APPENDICES

Appendix A:

List of specifications, properties & operating conditions used for the simulation & calculations in this study

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(1) Collector's dimensions and material properties

Notation	Value	Description
L_r	48 m	aperture (or receiver) length
W	5 m	aperture width
D_o	0.070 m	absorber outside diameter
D_i	0.060 m	absorber inside diameter
D_c	0.100 m	glass cover diameter
A_a	236.64 m^2	effective aperture area
A_r	10.56 m^2	absorber surface area
$W - D_o$	4.93 m	effective aperture
C_g	22.4	geometric concentration ratio
k	63.0 W/m.°C	thermal conductivity of absorber
α	0.90	absorptance of absorber
ε_r	0.16	emittance of absorber
τ	0.95	transmittance of glass cover
ε_c	0.88	emittance of glass cover
ρ	0.89	specular reflectance
γ	0.93	intercept factor

(2) Design operating parameters of the gasifier system

Agriculture residue used = rice husk

Yield of producer gas from rice husk = 1.60 m^3/kg

High heating value of producer gas = 11.11 MJ/m^3

Efficiency of gasifier = 0.5

Efficiency of combustion = 0.75

(3) Design operating parameters of the thermal energy storage system

Storage medium used = Therminol XP

Loss coefficient-area product of storage tank = 11.1 W/°C

Initial temperature of medium in storage tank = 100 °C

Desired storage temperature = 250 °C

Minimum storage capacity = 6 hr

(4) Design operating parameters of the power conversion unit

Parameters of the Rankine Cycle:

At Point 1: T1 = 165 °C, P1 = 7 bar, H1 = 2766 KJ/kg

At Point 2: T2 = 95 °C, P2 = 0.85 bar, H2 = 1533 KJ/kg

At Point 3: T3 = 95 °C, P3 = 0.85 bar, H3 = 1533 KJ/kg

Thermal cycle efficiency = 0.5207

Efficiency of expander (engine) = 0.5

Efficiency of electric generator = 0.9

Efficiency of PCU = 0.2343

Rated power of electric generator = 20 kW_e

Rated output of power plant = 72 MJ/hr

Heat addition to boiler = 307.3 MJ/hr

Operating hrs of PCU = 08:00 am to 16:00 pm

Saturation temperature in boiler = 165 °C at 7 bar

Overall heat transfer coefficient in the boiler heat exchanger = 120 W/°C

Heat transfer fluid used = Therminol XP

Maximum operating temperature of Therminol XP = 300 °C

(5) Assumptions used in the LEC analysis to compare solar & hybrid operation modes

Cost estimation of collector system:

Cost of collector per unit area = 8,000 Baht/m^2

Cost of HTF (Therminol XP) = 30 Baht/liter

Percentage of O & M cost to capital cost = 10% per year

Cost estimation of gasifier system:

Cost of gasifier per kW_{th} = 2,366 Baht/kW_{th}

Percentage of O & M cost to capital cost = 30% per year

Estimation of generation capacity:

Max possible generation = 365 days x 8 hr/day x 20 kW = 58,400 kWh/year

For solar mode, actual generation = 0.5 x 58,000 = 29,200 kWh/year

For hybrid mode, actual generation = 0.8 x 58,000 = 46,720 kWh/year

Appendix B:

Flow diagram to calculate the daily average hourly direct radiation of a parabolic trough collector based on "average radiation" method (for partly cloudy condition)

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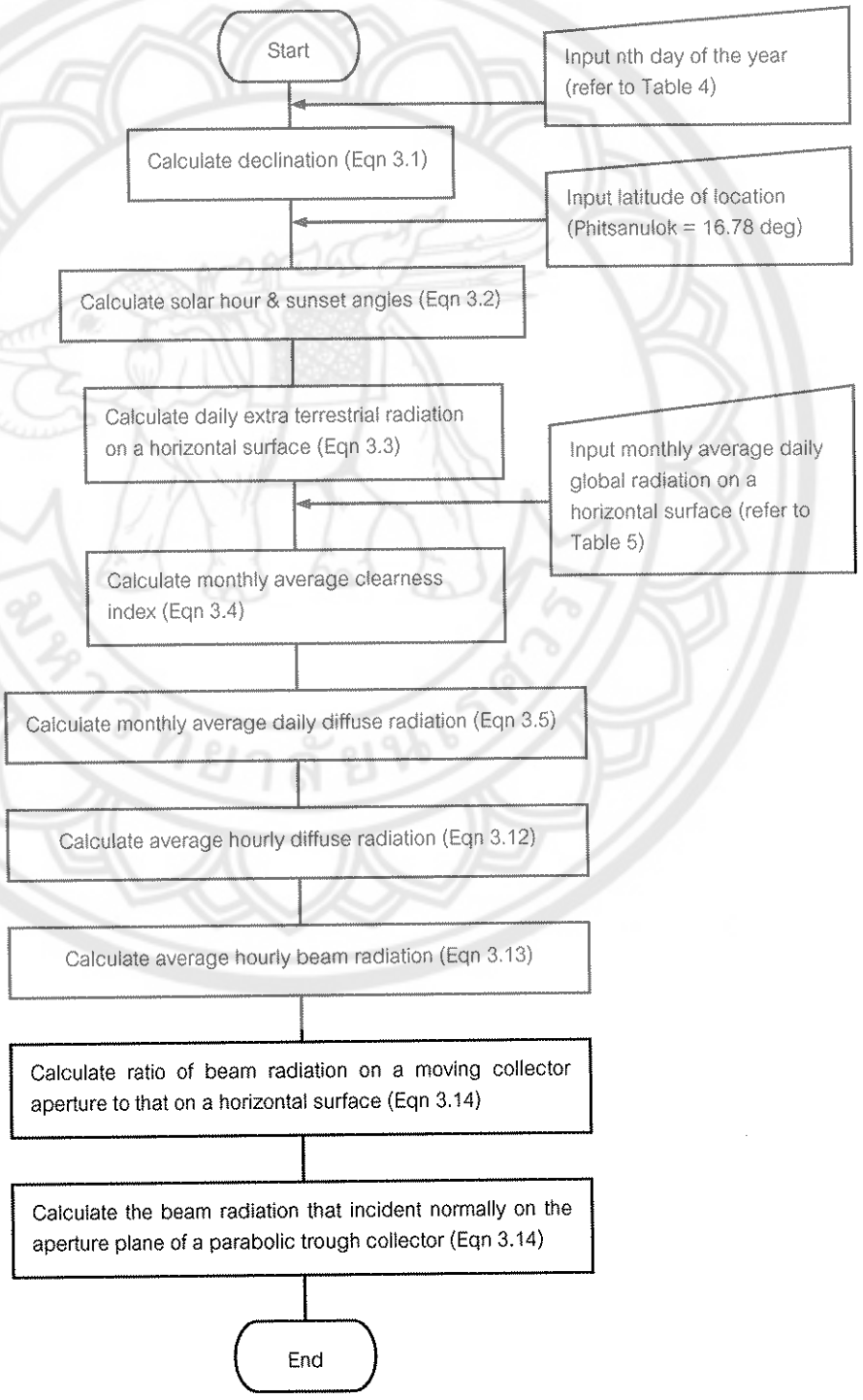

Appendix C:

Flow diagram to calculate the daily average hourly direct radiation of a parabolic trough collector based on "clear sky radiation" method (for sunny condition)

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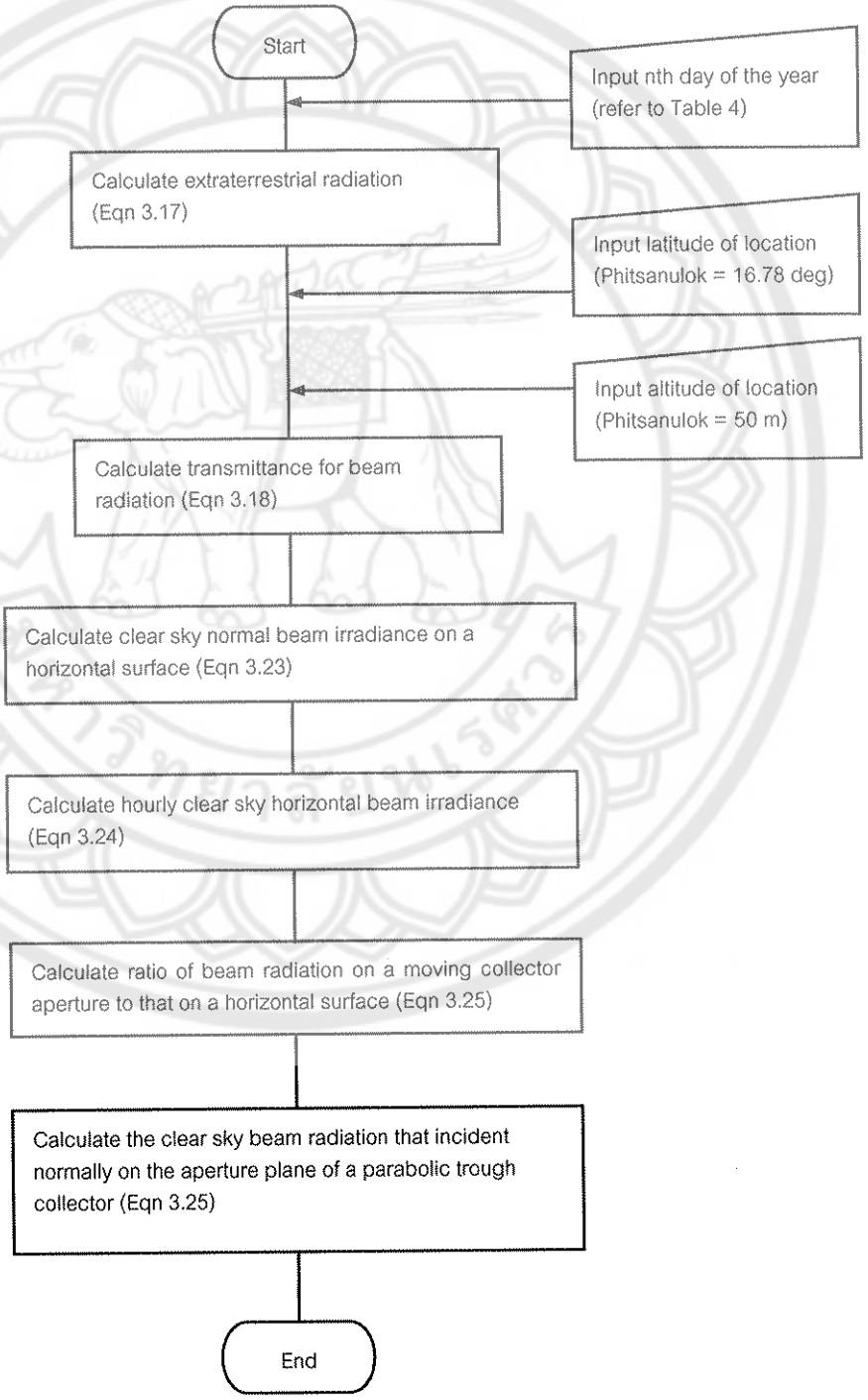
Flow diagram to calculate the daily average hourly direct radiation of a parabolic trough collector based on "clear sky radiation" method (for sunny condition)



Appendix D:

Flow diagram to calculate the fluid exit temperature, useful gain & instantaneous efficiency of the parabolic trough collector

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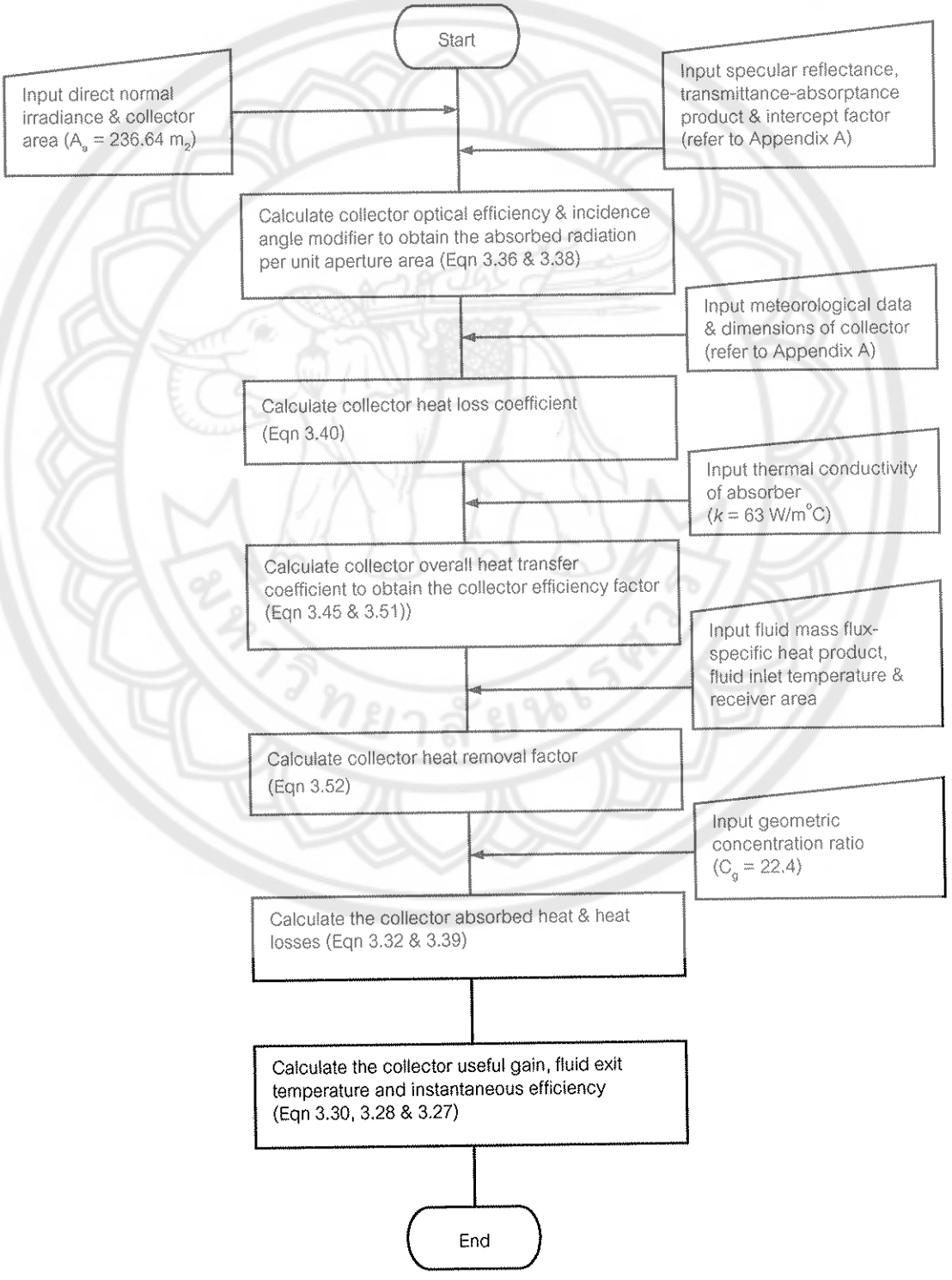
Flow diagram to calculate the fluid exit temperature, useful gain & instantaneous efficiency of the parabolic trough collector



Appendix E:

Flow diagram to calculate the thermal efficiency of Rankine cycle, efficiency of PCU, heat addition to boiler & mass flux of steam

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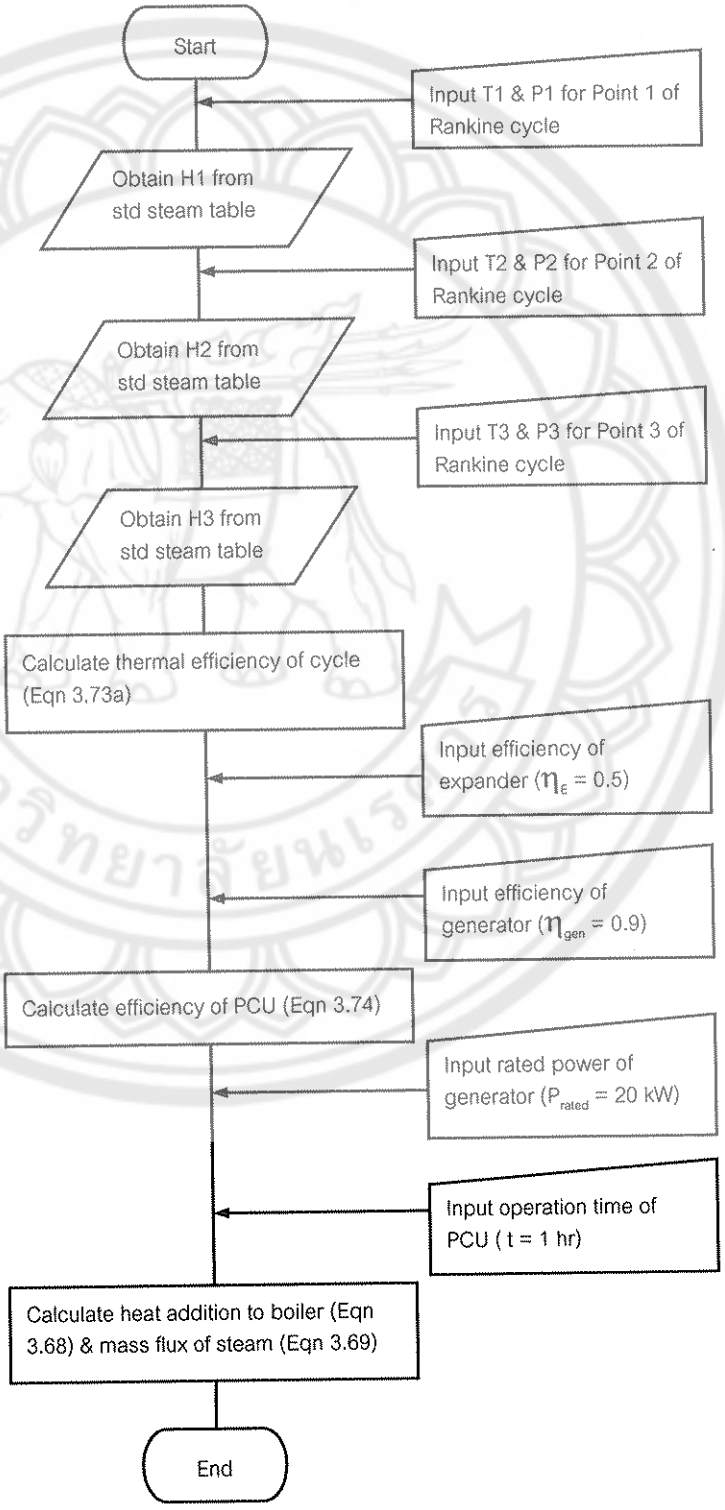

Appendix F:

Flow diagram to calculate the backup biomass energy produced by the gasifier system

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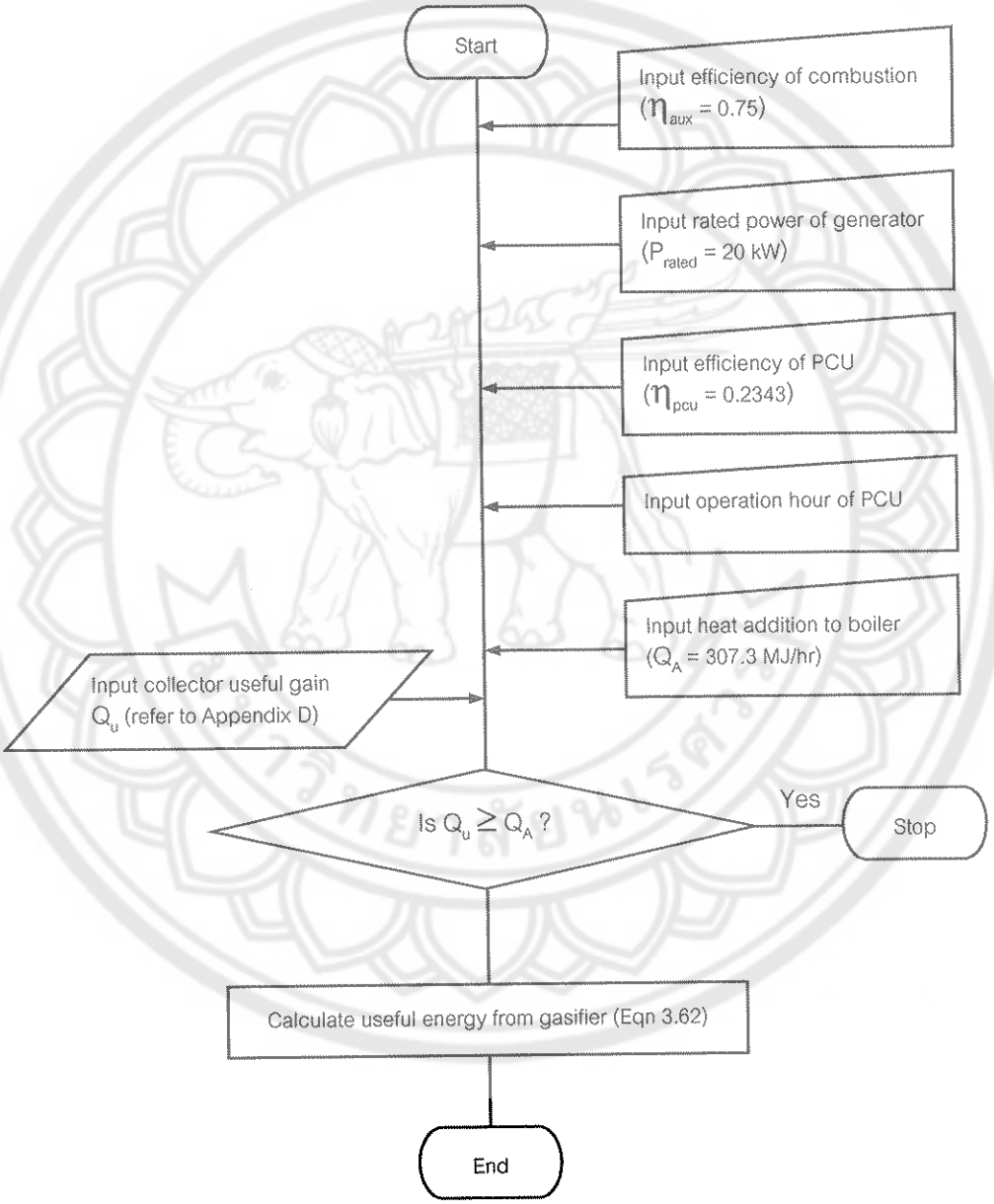

Appendix G:

Flow diagram to calculate the mass flux of the load stream and mass of media in storage tank

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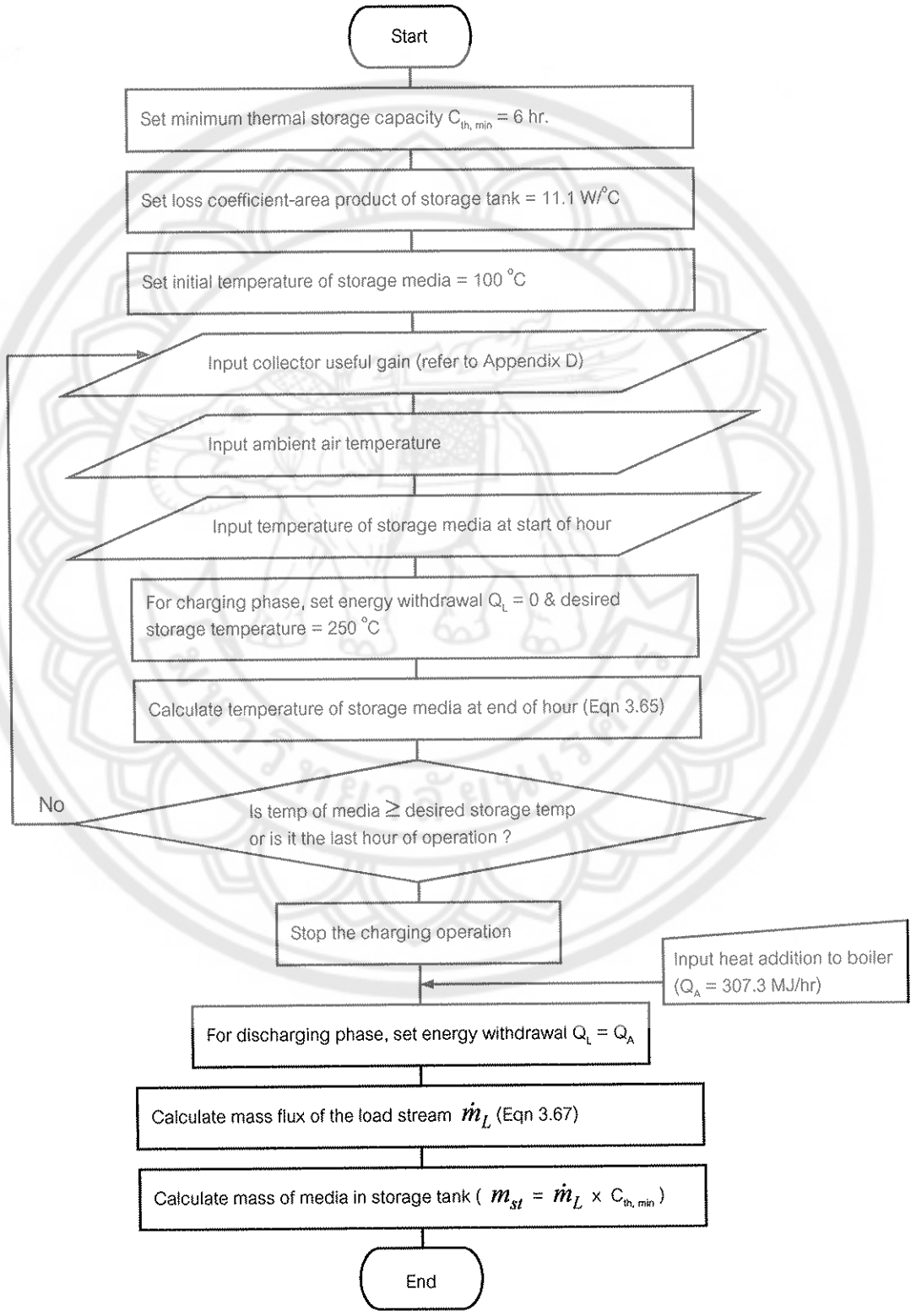

Appendix H:

Block diagram to show the energy flow during normal plant operation & during thermal charging/discharging

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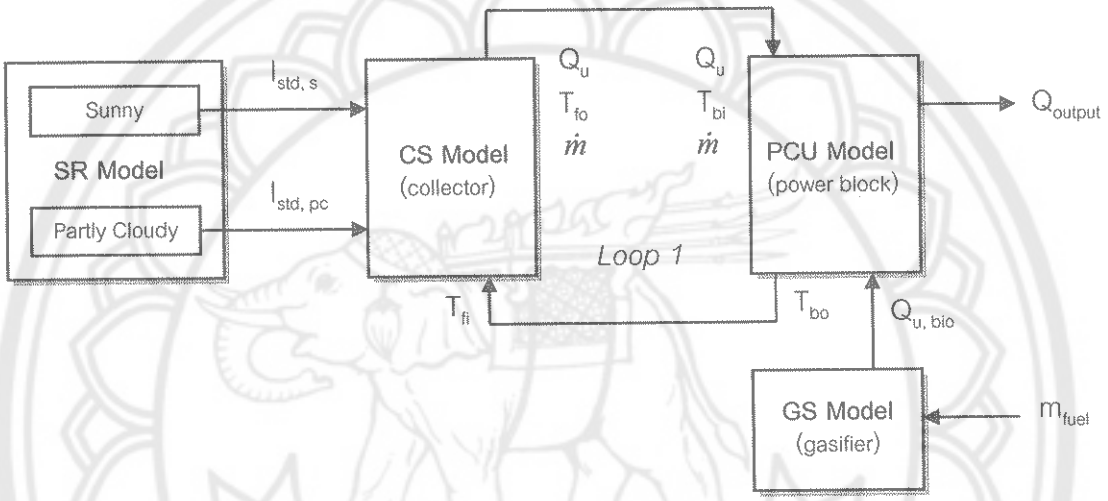
Block diagram to show the energy flow during normal plant operation & during thermal charging/discharging

(1) Energy flow during normal plant operation



(2) Energy flow during thermal charging/discharging