LAMPIRAN

Lampiran A Parameter simulasi model hidrogen hijau *offgrid*

```
%% Parameters for Green Hydrogen Microgrid
%% Hydrogen Properties

T_vect = [-75 -50 -25 0 25 50 75 100]+273.15;                   %K
h_vect = [2532 2875 3224 3578 3936 4295 4655 5017];             %kJ/kg
nu_vect = [6.77 7.34 7.88 8.42 8.94 9.44 9.93 10.41];           %s*uPa
cond_vect = [132.4 146.8 160.5 173.4 185.6 197.5 210.1 222.0]; %mW/kg/K
cp_vect = [13.57 13.87 14.08 14.23 14.33 14.4 14.45 14.47];     %kJ/kg/K

R_h2 = 4.12; %kJ/kg/K

%% Solar Data
% Time vector for solar profile
t_solar_profile = [0, 3600, 7200, 10800, 14400, 18000, 21600, 25200,...
        28800, 32400, 36000, 39600, 43200, 46800, 50400, 54000,...
        57600, 61200, 64800, 68400, 72000, 75600, 79200, 82800]';
% Solar profile
solar_profile =[4, 4, 4, 4, 4, 4, 240503.2, 903832.3, 1599329.0, 2333729.0, 2733793.5...
3022954.8, 3099251.6, 2833083.9, 2245935.5, 1587716.1, 976064.5, 366735.5, 19277.4, 4, 4, 4, 4, 4]';

temperature = 26.4; % Solar cell simulation temperature [degC]

%% Electrolyzer Unit

Plate.X = 77;  % cm
Plate.Y = 77; % cm
Plate.Z = 167; % cm
Electrolyzer.Np_electrodes = 3; % Number of electrode pairs
Electrolyzer.N_cell = 167;      % Number of cells
Electrolyzer.Temp_vect = linspace(273.15, 353.15, 5); % Temperature vector for efficiency [k]
Electrolyzer.Efficiency_vect = linspace(0.56,0.6,5);  % Efficiency vector [pu]
Electrolyzer.AreaMembrane = (Plate.Y*Plate.Z)*Electrolyzer.Np_electrodes; % Membrane area [cm^2]
Electrolyzer.Xd = 1;          % Membrane tickness [cm]
Electrolyzer.Resistance = 0.5; % Resistance [Ohm]
Heat.Resistance = 34.5; % Heating resistor [Ohm]

Tank.Area = (Plate.X*Plate.Y)*Electrolyzer.Np_electrodes; % Area of water tank [cm^2]
H2_Tank.Volume = 9910000;  % Volume of hydrogen tank [cm^3]
H2_Tank.T_storage = 273.15;    % Temperature of hydrogen tank [K]

Temp_vect_heat = [0 50 75 100]+273.15;
I_vect_heat = [100 75 0 0];

%% Ennergy Storage

Battery.Qn = 181818.18;
Battery.Qinit = 181818.18;
Battery.Q1 = Battery.Qn*0.75;
Battery.Rs = 0.25;
Battery.Un = 240;
Battery.U1 = 220;

Operation_Ref.Ie = [100 90 75 12.5 12.5];
Operation_Ref.Isolar = [0 5000 6000 7500 8000];
Converter.Iout = [6500 7500 8000];
Converter.Efficiency = [95 98 100];

%% Control Parameters

Ts         = 10; % Sample time [s]
```

Lampiran B Matlab *code* untuk *export* hasil simulasi

```
% Code to plot simulation results from GreenHydrogenMicrogrid
% Generate simulation results if they don't exist
if ~exist('simlog_GreenHydrogenMicrogrid', 'var') || ...
        simlogNeedsUpdate(simlog_GreenHydrogenMicrogrid, 'GreenHydrogenMicrogrid')
    sim('GreenHydrogenMicrogrid')
    % Model StopFcn callback adds a timestamp to the Simscape simulation data log
end

% Reuse figure if it exists, else create new figure
if ~exist('h1_GreenHydrogenMicrogrid', 'var') || ...
        ~isgraphics(h1_GreenHydrogenMicrogrid, 'figure')
    h1_GreenHydrogenMicrogrid = figure('Name', 'GreenHydrogenMicrogrid');
end
figure(h1_GreenHydrogenMicrogrid)
clf(h1_GreenHydrogenMicrogrid)

% Get simulation results
simlog_PElectrolyzer = logsout_GreenHydrogenMicrogrid.get('PElectrolyzer');
simlog_PSolar = logsout_GreenHydrogenMicrogrid.get('PSolar');
simlog_PStorage = logsout_GreenHydrogenMicrogrid.get('PStorage');
simlog_SOC = logsout_GreenHydrogenMicrogrid.get('SOC');
simlog_mH2 = logsout_GreenHydrogenMicrogrid.get('mH2');

% Plot results
simlog_handles(1) = subplot(4, 1, 1);
hold on
plot(simlog_PSolar.Values.Time/3600, simlog_PSolar.Values.Data, 'LineWidth', 1)
plot(simlog_PElectrolyzer.Values.Time/3600, simlog_PElectrolyzer.Values.Data, 'LineWidth', 1)

hold off
grid on
title('Daya PV dan Elektroliser')
ylabel('Daya (kW)')
xlabel('Waktu (jam)')
legend({'PV','Elektroliser'},'Location','Best');

simlog_handles(1) = subplot(4, 1, 2);
hold on
plot(simlog_PStorage.Values.Time/3600, simlog_PStorage.Values.Data, 'LineWidth', 1)
hold off
grid on
title('Baterai Discharge')
ylabel('Daya (kW)')
xlabel('Waktu (jam)')
legend({'baterai'},'Location','Best');


simlog_handles(2) = subplot(4, 1, 3);
plot(simlog_SOC.Values.Time/3600, simlog_SOC.Values.Data, 'LineWidth', 1)
hold off
grid on
title('Persentase Daya Baterai [%]')
ylabel('SOC')
xlabel('Waktu (jam)')

simlog_handles(3) = subplot(4, 1, 4);
plot(simlog_mH2.Values.Time/3600, simlog_mH2.Values.Data, 'LineWidth', 1)
grid on
title('Jumlah Produksi Hidrogen')
ylabel('Hidrogen[kg]')
xlabel('Waktu (Jam)')


linkaxes(simlog_handles, 'x')

% Remove temporary variables
clear simlog_handles temp_colororder
clear simlog_PElectrolyzer simlog_PSolar simlog_PStorage simlog_SOC simlog_mH2

```

Lampiran C Matlab *code* untuk menghitung LCOH

```
% MATLAB Code to Calculate Levelized Cost of Hydrogen (LCOH)

% Given data
initial_investment = 10495357.14; % Initial investment cost in dollars
annual_maintenance_cost = 413938.15; % Annual operational and maintenance costs in dollars
selling_price_per_kg = 13.7; % Selling price of hydrogen per kg in dollars
annual_hydrogen_production = 121391; % Annual hydrogen production in kg
battery_replacement_cost = 290800; % Battery replacement cost in dollars
battery_replacement_interval = 5; % Interval of battery replacement in years
lifecycle_years = 25; % Life cycle of the project in years
discount_rate = 0.05; % Discount rate (5%)

% Calculate total hydrogen production over the lifecycle
total_hydrogen_production = annual_hydrogen_production * lifecycle_years;

% Initialize cash flow array
total_costs = initial_investment; % Start with the initial investment

% Add annual maintenance costs and periodic battery replacement costs
for year = 1:lifecycle_years
    total_costs = total_costs + annual_maintenance_cost / (1 + discount_rate)^year;
    if mod(year, battery_replacement_interval) == 0
        total_costs = total_costs + battery_replacement_cost / (1 + discount_rate)^year;
    end
end

% Calculate Levelized Cost of Hydrogen (LCOH)
LCOH = total_costs / total_hydrogen_production;

% Display the result
fprintf('The Levelized Cost of Hydrogen (LCOH) is $%.2f per kg of hydrogen.\n', LCOH);
```

Lampiran D Matlab *code* untuk menghitung NPV, IRR dan BEP

```
% MATLAB Code to Calculate NPV, IRR, Break-Even Point and Graph NPV for Green Hydrogen System

% Given data
initial_investment = 10495357.14; % Initial investment cost in dollars
annual_maintenance_cost = 413938.15; % Annual operational and maintenance costs in dollars
selling_price_per_kg = 13.7; % Selling price of hydrogen per kg in dollars
annual_hydrogen_production = 121391; % Annual hydrogen production in kg
battery_replacement_cost = 290800; % Battery replacement cost in dollars
battery_replacement_interval = 5; % Interval of battery replacement in years
lifecycle_years = 25; % Life cycle of the project in years
discount_rate = 0.05; % Discount rate (5%)

% Calculate annual revenue
annual_revenue = annual_hydrogen_production * selling_price_per_kg;

% Initialize cash flow array
cash_flows = zeros(1, lifecycle_years + 1);
cash_flows(1) = -initial_investment; % Initial investment in year 0

% Populate cash flow array
for year = 1:lifecycle_years
    cash_flows(year + 1) = annual_revenue - annual_maintenance_cost; % Net annual cash flow
    if mod(year, battery_replacement_interval) == 0
        cash_flows(year + 1) = cash_flows(year + 1) - battery_replacement_cost; % Subtract battery replacement cost every 5 years
    end
end

% Calculate NPV over the years
npv_over_years = zeros(1, lifecycle_years + 1);
for year = 0:lifecycle_years
    npv_over_years(year + 1) = sum(cash_flows(1:year + 1) ./ (1 + discount_rate).^(0:year));
end

% Calculate Final NPV
npv = npv_over_years(end);

% Calculate IRR
irr = custom_irr(cash_flows);

% Calculate Break-Even Point
cumulative_cash_flows = cumsum(cash_flows);
break_even_year = find(cumulative_cash_flows >= 0, 1);

% Display the results
fprintf('The Net Present Value (NPV) of the green hydrogen system over %d years is $%.2f\n', lifecycle_years, npv);
fprintf('The Internal Rate of Return (IRR) of the green hydrogen system is %.2f%%\n', irr * 100);
if isempty(break_even_year)
    fprintf('The project does not break even within the lifecycle period.\n');
else
    fprintf('The project breaks even in year %d.\n', break_even_year - 1);
end

% Plot NPV over the years using a bar chart
figure;
bar(0:lifecycle_years, npv_over_years, 'FaceColor', [0.2 0.2 0.5]);
xlabel('Tahun');
ylabel('NPV ($)');
title('Net Present Value (NPV) selama 25 tahun operasi sistem hidrogen hijau');
grid on;

% Custom function to calculate IRR
function r = custom_irr(cash_flows)
    r = fzero(@(r) sum(cash_flows ./ (1 + r).^(0:length(cash_flows)-1)), 0.1);
end
```

Lampiran E Matlab *code* untuk menghitung sensitivitas NPV, IRR dan BEP terhadap harga hidrogen

```
% MATLAB Code to Calculate NPV, IRR, and Break-Even Point for Hydrogen Prices from $5 to $14 and Visualize

% Given data
initial_investment = 10495357.14; % Initial investment cost in dollars
annual_maintenance_cost = 413938.15; % Annual operational and maintenance costs in dollars
annual_hydrogen_production = 121391; % Annual hydrogen production in kg
battery_replacement_cost = 290800; % Battery replacement cost in dollars
battery_replacement_interval = 5; % Interval of battery replacement in years
lifecycle_years = 25; % Life cycle of the project in years
discount_rate = 0.05; % Discount rate (5%)
% Hydrogen price range
hydrogen_prices = 5:14; % Range of hydrogen prices from $5 to $14 per kg

% Initialize arrays to store results
npv_values = zeros(size(hydrogen_prices));
irr_values = zeros(size(hydrogen_prices));
break_even_years = zeros(size(hydrogen_prices));

% Loop through each hydrogen price and calculate NPV, IRR, and Break-Even Point
for i = 1:length(hydrogen_prices)
    selling_price_per_kg = hydrogen_prices(i);

    % Calculate annual revenue for the given hydrogen price
    annual_revenue = annual_hydrogen_production * selling_price_per_kg;

    % Initialize cash flow array
    cash_flows = zeros(1, lifecycle_years + 1);
    cash_flows(1) = -initial_investment; % Initial investment in year 0

    % Populate cash flow array
    for year = 1:lifecycle_years
        cash_flows(year + 1) = annual_revenue - annual_maintenance_cost; % Net annual cash flow
        if mod(year, battery_replacement_interval) == 0
            cash_flows(year + 1) = cash_flows(year + 1) - battery_replacement_cost; % Subtract battery replacement cost every 5 ye
        end
    end

    % Calculate NPV for the given hydrogen price
    npv = sum(cash_flows ./ (1 + discount_rate).^(0:lifecycle_years));
    npv_values(i) = npv; % Store NPV result

    % Calculate IRR for the given hydrogen price
    irr = custom_irr(cash_flows);
    irr_values(i) = irr; % Store IRR result

    % Calculate Break-Even Point for the given hydrogen price
    cumulative_cash_flows = cumsum(cash_flows);
    break_even_year = find(cumulative_cash_flows >= 0, 1);
    if isempty(break_even_year)
        break_even_years(i) = NaN; % No break-even point within the lifecycle
    else
        break_even_years(i) = break_even_year - 1; % Store Break-Even Point
    end
end

% Plot the NPV results as a bar chart
figure;
yyaxis left;
bar(hydrogen_prices, npv_values, 'FaceColor', [0.2 0.2 0.5], 'EdgeColor', 'none');
xlabel('Hydrogen Price ($/kg)');
ylabel('NPV ($)');
title('NPV, IRR, and Break-Even Point vs. Hydrogen Price');
grid on;

% Plot IRR and Break-Even Points on the same graph
yyaxis right;
plot(hydrogen_prices, irr_values * 100, '-o', 'LineWidth', 2, 'DisplayName', 'IRR (%)');
hold on;
plot(hydrogen_prices, break_even_years, '-s', 'LineWidth', 2, 'DisplayName', 'Break-Even Point (Years)');
ylabel('IRR (%) / Break-Even Point (Years)');

legend({'NPV', 'IRR (%)', 'Break-Even Point (Years)'}, 'Location', 'Best');

% Function to calculate IRR
function r = custom_irr(cash_flows)
    r = fzero(@(r) sum(cash_flows ./ (1 + r).^(0:length(cash_flows)-1)), 0.1);
end
```

Lampiran F Surat penawaran pembelian hidrogen

SAMATOR

Lampiran 3 : Format Surat Penawaran

Jakarta, 29 November 2023

Nomor : 268/SIG/PNWR-JS/IX/2023
Lampiran : 1 (satu berkas)
Perihal : Penawaran

Kepada :
Ibu Zahrah Zahirah Insani
PT PLN Indonesia Power Priok PGUJI.
Laksamana R. E. Martadinata,
Tanjung Priok, Jakarta Utara 14310

Yang bertandatangan di bawah ini,

Nama	: Ferryawan Utomo
Jabata	: Wakil Direktur Utama
Bertindak untuk dan atas nama	: PT. Samator Indo Gas Tbk
Alamat	: Gedung UGM Samator Pendidikan, Tower A, Lt. 5-6 Jl. Dr. Sahardjo No. 83, Manggarai Tebet, Jakarta Selatan 12850, Indonesia

Dengan ini menyatakan bahwa :

1. Dan dengan ini kami menyatakan tunduk pada ketentuan Dokumen Pengadaan Jasa Supply Hydrogen Cofiring PLTGU Priok Blok 12 Nomor 1156.DP/DAN.01.02/PRO-01/2023 dan ketentuan, peraturan dan perundang - undangan yang berlaku.
2. Bersedia dan sanggup melaksanakan Pengadaan Jasa Supply Hydrogen Cofiring PLTGU Priok Blok 12 sesuai dengan syarat - syarat yang tercantum dalam Dokumen Pengadaan :

Nomor	: 268/SIG/PNWR-JS/IX/2023
Tanggal	: 29 November 2023
Dengan harga penawaran sebesar	: **Rp 651.570.000,-**
Terbilang	: Enam Ratus Lima Puluh Satu Juta Lima Ratus Tujuh Puluh Ribu Rupiah

3. Harga penawaran tersebut di atas meliputi harga seluruh pekerjaan termasuk, pengepakan, transportasi (freight), *customs clearance*, *import duties*, bea - bea, dan pajak - pajak lainnyadan PPN 11% (sebelas persen), sesuai ketentuan yang berlaku (rincian penawaran terlampir).
4. Waktu pelaksanaan pekerjaan ditetapkan selambat - lambatnya 9 Hari Kalender sejak terbit Surat Perjanjian.
5. Penawaran ini mengikat dalam jangka waktu 120 Hari Kalender terhitung sejak tanggal pembukaan dokumen penawaran dan dapat diperpanjang lagi bila diperlukan.

Hormat kami,

PT. Samator Indo Gas Tbk

SAMATOR INDO GAS
METERAI TEMPEL
E8FAKX778586019

Ferryawan Utomo
Wakil Direktur Utama

PT Samator Indo Gas Tbk

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F1. Rincian harga penawaran

SAMATOR

RINCIAN HARGA PENAWARAN

Jakarta, 30 November 2023

No	NAMA BARANG/JASA	VOL	SAT	HARGA SATUAN	JUMLAH (Rp)	DELIVERY TIME
1	**Hidrogen UHP** Purity 99,999% Presure 200 Bar Volume : 4000 m3	20000	M3	Rp 9.000	Rp 360.000.000	9
2	***Sewa Peralatan*** *Tube H2 + Flexible hose H2*	10	Unit	Rp 3.000.000	Rp 30.000.000	9
3	***Man Power***					
	a. Operator H2 Tube (2 operator, 1 shift @12 jam)	4	LOT	Rp 2.000.000	Rp 8.000.000	9
	b. Akomodasi dan Transport	4	LOT	Rp 1.000.000	Rp 4.000.000	9
4	**Mobilisasi dan Demobilisasi** a. Head Trailer Plant H2 Cikampek - Indonesia Power PP (Head Truck With B3 Lincense)	10	Unit	Rp 16.000.000	Rp 160.000.000	9
	b. Standby Head Trailer	10	LOT	Rp 2.500.000	Rp 25.000.000	9
SUB TOTAL					Rp 587.000.000	
PPN 11%					Rp 64.570.000	
TOTAL HARGA PENAWARAN					Rp 651.570.000	
TERBILANG:Enam Ratus Lima Puluh Satu Juta Lima Ratus Tujuh Puluh Ribu Rupiah						

Hormat kami,
PT Samator Indo Gas Tbk

METERAI TEMPEL C8AAK...

Ferryawan Utomo
Wakil Direktur Utama

PT Samator Indo Gas Tbk

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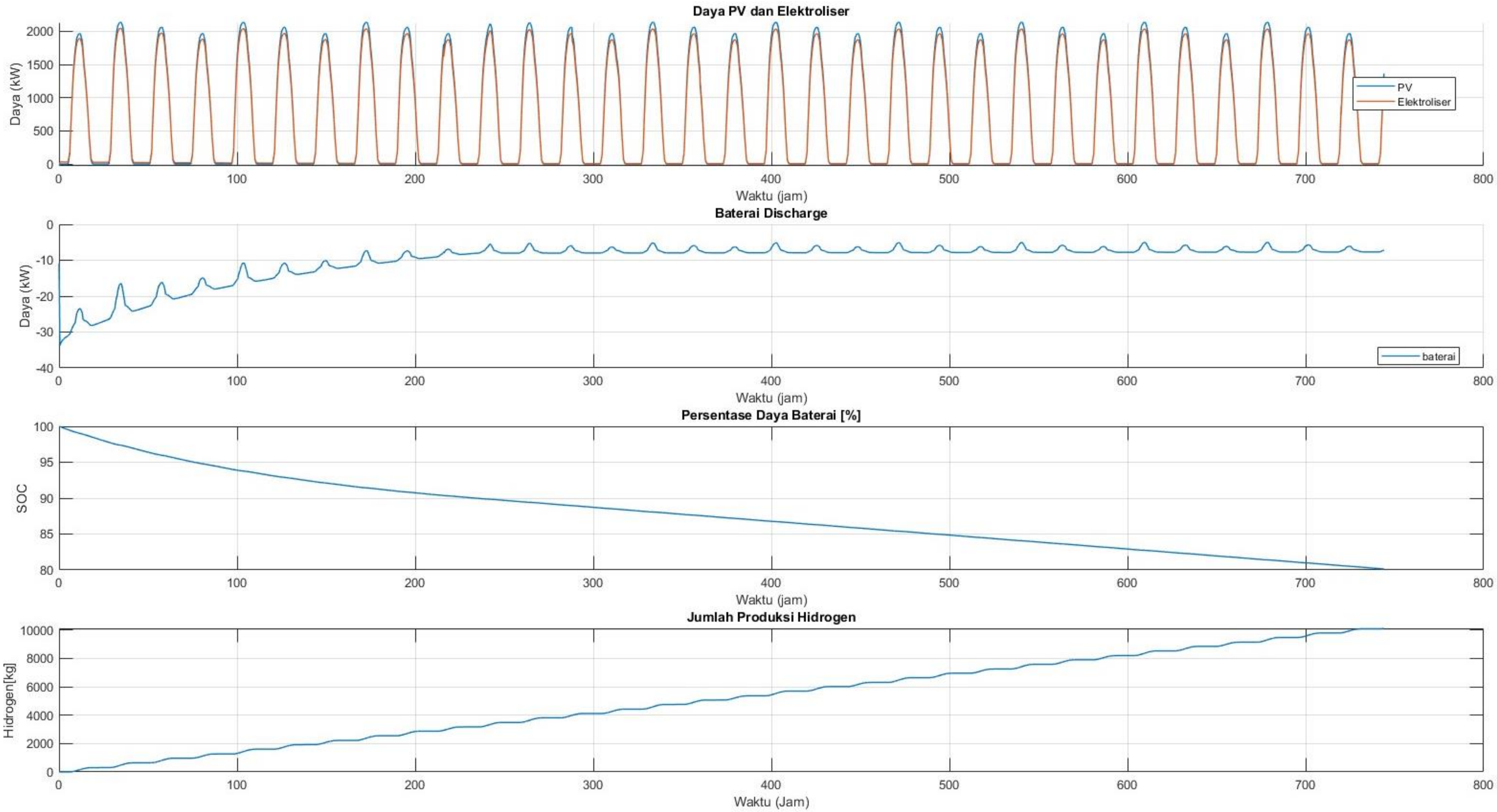
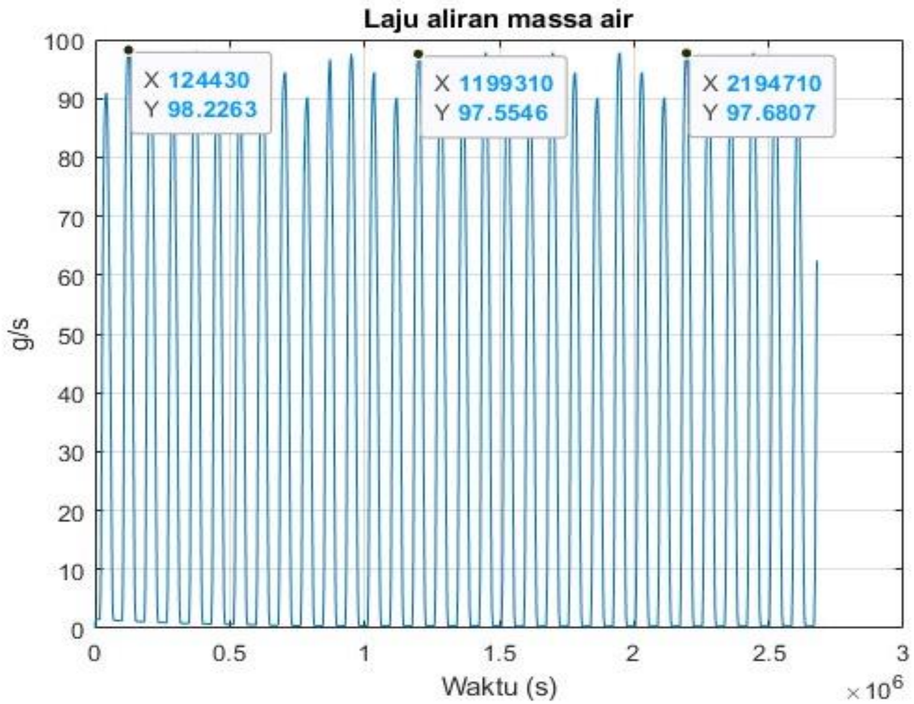
Sesuaikan table rincian harga sesuai pekerjaan dimaksud.

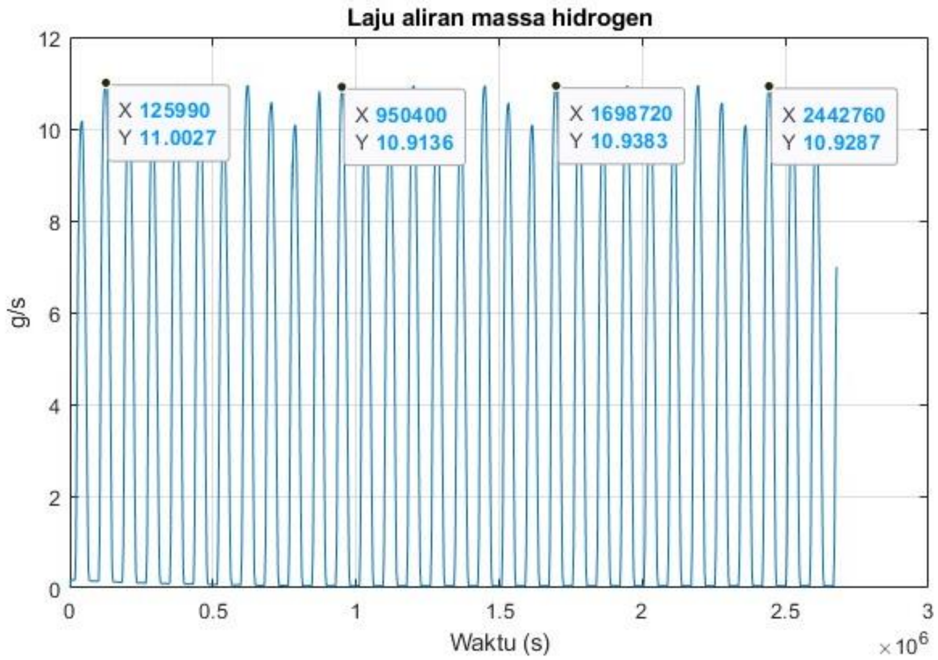
Lampiran G

Hasil simulasi model produksi hidrogen hijau selama 12 bulan tahun 2023

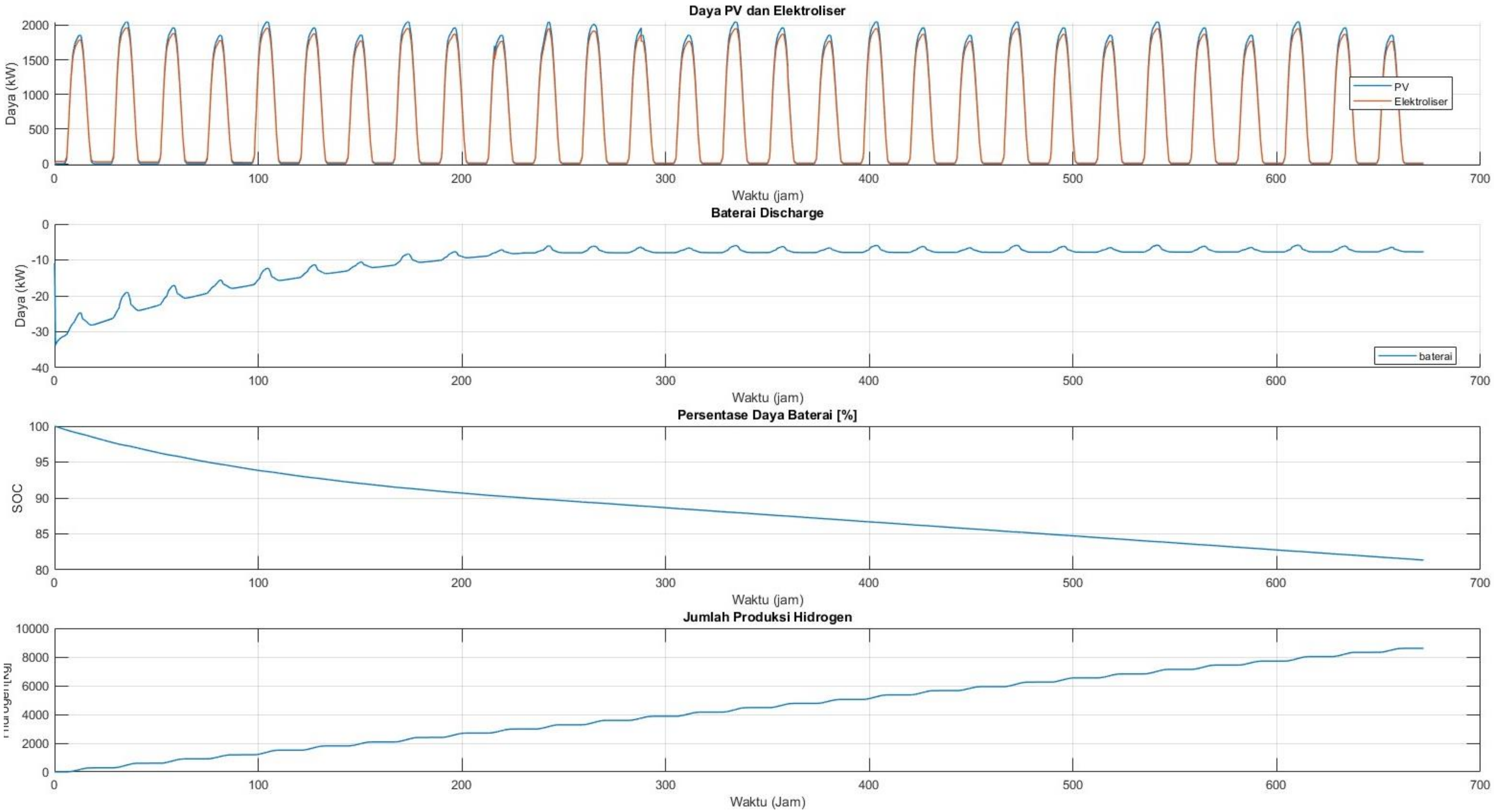
G1. Hasil simulasi bulan januari

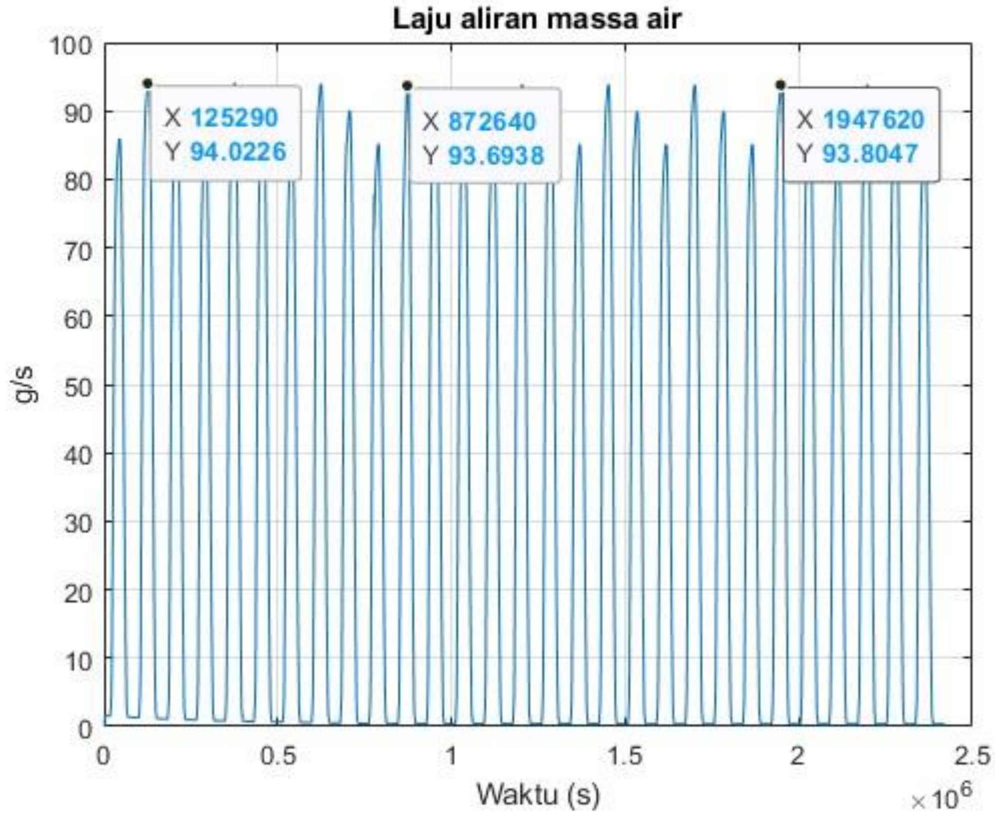


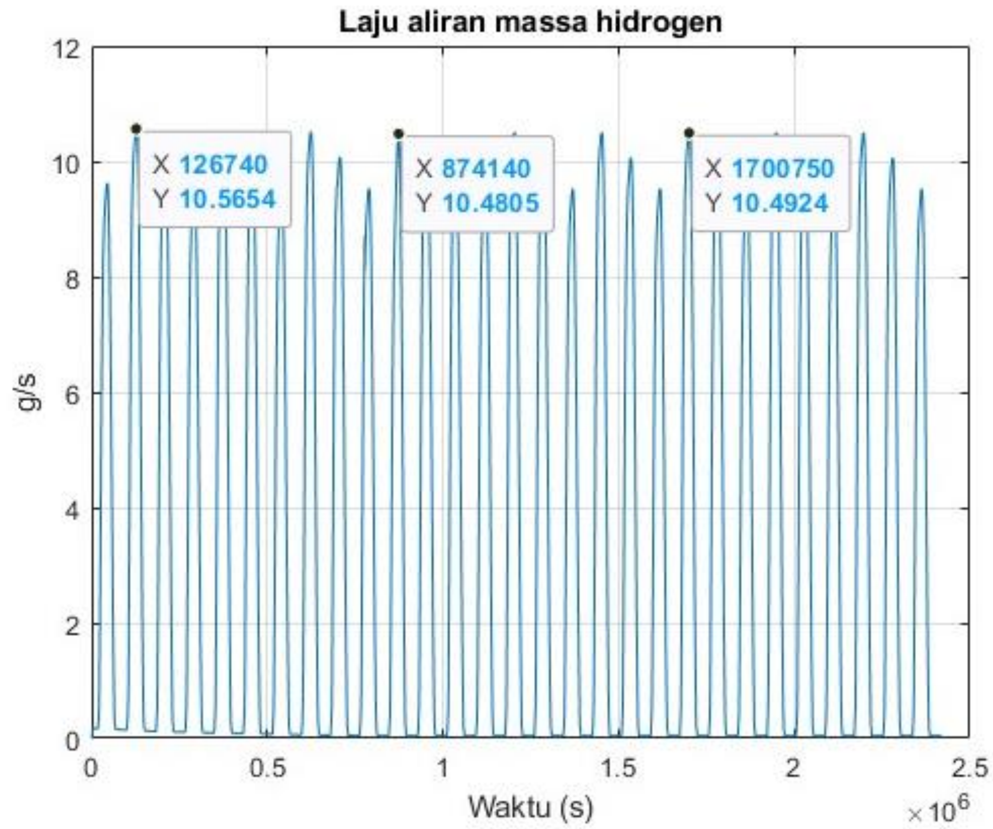

Laju aliran massa air
g/s
Waktu (s)
X 124430
Y 98.2263
X 1199310
Y 97.5546
X 2194710
Y 97.6807
×10^6


Laju aliran massa hidrogen
g/s
Waktu (s)
X 125990
Y 11.0027
X 950400
Y 10.9136
X 1698720
Y 10.9383
X 2442760
Y 10.9287
×10^6

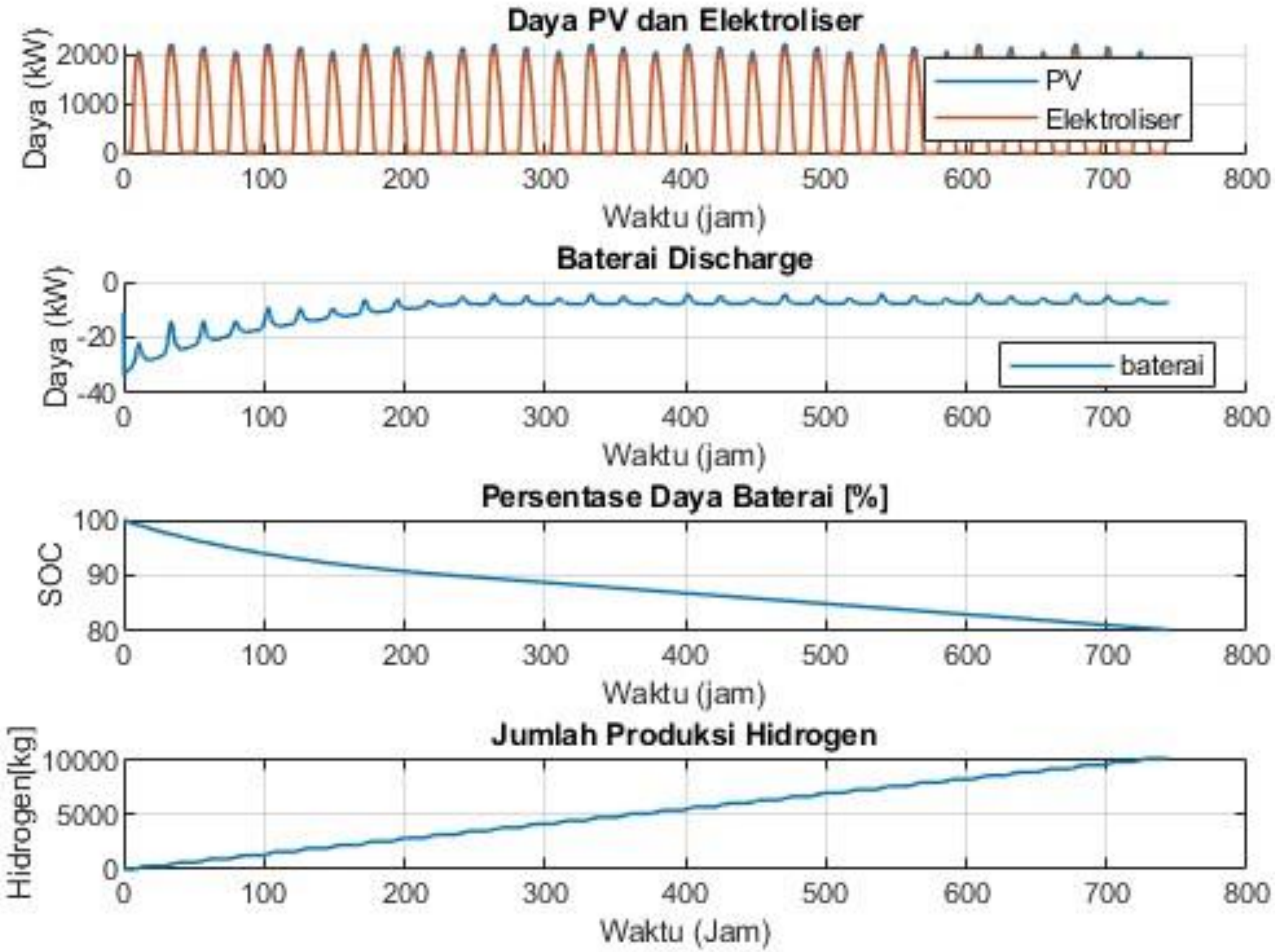
G2. Hasil simulasi bulan februari

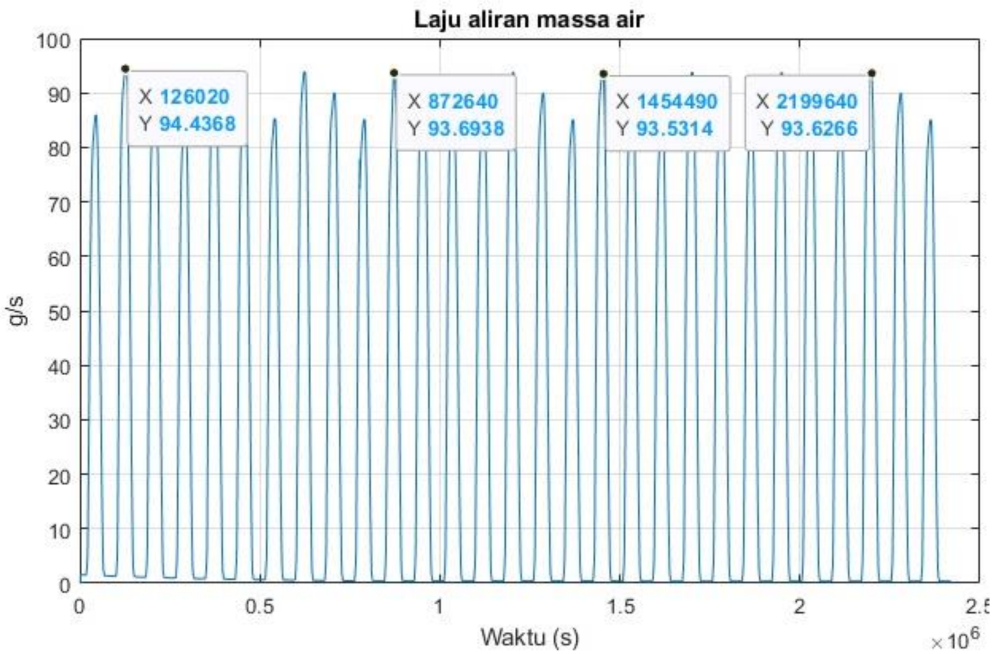


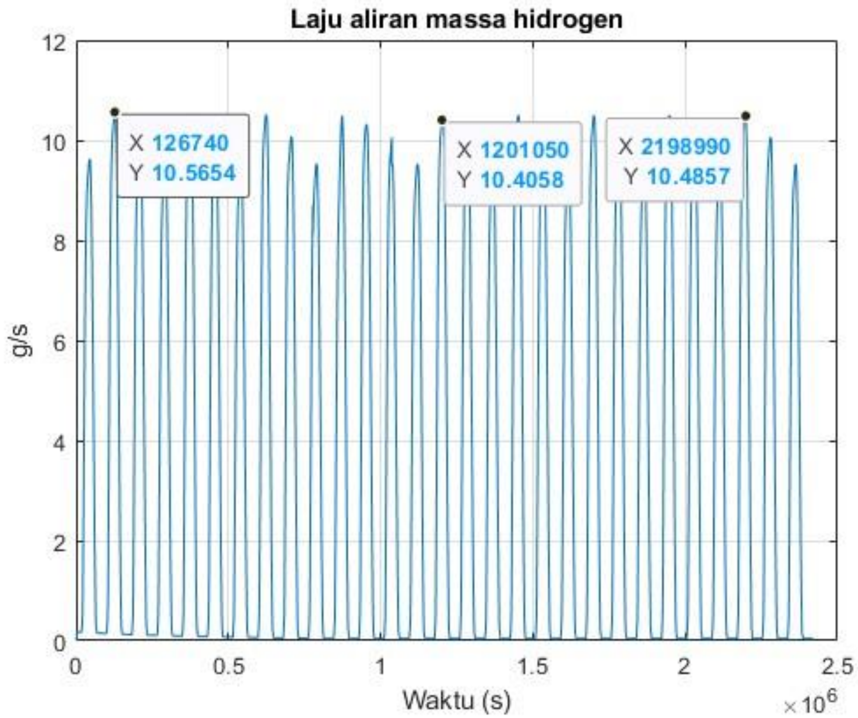

Laju aliran massa air
g/s
Waktu (s)
×10^6
X 125290
Y 94.0226
X 872640
Y 93.6938
X 1947620
Y 93.8047
0
10
20
30
40
50
60
70
80
90
100
0
0.5
1
1.5
2
2.5


Laju aliran massa hidrogen
g/s
Waktu (s)
×10^6
X 126740
Y 10.5654
X 874140
Y 10.4805
X 1700750
Y 10.4924
0
2
4
6
8
10
12
0
0.5
1
1.5
2
2.5

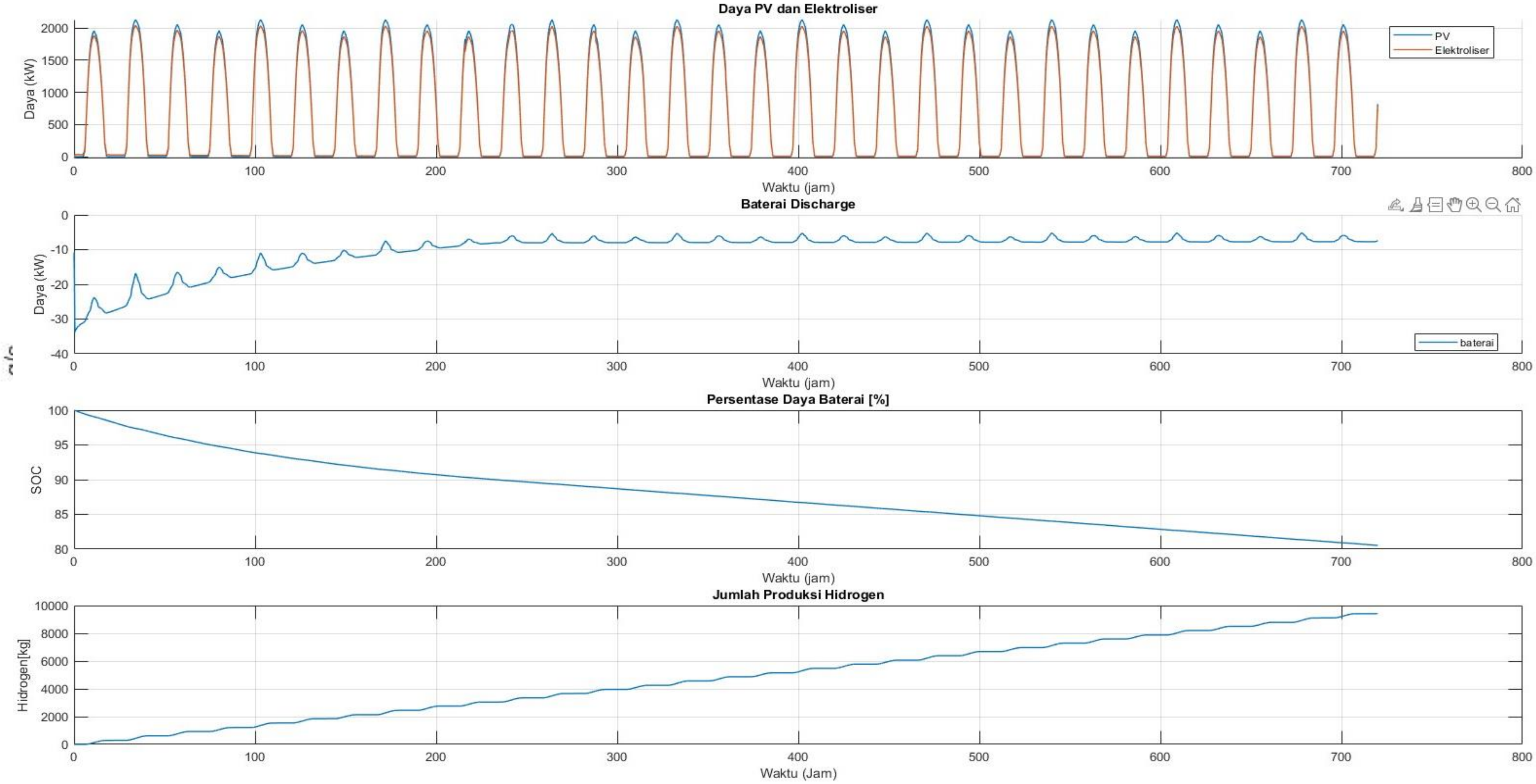
G3. Hasil simulasi bulan maret

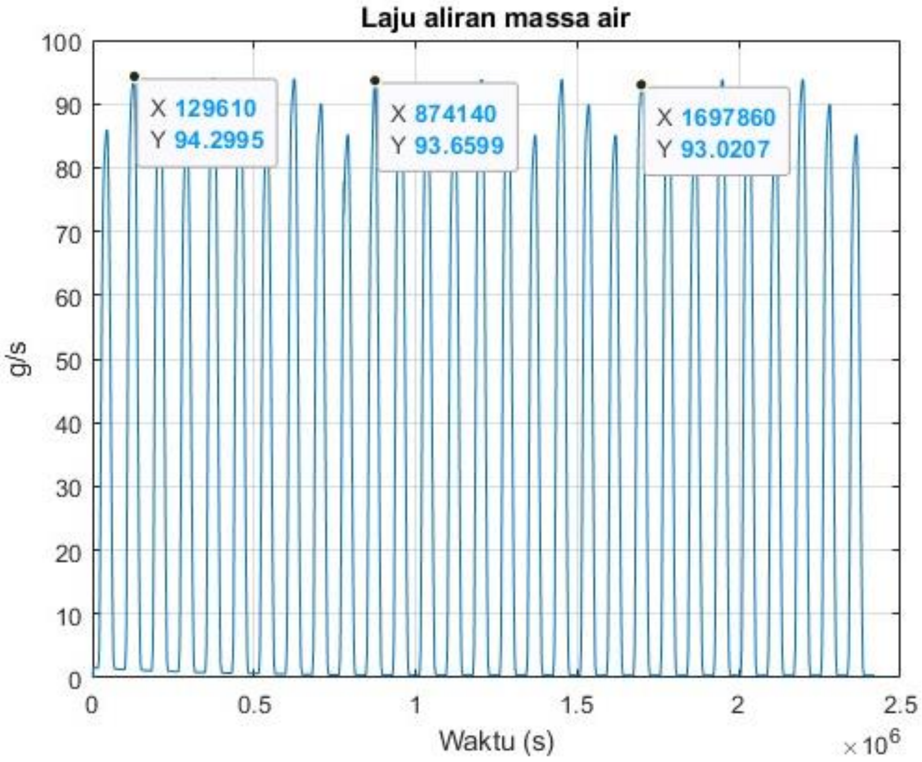


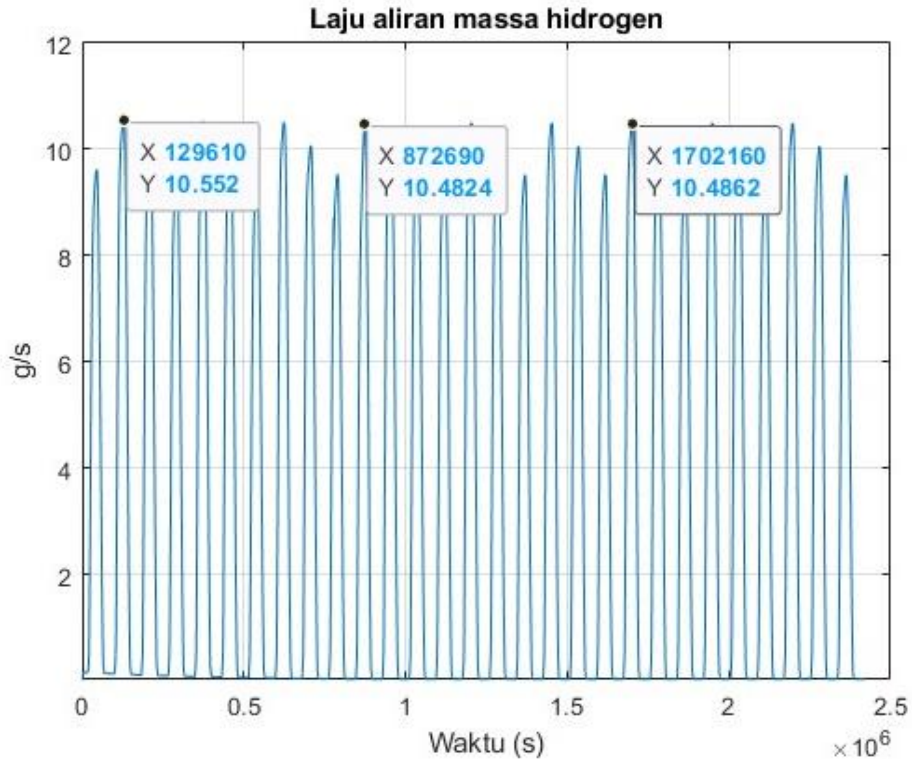

Laju aliran massa air
g/s
Waktu (s)
×10^6
X 126020
Y 94.4368
X 872640
Y 93.6938
X 1454490
Y 93.5314
X 2199640
Y 93.6266


Laju aliran massa hidrogen
g/s
Waktu (s)
×10^6
X 126740
Y 10.5654
X 1201050
Y 10.4058
X 2198990
Y 10.4857

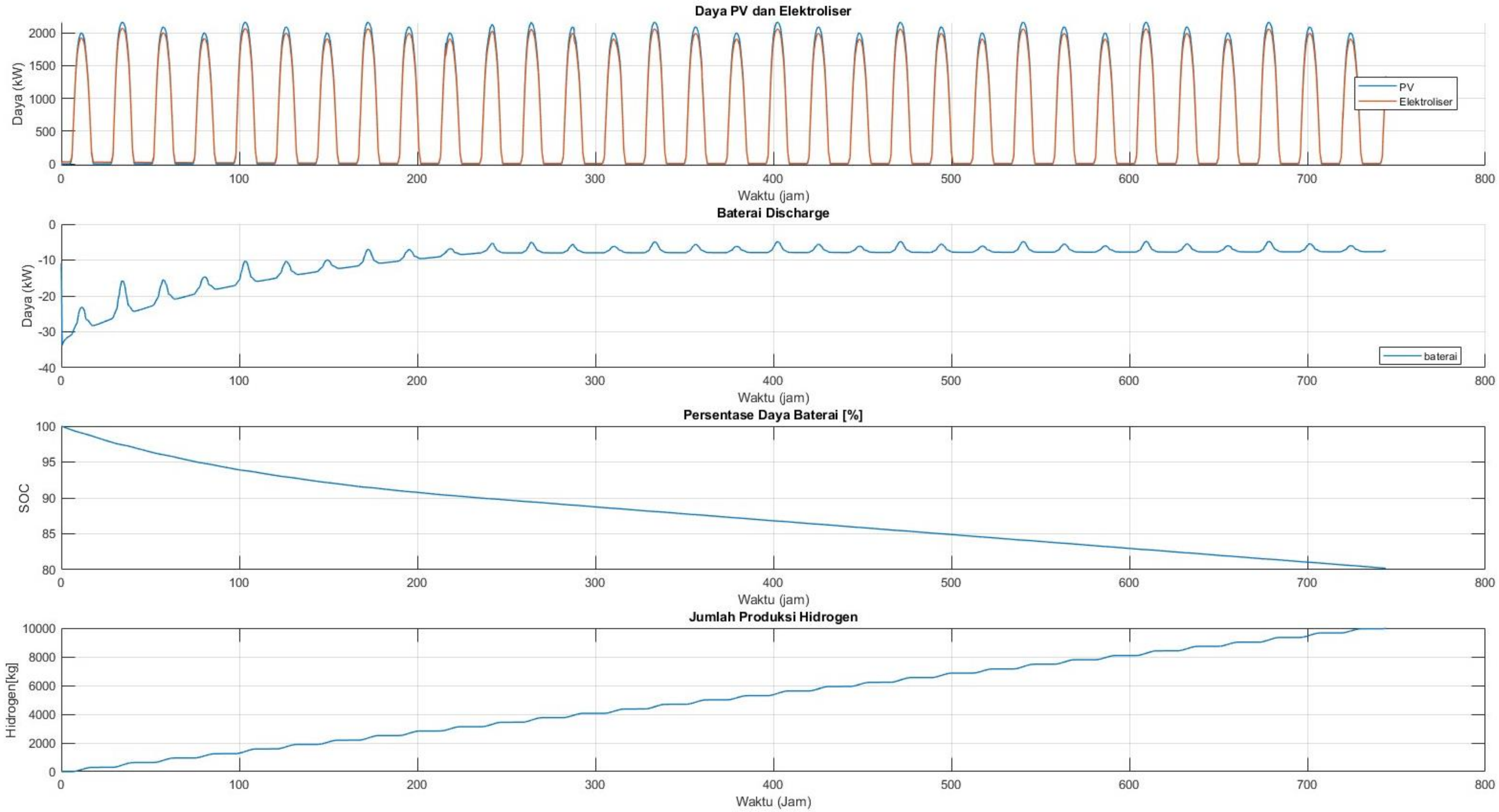
G4. Hasil simulasi bulan April

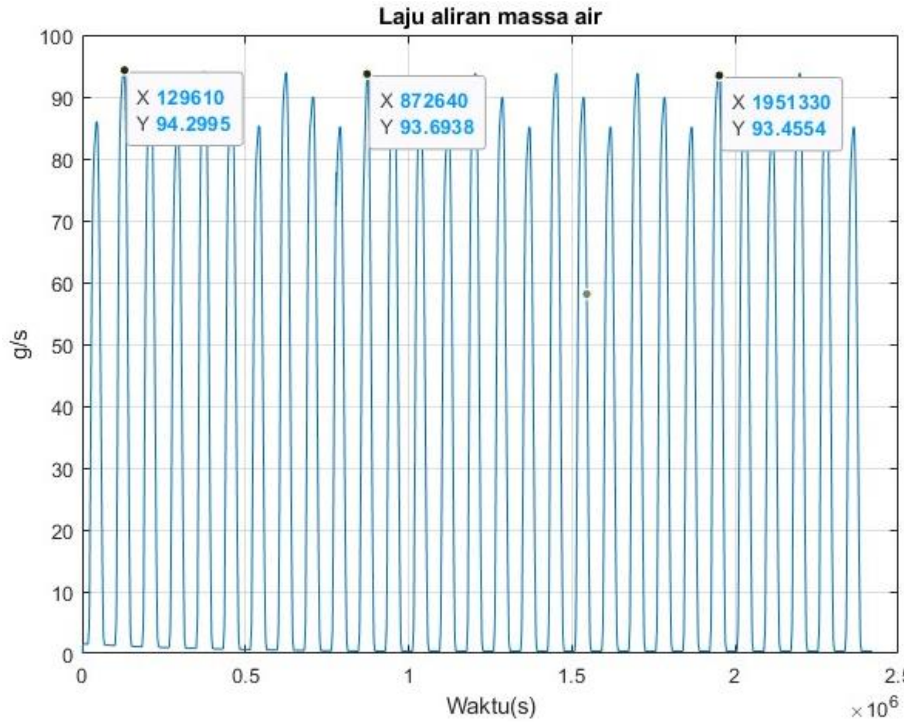


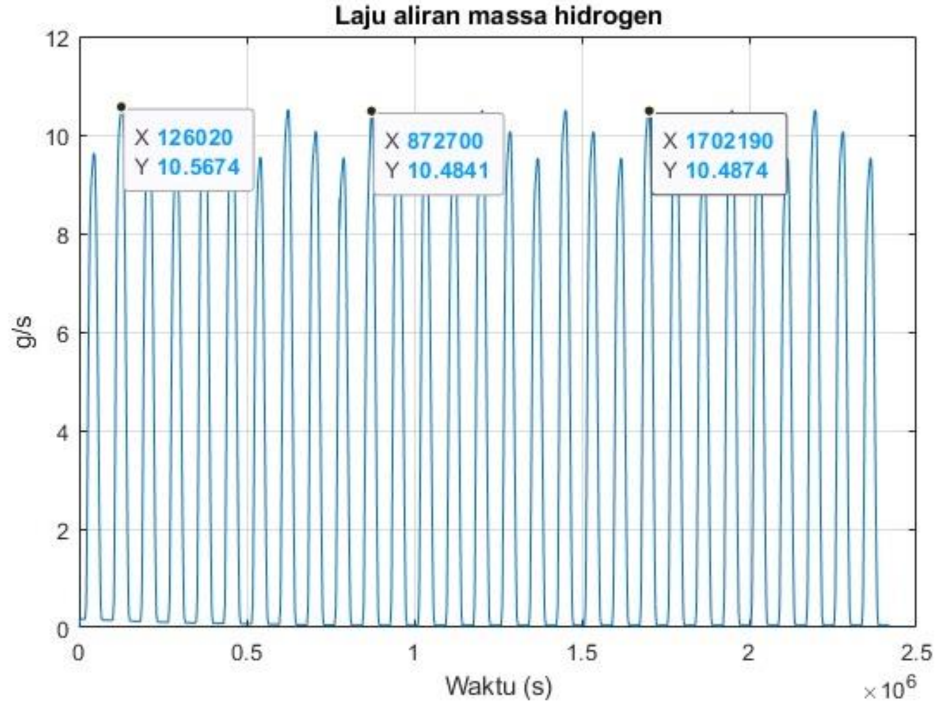

Laju aliran massa air
g/s
Waktu (s)
X 129610
Y 94.2995
X 874140
Y 93.6599
X 1697860
Y 93.0207
×10^6


Laju aliran massa hidrogen
g/s
Waktu (s)
X 129610
Y 10.552
X 872690
Y 10.4824
X 1702160
Y 10.4862
×10^6

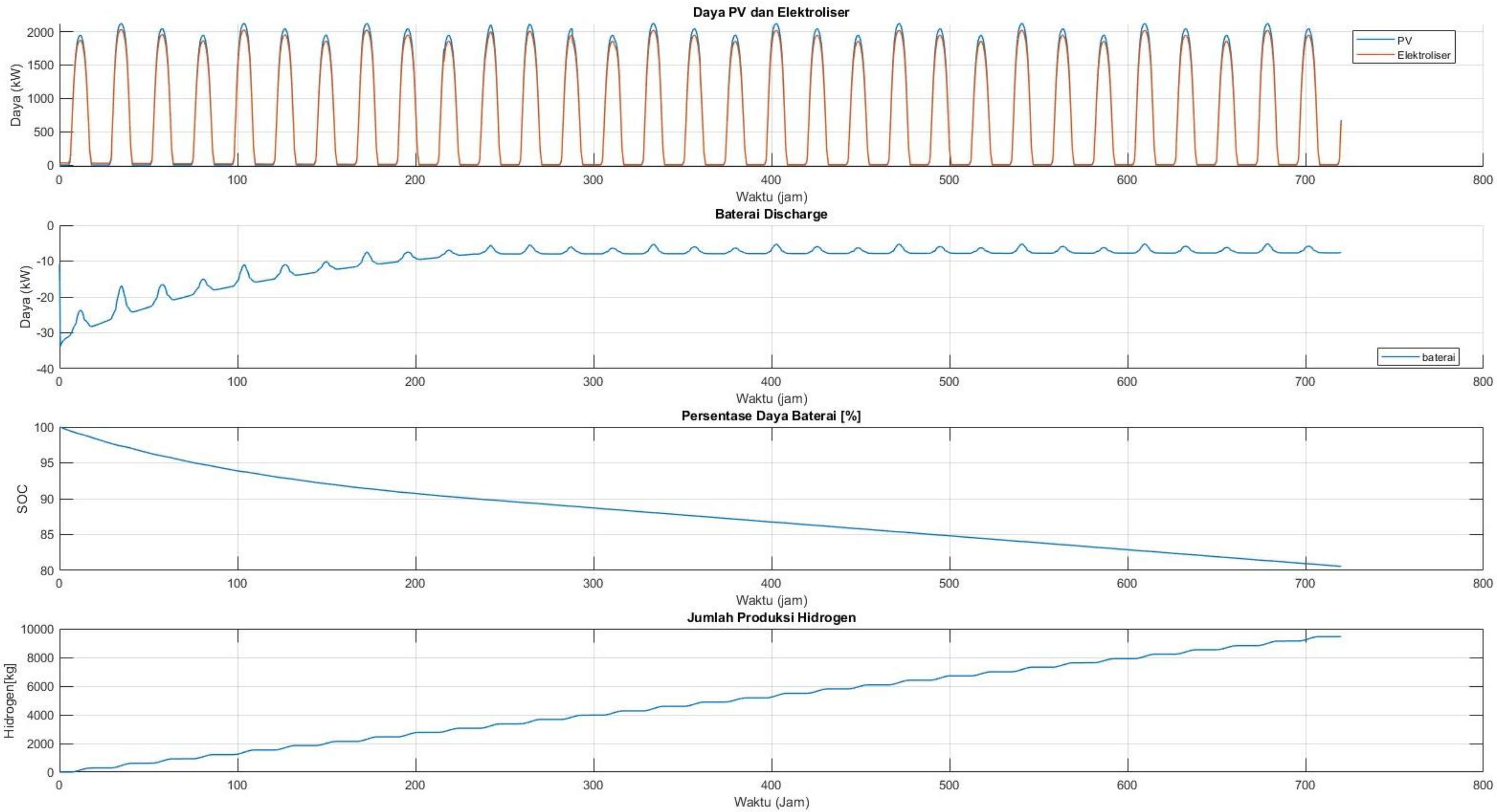
G5. Hasil simulasi bulan mei

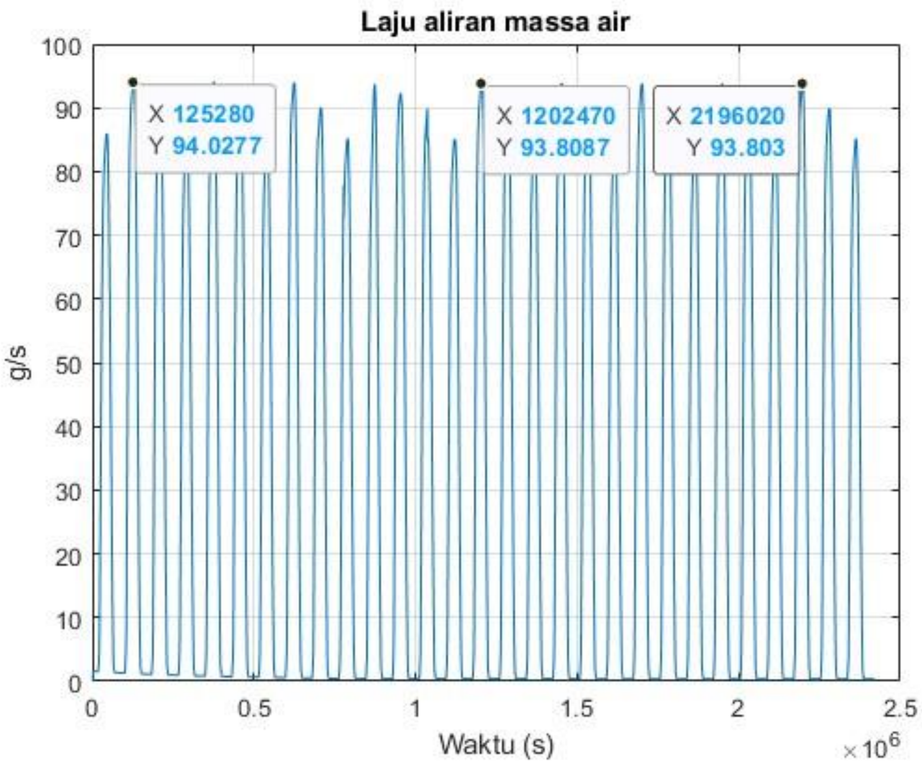



Laju aliran massa air
g/s
Waktu(s)
×10^6
X 129610
Y 94.2995
X 872640
Y 93.6938
X 1951330
Y 93.4554

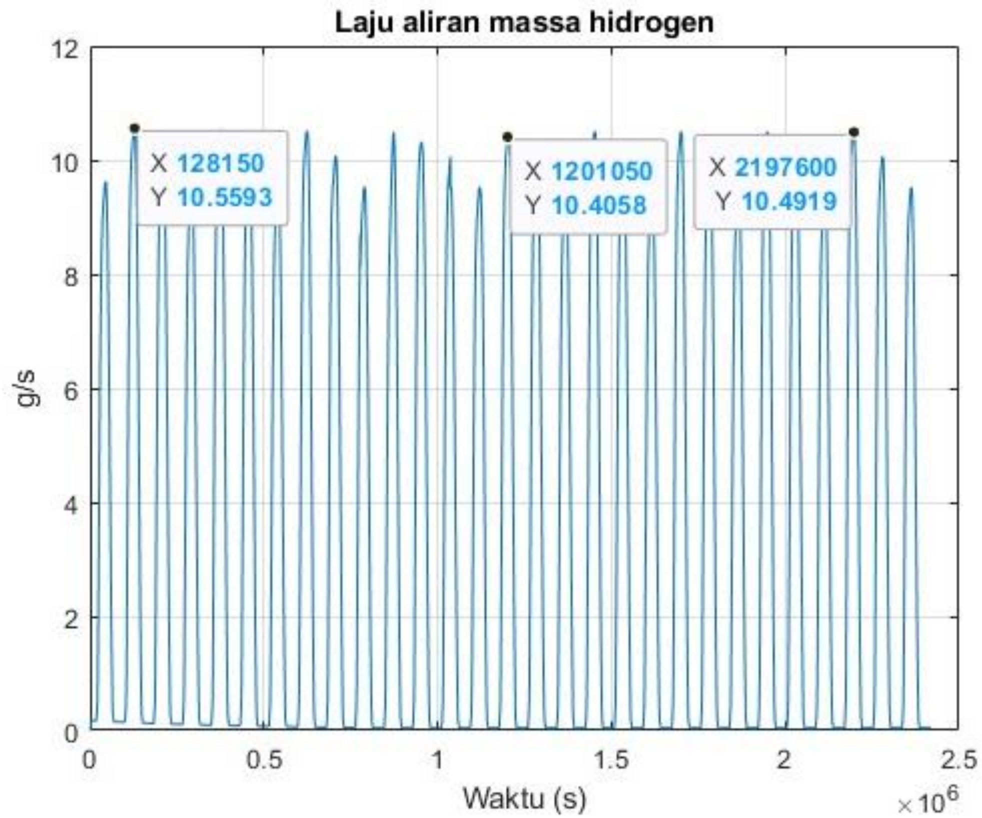

Laju aliran massa hidrogen
g/s
Waktu (s)
×10^6
X 126020
Y 10.5674
X 872700
Y 10.4841
X 1702190
Y 10.4874

G6. Hasil simulasi bulan juni



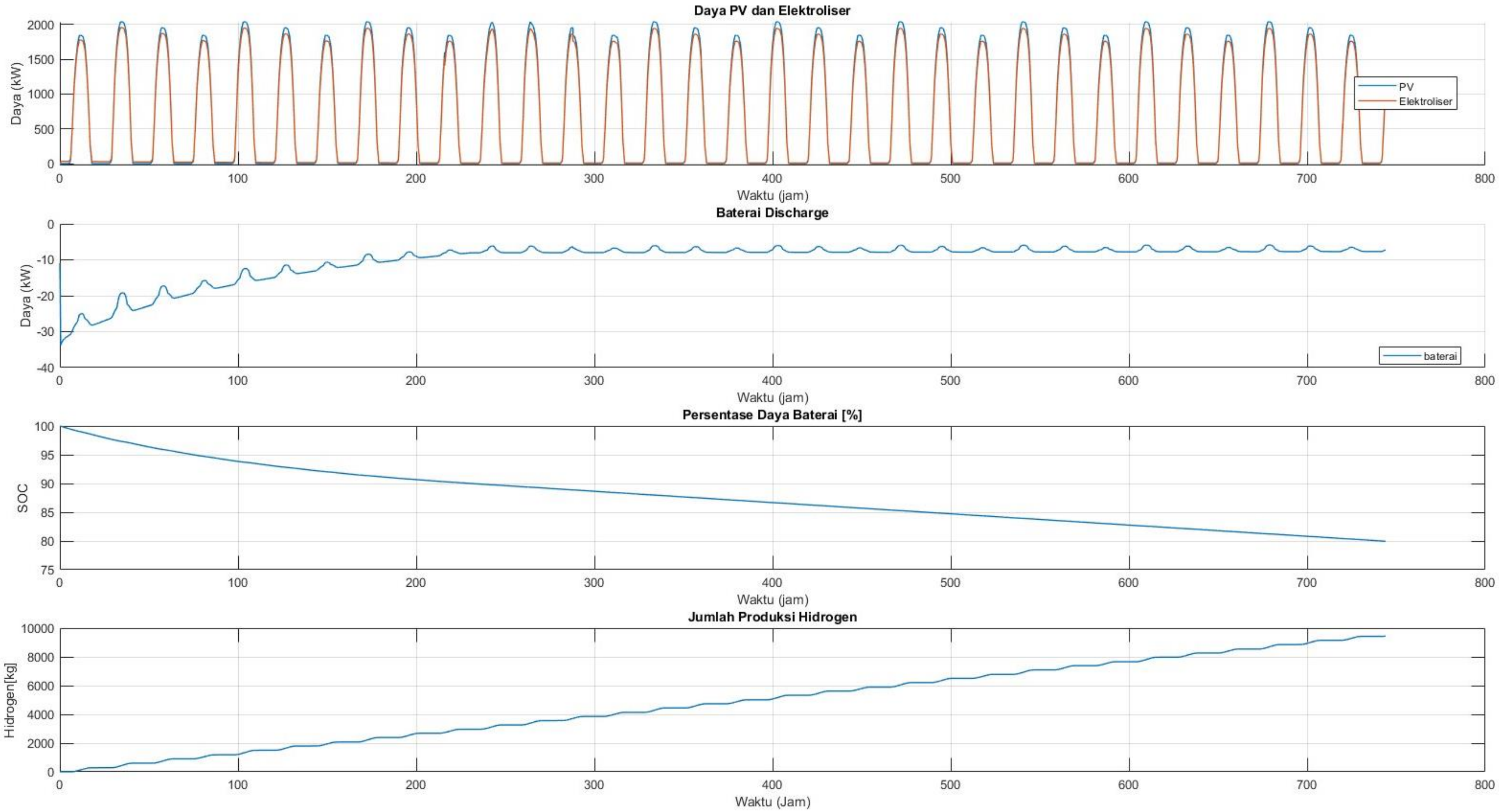


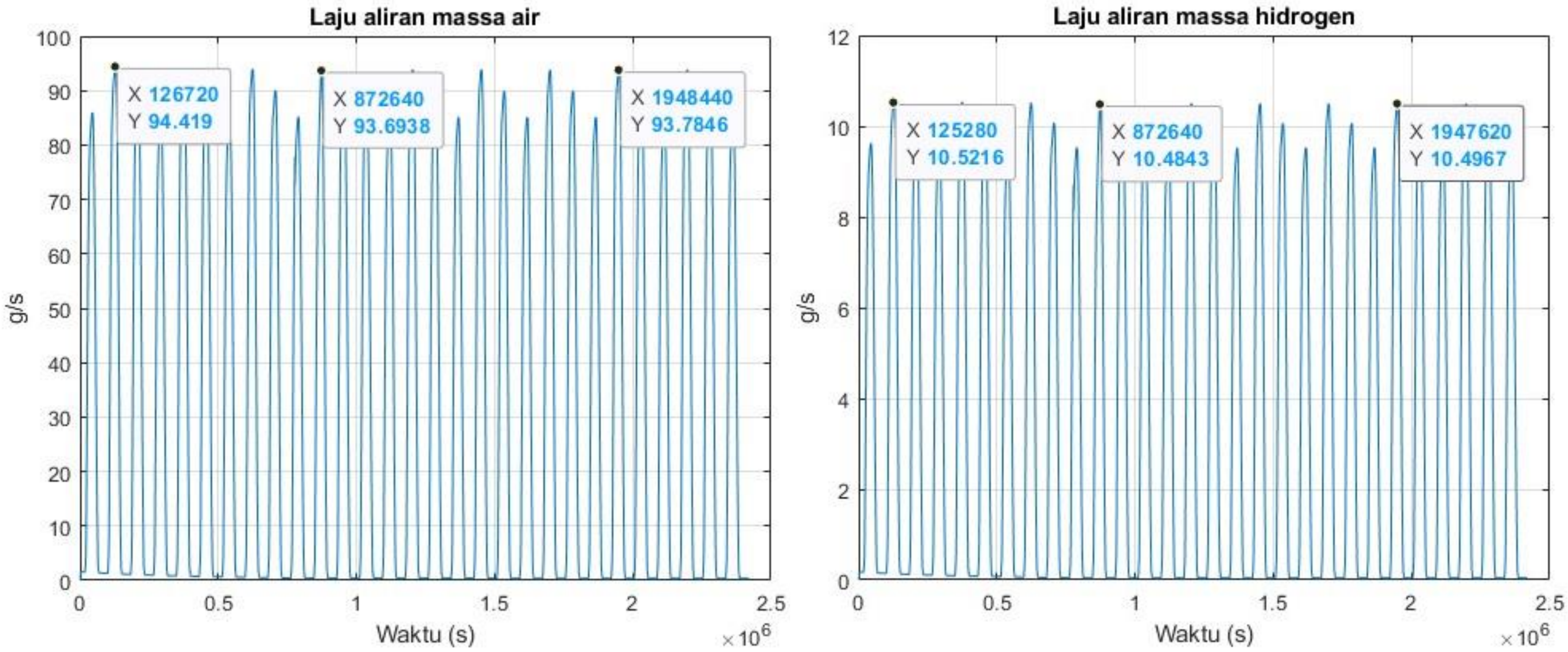
Laju aliran massa air
X 125280
Y 94.0277
X 1202470
Y 93.8087
X 2196020
Y 93.803
g/s
Waktu (s)
×10^6



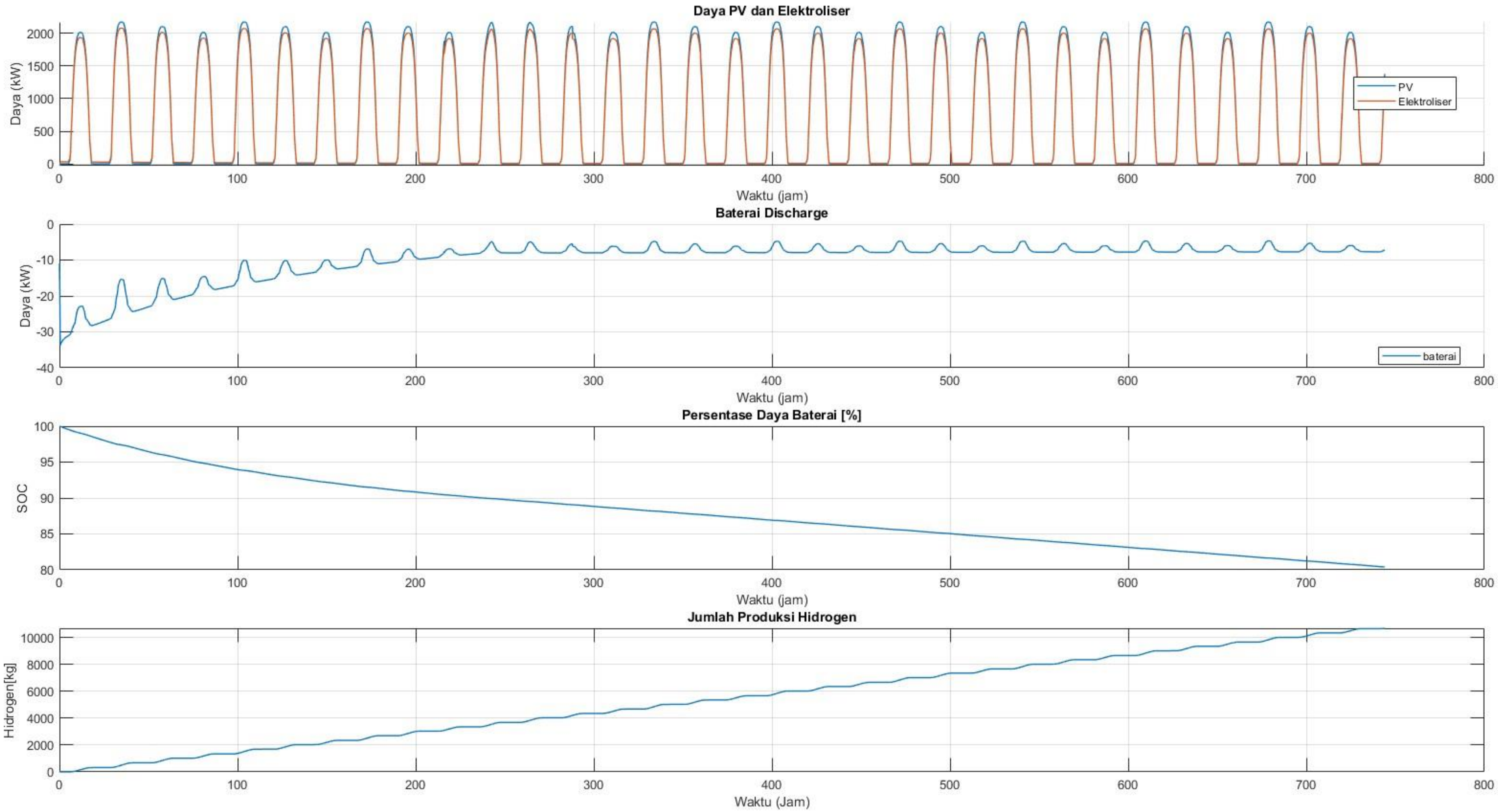
Laju aliran massa hidrogen
X 128150
Y 10.5593
X 1201050
Y 10.4058
X 2197600
Y 10.4919
g/s
Waktu (s)
×10^6

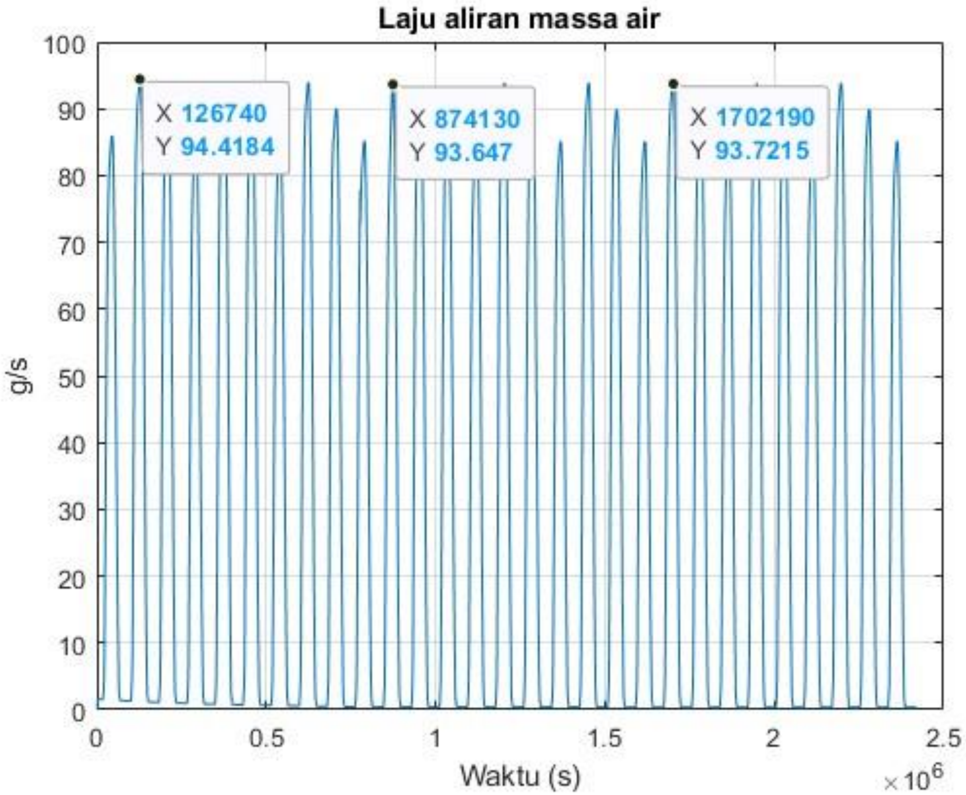
G7. Hasil simulasi bulan juli

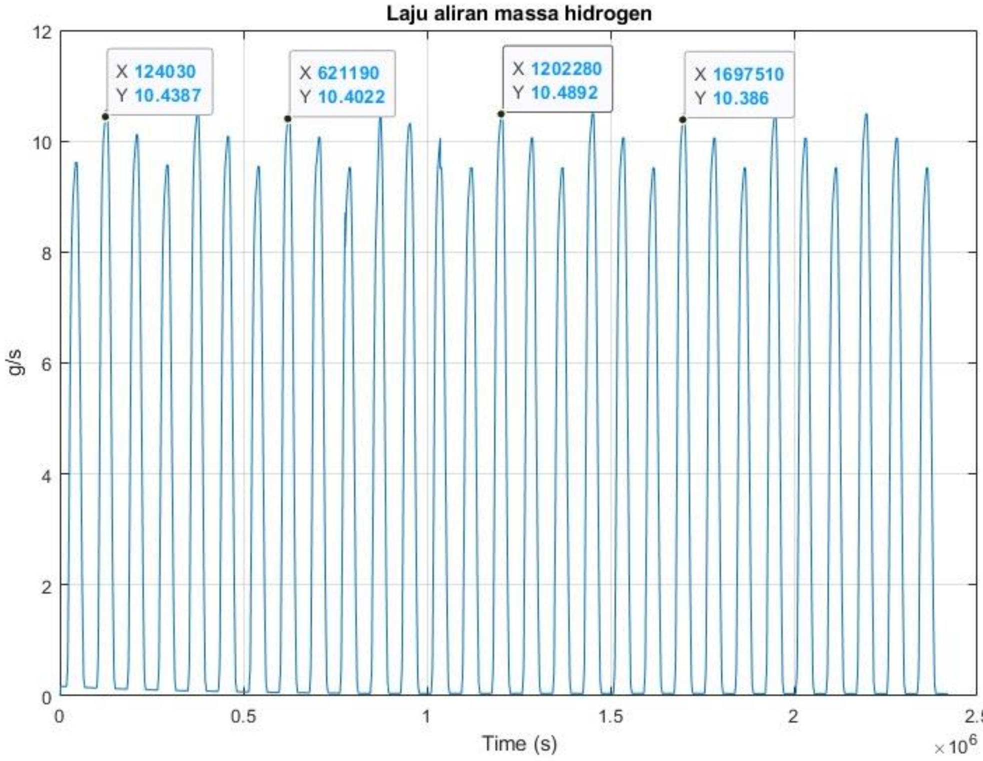



Laju aliran massa air
X 126720
Y 94.419
X 872640
Y 93.6938
X 1948440
Y 93.7846
g/s
Waktu (s)
×10^6
Laju aliran massa hidrogen
X 125280
Y 10.5216
X 872640
Y 10.4843
X 1947620
Y 10.4967
g/s
Waktu (s)
×10^6

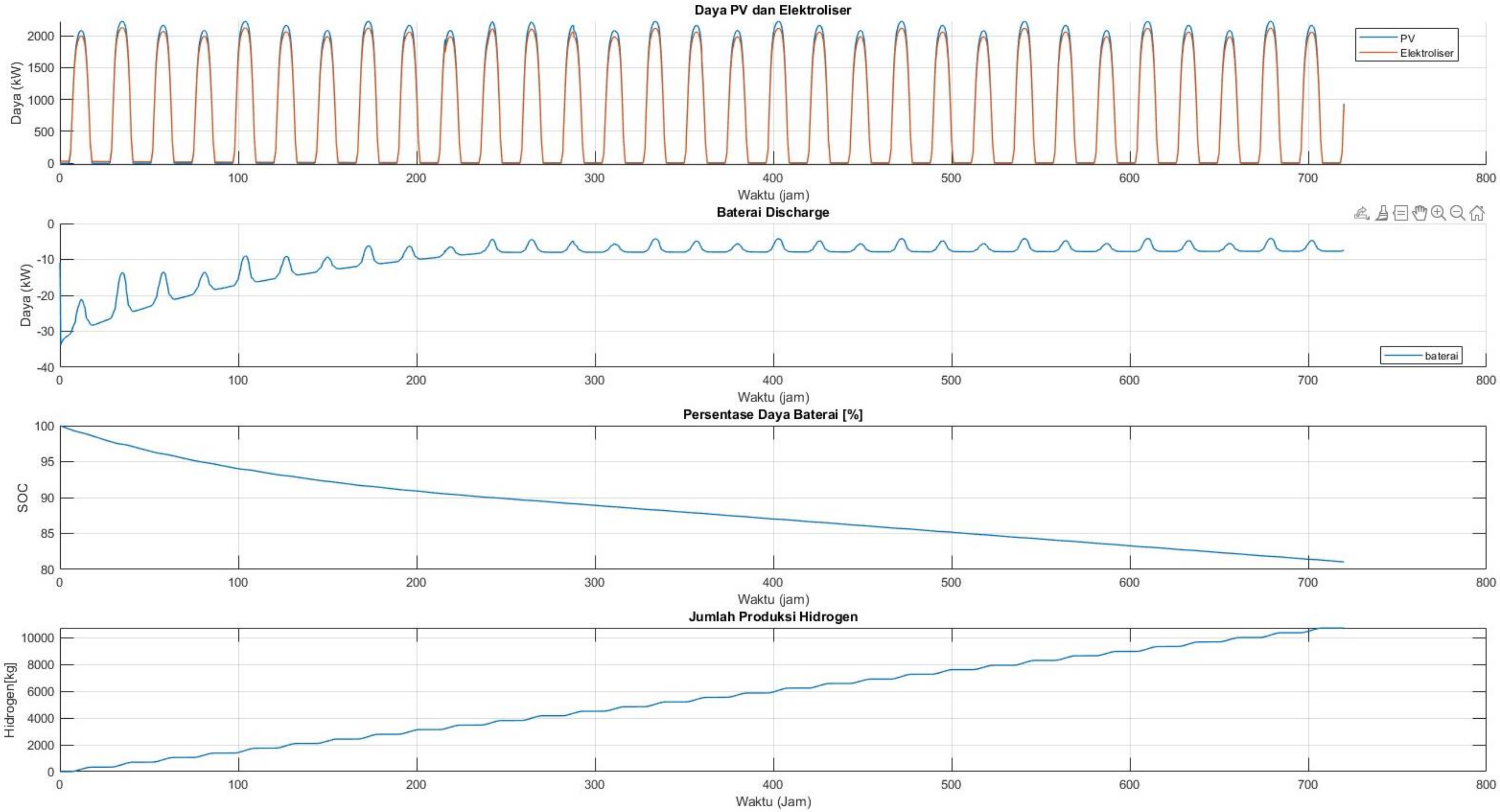
G8. Hasil simulasi bulan agustus

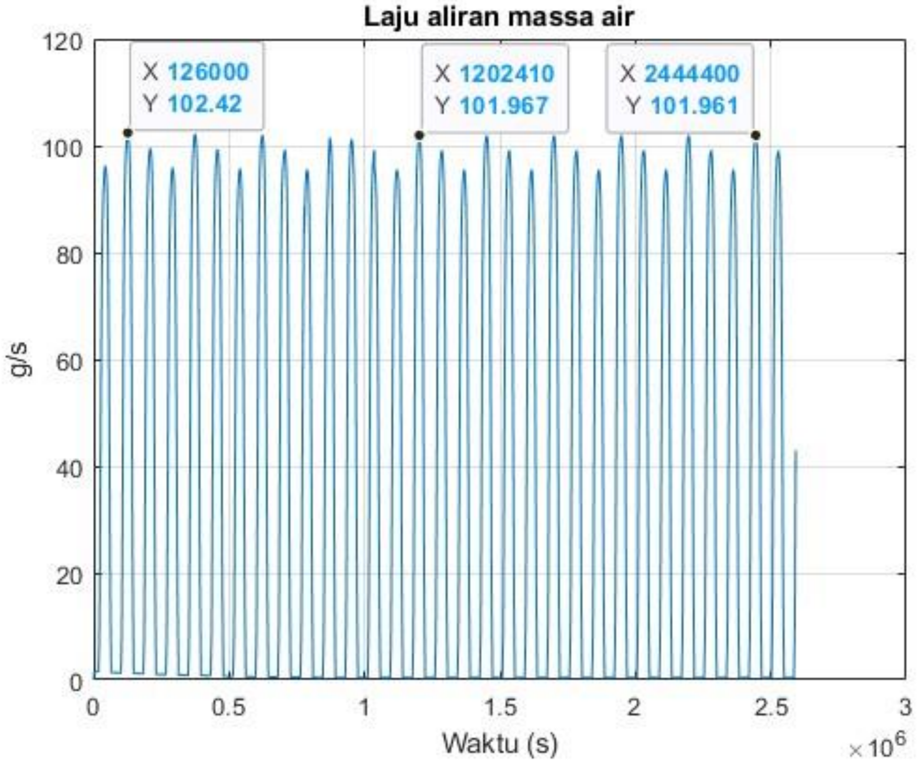


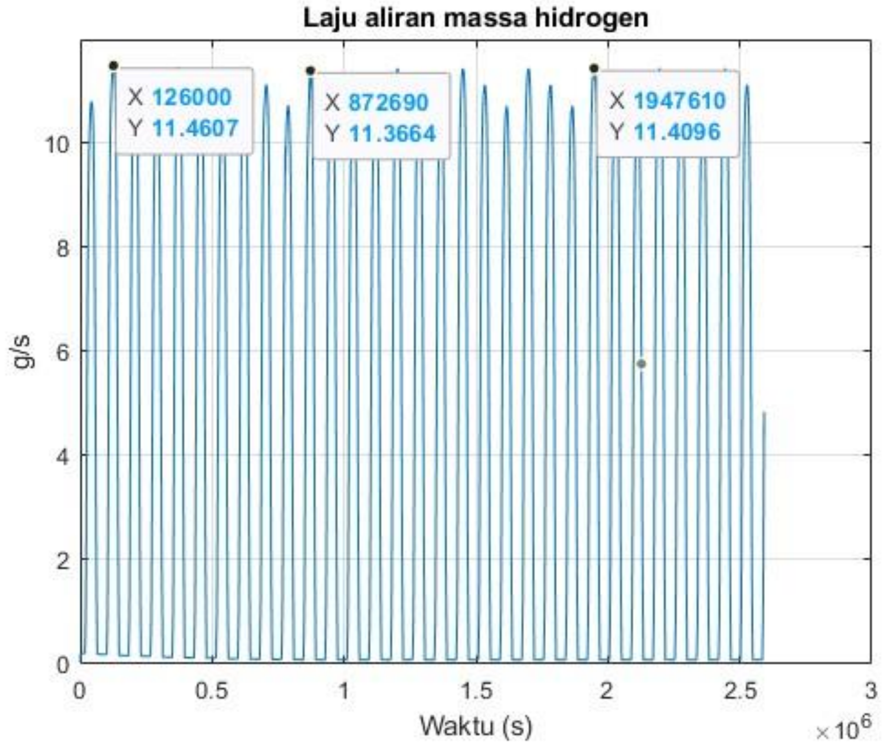

Laju aliran massa air
g/s
Waktu (s)
×10^6
X 126740
Y 94.4184
X 874130
Y 93.647
X 1702190
Y 93.7215


Laju aliran massa hidrogen
g/s
Time (s)
×10^6
X 124030
Y 10.4387
X 621190
Y 10.4022
X 1202280
Y 10.4892
X 1697510
Y 10.386

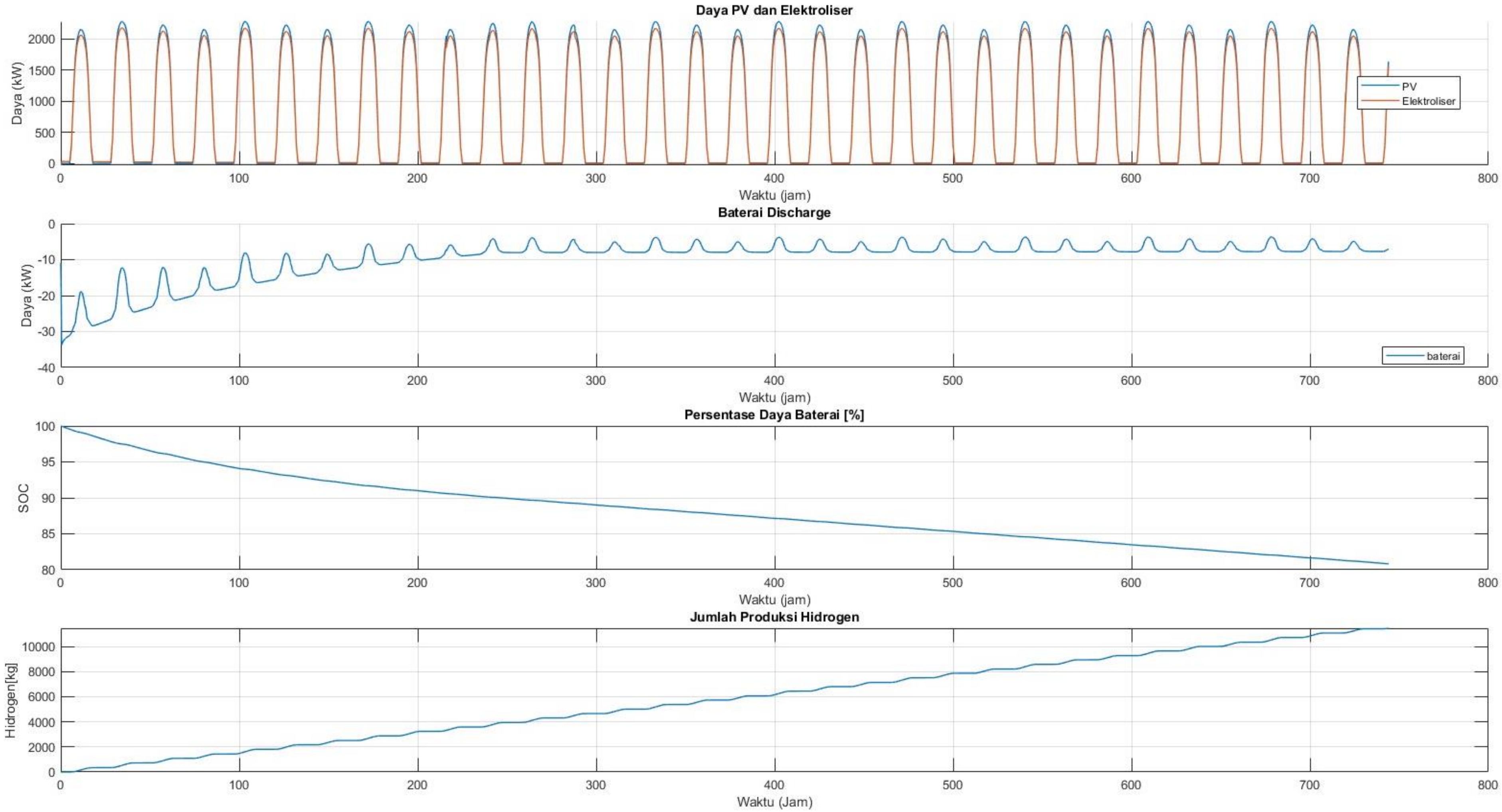
G9. Hasil simulasi bulan September

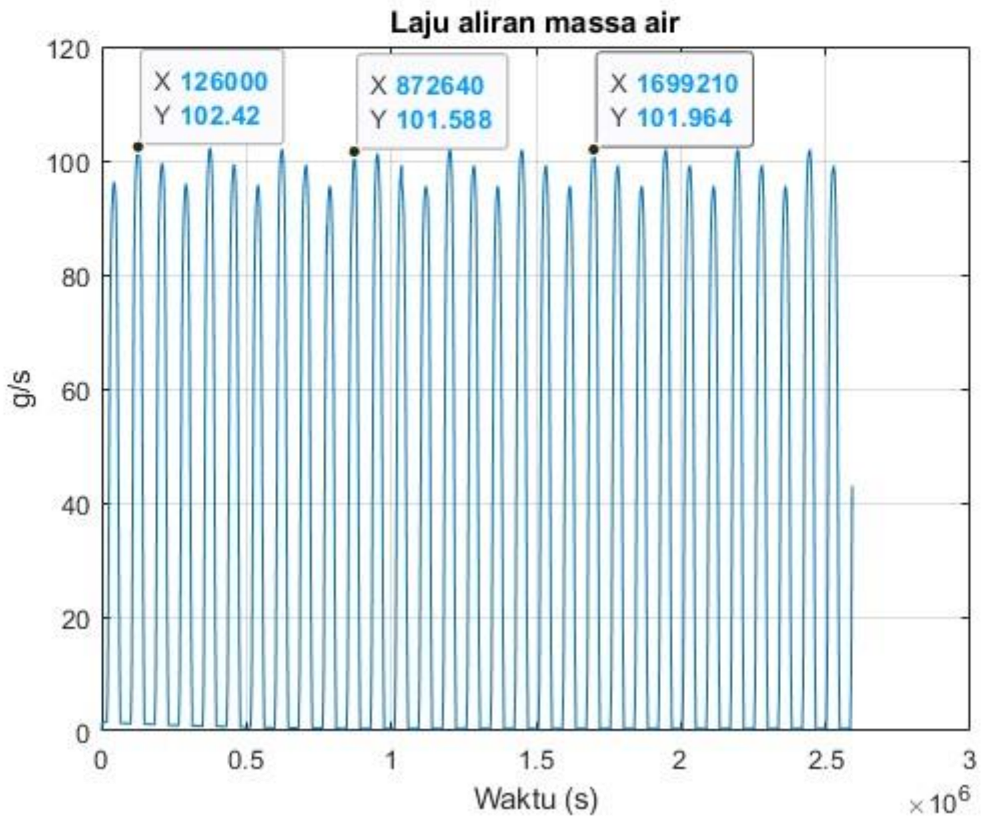


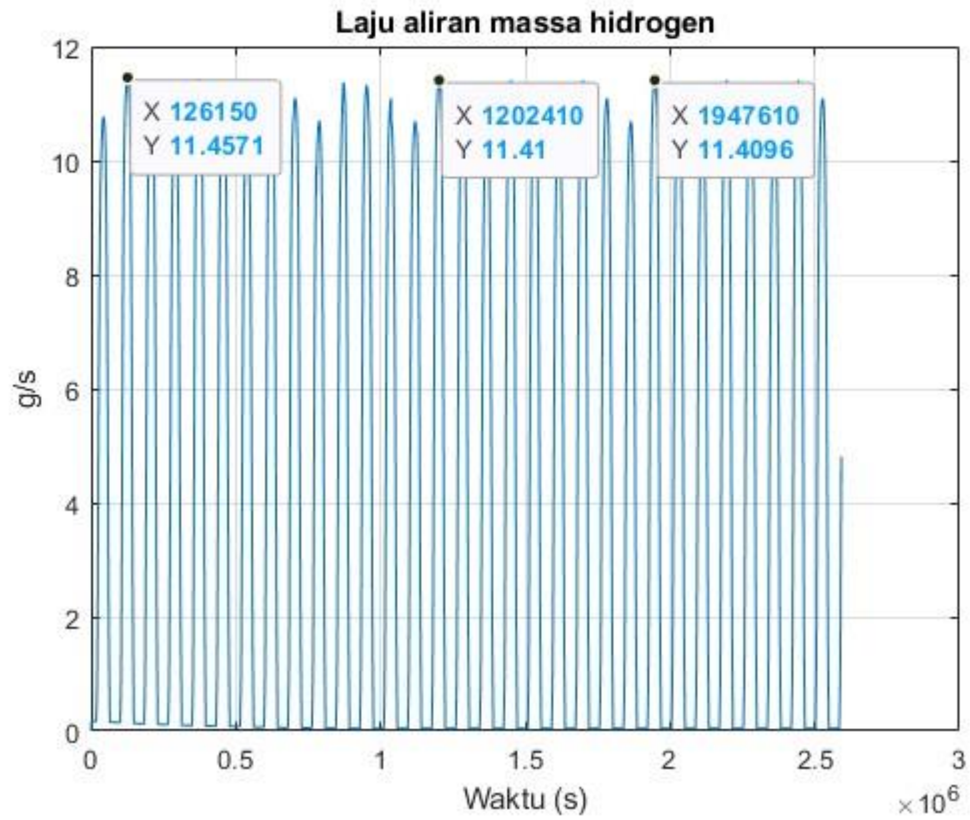

Laju aliran massa air
X 126000
Y 102.42
X 1202410
Y 101.967
X 2444400
Y 101.961
g/s
Waktu (s)
× 10^6


Laju aliran massa hidrogen
X 126000
Y 11.4607
X 872690
Y 11.3664
X 1947610
Y 11.4096
g/s
Waktu (s)
× 10^6

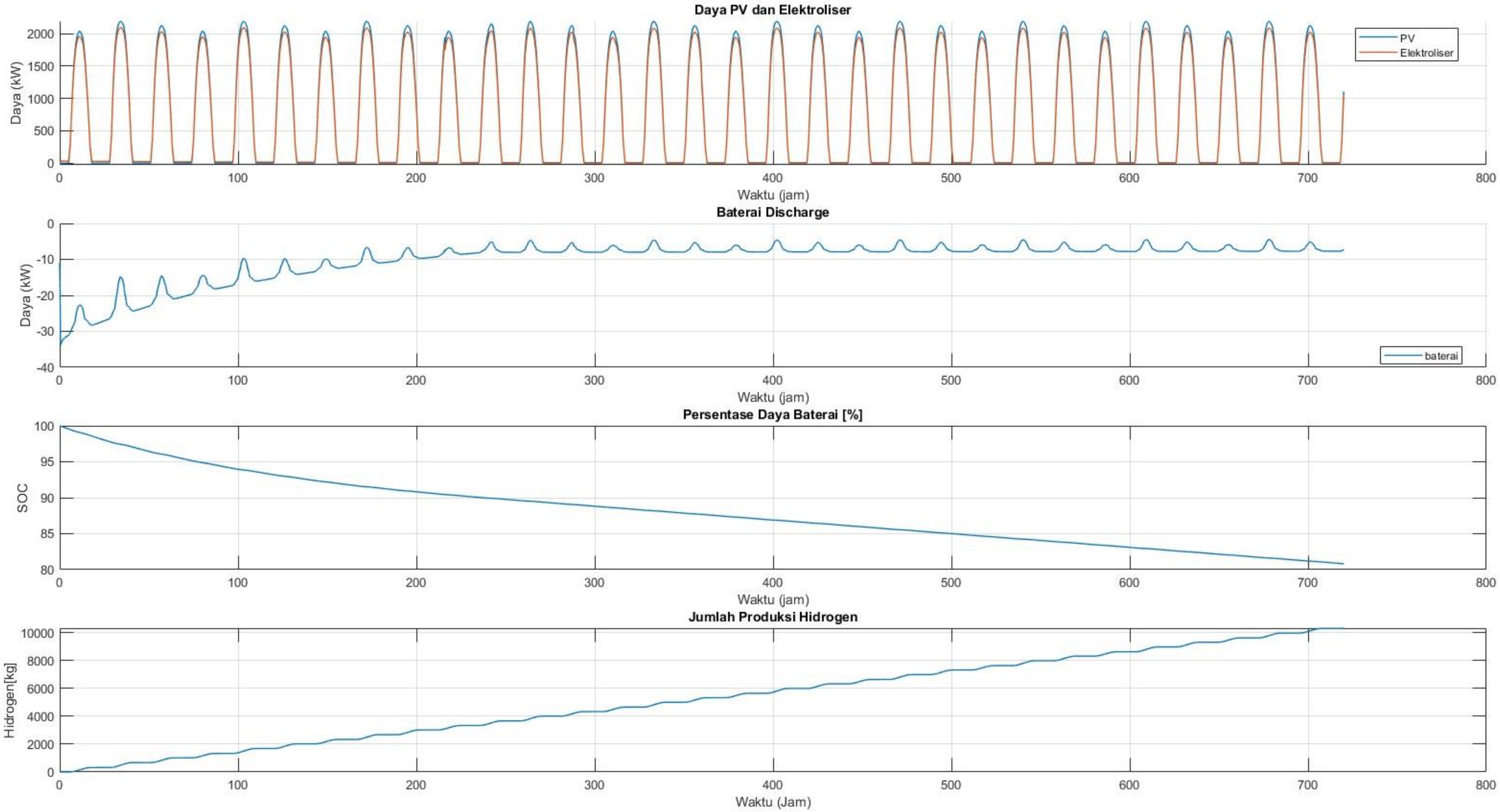
G10. Hasil simulasi bulan oktober

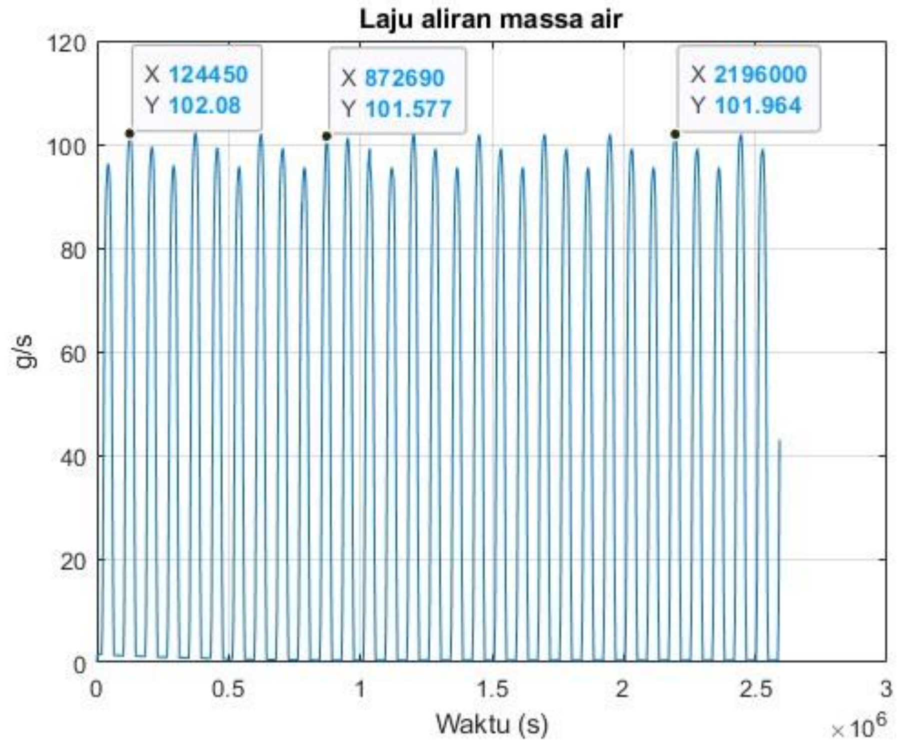



Laju aliran massa air
X 126000
Y 102.42
X 872640
Y 101.588
X 1699210
Y 101.964
g/s
Waktu (s)
×10^6

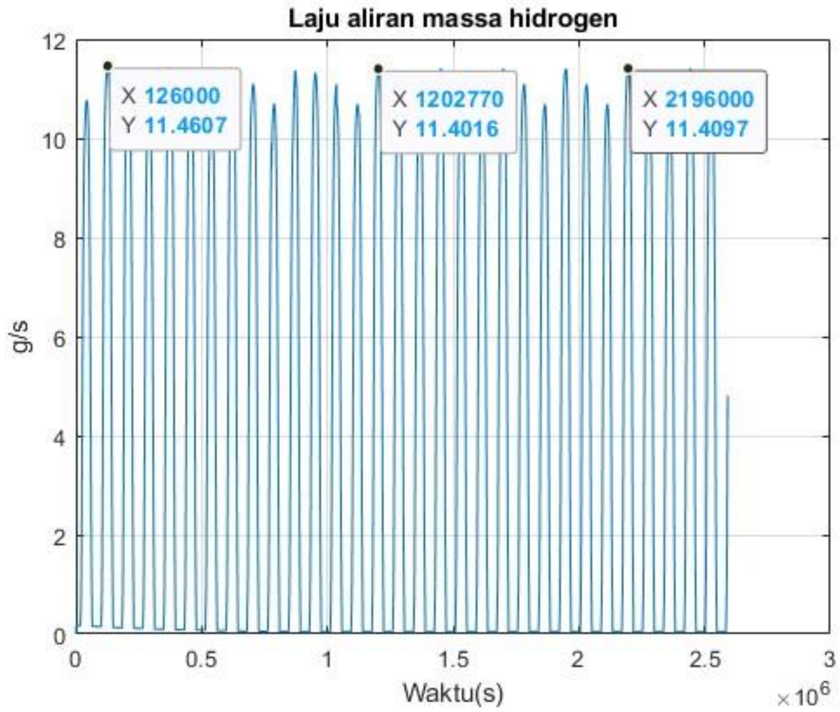

Laju aliran massa hidrogen
X 126150
Y 11.4571
X 1202410
Y 11.41
X 1947610
Y 11.4096
g/s
Waktu (s)
×10^6

G11. Hasil simulasi bulan november



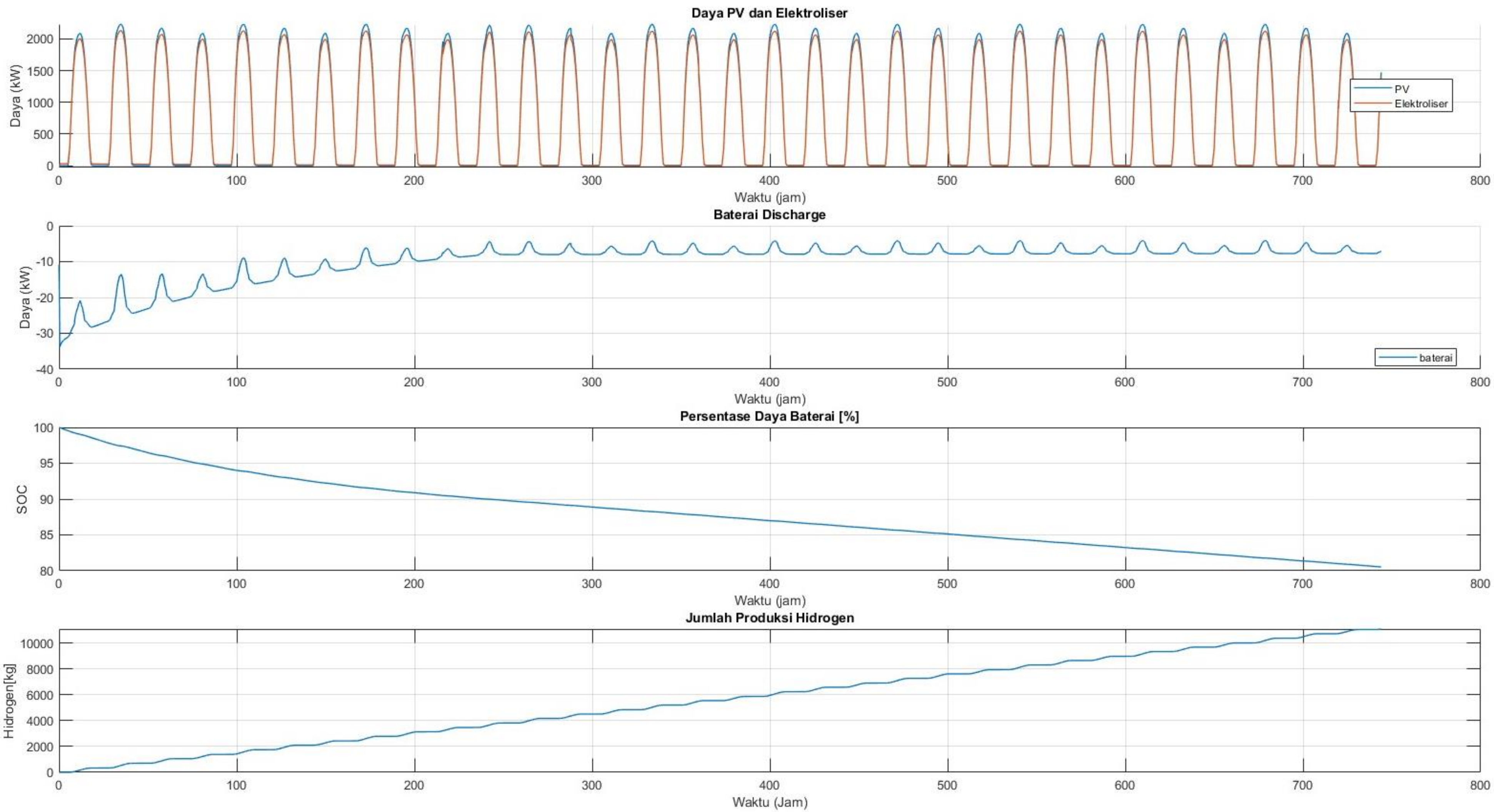


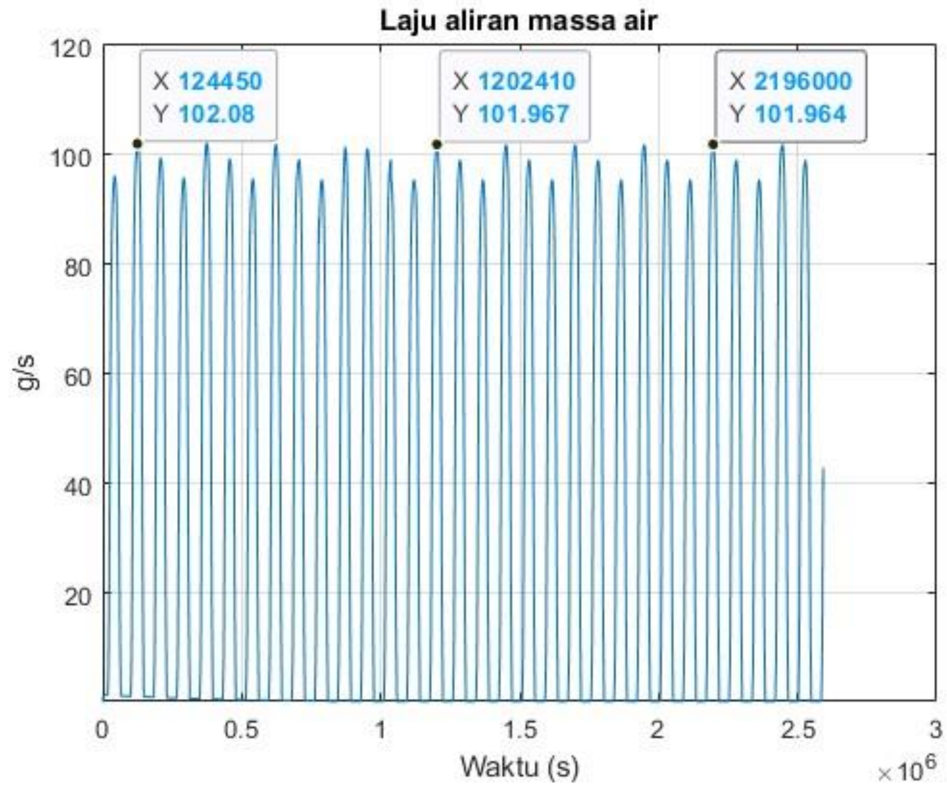
Laju aliran massa air
X 124450
Y 102.08
X 872690
Y 101.577
X 2196000
Y 101.964
g/s
Waktu (s)

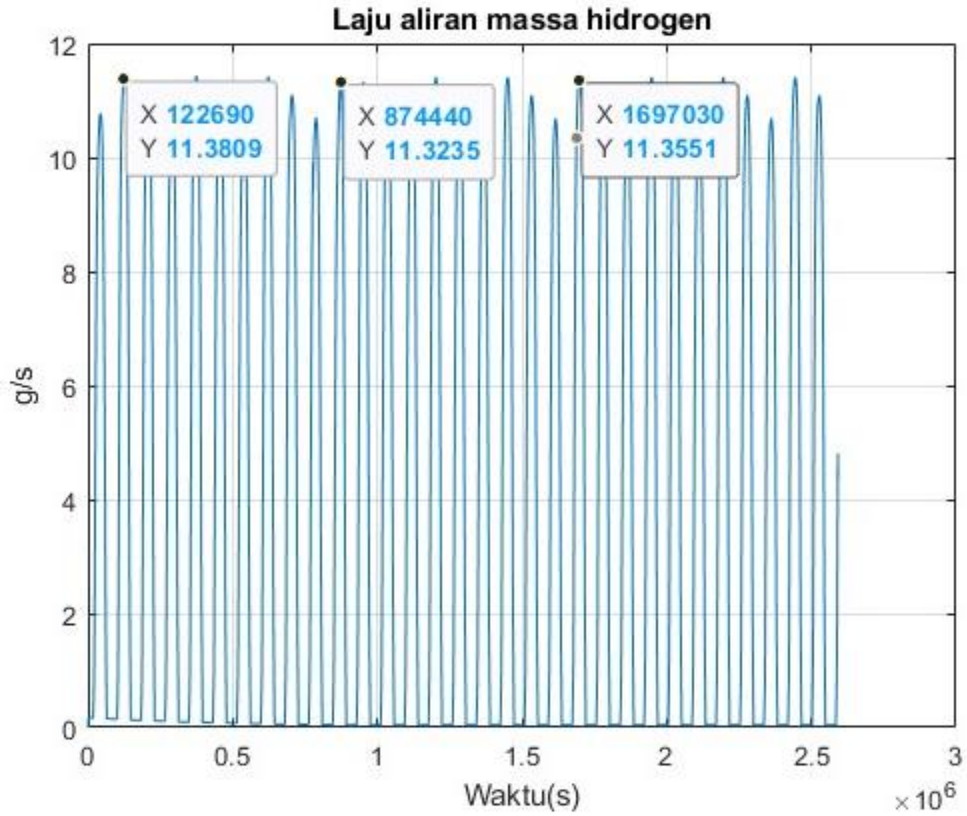


Laju aliran massa hidrogen
X 126000
Y 11.4607
X 1202770
Y 11.4016
X 2196000
Y 11.4097
g/s
Waktu(s)

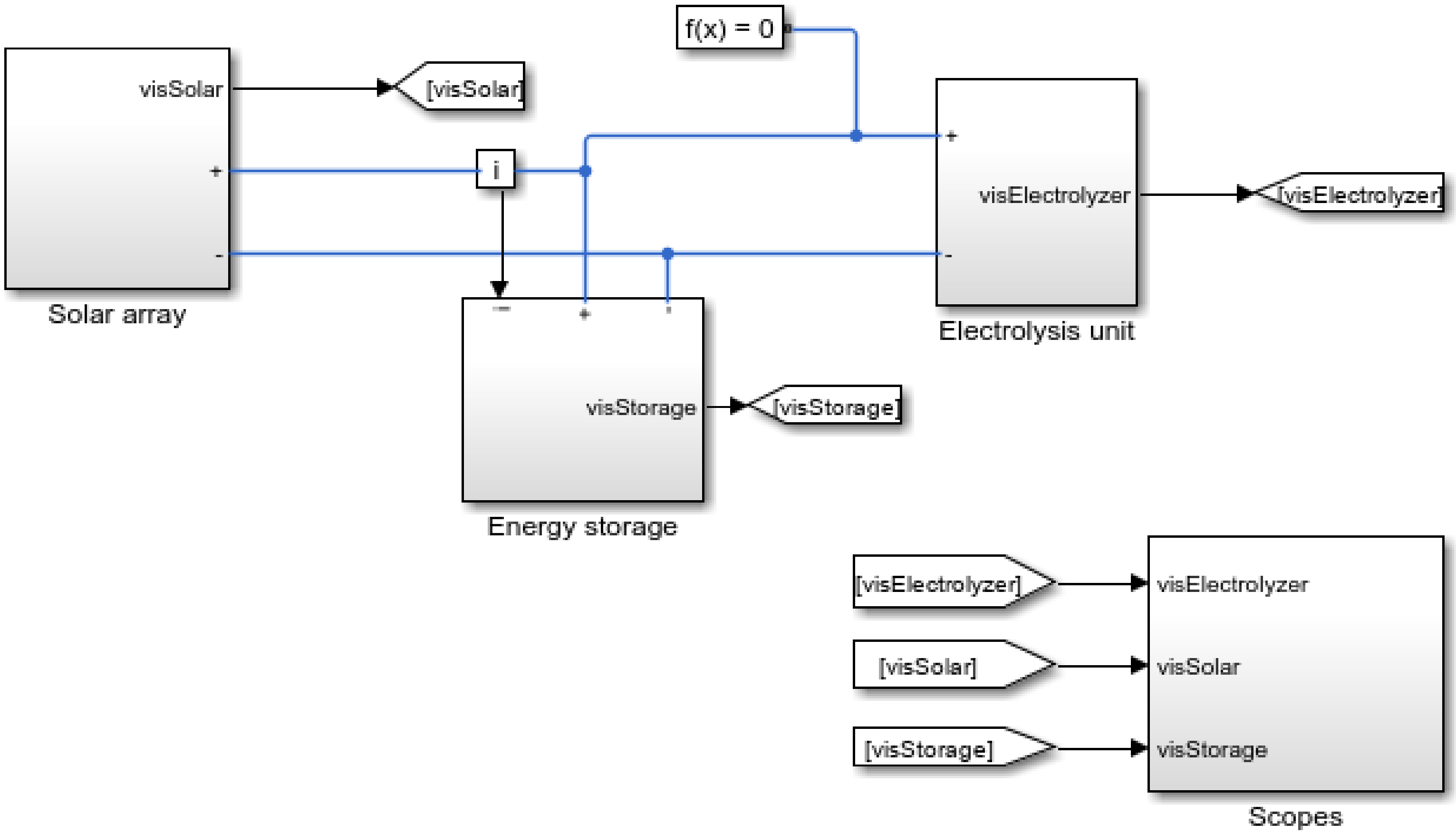
G12. Hasil simulasi bulan desember



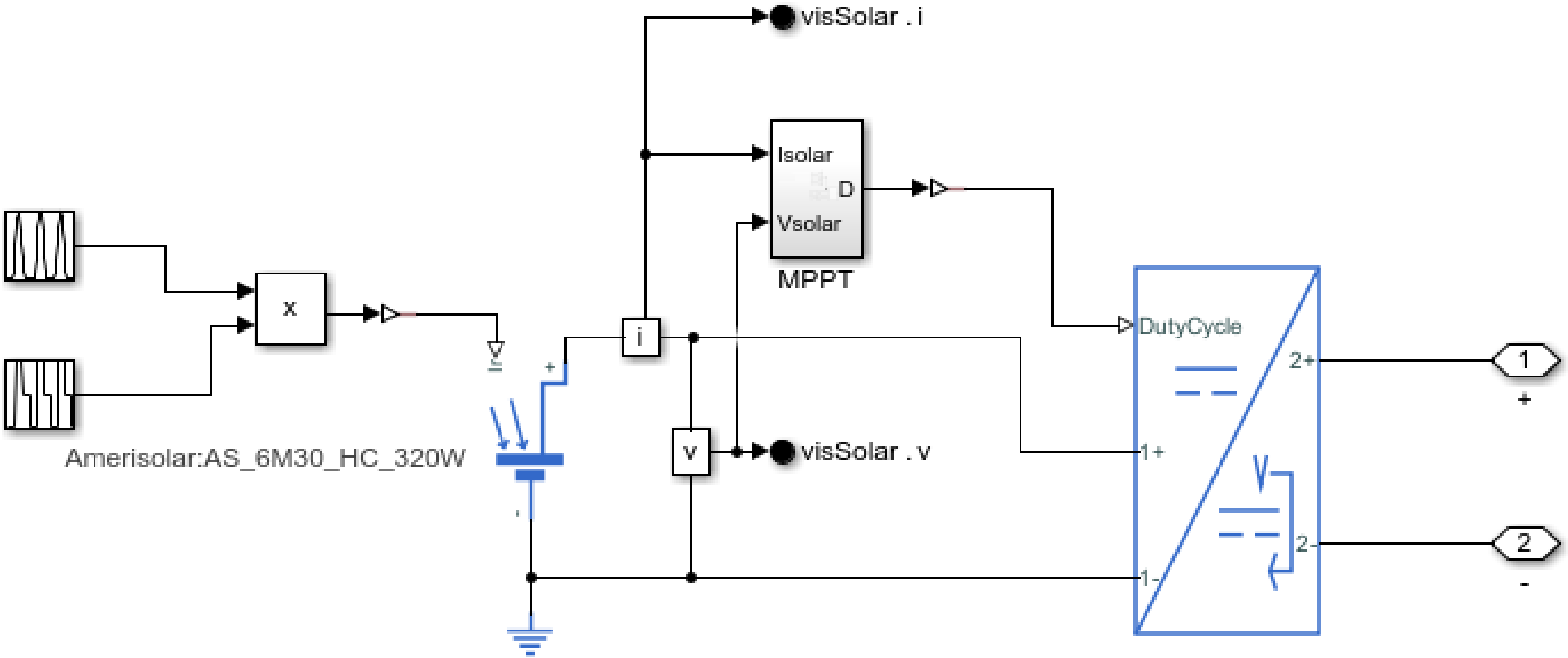

Laju aliran massa air
X 124450
Y 102.08
X 1202410
Y 101.967
X 2196000
Y 101.964
g/s
Waktu (s)
× 10^6


Laju aliran massa hidrogen
X 122690
Y 11.3809
X 874440
Y 11.3235
X 1697030
Y 11.3551
g/s
Waktu(s)
× 10^6

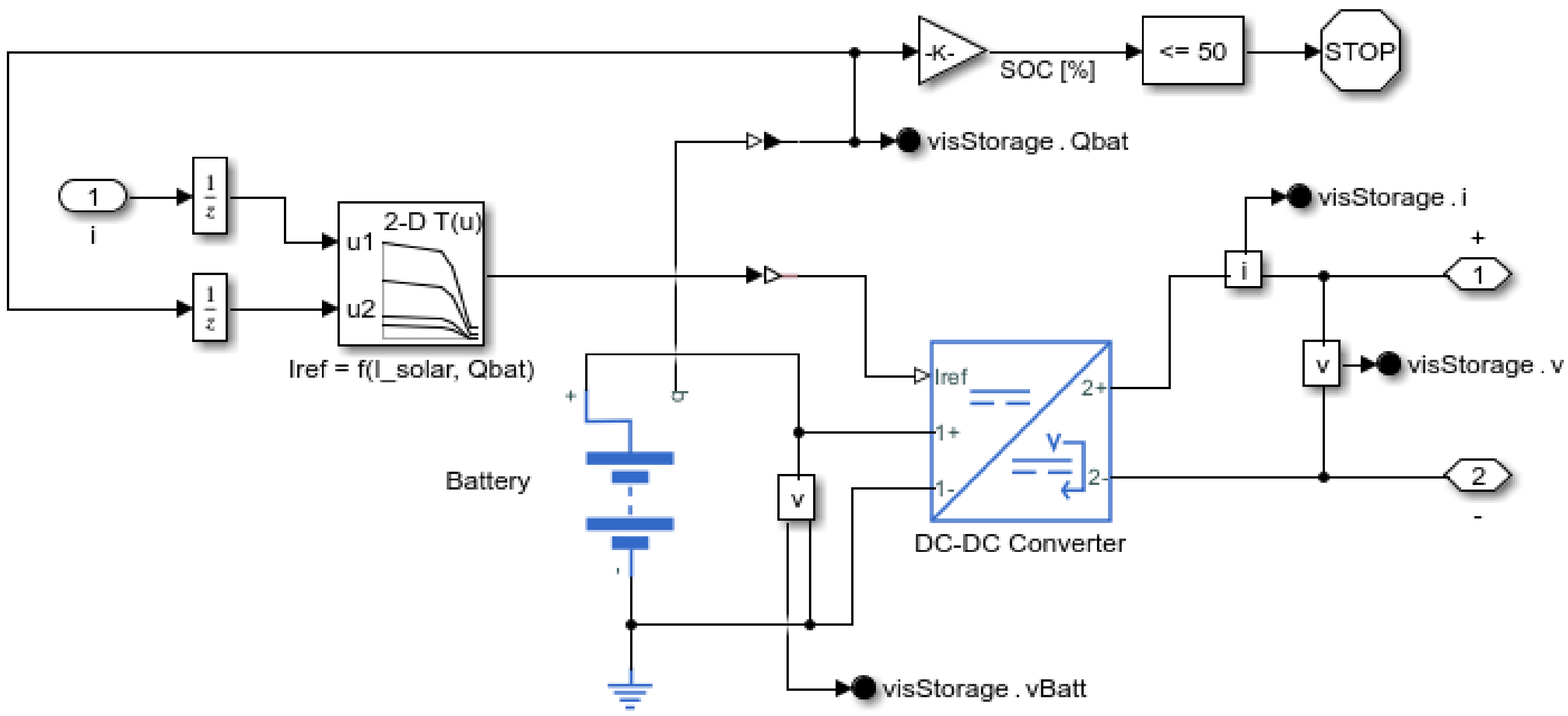
Lampiran H *Block diagram model* Sistem produksi hidrogen hijau di Simulink



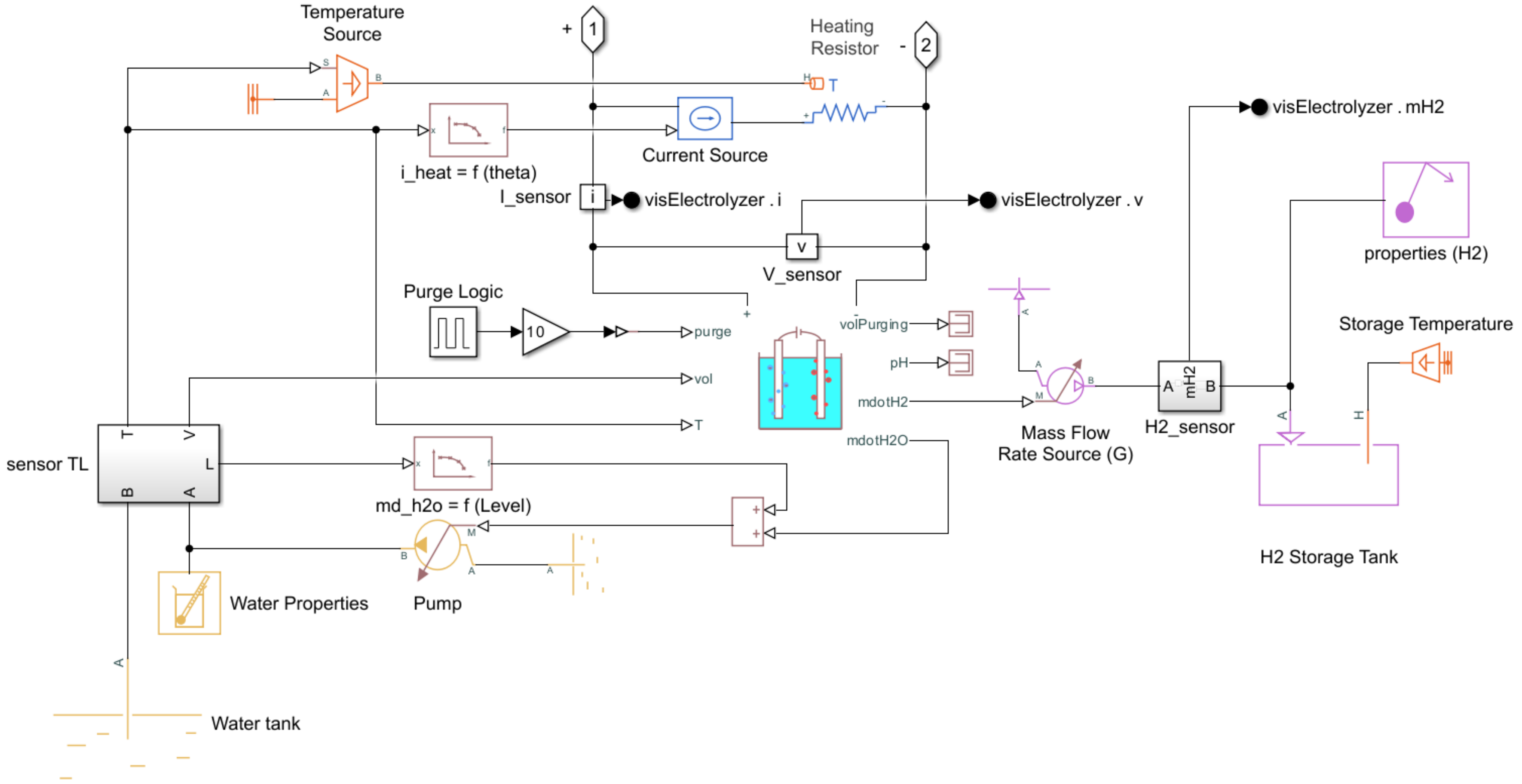
H1. Model Pembangkit Listrik Tenaga Surya



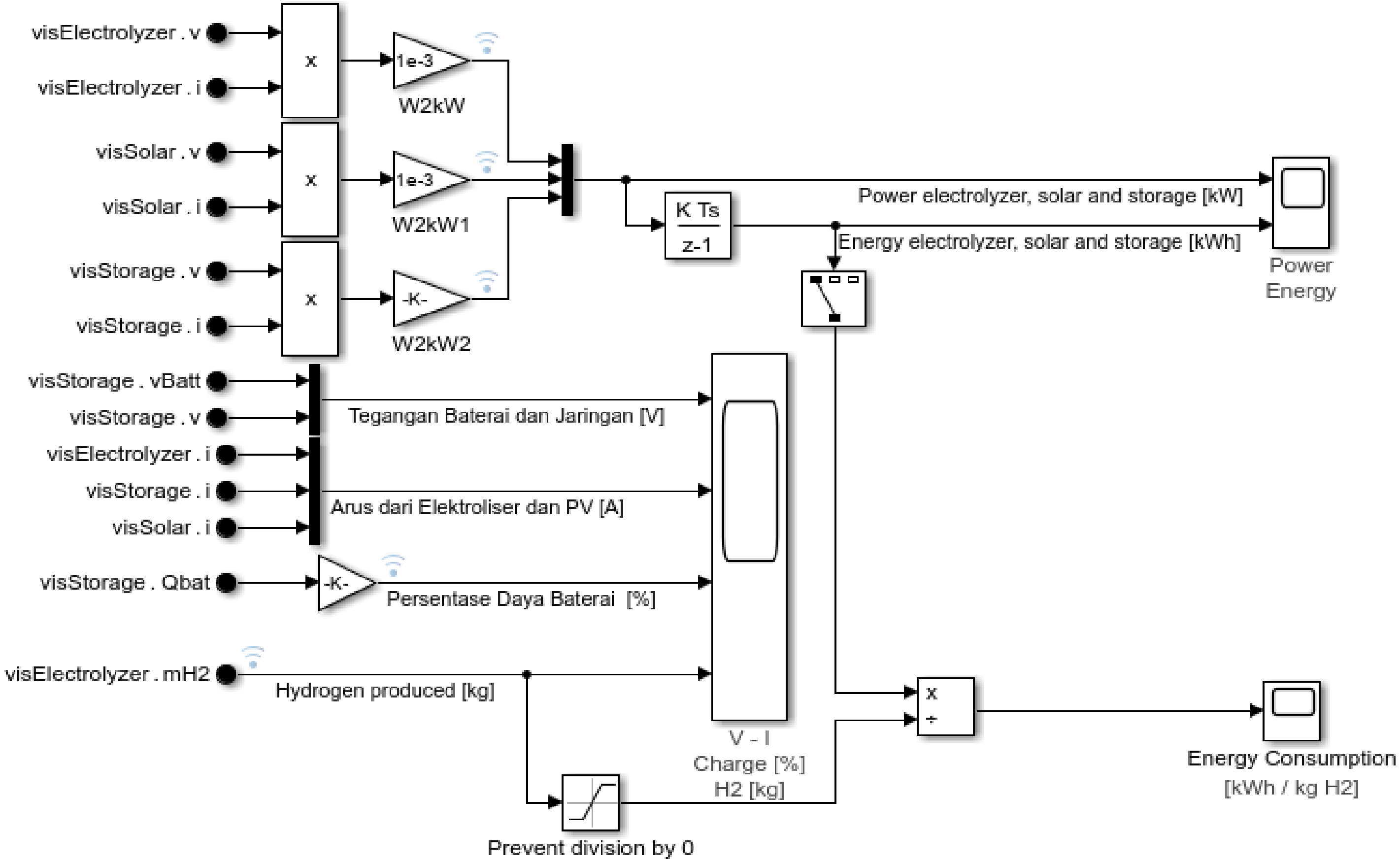
H2. Model sistem penyimpanan energi



H3. Model PEM elektroliser



H4. Model untuk visualisasi hasil simulasi



Lampiran I Rekomendasi elektroliser

PEM TECHNOLOGY

Proton Exchange Membrane (PEM) is the most robust and efficient technology for pure hydrogen generation at scale. Cummins is the industry benchmark for safe, widely proven PEM systems, delivering productivity and return on investment (ROI) beyond our competitors. Our 'plug-and-play' systems arrive onsite ready to safely and reliably produce very high purity hydrogen, continuously or flexibly, indoors, or out.

High efficiency aligns with low maintenance needs, delivering low capital and operational expense, with modularity that allows for simple scaling. Cummins systems connect to standard power and water connections and come equipped with standard water purification, power conditioning, hydrogen purification and remote servicing.

CUMMINS HyLYZER®

Cummins HyLYZER® Proton Exchange Membrane (PEM) technology is state-of-the-art. With the most efficient and compact solution on the market, HyLYZER® delivers on market leading operational expense and low levelized cost of hydrogen. Exceptionally compact systems deliver hydrogen at 30 bar without compression at extremely high purities.

Operating flexibly at higher current densities, HyLYZER® is perfectly suited to projects where dynamic operation is valuable, such as in combination with renewables. And where megawatt scale matters, HyLYZER® scales up to meet the highest output needs.

MEGAWATT SCALE STACKS

Industry-leading 2.5 MW stacks, highly scalable for larger demands.

EXCEPTIONALLY COMPACT

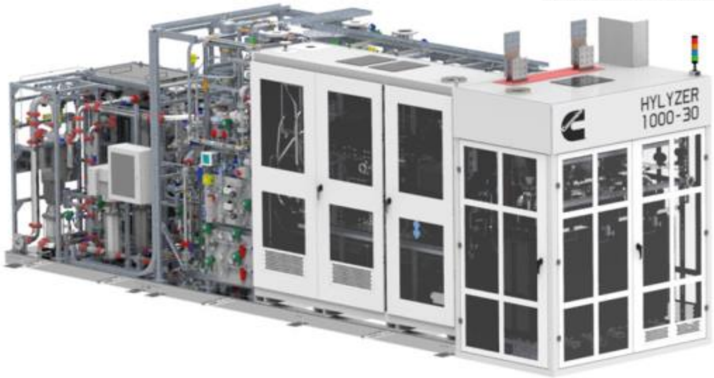
Industry-leading design – lower land, site preparation and building costs and shorter installation time.

RESPONSIVE

Ultrafast responses to changes in hydrogen demand or power input.

30 BAR PRESSURIZED STACKS

High output pressure without compressors.



LONG, MAINTENANCE-FREE LIFECYCLE

Limited and optimized maintenance, minimal degradation, 80,000 hours between stack membrane refurbishments; fast stack swap-out when required.

HIGH EFFICIENCY AND ADVANCED CONTROL SYSTEMS

Lower power usage and low annual maintenance costs, with integrated safety sensors for safe plant operations.

PEM Electrolyzers | HyLYZER® Series

Product	H2 Flow (Nm^3/h)	System efficiency (kWh/kg)	Equivalent power rating (MW)*	Output pressure (bar)	Outdoor / Indoor	Size Process module	Size Power module
HyLYZER® 200-30	200	≤ 55	1	30	Outdoor	40ft container	20ft container
HyLYZER® 250-30	250	≤ 55	1,25	30	Outdoor	40ft container	20ft container
HyLYZER® 400-30	400	≤ 54	2	30	Outdoor	40ft container	40ft container
HyLYZER® 500-30	500	≤ 54	2,5	30	Outdoor	40ft container	40ft container
HyLYZER® 1000-30	1000	≤ 51	5	30	Indoor	27.7ft x 7.5ft 8.5m x 2.3m	14.8ft x 8.2ft 4.5m x 2.5m
HyLYZER® 4000-30	4000	≤ 51	20	30	Indoor	50ft x 25ft 15.2m x 7.5m	23ft x 30ft 7m x 9m

The standard scope of supply for our electrolyzers differs between the outdoor and indoor products.

	Outdoor	Indoor
STACK AND BALANCE-OF-STACK (BOS)		
Cell stacks and Gas Generation System	•	•
Power rectifiers	•	•
Control Panel	•	•
Water quality monitoring system	•	•
Rectifier Cooling	•	•
BALANCE-OF-PLANT (BOP)		
Gas Cooling with Chiller	•	
Electrolysis Cooling with Dry Cooler	•	
Water Purification System	•	
Instrument Air Compressor	•	
Hydrogen Purification System	•	•

• = standard

* for the indicative power rating, a standard efficiency value of 5 kWh/Nm³ has been used across all products to give an indication of the product power rating. Our products are designed to supply a nominal hydrogen flowrate during its expected lifetime. In practice, our electrolyzers will consume less energy at the beginning of life (BOL) and more energy at the end of life (EOL) for a specific hydrogen production.

1kg of hydrogen is equivalent to 11,126 Nm³ (volume of hydrogen under normalized conditions of 1 atmosphere and 0°C).

Lampiran J Situs tentang cummins elektroliser

Web: https://www.cummins.com/news/2021/05/03/green-hydrogen-power-wind

web : https://www.cummins.com/sites/default/files/2023-10/electrolyzer-brochure.pdf

web: https://shop.cummins.com/SC/search/term#q=Electrolyzer