COST OF SERVICE STUDY DESCRIPTION - POWER

The purpose of the cost of service analysis is to distribute all of Electrico's costs amongst the various customer categories it serves.

The cost of service analysis breaks out all the costs of Electrico into simple functional areas (production, transmission, etc.) which are then classified by voltage level as being either energy related, demand related or customer related. These three major cost components are then allocated to the customer categories by voltage level based on allocation factors derived from basic customer data.

Attached Tables 1 to 5 are concerned with deriving allocation factors by voltage level and by customer category, considering customers' relative usage of system resources, including energy consumed, usage of system capacity and customer service resources. Table 6 then classifies Electrico's total cost of service into energy related, demand related and customer related cost components, by voltage level. On Table 7, the various allocation factors by customer category are then applied to the cost components and the total cost of service by customer category is derived. Finally, Table 8 provides a comparison of the allocated costs to revenues from existing tariffs which provides an indication of the adequacy of the existing tariff structure, as well as the extent of cross-subsidization between customer categories.

The detailed methodology of the study is described below, Table by Table.

Table 1 - Summary of basic customer data

This table provides most of the basic data used to develop allocation factors on Tables 3 to 5. In fact, this data makes up the majority of the information required for determining cost of service and, consequently, tariff design.

The data used are taken from Electrico's tariff application submitted to the REC in January 2001 and are forecasts for the full year 2001 (ending December 31). For regulatory submissions dealing with tariff changes, it is theoretically correct to use forecast data for a future "test" period, as tariff changes apply to future periods. On the other hand, actual data that are reconcilable with audited financial statements tend to be more reliable. As a result, data of both types are generally used, depending on particular regulatory requirements or what might be considered most appropriate at the time.

Table 1 contains three major pieces of data broken down by customer category and voltage level of supply. These include energy consumption, maximum demand and number of customers. Energy consumption plus losses (the effect on losses is addressed on Table 2) is an obvious basis for allocating energy-related costs. And, energy consumption by customer class and voltage level of supply has been taken from Table 24 of Electrico's January 2001 tariff application.

However, the relationship of customer demands to demand related costs and number of customers to customer related costs raises some questions.

Customer demands:

Although there is no doubt of the concept of demand related costs and that demand related costs require an basis for allocation formulated on customer demands, a number of problems are encountered in attempting to apply customer demands.

The first problem is which maximum demand to use. Alternatives include the non-coincident demand of the customer category, its coincident demand (that is, the categories' contributions to the system peak load) or, even perhaps non-coincident demands in the form of the sum of individual customer peak loads. It has also been argued that a portion of all demand costs, corresponding to base loads, is actually energy related. Or, that demand related costs corresponding to generation and main transmission facilities should be allocated based on system peak coincident demand and those corresponding to lower voltage levels should be allocated based on non-coincident demand. Although the allocation of demand costs has been (and still is) a subject of considerable debate, most electric utilities appear to prefer the coincident demand method, or a variant of it.

These variations typically entail calculating the average of customers' contributions to the system peak load for a number of peak load periods during the year. If, for example, a utility's peak load season extends over a period of three months, then the utility might take the average of the customers' contributions to the system peak load for each of the three months. This particular method would be called the "3CP" method, thus named because a 3 month average coincident peak is used. Different utilities have used the single CP method, 2CP, 3CP, etc.

The second problem associated with developing demand allocation factors is measurement. Generally, large electric utilities that can afford to carry out expensive load research studies can make reasonably good estimates of category peak demands and relative contributions to system peak demands, while smaller electric utilities must rely on estimates such as those made on Table 1. However, the uncertainty of these estimates can be mitigated by a sound knowledge of the load characteristics of the utility's customers.

The second to fifth columns of Table 1 provide an estimate of each category's contribution to the system's peak demand. The estimate is made in a two-step process.

First, estimates of each category's peak load are derived through the application of an estimated load factor to consumption. Except for the "Industrial Above 750 kVA" category, where some information on individual customer demands is available, all load factor estimates have been made based on Consultant experience. With Electrico staff possessing a more intimate knowledge of its system and associated customer consumption characteristics, more refined estimates can probably be made.

Customer billing demand in the case of Industrial Above 750 kVA is based on what is assumed to be metered maximum demand of 1472 MW, taken from Electrico's January 2001 tariff application. The maximum demands shown in the tariff application for other tariff categories do not make sense (probably because they have been estimated – and not very well – as opposed to

having been measured directly) and, therefore, are ignored for the purpose of this cost of service assessment.

Then, assuming 85% coincidence between the sum of individual maximum demands and the peak load of the whole category (based on Consultant experience and certain empirical research) results in category peak load of about 1,252 MW. As can be seen on Table 1, this amount has then been apportioned 785.6 MW to high voltage, 441.2 MW to medium voltage and 25.2 MW to low voltage, in proportion to Electrico's apportionment of the individual peak loads sum of 1,472 MW. This apportionment actually appears suspect because it is in exact proportion to the corresponding sales numbers by voltage level, which is possible, but unlikely. In any case, better data do not exist.

Based on the data provided by Electrico, load factors for Industrial customers have been estimated at the high end of their likely range. This results in a relatively low contribution by Industrial customers to the system peak load. To compensate, the load factors of other customer categories have therefore been estimated at the bottom of their likely ranges (based on Consultant experience) in order that the coincident peak loads add up to the system peak load (described in the following paragraphs).

The estimate of the category peak load in the third column on Table 1 is then computed in MW as the consumption in GWh divided by the load factor, divided by 8,760 hours per year and multiplied by 1,000 MWh per GWh.

In the fourth column of Table 1, an estimate is provided of the category's contribution to the system peak load in terms of the percentage of its peak load. For example, the category of Industrial over 750 kVA has been estimated to contribute 90% of its own peak load to the system peak load. The assumption is that category's actual peak load occurs at some other time.

Electrico's annual system peak load appears to occur just after dusk on a winter day in either December or January. This suggests that the peak load is mainly lighting based, occurring at a point during the day where economic activity is relatively high and there is a sudden need for lighting. During these months, this would occur late in the afternoon or early in the evening, sometime after 4:00 p.m., which is a typical peaking period. At this time, commercial and industrial activity is relatively high as it is not quite yet the end of the working day and, residential activity is also increasing as people trickle home from their daily activities. In addition, a very cold and windy day may result in a significant contribution, on top of lighting needs, from heating elements where either district heating and wood stoves do not exist or, merely to supplement these two main heating sources.

The percentage peak load contributions in the fourth column on Table 1 represent the Consultant's perception of what might be happening in the Electrico service area at about the time described above.

It can be seen on Table 1 that the sum of all peak demand "sales" is equal to 2,757.2 MW. This value has been estimated on Table 2 and is explained in the next section. For the sake of consistency, the total of 2,757.2 MW must be equal to the sum of the peak demand sales estimated

on Table 2. This total is arrived at on Table 1 on a "trial and error" basis by varying both category load factors and peak responsibilities within reasonable ranges. This also explains why all such estimates are rounded to the nearest 5% while the Wholesale customer peak responsibility estimate, being chosen as the "fine-tuning" number to arrive at a value of 2,752.7 MW, is expressed in one-hundredths of a percent.

The above process of playing with numbers to arrive at data that is at least consistent is performed in all cost of service analyses to varying degrees, depending on the accuracy of the available data. Electrico personnel are probably in a better position to make such estimates.

Number of customers

Electrico does not formally keep records of the number of connected customers. Although the numbers of customers shown in the final column of Table 1 have been provided by Electrico in a broad sense, the details (e.g., exact numbers by voltage level) have been estimated by the Consultant.

The number of customers by customer category and voltage level is used to develop allocation factors for customer related costs, with the justification that one customer, regardless of type or size, imposes an equal amount of effort in terms of customer related costs as any other customer. While this is not quite true (e.g., a large industrial customer requires a much more elaborate service entry and meter than a residential customer), this particular allocation basis results in an allocated cost that is much more reflective of cost causality than using kWh consumption.

As a refinement, customer related costs could be weighted so that a proportionately higher share is allocated to the larger customers to reflect higher costs of metering, more effort spent in terms of marketing, etc. However, based on Consultant experience, such a refinement normally does not significantly affect the analysis results, only because the sheer number of small customers connected to the system results in an overwhelming allocation of customer related costs to the smaller customers in any case. While a refinement such as this may be desirable in more detailed cost of service studies, for the present analysis, this is judged to be unnecessary.

Table 2 - Summary of losses by voltage level

The energy losses shown by voltage level at the top part of Table 2 have been indirectly estimated from Table 22 of Electrico's January 2001 tariff application. This part of the table combines the energy losses with sales and system use by voltage level (from Table 1) so all energy input to the grid from generating plants and purchases is accounted for. Company use for the purpose of the cost of service study is considered as a loss. Alternatively, Company use can be included as a "sale", that is, billed as any normal customer and, then, deducted as an expense.

It is not clear how Electrico has treated Company use in the January 2001 tariff application. However, it is assumed that one of the above methods has been used, thus simplifying the calculations and rendering the treatment of Company use as superfluous to this analysis.

The same principle of apportioning total GWh to sales and losses by voltage level is also applied to peak load losses at the bottom part of Table 2, except in this case, more estimates need to be made than in the case of energy. First, total peak load losses are estimated based on a generic relationship usually used by the Consultant in the absence of specific data. Electrico could probably develop better estimates.

In any case, peak load losses have been estimated to be 456.8 MW of the total peak load of 3,214 MW, thus leaving 2,757.2 MW in estimated peak load sales. These losses are then distributed by voltage level in the same proportion as energy losses.

Table 3 - Energy allocation factors

This table derives allocation factors by customer category for Electrico's energy related costs.

Starting with consumption by category at the low voltage level (as provided on Table 1), this calculation adds losses incurred (as per Table 2) plus consumption (as per Table 1) at each successively higher voltage level. As the calculation proceeds to the right, all energy input to the high voltage system is finally allocated to all the customer categories. This complete allocation of energy input to the system then forms the basis for the calculation of allocation factors for energy related costs, in the final column of the table.

Table 4 - Demand allocation factors

This table derives allocation factors by customer category for Electrico's demand related costs.

Starting with peak load responsibility by category at the low voltage level (as provided on Table 1), this calculation then adds peak load losses incurred (as per Table 2) plus demands (as per Table 1) at each successively higher voltage level. As the calculation proceeds to the right, all of the maximum demand of 3,214 MW input to the high voltage system is allocated to the customer categories. This complete allocation of maximum demand input to the system then forms the basis for the calculation of allocation factors for demand related costs in the final three columns of the table.

It should be noted that three sets of allocation factors are required in this case, because of the structure of demand related costs.

As will be seen on subsequent tables, demand related costs of transmission are allocated to all customer categories, as transmission facilities exist to meet the demands of all customers. Therefore, transmission voltage input by customer category is used as the basis for deriving the allocation factors.

On the other hand, because high voltage distribution facilities are not used at all to serve transmission customers, demand related costs of high voltage distribution are allocated to all customers except those taking supply at transmission voltage. Distribution system input by

customer category is used as the basis for deriving these allocation factors. And, for the same reason, demand related costs of low voltage facilities are allocated only to low voltage customers, with low voltage distribution input used as the basis for deriving the allocation factors.

Table 5 - Customer allocation factors

This table derives allocation factors by customer category for Electrico's customer related costs.

Starting with number of customers by category at the low voltage level (as provided on Table 1), this calculation then adds customers at each successively higher voltage level. These cumulative numbers of customers by voltage level then form the basis for the calculation of customer allocation factors in the final three columns of the table.

As with demand related costs, there are three levels of customer related costs, corresponding to transmission voltage, high voltage distribution and low voltage distribution.

With the customer allocation factors derived on Table 5, all customer-related costs are allocated to individual customers equally, regardless of size. Although this is a more accurate method of allocating customer-related costs than, say, using energy or maximum demand, it should be recognized that large customers are generally responsible for a larger portion of these costs than small customers. Certainly, relatively more effort in terms of metering resources, billing and customer service is directed towards larger customers. As a result, more refined cost of service analyses use "customer weighting factors" to increase the relative weight of larger customers.

For the time being, the development of such weighting factors is judged unnecessary, given the approximate nature of the input data in general. These factors may be developed if a more refined cost of service analysis is performed again for Electrico.

Table 6 - Summary of estimated 2001 costs and allocation to cost components

In the first column of this table, all of Electrico's estimated 2001 costs from the January 2001 tariff application are summarized into the main functional areas of production (including generation and purchases), "high" voltage (or transmission), "medium" voltage (or distribution high voltage) and low voltage.

It should be noted that a cost of service study usually provides a much more detailed listing of accounts than that shown on Table 6 and, further allocations are conducted within the study itself. In this particular case, many of the intricate allocations usually performed in a cost of service analysis have already been provided. The allocation, performed by Electrico, has been accepted for the current cost of service study, mainly for the purpose of presenting as simplified an analysis as possible.

In detailed cost of service analyses, Table 6 is usually first broken out into 4 or 5 separate tables, simply because it is too cumbersome to fit all the cost items onto one table. These detailed tables

typically include:

- Operating expenses.
- Depreciation expenses, if details exist of depreciation expense by type of plant.
- A detailed listing of fixed assets (or, better, a "rate base" which would typically consider the fixed assets net of accumulated depreciation and, may include other items of invested capital, such as working capital). This allocation, in turn, is then used to allocate return on capital, including profit, interest expense and, possibly, income taxes.

Then, considerable thought is usually given to how all the detailed items of cost can first be "functionalized" or allocated to the main functional areas of production, transmission and distribution.

For example, the allocation of transportation equipment costs should entail an analysis of the utility's whole transportation fleet, truck by truck, car by car, for each piece of equipment asking the question of whether it is used, wholly or partly, by the generation, transmission or distribution functions. Only after all cost items have been examined in this manner and then appropriately allocated, would items that cannot be directly assigned (e.g., costs incurred for a vehicle used by head office personnel for a number of general purposes) be allocated on a more general basis.

Thus, to arrive at a succinct breakdown of total utility costs, as shown in the first column of Table 6, is normally not a simple exercise and, in fact, is quite often is the subject of intense regulatory scrutiny.

Before moving beyond the first column of Table 6, it can be seen that "General Expenses" have been estimated by the Consultant to be 1,368,858 thousand Rubles. This amount has been further broken down as being one-third customer-related and two-thirds "all other", again estimated by the Consultant. These approximate breakdowns, based on Consultant experience, recognize that a significantly large part of total expenses relate to general and administrative activities. Furthermore, customer accounting activities, meter reading, billing, collecting and customer service, among other general expenses, can then be identified as distinctly customer related. Such expenses are usually well defined in a utility's code of accounts.

The remainder of Table 6 allocates the functionalized costs of the first column into energy-related, demand-related and customer-related cost components by voltage level of supply. The rationale for these allocations is provided in the following paragraphs.

<u>Production costs (including purchased power)</u>

In general, the fixed costs of production can be considered as demand related, while variable costs are energy related, simply because the fixed costs are incurred, regardless of actual output, to meet a level of maximum demand. Variable costs such as fuel depend on kWh produced.

The allocation of purchased power to demand and energy depend on the demand-energy structure

of the power purchase tariff. In this case, since the wholesale tariff to Electrico is completely energy based, all power purchase costs are considered energy related.

This fixed-variable demand-energy relationship is generally valid for all types of generating plant, except perhaps for hydro facilities with water storage (as opposed to run-of-river hydro plants). In this case, a portion of the fixed costs of civil works might be considered energy-related because the storage facilities provide energy as well as the capability to increase plant capacity from what is possible from a run-of-river plant. However, given the absence of hydro-based resources on the Electrico owned system, this is an academic discussion.

High Voltage (transmission) costs

These costs are considered 100% demand-related, because transmission facilities are sized to meet expected maximum demand.

Medium Voltage (high voltage distribution) and Low Voltage costs

Distribution systems are partly demand-related and partly customer-related.

Customer-related components in a distribution system would definitely include meters and specific service lines to customer facilities. Such facilities can be considered 100% customer-related, as they are installed for the purpose of serving specific customers.

Distribution lines that are used by more than customer (considered as being "above" the service line) are generally thought of as being partly customer-related and partly demand-related, although in some cost analyses, all facilities above the service line are treated as demand-related only. The rationale for the demand-related component is that these facilities are sized to meet maximum demand. Also, however, the extent of distribution lines depends on where customers are located and, therefore, a customer-related component exists.

The division of distribution costs into demand-related and customer-related components can be evaluated through a detailed analysis of the distribution system. The demand-related/ customer-related split on different distribution systems can be determined by undertaking "minimum system" and "zero intercept" studies, although such detailed analyses are much beyond the scope of the present work with Electrico.

Based on the Consultant's knowledge of the Electrico system and experience elsewhere, it is assumed that the demand/ customer split of the distribution system as a whole is 70% demand-related and 30% customer-related. More refined estimates may be made if a cost of service analysis is performed again for Electrico.

General expenses

As previously mentioned, General Expenses has been split into two components - those expenses that are customer related and those expenses that can really be classified as "general". It can be seen on Table 6 that the customer related general expenses have been allocated 100% to the "HV"

level, since such expenses would apply equally to all customers (subject to the discussion of customer weighting factors in Table 5).

The remaining general expenses are then allocated to each cost component and voltage level in proportion to the sum of the fixed costs of all the previous items allocated, from production to low voltage distribution.

It should be noted that the above allocation is normally performed as part of the "functionalization" process followed in arriving at the first column of Table 6. However, as previously mentioned, Electrico has already provided the first column of Table 6, which has been accepted for the purpose of the current cost of service analysis.

Profit

As can be seen on Table 6, Profit is allocated in a manner similar to General Expenses to the various cost components and voltage levels, that is, in proportion to all other fixed costs.

Conceptually, the notion of profit in the Russian power sector is as a markup on expenses. If this notion is correct, then the allocation of Profit on Table 6 is also correct.

However, profit is generally thought of as return on invested capital. Therefore, a more appropriate basis to allocate profit is in proportion to the assets in which the capital is invested, or, the previously mentioned "rate base".

On the other hand, the fixed asset records of Electrico may be suspect, as they probably are throughout the former Soviet Union. Also, Profit in this case only makes up about 9% of the total cost of service, meaning that the choice of allocation method for Profit will not have any great effect on the results of the analysis. Given these considerations, the particular allocation of Profit on Table 6 is the best allocation that can presently be made and, in any case, will not significantly the results for 2000. However, it should be noted that this allocation method is not conceptually correct.

In any case, as the regulatory environment develops and, the notion of a return on rate base becomes used, in addition to an eventual thorough valuation of fixed assets, then Profit can be better allocated.

Table 7 - Allocation of cost components to customer classes

In this table, the totals by cost component at the bottom of Table 6 are re-distributed to customer categories in accordance with the allocation factors derived on Tables 3 to 5. The particular allocation factors used for each cost component total are provided at the bottom of the table.

The summation of all costs allocated to each customer category is then shown in the extreme right-hand column of the table, thus providing the complete allocation of all estimated Electrico 2001 electricity costs to the various customer categories served.

Table 8 - Revenue/ cost comparison

This summary table provides an indication of the adequacy of Electrico's electricity tariffs over the course of 2001 and the levels of cross-subsidies in the tariff structure. This is done by comparing total revenues from tariffs in 2001 for each category to corresponding allocated costs, as finally derived on Table 7. The first column of Table 8 shows these total allocated costs.

The next three columns on the table calculate total revenues by customer category at expected 2001 tariff levels, according to the 2001 Business Plan. Since the timing of the Business Plan and the January 2001 tariff application do not coincide, it is recognized the data are not completely consistent. However, they judged to be close enough for the purpose of the cost of service study and its accuracy.

Not surprisingly, the total revenue calculation does not equal total allocated cost of service. The difference between the two numbers is about 3%. This error in the revenue calculation is then spread over all customer categories on a pro-rata basis, in the next column of the table.

This error will not have a large effect on the study results. For example, the revenue to cost ratios of about 10% for certain residential customers will not be greatly affected.

Finally, the ratio of total revenues to total costs is calculated in the final column.