UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Utilities Service

BULLETIN 1724D-101A

SUBJECT: **Electric System Long-Range Planning Guide**

TO: All RUS Electric Borrowers

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OFFICE OF PRIMARY INTEREST: Distribution Branch, Electric Staff Division

FILING INSTRUCTIONS: This bulletin is a reissue of Bulletin 1724D-101A that superseded RUS Bulletin 60-8, "System Planning Guide, Electric Distribution Systems" revised October 1980. Replace earlier issues of this bulletin and RUS bulletin 60-8 with this reissue.

PURPOSE: This bulletin provides general guidance in system planning for owners and engineers of electric systems and specific guidance for RUS electric borrowers in preparing their long-range engineering plans.

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ABBREVIATIONS

BER	Borrowers Environmental Report
CFR	Code of Federal Regulations
CWP	Construction Work Plan
FCR	Fixed Charge Rate
G&T	Generation and Transmission (Borrower)
GFR	General Field Representative
LRP	Long-Range Plan
O&M	Operations and Maintenance
PRS	Power Requirements Study
REA	Rural Electrification Administration
RUS	Rural Utilities Service
SCADA	Supervisory Control and Data Acquisition
TIER	Times Interest Earnings Ratio

APPENDICES:

1. PURPOSE: The purpose of this bulletin is to provide general guidance in system planning for owners and engineers of electric systems and specific guidance for RUS Electric Borrowers in preparing their long-range engineering plans. Detailed guidance for preparing construction work plans is provided in RUS Bulletin 1724D-101B "System Planning Guide, Construction Work Plans."

2. REQUIREMENTS OF THE LONG-RANGE PLAN: The long-range plan (LRP) is a management tool and a guide for the following:

a. The most practical and economical means of serving future loads while maintaining high quality service to the consumers.

b. An outline for anticipated system changes in terms of major facilities, demand levels and associated costs.

c. An indication of future system costs for financial planning and decision making.

3. PLANNING FUNCTIONS AND GENERAL GUIDELINES: There are four major functions of system management: objective setting, planning, execution, and control. System planning also has these four functions. Load forecasts and various system standards should be developed for the system (objectives); the long-range system plan should be developed (planning); the necessary facilities should be constructed in the appropriate time frame (execution); and the LRP should be periodically reviewed to verify its continued applicability (control). Thus system planning is a continuing dynamic process which results in a plan that is broad enough to cover all foreseeable problems and is flexible enough to allow for revision to cover changing circumstances.

3.1 It is the responsibility of the system planner, hereafter called the planning engineer, to sort out available information to determine the optimum approach for the individual system to use in attempting to provide adequate capacity and quality of service in a reliable, economical, and environmentally acceptable manner.

3.2 Some plans may require revision within a short time of completion while others may require no significant revisions after several years of use. Regardless of the date of preparation, the LRP being used should be appropriate and should consider the latest information available.

3.3 Long-range system planning calls for analysis of the system far beyond the present design requirements. See Section 4.4 for details regarding criteria for long-range system planning. In several regions of the country, generation and transmission (G&T) cooperatives arrange for all members to update LRPs at one time to facilitate G&T planning.

3.4 A LRP provides a guide for developing the existing system toward the capacity level which will be required at the end of the planning period, through construction of new facilities and expansion or replacement of existing facilities at appropriate times. By using this approach, any interim change or system addition will be compatible with the needs of the final study level.

3.5 Although each system's LRP will be different, all plans should have the following basic provisions:

a. Orderly system development to minimize waste due to early obsolescence or inadequacy of facilities.

b. As much as possible, system expansion investment that is in step with expected loads. Maximum use of opportunities to improve the quality of service at minimal cost.

c. Provisions for future decisions to incorporate appropriate developments in equipment design and application.

3.6 Owners of many systems have, or will have, large and complex communication facilities for collecting and/or disseminating information related to load management such as; Supervisory Control and Data Acquisition (SCADA), Distribution Automation (D.A.), and/or remote meter reading and consumer accounting via telephone, radio, or power line carrier. It is recommended that a long-range communication study and report be performed periodically and that a summary of this report be included in the LRP. As an alternate, the communication study may be done immediately following the LRP.

3.7 System planning can be divided into five distinct tasks, as follows:

a. Basic data should be maintained and continuously updated to facilitate the evaluation of newly proposed alternatives throughout the LRP period.

b. The existing system should be analyzed to ascertain its ability to serve present and projected requirements. Objectives of the owners should be considered in the system analysis. The planning engineer should determine what additional capacity is needed and what facilities will need replacing during the long-range planning period. This information will aid in the judicious selection of alternatives.

c. Once the system requirements have been determined, various alternative plans can be formulated which will satisfy these requirements.

d. By careful application of present worth analysis or some other valid economic analysis procedure, the owner or engineer can select the optimum plan for the projected requirements. It is extremely important that each alternative evaluated provides for adequate quality of service, environmental acceptability, and adequate system capacity at each level of the LRP period. Some alternatives may provide a temporary excess of capacity. This excess should be justified through reduced overall construction costs or reduced losses.

e. When starting a new construction work plan (CWP), the LRP should be reviewed in light of actual system developments to determine whether it needs to be revised or updated. A CWP should then be prepared to determine which of the facilities demonstrated to be necessary in the LRP will be most appropriate to install during the immediate work plan period.

4. INITIAL STEPS IN SYSTEM PLANNING: Although actual planning procedures followed by each planning engineer may vary in detail from those described in this guide, for the sake of uniformity, planning engineers should make an effort to follow the format presented here. The RUS GFR is available to assist the owner and the planning engineer in developing a useful and acceptable LRP.

4.1 Preliminary Conference: The owner should arrange a preliminary conference with the planning engineer. The RUS GFR and the power supplier should also be invited to attend.

4.1.1 At this conference, the owner should provide the planning engineer with the following basic data:

a. Up-to-date copies of circuit diagrams, one set of detail maps and a system key map, all showing the existing system.

b. The latest RUS approved Power Requirements Study (PRS) because the LRP loads must be consistent with the PRS.

c. Local Planning Board maps or other data regarding existing and projected (i) population density; (ii) zoning and land use; and (iii) areas known to be environmentally sensitive.

d. Locations of existing and expected future housing developments, large power, irrigation and special loads.

e. The latest available data concerning load factors.

f. Detailed outage records for the distribution system, transmission system and power supplier delivery points. Causes of power supplier outages should be accounted for.

g. A copy of the owner's energy conservation plan along with information on any existing or proposed load management system.

h. Results of all recent voltage and current investigations, phase balance and sectionalizing studies and information on power factor of the system and of distinct areas of the system.

i. Present and projected wholesale power contracts and rates for both existing and planned power sources.

j. Existing and future fault current (or impedance) and voltage limit calculations from power supplier and their statement of future limits of capacity, provisions for future delivery (metering) points, and plans for future transmission lines.

k. Plans for any new transmission delivery points or voltage changes.

l. A copy of the latest RUS Form 300, "Review Rating Summary."

m. Cost summaries for recent construction of various types of facilities in the existing system and other records of operations on which cost estimates may be based.

n. Costs of metering points if furnished by others and charged in some manner to the borrower.

o. The cost and availability of new capital to a borrower, which should be studied and tested for sensitivity. (Trends should be established, on an embedded cost of capital for the life of the LRP. It is appropriate to include in the fixed charge rate (FCR) and a return on the member/owner's equity which is related to the borrower's Times Interest Earnings Ratio [TIER]).

p. The correct determination of the borrower's fixed charge rate(s) which is crucial to the proper selection of economic system improvements. There may be different fixed charge rates for distribution or transmission or communication projects; or for RUS financed or non-RUS financed projects. (Appendix III presents data useful in calculation of a FCR.)

q. In some planning alternatives, other related organizations' investments and their FCR may be needed.

r. The assumptions and methods used in arriving at the financial criteria. (It should also be documented in the LRP.)

s. Any other pertinent data related to the services to be performed by the planning engineer, such as possibilities for joint ventures with neighboring utilities, and the owner's current study of economic standard conductor sizes.

4.1.2 Much of the above information may already be in the possession of the engineer or available from billing files. The planning engineer should assist the owner in establishing and developing a procedure for updating this basic data file which will be useful in future planning activities. The planning engineer should also recommend methods of and locations for voltage and current investigations and methods for extracting the necessary load data from computerized billing files. This load data is invaluable for load forecasts, rate analysis, and long-range financial forecasts.

4.1.3 Since the LRP will be no better than the data on which it is based, the planning engineer should review the basic data for adequacy. The planning engineer should request any necessary additional data and recommend improvements in programs used for regular data collection and record-keeping. This will insure availability of sound data for continuing system planning activities.

4.2 Analysis of Existing System: The analysis of the existing system may indicate where alternate proposals are most likely to be economical and provide insight into the development of a practical transition from the existing to the proposed long-range system.

4.2.1 While the CWP covers many of the same topics as the analysis of existing system, the analysis of existing system should approach the subject from the standpoint of major, basic, design needs while the CWP should approach the subject from the standpoint of necessary changes in facilities within the context of established basic design. Therefore, even if a CWP has recently been completed, an analysis of existing system should be prepared for the LRP.

4.2.2 It will be necessary for the planning engineer to determine how the system load will be distributed among the various regions of the system. To predict with reasonable accuracy the requirements of these various regions of the system, by line section, substation area or by geographical sections, it is necessary to have information on the number of consumers, load per consumer, load growth potential, density, types of load expected, and total load for various regions of the service areas in the present and the projected system. Data should be collected for small enough unit areas to indicate boundaries of larger load density regions. Even a system which anticipates an overall zero or negative load growth must prepare for the possibility of some regional load growth. Valuable regional growth information may be obtained from local land use planning organizations, chambers of commerce, etc. An econometric model, if available, may provide some of this data.

4.2.3 The existing system should first be analyzed to determine how well the existing facilities are meeting the present needs of the system as indicated by metering and billing data. The areas of the system where it is difficult to achieve acceptable levels of system performance should be identified. This information along with the system growth patterns, discussed above, should indicate the areas where the most drastic or immediate action is needed.

4.2.4 In addition to such considerations as transformer capacity in existing substations, the planning engineer should review the space limitations for increasing the capacity of present substations. A determination should be made if there is room for installing recommended new circuits, if there is room for additional feeders along existing rights-of-way, if the substation can be expanded to include transfer (by-pass) buses or for upgrading high-side fuses to breakers, etc.

4.2.5 Studies should be made to determine which areas of the system are voltage limited and which are thermally limited and if some facilities are so old that they will need replacement during the term of the LRP based on age or deterioration.

4.2.6 If system aging studies have been performed on all or parts of the supply facilities of the system, then the results of these studies should be analyzed and included both in the analysis of the existing system and the engineering analysis used during the preparation of the LRP. If no such study has been previously prepared, the planning engineer should determine (generally by multi-year increments and percentages) and analyze the age of the supply facilities. Of particular concern are the facilities which will be beyond their useful life before the end of the planning period. The planning engineer should document this data and the methodology and assumptions used in deriving it, and use this information during the preparation of the LRP.

4.2.7 By comparing the performance of various areas of the system, the planning engineer can locate those sections which will benefit from more drastic improvement efforts. Analysis of the following conditions will indicate the level of performance of the existing system:

- **a.** The results of voltage, current and power factor measurements, and voltage drop calculations for critical feeder points should be reviewed.

- **b.** A service reliability study will indicate areas of the system which need special attention and may even indicate the general type of work which will be most cost effective in correcting such service deficiencies.

Service interruption records for the preceding five year period should be examined with particular attention given to interruption averages for each distribution feeder and for each substation. These averages will indicate major differences in service reliability in various regions of the system. Frequent and/or long duration outages should be noted and the probable cause determined. This information should be compared to the service reliability standard set by the owner. If the power supplier is responsible for an excessive amount of the outage time (typically, more than one (1) consumer-hr per consumer/yr averaged or trended over 5 years), this should be noted. The power supplier should be requested to supply comparable outage analysis for all similar delivery points.

c. Demand and energy losses are extremely important. Through review of operating records, the demand losses at peak time, and energy losses in kWh per year and in percent should be determined for substation and metering point areas throughout the system. These loss levels should then be compared with those of other similar borrowers. The probable cause of any excessive area losses should be determined and noted for possible corrective measures. Power factor analysis should be used to arrive at an economic power factor for the system, which should decrease losses.

d. O&M expenses on a system are dependent on such factors as cost of labor, load density, number, size, and age of facilities. By analyzing the O&M expense allocations on the system, those items with exceptionally high operating expense rates can be properly identified and methods of reducing those expenses evaluated. O&M items which appear not to be receiving adequate funds should be compared with outage and inspection reports to ascertain if additional emphasis is required. (Most systems are at an age where certain obsolescent components should be budgeted for orderly replacement. This may reduce O&M expenses.)

4.2.8 Based on the analysis of the existing system, the planning engineer should make recommendations for improving system performance and increasing system capacity for expansion. In addition, the planning engineer should recommend more detailed measuring or record keeping for those areas where data is inadequate. The basic data and analysis of the existing system should be prepared in draft form for use during the intermediate conference. Later the final report should be made a part of the system planning report. (See Appendix II).

4.3 <u>Intermediate Conference</u>: When the planning engineer has completed the analysis of the existing system, the owner should arrange an intermediate conference to discuss the study (to date) and the direction in which the study should continue. The conference should be attended by the manager, the operations manager and the line superintendent, any other appropriate system personnel, and the planning engineer. The RUS GFR and a representative of the power supplier should be invited to attend. The conferees should review the analysis and the basic data for adequacy, and determine if any additional data is needed and the method to be used in obtaining it. Basic planning criteria should be established for the LRP at this conference.

4.4 Criteria for Long-Range System Planning: Since the LRP should be used to guide the development of the system for a number of years, the criteria used in formulating the plan is of utmost importance. The owner has the primary responsibility for selecting the planning criteria. The recommendations of the planning engineer and the RUS GFR should be considered before selecting the planning criteria. The following brief discussions suggest some of the planning criteria that should be established.

4.4.1 The LRP should be designed to anticipate what needs to be done for the system to provide adequate and reliable electric service to the consumers over a long period. It is recommended that the LRP provide for the system requirements for 10 or more years in the future. For most systems, this will allow comparisons of alternate plans of providing for increased service in various parts of the system and in the system as a whole, without going to extremes of too short or too long a period to be credible.

4.4.2 Other long-range planning periods can and should be used if the choice for an alternate time period is adequately explained and justified by the planning engineer. The appropriate span of the planning period is a function of the following factors:

a. The anticipated load levels at the end of the planning period.

b. The forecasted growth rate of the system or major portions of the system;

c. The age of the electrical supply facilities, both at the beginning and the end of the period. Particular attention must be given to the percentage of the facilities which are or will be beyond their useful life; and,

d. The validity of the future economic factors, such as inflation rate, especially toward the end of the planning period, which are being used for the engineering economic analysis of the alternate plans in the study.

4.4.3 For growing systems, or systems which have areas of load growth, the following compound growth rate equations can be used to forecast loads beyond the period of the PRS.

$$\text{Future Value} = ES \times (1 + i)^{n}$$

where ES = existing system parameter
i = the annual average long-term growth rate
n = number of years.

System loads and growth rate should be consistent with the PRS.

4.4.4 Systems with negative, zero, or slow growth need a careful analysis of their special conditions to assure that their systems are optimized. For instance, feeder lines may require replacement due to age rather than because of thermal loading or voltage drop.

4.4.5 The effectiveness of the long-range demand level is generally more dependent on its relative magnitude than the time frame. In some critical situations, however, the exact time frame will determine which of two alternatives will be more economical. In such cases, more precision should be used in establishing the time frame during the plan selection phase.

4.4.6 Very seldom will a system have uniform load density and growth potential. However, by analyzing the system load and population and/or electric service maps prepared as suggested in section 4.2, and land use plans for the system area, those regions with similar requirements can be located and grouped for similar handling. Estimates of growth potential and realistic maximum energy usage per consumer should be incorporated to project ultimate area demand levels. Thus the total system demand and the average growth rate of the entire system will be determined by the demand and growth rate of the various portions of the system.

4.4.7 Depending on the size of the system, loads with more than a predetermined size (100-1000 kVA) of connected transformer capacity, and concentrations of small pumping and irrigation loads, should be identified by size and location. These special loads will require special consideration with regard to their demand on the system. Management should analyze the special loads presently served to determine the kW size for each of those to be considered in the LRP. Only those which are large enough to significantly affect the supply system need be analyzed. Those special loads that management is reasonably sure will be served by the long-range system should be provided for in the plan. Other special loads, not supported by reasonably firm data can be designed for on an individual basis as they develop.

4.4.8 A service reliability standard provides a basis on which management can evaluate system performance. The importance of service reliability should be reflected in the long-range system plan. Because of wide differences in operating conditions and local requirements, RUS does not attempt to specify a service reliability standard for all systems. However, each borrower should adopt a standard which will serve as a goal in the development of its system. The five consumer hours per consumer per year interruption rate used for loan applications should not be considered as a goal. Rather, system goals should be nearer one hour for suburban and two hours for rural consumers. Furthermore, it should be recognized that except during truly unusual major storms, consumers are not concerned with the source of an interruption. Whether the power is off only for their individual transformer or because of a power supplier's interruption, makes little difference to the consumer. Thus all sources of interruption should be considered for possible improvement in service reliability.

4.4.9 Any additional criteria which management is considering, should be carefully evaluated for its benefit to cost relationship and should be discussed thoroughly with the planning engineer and the RUS GFR.

5. DESIGN CONSIDERATIONS: The system should be designed to provide adequate, reliable, and quality service at a reasonable cost to all consumers. Many decisions made in formulating the LRP will affect or be affected by the system design. It is therefore important that the system planners are cognizant of these effects. The following discussions present items to consider in the design of the system.

5.1 Power Sources: Planning engineers should carefully consider the capacity and adequacy of all existing and prospective power sources. If the source is unable to supply the necessary quantity of power for its area, if the interruption record is poor, or if voltage levels will be inadequate, then alternative sources of power should be investigated. If the owner is a member of a G&T, these problems should be taken up with the G&T staff and/or the board. Interruption data should be recorded and evaluated on a regular basis for all existing power sources and interruption rates for prospective sources should be estimated based on records for facilities with similar characteristics.

5.1.1 The Public Utility Regulatory Policies Act of 1978 (PURPA) requires that electric utilities allow their consumers to interconnect privately owned generating equipment and requires the utilities to purchase power and energy from such facilities at reasonable prices. Thus the owner and/or the power supplier, through a coordinated effort if applicable, should establish a policy covering purchase of power from consumer-owned solar, wind, diesel, small hydro and co-generation installations. The owner should also consider the possibility of installing such facilities of its own as compared with the use of energy purchased from conventional generating facilities.

5.1.2 Differences in cost of power between alternative wholesale power sources should be considered (although it is usually unwise to design or redesign a system to take advantage of a temporary condition). Consideration should be given to the investment required in facilities to utilize the power and the availability of sufficient power when and where it is needed. The nearest or cheapest sources of power need not be selected if, overall, another source can be shown to be more appropriate. However, this option may not be appropriate for members of G&T's.

5.2 **Transmission Lines:** Although the LRP is not the place for detailed design of transmission lines, attention given to the proper aspects of transmission line planning may avert serious problems later. It is extremely important that the distribution system's LRP be coordinated with the LRP of the power supplier regarding transmission planning. Whether the transmission lines are owned by the distribution system or the power supplier, planning should be approached on a "one system" concept. Excessive costs for transmission facilities cannot be justified by minor savings on one part of the system. The converse is also true that excessive distribution plant should not be constructed simply to avoid transmission construction. Transmission facilities which are well planned will provide high continuity of service, long life of physical equipment, and safe operation at relatively low overall cost. The following factors should be determined for all transmission lines in the LRP.

5.2.1 The proposed line length, line-end points and future extensions should be approximated.

5.2.2 The voltage class of the transmission lines should generally be determined by the voltage of the line to be tapped. Occasionally an exception is justified due to superior reliability for a small increase in cost or where total benefits outweigh the added cost of the alternative.

5.2.3 Transmission conductors should be tentatively sized based on economic studies taking into consideration line losses, present and future power requirements, cost of upgrading the line when the conductor is no longer adequate, and the cost of carrying excess capacity until it is needed. Cost of stocking and hardware standardization should also be considered where a new conductor size has been indicated by other factors.

5.2.4 Environmentally sensitive areas along the corridor proposed for line routing should be avoided if possible. Also right-of-way requirements should be considered.

5.2.5 At least a rough check for stability and load flow characteristics should be made and if it indicates the need, more extensive studies (computer load flow, stability and transient network analyzer studies) should be performed. In some cases, load flow studies will influence the location and timing of major substation additions. The planning engineer should coordinate these studies with the owner and the power supplier.

5.2.6 The economy of radial feed substations should be weighed against the reliability of loop feed substations. The applicability of each design, as it pertains to the basic system design and established operating practices, should be carefully considered. Any proposed changes should be coordinated with the power supplier if applicable.

5.2.7 Acceptable transmission system voltage levels and variations from no-load (or light-load) to peak load need to be decided upon based on service voltage at a point of delivery, transmission line characteristics, load growth, type of load, distribution substation transformer characteristics, ability to regulate voltage on the distribution bus, and contractual provisions. For instance, some wholesale power contracts call for a ±5% variation under normal conditions, and a -10% variation during a single contingency condition.

5.3 Substations: A major decision to be made in long-range planning is the optimum number and size of substations needed to provide services to the system. If possible, the cost and reliability of additional substations should be weighed against the cost and reliability of other alternatives. Decisions as to the exact location of substations should be reserved for consideration in the construction work plan, with only relative locations considered in the LRP.

5.4 Reliability: Generally, shorter lines from smaller substations will lead to higher reliability; however, line reclosers and sectionalizers will improve reliability to some extent on long radial lines. Multiple substation transformers (four single-phase or two three-phase units), loop feeds into substations, and the availability of a mobile transformer or mobile substation all improve reliability. The decision on the size and number of substations needed in the LRP should be made based in part on system experience with the source of interruption hours and the cost of improving reliability in those areas.

5.4.1 It is not always possible to use the most economical system configuration (conductor size, line voltage and number of phases) and still meet system standards for voltage levels, service reliability and economy. Service reliability should be improved to any portion of the line of supply to the consumer where it can be done at a reasonable expense. Estimates of the incremental improvement in service reliability can be developed from experience with similar facilities.

5.5 Primary Distribution Lines: Whether primary lines are constructed overhead or underground, effective planning is needed to avoid premature obsolescence of facilities. Owners should have performed a study of economic standard conductor sizes that will give guidance in selection of conductor size, circuit voltage and number of phases for economic construction and operation of new and converted overhead and underground distribution lines.

5.5.1 It is necessary to consider many factors in determining whether distribution line construction should be overhead or underground. Overhead lines generally involve lower construction costs and ease of constructing additions and of maintenance. Underground lines generally have less environmental concerns, are less affected by storms, have lower line losses and less voltage drop for a given ampacity. However, underground lines are sometimes subject to certain technical problems, such as difficulty in adding voltage control or sectionalizing equipment, and high replacement costs.

5.5.2 Distribution lines should meet the voltage standards required by RUS or any more stringent local regulations when required. Generally, maximum voltage drop at extremities of feeder taps and minimum power factor are specified.

5.5.3 In spite of the high cost of rebuilding lines, and the careful planning done in the past, it will often be necessary to increase the capacity of existing sections of distribution line. Before deciding to rebuild a line, careful consideration should be given to a number of factors including:

a. If the line is quite old and will need replacement by the end of the LRP period, then rebuilding with increased capacity may be a better way of obtaining increased ability to serve load than building an additional line. In some cases, considerable research may be needed to determine the age of various lines. However, rough estimates of effective age considering the amount of maintenance which has been performed will be adequate for these purposes.

b. Since the rebuilding operation will probably require replacement of most if not all poles, a different route may now be more desirable than the original one. For example, a line originally constructed on a right-of-way remote from the highway might be moved adjacent to the highway providing more economical maintenance of both the line and the right-of-way, with perhaps a net increase in reliability. Environmental considerations, or territorial limitations of course, may preclude any rebuilding of lines in a given area. The alternatives should be considered carefully before a decision is made to re-route a distribution line.

c. It may be practical to serve sections from an alternate circuit or substation for a time until an improvement is constructed.

d. If another system improvement, such as a new substation or an additional new feeder, is planned for the area in the not too distant future, then the earlier construction of the other planned improvements should be considered.

5.5.4 When new distribution lines are needed, the routes should be chosen, where feasible, to be along improved roads to facilitate operation and maintenance and to provide maximum opportunity to serve existing and potential consumers. The specific details of the line location and design need not be determined until prior to the inclusion of the CWP.

5.5.5 Where it might be advantageous to change the system standard distribution voltage class, consideration should be given to all standard distribution voltage classes. Frequently only one alternative voltage will be feasible; however, occasionally a voltage class which was not considered at first will provide greater long-term benefits. After a voltage conversion has been made, a further conversion will not be feasible as many of the costs associated with another change would be incurred a second time with a smaller offsetting savings.

5.5.6 Virtually all systems use voltage regulators to maintain adequate voltage levels at extremities of distribution lines until major improvements can be justified. RUS recommends that some form of voltage regulation be used in substation and distribution metering points (unless a metering point has a well regulated supply). RUS further recommends that, in general, only one voltage regulator should be installed on the distribution line between any consumer and the substation. These are recommendations and not hard and fast rules. The LRP should provide for maintaining a regulated primary distribution voltage with a maximum voltage drop of no more than 8 volts at the extremities. Where more stringent requirements are imposed by local authorities, they must, of course, take precedence. Line drop compensation, which can improve operation and/or extend the range of voltage regulators, should be taken into consideration.

5.5.7 Consideration should also be given to the installation and optimum location of shunt capacitors on distribution lines. Capacitors provide a relatively low cost means to boost voltage and improve and control power factor. These improvements usually result in some demand reductions, energy conservation and lower power costs. Some voltage regulations can be achieved with the judicious sizing and locating of (usually switched) capacitor banks.

6. DEVELOPMENT OF THE LONG-RANGE PLAN: Because the plan should be based on the planning criteria, design considerations, basic data, and the analysis of existing system, little can be done regarding specific alternatives until after the intermediate conference. However, certain existing conditions will be evident as problem areas requiring that alternative configurations be considered for later economic comparison. After the intermediate conference, the major steps discussed below should be taken to develop the LRP.

6.1 **Exploratory Plans:** Typically, the demand level established for the long-range system should be large enough to permit the planning engineer to explore many possible plans and system configurations. The planning criteria and design considerations established in the intermediate conference should be followed in developing each exploratory plan. Each plan should make maximum economical use of existing facilities or correct a major problem while satisfying the planning criteria to the greatest extent possible. System standards for voltage, service reliability, etc., should be maintained by those facilities installed during the transition from the existing to the long-range system. Generally, only major items such as substations, transmission lines, and distribution feeder main lines, should be considered. The following are typical considerations for exploratory plans:

- **a.** Increase the capacity of existing substations and reconductor the distribution lines.
- **b.** Install additional substations, effectively shortening the distribution lines.
- **c.** Install loop feed transmission lines to substations.
- **d.** Install radial feed transmission lines to substations.
- **e.** Convert areas to a higher voltage class.
- **f.** Replace distribution metering points with transmission metering points or substations.
- **g.** Install additional feeders from existing substations.
- **h.** Install inter-substation ties.

6.1.1 Due to the nature of the LRP and the approximations made in various projections, detailed calculations are seldom cost effective for analyzing exploratory plans.

6.1.2 The planning engineer may wish to consider other approaches to expand the existing facilities to serve the long-range load. In most cases, it will be possible to establish two or three preferred exploratory plans without the time-consuming task of laying out and comparing a large number of designs. If the criteria prove too restrictive causing the exploratory plans to be unreasonable, the planning engineer should inform management giving recommendations for modifying the criteria.

6.1.3 Each exploratory plan should consider the major facilities required to provide a transition from the existing to the long-range system. The plans should be expressed in terms of capacity, costs and estimated years of expenditures. A list of required major system improvements should be prepared showing costs and the projected years in which they will be needed, respectively, for each exploratory plan.

6.1.4 Although each exploratory plan may not be able to have the same capacity each year of the study period, each alternative must provide similar reliability and capacity at the long-range load level. For certain facilities, capacity constructed before it is actually needed may help pay for the additional ownership cost from savings realized by reduced losses and avoidance of cost escalations. However, other facilities may not provide these benefits and should not be constructed before they are absolutely necessary.

6.2 Comparison of Plans: The following are typical of the comparisons and considerations which should be made in connection with developing the exploratory plans. This should not, however, be construed as limiting consideration to these examples.

6.2.1 Although an existing distribution metering point might continue to be used in the long-range system to serve the increased load by increasing the size of the conductor on the main feeder, the costs and benefits of such a plan should be compared with those of a plan involving the construction of a transmission line and substation to replace the metering point. Reliability of service should be examined for each of the plans being compared.

6.2.2 Although existing substations might be used in the long-range system to meet the increased system load through the conversion of 12.5/7.2 kV distribution lines to 24.9/14.4 kV, the costs and benefits of such a plan should be compared with those of an exploratory plan involving the construction of additional substations and transmission lines. All foreseeable costs associated with converting to the higher voltage level should be considered in the comparison, including increased costs of transformers for connecting new consumers and for changing transformer installations to existing consumers. The costs that may result from possible changes due to additional clearances need not be considered unless they can be documented.

6.2.3 Reliability of service should be examined under each of the plans being compared. Normally, establishing new load centers would effectively shorten the distribution lines, whereas, voltage conversion may result in an effective sacrifice in reliability. Consideration should therefore be given to methods of obtaining an offsetting increase in reliability, such as installing two three-phase transformers or a mobile substation. The incremental increase in reliability and cost of each alternative should be evaluated. Consideration should also be given to such possibilities as loop-feed transmission to the substation or more sophisticated distribution line sectionalizing to improve the reliability of the supply. Thus, the exploratory plans to be compared can be made to have similar reliability levels.

6.2.4 Where it is deemed necessary to abandon a delivery point (distribution or transmission) because of excessive outages attributable to the power supplier, the planning engineer should present supporting outage data plus any other information available which will justify replacing the metering point.

6.2.5 If an exploratory plan calls for the construction of transmission facilities because the existing power supplier's facilities are inadequate or unreliable, the planning engineer should, in addition to making comparative economic studies, present data to show evidence that the existing power supplier has been contacted and has not corrected the inadequacies. The point of delivery for the proposed transmission facilities will need to be from a reliable power source. If a change in power supplier is involved, information should be furnished to show that the new power supplier's facilities are adequate and reliable. The savings, if any, resulting from the change in wholesale cost of power, gained through construction of the transmission facilities, should be commensurate with the additional investment in facilities necessary to make the change. It should be shown that this is the most beneficial means for providing the reliability or capacity needed.

6.2.6 It may be that the power supplier will not provide bulk power at or near the owner's load centers. If the owner considers construction of its own transmission facilities, a careful comparison should be made of long-range costs and benefits of constructing and operating the transmission option versus long and/or large capacity distribution lines from the alternative substation to the load center.

6.2.7 Each exploratory plan should be based on power sources that the planning engineer and system's management are reasonably sure will be available. Every attempt should be made to persuade the existing power supplier to furnish adequate and reliable sources of power where they are needed.

6.2.8 Where necessary, alternative recommendations should be made based on savings that would be realized if the power sources could be obtained closer to the load centers. These alternative recommendations should be provided only for those cases that appear reasonable and practical.

6.3 Plan Selection: The development of the LRP should not be restricted by the limitations of the existing system. Although it must be recognized that there are certain inherent benefits associated with the continued use of installed facilities, alternative proposals should be adopted if the projected benefits from the change will exceed the cost of the change. Several factors must be considered in selecting the recommended LRP.

6.3.1 The primary concern in plan selection will generally be for comparative economics. In evaluating alternative exploratory plans, it will frequently be necessary to compare plans with widely varying time/cost distribution, i.e., one plan may have high first cost and another plan may have high annual costs. Simply selecting on the basis of lowest first cost or lowest annual costs may eliminate the alternative which would provide the best service at the most reasonable cost to the consumer. There are numerous methods of performing economic comparisons: present worth, annual costs, capitalized annual cost, minimum revenue requirements, etc. Any good textbook on engineering economics will explain several of these methods. Whichever method is used, the following factors should be considered:

a. Time Value of Money - The dollars spent this year are worth more than the dollars spent next year.

b. Inflation - Labor and material costs are increasing and will most probably continue to rise.

c. Specific Fixed Costs of the Owner - The owner's system has historical fixed charge rates provided as basic data. These rates may change with replacement of older facilities (decreased O&M, increased taxes, etc.) and would be expected to be different in the future. See Appendix III, Fixed Charge Rate Calculation Guide.

d. Demand and Energy Losses - It should be recognized that not only will the peak-load demand losses and the annual kWh losses increase with the system load growth, but the cost of those losses will also most likely increase.

6.3.2 When the economic comparison indicates the costs of two alternative plans are within 10 percent of each other, a sensitivity analysis should be performed to verify the validity of assumptions. Increase in interest, inflation, energy losses, growth rate, etc., should be considered to determine if the selected plan is likely to become less feasible after the owner has become committed to it. The results of the economic analysis and sensitivity should be represented in tabular form and included in the LRP report.

6.3.3 If two plans are still close after analyzing their sensitivity to overall cost changes, other factors should be considered:

a. Energy Conservation - Although energy losses were considered in the economic analysis, if two plans will cost roughly the same amount but one plan will result in a net energy savings, then that plan should be given a priority credit.

b. Excess Capacity - Although each plan must provide the minimum capacity required to serve the projected system load, one plan may provide more excess capacity at the end of the evaluation period. In that respect the plan with excess capacity is superior.

c. Service Reliability - Although each plan must provide for minimum levels of service reliability, one plan may involve inherently better service reliability. In that respect this plan is superior.

d. System Labor Costs - If a system has labor costs below the national average, a more labor-intensive alternative may be appropriate. However, if additional labor is not available in the community, a large construction program will require use of outside contractors for a larger percentage of the work to be done, which may change the system's average labor costs.

e. Flexibility - One plan may be superior in its capability of further expansion beyond the LRP level while the other will require radical changes in basic design parameters at that point. For instance, a superior option would be one which has a longer useful life than other options. On the other hand, the plan which defers major expenditures has the value of increased flexibility to take advantage of future developments.

f. Solution of Chronic Problems - One plan may eliminate a problem which has given management continuous service problems while the other plan does not. This should also be considered.

6.3.4 The techniques of cost benefit analysis may be helpful in evaluating alternatives based on the above factors. A good textbook on cost benefit analysis will explain the procedure.

6.3.5 Annual costs that are common to all plans may be omitted from the summary but explanatory notes should be included.

6.3.6 While economic comparison is the primary basis for plan selection, there is no substitute for good judgment based on all available facts. In some instances, indeterminate factors may necessitate the inclusion of an alternative plan to the selected LRP.

6.3.7 All work sheets, sketches, maps, etc., used in developing and testing the LRP should be retained for future reference. At the discretion of the owner, they may be retained by the planning engineer or may be turned over to the system staff.

6.4 Draft Review Conference: Following completion of the exploratory plans and the preliminary selection of the LRP by the planning engineer, a conference should be held to review the rough draft of the LRP. The planning engineer, the system manager, and other appropriate personnel should attend the conference. The RUS GFR and a representative of the power supplier should be invited to attend this conference. Based on the decisions made at the conference, the planning engineer should prepare a summary planning report. (Appendix IV is a sample form for the "Summary of System Planning Report" which the engineer may elect to use).

6.4.1 The owner should review the draft LRP report to verify that the plan:

a. Is the result of adequate and appropriate data, engineering analysis and judgment.

b. Provides sufficient data to serve as a guide for preparation of construction work plans and long-range financial forecasts.

6.5 Preparation of the Long-Range Engineering Plan: The long-range engineering plan should present the planning engineer's analysis of the existing system and the recommended LRP including the transition to the long-range system. An alternative plan should be included if there are indeterminate factors. The report should not present detailed analysis of exploratory plans; it should contain sufficient explanatory data and summaries of engineering analyses of these plans. The superiority of the proposed plan should be indicated and the cost differentials should be shown in dollars. The method of economic analysis should be indicated. When appropriate, small sketches of the system, or sections of the system, should be used to simplify or replace written descriptions. It is also suggested that summaries of basic data, economic comparisons, costs data and engineering analysis be presented in the form of tables or graphs.

6.5.1 The planning engineer should make suggestions to the owner of appropriate items to be standardized, such as conductor sizes, substation capacity, etc.

6.5.2 New construction and major system improvement items should be tabulated with approximate cost estimates and the approximate year of installation. Groups of other system improvements, including increase in capacity of services and transformers should be tabulated with cost estimates for each year of the plan. Existing plant investments and estimated annual cost of connecting new consumers should also be included.

6.5.3 Most RUS borrowers have extensive replacement programs in effect which will continue through the transition to the long-range system. Ordinary replacements are those resulting from rot, corrosion, wear and tear, damage, etc., and do not involve an increase in capacity or quality of service. The estimated annual costs of ordinary replacements should be tabulated as a separate item in the cost summary, as should maintenance and system improvements for each exploratory plan. These items would be included in future CWPs. The cost of replacements in connection with system improvements should be included in the investment figures for the system improvements.

6.5.4 The cost data tabulations should be broken down by types of facilities such as distribution, transmission and generation, if any. The report should include graphs or tabulations of the projected kW demand as related to time for each substation area or areas which have different levels of usage. Management will thus be able to relate investment in facilities to the time of installation for use in preparation of long-range financial forecasts.

6.5.5 A note should be added indicating the month and year on which cost estimates are based. Normally, all cost estimates should be based on present price levels with appropriate escalation factors used to estimate future construction costs.

6.5.6 A circuit diagram should be prepared for each major step in the transition including the existing system and for the long-range system. The diagrams should show regulated and unregulated voltage drops resulting from system loading at each step with and without the recommended improvements. Transmission lines of the borrower's system, the power supplier, and other transmission lines traversing the owner's system should be shown on either the circuit diagram or on a separate transmission diagram.

6.5.7 Detailed calculations upon which engineering analyses and other planning investigations are based need not be included in the long-range planning report. However, summaries of findings and assumptions used should be included to help management determine the continued validity of and make revisions to the study. Also, a bibliography which identifies all data, external documents and judgement sources should be included. Normally, the planning engineer should retain the calculations and work sheets as long as the system planning contract is in effect. Upon completion or termination of the contract, these files should be made available to the owner.

6.5.8 Appendix II, "The Suggested Table of Contents for Long-Range Engineering Plan," can be used as a guide in organizing the report and its table of contents. The order in which major sections are listed may be changed if it will improve the report. However, care should be taken to see that the requirements of RUS electric loan policies and application procedures are fulfilled and the presentation demonstrates good practice for engineering reports.

6.5.9 The LRP information should be summarized in a format similar to the sample form in Appendix IV.

6.6 Acceptance of Plan: The long-range engineering plan is subject to acceptance by both the owner's management and by RUS.

The owner's board of directors should signify its approval of the report by issuing a resolution. A copy of this resolution should be forwarded to the RUS GFR along with two copies of the report for RUS acceptance. At least five copies of the long-range engineering plan should be prepared: two copies are for the owner; two copies are for the RUS GFR; and one copy to be retained by the planning engineer. Other copies may be distributed to the power supplier and the Local Planning Board(s).

7. CONTINUING PLANNING ACTIVITIES: Planning for the future is a continuing process. Data should continually be collected to check the soundness of the existing plan and later to aid in preparing a new plan. The planning engineer should assist the owner in establishing methods for obtaining the required data from various operating records and files. Good system planning requires methods for keeping the plan up-to-date. It should also provide for CWPs to implement the transition through timely installation of facilities.

7.1 A CWP should provide a coordinated construction program. It should also provide much of the basic data needed in preparing the system's budget for additional capital investment. RUS Bulletin 1724D-101B, "System Planning Guide, Construction Work Plans," provides guidance in preparation, approval, and use of construction work plans. A well prepared construction work plan based on an accepted, up-to-date LRP is generally adequate to demonstrate planning support for a loan application to RUS.

7.2 The LRP should be reviewed prior to the preparation of a CWP to verify its continued validity. If the owner finds it necessary, due to unforeseen developments, more frequent reviews may be conducted. The basic data, design criteria, and assumptions used in its preparation should be compared with actual system developments. A recommended guide for reviewing and determining the adequacy of the current LRP, and documentation thereof, is found in RUS Bulletin 1724D-101B, "System Planning Guide, Construction Work Plans," Exhibit II-D1 (3 pages). If the LRP proves to be valid by the reviewer, it should be so documented in the construction work plan. If a revision to the plan is deemed necessary, the revision should be a separate concise report, with an appropriate title, properly dated and with the necessary references to the parts of the existing report that are being revised. The distribution of copies of any revisions should be the same as for the original system planning report. LRP revisions are subject to approval by the owner's board of directors and acceptance by RUS, similar to the acceptance of the original LRP.

7.3 Review (and revision as necessary) of the LRP will extend its useful life and indicate the need for a new plan when revisions are no longer adequate. Many things can happen to necessitate revision or replacement of the LRP. Loads may develop faster than projected in some areas and slower than projected in other areas; power suppliers may change their plans;

it may be necessary to provide for extensive transmission system construction; necessary rights-of-way may not be obtainable; laws and ordinances may change (such as requirements for underground line construction); and technological developments may occur. Any one of these may be reason for adjustment or replacement of the plan. Even if no major changes are needed, numerous minor revisions may necessitate a new LRP. The cost of planning activities should be considered as an investment which may minimize necessary expenditures. Thus long-range planning may be one of the most cost effective actions available to electric system management.

APPENDIX I

Definitions of Terms and Abbreviations

System Planning: System Planning is the careful analysis and evaluation of an electric power system, the consideration of alternative methods of meeting the electric power needs of the consumers, and the selection of the most promising of the viable alternatives for providing reliable, environmentally acceptable service at reasonable cost. System planning by RUS borrowers is manifested in the long-range plan (LRP) and the construction work plan (CWP).

Borrower: A Borrower is an organization which borrows or seeks to borrow money from, or arranges financing through, RUS for the purpose of constructing facilities or making improvements in that organization's electric system.

Owner: An Owner is the same as a Borrower, except that the term Borrower implies a relationship with RUS, while the term Owner implies a relationship with consultants, power supplier, etc. The responsibilities of the owner are generally carried out by the general manager (or person with similar title) of the owner.

Board: The Board is the board of directors or board of trustees of the owner. The board is responsible for setting policy including final approval of the LRP.

Planning Engineer: The planning engineer is the individual responsible for conducting all necessary studies and preparing the planning report. It is desirable that this individual be a duly registered professional engineer under state laws and recognized by RUS as being qualified in preparing LRPs. Although the planning engineer is usually an outside consultant, the planning engineer may be a member of the owner's staff or combination thereof. Although many Owner's staff engineers compile CWPs, an owner should evaluate the advantage of additional perspectives, skills and available time provided by an outside consultant when involved in the LRP.

Power Supplier: The Power Supplier is an organization from which the owner purchases wholesale power and energy. The role of the power supplier may be filled by a private power company, a governmental agency, or a generation and transmission cooperative (G&T) of which the owner is a member. In many cases, the owner purchases energy from more than one power supplier. In cases where all purchases are coordinated through one organization, that organization is the power supplier even if that organization has no generating capacity of its own.

SCADA: Abbreviation for Supervisory Control and Data Acquisition.

D.A.: Abbreviation for Distribution Automation, a system which enables an electric utility to monitor, coordinate and operate electric system and consumer components in a real-time mode from remote locations.

APPENDIX II

Suggested Table of Contents for
Long-Range Engineering Plan

I. Introduction

II. Purpose of Report

III. Summary of Report, Conclusion and Recommendations

IV. Analysis of Existing System and Basic Data
- A. Introduction
- B. Purpose of Analysis
- C. Summary of Analysis, Conclusion and Recommendations
- D. System Growth Patterns
  - 1. Land Use Plans
  - 2. Load Density Projections
- E. Capacity of Existing System
  - 1. Service to Present Loads
  - 2. Service to Future Loads
  - 3. System Performance
    - a. Voltage Levels
    - b. Service Reliability
    - c. Demand and Energy Losses
    - d. Operating Expenses
- F. Environmentally Sensitive Areas
- G. Adequacy of Basic Data
- H. Existing Communication Equipment and Methods

V. Planning Criteria
- A. Long-Range Demand Level
- B. Area Load Density and Growth Potential
- C. Special Loads
- D. Service Reliability
- E. Financial Criteria
- F. Other Criteria
- G. Assumptions
- H. Facilities and Equipment

VI. Long-Range Plan
- A. The Recommended Plan
- B. Alternate Recommendations
- C. Exploratory Plans
- D. Plan Selection
  - 1. Examination of the Transition
  - 2. Economic Justification
  - 3. Other Justification

VII. Summary of Future Communication Equipment and Methods

VIII. Exhibits
- A. Tabulations of Supporting Data
- B. Sketches, Maps and Circuit Diagrams
- C. Copies of Pertinent Correspondence
- D. Bibliography
- E. Other Exhibits

APPENDIX III

Fixed Charge Rate Calculation Guide

Following is some data to assist in the calculation of a Fixed Charge Rate. A fixed charge rate is composed of several factors: the cost of capital, operation & maintenance, taxes, insurance and depreciation. Calculating the cost of insurance as a percent of investment is difficult, and the result makes little difference; therefore, it can be ignored for most applications. The fixed charge rate is not an exact figure, but an estimate which is dependent on the quality of the assumptions involved in its calculation.
NOTE: References to annual Form 7 are based on the 06-94 Revision of Form 7:

COMPONENT of FCR

I. COST OF CAPITAL:

A. It is important to recognize the cost of capital, which is greater than the cost of debt. This is because there is a cost of member equity. The return on equity portion of this calculation can be figured in at least three ways. The Goodwin method includes the cycle of capital credits in calculating the return on equity. Or, one may adopt a return on equity that a state regulatory authority has declared to be adequate for electric utilities. Or, a TIER-based calculation such as is illustrated below, may be used.

B. Net TIER (Times Interest Earnings Ratio):

1. For future projects, TIER should be selected in accordance with the owner's Equity Management Plan.

2. For comparison, TIER for a past year could be calculated from data on the annual Form 7:

TIER = Interest [PartA, line15(b)] + Margins [Part A, line 27(b)] / Interest [Part A, line 15(b)] = ($______ $______) / $______ = ______

C. CAPITAL STRUCTURE:

1. For future projects, the debt ratio should be in accordance with the owner's Equity Management Plan. Line of credit or short-term borrowing should be taken into consideration in long-term financial decisions.

2. For comparison, the debt ratio for a past year could be calculated from data on the annual Form 7:

Debt ratio = LTD (Part C, line 35) x100 / LTD (Part C, line 35) + Tot. Marg. & Eq. (Part C, line 32) = ($______ x100) / ($______ +$______) = ______%

D. COST OF CAPITAL:

1. For future projects the cost of debt should be estimated carefully, taking long-term trends into account.
A suggested form would be:

	Proportion of debt		Long-range est. of interest rate		Component	
RUS	______%	x	______%	=	______%	(a)
Supplemental Lender	______%	x	______%	=	______%	(b)
Cost of debt = (a)+(b) =					______%	

2. In case one needs to calculate the embedded cost of debt for a past year, it can be calculated from the annual Form 7:

[Embedded cost of debt] = Part A, line 15(b) / Part C, line 35 x 100 = $______ / $______ x 100 = ______%

3. Weighted cost rate of debt:

Debt Ratio (from I.C. above)	x	cost of debt (from I.B. above)	=	
______	x	______	=	______%

4. Cost of capital:

Wtd cost rate of debt (from I.D.3. above)	x	TIER (from I.B. above)	=	
______	x	______	=	______% (CC)

II. OPERATION & MAINTENANCE:

A. For future projects, O&M should be selected to agree with the various plan alternatives. If a more costly alternative promises lower O&M, it should be reflected here.

B. For comparison, a historic distribution-plant O&M could be calculated by this form, with figures from the annual Form 7:

	Part E line 14(a)		Part F line 7(a)			
Net Distribution Plant, annual Form 7, last year	$______	-	$______	=	$______	
Net Distribution Plant, annual Form 7, 2 years ago	$______	-	$______	=	$______	
Average Net Distribution Plant last year				=	$______	(a)
Distribution Operations: Part A, line 5(b):				=	$______	(b)
Distribution Maintenance: Part A, line 6(b):				=	$______	(c)
O&M as a % of Avg. Net Distn. Plant [(b)+(c)]/(a) x 100; or estimated from II. A., above					______%	(O&M)

III. TAXES:

Property tax: annual Form 7, last year, Part A, line 13(b)	$______	(a)
Plant the taxes were paid on: annual Form 7, 2 years ago, Part C, line 5 + line 20	$______	(b)
Tax Rate: [(a)/(b)] x 100; or estimated future tax rate	______%	(Tx)

IV. DEPRECIATION:

Use an appropriate depreciation figure for the project alternative(s) being studied. Most owners use straight-line depreciation where the depreciation rate is the reciprocal of the asset's life.

Annual rate for coop, for plant or for classes of plant ______% (Dep)

V. Total Annual Fixed Charge Rate = Cost of Capital (CC) + Oper. & Main. (O&M) + Taxes (Tx) + Depreciation (Dep) = ______%