

# Quantification of Energy Efficiency in the Utilities of the U.S. Affiliate States (Excluding US Virgin Islands)

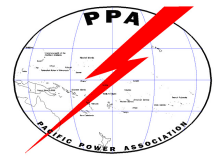
## Data Handbook



Pacific Power Association.

Prepared for Commonwealth Utilities Corporation (CUC).

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## 1. Introduction

KEMA Inc has been awarded by the Pacific Power Association (PPA) in Fiji to carry out a project called "Quantification of Energy Efficiency in the Utilities of the U.S. Affiliate States (Excluding US Virgin Islands)".

As part of the deliverables of this project, an Electrical Data Handbook has been prepared containing all the electrical characteristics of the power system high voltage equipment for each of the utilities. This document represents the Electrical Data Handbook for Commonwealth Utilities Corporation (CUC) of Saipan. All relevant data of the high and medium voltage assets, such as generation data, impedances of lines, cables, transformers, and other equipments are included as far as the relevant data could be gathered. KEMA has incorporated major data of components and equipment in power generation, transmission, distribution and metering. A data template is established to hold comprehensive equipment data, for example for transformer power ratings, primary and secondary voltages, load and no load losses, tap changer data, BIL ratings, cooling class, applicable standards, weight, etc.

## 2. Data Content

All data contents are identified based on the information KEMA received.

### 2.1 Substation Buses

Substation bus data are listed in the Table 1.

**Table 1 – Substation Buses**

| Name            | Base kV | Area        | Zone    | Rating Amps | Bracing kA | Material | Remarks |
|-----------------|---------|-------------|---------|-------------|------------|----------|---------|
| PP-1 Bus 1      | 13.8 kV | Lower Base  | Central | 1200 A      | 62.5 kA    | Copper   |         |
| PP-1 Bus 2      | 13.8kV  | Lower Base  | Central | 1500 A      | 62.5 kA    | Copper   |         |
| PP-1 Bus 3      | 13.8kV  | Lower Base  | Central | 1500 A      | 62.5 kA    | Copper   |         |
| PP-1 S/S Bus 31 | 0.480kV | Lower Base  | Central | 3100 A      | 105 kA     | Copper   |         |
| PP-1 S/S Bus 32 | 0.480kV | Lower Base  | Central | 3100 A      | 105 kA     | Copper   |         |
| PP-1 S/S Bus 33 | 0.480kV | Lower Base  | Central | 3100 A      | 105 kA     | Copper   |         |
| PP-1 S/S Bus 34 | 0.480kV | Lower Base  | Central | 3100 A      | 105 kA     | Copper   |         |
| PP-2 Bus 4      | 4.160kV | Lower Base  | Central | 2000 A      | 25 kA      | Copper   |         |
| PP-2 S/S Bus 36 | 0.480kV | Lower Base  | Central | 300 A       | 14 kA      | Copper   |         |
| PP-4 Bus 5      | 13.8kV  | Puerto Rico | Central | 1000 A      | 25 kA      | Copper   |         |
| PP-4 Bus 6      | 4.160kV | Puerto Rico | Central | 1600 A      | 25 kA      | Copper   |         |
| PP-4 Bus 7      | 0.400kV | Puerto Rico | Central | 2000 A      | 25 kA      | Copper   |         |
| PP-4 S/S Bus 37 | 0.480kV | Puerto Rico | Central | 800 A       | 50 kA      | Copper   |         |
| LB SS Bus 11    | 34.5kV  | Lower Base  | Central | 1200 A      | 25 kA      | Copper   |         |

|                   |        |                 |         |        |       |        |  |
|-------------------|--------|-----------------|---------|--------|-------|--------|--|
| LB SS Bus 12      | 34.5kV | Lower Base      | Central | 1200 A | 25 kA | Copper |  |
| Kiya SS Bus 23/24 | 13.8kV | Kiya Substation | South   | 2000 A | 25 kA | Copper |  |
| Kiya SS Bus 25/26 | 34.5kV | Kiya Substation | South   | 1200 A | 25 kA | Copper |  |

Note:

S/S Station Services

SS Sub-Station

PP-1 Power Plant -1

## 2.2 Generators

Generator data are listed in the Table 2, Table 3 and Table 4.

**Table 2 – Generators**

| Plant            | Power Plant 1                                    |                                                  |                                                  |                                                  |                                                  |                                                  |                                                  |                                                  |
|------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|
| Unit             | D/E 1                                            | D/E 2                                            | D/E 3                                            | D/E 4                                            | D/E 5                                            | D/E 6                                            | D/E 7                                            | D/E 8                                            |
| Engine Make      | Mitsubishi                                       | Mitsubishi                                       | Mitsubishi                                       | Mitsubishi                                       | Mitsubishi                                       | Mitsubishi                                       | Mitsubishi                                       | Mitsubishi                                       |
| Engine Type      | 4-stroke cycles, Constant pressure turbocharging | 4-stroke cycles, Constant pressure turbocharging | 4-stroke cycles, Constant pressure turbocharging | 4-stroke cycles, Constant pressure turbocharging | 4-stroke cycles, Constant pressure turbocharging | 4-stroke cycles, Constant pressure turbocharging | 4-stroke cycles, Constant pressure turbocharging | 4-stroke cycles, Constant pressure turbocharging |
| Engine Model     | 18V 40/54A                                       | 18V 40/54A                                       | 18V 40/54A                                       | 18V 40/54A                                       | 18V 52/55B                                       | 18V 52/55B                                       | 18V 52/55B                                       | 18V 52/55B                                       |
| Serial Number    | D154193                                          | D154194                                          | D154195                                          | D154217                                          | D155138                                          | D155139                                          | D155142                                          | D155143                                          |
| Speed (rpm)      | 450                                              | 450                                              | 450                                              | 450                                              | 450                                              | 450                                              | 450                                              | 450                                              |
| Bore (mm)        | 400                                              | 400                                              | 400                                              | 400                                              | 520                                              | 520                                              | 520                                              | 520                                              |
| Stroke (mm)      | 540                                              | 540                                              | 540                                              | 540                                              | 550                                              | 550                                              | 550                                              | 550                                              |
| Capacity (MW)    | 7.27                                             | 7.27                                             | 7.27                                             | 7.27                                             | 13.04                                            | 13.04                                            | 13.04                                            | 13.04                                            |
| No. of Cylinders | 18, V-form                                       | 18, V-form                                       | 18, V-form                                       | 18, V-form                                       | 18, V-form                                       | 18, V-form                                       | 18, V-form                                       | 18, V-form                                       |
| Alternator Make  | Meidensha                                        | Meidensha                                        | Meidensha                                        | Meidensha                                        | Meidensha                                        | Meidensha                                        | Meidensha                                        | Meidensha                                        |
| Type/Model       | ED-AF                                            | ED-AF                                            | ED-AF                                            | ED-AF                                            | ED-AF                                            | ED-AF                                            | ED-AF                                            | ED-AF                                            |
| Serial Number    | 5G8256R1                                         | 5G8256R2                                         | 5G8256R3                                         | 1H9729R1                                         | 8N8178R1                                         | 8N8178R2                                         | 8N9823R1                                         | 8N9823R2                                         |
| Rating           | Continuous                                       | Continuous                                       | Continuous                                       | Continuous                                       | Continuous                                       | Continuous                                       | Continuous                                       | Continuous                                       |

|                             |                       |                       |                       |                       |                       |                       |                       |                       |
|-----------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <b>Rated kV</b>             | 13.8                  | 13.8                  | 13.8                  | 13.8                  | 13.8                  | 13.8                  | 13.8                  | 13.8                  |
| <b>Rated Output</b>         | 10 MVA                | 10 MVA                | 10 MVA                | 10 MVA                | 16.3 MVA              | 16.3 MVA              | 16.3 MVA              | 16.3 MVA              |
| <b>Phase</b>                | 3                     | 3                     | 3                     | 3                     | 3                     | 3                     | 3                     | 3                     |
| <b>No. of Poles</b>         | 16                    | 16                    | 16                    | 16                    | 16                    | 16                    | 16                    | 16                    |
| <b>RPM</b>                  | 450                   | 450                   | 450                   | 450                   | 450                   | 450                   | 450                   | 450                   |
| <b>Power Factor</b>         | 0.8                   | 0.8                   | 0.8                   | 0.8                   | 0.8                   | 0.8                   | 0.8                   | 0.8                   |
| <b>Frequency (Hz)</b>       | 60                    | 60                    | 60                    | 60                    | 60                    | 60                    | 60                    | 60                    |
| <b>Amps</b>                 | 418                   | 418                   | 418                   | 418                   | 682                   | 682                   | 682                   | 682                   |
| <b>Exciter Volts</b>        | 86.9                  | 86.9                  | 86.9                  | 86.9                  | 175                   | 175                   | 175                   | 175                   |
| <b>Field Amp</b>            | 605                   | 605                   | 605                   | 605                   | 608                   | 608                   | 608                   | 608                   |
| <b>Insulation Class</b>     | Armature=B<br>Field=B | Armature=B<br>Field=B | Armature=B<br>Field=B | Armature=B<br>Field=B | Armature=F<br>Field=F | Armature=F<br>Field=F | Armature=F<br>Field=F | Armature=F<br>Field=F |
| <b>Year Built</b>           | Jul-1979              | Sep-1979              | Aug-1979              | Mar-1983              | Dec-1989              | Dec-1989              | Mar-1991              | Aug-1991              |
| <b>NamePlate Rate (MW)</b>  |                       |                       |                       |                       |                       |                       |                       |                       |
| <b>De-rated (MW)</b>        |                       |                       |                       |                       |                       |                       |                       |                       |
| <b>Xd</b>                   | 117%                  | 117%                  | 117%                  | 117%                  | 126%                  | 126%                  | 126%                  | 126%                  |
| <b>Xd'</b>                  | 39%                   | 39%                   | 39%                   | 39%                   | 40%                   | 40%                   | 40%                   | 40%                   |
| <b>Xd''</b>                 | 28%                   | 28%                   | 28%                   | 28%                   | 30%                   | 30%                   | 30%                   | 30%                   |
| <b>X0v</b>                  |                       |                       |                       |                       |                       |                       |                       |                       |
| <b>Xlr</b>                  |                       |                       |                       |                       |                       |                       |                       |                       |
| <b>Fuel Type</b>            | Diesel                | Diesel                | Diesel                | Diesel                | Diesel                | Diesel                | Diesel                | Diesel                |
| <b>Efficiency (kwh/gal)</b> |                       |                       |                       |                       |                       |                       |                       |                       |



|                                  |          |          |          |          |          |          |          |          |
|----------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| <b>Break Mean Press (kg/cm2)</b> | 18.4     | 18.4     | 18.4     | 18.4     | 17.4     | 17.4     | 17.4     | 17.4     |
| <b>Commissioning Date</b>        | Mar-1980 | Mar-1980 | Mar-1980 | Jun-1983 | Apr-1990 | May-1990 | Mar-1992 | Mar-1992 |
| <b>Remarks</b>                   |          |          |          |          |          |          |          |          |

**Table 3 – Generators (Cont)**

| <b>Plant</b>            | <b>Power Plant 2</b> |                 |                 |                |                |                |
|-------------------------|----------------------|-----------------|-----------------|----------------|----------------|----------------|
| <b>Unit</b>             | <b>D/E 1</b>         | <b>D/E 2</b>    | <b>D/E 3</b>    | <b>D/E 4</b>   | <b>D/E 5</b>   | <b>D/E 6</b>   |
| <b>Engine Make</b>      | GM                   | GM              | GM              | GM             | GM             | GM             |
| <b>Engine Type</b>      | 2-stroke cycle       | 2-stroke cycle  | 2-stroke cycle  | 2-stroke cycle | 2-stroke cycle | 2-stroke cycle |
| <b>Engine Model</b>     | L20-645-E9           | L20-645-E9      | L20-645-E9      | L20-645-E9     | L20-645-E9     | 20-645-E4      |
| <b>Serial Number</b>    | 72-F1-1046           | 72-F1-1082      | 72-F1-1073      | 76-C1-1105     | 76-C1-1154     | 71-K1-1009     |
| <b>Speed (rpm)</b>      | 900                  | 900             | 900             | 900            | 900            | 900            |
| <b>Bore (mm)</b>        | --                   | --              | --              | --             | --             | --             |
| <b>Stroke (mm)</b>      | --                   | --              | --              | --             | --             | --             |
| <b>Capacity (MW)</b>    | 2.5                  | 2.5             | 2.5             | 2.5            | 2.5            | 2.5            |
| <b>No. of Cylinders</b> | 20                   | 20              | 20              | 20             | 20             | 20             |
| <b>Alternator Make</b>  | Fairbanks Morse      | Fairbanks Morse | Fairbanks Morse | EMD            | EMD            | EMD            |
| <b>Type/Model</b>       | TBG ZJ               | TBG ZJ          | TBG ZJ          | A20 T24        | A20 T24        | A 20-61        |
| <b>Serial Number</b>    | 503825 R4            | 503825 R3       | 503825 R2       | 76-D1-1023     | 76-C1-1023     | 71-K1-1076     |

|                     |        |        |        |        |        |        |
|---------------------|--------|--------|--------|--------|--------|--------|
| Rating              | --     | --     | --     | --     | --     | --     |
| Rated kV            | 4.16   | 4.16   | 4.16   | 4.16   | 4.16   | 4.16   |
| Rated Output        | 2.5 MW | 2.5 MW | 2.5 MW | 2.5 MW | 2.5 MW | 2.5 MW |
| Phase               | 3      | 3      | 3      | 3      | 3      | 3      |
| No. of Poles        | --     | --     | --     | --     | --     | --     |
| RPM                 | --     | --     | --     | --     | --     | --     |
| Power Factor        | --     | --     | --     | --     | --     | --     |
| Frequency (Hz)      | 60     | 60     | 60     | 60     | 60     | 60     |
| Amps                | --     | --     | --     | --     | --     | --     |
| Exciter Volts       | --     | --     | --     | --     | --     | --     |
| Field Amp           | --     | --     | --     | --     | --     | --     |
| Insulation Class    | --     | --     | --     | --     | --     | --     |
| Year Built          | 1972   | 1972   | 1972   | 1976   | 1976   | 1971   |
| NamePlate Rate (MW) |        |        |        |        |        |        |
| De-rated (MW)       |        |        |        |        |        |        |
| Xd                  |        |        |        |        |        |        |
| Xd'                 |        |        |        |        |        |        |
| Xd''                |        |        |        |        |        |        |
| X0v                 |        |        |        |        |        |        |
| Xlr                 |        |        |        |        |        |        |
| Fuel Type           |        |        |        |        |        |        |
| Efficiency          |        |        |        |        |        |        |

|                           |      |      |      |      |      |      |
|---------------------------|------|------|------|------|------|------|
| (kwh/gal)                 |      |      |      |      |      |      |
| Break Mean Press (kg/cm2) |      |      |      |      |      |      |
| Commissioning Date        | 1986 | 1986 | 1986 | 1986 | 1986 | 1986 |
| Remarks                   |      |      |      |      |      |      |

**Table 4 – Generators (Cont)**

| Plant         | Power Plant 4     |              |              |                |                |                 |                 |                 |                 |                |
|---------------|-------------------|--------------|--------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|----------------|
| Unit          | D/E 1             | D/E 2        | D/E 3        | D/E 4          | D/E 5          | D/E 6           | D/E 7           | D/E 8           | D/E 9           | D/E 10         |
| Engine Make   |                   | Nordberg Mfg | Nordberg Mfg | GM             | GM             | Newage Stamford | Newage Stamford | Newage Stamford | Newage Stamford | GM             |
| Engine Type   |                   |              |              | 2-stroke cycle | 2-stroke cycle | 2-stroke cycle  | 2-stroke cycle  | 2-stroke cycle  | 2-stroke cycle  | 2-stroke cycle |
| Engine Model  | Enterprise DSR-48 | FS-1312-HSC  | FS-1312-HSC  | 20-645-E4      | 20-645-E4      | KTA50G3         | KTA50G3         | KTA50G3         | KTA50G3         | 20-645-E3      |
| Serial Number |                   | 1030-1257    | 1030-1256    | 20E-72C33 531  | 77-HI-1066     | 3.3E+07         | 3.3E+07         | 3.3E+07         | 3.3E+07         | 82-D3-1504     |
| Speed (rpm)   |                   | 600          | 600          | 900            | 900            | 900             | 900             | 900             | 900             | 900            |
| Bore (mm)     |                   |              |              |                |                |                 |                 |                 |                 |                |
| Stroke (mm)   |                   |              |              |                |                |                 |                 |                 |                 |                |
| Capacity (MW) |                   | 2.2          | 2.2          | 2.5            | 2.5            | 1               | 1               | 1               | 1               | 2.6            |

| No. of Cylinders    |      | 12                   | 12                   | 20              | 20              | 16      | 16      | 16      | 16      | 20              |
|---------------------|------|----------------------|----------------------|-----------------|-----------------|---------|---------|---------|---------|-----------------|
| Alternator Make     |      | The Electric Product | The Electric Product | Fairbanks Morse | Fairbanks Morse | Newage  | Newage  | Newage  | Newage  | Fairbanks Morse |
| Type/Model          |      | L-10768              | L-10768              | A-20-T24        | A-20-T24        | 9827496 | 9827496 | 9827496 | 9827496 | A-20-T24        |
| Serial Number       |      |                      |                      |                 |                 |         |         |         |         |                 |
| Rating              |      |                      |                      |                 |                 |         |         |         |         |                 |
| Rated kV            |      | 13.8                 | 13.8                 | 4.16            | 4.16            | 0.44    | 0.44    | 0.44    | 0.44    | 4.16            |
| Rated Output        |      | 2.285 MW             | 2.285 MW             | 2.5 MW          | 2.5 MW          | 1.14 MW | 1.14 MW | 1.14 MW | 1.14 MW | 2.6 MW          |
| Phase               |      |                      |                      |                 |                 |         |         |         |         |                 |
| No. of Poles        |      |                      |                      |                 |                 |         |         |         |         |                 |
| RPM                 |      |                      |                      |                 |                 |         |         |         |         |                 |
| Power Factor        |      |                      |                      |                 |                 |         |         |         |         |                 |
| Frequency (Hz)      |      | 60                   | 60                   | 60              | 60              | 60      | 60      | 60      | 60      | 60              |
| Amps                |      |                      |                      |                 |                 |         |         |         |         |                 |
| Exciter Volts       |      |                      |                      |                 |                 |         |         |         |         |                 |
| Field Amp           |      |                      |                      |                 |                 |         |         |         |         |                 |
| Insulation Class    |      |                      |                      |                 |                 |         |         |         |         |                 |
| Year Built          | 1974 | 1957                 | 1956                 | 1972            | 1977            | 1998    | 1998    | 1998    | 1998    | 1980            |
| NamePlate Rate (MW) |      |                      |                      |                 |                 |         |         |         |         |                 |
| De-rated (MW)       |      | 2 MW                 | 2 MW                 | 2 MW            | 2 MW            | 0.9 MW  | 0.9 MW  | 0.9 MW  | 0.9 MW  | 2.2             |
| Xd                  |      |                      |                      |                 |                 |         |         |         |         |                 |

|                              |                                                          |  |  |  |  |  |  |  |  |  |
|------------------------------|----------------------------------------------------------|--|--|--|--|--|--|--|--|--|
| Xd'                          |                                                          |  |  |  |  |  |  |  |  |  |
| Xd''                         |                                                          |  |  |  |  |  |  |  |  |  |
| X0v                          |                                                          |  |  |  |  |  |  |  |  |  |
| Xlr                          |                                                          |  |  |  |  |  |  |  |  |  |
| Fuel Type                    |                                                          |  |  |  |  |  |  |  |  |  |
| Efficiency<br>(kwh/gal)      |                                                          |  |  |  |  |  |  |  |  |  |
| Break Mean<br>Press (kg/cm2) |                                                          |  |  |  |  |  |  |  |  |  |
| Commissionin<br>g Date       |                                                          |  |  |  |  |  |  |  |  |  |
| Remarks                      | Inoperati<br>onal due<br>to<br>damaged<br>crank<br>shaft |  |  |  |  |  |  |  |  |  |

## 2.3 Power Transformers

Power transformer data are listed in the Table 5.

**Table 5 – Power Transformers**

| Name                | PP-1 SS T1          | PP-1 SS T2          | PP-1 S/S T1         | PP-1 S/S T2         | PP-1 S/S T3         | PP-1 S/S T4         | PP-2 T1             | PP-2 T2             |
|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Type                | Oil                 | Oil                 | Oil                 | Oil                 | Oil                 | Oil                 | Oil                 | Oil                 |
| Class               | OA/FA/FA            | OA/FA/FA            | OA                  | OA                  | OA                  | OA                  | OA/AF               | OA/AF               |
| Temperature         | 55/65 deg.C         | 55/65 deg.C         | 55 deg.C            | 55 deg.C            | 55 deg.C            | 55 deg.C            | 55 deg.C            | 55 deg.C            |
| Form                | Core                | Core                | Core                | Core                | Core                | Core                | Core                | Core                |
| From Connection     | Delta               | Delta               | Delta               | Delta               | Delta               | Delta               | Wye                 | Wye                 |
| To Connection       | Wye-grd             | Wye-grd             | Wye-grd             | Wye-grd             | Wye-grd             | Wye-grd             | Delta               | Delta               |
| From kV             | 13.8kV              | 13.8kV              | 13.8kV              | 13.8kV              | 13.8kV              | 13.8kV              | 4.16kV              | 4.16kV              |
| To kV               | 34.5<br>Y/19.92 kV  | 34.5<br>Y/19.92 kV  | 0.48kV              | 0.48kV              | 0.48kV              | 0.48kV              | 13.8kV              | 13.8kV              |
| From Tap            | 32.78 kV            | 32.78 kV            | 13.8kV              | 13.8kV              | 13.8kV              | 13.8kV              | 4.16kV              | 4.16kV              |
| To Tap              | 36.22 kV            | 36.22 kV            | 0.48kV              | 0.48kV              | 0.48kV              | 0.48kV              | 13.8kV              | 13.8kV              |
| MVA                 | 30/40/50            | 30/40/50            | 1.0                 | 1.0                 | 2.5                 | 2.5                 | 10.0                | 10.0                |
| MVA Overload        | 33.6/44.8/56        | 33.6/44.8/56        |                     |                     |                     |                     |                     |                     |
| Z%                  | 7.42                | 7.47                | 6.04                | 6.04                | 6.48                | 6.48                | 5.6                 | 5.6                 |
| Z0%                 | 85                  | 85                  | 85                  | 85                  | 85                  | 85                  | 85                  | 85                  |
| X/R RATIO           |                     |                     |                     |                     |                     |                     |                     |                     |
| GROUNDING IMPEDANCE | 0- Solidly grounded | 0- Solidly grounded | 0- Solidly grounded | 0- Solidly grounded | 0- Solidly grounded | 0- Solidly grounded | 0- Solidly grounded | 0- Solidly grounded |

| GROUNDING<br>Amp CLASS |                                      |                                      |                                                |                                                |                                                |                                                |                        |                        |
|------------------------|--------------------------------------|--------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------|------------------------|
| LTC TAP                | Off LTC                              | Off LTC                              | Off LTC                                        | Off LTC                                        | Off LTC                                        | Off LTC                                        | Off LTC                | Off LTC                |
| LTC STEP<br>SIZE       |                                      |                                      |                                                |                                                |                                                |                                                |                        |                        |
| MIN TAP                |                                      |                                      |                                                |                                                |                                                |                                                |                        |                        |
| MAX TAP                |                                      |                                      |                                                |                                                |                                                |                                                |                        |                        |
| CONTROL<br>TYPE        |                                      |                                      |                                                |                                                |                                                |                                                |                        |                        |
| CONTROL<br>VALUE       |                                      |                                      |                                                |                                                |                                                |                                                |                        |                        |
| CONTROL<br>SIDE        |                                      |                                      |                                                |                                                |                                                |                                                |                        |                        |
| REMARKS                | Step-up<br>Substation<br>Transformer | Step-up<br>Substation<br>Transformer | Station<br>Service<br>Step down<br>Transformer | Station<br>Service<br>Step down<br>Transformer | Station<br>Service<br>Step down<br>Transformer | Station<br>Service<br>Step down<br>Transformer | Step up<br>Transformer | Step up<br>Transformer |

**Table 6 – Power Transformers (Cont)**

| Name               | PP-4 T1  | PP-4 T2  | PP-4 T3  | PP-5 T4  | PP-6 T5  | Kiya SS T1  | Kiya SS T2  |
|--------------------|----------|----------|----------|----------|----------|-------------|-------------|
| Type               | Oil      | Oil      | Oil      | Oil      | Oil      | Oil         | Oil         |
| Class              | OA       | OA       | OA       | OA       | OA       | OA/FA/FA    | OA/FA/FA    |
| Temperature        | 55 deg.C | 55 deg.C | 55 deg.C | 55 deg.C | 55 deg.C | 55/65 deg.C | 55/65 deg.C |
| Form               | Core     | Core     | Core     | Core     | Core     | Core        | Core        |
| From<br>Connection | Delta    | Wye      | Wye      | Wye      | Wye      | Delta       | Delta       |
| To<br>Connection   | Wye      | Delta    | Delta    | Delta    | Delta    | Wye-grd     | Wye-grd     |
| From kV            | 4.16kV   | 4.16kV   | 4.16kV   | 0.4kV    | 0.4kV    | 34.5kV      | 34.5kV      |

|                     |                     |                     |                     |                           |                           |                                            |                                            |
|---------------------|---------------------|---------------------|---------------------|---------------------------|---------------------------|--------------------------------------------|--------------------------------------------|
| To kV               | 13.8kV              | 13.8kV              | 13.8kV              | 13.8kV                    | 13.8kV                    | 13.8 Y/7.97 kV                             | 13.8 Y/7.97 kV                             |
| From Tap            | 4.16kV              | 4.16kV              | 4.16kV              | 0.4kV                     | 0.4kV                     | 32.78 kV                                   | 32.78 kV                                   |
| To Tap              | 13.8kV              | 13.8kV              | 13.8kV              | 13.8kV                    | 13.8kV                    | 36.22 kV                                   | 36.22 kV                                   |
| MVA                 | 3.0                 | 2.5                 | 5                   | 2.5                       | 2.5                       | 30/40/50                                   | 30/40/50                                   |
| MVA Overload        |                     |                     |                     |                           |                           | 33.6/44.8/56                               | 33.6/44.8/56                               |
| Z%                  | 4.9                 | 6.12                | 5.4                 | 5.1                       | 5.1                       | 8.32                                       | 8.38                                       |
| Z0%                 | 85                  | 85                  | 85                  | 85                        | 85                        | 85                                         | 85                                         |
| X/R RATIO           |                     |                     |                     |                           |                           |                                            |                                            |
| GROUNDING IMPEDANCE | 0- Solidly grounded | 0- Solidly grounded | 0- Solidly grounded | 0- Solidly grounded       | 0- Solidly grounded       | 0- Solidly grounded                        | 0- Solidly grounded                        |
| GROUNDING Amp CLASS |                     |                     |                     |                           |                           |                                            |                                            |
| LTC TAP             | Off LTC             | Off LTC             | Off LTC             | Off LTC                   | Off LTC                   | "To "                                      | "To "                                      |
| LTC STEP SIZE       |                     |                     |                     |                           |                           | 0.6%                                       | 0.6%                                       |
| MIN TAP             |                     |                     |                     |                           |                           | 12.42kV                                    | 12.42kV                                    |
| MAX TAP             |                     |                     |                     |                           |                           | 15.18kV                                    | 15.18kV                                    |
| CONTROL TYPE        |                     |                     |                     |                           |                           | Voltage                                    | Voltage                                    |
| CONTROL VALUE       |                     |                     |                     |                           |                           | 0.975p.u - 1.01p.u                         | 0.975p.u - 1.01p.u                         |
| CONTROL SIDE        |                     |                     |                     |                           |                           | Voltage                                    | Voltage                                    |
| REMARKS             | Step Up Transformer | Step Up Transformer | Step Up Transformer | Dyn11 Step Up Transformer | Dyn11 Step Up Transformer | Step-down Substation Transformer w/ LV-LTC | Step-down Substation Transformer w/ LV-LTC |

Note:



S/S Station Services  
 SS Substation-Station  
 PP-1 Power Plant -1  
 T1 Transformer -1

Average losses of power transformers are listed in Table 7.

**Table 7 – Power Transformers Average Losses**

| Item | Size (MVA) | No Load Losses Watts | Load Losses Watts |
|------|------------|----------------------|-------------------|
| 1    | 50         | 19,500               | 99,600            |

Power transformer model data as typical parameters provided in the Easy Power equipment library are listed in Table 8. Note that certain parameters are selected as default model in the equipment library provided in the Easy Power package. Those parameters are provided here as reference and should be updated according to the specific data provided by manufacturers.

**Table 8 – Power Transformers Model Data**

| No.                 | 1             | 2             | 3         | 4         | 5        | 6        | 7        | 8        | 9        | 10     | 11     |
|---------------------|---------------|---------------|-----------|-----------|----------|----------|----------|----------|----------|--------|--------|
| <b>ID Name</b>      | KIYA-SS-T1    | KIYA-SS-T2    | PP1-SS-T1 | PP1-SS-T2 | PP2-T1   | PP2-T2   | PP4-T1   | PP4-T2   | PP4-T3   | PP4-T4 | PP4-T5 |
| <b>Status</b>       | On            | On            | On        | On        | On       | On       | On       | On       | On       | On     | On     |
| <b>From bus</b>     | KIYA-SS-BUS25 | KIYA-SS-BUS26 | PSS-BUS1  | PPS-BUS2  | PP2-BUS4 | PP2-BUS4 | PP4-BUS6 | PP4-BUS6 | PP4-BUS6 | F1-P41 | F1-P41 |
| <b>From Base kV</b> | 34.5          | 34.5          | 13.8      | 13.8      | 4.16     | 4.16     | 4.16     | 4.16     | 4.16     | 13.8   | 13.8   |

| From Conn   | D             | D             | D           | D           | Y          | Y          | D      | D      | D      | D        | D        |
|-------------|---------------|---------------|-------------|-------------|------------|------------|--------|--------|--------|----------|----------|
| To Bus      | KIYA-SS-BUS23 | KIYA-SS-BUS24 | LB-SS-BUS11 | LB-SS-BUS12 | PP2-13.8-1 | PP2-13.8-2 | F3-PP4 | F3-PP4 | F3-PP4 | PP4-BUS7 | PP4-BUS7 |
| To Base kV  | 13.8          | 13.8          | 34.5        | 34.5        | 13.8       | 13.8       | 13.8   | 13.8   | 13.8   | 0.44     | 0.44     |
| To Conn     | YG            | YG            | YG          | YG          | D          | D          | Y      | YG     | YG     | Y        | Y        |
| Unit        | US            | US            | US          | US          | US         | US         | US     | US     | US     | US       | US       |
| Type        | Oil           | Oil           | Oil         | Oil         | Oil        | Oil        | Oil    | Oil    | Oil    | Oil      | Oil      |
| Class       | OA/FA/FA      | OA/FA/FA      | OA/FA/FA    | OA/FA/FA    | OA/FA      | OA/FA      | OA     | OA     | OA     | OA       | OA       |
| Temp        | 55/65         | 55/65         | 55/65       | 55/65       | 55         | 55         | 55     | 55     | 55     | 55       | 55       |
| Form        | Core          | Core          | Core        | Core        | Core       | Core       | Core   | Core   | Core   | Core     | Core     |
| From Nom kV | 34.5          | 34.5          | 13.8        | 13.8        | 4.16       | 4.16       | 4.16   | 4.16   | 4.16   | 13.8     | 13.8     |
| From Tap kV | 34.5          | 34.5          | 13.8        | 13.8        | 4.16       | 4.16       | 4.16   | 4.16   | 4.16   | 13.8     | 13.8     |
| From Gnd R  | 0             | 0             | 0           | 0           | 0          | 0          | 0      | 0      | 0      | 0        | 0        |
| From Gnd jX | 0             | 0             | 0           | 0           | 0          | 0          | 0      | 0      | 0      | 0        | 0        |
| To Nom kV   | 13.8          | 13.8          | 34.5        | 34.5        | 13.8       | 13.8       | 13.8   | 13.8   | 13.8   | 0.44     | 0.44     |
| To Tap kV   | 13.8          | 13.8          | 34.5        | 34.5        | 13.8       | 13.8       | 13.8   | 13.8   | 13.8   | 0.44     | 0.44     |
| To Gnd R    | 0             | 0             | 0           | 0           | 0          | 0          | 0      | 0      | 0      | 0        | 0        |
| To Gnd jX   | 0             | 0             | 0           | 0           | 0          | 0          | 0      | 0      | 0      | 0        | 0        |
| MVA         | 30            | 30            | 30          | 30          | 10         | 10         | 3      | 2.5    | 5      | 2.5      | 2.5      |
| MVA O/L     | 33.6          | 33.6          | 33.6        | 33.6        | 12.5       | 12.5       | 3      | 2.5    | 5      | 2.5      | 2.5      |
| Z           | 8.32          | 8.38          | 7.42        | 7.42        | 5.6        | 5.6        | 4.9    | 6.12   | 5.4    | 5.1      | 5.1      |
| Z0          | 7.072         | 7.123         | 6.307       | 6.307       | 4.76       | 4.76       | 4.165  | 5.202  | 4.59   | 4.335    | 4.335    |
| X/R         | 25.932        | 25.932        | 25.932      | 25.932      | 16.698     | 16.698     | 10.799 | 7.128  | 12.578 | 7.128    | 7.128    |
| LTC Tap     | None          | None          | None        | None        | None       | None       | None   | None   | None   | None     | None     |
| LTC Step    | 0.625         | 0.625         | 0.625       | 0.625       | 0.625      | 0.625      | 0.625  | 0.625  | 0.625  | 0.625    | 0.625    |
| LTC Min Tap | 0.1           | 0.1           | 0.1         | 0.1         | 0.1        | 0.1        | 0.1    | 0.1    | 0.1    | 0.1      | 0.1      |

|                     |              |              |              |              |              |              |              |              |              |              |              |
|---------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| LTC Max Tap         | 1500         | 1500         | 1500         | 1500         | 1500         | 1500         | 1500         | 1500         | 1500         | 1500         | 1500         |
| Ctl Type            | V (PU)       | V (PU)       | V (PU)       | V (PU)       | V (PU)       | V (PU)       | V (PU)       | V (PU)       | V (PU)       | V (PU)       | V (PU)       |
| Ctl Value           | 1            | 1            | 1            | 1            | 1            | 1            | 1            | 1            | 1            | 1            | 1            |
| Zps R1 pu           | 0.0011       | 0.0011       | 0.00095      | 0.00095      | 0.0033       | 0.0033       | 0.0151       | 0.034        | 0.0086       | 0.0283       | 0.0283       |
| Zps X1 pu           | 0.0277       | 0.0279       | 0.0247       | 0.0247       | 0.0559       | 0.0559       | 0.1626       | 0.2424       | 0.1077       | 0.202        | 0.202        |
| Zps R0 pu           | 1000         | 1000         | 1000         | 1000         | 1000         | 1000         | 1000         | 1000         | 1000         | 1000         | 1000         |
| Zps X0 pu           | 100000<br>0  | 1000000      | 100000<br>0  | 100000<br>0  | 100000<br>0  | 100000<br>0  | 100000<br>0  | 100000<br>0  | 100000<br>0  | 100000<br>0  | 100000<br>0  |
| Rps0+3Rpsg          | 0.00091      | 0.00092      | 0.00081      | 0.00081      | 1000         | 1000         | 1000         | 0.0289       | 0.0073       | 1000         | 1000         |
| Xps0+3Xpsg          | 0.0236       | 0.0237       | 0.021        | 0.021        | 100000<br>0  | 100000<br>0  | 100000<br>0  | 0.2061       | 0.0915       | 100000<br>0  | 100000<br>0  |
| From Gnd R1 pu      | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            |
| From Gnd jX pu      | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            |
| To Gnd R1 pu        | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            |
| To Gnd jX pu        | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0            |
| TCC Standard        | ANSI C57.109 | ANSI C57.109 | ANSI C57.109 | ANSI C57.109 | ANSI C57.109 | ANSI C57.109 | ANSI C57.109 | ANSI C57.109 | ANSI C57.109 | ANSI C57.109 | ANSI C57.109 |
| TCC FLA Based On    | MVA O/L      | MVA O/L      | MVA O/L      | MVA O/L      | MVA O/L      | MVA O/L      | MVA O/L      | MVA O/L      | MVA O/L      | MVA O/L      | MVA O/L      |
| Freq Fault Curve    | Yes          | Yes          | Yes          | Yes          | Yes          | Yes          | Yes          | Yes          | Yes          | Yes          | Yes          |
| TCC Max Plot Time   | 500          | 500          | 500          | 500          | 500          | 500          | 500          | 500          | 500          | 500          | 500          |
| TCC Inrush FLA Mult | 8            | 8            | 8            | 8            | 8            | 8            | 8            | 8            | 8            | 8            | 8            |
| TCC Inrush Cycles   | 6            | 6            | 6            | 6            | 6            | 6            | 6            | 6            | 6            | 6            | 6            |

| Hrm RC Factor     | R-EXP   | R-EXP   | R-EXP   | R-EXP   | R-EXP  | R-EXP  | R-EXP   | R-EXP   | R-EXP   | R-EXP   | R-EXP   |
|-------------------|---------|---------|---------|---------|--------|--------|---------|---------|---------|---------|---------|
| Hrm RC Value      | 0       | 0       | 0       | 0       | 0      | 0      | 0       | 0       | 0       | 0       | 0       |
| Hrm Pec-r %       | 15      | 15      | 15      | 15      | 15     | 15     | 15      | 15      | 15      | 15      | 15      |
| Hrm From I Rating | 502.044 | 502.044 | 1255.1  | 1255.1  | 1387.9 | 1387.9 | 416.358 | 346.965 | 693.931 | 104.592 | 104.592 |
| Hrm To I Rating   | 1255.1  | 1255.1  | 502.044 | 502.044 | 418.37 | 418.37 | 125.511 | 104.592 | 209.185 | 3280.4  | 3280.4  |
| Comment           |         |         |         |         |        |        |         |         |         |         |         |

## 2.4 Overhead Lines

Overhead line data are listed in Table 9.

**Table 9 – Overhead Line Data**

| Feeder Name         | F-1      | F-2 <sup>1</sup> |          | F-3      | F-4      | F-7      | K-1      | K-2      |          | K-4 <sup>2</sup> |          |
|---------------------|----------|------------------|----------|----------|----------|----------|----------|----------|----------|------------------|----------|
| Conductor per Phase | 1        | 1                | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1                | 1        |
| Material            | Aluminum | Aluminum         | Aluminum | Aluminum | Aluminum | Aluminum | Aluminum | Aluminum | Aluminum | Aluminum         | Aluminum |
| Size                | 556.5    | 556.5            | 397.5    | 556.5    | 556.5    | 556.5    | 556.5    | 556.5    | 556.5    | 556.5            | 397.5    |
| Length (mile)       | 3.5227   | 0.5492           | 6.6856   | 5.6288   | 8.7689   | 8.7121   | 11.3636  | 1.1000   | 4.5644   | 0.7955           | 1.9318   |
| Temperature         | 75 C     | 75 C             | 75 C     | 75 C     | 75 C     | 75 C     | 75 C     | 75 C     | 75 C     | 75 C             | 75 C     |
| Earth Resistance    |          |                  |          |          |          |          |          |          |          |                  |          |
| GMD                 | 2.92 Ft  | 3.66 Ft          | 3.66 Ft  | 3.66 Ft  | 3.66 Ft  | 5.54 Ft  | 3.66 Ft  | 2.92 Ft  | 3.66 Ft  | 3.66 Ft          | 3.66 Ft  |
| Average Height      | 36 Ft    | 36 Ft            | 36 Ft    | 36 Ft    | 36 Ft    | 36 Ft    | 36 Ft    | 36 Ft    | 36 Ft    | 36 Ft            | 36 Ft    |
| R1 (Ohms/mile)      | 0.20200  | 0.20200          | 0.28134  | 0.20200  | 0.20200  | 0.20200  | 0.20200  | 0.20200  | 0.20200  | 0.20200          | 0.28134  |
| X1 (Ohms/mile)      | 0.56831  | 0.59571          | 0.61623  | 0.59571  | 0.59571  | 0.64601  | 0.59571  | 0.56831  | 0.59571  | 0.59571          | 0.61623  |
| R0 (Ohms/mile)      | 0.48628  | 0.48628          | 0.56605  | 0.48628  | 0.48628  | 0.48628  | 0.48628  | 0.48628  | 0.48628  | 0.48628          | 0.56605  |
| X0 (Ohms/mile)      | 3.06614  | 3.01132          | 3.03184  | 3.01132  | 3.01132  | 2.91072  | 3.01132  | 3.06614  | 3.01132  | 3.01132          | 3.03184  |
| Xc (Mohm-mile)      | 0.13067  | 0.13737          | 0.14233  | 0.13737  | 0.13737  | 0.14966  | 0.13737  | 0.13067  | 0.13737  | 0.13737          | 0.14233  |
| Xc0 (Mohm-mile)     | 0.41606  | 0.40266          | 0.40763  | 0.40266  | 0.40266  | 0.37807  | 0.40266  | 0.41606  | 0.40266  | 0.40266          | 0.40763  |

| Rating Amps | 552               | 552               | 453                      | 552               | 552               | 552               | 552               | 552               | 552               | 552               | 453                      |
|-------------|-------------------|-------------------|--------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------------|
| Remarks     | Dahlia, main line | Dahlia, main line | Canna, part of main line | Dahlia, main line | Dahlia, main line | Dahlia, main line | Dahlia, main line | Dahlia, main line | Dahlia, main line | Dahlia, main line | Canna, part of main line |

Note:

1. F-2 conductor size and length are listed as provided in CUC Data feb 19 10.xls as received. However, the actual model in EasyPower is developed based on the DPA feeder file F2DATA.TXT to reflect feeder structure.
2. K-4 conductor size and length are listed as provided in CUC Data feb 19 10.xls as received. However, the actual model in EasyPower is developed based on the DPA feeder file F2DATA.TXT to reflect feeder structure.
3. R1, X1, R0, X0, Xc, Xc0 are calculated by EasyPower based on the other parameters provided.

## 2.5 Underground Cables

34.5 kV underground cables connect the power plant substation and Chalan Kiya substation. Cable data are listed in Table 10.

**Table 10 – Underground Cable Data**

| Cable       | Name                      | 34.5kV TL-1                        | 34.5kV TL-2                        |
|-------------|---------------------------|------------------------------------|------------------------------------|
|             | Conductor per Phase       | 1                                  | 1                                  |
|             | Material                  | Copper                             | Copper                             |
|             | Size                      | 500                                | 500                                |
|             | Length                    | 6.5 Mile                           | 6.5 Mile                           |
|             | Earth Resistance          |                                    |                                    |
|             | GMD                       |                                    |                                    |
|             | Average Height            |                                    |                                    |
|             | Operation Temperature (C) | 50                                 | 30                                 |
|             | Ambient Temperature (C)   | 50                                 | 30                                 |
|             | R1 (Ohms/1000 feet)       | 0.0254                             | 0.0254                             |
|             | X1 (Ohms/1000 feet)       | 0.0392                             | 0.0392                             |
|             | R0 (Ohms/1000 feet)       | 0.0507                             | 0.0507                             |
|             | X0 (Ohms/1000 feet)       | 0.0784                             | 0.0784                             |
|             | Xc (Ohms-1000 feet)       | 0.0288                             | 0.0288                             |
|             | Xc0 (Ohms-1000 feet)      | 0.0288                             | 0.0288                             |
|             | RATING Amps               | 480                                | 480                                |
| Raceway     | Insulation                | Armored Cable, 3/C-XLPE Insulation | Armored Cable, 3/C-XLPE Insulation |
|             | TYPE                      | 3/C                                | 3/C                                |
|             | SIZE                      | 500 MCM                            | 500 MCM                            |
|             | INSULATION                | 133%                               | 133%                               |
|             | TYPE                      | Direct Burial                      | Direct Burial                      |
| Ground Wire | MATERIAL                  | Al. & PVC                          | Al. & PVC                          |
|             | TYPE                      | Group                              | Group                              |
|             | NUMBER                    | 1                                  | 1                                  |

|              |              |                                       |                                       |
|--------------|--------------|---------------------------------------|---------------------------------------|
|              | SIZE         | 1/0                                   | 1/0                                   |
|              | MATERIAL     | Copper                                | Copper                                |
| Neutral Wire | INSULATION   | THW                                   | THW                                   |
|              | NEUTRAL WIRE | Yes                                   | Yes                                   |
|              | NUMBER       | 1                                     | 1                                     |
|              | INSULATED    | No                                    | No                                    |
|              | MATERIAL     | Copper                                | Copper                                |
|              | RATING Amps  | 230                                   | 230                                   |
| REMARKS      |              | 34.5kV, 3 Cu, Cond., 1 grd. & 1 neut. | 34.5kV, 3 Cu, Cond., 1 grd. & 1 neut. |

Note:

R1, X1, R0, X0, Xc, Xc0 are calculated by EasyPower based on typical equipment with parameters provided.



## 2.6 Shunt Capacitors

Fixed Shunt Capacitors data are listed in Table 11.

**Table 11 – Shunt Capacitors**

| Location     | Voltage Rating | MVAr     | Quantity | Remarks                            |
|--------------|----------------|----------|----------|------------------------------------|
| K1-1         | 13.8kV         | 0.9 MVAr | 1        | Pole Mounted fixed capacitor banks |
| K2-1         | 13.8kV         | 0.3 MVAr | 1        | Pole Mounted fixed capacitor banks |
| K2-2         | 13.8kV         | 0.3 MVAr | 1        | Pole Mounted fixed capacitor banks |
| K4-1         | 13.8kV         | 0.3 MVAr | 1        | Pole Mounted fixed capacitor banks |
| K4-2         | 13.8kV         | 0.3 MVAr | 1        | Pole Mounted fixed capacitor banks |
| K4-3         | 13.8kV         | 0.3 MVAr | 1        | Pole Mounted fixed capacitor banks |
| <b>Total</b> |                | 2.4 MVAr | 6        |                                    |

## 2.7 Distribution Transformers

Data of pole mount type transformers are provided by CUC. Average typical no-load and full-load losses are listed for each kVA size in Table 12.

**Table 12 – Distribution Transformers**

| Item | Size (kVA) | No Load<br>Losses Watts | Load<br>Losses Watts |
|------|------------|-------------------------|----------------------|
| 1    | 5          | 22                      | 64                   |
| 2    | 10         | 31                      | 120                  |
| 3    | 15         | 41                      | 161                  |
| 4    | 25         | 55                      | 227                  |
| 5    | 37.5       | 79                      | 335                  |
| 6    | 50         | 102                     | 528                  |
| 7    | 75         | 137                     | 676                  |
| 8    | 100        | 160                     | 745                  |
| 9    | 167        | 410                     | 2151                 |

No Appendix for this document.