



**OPTIMIZATION OF DISTRIBUTED
GENERATION PLACEMENT AND CAPACITY IN
DISTRIBUTION SYSTEM USING GENETIC
ALGORITHM METHOD**

by

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TABLE OF CONTENTS

| | PAGE |
|--------------------------------------|--------------|
| DECLARATION OF THESIS | i |
| ACKNOWLEDGEMENT | ii |
| TABLE OF CONTENTS | iv |
| LIST OF TABLES | ix |
| LIST OF FIGURES | xvi |
| LIST OF ABBREVIATIONS | xviii |
| LIST OF SYMBOLS | xix |
| ABSTRAK | xx |
| ABSTRACT | xxi |
| CHAPTER 1 : INTRODUCTION | 1 |
| 1.1 Background of study | 1 |
| 1.2 Research issue/motivation | 8 |
| 1.3 Problem Statement | 11 |
| 1.4 Research Objectives | 14 |
| 1.5 Contributions | 15 |
| 1.6 Scope of Research | 16 |
| 1.7 Outcome | 17 |
| CHAPTER 2 : LITERATURE REVIEW | 19 |
| 2.1 Introduction | 19 |
| 2.2 Electric Power System | 19 |

| | | |
|--------------------|--|-----------|
| 2.3 | Distributed Generators | 21 |
| 2.4 | Impact of Distributed Generation for Power System | 24 |
| 2.4.1 | Impact of DG on Voltage Regulation | 29 |
| 2.4.2 | Impact of Distributed Generation on Losses | 30 |
| 2.4.3 | Impact of Distributed Generation on Power Quality | 31 |
| 2.4.4 | Impact of Distributed Generation on Reliability | 32 |
| 2.5 | Operation of Distributed Generation | 32 |
| 2.6 | Placement of Distributed Generation | 33 |
| 2.7 | Capacity of Distributed Generation | 34 |
| 2.8 | The Gap In The Existing Knowledge | 35 |
| 2.9 | Conceptual Solution | 36 |
| 2.10 | Summary | 37 |
| CHAPTER 3 : | METHODOLOGY | 38 |
| 3.1 | Introduction | 38 |
| 3.2 | Research Flow | 38 |
| 3.3 | Selecting the Electric Power System Model | 40 |
| 3.3.1 | The Electric Power System Model for Reference | 40 |
| 3.3.2 | The Electric Power System Model for Application | 43 |
| 3.4 | Initial System Conditions | 44 |
| 3.5 | Determining Critical Bus and Distributed Generations | 46 |
| 3.6 | Objective Function | 47 |
| 3.7 | Genetic Algorithm Method | 49 |
| 3.8 | Determining the System Capability Estimation After Installing DG | 51 |
| 3.8.1 | Determining next Critical Bus | 51 |
| 3.8.2 | Determining System Capabilities After Installing DG | 52 |
| 3.9 | Summary | 53 |

| | | |
|--------------------|--|------------|
| CHAPTER 4 : | RESULTS & DISCUSSION | 54 |
| 4.1 | Introduction | 54 |
| 4.2 | Initial Condition System | 55 |
| 4.3 | Distributed Generation to Supply the Active Power and Reactive Power | 60 |
| 4.3.1 | Scenario 1, installed at one point | 60 |
| 4.3.2 | Scenario 2, installed at two points | 65 |
| 4.3.3 | Scenario 3, installed at three points | 70 |
| 4.3.4 | Scenario 4, installed at four points | 75 |
| 4.3.5 | Scenario 5, installed at five points | 80 |
| 4.4 | Distributed Generation with voltage magnitude is set with a value of 1 p.u (V = 1 p.u.). | 86 |
| 4.4.1 | Scenario 1, installed at one point | 86 |
| 4.4.2 | Scenario 2, installed at two points | 91 |
| 4.4.3 | Scenario 3, installed at three points | 96 |
| 4.4.4 | Scenario 4, installed at four points | 101 |
| 4.4.5 | Scenario 5, installed at five points | 106 |
| 4.5 | Distributed Generation with the active power supply only (P) | 112 |
| 4.5.1 | Scenario 1, installed at one point | 112 |
| 4.5.2 | Scenario 2, installed at two points | 117 |
| 4.5.3 | Scenario 3, installed at three points | 121 |
| 4.5.4 | Scenario 4, installed at four points | 126 |
| 4.5.5 | Scenario 5, installed at five points | 131 |
| 4.6 | Estimated System Capacity after DG Installation | 137 |
| 4.7 | Summary | 140 |
| CHAPTER 5 : | CONCLUSION | 142 |
| 5.1 | Conclusion | 142 |
| 5.2 | Suggestions | 144 |

| | |
|--------------------|------------|
| REFERENCES | 146 |
| APPENDIX 1 | 155 |
| APPENDIX 2 | 157 |
| APPENDIX 3 | 159 |
| APPENDIX 4 | 160 |
| APPENDIX 5 | 161 |
| APPENDIX 6 | 162 |
| APPENDIX 7 | 163 |
| APPENDIX 8 | 164 |
| APPENDIX 9 | 165 |
| APPENDIX 10 | 166 |
| APPENDIX 11 | 167 |
| APPENDIX 12 | 168 |
| APPENDIX 13 | 169 |
| APPENDIX 14 | 170 |
| APPENDIX 15 | 171 |
| APPENDIX 16 | 172 |
| APPENDIX 17 | 173 |
| APPENDIX 18 | 174 |
| APPENDIX 19 | 175 |
| APPENDIX 20 | 177 |

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LIST OF TABLES

| | | PAGE |
|------------|--|-------------|
| Table 4.1 | General information on power flow analysis in initial conditions before installation of DG | 56 |
| Table 4.2 | Results of power flow analysis at initial conditions for data bus | 57 |
| Table 4.3 | Results of initial state power flow analysis for critical bus sequences | 59 |
| Table 4.4 | Capacity range DG when installing 1 unit DG PQ type on bus number 2 | 60 |
| Table 4.5 | General information on power flow analysis after installation of one DG on bus 2 | 61 |
| Table 4.6 | Voltage magnitude for each bus, power generation on the generator bus when installing 1 DG with PQ type on a 2 bus | 62 |
| Table 4.7 | Power flow calculation results when installed 1 DG with PQ type on bus 2 for critical bus sequences | 64 |
| Table 4.8 | Parameters of 1 DG with PQ type when installed on bus number 2 | 64 |
| Table 4.9 | Range of DG capacity when installing 2 DG with PQ type on buses number 2 and 7 | 65 |
| Table 4.10 | General information on power flow analysis when 2 DGs are installed on buses 2 and 7 | 66 |
| Table 4.11 | Voltage for each bus, power generation on the generator bus when 2 DGs with PQ type is installed on buses 2 and 7 | 67 |

| | | |
|------------|--|----|
| Table 4.12 | Power flow calculation results when installed 2 DGs with PQ type on buses 2 and 7 for critical bus sequences | 69 |
| Table 4.13 | Parameters of 2 DGs with PQ type when installed on buses 2 and 7 | 69 |
| Table 4.14 | Range of DG capacity when installing 3 DG with PQ type on buses number 2, 7 and 12 | 70 |
| Table 4.15 | General information on power flow analysis when 3 DGs are installed on buses 2, 7 and 12 | 71 |
| Table 4.16 | Voltage for each bus, power generation on the generator bus when 3 DGs with PQ type is installed on buses 2, 7 and 12 | 72 |
| Table 4.17 | Power flow calculation results when installed 3 DGs with PQ type on buses 2, 7 and 12 for critical bus sequences | 73 |
| Table 4.18 | Parameters of 3DGs with PQ type when installed on buses 2, 7 and 12 | 74 |
| Table 4.19 | Range of DG capacity when installing 4 DG with PQ type on buses number 2, 7, 12 and 4 | 75 |
| Table 4.20 | General information on power flow analysis when 4 DGs are installed on buses 2, 7, 12 and 4 | 75 |
| Table 4.21 | Voltage for each bus, power generation on the generator bus when 4 DGs with PQ type is installed on buses 2, 7, 12 and 4 | 77 |
| Table 4.22 | Power flow calculation results when installed 4 DGs with PQ type on buses 2, 7, 12 and 4 for critical bus sequences | 78 |
| Table 4.23 | Parameters of 4DGs with PQ type when installed on buses 2, 7, 12 and 4 | 79 |
| Table 4.24 | Range of DG capacity when installing 5 DG with PQ type on buses number 2, 7, 12, 4 and 5 | 80 |

| | | |
|------------|--|----|
| Table 4.25 | General information on power flow analysis when 5 DGs are installed on buses 2, 7, 12, 4 and 5 | 81 |
| Table 4.26 | Voltage for each bus, power generation on the generator bus when 5 DGs with PQ type is installed on buses 2, 7, 12, 4 and 5 | 82 |
| Table 4.27 | Power flow calculation results when installed 5 DGs with PQ type on buses 2, 7, 12, 4 and 5 for critical bus sequences | 84 |
| Table 4.28 | Parameters of 5 DGs with PQ type when installed on buses 2, 7, 12, 4 and 5 | 84 |
| Table 4.29 | Range of DG capacity when installing 1 DG with ($V = 1$ p.u.) type on bus 2 | 87 |
| Table 4.30 | General information on power flow analysis when 1 DG is installed on bus 2 | 87 |
| Table 4.31 | Voltage for each bus, power generation on the generator bus when 1 DG with ($V = 1$ p.u.) type is installed on bus 2 | 88 |
| Table 4.32 | Power flow calculation results when installed 1 DG with ($V = 1$ p.u.) type on bus 2 for critical bus sequences | 90 |
| Table 4.33 | Parameters of 1 DG with ($V = 1$ p.u.) type when installed on bus 2 | 91 |
| Table 4.34 | Range of DG capacity when installing 2 DG with ($V = 1$ p.u.) type on buses 2 and 7 | 91 |
| Table 4.35 | General information on power flow analysis when 2 DGs is installed on buses 2 and 7 | 92 |
| Table 4.36 | Voltage for each bus, power generation on the generator bus when 2 DGs with ($V = 1$ p.u.) type is installed on bus 2 and 7 | 93 |
| Table 4.37 | Power flow calculation results when installed 2 DGs with ($V = 1$ p.u.) type on buses 2 and 7 for critical bus sequences | 95 |

| | | |
|------------|---|-----|
| Table 4.38 | Parameters of 2DGs with ($V - 1$ p.u.) type when installed on buses 2 and 7 | 96 |
| Table 4.39 | Range of DG capacity when installing 3 DG with ($V = 1$ p.u.) type on buses 2, 7 and 12 | 96 |
| Table 4.40 | General information on power flow analysis when 3 DGs is installed on buses 2, 7 and 12 | 97 |
| Table 4.41 | Voltage for each bus, power generation on the generator bus when 3 DGs with ($V = 1$ p.u.) type is installed on bus 2, 7 and 12 | 98 |
| Table 4.42 | Power flow calculation results when installed 3 DGs with ($V = 1$ p.u.) type on buses 2, 7 and 12 for critical bus sequences | 100 |
| Table 4.43 | Parameters of 3DGs with ($V - 1$ p.u.) type when installed on buses 2, 7 and 12 | 101 |
| Table 4.44 | Range of DG capacity when installing 4 DG with ($V = 1$ p.u.) type on buses 2, 7, 12 and 4 | 101 |
| Table 4.45 | General information on power flow analysis when 4 DGs is installed on buses 2, 7, 12 and 4 | 102 |
| Table 4.46 | Voltage for each bus, power generation on the generator bus when 4 DGs with ($V = 1$ p.u.) type is installed on bus 2, 7, 12 and 4 | 103 |
| Table 4.47 | Power flow calculation results when installed 4 DGs with ($V = 1$ p.u.) type on buses 2, 7, 12 and 4 for critical bus sequences | 105 |
| Table 4.48 | Parameters of 4DGs with ($V - 1$ p.u.) type when installed on buses 2, 7, 12 and 4 | 106 |
| Table 4.49 | Range of DG capacity when installing 5 DG with ($V = 1$ p.u.) type on buses 2, 7, 12, 4 and 5 | 106 |

| | | |
|------------|--|-----|
| Table 4.50 | General information on power flow analysis when 5 DGs is installed on buses 2, 7, 12, 4 and 5 | 107 |
| Table 4.51 | Voltage for each bus, power generation on the generator bus when 5 DGs with ($V = 1$ p.u.) type is installed on bus 2, 7, 12, 4 and 5 | 108 |
| Table 4.52 | Power flow calculation results when installed 5 DGs with ($V = 1$ p.u.) type on buses 2, 7, 12, 4 and 5 for critical bus sequences | 110 |
| Table 4.53 | Parameters of 5 DGs with ($V = 1$ p.u.) type when installed on buses 2, 7, 12, 4 and 5 | 111 |
| Table 4.54 | Range of DG capacity when installing 1 DG with P type on bus 2 | 112 |
| Table 4.55 | General information on power flow analysis when 1 DG is installed on bus 2 | 113 |
| Table 4.56 | Voltage for each bus, power generation on the generator bus when 1 DG with P type is installed on bus 2 | 114 |
| Table 4.57 | Power flow calculation results when installed 1 DG with P type on buses 2 for critical bus sequences | 116 |
| Table 4.58 | Parameters of 1 DG with P type when installed on bus 2 | 117 |
| Table 4.59 | Range of DG capacity when installing 2 DG with P type on buses 2 and 7 | 117 |
| Table 4.60 | General information on power flow analysis when 2 DGs is installed on buses 2 and 7 | 118 |
| Table 4.61 | Voltage for each bus, power generation on the generator bus when 2 DGs with P type is installed on bus 2 and 7 | 119 |
| Table 4.62 | Power flow calculation results when installed 2 DGs with P type on buses 2 and 7 for critical bus sequences | 120 |

| | | |
|------------|---|-----|
| Table 4.63 | Parameters of 2 DGs with P type when installed on buses 2 and 7 | 121 |
| Table 4.64 | Range of DG capacity when installing 3 DG with P type on buses 2, 7 and 12 | 122 |
| Table 4.65 | General information on power flow analysis when 3 DGs is installed on buses 2, 7 and 12 | 122 |
| Table 4.66 | Voltage for each bus, power generation on the generator bus when 3 DGs with P type is installed on bus 2, 7 and 12 | 123 |
| Table 4.67 | Power flow calculation results when installed 3 DGs with P type on buses 2, 7 and 12 for critical bus sequences | 125 |
| Table 4.68 | Parameters of 3 DGs with P type when installed on buses 2, 7 and 12 | 126 |
| Table 4.69 | Range of DG capacity when installing 4 DG with P type on buses 2, 7, 12 and 4 | 126 |
| Table 4.70 | General information on power flow analysis when 4 DGs is installed on buses 2, 7, 12 and 4 | 127 |
| Table 4.71 | Voltage for each bus, power generation on the generator bus when 4 DGs with P type is installed on bus 2, 7, 12 and 4 | 128 |
| Table 4.72 | Power flow calculation results when installed 4 DGs with P type on buses 2, 7, 12 and 4 for critical bus sequences | 130 |
| Table 4.73 | Parameters of 4 DGs with P type when installed on buses 2, 7, 12 and 4 | 131 |
| Table 4.74 | Range of DG capacity when installing 5 DG with P type on buses 2, 7, 12, 4 and 5 | 131 |
| Table 4.75 | General information on power flow analysis when 5 DGs is installed on buses 2, 7, 12, 4 and 5 | 132 |

| | | |
|------------|--|-----|
| Table 4.76 | Voltage for each bus, power generation on the generator bus when 5 DGs with P type is installed on bus 2, 7, 12, 4 and 5 | 133 |
| Table 4.77 | Power flow calculation results when installed 5 DGs with P type on buses 2, 7, 12, 4 and 5 for critical bus sequences | 135 |
| Table 4.78 | Parameters of 5 DGs with P type when installed on buses 2, 7, 12, 4 and 5 | 135 |
| Table 4.79 | The magnitude of the voltage before and after the increase in load on the system that has been installed DG | 138 |
| Table 4.80 | Results of power flow analysis for line power losses when installing 1 DG type PQ on bus 2 | 163 |

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LIST OF FIGURES

| | PAGE |
|--|-------------|
| Figure 1. 1 Annual electricity sales by sector, 1980-2030 (billion kilowatt-hours) (Centre, 2020) | 2 |
| Figure 2. 1 Stages of The Electric Power System | 21 |
| Figure 2. 2 Voltage Profiles With And Without DG | 30 |
| Figure 3. 1 Outline of the research flow chart | 38 |
| Figure 3. 2 Research flow chart determines the location and capacity of DG as well as the system capabilities after installation of DG | 39 |
| Figure 3. 3 One line diagram of the electric power system IEEE 30 bus (Alzate et al., 2019) (Touma, 2016) (Oni et al., 2016) | 42 |
| Figure 3. 4 One line diagram of the electric power system distribution in Medan City state electricity company (PT PLN Persero) in Indonesia | 43 |
| Figure 3. 5 Flow chart for load flow analysis using the Newton Raphson method | 45 |
| Figure 3. 6 The genetic algorithm flow chart | 50 |
| Figure 3. 7 Flowchart renovation the system loading capacity of the system | 52 |
| Figure 4. 1 Graph of voltage magnitude for each bus at the initial state of the system before DG installation | 55 |
| Figure 4. 2 Graph of active power loss at initial conditions before DG installation | 59 |

| | | |
|-------------|---|-----|
| Figure 4. 3 | System voltage graph when DG with PQ type is installed in Medan City Distribution System | 85 |
| Figure 4. 4 | Graph of active power losses (P_{losses}) of the system after being installed DGwith PQ type in the Medan City Distribution System | 86 |
| Figure 4. 5 | Graph of voltage magnitude for each bus after installation of type DG ($V = 1$ p.u.) | 111 |
| Figure 4. 6 | Graph of active power losses (P_{losses}) of the system after being installed DG with $V=1$ p.u. type in the Medan City Distribution System | 112 |
| Figure 4. 7 | System voltage graph when DG with P type is installed in Medan City Distribution System | 136 |
| Figure 4. 8 | Graph of active power losses (Process) of the system after being installed DG with P type in the Medan City Distribution System | 136 |
| Figure 4. 9 | Chart of voltage magnitude of each bus after DG installation and 17% load increase condition | 139 |

LIST OF ABBREVIATIONS

| | |
|--------|---------------------------------------|
| APM | Airborne particulate matter |
| BBB | blood-brain barrier |
| BMU | Best Matching Unit |
| CMB | Chemical Mass Balance |
| CPCA | Consensus PCA |
| CSI | Class Separation Indices |
| CSM | Class Sample Matrix |
| CSV | Class Sample Vector |
| CWM | Class Weight Matrix |
| CWV | Class Weight Vector |
| EDC | Euclidean Distance to Centriods |
| HFCT | High Frequency Current Transformer |
| HV | High Voltage |
| IoT | Internet of Thing |
| LCC | Line Communicate Converter |
| MV | Medium Voltage |
| OWTS | Oscillating Wave Testing System |
| PD | Partial Discharge |
| RC | Rogowski Coil |
| RF | Radio Frequency |
| RMS | Root Mean Squares |
| TDR | Time Domain Reflectometry |
| PLN | Perusahaan Listrik Negara |
| ULM | Universal Line Model |
| UniMAP | Universiti Malaysia Perlis |
| VHDL | Verilog Hardware Description Language |
| XLPE | Cross-Linked Polyethylene |

LIST OF SYMBOLS

| | |
|-----------------|--|
| A | Number of PLS or PCA components in the model |
| A | Number of the PLS or PCA component |
| B | PLS regression coefficient |
| B | Number of blocks (b=1,2,3.....,K) |
| C | Coarse APM block |
| C_p | Pooled covariance matrix for the two classes |
| Cos φ | Power factor |
| DG _i | DG position on ith bus |
| I | Current flowing on the line |
| P | Load power at the receiving end of line |
| P_{DG} | Real power of a distributed generator |
| PDGopt | The number of optimum capacity of the distributed power of generating generation |
| P_{loss} | Line power losses |
| Q_{DG} | Reactive power of a distributed generator |
| R | Resistance in wire line |
| V_i | Voltage magnitude on the i-bus |
| VR | Phase to phase voltage at the receiving end of line |
| β | Load growth factor |

Pengoptimuman Penempatan dan Kapasiti Penjanaan Teragih dalam Sistem Agihan menggunakan Kaedah Algoritma Genetik

ABSTRAK

Pertumbuhan penduduk, pertumbuhan ekonomi, dan pembangunan industri boleh membawa kepada peningkatan dalam keperluan tenaga elektrik. Peningkatan beban yang berterusan pada sistem kuasa elektrik boleh mengakibatkan pengurangan kapasiti rangkaian kuasa elektrik sedia ada. Penurunan ini boleh ditunjukkan dengan meningkatkan kehilangan kuasa, menurunkan voltan dan juga kapasiti sistem berkurangan. Satu penyelesaian ialah menambah sumber tenaga elektrik terus ke bahagian beban dengan memasang penjana teragih (PT) dalam sistem. Suntikan penjanaan teragih ke dalam sistem kuasa boleh menjejaskan sistem dengan ketara. Kesan yang berlaku bergantung pada lokasi dan saiz PT. Dalam kajian ini, pendekatan algoritma adalah gabungan kaedah Newton Raphson dan Algoritma Genetik yang digunakan untuk menentukan lokasi dan kapasiti optimum penjana teragih (PT). Berapa lama keupayaan sistem selepas pemasangan janakuasa teragih (PT) juga dinilai. Perletakan yang betul dan kapasiti PT yang optimum boleh mengurangkan kehilangan kuasa sistem dan meningkatkan voltan pada bus. Pendekatan baharu ini telah diuji pada sistem bus standard IEEE 30. Kajian ini digunakan pada sistem pengedaran 20 bus dan 21 saluran di Medan, Indonesia. Keputusan yang diperolehi ialah pemasangan DG digunakan pada bus 2 dengan bekalan kuasa aktif dan reaktif sebanyak 676.6612 MW dan 240.2443 MVAR. Terdapat penurunan dalam kehilangan kuasa sebanyak 52.55% daripada 718.16 MW kepada 340.77 MW dan profil voltan menjadi jauh melebihi 0.9500 p.u. Keupayaan sistem selepas pemasangan penjana teragih dianggarkan sehingga 10 tahun..

Optimization of Distributed Generation Placement and Capacity in Distribution System using Genetic Algorithm Method

ABSTRACT

Population growth, economic growth, and industrial development can lead to an increase in the need for electrical energy. The continuous increase in the load on the electric power system can result in a decrease in the capacity of the existing power grid. This decrease can be shown by increasing power losses, decreasing voltage so that the system capacity decreases. One solution is to add a source of electrical energy directly to the load side by installing a distributed generator (DG) in the system. The injection of distributed generators into the power system can significantly affect the system. The effect that occurs depends on the location and size of the DG. In this study, the Genetic Algorithm approach is used to determine the location and optimum capacity of a distributed generator (DG). How long the system's capability after the installation of distributed generation (DG) is also assessed. Proper placement and optimal DG capacity can reduce system power losses and increase bus voltage. This new approach has been tested on the IEEE 30 standard bus system. The study was applied to the 20 buses and 21 lines distribution system in Medan Indonesia. The results obtained are that the DG installation is applied to bus 2 with active and reactive power supplies of 676.6612 MW and 240.2443 MVAR. There was a decrease in power losses by 52.55% from 718.16 MW to 340.77 MW and the voltage profile became well above 0.9500 p.u. The capability of the system after installation of the distributed generator is estimated to be up to 10 years.

CHAPTER 1 : INTRODUCTION

1.1 Background of study

Energy is important for all living things in the world. Energy cannot be made and destroyed but can be transformed from one form to another. In this regard, the interests of modern lifestyles are increasing, because a faster life means faster communication, faster manufacturing processes, and transportation (Atzori et al., 2017). One of the largest consumer markets in the world is the electric power industry. Electrical energy is the need for the fastest-growing energy source, and over the next 25 years, it continues to exceed overall energy consumption. The electricity sector is now attracting more investment than the combined oil and gas sector - investment is needed as changes in the generation mix and aging infrastructure are improved (Brown, 2017).

The electric power system is in desperate need of alternative generation other than the conventional type because it faces increasing demand (Centre, 2020). Electricity costs are calculated at around 50% for fuel, 20% for power generation, 5% for transmission, and 25% for distribution which increases the need for alternative resources at the allocation level (Schiffer et al., 2018). The distribution system should deliver electricity to any customer's service centre at the proper voltage level. According to estimates by the International Energy Agency (IEA) (Centre, 2020), up to 2030 global energy demand will increase by 45% with an average increase of 1.6% per year. Most of about 80% of world energy needs are supplied from fossil fuels while renewable energy-based energy use involves hydropower (2.0%), biomass and waste energy (1.3%), and other renewable energy (6.6%).

According to AEO 2008, total electricity sales rose 29 percent, from 3,659 billion kilowatt-hours in 2006 to 4,705 billion in 2030, with an average rate of 1.1 percent per year. Relatively slow growth follows the historical trend, with growth rates delaying down in the next decade. Electricity sales, which are powerfully influenced by economic growth, are expected to increase by 39 percent in the case of high growth of 5,089 billion kilowatt-hours in 2030, but only 18 percent in the case of low growth of 4,319 billion kilowatt-hours in 2030. In figure 1.1, the biggest increase is in the commercial sector, which is 49 percent from 2006 to 2030 (Figure 1.1), because the service industry continues to drive growth. Electricity demand grew by 27 percent in the housing sector and only 3 percent in the industrial sector. Population growth and income lead to increased demand for products, services, and floor space. The population shifting to warmer regions also increases the need for cooling (Centre, 2020).

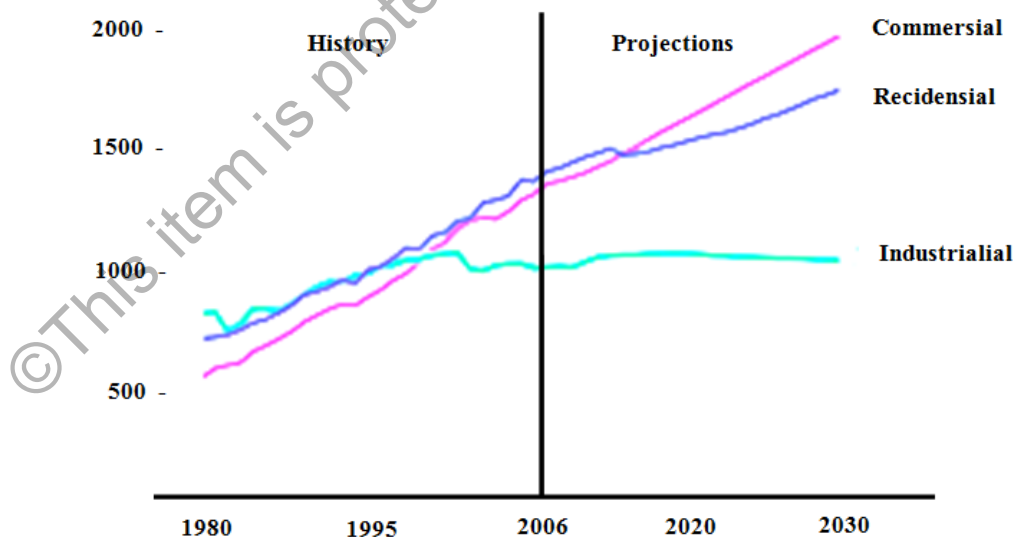


Figure 1. 1 Annual electricity sales by sector, 1980-2030 (billion kilowatt-hours) (Centre, 2020)

Furthermore, research shows that around 13% of the total energy produced is lost in the allocation system. Losses that cannot be ignored have a direct influence on the financial aspect and the overall efficiency of utility allocation (Schiffer et al., 2018). All of this leads to an increase in energy demand. Innovative distribution networks are always faced with increasing load demands, this increase in load leads to increased power losses and reduced voltage profiles. Even in certain industrial areas that have a critical load, it can cause a voltage profile to collapse (Larik et al., 2019). Therefore, improving the voltage profile and reducing electric power loss, required the optimal placement and size of the distributed era.

Modern electricity distribution webs are always faced with increasing demand for loads, which results in increased power losses and reduced voltage profiles (Ismael et al., 2019). Distribution networks also have the characteristic that the magnitude of the voltage at the node can be reduced when moved from the substation. This voltage drop is especially due to an inadequate amount of reactive power. Even at critical loads in certain industrial areas, it can cause voltage collapse. Thus to increase the voltage profile and avoid voltage collapse, reactive compensation is needed (Ghahremani et al., 2018) (Brown, 2017). The ratio X and R for distribution are lower than the transmission line, this results in a higher power loss and also a decrease in the voltage magnitude along with the radial distribution (Brown, 2017). These non-negligible losses have a direct impact on financial problems and the overall efficiency of the allocation utility.

The requirement to improve general power delivery efficiency has forced electric utilities to reduce losses on the distribution level. Many arrangements can be made to reduce these power losses such as network reconfiguration, placement of shunt