## 10-31-2013-energy-cost-calculator-gasification-power-generation-model

Input are highlighted in green

### Unit Conversions

BtuPerCubicFoot = 150

BtuPerPound = 8000

MetricTonsPerHour = 24

DollarPerMetricTons = 20

CubicFootPerPonds = 5.6

DollarPerMillionBtu = 5

KjPerCubicMeter = BtuPerCubicFoot\*1.055056\*35.31

KjPerKg = BtuPerPound\*1.055056/0.4535924

USTonsPerHour = MetricTonsPerHour/0.907

DollarPerUSTons = DollarPerMetricTons/0.907

CubicMeterPerKg = CubicFootPerPonds/35.31\*2.205

DollarPerMillionBtu = DollarPerMillionBtu/1055\*3.6

### Fuel Properties

GasolineDensity = 750

GasolineHigherHeatingValueMjPerKg=47.3

GasolineLowerHeatingValueMjPerKg=44

LightDieselDensity=810

LightDieselHigherHeatingValueMjPerKg=46.1

LightDieselLowerHeatingValueMjPerKg=43.2

HeavyDieselDensity=850

HeavyDieselHigherHeatingValueMjPerKg=45.5

HeavyDieselLowerHeatingValueMjPerKg=42.8

NaturalGasDensity=0.724

NaturalGasHigherHeatingValueMjPerKg=50

NaturalGasLowerHeatingValueMjPerKg=45

COHigherHeatingValueMjPerKg = 10.1

COLowerHeatingValueMjPerKg=10.1

H2HigherHeatingValueMjPerKg=142

H2LowerHeatingValueMjPerKg=120

CH4HigherHeatingValueMjPerKg=55.5

CH4LowerHeatingValueMjPerKg=50

CODensity=101325\*28/8314/298

H2Density =101325\*2/8314/298

CH4Density =101325\*16/8314/298

GasolineHigherHeatingValueKjPerL =GasolineHigherHeatingValueMjPerKg\*GasolineDensity

GasolineLowerHeatingValueKjPerL =GasolineLowerHeatingValueMjPerKg\*GasolineDensity

LightDieselHigherHeatingValueKjPerL =LightDieselHigherHeatingValueMjPerKg\*LightDieselDensity

LightDieselLowerHeatingValueKjPerL =LightDieselLowerHeatingValueMjPerKg\*LightDieselDensity

HeavyDieselHigherHeatingValueKjPerL =HeavyDieselHigherHeatingValueMjPerKg\*HeavyDieselDensity

HeavyDieselLowerHeatingValueKjPerL =HeavyDieselLowerHeatingValueMjPerKg\*HeavyDieselDensity

NaturalGasHigherHeatingValueKjPerL=NaturalGasHigherHeatingValueMjPerKg\*NaturalGasDensity\*1000

NaturalGasLowerHeatingValueKjPerL =NaturalGasLowerHeatingValueMjPerKg\*NaturalGasDensity\*1000

COHigherHeatingValueKjPerM =COHigherHeatingValueMjPerKg\*CODensity\*1000

COLowerHeatingValueKjPerM =COLowerHeatingValueMjPerKg\*CODensity\*1000

H2HigherHeatingValueKjPerM =H2HigherHeatingValueMjPerKg\*H2Density\*1000

H2LowerHeatingValueKjPerM =H2LowerHeatingValueMjPerKg\*H2Density\*1000

CH4HigherHeatingValueKjPerM =CH4HigherHeatingValueMjPerKg\*CH4Density\*1000

CH4LowerHeatingValueKjPerM =CH4LowerHeatingValueMjPerKg\*CH4Density\*1000

### Capital Cost

GasifierSystemCapitalCost = 300000

GasCleaningSystemCapitalCost = 50000

PowerGenerationCapitalCost = 450000

EmissionControlSystemCapitalCost = 25000

HeatRecoverySystemCapitalCost = 50000

GasifierSystemCapitalCostPerKwe = GasifierSystemCapitalCost/NetElectricalCapacity

GasCleaningSystemCapitalCostPerKwe = GasCleaningSystemCapitalCost/NetElectricalCapacity

PowerGenerationCapitalCostPerKwe = PowerGenerationCapitalCost/NetElectricalCapacity

EmissionControlSystemCapitalCostPerKwe = EmissionControlSystemCapitalCost/NetElectricalCapacity

HeatRecoverySystemCapitalCostPerKwe = HeatRecoverySystemCapitalCost/NetElectricalCapacity

TotalFacilityCapitalCost = GasifierSystemCapitalCost + GasCleaningSystemCapitalCost + PowerGenerationCapitalCost + EmissionControlSystemCapitalCost + HeatRecoverySystemCapitalCost

TotalFacilityCapitalCostPerKwe = TotalFacilityCapitalCost/NetElectricalCapacity

### Electrical and Fuel--base year

GrossElectricalCapacity = 650

NetElectricalCapacity = 500

CapacityFactor = 85

HHVEfficiencyOfGasificationSystem = 65

NetHHVEfficiencyofPowerGeneration = 23

FractionOfInputEnergy = 20

CleanGasComposition = ?

CO = 20

HydrogenGas = 12

Hydrocarbons = 5

CarbonDioxide = 12

Oxygen = 0

HigherHeatingValue = 18608

MoistureContent = 15

AshContent = 5

CarbonConcentration = 30

ParasiticLoad =GrossElectricalCapacity-NetElectricalCapacity

AnnualHours =CapacityFactor/100\*8760

AnnualNetElectricityGeneration =NetElectricalCapacity\*AnnualHours

OverallNetSystemEfficiency=HHVEfficiencyOfGasificationSystem\*NetHHVEfficiencyofPowerGeneration/100

NitrogenGas =100-(CO+HydrogenGas+Hydrocarbons+CarbonDioxide+Oxygen)

CleanGasMolecularMass=(CO\*28+HydrogenGas\*2+Hydrocarbons\*16+CarbonDioxide\*44+Oxygen\*32+NitrogenGas\*28)/100

CleanGasDensity =101325\*CleanGasMolecularMass/8314/298

CleanGasHigherHeatingValue=(CO\*COHigherHeatingValueKjPerM+HydrogenGas\*H2HigherHeatingValueKjPerM+Hydrocarbons\*CH4HigherHeatingValueKjPerM)/100

CleanGasLowerHeatingValue =(CO\*COLowerHeatingValueKjPerM+HydrogenGas\*H2LowerHeatingValueKjPerM+Hydrocarbons\*CH4LowerHeatingValueKjPerM)/100

TotalFuelPowerInput =NetElectricalCapacity/(NetHHVEfficiencyofPowerGeneration/100)

CleanGasPowerInput =TotalFuelPowerInput\*(1-FractionOfInputEnergy/100)

DualFuelPowerInput =TotalFuelPowerInput\*FractionOfInputEnergy/100

CleanGasFlowRateVolume =CleanGasPowerInput/CleanGasHigherHeatingValue\*3600

CleanGasFlowRateMass =CleanGasFlowRateVolume\*CleanGasDensity

AnnualCleanGasConsumption =CleanGasFlowRateMass\*AnnualHours/1000

DualFuelFlowRate =DualFuelPowerInput/HeavyDieselHigherHeatingValueKjPerL\*3600

AnnualDualFuelConsumption =DualFuelFlowRate\*AnnualHours

BiomassFeedRate=CleanGasPowerInput/(HHVEfficiencyOfGasificationSystem/100)/HigherHeatingValue\*3600

AnnualBiomassConsumptionDryMass =BiomassFeedRate\*AnnualHours/1000

AnnualBiomassConsumptionWetMass =AnnualBiomassConsumptionDryMass/(1-MoistureContent/100)

CharProductionRate =AshContent/100\*BiomassFeedRate/(1-CarbonConcentration/100)

AnnualCharProduction =CharProductionRate\*AnnualHours/1000

### Heat--base year

AggregateFractionOfHeatRecovered=50

AggregateSalesPriceForHeat=0.01

TotalHearProductionRate=TotalFuelPowerInput-GrossElectricalCapacity

RecoveredHeat=TotalHearProductionRate\*AggregateFractionOfHeatRecovered/100

AnnualHeatSales=RecoveredHeat\*AnnualHours

TotalIncomeFromHeatSales=AnnualHeatSales\*AggregateSalesPriceForHeat

HeatIncomePerUnitElecEnergy=TotalIncomeFromHeatSales/AnnualNetElectricityGeneration

GrossCHPEfficiency=(GrossElectricalCapacity\*AnnualHours+AnnualHeatSales)/(TotalFuelPowerInput\*AnnualHours)\*100

NetCHPEfficiency=(AnnualNetElectricityGeneration+AnnualHeatSales)/(TotalFuelPowerInput\*AnnualHours)\*100

### Expenses--base year

BiomassFuelCost=22.05

DualFuelCost=0.3

LaborCost=20000

MaintenanceCost=4000

WasteTreatment=2000

Insurance=1000

Utilities=1000

Management=1000

OtherOperatingExpenses=1000

BiomassFuelCostPerKwh =AnnualBiomassConsumptionDryMass\*BiomassFuelCost/AnnualNetElectricityGeneration

DualFuelPerKwh =DualFuelCost\*AnnualDualFuelConsumption/AnnualNetElectricityGeneration

LaborCostPerKwh =LaborCost/AnnualNetElectricityGeneration

MaintenanceCostPerKwh =MaintenanceCost/AnnualNetElectricityGeneration

WasteTreatmentPerKwh =WasteTreatment/AnnualNetElectricityGeneration

InsurancePerKwh =Insurance/AnnualNetElectricityGeneration

UtilitiesPerKwh =Utilities/AnnualNetElectricityGeneration

ManagementPerKwh =Management/AnnualNetElectricityGeneration

OtherOperatingExpensesPerKwh =OtherOperatingExpenses/AnnualNetElectricityGeneration

TotalNonFuelExpenses =LaborCost+MaintenanceCost+WasteTreatment+Insurance+Utilities+Management+OtherOperatingExpenses

TotalNonFuelExpensesPerKwh =LaborCostPerKwh+MaintenanceCostPerKwh+WasteTreatmentPerKwh+InsurancePerKwh+UtilitiesPerKwh+ManagementPerKwh+OtherOperatingExpensesPerKwh

TotalExpensesIncludingFuel =BiomassFuelCost\*AnnualBiomassConsumptionDryMass+DualFuelCost\*AnnualDualFuelConsumption+TotalNonFuelExpenses

TotalExpensesIncludingFuelPerKwh =BiomassFuelCostPerKwh+DualFuelPerKwh+TotalNonFuelExpensesPerKwh

### Taxes

FederalTaxRate=34

StateTaxRate=9.6

ProductionTaxCredit=0.009

CombinedTaxRate =StateTaxRate+FederalTaxRate\*(1-StateTaxRate/100)

### Income other than energy

ElectricityCapacityPayment=0

InterestRateOnDebtReserve=2

SalesPriceForChar=0

AnnualCapacityPayment =ElectricityCapacityPayment\*NetElectricalCapacity

AnnualDebtReserveInterest =DebtReserve\*InterestRateOnDebtReserve/100

AnnualIncomeFromChar =SalesPriceForChar\*AnnualCharProduction

### Escalation/Inflation

GeneralInflation=2.1

EscalationBiomassFuel=2.1

EscalationDualFuel=2.1

EscalationProductionTaxCredit=2.1

EscalationHeatSales=2.1

EscalationCharSales=2.1

EscalationOther=2.1

### Financing

DebtRatio=90

InterestRateOnDebt=5

EconomicLife=20

CostOfEquity=15

EquityRatio =100-DebtRatio

CostOfMoney =DebtRatio/100\*InterestRateOnDebt+EquityRatio/100\*CostOfEquity

TotalCostOfPlant =TotalFacilityCapitalCost

TotalEquityCost =TotalCostOfPlant\*EquityRatio/100

TotalDebtCost =TotalCostOfPlant\*DebtRatio/100

CapitalRecoveryFactorEquity =CostOfEquity/100\*(1+CostOfEquity/100)^EconomicLife/((1+CostOfEquity/100)^EconomicLife-1)

CapitalRecoveryFactorDebt =InterestRateOnDebt/100\*(1+InterestRateOnDebt/100)^EconomicLife/((1+InterestRateOnDebt/100)^EconomicLife-1)

AnnualEquityRecovery =CapitalRecoveryFactorEquity\*TotalEquityCost

AnnualDebtPayment =TotalDebtCost\*CapitalRecoveryFactorDebt

DebtReserve =AnnualDebtPayment

### Depreciation Schedule

DepreciationFraction =1/EconomicLife

### Tax Credit Schedule

"TaxCreditFrac": [1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]

### Annual Cash Flows

Year=Year

EquityRecovery=AnnualEquityRecovery

EquityInterest=CostOfEquity/100\*TotalEquityCost

EquityPrincipalPaid=EquityRecovery-EquityInterest

EquityPrincipalRemaining=TotalEquityCost-EquityPrincipalPaid

RebtRecovery=AnnualDebtPayment

DebtInterest=InterestRateOnDebt/100\*TotalDebtCost

DebtPrincipalPaid=RebtRecovery-DebtInterest

DentPrincipalRemaining=TotalDebtCost-DebtPrincipalPaid

BiomassFuelCostCF=AnnualBiomassConsumptionDryMass\*BiomassFuelCost

DualFuelCostCF=AnnualDualFuelConsumption\*DualFuelCost

NonFuelExpensesCF=TotalNonFuelExpenses

DebtReserveCF=DebtReserve

Depreciation=TotalCostOfPlant\*DepreciationFraction

CapacityIncome=AnnualCapacityPayment

HeatIncome=TotalIncomeFromHeatSales

CharIncome=AnnualIncomeFromChar

InterstOnDebtReserve=AnnualDebtReserveInterest

TaxWithoutCredit=((CombinedTaxRate/100)/(1-CombinedTaxRate/100))\*(EquityPrincipalPaid+DebtPrincipalPaid+EquityInterest-Depreciation+DebtReserveCF)

TaxCredit=AnnualNetElectricityGeneration\*ProductionTaxCredit\*B163

Taxes=((CombinedTaxRate/100)/(1-CombinedTaxRate/100))\*(EquityPrincipalPaid+DebtPrincipalPaid+EquityInterest-Depreciation+DebtReserveCF-TaxCredit)

EnergyRevenueRequired=EquityRecovery+RebtRecovery+BiomassFuelCostCF+DualFuelCostCF+NonFuelExpensesCF+Taxes+DebtReserveCF-CapacityIncome-InterstOnDebtReserve-HeatIncome-CharIncome

### Current $ Level Annual Cost (LAC)

LACCostOfMoney =CostOfEquity/100

PresentWorth =EnergyRevenueRequired\*(1+LACCostOfMoney)^-B185

TotalPresentWorth =SUM(PresentWorth)

CurrentCapitalRecoveryFactor= LACCostOfMoney\*(1+LACCostOfMoney)^EconomicLife/((1+LACCostOfMoney)^EconomicLife-1)

CurrentAnnualRevenueRequirements =TotalPresentWorth\*CurrentCapitalRecoveryFactor

CurrentLACPerKwh =CurrentAnnualRevenueRequirements/AnnualNetElectricityGeneration

### Constant $ Level Annual Cost

RealCostOfMoney =(1+LACCostOfMoney)/(1+GeneralInflation/100)-1

ConstantCapitalRecoveryFactor =RealCostOfMoney\*(1+RealCostOfMoney)^EconomicLife/((1+RealCostOfMoney)^EconomicLife-1)

ConstantLevelAnnualRevenue =TotalPresentWorth\*ConstantCapitalRecoveryFactor

ConstantLACPerKwh =ConstantLevelAnnualRevenue/AnnualNetElectricityGeneration