

1 **Q. In order to prevent misunderstandings, it will be necessary for the parties to**
2 **agree on what they mean by “cost.” Yet there are many different cost terms in**
3 **use. Would you please identify and define the major terms that can be used to**
4 **describe cost studies?**

5 A. Certainly. For purposes of this discussion, the most fundamental and important types
6 of cost are *fixed cost, variable cost, total cost, average cost, marginal cost, and*
7 *incremental cost*--all of which are integral parts of economic theory--as well as the
8 cost concepts, derivative of the above, that have recently come into use in discussions
9 of telecommunications cost theory. The latter include *long run incremental cost, total*
10 *service long run incremental cost, average service long run incremental cost, and*
11 *incremental service incremental cost*. For orientation purposes, I have provided
12 brief definitions of these terms below. I will also make use of certain other familiar cost
13 terms--*sunk cost, direct cost, joint cost, common cost, embedded cost, fully*
14 *allocated costs, etc.*, that are prevalent in the literature. Appendix B, attached to my
15 testimony, contains definitions and more detailed explanations of all these terms.

16 **Fixed costs** do not change with the level of production, during the planning
17 period or “run” under consideration. **Variable costs** change directly (but not
18 necessarily proportionately) with the level of production. Together, these constitute
19 **total cost**, which is the sum of all costs incurred by the firm to produce any given level
20 of output. Dividing the total cost of producing a given quantity of output by the total
21 number of units produced, one can calculate **average total cost**.

22 **Incremental cost** is the change in total cost resulting from a specified increase
23 or decrease in output. In mathematical terms, incremental cost equals total cost
24 assuming the increment of output is produced, minus total cost assuming the increment
25 is not produced. Incremental cost is typically stated on a per-unit basis, with the change
26 in cost divided by the change in output. Incremental cost can vary widely, depending

1 upon the increment of output which is being considered. If the entire increment from
2 zero units to the total volume of output is considered, incremental cost is identical to
3 total cost. Similarly, where the increment ranges from zero to total output, incremental
4 cost per unit is identical to average cost per unit. Because a wide variety of different
5 increments can be specified, a wide variety of different incremental costs can be
6 calculated. Thus, in considering any estimate of incremental cost it is crucially important
7 to determine whether or not the specified increment is relevant to the issues at hand.

8 **Marginal cost** is the same as incremental cost where the increment is
9 extremely small (e.g one unit) and the cost function is smooth and continuous. In
10 mathematical terms, marginal cost is the first derivative of the total cost function with
11 respect to output--that is, it is the rate of change in total cost as output changes.
12 Conceptually, marginal and incremental cost are very similar; however, there are a wide
13 array of incremental cost concepts, corresponding to the wide array of possible
14 increments that can potentially be analyzed. In contrast, marginal cost corresponds to
15 one small portion of this array--where the increment is narrowly defined and extremely
16 small.

17 **Long run costs** are those calculated under the assumption that most, if not all,
18 costs are variable, and few, if any, are fixed or sunk. In contrast, **short run costs** are
19 those which arise in situations where most costs are fixed. The classic long run concept
20 is sometimes known as a "scorched earth" approach--that is, no preexisting plant is
21 considered in the analysis. Instead, the firm is free to build precisely the size and type of
22 plant which best fits its assumed output level

23 All of these cost concepts have well-established definitions in the economics
24 literature, with characteristics and implications that are widely understood and accepted
25 amongst economists. More recently, some related costing concepts have been

1 developed that are of particular interest in the context of multi-product firms like
2 telecommunications carriers. While a variety of different names have been used to
3 describe these concepts, for convenience I will use those adopted by the Colorado
4 Public Utilities Commission, as set forth in their rules governing the costing and pricing
5 of telecommunications services. I have included a copy of these rules as Appendix C to
6 my testimony.

7 The **total service long run incremental cost** (TSLRIC) of a service (or
8 group of services) is equal to the firm's total cost of producing all its services including
9 the service (or group of services) in question, minus the firm's total cost of producing all
10 its services EXCEPT the service (or group of services) in question. Thus, it is a
11 particular form of long run incremental cost (LRIC), in which the specified increment is
12 the entire volume of output of a particular service, while all other services remain
13 unchanged.

14 The **average service long run incremental cost** (ASLRIC) of a service (or
15 services) is the total service long run incremental cost divided by the total number of
16 units of the service(s) in question. The **incremental service incremental cost** (ISIC)
17 of a service is the change in total cost resulting from increasing (or decreasing) the
18 quantity of output of the service by a small number of units, divided by that small
19 number. If the cost function is smooth and the increment is sufficiently small, ISIC will
20 approximate marginal cost.

21 As discussed more fully in my Appendix B, TSLRIC studies can be useful in
22 determining the existence and extent of subsidies and in developing public policies for
23 the preservation of universal service under circumstances where new entrants may
24 engage in "cream skimming" or where barriers to entry may exist (e.g., in rural, high-
25 cost areas). Other state commissions have endorsed the use of TSLRIC studies for this

1 purpose. For example, the Pennsylvania Public Service Commission endorsed TSLRIC
2 and rejected the use of embedded cost studies, which it concluded have been
3 "increasingly discredited by most sectors of the industry and most outside observers"
4 because their methodology is limited to embedded costs and fails to "provide for an
5 adequate depiction of future economic costs of telecommunications networks."
6 [Order, Docket No. I-00940035, at 11.]

7
8 **Q. Would you provide an example to illustrate the distinction between analyzing**
9 **average cost and analyzing incremental or marginal cost?**

10 A. Yes. The clearest distinction exists between marginal and average costs as these relate
11 to the manner in which fixed costs are treated. Average total costs include the total of
12 all fixed and variable costs, divided by the number of units of output. In contrast,
13 marginal cost includes only the rate of change in variable costs as output increases.

14 Consider, for example, the treatment of the cost of a pole. An average cost
15 estimate may include the total cost of the pole divided by the number of loops attached
16 to the pole. However, a marginal cost estimate would most likely exclude any costs of
17 the pole, since poles would be considered largely, or entirely, fixed.

18 Some might argue that in the long run, all costs are variable, and thus even pole
19 costs would vary somewhat. However, even if the pole costs do vary with output, they
20 wouldn't vary by much. The marginal cost of poles most likely would be very low, or
21 even zero, in the long run, despite the fact that the cost of poles is considered variable.
22 The reason is simple: the change in the total cost of poles resulting from changes in the
23 number of loops generally would be very small, or zero. In contrast, when computing
24 average cost, the entire cost of the pole is included, and this amount is divided by the
25 number of loops attached to the pole.

1 Admittedly, on some occasions the size of the pole might increase slightly as the
2 number of loops (and total weight of the cable) increased; or perhaps the spacing of the
3 poles would be reduced for the same reason. The point is not that pole costs are
4 absolutely fixed under any and all circumstances. Rather, the point is that any increase
5 in pole costs would normally be far less than proportional to the rate of increase in the
6 number of loops, and thus the marginal cost would be far less than the average total
7 cost.

8 In other words, even in the long run, where the number and size of the poles
9 can be optimized, and this optimizing process considers the number of loops, there will
10 be very little, if any, resulting variation in costs. This means that the rate of change in the
11 cost of poles will be extremely small, or zero, and thus the marginal cost associated
12 with poles will be far less than the average cost, even in the long run.

13 The same principle holds true for other costs which are largely or entirely fixed,
14 such as the cost of installing a cable on the pole. The cost of attaching a small cable,
15 such as one containing 25 loops, will not differ greatly from attaching a much larger
16 cable, such as one containing 900 loops. With the notable exception of splicing costs,
17 most cable installation costs vary less than proportionally with variations in the size of
18 the cable.

19
20 **Q. You have discussed a wide variety of different cost concepts. Which one(s)**
21 **should be used by this Board?**

22 A. The selection of costing methodology depends at least in part on the questions which
23 the Board wants to answer. Put another way, depending upon the purpose, more than
24 one cost concept may be appropriate.

1 For example, if the purpose is to analyze the relationship of a company's rates
2 for individual services to the resources which are expended when these services are
3 consumed, or if the purpose is to analyze appropriate rates which best achieve
4 economic efficiency, then marginal costs are usually relevant, and the ISIC may be
5 offered in the practical application of this concept.

6 Likewise, marginal cost information is useful in determining the presence or
7 absence of subsidies within a rate design. While the term "subsidy" is often used loosely
8 to describe any situation in which a rate element appears to be priced below cost,
9 under the economic definition a service is said to be subsidized only if the rate(s) are
10 below marginal cost. When speaking of whether or not a *particular item* or a
11 particular customer, or group of customers is being subsidized, one needs to focus on
12 the incremental cost associated with the specific increment of volume in question.

13 For instance, if one wants to know whether low income customers purchasing
14 local service under a special program are being subsidized, one needs to focus on the
15 specific increase in total costs that results from serving this particular group of
16 customers. Similarly, if one wants to test a particular rate element (e.g., toll calls in a
17 particular mileage band at night) for the presence or absence of a subsidy, it is
18 necessary to focus on the increase in costs that occurs when this particular usage
19 occurs. In this context, the marginal cost, or ISIC, is generally the best and most
20 appropriate cost measure to use in answering the subsidy question.

21 In contrast, if one is interested in testing whether an entire service offering
22 benefits from a subsidy, or whether an entire class of customers is being subsidized, a
23 broader measure of cost may be needed for an accurate answer. In this latter context, it
24 is necessary to consider the incremental cost associated with the entire service, or the
25 entire volume of output consumed by the class of customers in question. Accordingly,

1 when analyzing whether or not an *entire category of service* is being subsidized (e.g.,
2 basic local service as a whole), the TSLRIC is generally the appropriate test.
3