HAWAIIAN ELECTRIC COMPANY, INC.

SHARI Y. ISHIKAWA

EDUCATIONAL BACKGROUND AND EXPERIENCE

Business Address:	Hawaiian Electric Company, Inc. (HECO) P.O. Box 2075 Honolulu, HI 96840	
Position:	Principal Transmission Planning Engineer Planning & Engineering Department	
Years of Service:	6	
Education:	Illinois Institute of Technology BS Electrical Engineering (1993) University of Hawaii, Manoa MBA (2000)	
Other Qualifications:	Registered Professional Engineer Hawaii Electrical Branch - 1998	
Previous Positions:	2002-Present	HECO Principal Transmission Planning Engineer
	2000-2002	HECO Senior Planning Engineer Generation Planning Division
	1997-2000	HECO Planning Engineer Generation Planning Division
	1995-1997	ComEd Distribution Design Engineer, Southern Division

Previous Positions (cont) :	
1993-1995	ComEd Tech Staff Engineer, Will County Generating Station
Previous Testimony:	Hawaiian Electric Company, Inc. East Oahu Transmission Project Docket No. 03-0417

Hawaiian Electric Company
Engineering Standard Practices Manual

ENERGY DELIVERY/Engineering
Section 5, Engineering Department, Subsec. D, Part 11.4
h:\ed_engr\manuals\espm-htm\sec-5\sub-d\5d11-4.htm
Revised January 28, 1997; For Internal Use Only

HECO-Criteria for Transmission Planning

Purpose

The purpose of these criteria is to establish guidelines for planning a reliable transmission system for the island of Oahu.

Generation planning criteria (see ESP VB11.1) are concerned with real power supply. These transmission planning criteria are used to plan for the reliable delivery of that power to the subtransmission load centers. They are also used to plan for a reliable source of reactive power to those same load centers, whether this source is a generator, a transmission var source, or a distribution var source.

Transmission System Defined

For purposes of these criteria, the transmission system is defined as all substation equipment, lines, structures, and land utilized for transporting power at 138 kv and above. In addition, the following 138-46 kv transformers, 46 kv buses, and 46 kv circuits will be considered to be part of the transmission system.

1. HonoluluSchool No. 1 and No. 2, 46 kv circuits.
2. HonoluluIwilei No. 1 and No. 2, 46 kv circuits.
3. IwileiSchool 46 kv circuit.
4. School Street 48/80 mva, 13846 kv Transformers A and B.
5. Iwilei 48/80 mva, 13846 kv Transformers A and B.
6. Waiau 48/80 mva, 13846 kv Transformers A and B.
7. Honolulu 46 kv Buses A and B.
8. Waiau 46 kv Buses A and B.
9. School 46 kv Buses A and B.
10. Iwilei 46 kv Buses A and B.

Criteria for Making Additions

The transmission system shall be planned on the basis of serving the predicted peak kva on any part of the system each year. Additions to the transmission system will be planned to be installed before the upper loading limits of Section V or the upper or lower voltage limits of Section VI are violated for any of the conditions listed in Section IV. Var compensation systems will be considered along with reconductoring and adding new transmission lines to correct any deficiency.

The transmission system will be planned without having to dispatch generating units in addition to those required to meet margin and quick load pickup rules, as established in "Capacity Planning Criteria for Addition of Generation", ESP VB11.1. Generating units will be able to be committed and dispatched economically for any maintenance condition for which the transmission system is planned.

In addition to meeting system electrical requirements, the economics of reconductoring a transmission line or adding a static var source will be considered on the basis of reducing system losses, both kwh and kw demand.

Each case will be evaluated from the standpoint of operational experience and engineering design criteria before projects are budgeted.

Static var sources that are added to transmission substations should be controlled by the Energy Management System. This is to allow these sources to be adjusted or switched to prevent excessive voltages during minimum load conditions.

The voltage requirements specified under "Standards of Quality of Service" in General Order No. 7 of the PUC must be followed when static var sources are energized or deenergized.

Conditions for Which the Transmission System is Planned

The transmission system shall be planned for the following conditions:

1. With any generating unit off for overhaul, no transmission system component loading will exceed its **NORMAL** rating, nor will voltage levels violate their upper or lower limits for any of the following outages:
   a. Any other generating unit.
   b. Any transmission circuit.

c. Any transmission transformer.

d. Any transmission bus.

2. With any generating unit off for overhaul, no transmission system component will exceed its **EMERGENCY** rating, nor will voltage levels violate their upper or lower limits for any multiple transmission circuit outage caused by a line down at a crossing point.

3. With any generating unit off for overhaul, and any transmission line out of service for maintenance, no transmission system component will exceed its **EMERGENCY** rating, nor will voltage levels violate their upper or lower limits for any of the following outages:

   a. Any other generating unit.

   b. Any other transmission circuit.

   c. Any multiple transmission circuit outage caused by a line down at a crossing point.

   d. Any transmission transformer.

   e. Any transmission bus.

   NOTE*:* The purpose of criterion 3 is to help assure that the system will survive. All loads may not continue to be served, but those that do will not cause any transmission system component to exceed its **EMERGENCY** rating, or any voltage level to violate its upper or lower limits. Manual intervention will not be required to meet these conditions.

4. Each single generating station should be able to export power equal to the sum of the individual generating unit **NORMAL** capability ratings in mw at 105 percent of rated generator field current with no transmission system component loading exceeding its **EMERGENCY** rating, nor will voltage levels violate their upper or lower limits for any of the following outages:

   a. Any transmission circuit.

   b. Any multiple transmission circuit outage caused by a line down at a crossing point.

   c. Any transmission transformer.

   d. Any transmission bus.

5. Each individual generating station should be able to export all the real and reactive power that it can generate. For this criterion, this is measured by summing all the individual generating unit **EMERGENCY** capability ratings in mw and assuming 110 percent of rated generator field current. It is further assumed that all transmission lines and associated transmission equipment are in service.

6. With the transmission system intact, the failure of any single transmission component, coupled with a 138 kv breaker failure while attempting to clear the initial failure, will not result in the loss of:

   a. More than one generator.

   b. More than one subtransmission transformer.

   c. More than one "source" circuit to a transmission station.

7. Two 138 kv transmission circuits on common steel poles can be taken out of service at the same time for maintenance. This is a maintenance requirement based on present maintenance practices.

Loading Limits

1.

TRANSFORMER LOADING LIMITS

Loading limits of transmission power transformers shall be as follows:

a. The normal loading limit of a transmission power transformer shall be its zero percent loss-oflife kva capability.

b. The emergency loading limit of a transmission power transformer shall be its one percent lossoflife kva capability.

c. The extreme emergency loading limit of a transmission power transformer shall be 200 percent of its maximum nameplate rating.

d. Refer to ESPVG21.1 for power transformer normal mva ratings with different combinations of fans and pumps.

Loading limits shall be determined in accordance with the latest edition of C57.92, ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55° C or 65°C Winding Rise.

2. **CURRENT CARRYING CAPACITY**

a. **Overhead Conductor**

Conductor for overhead transmission lines shall be considered to have current carrying capacity in accordance with Engineering Standard 12038, "Current Carrying Capacity-Outdoor Bare Conductor." A conductor bundle with identical conductors shall have the rating of a single conductor multiplied by the number of conductors per phase in the bundle.

b. **Underground Cable**

The 46 kv underground transmission circuits ampacities are:

	NORMAL	**CONTINGENCY "A"**	**CONTINGENCY "B"**
Hono-Iwilei #1 & #2	315 Amps	400 Amps	375 Amps
Hono-School #1 & #2	315 Amps	375 Amps	400 Amps
Iwilei-School	292 Amps	375 Amps	349 Amps

Contingency "A" rating is based on one HonoluluIwilei circuit out of service.
Contingency "B" rating is based on one HonoluluSchool circuit out of service.

Reference: 9/22/86 IOC from Engineering.

c. **Open Buses**

Open buses shall be considered to have current carrying capacity in accordance with Engineering Standard, 12039, "Current Carrying CapacityOutdoor Open Bus."

d. **Power Transformer Equipment**

Transmission power transformer connections, switches, protective relays, and current transformers shall be designed to allow the power transformer to carry 200 percent of maximum nameplate rating under extreme emergency conditions in accordance with the latest edition of C57.92, ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise. (The relay settings associated with this type of transformer shall allow the transformer to carry 200 percent of maximum nameplate rating.)

e. **Substation Equipment**

Switches, disconnects, circuit breakers, and associated equipment shall be considered to have a current carrying capacity equivalent to their respective nameplate current rating.

3. **GENERATOR MVAR LOADING LIMITS**

For planning purposes, the reactive capability of a given machine will be determined using the manufacturer's generator capability curve and the generator normal rating in mw as specified in "Capacity Planning Criteria for Addition of Generation", ESP VB11.1. At no time will the system be planned with any generator exceeding its rating as determined by its capability curve.

Voltage Levels

Transmission voltage levels are to be kept within the prescribed limits for any condition for which the transmission system is planned. These limits apply after automatic corrective action has been taken by LTC and/or switched capacitors.

1. **Maximum Voltage**

The maximum voltage limits are based on ANSI Standard C84.1, "American National Standard for Electric Power Systems and Equipment Voltage Ratings (60 Hz)".

a. **138 kv System.** For any system operating condition, the voltage at any 138 kv bus shall not exceed 145 kv.

b. **46 kv System.** For any system operating condition, the voltage on the 46 kv system shall not exceed 48 kv; except that on any 44 kv LPGF cable, the voltage shall not exceed 46 kv.

2. **Minimum Voltage**

The minimum voltage limits are based upon maintaining customer voltages within our tariff. To accomplish this, the 46 kv bus voltages at the transmission substations must be maintained within the limits that are used to plan the subtransmission system. Refer to ESP VIID11.5 for these limits.

a. **138 kv System.** The minimum allowable voltage on any 138 kv bus is 126.5 kv for any emergency condition for which the transmission system is planned.

b. **46 kv System.** The minimum allowable voltage on any 46 kv bus is 45 kv for any emergency condition for which the system is planned.

Crossing Points

All transmission line crossing points are to be considered while planning the transmission system. Following is a list of known crossing points.

1. HalawaMakalapa and Waiau Koolau (near Halawa)
2. HalawaMakalapa and WaiauKoolauPukele (near Halawa)
3. KaheHalawa No. 1 and Waiau Wahiawa (bet str 21 and 22)
4. KaheHalawa No. 2 and WaiauWahiawa (at str 26/85)
5. WaiauKoolauPukele and WaiauWahiawa (bet str 18 and 19)

The following line crossings are partially protected by an "apron", which is designed to prevent lines from coming into contact upon conductor failure at their supported ends. This factor should be considered prior to initiating projects related to eliminating these line crossings.

6. HalawaIwilei and WaiauKoolau
7. HalawaIwilei and WaiauKoolauPukele
8. HalawaSchool and WaiauKoolau
9. HalawaSchool and WaiauKoolauPukele

Other Considerations

1. Criteria on Bulk Load Shedding application. (Refer to ESP VE21.3)

2. Criteria on circuit breaker interrupting capability versus short circuit duty. (Refer to ESP VE21.1)

3. For clarification of responsibilities between the Engineering Department and System Planning Department, refer to ESP VF31.1 entitled "Protection for Switching Stations and Major Substations".

Please share your comments with the Responsible Department/Division listed in the header at the top of this document.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

| Top | | Table of Contents | HomePage | | Send e-mail to Myla Washington |

Hawaiian Electric Company
Engineering Standard Practices Manual

ENERGY DELIVERY/Engineering
Section 5, Engineering Department, Subsec. D, Part 14.1
h:\ed_engr\manuals\espm-htm\sec-5\sub-d\5d14-1.htm
Revised January 23, 1997; For Internal Use Only

HELCO-Criteria for Transmission Planning

Transmission System

The transmission system shall be planned on the basis of serving the predicted peak kva on any part of the system each year.

Additions to the transmission system will be planned for the year in which it is predicted that:

1. The emergency current carrying capacity of any transmission circuit will be exceeded during any condition for which the transmission system is planned or,

2. Voltage levels cannot be kept within required limits.

The planning criteria outlined below are intended to be used as a general guide in developing HELCO's transmission system. Individual transmission projects developed under these planning criteria must be evaluated on the following: (1) Engineering design criteria, (2) Operational experience, (3) Risks involved, and, (4) Financial constraints. As a result of these considerations, approved projects may deviate from the established planning criteria.

The transmission system includes all land, structures, lines, and substation equipment employed with all 69 kv and 34.5 kv circuits, and 13.8 kv tie circuits listed below. For purposes of the following discussion, all 6934.5 kv, 6913.8 kv, and 34.513.8 kv tie transformers will be considered under Transmission System Planning.

13.8 KV Tie Circuits

TIE I (1100 Line)
TIE II (1200 Line)
TIE III (1300 Line)
Puueo - Waiau B (1800 Line)

The following substations are to be considered transmission plant. All other substations are to be distribution plant, even though they may be connected to transmission lines.

Transmission Plants

Anaehoomalu	Mauna Lani
Honokaa	Pepeekeo
Kanoelehua	Puna
Kaumana	Puueo
Keahole	Shipman
Kealia	Waiau
Keamuku	Waimea
Kilauea	

Transmission Circuits

NORMAL CONDITIONS

The radial transmission system shall be planned to provide for the following normal conditions:

1. The radial sources to distribution substations in the same area will be from the same transmission substation (but possibly different transformers) or source of generation, whenever practical, to allow paralleling of distribution feeders during switching operations.
2. Distribution substations with only one transformer need have only one source, provided that backup is available on the distribution system. (Substations in remote areas need not have backup if it is uneconomical to do so. Approval by the President of HELCO will be required in the application of this criterion.)
3. Existing distribution substations that have at least two sources may be switched through and used as transmission lines to other distribution substations, provided backup to that station can be provided by manual switching on the source or load side.

EMERGENCY CONDITIONS

The transmission system shall be planned to provide for the following emergency conditions:

1. Outage of any overhead transmission circuit.

2. Outage of any transmission wood structure.

3. Outage of any underground transmission circuit.

4. Outage of any transmission transformer.

5. At each single generating station, exporting power equal to the sum of the individual generating unit Normal Top Load Ratings in kw at rated power factor, and outage of any one of the following:

    - Any overhead transmission circuit.
    - Any transmission wood structure.
    - Any underground transmission circuit.
    - Any transmission transformer.

6. At each single generating station, exporting power equal to the sum of the individual generating unit Emergency Ratings in kw at 110 percent of rated generator field current with all transmission line structures, cables, and transformers in service for outage of remote generation and/or transmission facilities.

7. Outage of not more than one generating unit caused by failure of a transmission circuit breaker to operate during fault conditions.

8. The radial transmission system shall be planned to consider only one line serving a specific area being out at any one time.

EXCEPTIONS

The transmission system is not planned to provide for the following emergency conditions:

1. Failure of any line while another line is out for maintenance or construction.

2. Failure of any transformer while another is out for maintenance.

3. Failure of a transmission circuit breaker, except at a generating station to prevent loss of more than one generating unit.

4. Outage of two transmission lines supported by a common metal structure.

5. The radial transmission system is not planned to provide for multiple circuit outages due to transformer outages, bus faults, crossing contacts, or structure failures.

TRANSFORMER LOADING LIMITS

Loading limits of transmission power transformers shall be as follows:

1. The normal loading limit of a transmission power transformer shall be its zero percent lossoflife kva capability.

   One hundred (100) percent of the nameplate rating of the transformer when manufacturer's transformer test data are not available.

2. The emergency loading limit of a transmission power transformer shall be its one percent lossof-life kva capability.

   One hundred thirty three and one third (133 1/3) percent of the nameplate rating of the transformer when manufacturer's transformer test data are not available.

3. The extreme emergency loading limit of a transmission power transformer shall be 200 percent of its maximum nameplate rating in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise.

PLANNING SLD'S

In reviewing and evaluating proposed additions, with the HECO Engineering Department Design Manual used as a guide, the following design conditions should be considered:

1. With approval of the President of HELCO, circuiting diagrams may show overhead circuits on both sides of a street to avoid installation of an underground circuit.

2. Unless required for engineering and/or operating reasons, a singleline diagram will not show installation of a new 69 kv, 34.5 kv or 13.8 kv underground circuit.

Voltage Levels

Voltage levels are to be kept within the prescribed limits for any normal or emergency condition for which the transmission system is planned. Capacitor and regulator additions to the transmission system will be considered before any other capital additions for the year in which the predicted voltage at any transmission system bus will be below the minimum voltage level for any condition for which the transmission system is planned.

Application of the best combination of automatic voltage regulating equipment and transformer fixed taps shall be made to satisfy the following maximum and minimum voltage limits.

Maximum and Minimum Voltages

1. Voltage shall conform to the requirements of STANDARDS FOR ELECTRIC UTILITY SERVICE IN THE STATE OF HAWAII (General Order No. 7). Nominal transmission voltages for HELCO shall be 69 kv, 34.5 kv, and 13.8 kv.

2. For any system operating conditions the voltages at any 69 kv and 34.5 kv bus shall not exceed $\pm$10 percent of the nominal voltage.

3. For the Kanoelehua 13.8 kv generator bus, the voltage shall not exceed + 5% or - 10% of the nominal voltage.

At minimum load, with no distribution substation transformer voltage drop and transformer regulators at full buck, there will not be excessive voltage on the distribution system when using the primary tap setting of the distribution substation transformer.

Generator Mvar Optimization

The following rules apply to generator mvar optimization:

1. Under normal conditions when a generating unit is loaded below its Normal Top Load Rating, the unit can be operated up to rated field current to maintain normal switching station bus voltages.

2. Under normal conditions when a generating unit is loaded at or above its Normal Top Load Rating, the unit can be operated up to but not in excess of specified mvar values based on the manufacturer's generator capability curves. This infers operation at less than rated field current.

3. Under emergency conditions generating units may be operated at 110 percent of rated field current. (Under these conditions, caution must be used because the generator mva rating could be exceeded.)

Current Carrying Capacity

1. **Overhead Conductor**

   Conductor for overhead transmission lines shall be considered to have current carrying capacity in accordance with HECO Engineering Standard 12038, "Current Carrying CapacityOutdoor Bare Conductor." A conductor bundle with identical conductors shall have the rating of a single conductor multiplied by the number of conductors per phase in the bundle.

2. **Underground Cable**

   Cable for underground transmission circuits shall be considered to have current carrying capacity in accordance with HECO Engineering Standard 211021, "Cable Ampacity TablesUnderground Data."

3. **Open Buses**

   Open buses shall be considered to have current carrying capacity in accordance with HECO Engineering Standard, 12039, "Current Carrying CapacityOutdoor Open Bus."

4. **Power Transformer Equipment**

   Transmission power transformer connections, switches, protective relays and current transformers shall be rated to allow the power transformer to carry 200 percent of maximum nameplate rating under extreme emergency conditions in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise. (The relay settings associated with this type of transformer shall allow the transformer to carry 200 percent of maximum nameplate rating.)

5. **Substation Equipment**

   Switches, disconnects, circuit breakers, and associated equipment shall be considered to have a current carrying capacity equivalent to their respective nominal current rating.

Other Considerations

1. HELCO Criteria on Load Shedding application. (Refer to VE24.5)
2. HELCO Criteria on circuit breaker interrupting capability versus short circuit duty. (Refer to VE-24.3)
3. HELCO Criteria on system reactive var requirements. (Refer to VE24.4)

Please share your comments with the Responsible Department/Division listed in the header at the top of this document.

Hawaiian Electric Company
Engineering Standard Practices Manual

ENERGY DELIVERY/Engineering
Section 5, Engineering Department, Subsec. D, Part 12.1
h:\ed_engr\manuals\espm-htm\sec-5\sub-d\5d12-1.htm
Revised January 23, 1997; For Internal Use Only

MECO-Criteria for Transmission Planning

Transmission System

The transmission system shall be planned on the basis of serving the predicted peak kva on any part of the system each year.

Additions to the transmission system will be planned for the year in which it is predicted that:

1. The emergency current carrying capacity of any transmission circuit will be exceeded during any condition for which the transmission system is planned or,

2. Voltage levels cannot be kept within required limits.

Where applicable, each case will be evaluated on an individual basis from the standpoint of operational experience and engineering design criteria before projects are budgeted.

The transmission system includes all land, structures, lines, and substation equipment employed with all 69 KV and 23 KV circuits. For purposes of the following discussion, all 6923 KV tie transformers will be considered under Transmission System Planning.

For purposes of these criteria, the transmission system shall mean to include both the loop and radial transmission systems unless otherwise stated.

The following substations are to be considered transmission plant. All other substations are to be distribution plant, even though they may be connected to transmission lines.

Transmission Plants

Sub 2 Kanaha
Sub 3 - Wailuku
Sub 4 - Puunene
Sub 6 - Paia
Sub 8 - Kahului
Sub 13 - Kula
Sub 17 Pukalani
Sub 25 - Wailea
Sub 35 - Kihei
Sub 36 Waiinu
Kahului Power Plant
Maalaea Power Plant

Transmission Circuits

NORMAL CONDITIONS

The radial transmission system shall be planned to provide for the following normal conditions:

1. The radial sources to distribution substations in the same area will be from the same transmission substation (but possibly different transformers) or source of generation, whenever practical, to allow paralleling of distribution feeders during switching operations.

2. Distribution substations with only one transformer need have only one source, provided that backup is available on the distribution system.

   (Substations located in remote areas need not have backup if uneconomical to do so. Approval by the President of MECO will be required in the application of this criterion.)

3. Existing distribution substations that have at least two sources may be switched through and used as transmission lines to other distribution substations, provided backup to the station being switched through can be provided by manual switching on the source or load side.

EMERGENCY CONDITIONS

The transmission system shall be planned to provide for the following emergency conditions:

1. Outage of any overhead transmission circuit.

2. Outage of any transmission wood structure.

3. Outage of any underground transmission circuit.

4. Outage of any transmission transformer.

5. At each single generating station, exporting power equal to the sum of the individual generating unit Normal Top Load Ratings in kw at rated power factor, and outage of any one of the following:

   - Any overhead transmission circuit.
   - Any transmission wood structure.
   - Any underground transmission circuit.
   - Any transmission transformer.

6. At each single generating station, exporting power equal to the sum of the individual generating unit Emergency Ratings in kw at 110 percent of rated generator field current with all transmission line structures, cables, and transformers in service for outage of remote generation and/or transmission facilities.

7. Outage of not more than one generating unit or generator stepup transformer caused by failure of a transmission circuit breaker to operate during fault conditions.

8. The radial transmission system shall be planned to consider only one line serving a specific area being out at any one time.

EXCEPTIONS

The transmission system is not planned to provide for the following emergency conditions:

1. Failure of any line while another line is out for maintenance or construction.

2. Failure of any transformer while another is out for maintenance.

3. Failure of a transmission circuit breaker, except at a generating station to prevent loss of more than one generating unit.

4. Outage of two transmission lines supported by a common metal structure.

5. The radial transmission system is not planned to provide for multiple circuit outages due to transformer outages, bus faults, or structure failures.

TRANSFORMER LOADING LIMITS

Loading limits of transmission power transformers shall be as follows:

1. The normal loading limit of a transmission power transformer shall be its zero percent lossoflife kva capability.

   One hundred (100) percent of the nameplate rating of the transformer when manufacturer's transformer test data are not available.

2. The emergency loading limit of a transmission power transformer shall be its one percent lossof-life kva capability.

   One hundred thirty three and one third (133 1/3) percent of the nameplate rating of the transformer when manufacturer's transformer test data are not available.

3. The extreme emergency loading limit of a transmission power transformer shall be 200 percent of its maximum nameplate rating in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise.

PLANNING SLD'S

In reviewing and evaluating proposed additions, with the HECO Engineering Department Design Manual used as a guide, the following design conditions should be considered:

1. With approval of the President of MECO, circuiting diagrams may show overhead circuits on both sides of a street to avoid installation of an underground circuit.

2. Unless required for engineering and/or operating reasons, a singleline diagram will not show installation of a new 69 KV or 23 KV underground circuit.

Voltage Levels

Voltage levels are to be kept within the prescribed limits for any normal or emergency condition for which the transmission system is planned. Capacitor and regulator additions to the transmission system will be considered before any other capital additions for the year in which the predicted voltage at any transmission system bus will be below the minimum voltage level for any condition for which the transmission system is planned.

Application of the best combination of automatic voltage regulating equipment and transformer fixed taps shall be made to satisfy the following maximum and minimum voltage limits.

Maximum and Minimum Voltages

1. Voltage shall conform to the requirements of STANDARDS FOR ELECTRIC UTILITY SERVICE IN THE STATE OF HAWAII (General Order No. 7). Nominal transmission voltages for MECO shall be 69 KV and 23 KV.

2. For any system operating conditions the voltages at any 69 KV and 23 KV bus shall not exceed + 5% or - 10% of the nominal voltage.

At minimum load, with no distribution substation transformer voltage drop and transformer regulators at full buck, there will not be excessive voltage on the distribution system when using the primary tap setting of the distribution substation transformer.

Generator Mvar Optimization

The following rules apply to generator mvar optimization:

1. Under normal conditions when a generating unit is loaded below its Normal Top Load Rating, the unit can be operated up to rated field current to maintain normal switching station bus voltages.

2. Under normal conditions when a generating unit is loaded at or above its Normal Top Load

Rating, the unit can be operated up to but not in excess of specified mvar values based on the manufacturer's generator capability curves. This infers operation at less than rated field current.

3. Under emergency conditions generating units may be operated at 110 percent of rated field current. (Under these conditions, caution must be used because the generator mva rating could be exceeded.)

Current Carrying Capacity

1. **Overhead Conductor**

   Conductor for overhead transmission lines shall be considered to have current carrying capacity in accordance with HECO Engineering Standard 12038, "Current Carrying CapacityOutdoor Bare Conductor." A conductor bundle with identical conductors shall have the rating of a single conductor multiplied by the number of conductors per phase in the bundle.

2. **Underground Cable**

   Cable for underground transmission circuits shall be considered to have current carrying capacity in accordance with HECO Engineering Standard 211021, "Cable Ampacity TablesUnderground Data."

3. **Open Buses**

   Open buses shall be considered to have current carrying capacity in accordance with HECO Engineering Standard 12039, "Current Carrying CapacityOutdoor Open Bus."

4. **Power Transformer Equipment**

   Transmission power transformer connections, switches, protective relays and current transformers shall be rated to allow the power transformer to carry 200 percent of maximum nameplate rating under extreme emergency conditions in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise. (The relay settings associated with this type of transformer shall allow the transformer to carry 200 percent of maximum nameplate rating.)

5. **Substation Equipment**

   Switches, disconnects, circuit breakers, and associated equipment shall be considered to have a current carrying capacity equivalent to their respective nominal current rating.

Other Considerations

1. MECO Criteria on Load Shedding application. (Refer to VE22.5)

2. MECO Criteria on circuit breaker interrupting capability versus short circuit duty. (Refer to VE-22.3)

3. MECO Criteria on system reactive var requirements. (Refer to VE22.4)

Please share your comments with the Responsible Department/Division listed in the header at the top of this document.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

| Top | | Table of Contents | HomePage | | Send e-mail to Myla Washington |

Hawaiian Electric Company
Engineering Standard Practices Manual

ENERGY DELIVERY/Engineering
Section 5, Engineering Department, Subsec. E, Part 11.1
h:\ed_engr\manuals\espm-htm\sec-5\sub-e\5e11-1.htm
Revised January 27, 1997; For Internal Use Only

HECO-Criteria for Distribution Substation and Feeder Planning

Introduction

The distribution system includes all land, structures, lines, and substation equipment employed with 25 kv class and lower.

The distribution system shall be planned on the basis of serving the predicted peak kva on any part of the system each year.

Additions to the distribution system will be planned for the year in which it is predicted that:

1. The normal current carrying capacity of any distribution system components will be exceeded under normal condition.

2. The emergency current carrying capacity of any distribution circuit will be exceeded during any emergency condition.

3. Voltage levels cannot be kept within required limits.

Where applicable, each case will be evaluated on an individual basis, based on operational experience and engineering design criteria before projects are budgeted.

Unless stated otherwise, the criteria described applies to facilities and equipment operating at more than 600 volts but less than 25,000 volts.

Distribution Substation Transformer

GENERAL

As used in this section, a distribution substation and the transformer(s) therein supply more than one billable customer.

1. A substation lot purchased in a new subdivision will not be developed until it is predicted that a distribution substation transformer installed on the lot can be reasonably loaded.

2. Distribution substation transformers are generally supplied by the 46 kv system. Distribution substation with 46 kv automatic transfer facilities will normally be supplied by 46 kv lines originating from different 46 kv buses at a 138 kv station.

3. Distribution substations with only one transformer will require only one 46 kv source if the loads supplied by the substation have a backup. However, a second 46 kv source may be required for engineering and/or operating reasons.

4. The company policy on service to customers from a system voltage of 46 kv or higher is described in Section VII, Subsection B, Part 11.1 of the Engineering Standard Practice Manual.

NORMAL CONDITIONS

The normal loading limit on a distribution substation transformer shall be its 0% lossoflife KVA rating when manufacturers' transformer test data are available. Otherwise, the highest nameplate (OA/FA) KVA rating shall be used.

The distribution system shall be planned so that routine maintenance can be performed on any distribution substation transformer during normal working hours.

EMERGENCY CONDITIONS

The distribution system shall be planned to provide for distribution substation transformer failures. In the application of this criterion, service must be able to be restored in a reasonable amount of time to loads not automatically transferred to a standby feeder. Loads which are automatically transferred to other feeders shall not cause those standby feeders to become loaded beyond their rated current carrying capacity.

The distribution substation transformer emergency loading limit shall be:

1. The one percent lossoflife kva capability of the transformer when manufacturers' transformer test data are available. (Forced cooling equipment will be installed as required such that this capability will be at least 150 percent of the OA kva rating.) Otherwise, the highest nameplate (OA/FA) or (OA/FA/FOA) KVA rating where applicable shall be used.

2. Refer to Engineering Standard Practice Section IV, Subsection A, Part 41.4, on Determination of LossofLife Data for Distribution Substation Transformers for loading capabilities on existing transformers for which manufacturers' transformer test data are not available.

3. The extreme emergency loading limit of a distribution substation transformer shall be 200 percent of its maximum nameplate rating in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55° C or 65° C Winding Rise.

Distribution System Circuits

NORMAL CONDITIONS

The distribution circuit normal loading limit shall be its normal circuit rating. The distribution system shall be planned so that switching will normally be made by closed transition. Where facilities are served by two circuits through individual switches, one switch is normally open while the other switch is normally closed. When it is necessary to change the normal circuit to a facility, both switches should be closed before the normally closed switch is opened. This is known as closed transition. Open transition means to open the normally closed switch, resulting in load being dropped, and then closing the normally open switch.

EMERGENCY CONDITIONS

The distribution system shall be planned to provide for the following emergency conditions:

1. Outage of any overhead distribution primary main circuit.

2. Outage of any underground distribution primary main circuit.

3. Outage of any one distribution substation circuit in a specific area.

4. Outage of distribution substation circuits backing up each other originate from different size transformers. Consider special switching arrangements.

5. Outage of any one of multiple 46 kv circuits into a substation.

PLANNING SLD'S

In reviewing and evaluating proposed additions, with the Engineering Department Design Manual used as a guide, the following conditions should be considered:

1. Circuiting diagrams may show overhead circuits on both sides of a street to avoid installation of an underground circuit.

2. When overbuilding, relocating, reconductoring, or increasing voltage, lines will be rebuilt only as necessary.

3. In underground areas requiring switching vaults, automatic transfer equipment will normally be installed.

Voltage Levels

Voltage levels are to be kept within the prescribed limits for any normal or emergency condition for which the distribution system is planned. Capacitor and regulator additions to the distribution system will be considered before any other capital additions for the year in which the predicted voltage on the distribution system will be below the minimum voltage level for any condition for which the distribution system is planned.

Application of the best combination of automatic voltage regulating equipment and transformer fixed taps shall be made to satisfy the following maximum and minimum voltage limits:

1. **Maximum Voltage**

   24.94, 12.47, 11.5, 4.16, and 2.4 KV Substations (nominal voltages)

   For any system operating condition, the voltage at any point on the distribution system shall not exceed 105 percent of the appropriate nominal voltage.

2. **Minimum Voltage**

   a. **Normal**

   Voltage shall conform to the requirements of STANDARDS FOR ELECTRIC UTILITY SERVICE IN THE STATE OF HAWAII (General Order No. 7). Refer to Section VII, Subsection B, Part 11.1, of the Engineering Standard Practice Manual for "Service to Customers From a 44 kv or Higher Source Voltage."

   b. **Emergency**

   For any system emergency operating condition, the voltage at any point on the distribution system shall not be less than 90 percent of the nominal source voltage.

   This minimum voltage is based on distribution substation transformers having a primary tap setting of 5 percent boost, nameplate maximum kva at 90 percent power factor through the transformer, the transformer regulator at full boost, and 2.5 percent primary voltage drop on distribution circuits, with service voltage in the extreme zone. (With Waiau and Honolulu bus voltage at 46 kv or 46 kv on the secondary of any 13846 kv transformer, the service voltage can be brought out of the extreme zone into the tolerable zone. The extreme and tolerable zones are described in ANSI Voltage Rating for Electric Power Systems and Equipment (60 Hz), C84.1.)

   At minimum load, with no distribution substation transformer voltage drop and the transformer regulator at full buck, there will not be excessive voltage on the distribution system when using the above primary tap setting of the distribution substation transformer. (For distribution substation transformers with capacitors, a primary tap setting of 5 percent boost may not be required to stay within the voltage limits described.)

   11.0 kv System. The minimum allowable voltage on the 11 kv buses at the Iwilei and School Street Substations is 11.0 kv. With a 2.5 percent primary voltage drop on distribution circuits, this assures service voltages in the tolerable zone.

Current Carrying Capacity

1. **Overhead Conductor**

   Conductor for overhead distribution circuits shall be considered to have current carrying capacity in accordance with Engineering Standard 12038, "Current Carrying CapacityOutdoor Bare Conductor."

2. **Underground Cable**

   Cable for underground distribution circuits shall be considered to have current carrying capacity in accordance with Engineering Standard 211020, "Cable Ampacity TablesUnderground Data."

3. **Open Buses**

   Open buses shall be considered to have current carrying capacity in accordance with Engineering Standard 12039, "Current Carrying CapacityOutdoor Open Bus."

4. **Distribution Substation Transformer Equipment**

   For new distribution substation transformer installations, the transformer connections, switches, protective relays, and current transformers shall be rated to allow the transformer to carry 200 percent of maximum nameplate rating under extreme emergency conditions in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55° C or 65° C Winding Rise.

5. **Substation Equipment**

   Switches, disconnects, circuit breakers, and associated equipment shall be considered to have a current carrying capacity equivalent to their respective nominal current rating.

Automatic Transfer Equipment

1. Automatic transfer equipment paid for by customers shall not be made inoperative for normal system conditions.
2. HECOowned automatic transfer equipment may be blocked to defer a project after the circumstances have been investigated and a decision made on an individual basis by the Manager of System Planning.

Other Considerations

1. Criteria on Distribution Substation Load Shedding application. (Refer to ESP VIIM21.1)
2. Criteria on circuit breaker interrupting capability versus short circuit duty. (Refer to ESP VE21.1)
3. Criteria for determining installation of switching vaults. (Refer to ESP VIIK11.1)
4. Criteria for use of Mobile Substation. (Refer to ESP VIIA11.1)

Please share your comments with the Responsible Department/Division listed in the header at the top of this document.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

| Top | | Table of Contents | HomePage | | Send e-mail to Myla Washington |

Hawaiian Electric Company
Engineering Standard Practices Manual

ENERGY DELIVERY/Engineering
Section 5, Engineering Department, Subsec. E, Part 14.1
h:\ed_engr\manuals\espm-htm\sec-5\sub-e\5e14-1.htm
Revised January 28, 1997; For Internal Use Only

HELCO-Criteria for Distribution Substation and Feeder Planning

Introduction

The distribution system shall be planned on the basis of serving the predicted peak kva on any part of the system each year.

Additions to the distribution system will be planned for the year in which it is predicted that:

1. The emergency current carrying capacity of any distribution circuit will be exceeded during any condition for which the distribution system is planned or,

2. Voltage levels cannot be kept within required limits.

The planning criteria outlined below are intended to be used as a general guide in developing HELCO's distribution system. Individual distribution projects developed under these planning criteria must be evaluated on the following: (1) Engineering design criteria, (2) Operational experience, (3) Risks involved, and, (4) Financial constraints. As a result of these considerations, approved projects may deviate from the established planning criteria.

The distribution system includes all land, structures, lines, and substation equipment employed with 15 KV class and lower circuits except those listed in the HELCO Criteria for Transmission System Planning in Section V, Subsection D, Part 21.6 of HECO's Engineering Standard Practice Manual.

Unless stated otherwise, the criteria described applies to facilities and equipment operating at more than 600 volts but less than 15,000 volts.

Distribution System Circuits

NORMAL CONDITIONS

The distribution system shall be planned so that switching will normally be by closed transition. Where facilities are served by two circuits through individual switches, one switch is normally open while the other switch is normally closed. When it is necessary to change the normal circuit to a facility, both switches should be closed before the normally closed switch is opened. This is known as closed transition. Open transition means to open the normally closed switch, resulting in load being dropped, and then closing the normally open switch.

Open transition switching will require approval by the President of HELCO in the application of this criterion.

EMERGENCY CONDITIONS

The distribution system shall be planned to provide for the following emergency conditions:

1. Outage of any overhead distribution primary main circuit.

2. Outage of any underground distribution primary main circuit.

3. The distribution substation circuits in a specific area shall be planned to provide for the outage of any one distribution substation circuit.

4. The distribution system shall not be planned to provide backup when one circuit is out for maintenance or construction and another circuit in the same area fails.

5. Special switching considerations may be required in areas where distribution substation circuits backing up each other originate from different size transformers.

6. The distribution system shall be planned to provide for the outage of any one of multiple source circuits into a substation.

PLANNING SLD'S

In reviewing and evaluating proposed additions, with the HECO Engineering Department Design Manual used as a guide, the following conditions should be considered:

1. With approval of the President of HELCO, circuiting diagrams may show overhead circuits on both sides of a street and/or double circuited on the same side of the street to avoid installation of an underground circuit.

2. When overbuilding, relocating, reconductoring, or increasing voltage, lines will be rebuilt only as necessary. Approval by the President of HELCO will be required to rebuild more than is necessary, so that additional work will not have to be done within a short period of time thereafter.

3. The number of ducts specified shall be limited to only those necessary for initial requirements and requirements reasonably foreseeable within the next few years.

Distribution Substation Transformer

GENERAL

As used in this section, a distribution substation and the transformer(s) therein supply more than one billable customer.

1. Distribution substation transformers no longer required to meet load demand will be removed and relocated whenever it is economical to do so.

2. A substation lot purchased in a new subdivision will not be developed until it is predicted that a distribution substation transformer installed on the lot can be reasonably loaded. Only the portion of the lot required for the initial installation will be developed if economical to do so.

3. Substation lots shall be leased when outright purchase in fee is not possible.

4. Distribution substation transformers are generally supplied by the 69 KV or 34.5 KV system. Distribution substation source side buses having automatic transfer facilities will normally be supplied by different transmission lines originating from different buses or source of generation unless the transmission lines are part of a loop system.

5. Distribution substations with only one transformer need have only one transmission source if the loads supplied by the substation have a backup, unless a second source is required for engineering and/or operating reasons. HELCO President approval to install a second source will be required in the application of this criterion.

NORMAL CONDITIONS

The distribution substation transformer normal loading limit shall be:

1. The zero percent lossoflife kva capability of the transformer when manufacturers' transformer test data are available.

2. One hundred (100) percent of the nameplate rating of the transformer when manufacturers' transformer test data are not available.

The distribution system shall be planned so that routine maintenance can be performed on any distribution substation transformer during normal working hours.

The distribution system will not be planned to provide for distribution substation transformer failures unless for engineering and/or operating reasons, transformer failures will cause an untenable situation. Approval by the President of HELCO will be required in the application of this criterion. In the application of this criterion, service must be able to be restored in a reasonable amount of time to loads not transferred to a standby feeder. Loads which are transferred to other feeders shall not cause those standby feeders to become loaded beyond their rated current carrying capacity.

EMERGENCY CONDITIONS

The distribution substation transformer emergency loading limit shall be:

1. The one percent lossoflife kva capability of the transformer when manufacturers' transformer test data are available. (Forced cooling equipment will be installed as required such that this capability will be at least 150 percent of the OA kva rating.)

2. One hundred thirtythree and onethird (133 1/3) percent of the nameplate rating of the transformer when manufacturers' transformer test data are not available.

3. The extreme emergency loading limit of a distribution substation transformer shall be 200 percent of its maximum nameplate rating in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise.

Voltage Levels

Voltage levels are to be kept within the prescribed limits for any normal or emergency condition for which the distribution system is planned. Capacitor and regulator additions to the distribution system will be considered before any other capital additions for the year in which the predicted voltage on the distribution system will be below the minimum voltage level for any condition for which the distribution system is planned.

Application of the best combination of automatic voltage regulating equipment and transformer fixed taps shall be made to satisfy the following maximum and minimum voltage limits:

1. **Maximum Voltage**

   13.8, 12.47, 7.2, 4.16, and 2.4 KV Substations (nominal voltages)

   For any system operating condition, the voltage at any point on the distribution system shall not exceed 105 percent of the appropriate nominal voltage.

2. **Minimum Voltage**

   a. **Normal**

   Voltage shall conform to the requirements of STANDARDS FOR ELECTRIC UTILITY SERVICE IN THE STATE OF HAWAII (General Order No. 7).

   b. **Emergency**

   For any system emergency operating condition, the voltage at any point on the distribution system shall not be less than 90 percent of the nominal source voltage.

   This minimum voltage is based on distribution substation transformers having a primary tap setting of 5 percent boost, nameplate maximum kva of 90 percent power factor through the transformer, the transformer regulator at full boost, and 2.5 percent primary voltage drop on distribution circuits, with service voltage in the extreme zone. With a nominal source voltage, the service voltage can be brought out of the extreme zone into the tolerable zone. (The extreme and tolerable zones are described in ANSI Voltage Rating for Electric Power Systems and Equipment (60 Hz), C84.1.)

At minimum load, with no distribution substation transformer voltage drop and the transformer regulator at full buck, there will not be excessive voltage on the distribution system when using the above primary tap setting of the distribution substation transformer. (For distribution substation transformers with capacitors, a primary tap setting of 5 percent boost may not be required to stay within the voltage limits described.)

Current Carrying Capacity

1. **Overhead Conductor**

   Conductor for overhead distribution circuits shall be considered to have current carrying capacity in accordance with HECO Engineering Standard 12038, "Current Carrying CapacityOutdoor Bare Conductor."

2. **Underground Cable**

   Cable for underground distribution circuits shall be considered to have current carrying capacity in accordance with the HECO Engineering Standard 211020, "Cable Ampacity Tables-Underground Data."

3. **Open Buses**

   Open buses shall be considered to have current carrying capacity in accordance with HECO Engineering Standard 12039, "Current Carrying CapacityOutdoor Open Bus."

4. **Distribution Substation Transformer Equipment**

   For new distribution substation transformer installations, the transformer connections, switches, protective relays, and current transformers shall be rated to allow the transformer to carry 200 percent of maximum nameplate rating under extreme emergency conditions in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise.

5. **Substation Equipment**

   Switches, disconnects, circuit breakers, and associated equipment shall be considered to have a current carrying capacity equivalent to their respective nominal current ratings.

Automatic Transfer

1. Automatic transfer equipment paid for by customers shall not be made inoperative for normal system conditions.

2. HELCOowned automatic transfer equipment may be blocked to defer a project after the circumstances have been investigated and a decision made on an individual basis by the President of HELCO.

Other Considerations

1. HELCO Criteria on Distribution Substation Load Shedding application. (Refer to VE24.5)
2. HELCO Criteria on circuit breaker interrupting capability versus short circuit duty. (Refer to VE-24.2)
3. HELCO Criteria for determining installation of switching vaults. (Refer to VE14.3)
4. HELCO Criteria for use of mobile substation. (Refer to VE14.2)

Please share your comments with the Responsible Department/Division listed in the header at the top of this document.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

| **Top** | | **Table of Contents** | **HomePage** | | **Send e-mail to Myla Washington** |

Hawaiian Electric Company
Engineering Standard Practices Manual

ENERGY DELIVERY/Engineering
Section 5, Engineering Department, Subsec. E, Part 12.1
h:\ed_engr\manuals\espm-htm\sec-5\sub-e\5e12-1.htm
Revised January 28, 1997; For Internal Use Only

MECO-Criteria for Distribution Substation and Feeder Planning

Introduction

The distribution system shall be planned on the basis of serving the predicted peak kva on any part of the system each year.

Additions to the distribution system will be planned for the year in which it is predicted that:

1. The emergency current carrying capacity of any distribution circuit will be exceeded during any condition for which the distribution system is planned or,

2. Voltage levels cannot be kept within required limits.

Where applicable, each case will be evaluated on an individual basis from the standpoint of operational experience and engineering design criteria before projects are budgeted.

The distribution system includes all land, structures, lines, and substation equipment employed with 15 KV class and lower circuits.

Unless stated otherwise, the criteria described applies to facilities and equipment operating at more than 600 volts but less than 15,000 volts.

Distribution System Circuits

NORMAL CONDITIONS

The distribution system shall be planned so that switching will normally be by closed transition. Where facilities are served by two circuits through individual switches, one switch is normally open while the other switch is normally closed. When it is necessary to change the normal circuit to a facility, both switches should be closed before the normally closed switch is opened. This is known as closed transition. Open transition means to open the normally closed switch, resulting in load being dropped, and then closing the normally open switch.

Open transition switching will require approval by the President of MECO in the application of this criterion.

EMERGENCY CONDITIONS

The distribution system shall be planned to provide for the following emergency conditions:

1. Outage of any overhead distribution primary main circuit.
2. Outage of any underground distribution primary main circuit.
3. The distribution substation circuits in a specific area shall be planned to provide for the outage of any one distribution substation circuit.
4. The distribution system shall not be planned to provide backup when one circuit is out for maintenance or construction and another circuit in the same area fails.
5. Special switching considerations may be required in areas where distribution substation circuits backing up each other originate from different size transformers.
6. The distribution system shall be planned to provide for the outage of any one of multiple source circuits into a substation.

PLANNING SLD'S

In reviewing and evaluating proposed additions, with the HECO Engineering Department Design Manual used as a guide, the following conditions should be considered:

1. With approval of the President of MECO, circuiting diagrams may show overhead circuits on both sides of a street and/or double circuited on the same side of the street to avoid installation of an underground circuit.
2. When overbuilding, relocating, reconductoring, or increasing voltage, lines will be rebuilt only as necessary. Approval by the President of MECO will be required to rebuild more than is necessary, so that additional work will not have to be done within a short period of time thereafter.

3. The number of ducts specified shall be limited to only those necessary for initial requirements and requirements reasonably foreseeable within the next few years.

Distribution Substation Transformer

GENERAL

As used in this section, a distribution substation and the transformer(s) therein supply more than one billable customer.

1. Distribution substation transformers no longer required to meet load demand will be removed and relocated whenever it is economical to do so.

2. A substation lot purchased in a new subdivision will not be developed until it is predicted that a distribution substation transformer installed on the lot can be reasonably loaded. Only the portion of the lot required for the initial installation will be developed if economical to do so.

3. Substation lots shall be leased when outright purchase in fee is not possible.

4. Distribution substation transformers are generally supplied by the 69 KV or 23 KV system. Distribution substation source side buses having automatic transfer facilities will normally be supplied by different transmission lines originating from different buses or source of generation unless the transmission lines are part of a loop system.

5. Distribution substations with only one transformer need have only one transmission source if the loads supplied by the substation have a backup, unless a second source is required for engineering and/or operating reasons. MECO President approval to install a second source will be required in the application of this criterion.

NORMAL CONDITIONS

The distribution substation transformer normal loading limit shall be:

1. The zero percent lossoflife kva capability of the transformer when manufacturers' transformer test data are available.

2. One hundred (100) percent of the nameplate rating of the transformer when manufacturer's transformer test data are not available.

The distribution system shall be planned so that routine maintenance can be performed on any distribution substation transformer during normal working hours.

The distribution system will not be planned to provide for distribution substation transformer failures unless for engineering and/or operating reasons, transformer failures will cause an untenable situation. Approval by the President of MECO will be required in the application of this criterion. In the application of this criterion, service must be able to be restored in a reasonable amount of time to loads not transferred to a standby feeder. Loads which are transferred to other feeders shall not cause those standby feeders to become loaded beyond their rated current carrying capacity.

EMERGENCY CONDITIONS

The distribution substation transformer emergency loading limit shall be:

1. The one percent lossoflife kva capability of the transformer when manufacturers' transformer test data are available. (Forced cooling equipment will be installed as required such that this capability will be at least 150 percent of the OA kva rating.)

2. One hundred thirtythree and onethird (133 1/3) percent of the nameplate rating of the transformer when manufacturer's transformer test data are not available.

3. The extreme emergency loading limit of a distribution substation transformer shall be 200 percent of its maximum nameplate rating in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise.

Voltage Levels

Voltage levels are to be kept within the prescribed limits for any normal or emergency condition for which the distribution system is planned. Capacitor and regulator additions to the distribution system will be considered before any other capital additions for the year in which the predicted voltage on the distribution system will be below the minimum voltage level for any condition for which the distribution system is planned.

Application of the best combination of automatic voltage regulating equipment and transformer fixed taps shall be made to satisfy the following maximum and minimum voltage limits:

1. **Maximum Voltage**

   12.47, 7.2, 4.16, and 2.4 KV Substations (nominal voltages)

   For any system operating condition, the voltage at any point on the distribution system shall not exceed 105 percent of the appropriate nominal voltage.

2. **Minimum Voltage**

   - **Normal**

     Voltage shall conform to the requirements of STANDARDS FOR ELECTRIC UTILITY SERVICE IN THE STATE OF HAWAII (General Order No. 7).

   - **Emergency**

     For any system emergency operating condition, the voltage at any point on the distribution system shall not be less than 90 percent of the nominal source voltage.

     This minimum voltage is based on distribution substation transformers having a primary tap setting of 5 percent boost, nameplate maximum kva of 90 percent power factor through the transformer, the transformer regulator at full boost, and 2.5 percent primary voltage drop on distribution circuits, with service voltage in the extreme zone. With a nominal source voltage, the service voltage can be brought out of the extreme zone into the tolerable zone. (The extreme and tolerable zones are described in ANSI Voltage Rating for Electric Power Systems and Equipment (60 Hz), C84.1.)

At minimum load, with no distribution substation transformer voltage drop and the transformer regulator at full buck, there will not be excessive voltage on the distribution system when using the above primary tap setting of the distribution substation transformer. (For distribution substation transformers with capacitors, a primary tap setting of 5 percent boost may not be required to stay within the voltage limits described.)

Current Carrying Capacity

1. **Overhead Conductor**

   Conductor for overhead distribution circuits shall be considered to have current carrying capacity in accordance with HECO Engineering Standard 12038, "Current Carrying CapacityOutdoor Bare Conductor."

2. **Underground Cable**

   Cable for underground distribution circuits shall be considered to have current carrying capacity in accordance with the HECO Engineering Standard 211020, "Cable Ampacity Tables-Underground Data."

3. **Open Buses**

   Open buses shall be considered to have current carrying capacity in accordance with HECO Engineering Standard 12039, "Current Carrying CapacityOutdoor Open Bus."

4. **Distribution Substation Transformer Equipment**

   For new distribution substation transformer installations, the transformer connections, switches, protective relays, and current transformers shall be rated to allow the transformer to carry 200 percent of maximum nameplate rating under extreme emergency conditions in accordance with the ANSI Guide for Loading Mineral Oil Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise.

5. **Substation Equipment**

   Switches, disconnects, circuit breakers, and associated equipment shall be considered to have a current carrying capacity equivalent to their respective nominal current ratings.

Automatic Transfer Equipment

1. Automatic transfer equipment paid for by customers shall not be made inoperative for normal system conditions.

2. MECOowned automatic transfer equipment may be blocked to defer a project after the circumstances have been investigated and a decision made on an individual basis by the President of MECO.

Other Considerations

1. MECO Criteria on Distribution Substation Load Shedding application. (Refer to VE22.5)

2. MECO Criteria on circuit breaker interrupting capability versus short circuit duty. (Refer to VE-22.2)

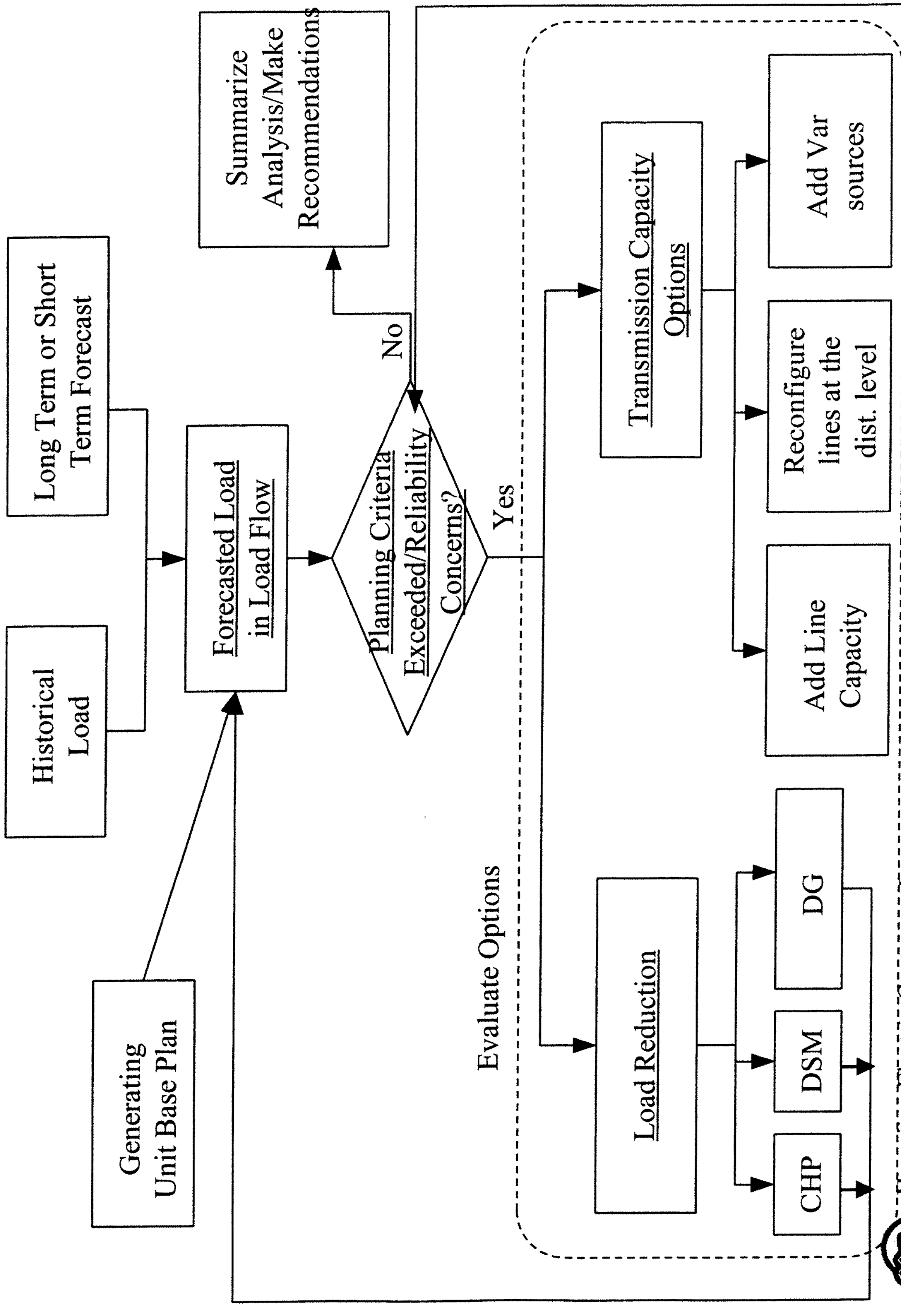
3. MECO Criteria for determining installation of switching vaults. (Refer to VE12.3)

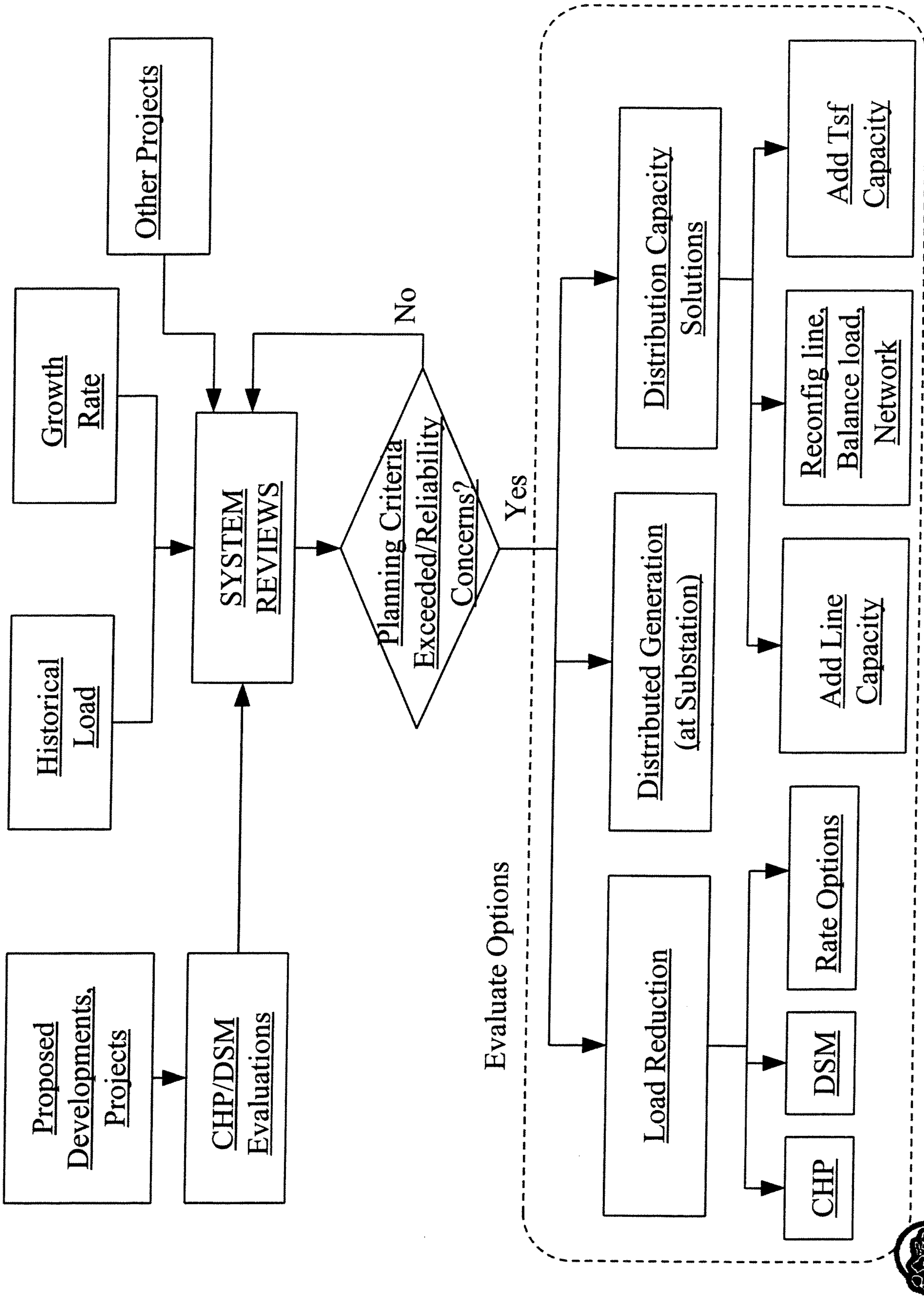
4. Criteria for use of mobile substation. (Refer to VE12.2)

Please share your comments with the Responsible Department/Division listed in the header at the top of this document.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

| **Top** | | **Table of Contents** | **HomePage** | | **Send e-mail to Myla Washington** |


Historical Load
Long Term or Short Term Forecast
Generating Unit Base Plan
Forecasted Load in Load Flow
Planning Criteria Exceeded/Reliability Concerns?
No
Yes
Summarize Analysis/Make Recommendations
Evaluate Options
Load Reduction
CHP
DSM
DG
Transmission Capacity Options
Add Line Capacity
Reconfigure lines at the dist. level
Add Var sources



Hawaiian Electric Company, Inc.

II. Introduction

The purpose of this study is to estimate the 2000 system losses for the Hawaiian Electric Co.(HECO) system. The last system loss analysis for the HECO system was completed in April 1993. Since 1993, changes have occurred that can impact the system losses such as the growth and shifting of customer loads, a change in the generator commitment rules, and the completion of the Waiau-CIP circuits. Such changes are taken into account in the current study.

In addition, a revised methodology is employed in this study to calculate the losses. The old method used a single peak demand loss value and a system loss factor calculated using a Mainland empirical formula to estimate the annual generator-related and transmission energy losses. The use of the single peak demand loss value can cause unrealistically wide variations in the energy loss estimates from one year to the next. The revised method uses a range of demand loss values for various load levels to form loss functions which are then numerically integrated using a load duration curve descriptive of the HECO system to obtain the annual energy losses. The old method also used voltage-insensitive hand calculations to estimate the subtransmission, distribution, and secondary losses. The revised method also employs load flow modeling and analysis in estimating the subtransmission and distribution losses. The greater detail of the revised methodology should improve the loss estimates.

III. Methodology

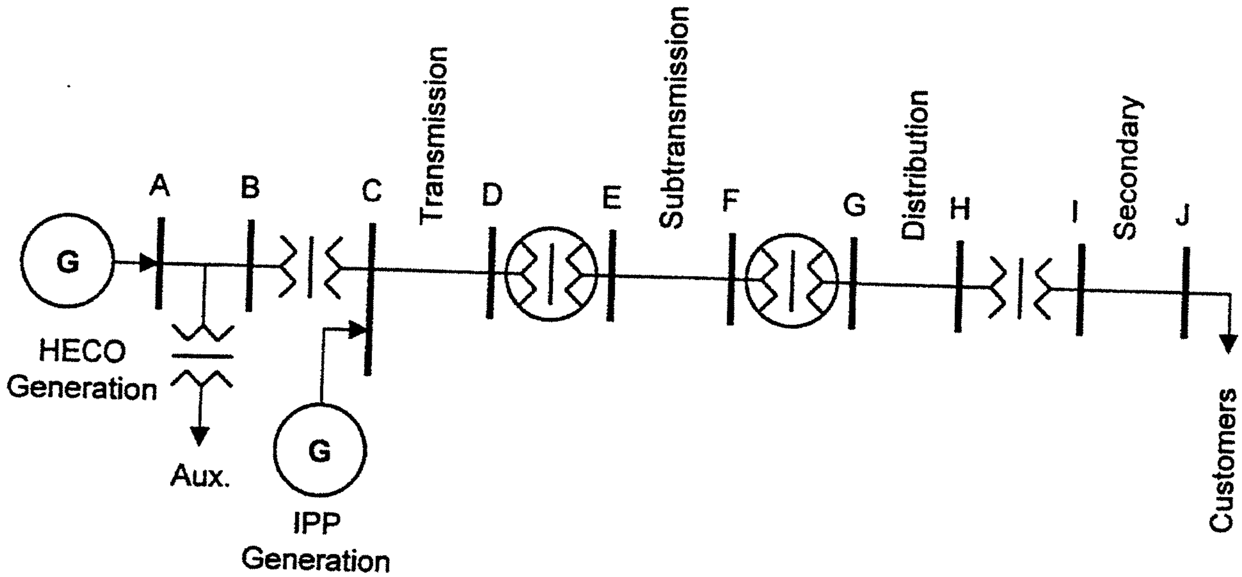
A. System Losses Overview

The HECO energy delivery system can be divided into the component levels shown in Figure 1. Losses are estimated for each component level with the total T&D losses being the sum of the individual component level losses excluding the auxiliary load component. Unlike the T&D losses, the power-plant auxiliary loads are not resistive losses. However, auxiliary loads are incurred in the process of generating electricity and thus, they are also estimated like the T&D losses to facilitate the conversion of HECO gross generation to net generation.

There are two aspects of losses, demand losses(units of watts) and energy losses(units of watt-hours).

B. Estimating Demand Losses

The demand losses are estimated using demand loss functions. Demand losses are calculated for each component level at seven system load levels. Curve fitting is then used with the calculated loss values to derive a loss function for each component level.



<u>System Connections</u>
A. HECO Gross Generation
B. HECO Net Generation
C. To Transmission Lines
(Point of IPP Generation Injection)
D. To Subtransmission Tranformers
E. To Subtransmission Lines
F. To Distribution Transformers
G. To Distribution Lines
H. To Secondary Transformers
I. To Secondary Lines
J. To Customers

<u>Component Levels</u>
A-B HECO Auxiliary Loads
B-C HECO Generator Step-Up Transformers
C-D Transmission Lines
D-E Subtransmission Transformers
E-F Subtransmission Lines
F-G Distribution Transformers
G-H Distribution Lines
H-I Secondary Transformers
I-J Secondary Lines

Figure 1
HECO Energy Delivery System

A quadratic function is used in the loss-function curve fitting. For a given load level, the demand losses can be calculated from the resulting demand loss functions.

The seven system load levels used to derive the demand loss functions are 503 MW, 625 MW, 745 MW, 865 MW, 985 MW, 1105 MW, and 1220 MW. This range of load levels should encompass the system load levels that occur on the HECO system over the course of a year such as the year 2000. The substation load distribution and power factor changes that occur over the course of the day are estimated by using the recorded 1997 system minimum substation load distribution and power factors for the 503 MW load level, data from the recorded 1997 system day peak for the 985 MW and 1105 MW load levels, and data from the recorded 1997 system evening peak for the remaining load levels.

C. Estimating Energy Losses

Generator outages can alter the auxiliary loads, the generator step-up transformer losses, and the transmission line losses. To account for the generator outages, several sets of loss data are used to derive the demand loss function for the component levels between A through E(see Figure 1). For each of these component levels, a set of loss data is calculated for an all-generators-available case and for cases where each base load generator is outaged. Non-base load generator outages are ignored to economize the amount of calculations needed; the impact of non-base load generator outages on the annual energy-loss estimates are significantly less than the base load generator outages.

For each component level, the different sets of loss data are averaged using the availability of the base load generators as weighting. A generator's availability takes into consideration both their equivalent forced outage rate(EFOR) and their equivalent maintenance outage rate. This method for averaging the calculated loss data assumes base load generators are outaged only one at a time. Finally, each component level's averaged loss data are used to derive their loss function used in estimating the annual energy losses. Appendix A list the generator forced outage rates and the forecasted maintenance schedule used in determining the maintenance outage rates.

To make the loss estimates more general, the maintenance outage rate used for each generator is an average value based on the generator's forecasted maintenance schedule from 2000 to 2005 instead of just its year-2000 maintenance schedule. A six year period was chosen for the averaging because major generator overhauls are scheduled in six-year cycles.

The annual energy losses are estimated by numerically integrating the averaged loss functions with the HECO load duration curve. Note, the available load duration curve is based on gross generation. Since the shape of the gross generation load duration curve is a function of the system losses, the 1999 system losses are estimated first so that a customer load duration curve can be extracted from the 1999 gross generation load duration curve. In extracting the customer load duration curve, only the actual 1999 generator maintenance schedule is used in determining the generator maintenance outage rates because the calculations involve what had already transpired. The 1999 load duration curves can be found in Appendix B.

A 2000 customer load duration curve is derived by scaling the 1999 customer load duration curve such that the resulting 2000 gross generation load duration curve which combines the 2000 customer load duration curve and the 2000 estimated system losses will have a system peak and a system minimum consistent with the 7/99 forecasted 2000 peak and minimum. The 2000 customer load duration curve is used in the numerical integration to estimate the energy losses for the year 2000. In keeping with the goal of making the loss estimates more general, the 2000 leap day is ignored in the calculations.

D. Component Level Loss Calculations

Generators are committed per current HECO unit commitment rules, and are economically dispatched per the "ABC coefficient" data(HECO 7/31/98 & IPPs 9/8/98) installed by HECO System Operations modified by the penalty factors listed in HWL's 11/13/98 IOC. Generator auxiliary load levels(component A-B) are estimated using the curves found in the 1990 HECO System Loss Analysis report, Attachments 2 through 6.

The HECO generator step-up transformer losses(component B-C), the transmission line losses(component C-D), and the subtransmission transformer losses(component D-E) are calculated using PTI's PSS/E load flow software. The complete HECO transmission system is represented in the load flows. The load flows can be found in Appendix C.

Since the HECO system include 57 subtransmission circuits with 267 distribution transformers and their associated circuits, modeling the entire subtransmission and distribution systems for load flow analysis would be difficult to do within the time frame of this study. Instead, the subtransmission and distribution system losses are calculated by running load flows for a few subtransmission and distribution sample subsystems, and then extrapolating the results to the rest of the subtransmission and distribution systems. The sample subsystems are selected by finding subsystems with loads judged to be representative of the customer sales composition statistics in the 1999 HECO Financial and Statistical Data booklet.

PSS/E load flow is used in the loss calculations for the subtransmission system: the subtransmission line losses(component E-F) and the distribution transformer losses(component F-G). Listed in Table 1 are the selected sample transformers and their associated circuits for the load flow calculations. Single-line diagrams for these subtransmission subsystems are shown in Appendix D.

Scott & Scott's DPA/G distribution load flow software is used in the loss calculations for the distribution system: the distribution line losses(component G-H) and the secondary transformer losses(component H-I). Listed in Table 1 are the selected sample distribution feeders for the load flow calculations. Single-line diagrams for these distribution subsystems are shown in Appendix E.

Table 1
Selected Subtransmission & Distribution Subsystems
For Load Flow Modeling & Analysis

Customer Load Type	Distribution Subsystems (Tsf./Ckt.)	Subtransmission Subsystems	
		Subtransmission Transformer	Subtransmission Circuits
Commercial/Large	Makaloa 3/Makaloa	Archer B	Archer 43 Archer 44A
	Waikiki 3/Waikiki 6	CEIP 3	CEIP 45 CEIP 46
		Pukele 2	Pukele 3 Pukele 4
General/Residential	Hala 1/Hala 2	Halawa 1	Halawa 1 Halawa 2
	Upper Kipapa 1/ Kuahelani 1 Waimano 3/ Highlands	Waiau 46 kV Substation	Waiau-Barbers Pt. Waiau-Mililani Waiau-Waimano Waiau 41 Waiau 43

The secondary line and meter losses(component I-J) are calculated using typical loss data from the utility industry as described in the PTI Power System Planning Techniques course notes(1993). Data relating to HECO's secondary-voltage installations is insufficient to conduct comprehensive load flow modeling and analysis for the present study. The PTI document indicates secondary line and meter losses are typically 13% of the total system demand losses at the system peak load. This information is used to develop a parabolic function for calculating secondary line and meter losses where zero losses are assumed when the customer load is zero. This calculation is similar to the hand calculations used in the old methodology.

IV. Results

A. The Revised Methodology Versus The Old Methodology

The 1997 total T&D energy losses are estimated using both the revised and the old methodologies to compare the performance of the two. 1997 is chosen because recorded generation and sales data are available for comparison with the estimates. 1998 was not chosen for the comparison because the change in HECO's unit commitment rules in the middle of 1998 required a doubling of the number of calculations: pre- and post-rules change. From the 1999 HECO Financial and Statistical Data booklet, the 1997 system unaccounted-for energy and total T&D energy losses is 368.8 GWH. Most of this value, if not all of it, is likely T&D losses.

Using the old methodology, a system loss factor calculated from the 1997 load(gross) factor and a load flow case representing the 1997 evening peak are used to estimate the generator-related and transmission losses. The subtransmission, distribution, and secondary loss values calculated in the 1990 loss analysis study are scaled as in the 1993 loss analysis study to estimate the subtransmission, distribution, and secondary losses. Using the old methodology, the estimated 1997 total T&D energy losses is 401.2 GWH. Which is about 8.8% greater than the 1997 recorded value.

Using the revised methodology, the 1997 load duration curve and the 1997 generator maintenance schedule are used in the loss calculations. Note, in applying both old and revised methodologies, 1997 heat rate data and commitment rules are used to economically dispatch and commit generators in the calculations. Using the revised methodology, the estimated 1997 total T&D energy losses is 370.4 GWH. Which is only about 0.4% greater than the 1997 recorded value. The discrepancy between the 1997 estimate and actual is a magnitude smaller using the revised methodology compared with using the old methodology.

B. System Losses

Table 2 shows the allocation of demand and energy losses for each component level as well as the total T&D losses. Table 2 also shows the demand/energy losses and the delivered power/energy as percentages of the system gross power/energy generation.