DAFTAR ISI

LEMBAR PERSETUJUAN ........................................................................................................... i
KATA PENGANTAR .............................................................................................................. iii
ABSTRAK .............................................................................................................................. iv
DAFTAR ISI ........................................................................................................................... vi
DAFTAR TABEL ...................................................................................................................... vii
DAFTAR GAMBAR ................................................................................................................ viii
DAFTAR LAMPIRAN ............................................................................................................... ix

BAB I PENDAHULUAN
1.1 Latar Belakang ................................................................................................................... 1
1.2 Identifikasi Masalah .......................................................................................................... 2
1.3 Batasan Masalah ............................................................................................................... 2
1.4 Rumusan Masalah .......................................................................................................... 2
1.5 Tujuan dan Manfaat ....................................................................................................... 3

BAB II TINJAUAN PUSTAKA
2.1 Umum ............................................................................................................................ 4
2.2 Terowongan Tekan (Headrace Tunnel) .......................................................................... 5
2.3 Pipa pesat (Penstock) .................................................................................................... 8
  2.3.1 Diameter Pipa Pesat ................................................................................................... 9
  2.3.2 Tebal Pipa Pesat ....................................................................................................... 11
  2.3.3 Koefisien Tinggi Tekan pada Pipa Pesat ................................................................ 12
2.4 Tekanan Hidrodinamis ................................................................................................. 12
2.5 Pukulan Air (Water Hammer) ....................................................................................... 13
2.6 Tangki Gelombang (Surge Tank) .................................................................................. 17
  2.6.1 Perencanaan Hidraulik Tangki Gelombang Sederhana ......................................... 18
  2.6.2 Stabilitas Fluktuasi Muka Air ................................................................................. 20
2.7 Kekuatan Pipa ................................................................................................................ 23
  2.7.1 Perhitungan Kekuatan Pipa Baja ............................................................................ 23
  2.7.2 Perhitungan Kekuatan Pipa Beton ........................................................................... 24
2.8 Tile Water Level (TWL) .................................................................................................. 25
2.9 Tinggi Jatuh Efektif ($H_{ef}$) ......................................................................................... 26
2.10 Turbin ........................................................................................................................... 27
2.10.1 Klasifikasi Turbin ................................................................. 27
2.10.2 Karakteristik Turbin ............................................................... 28
2.10.3 Dimensi Turbin ................................................................. 30
2.10.4 Kavitasi ............................................................................. 30
2.10.5 Bangunan Pelengkap .......................................................... 32
2.11 Daya ...................................................................................... 33
2.12 Daya Generator .................................................................... 33
2.13 Energi ................................................................................... 34
2.14 Analisa Ekonomi .................................................................. 34
  2.14.1 Komponen Manfaat (Benefit) ............................................. 34
  2.14.2 Komponen Biaya (Cost) ..................................................... 35
2.15 Indikator Kelayakan Ekonomi ................................................... 39
  2.15.1 BCR (Benefit Cost Ratio) .................................................. 39
  2.15.2 NPV (Net Present Value) .................................................. 40
  2.15.3 IRR (Internal Rate of Return) ............................................ 40

BAB III METODOLOGI STUDI
3.1 Kondisi Umum ......................................................................... 41
  3.1.1 Kondisi Geografis Kabupaten Sumedang .......................... 41
  3.1.2 Batas Wilayah ................................................................. 42
3.2 Kondisi Daerah Studi ................................................................. 42
3.3 Data-data Yang Dibutuhkan ....................................................... 42
3.4 Data Teknis Waduk Jatigede ...................................................... 43
3.5 Tahan Perencanaan ................................................................. 44

BAB IV ANALISIS DATA DAN PEMBAHASAN
4.1 Outflow Waduk ...................................................................... 50
  4.1.1 Debit Operasi Waduk ......................................................... 50
  4.1.2 Muka Air Operasi Waduk ................................................. 51
4.2 Tinggi Jatuh Bruto ($H_{\text{gross}}$) ............................................... 52
4.3 Terowongan Tekan .................................................................. 53
  4.3.1 Perhitungan Kapasitas Pengaliran Terowonga Tekan .......... 53
  4.3.2 Perhitungan Biaya Kehilangan Energi ................................. 54
  4.3.3 Perhitungan Biaya Konstruksi Terowongan Tekan ............. 55
  4.3.4 Penentuan Diameter Terowongan Tekan ............................ 56
4.4 Diameter Pipa Pesat ................................................................. 63
4.5 Tekanan Hidrodinamis pada Power Waterway .................................................................63
  4.5.1 Kehilangan Tinggi pada Power Waterway.................................................................63
  4.5.2 Tekanan Hidrodinamis pada Power Waterway..........................................................69
4.6 Pukulan Air (Water Hammer) .........................................................................................73
4.7 Tebal Pipa Pesat ..............................................................................................................76
4.8 Kekuatan Pipa ..................................................................................................................76
  4.8.1 Kekuatan Pipa Pesat Vertikal ......................................................................................76
  4.8.2 Kekuatan Pipa Pesat Horisontal ................................................................................76
  4.8.3 Kekuatan Pipa Pesat Conduit .....................................................................................77
4.9 Tangki Peredam (Surge Tank) .........................................................................................77
  4.9.1 Perencanaan Tangki Peredam .....................................................................................78
  4.9.2 Stabilitas Tangki Peredam .........................................................................................81
  4.9.3 Perencanaan Tangki Peredam Hilir .............................................................................82
4.10 Tinggi Jatuh Efektif .......................................................................................................84
4.11 Daya dan Energi ............................................................................................................86
  4.11.1 Daya ..........................................................................................................................86
  4.11.2 Energi ........................................................................................................................87
4.12 Turbin ..............................................................................................................................87
  4.12.1 Pemilihan Turbin .......................................................................................................87
  4.12.2 Dimensi Turbin .........................................................................................................88
  4.12.3 Kavitasi .....................................................................................................................89
4.13 Analisis Kelayakan Ekonomi .........................................................................................90
  4.13.1 Biaya (Cost) ...............................................................................................................90
  4.13.2 Manfaat (Benefit) .....................................................................................................97
  4.13.3 Present Value (PV) ...................................................................................................97
  4.13.4 BCR ..........................................................................................................................98
  4.13.5 NPV ..........................................................................................................................98
  4.13.6 IRR ...........................................................................................................................99
  4.13.7 Payback Periode .......................................................................................................99

BAB V PENUTUP
5.1 Kesimpulan .......................................................................................................................101
5.2 Saran .................................................................................................................................101

DAFTAR PUSTAKA

LAMPIRAN
DAFTAR TABEL

Tabel 2.1 Koefisien Kehilangan karena Pemasukan ........................................ 7
Tabel 2.2 Koefisien Tinggi Tekan pada Penyempitan ......................................... 7
Tabel 2.3 Nilai $E_p$ Bermacam-macam Bahan Pipa .............................................. 17
Tabel 2.4 Kekuatan Baja ....................................................................................... 23
Tabel 2.5 Kekuatan Beton .................................................................................... 25
Tabel 2.6 Koefisien Manning ................................................................................ 26
Tabel 2.7 Pengelompokan Turbin ........................................................................ 27
Tabel 2.8 Jenis Turbin Berdasarkan Tinggi Tekan .................................................. 27
Tabel 2.9 Jenis Turbin Berdasarkan Arah Aliran .................................................... 28
Tabel 2.10 Jenis Turbin Berdasarkan Kecepatan Tertentu ...................................... 28
Tabel 2.11 Hubungan Antara Elevasi dan Tekanan Atmosfir ................................. 31
Tabel 2.12 Hubungan Antara Suhu Air dan Tekanan Uap ....................................... 32
Tabel 2.13 Besar Biaya Tahunan untuk O & P ........................................................ 39
Tabel 4.1 Data Inflow dan Outflow Bulanan Waduk Jatigede dalam Satu Tahun .... 50
Tabel 4.2 Muka Air Operasi Waduk ................................................................... 51
Tabel 4.3 Tinggi Jatuh Bruto ($H_{gross}$) ............................................................... 53
Tabel 4.4 Kapasitas Pengaliran Terowongan Tekan .............................................. 58
Tabel 4.5 Biaya Kehilangan Energi ................................................................ ....... 59
Tabel 4.6 Biaya Konstruksi Terowongan Tekan ..................................................... 60
Tabel 4.7 Biaya Tahunan dan Rekapitulasi Biaya Total .......................................... 61
Tabel 4.8 Kehilangan Tinggi pada Terowongan Tekan ......................................... 67
Tabel 4.9 Kehilangan Tinggi pada Pipa Pesat ....................................................... 68
Tabel 4.10 Tekanan Hidrodinamis pada Power Waterway .................................... 72
Tabel 4.11 Pukulan Air dengan Berbagai Waktu Penutupan Katup ....................... 75
Tabel 4.12 Perhitungan Tangki Peredam dengan Berbagai Luasan ....................... 80
Tabel 4.13 Tinggi Jatuh Efektif .......................................................................... 84
Tabel 4.14 Daya yang Dibangkitkan .................................................................... 86
Tabel 4.15 Energi yang Dihasilkan ...................................................................... 87
Tabel 4.16 Kavitasi pada Turbin ........................................................................... 90
Tabel 4.17 Perhitungan Internal Rate of Return ................................................... 100
DAFTAR GAMBAR

Gambar 2.1  Skema Konversi Energi Pada Pembangkit Listrik Tenaga Air .................4
Gambar 2.2  Diameter Optimum Pipa Pesat ..........................................................10
Gambar 2.3  Kondisi Aliran Dalam Pipa Terhadap Berbagai Operasi Katup .............14
Gambar 2.4  Tekanan Pukulan Air pada Pipa ..........................................................15
Gambar 2.5  Perilaku Pengaruh Kekasaran pada Tekanan dalam Waktu Tertentu ...15
Gambar 2.6  Bentuk Kurva pada Penutupan Katup ..................................................15
Gambar 2.7  Grafik Calame-Gaden’s .................................................................22
Gambar 2.8  Tegangan Tangensial pada Pipa Tipis ................................................23
Gambar 2.9  Tegangan Tangensial pada Pipa Tebal ..............................................24
Gambar 2.10 Penampang Saluran yang Paling Baik .............................................25
Gambar 2.11 Grafik Pemilihan Turbin .................................................................28
Gambar 2.12 Karakteristik Utama dari Turbin ......................................................29
Gambar 3.1  Diagram Alir Pengerjaan Skripsi ......................................................46
Gambar 3.2  Lokasi Bendungan Jatigede menurut Peta Administratif ...................47
Gambar 3.3  Lokasi Bendungan Jatigede menurut Google Earth ..........................48
Gambar 3.4  Profil Potongan Melintang Main Dam Bendungan Jatigede ...............49
Gambar 4.1  Debit Inflow dan Outflow Waduk Jatigede .....................................51
Gambar 4.2  Elevasi Muka Air Bulanan Waduk Jatigede ....................................52
Gambar 4.3  Diameter Ekonomis Terowongan Tekan ...........................................62
Gambar 4.4  Pembagian Pias Tekanan Hidrodinamis pada Power Waterway PLTA Jatigede .................................................................71
Gambar 4.5  Fluktuasi Muka Air pada Tangki Peredam PLTA Jatigede ...............83
Gambar 4.6  Tinggi Jatuh Power Waterway PLTA Jatigede ................................85
Gambar 4.7  Diagram Cost-Benefit ........................................................................97
DAFTAR LAMPIRAN

*General Layout Plan* PLTA Bendungan Jatigede
*Longitudinal Plan* PLTA Bendungan Jatigede
Tabel Bunga pada Bunga Kompon
Tarif Dasar Listrik PT. PLN (Persero)
Suku Bunga Pinjaman Rupiah yang Diberikan Menurut Kelompok Bank
Harga Katup *Butterfly* Stockham
Foto Dokumentasi Lokasi Proyek Bendungan Jatigede