one or two refineries permanently shutdown ever year.

Land and Real Property Values

There are often numerous high quality, heavy duty industrial buildings at petroleum and ethanol refineries, representing a considerable aggregate building value relative to many general commercial properties in the area. Still, the land and overall real property at petroleum and ethanol refineries often contributes little, relatively speaking, to MVTAB. At petroleum refineries, the machinery is simply massive and extensive. Petroleum refineries are frequently located on larger parcels in older industrial areas, where the possibility of environmental issues is a concern. At ethanol refineries, the machinery while not at extensive as petroleum, is still relatively high value compared to the real property. Ethanol refineries are usually located in rural, low land value areas and are commonly developed on green field sites. Their total acreage and the cost of approvals and permits can be high, thus representing a high land value relative to many adjacent properties.

The machinery at biodiesel refineries is often common off-the-shelf technology and materials. Given that machinery at biodiesel refineries is a relatively smaller portion of the total property, plant and equipment, land value and overall real property at such refineries can represent a sizable portion of the MVTAB.

An across-the-fence method,[10] assuming highest and best use similar to the properties from "across the fence," is typically employed to measure the value of the underlying land at refineries. The value of licenses, permits, and approvals for the refinery activity, which can be substantial, are generally accounted for in the soft cost of construction. These land parcels frequently have intermodal transportation features, which can add value but to a limited market.

The real property improvements can frequently be classified as industrial with support offices, and miscellaneous other types of space. There may be several types of industrial space with each deserving its own separate cost estimate, especially when some of the industrial space can be

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[10] **Across-the-fence method -** A land valuation method often used in the appraisal of corridors. The across-the-fence method is used to develop a value opinion based on comparison to abutting land. The Dictionary of Real Estate Appraisal, Sixth Ed., Chicago, Appraisal Institute, Page 3.

very large and for very heavy-duty industrial activities, while some support buildings at the same plant can be of fairly low value.

Sales Comparison Approach

While the use of the sales comparison approach is common in the appraisal of general commercial properties, this approach is rarely probative in refinery appraisals. Research on sales of comparable fuel refineries rarely yields appropriate and adequate data for a credible sales approach. The market for fuel refineries is national and sometimes international. It is easy to find evidence of an active sales market; however, relevant critical details about the individual sales are often unattainable. An important qualification of each credible comparable sale is the level of supporting data that is publicly available. Since many details concerning the sales of fuel refineries are confidential, even though the sellers and buyers are often public companies, the sales are not adequately verifiable and/or cannot be soundly adjusted. Since fuel refineries are typically business combinations, the sales are for combinations of assets; real, personal, and business assets. Many sales include corporate (business) and personal property assets. Further, these transactions often include assets beyond the tangible refinery, such as investment participation, corporate financing, partial interests, off-take and supply contracts, and other valuable closing contingencies. Buyers and sellers are under no obligation to publicly report the portion of the price attributable to the parts of the total sales price in a format that is useful to appraisers. Information on the refinery or the real property portion of the price may be reported to state and local taxing authorities, based on an allocation of the refinery purchase price. In theory, that can serve as a basis of comparison in an appraisal, although some court cases point out limitations[11]. Publicly traded companies may report some details on the sale of a refinery. Again, in theory, that data can serve as a basis of a comparable in an appraisal. Unfortunately, this reporting often is still not complete enough. Therefore, while there is frequently available data to identify comparable sales, there is not sufficient public data in many cases to fully complete a credible appraisal adjustment process.

Lastly, many of the sales of refineries within the last decade are of financially troubled assets. Such sales were predominant at moments in the market, while other refineries did not sell or suffered financial collapse. The troubled sales are not reliable indicators for value under a going concern premise, but may be indicative of liquidation values.

Market condition adjustments are important as values for fuel refineries change frequently market-wide, due to macroeconomic conditions, including the general economy trend, feedstock and fuel price trends, regulations, and green energy trends. Since refineries are subject to the variability of commodities markets, their values are more volatile than general commercial real estate markets. Adjustments for physical characteristics are typically made for plant design, process type, unit size, capacity reliability, plant condition, age, super adequacy, functional utility, and remaining life; however, required adjustments for these factors often cannot be made reliably because many physical characteristics of the comparable sales are not released as public information. Location-based revenue differences should be analyzed, as feed stock and product prices are usually dependent on the location of each plant. Other locational differences may

[11] Mobile Telecommunications Technologies, LLC V. Sprint Nextel Corporation, Case No. 2:12-CV-832-RSP

include the proximity and availability of pipelines, railroads, natural gas and electricity lines, water supply, and dockage. Additionally, adjustments related to income tax differences may be necessary, as taxes are an important factor in the MVTAB of refineries.

Income Approach

Traditionally, income strictly attributable to the real property at general commercial real estate such as offices and apartments is ubiquitously prescribed by real estate leases or the market potential to be leased. Fuel refineries are very rarely rented. They are mostly owner occupied. When rented separately, the leases are usually part of structured financing that limits the lease's probative utility within appraisal. Biodiesel plants are smaller and often developed within conventional industrial buildings. The real property at biodiesel refineries is regularly rented.

Nonetheless, fuel refineries are income producing assets where the income is generated by the operation of the combination of real and personal property and any business intangibles. At fuel refineries, there is typically no credible and reliable way to isolate the income solely attributable to the real property, such as a lease. The income utilized in the fuel refinery income approach is from operation of the combined assets of the business enterprise. Such intermingling conditions also exist at many other types of commercial property, such as hotels, theaters, hospitals, telephone companies, water companies, landfills, and racetracks. Given this issue, the appraiser commonly first concludes an MVTAB based on the income of the plant, and then employs various appropriate appraisal procedures to separate out the value of the real and/or personal property, intangibles, or other target interest at the plant.

Given the volatility of the commodities that drive the income and expenses at refineries, a discounted cash flow ("DCF") analysis is preferred over a direct capitalization technique. Additionally, since income tax consequences are distinct from time to time and from refinery to refinery, it essential, in most cases, to conduct after-tax analyses and comparisons. For example, the tax incentives play a major role in the feasibility of ethanol and biodiesel refineries. These are standard practices in the valuation of fuel refineries.

The holding period for fuel refineries is driven by physical considerations as well as legal, regulatory, and contractual conditions, and is often prescribed by common practice among market participants. The analyst looks to the finite remaining life of the plant to form the basis of the holding period. As such, it is common practice to assume a holding period equal to a plant's estimated remaining economic life, with no reversion. Consequently, some discounted cash flow ("DCF") analyses are projected as long as 35 years for ethanol refineries. Since history shows that petroleum refineries can have lives over 75 years, DCFs of 10 years with a reversion are most common.

Reversionary Value

A reversionary value is assumed in most DCF analyses for commercial real estate. This value captures the income generated from the asset after the end of the holding period and is typically calculated by utilizing a direct capitalization method and then discounting that value to the valuation date. This is true of most DCF analysis on petroleum refineries, because at this time most remaining petroleum refineries are expected to continue well into the future; however, unlike general real estate and petroleum refineries, ethanol and biodiesel refineries are expected to have relatively short, finite lives. When the holding period for a refinery is assumed to be equal to its remaining economic life, then there will not be a reversionary value for the plant at the end of the holding period. Assumptions made about disposition of the remaining assets (or liabilities) may be broken down in three categories: decommissioning liability, salvage and scrap value, and land value. Often, refinery appraisers conclude that the sum of the three reversionary considerations net to a zero value.

When a direct capitalization method is completed, the cap rate must be adjusted upward to reflect the fact that the income and value may decline to zero over the holding period, since the reversionary value of a plant with a finite life is zero. It is common practice in refinery valuation to avoid this issue in DCF reversionary cap rates by setting the holding period equal to the plant's remaining economic life.

Supply and Offtake Agreements

Plant owners regularly contract in advance to sell their products via long term offtake agreements, instead of selling their products in the daily mass markets. Similarly, plant owners regularly contract in advance to buy feedstocks, electricity, and natural gas, via long term supply contracts. These agreements fall into two broad categories; those that have contract prices for at or near market prices, and those that have contract prices at substantially above or below market prices. The reason that contract prices are substantially above or below market prices may be that 1) they are sometimes between related parties, 2) there might be more to the transaction than just the sale of the commodity, 3) they represent a business mistake, or 4) they are hedging contracts. These agreements do not meet the criteria of market-indicative transactions, and cannot be used to determine market value, but can certainly indicate the value of the going concern or value-in-use. This is analogous to appraising an office building which has inter-company leases or sale-leasebacks that were not based on market terms. If the purpose of the appraisal is to determine market value assuming fee-simple, value-in-exchange conditions, the atypical office leases are replaced with normal market-based terms.

Hedging Contracts

Judging the significance of contracts that are above or below market is always difficult but even more so when the contracts represent hedging exercises that may be impacting the risk associated with the refinery business. Hedging is contracting over the longer term for steady supplies and prices at the cost of higher prices for the benefit of avoiding inadequate supplies and potentially very high spikes in prices. Hedging lowers risks associated with commodity volatility. While hedging may moderately increase prices, it preserves and may enhance value by decreasing risk. The fuel refining industry regularly hedges crude oil, refined petroleum products, corn, and natural gas.

Long and Short Term Trending

The Appraisal of Liquid Fuel Refineries

Unlike DCF forecasts for general real estate, which are commonly for ten years, refinery forecasts are regularly up to 35 years. The Consumer Price Indices (CPI) provide an excellent source for forecasting commodity and fuel prices, and the general expense rate of inflation over the very long term. The CPIs are well documented and refinery market participants often rely upon them. The data reveals several important trends. Generally, commodity inflation rates have not kept pace with general inflation over the decades. The general CPI is the average of all products and services, but there are indices specific to fuels and energy. Commodities, like crude and corn, trend at rates lower than other products and services in our economy, some of which (such as health care, college education) suffer more from inflationary forces.

In the short term, the appraiser ought not to assume current prices for inputs to an income approach are at long term trend line. These inputs concern commodities, which are volatile. Price trends for any given plant will be driven by local market conditions and will likely be off of long-term trends on a regular basis. Appraisers must examine local plans for plant retirements and new additions, as well as market constraints, and commodity supply and demand conditions. These local trends can cause local prices to trend in a dramatically different fashion than the long-term CPI trends, until a new market equilibrium is achieved.

Current prices and short- and long-term trends can be found in various government reports. Numerous financial data sources exist online. Also, there are several national forecasting services, such as Standard and Poors. Then, there are refining industry trade groups and consultants that provide information regularly utilized by appraisers.

Fixed and Variable Expenses

Operations and maintenance (O&M) expenses are analyzed as is normally done in the appraisal of income producing properties, namely based on historical and comparable expenses, with one exception. Considerable special efforts are typically made to forecast feedstock and product commodity expenses, separate and apart from other O&M expenses. Also, parent company general and administrative expenses may need to be apportioned down to the subject plant, when the plant is owned and managed in a portfolio of plants.

Income Taxes

Unlike nearly all appraisals of general real estate, refinery income approaches are usually completed after deducting income taxes. This is useful and often necessary for several reasons. A major contributor to the value of many plants is its effective income tax rate. Fuel refineries often have tax benefits, including accelerated depreciation, investment tax credits, exemptions, or others. Also, while traditional real estate appraisals are completed before income taxes and most of the theory and data in the real estate appraisal community is arranged for before income tax analysis, business appraisals are traditionally completed on an after-income tax basis. Most of the financial market data available for the appraisal of the fuel refining industry is on an after-income tax basis. Nearly all market participants appraise on an after-income tax basis. In theory, both before and after income tax appraisals should yield the same indication of value, but only when the tax benefits are fully and properly adjusted for. Another advantage of the after-income tax analysis is that the inputs and adjustments are explicit and thus, are available for easier review.

Capital expenses, depreciation, and interest expenses must be computed in order to compute the effective income taxes. Given the magnitude of capital expenses, prudent management budgets for them many years out. The appraiser ought to review cap ex history, as well as budgets. Depreciation expenses should be calculated utilizing the modified accelerated cost recovery system ("MACRS"); however, simpler methods may be acceptable in some cases. The refining industry relies on debt financing. If the goal is to estimate market value, appraisers forecast the interest expense by applying industry/market-specific interest rates as of the valuation date to the portion of the plant's value that is estimated to be financed with debt.

Capitalization and Discount Rates

Theoretically, there are several possible methods for estimating capitalization and discount rates, including market surveys, extraction from market sales, and various mathematical financial formulas. Extraction from refinery sales very rarely yields sound or adequate data. Also, there are no surveys of refinery cap and discount rates. Therefore, rates are usually determined using well known financial formulas.

Refinery appraisers frequently complete a formula-based analysis of discount rates known as the Weighted Average Cost of Capital[12] ("WACC") in the business appraisal community. In the real estate appraisal community, this formula is recognized as a Band of Investment[13] formula. The major difference is that the Band of Investment formula is typically utilized to determine cap rates for real estate before income taxes, while the WACC is typically utilized for discount rates after income taxes. The basic elements of yield (or capitalization) rates are debt and equity. When combined, they indicate the overall investment yield. This cost of capital analysis is "weighted" because it incorporates the percentage of the total investment that debt contributes and the percentage that equity contributes, which is a weighted average concept.

Algebraically the WACC analysis is expressed in the following figure:

The Formulaic Derivation of an After Income Tax Discount Rate

Weighted Average Cost of Capital (WACC)

$$Yo = (M \times Ym \times (1-t)) + ((1-M) \times Ye)$$

Where,

Yo = Overall Yield Rate

M = Debt to Value Ratio

[12] Weighted Average Cost of Capital - The cost of capital (discount rate) determined by the weighted average, at market values, of the cost of all financing sources in the business enterprise's capital structure. The Dictionary of Real Estate Appraisal, Sixth Ed., Chicago, Appraisal Institute, Page 248.

[13] Band of Investment - A technique in which the capitalization rates attributable to components of a capital investment are weighted and combined to derive a weighted-average rate attributable to the total investment. The Dictionary of Real Estate Appraisal, Sixth ed. Page 19. Chicago: Appraisal Institute, 2010.

Ym = Debt Yield Rate

Ye = Equity Yield Rate

t = Effective Income Tax Rate

Equity and Debt Yields

There are several well-developed theories and widely used effective methods for estimating the equity cost of capital, including a build-up method and the Capital Asset Pricing Model[14] (CAPM). The build-up method is an additive model in which the equity return on an asset is estimated as the sum of a risk-free rate and one or more risk premiums. The risk-free rate is usually long-term United States government bond yields. The risk premiums adjust for risks associated with systematic and unsystematic risks, size and industry risk, illiquidity, managerial effort, and others. The CAPM formula considers the sensitivities to non-diversifiable risk (also known as systematic risk or market risk), often represented as a beta[15] coefficient. Like the build-up method, it begins with the expected return of a risk-free asset and then adjusts for the market-wide expected return. There is much literature on both the build-up and CAPM formulas, and thus, they will not be covered further herein.

Debt rates are estimated the usual way with one exception: the pre-income tax debt rate is adjusted for the ability to deduct debt interest expenses from income taxes, by multiplying the cost of debt by one minus the income tax rate.

[14] Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk, William F. Sharpe, The Journal of Finance, Vol. 19, No. 3 (Sep., 1964), pp. 425-442.
[15] Ibid.

Working with Other Professions

The refinery appraiser will frequently join with professionals from other disciplines in order to complete a refinery appraisal. Refinery appraisals often benefit from consultation with professional engineers. Further, refinery appraisers regularly use the services of commodity price forecasters. Other professionals may include regulatory experts, economists, mathematicians, attorneys, and accountants who have expertise in some element related to the appraisal problem at hand.

Reconciliation of Value

There are two considerations one must weigh when applying various approaches to value. First, appraisers should use those approaches commonly utilized by market participants[16]. Second, the supply of data within a market or within a particular timeframe may preclude the development of one or more of the approaches to value commonly employed in other appraisal practice areas or times. Generally, the sales comparison approach is not employed to determine the value of fuel refineries due to the lack of reliable public market data. Generally, the income approach is the primary method utilized by market participants, and is typically the approach prescribed by appraisal theory as being the most appropriate. Generally, the cost approach is of limited probity when issues of functional or economic obsolescence arise. If the refinery is in a healthy

[16] **USPAP, 2014,** Standards Rule 1-6, In developing a real property appraisal, an appraiser must: (a) reconcile the quality and quantity of data available and analyzed within the approaches used; and (b) reconcile the applicability or suitability of the approaches used to arrive at the value conclusion(s).

economic market and time frame and is newer, the cost approach can be as strong an indicator as the income approach. Given that fuel refineries may be classified as special purpose properties, local law may emphasize or mandate one or more approaches to value.

Conclusion

Appraising fuel refineries is a specialty practice and will require the utilization of infrequently employed appraisal theory and techniques, but in the end no new practices will be needed for the widely read appraiser.