INCENTIVE RATEMAKING REPORT

Prepared for: Enbridge Gas Distribution

CONCENTRIC ENERGY ADVISORS, INC.
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company by the annual materials price index. Materials Quantity is equivalent to real non-labour O&M expense (expressed in $2009).

D. Capital

1. Capital Approach

Measuring Capital quantity is less straightforward than measuring Labour or Materials quantity. In recent utility TFP analyses, three approaches to quantifying capital have been used, referred to as "Geometric Decay", "Cost of Service" and "One Hoss Shay".

Geometric Decay: In the geometric decay model, capital quantity reflects the concept that the plant additions of each vintage become less productive, or efficient, over time, and that the pattern of the decline in productivity is geometric. The geometric decay capital price, which is also called the user cost or service price, represents the price of employing a unit of net capital for one year. The capital price is based on the relationship between the price of new capital and the present value of future services of current capital; the Geometric Decay capital price incorporates financial costs and economic depreciation.[99] The economic depreciation[100] component in the price calculation measures the decline in the price of the capital asset as it ages. Capital cost is calculated by multiplying the Geometric Decay capital quantity and capital price. The geometric decay approach has been promoted extensively in academic literature.[101]

Cost of Service: The cost of service approach to calculating capital cost reflects the way capital cost is determined in utility regulation.[102,103] Cost of Service capital quantity is

[99] Economic depreciation measures the change in the market value of an asset over time while the accounting depreciation reveals nothing about the market value. Accounting depreciation is simply the allocation of the historical cost of an asset to the periods in which the services of the asset are recovered from ratepayers.

[100] In the case of geometric decay, economic depreciation is equal to efficiency decline.

[101] A few example include: Hulten, Charles (1990), "The Measurement of Capital", in Ernst Berndt and Jack Triplett (eds.) Fifty Years of Economic Measurement, National Bureau of Economic Research Studies in Income and Wealth, volume 54, The University of Chicago Press, Chicago.; Hulten, Charles and Frank Wykoff (1981), "The Estimation of Economic Depreciation" in Charles Hulten (ed.) Depreciation, Inflation, and the Taxation of Income from Capital, Urban Institute, Washington.; Mark E Doms, 1992. "Estimating Capital Efficiency Schedules Within Production Functions," Working Papers 92-4, Center for Economic Studies, U.S. Census Bureau; and Nehru, Vikram and Ashok Dhareshwar (1993). A New Database on Physical Capital Stock: Sources, Methodology and Results, Revista de Analisis Economico. 8: 37–59.

[102] A few examples include: Lowry, Mark (2007), "Rate Adjustment Indexes for Ontario's Natural Gas Utilities," Report filed on behalf of the Ontario Energy Board.; Lowry, Mark (2011), "PBR Plans for Alberta Energy Distributors," Report filed on behalf of the Consumer's Coalition of Alberta before the Alberta

determined based on the assumption that the efficiency of each vintage of plant additions declines in accordance with a straight line pattern.[104] The Cost of Service capital price is determined by a weighted average of current and past construction or asset prices. As a result, the Cost of Service capital price is an implicit price determined by the deflated sum of financial costs and accounting depreciation. The financial costs and accounting depreciation are both based on the historic (book) value of the plant.

<u>One Hoss Shay:</u> The One Hoss Shay approach to determining capital cost assumes that an asset retains full efficiency until the end of its service life.[105] The One Hoss Shay Capital quantity is measured by gross plant; total gross plant is determined by summing plant additions by vintage. The One Hoss Shay Capital price is computed by incorporating financial costs and economic depreciation; economic depreciation must be estimated using several factors, including the real rate of interest (discount factor).[106]

The simplicity of the geometric model provides several advantages over the cost of service and One Hoss Shay models, including: economic depreciation equals efficiency decline, no system of vintage accounting needs to be maintained because of the constant rate of depreciation, and depreciation is independent of the real rate of interest.[107] The geometric decay model is the only model where the economic depreciation equals the efficiency decay. This simplifies the calculation because it avoids the tedious task of estimating the economic depreciation. In addition, if the two are not equal, the depreciation function can take on several forms due to its sensitivity to factors such as the real interest rate. For example, in the case of One Hoss Shay, if the interest rate is zero, we can conclude that the depreciation will exhibit a straight line pattern; however, if the real interest rate is positive, the depreciation function will exhibit a concave pattern. The geometric decay model eliminates

utilities Commission.; and Kaufmann, Larry (2011), "Assessment of Union Gas Ltd. and Enbridge Gas Distribution Inc. Incentive Regulation Plans," Report filed on behalf of the Ontario Energy Board.

103 The lack of detailed documentation and academic literature on the Cost of Service approach does not permit us to fully understand the methodology.

104 That is, the efficiency of a specific addition to plant declines at the same rate (percent of original plant) each year.

105 This approach was recently promoted by NERA in the Alberta generic IR case. Makholm, Jeff (2010), "Total Factor Productivity Study for Use in AUC Proceeding 566 – Rate Regulation Initiative," Report filed on behalf of the Alberta Utilities Commission.

106 Due to the interdependence of the Capital price and economic depreciation, One Hoss Shay economic deprecation will in general follow a concave pattern, which assumes that the price of the asset declines at a slower pace in earlier years and an accelerated pace toward the end of its service life.

107 Harper (1982), "The Measurement of Productive Capital Stock, Capital Wealth, and Capital Services."

the necessity of a depreciation calculation. Furthermore, the geometric decay model does not require a system of vintage accounting due to the constant rate of depreciation. The capital price does not depend on the historical pattern of past asset prices; it only depends on the current price of used assets, which can be expressed in terms of a new asset's price.[108] This greatly reduces the data demands associated with the geometric decay model.

The geometric decay model has been applied empirically on numerous occasions. One highly cited empirical study was developed by Hulten and Wykoff (1981). Hulten and Wykoff estimated the capital price index (age/price profile) by using prices of used capital assets. The study examined three common models: One Hoss Shay, straight line and geometric decay. Hulten and Wykoff concluded that geometric decay was the most appropriate method for estimating the age/price profile. Due to the dual property discussed above (economic depreciation equals efficiency decay), we can also assume that geometric decay would be the most accurate efficiency profile. Other studies using alternative approaches to estimating efficiency schedules have also been conducted. For example, Doms (1992) estimated efficiency schedules within production functions which resulted in relative efficiencies that declined geometrically.

The cost of service model, while trying to more accurately reflect the way capital cost is determined in utility regulation, has not been extensively studied in scholarly literature; therefore, there is no independent evaluation of the approach. In addition, to our knowledge, the model has only been used empirically by Pacific Economics Group. These factors make the cost of service approach difficult to evaluate. In addition, the model contains theoretical inconsistencies. Hulten (1990) showed that economic depreciation and efficiency decay are not independent concepts. One cannot select an efficiency pattern independent of the depreciation pattern and one cannot select a depreciation pattern independent of an efficiency pattern. Hulten used the example of straight line efficiency decay and showed that if one selects straight line efficiency decay then one has committed to using a non-straight line pattern of depreciation. The cost of service model uses straight line efficiency decay and depreciation, which is in direct violation of the theoretical framework developed by Hulten. In addition, accounting depreciation is being incorrectly used a proxy for economic depreciation.

108 Fuss (2012), "Response to Pacific Economics Group's September 2011 Report" Report filed on behalf of Union Gas before the Ontario Energy Board.

The One Hoss Shay method assumes that assets retain full efficiency until the asset reaches the end of its service life. However, OECD (2001)[109] states that there are relatively few assets that will actually maintain full efficiency throughout their useful lives. As noted above, Hulten (1990) showed that economic depreciation and efficiency decay are not independent concepts and therefore, cannot be chosen independently of one another. In the case of One Hoss Shay efficiency decline, the depreciation function often takes on a concave pattern.[110] However, a concave depreciation function is often at odds with empirical research. As Hulten and Wykoff (1981) show, depreciation generally exhibits a convex or geometric pattern. Furthermore, if a One Hoss Shay pattern of efficiency for an aggregation of capital assets is used, it is assumed that the useful life of all those assets are the same and that the efficiency decay of each asset is One Hoss Shay. Both assumptions are implausible.

Therefore, Concentric used the geometric decay approach to estimate capital cost and capital price, based on the following considerations:

(a) The geometric decay approach has been studied extensively in the literature and applied empirically in academic studies, including studies of utility regulation.

(b) The geometric approach is (relatively) straightforward.

(c) The Geometric Decay approach is consistent with the theoretical framework for determining capital cost. In capital theory, the price of an asset in a competitive market must be equal to the present discounted value of the expected annual rental rates of that asset over its entire service life with each expected rental rate being weighted by the corresponding annual productive efficiency.[111] The capital quantity and capital price obtained in the geometric decay model satisfies this fundamental equation.

2. Capital Quantity

Capital Quantity is a measure of a utility's distribution capital stock in any year. Capital Quantity reflects the value of the plant that is available to be used in a year, accounting for the value of plant additions in each earlier year and the remaining useful portion of that vintage of plant additions and plant retirements. Ideally Capital Quantity would be measured by compiling the annual additions and retirements, measured in real dollars, starting at a company's inception. However, because published plant data of this nature is

109 OECD (2001), "Measuring Capital," OECD Manual.

110 Unless the real interest rate is zero, in which case the depreciation function is of the straight line pattern.

111 The theoretical framework is developed in Fuss (2012), Hall and Jorgenson (1967), Hulten (1990) as well as others.