Integrated Biorefinery of Empty Fruit Bunch from Palm Oil Industries to Produce Valuable Biochemicals

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Supplementary Information

This Supplementary Information has the following sections:

(A) sustainability assessment,

(B) multi-objective optimization code, and

(C) multi-criteria decision making.

A. Sustainability Assessment

The integrated biorefinery of empty fruit bunch (EFB) is modelled in Aspen Plus, and all information shown in this supplementary data is for the base case capacity of 75 ton/h of EFB
1. Techno-economic analysis

Tables S1 and S2 display the factors used for the estimation of capital investment and for the estimation of operating costs, respectively. Table S3 and S4 are a summary of raw material cost and selling price of products and economic results for all production processes involved.

Table S1. The estimation of capital investment

| Component of investment                      | Factor |
|----------------------------------------------|--------|
| **A. Total plant direct cost (TPDC)**        |        |
| Equipment purchase cost                      | 1      |
| purchased equipment installation             | 0.39   |
| instrumentations and control-installed       | 0.13   |
| piping-installed                             | 0.31   |
| electrical installed                         | 0.1    |
| buildings-including services                 | 0.29   |
| yard improvement                             | 0.1    |
| service facilities-installed                 | 0.55   |
| **B. Total plant indirect cost (TPIC)**      |        |
| Engineering and supervision                  | 0.32   |
| Construction expenses                        | 0.34   |
| **C. Total direct and indirect costs (TPC = TPDC + TPIC)** |         |
| **D. Contractor’s fee and contingency (CFC)** |        |
| contractor’s fee                             | 0.05   |
| Contingency                                  | 0.1    |
| **E. Fixed Capital Investment (FCI = TPC + CFC)** |        |
| Working capital (30% of FCI) (WC)            | 0.3    |
| Land use (6% of Equipment purchase cost)     | 0.06   |
| **Total Capital Investment (TCI = FCI + WC + LU)** |         |
Table S2. The estimation of operating costs

| Category                              | Feature                          | Value used in Text |
|---------------------------------------|----------------------------------|--------------------|
| Direct manufacturing costs (DMC)      | Raw material cost                | $C_{RM}$           |
|                                       | Utilities cost                   | $C_{WT}$           |
|                                       | Operating labor                  | $C_{OL}$           |
|                                       | Supervisory and clerical labor   | 0.2 $C_{OL}$       |
|                                       | Maintenance and repair           | 0.06 FCI           |
|                                       | Operating supplies               | 0.009 FCI          |
|                                       | Laboratory charges               | 0.15 $C_{OL}$      |
|                                       | Patent and royalties             | 0.03 $C_{OM}$      |
| Fixed manufacturing costs (FMC)       | Local taxes and insurance        | 0.03 FCI           |
|                                       | Plant overhead                    | 0.708 $C_{OL}$ + 0.036 FCI |
| General manufacturing costs (GMC)     | Administration costs             | 0.177 $C_{OL}$ + 0.009 FCI |
|                                       | Distribution and selling costs   | 0.11 $C_{OM}$      |
|                                       | Research and development         | 0.05 $C_{OM}$      |

Table S3. Raw material and product selling price

| Raw material                  | Price ($/kg) |
|-------------------------------|--------------|
| Empty fruit bunch             | 0.005        |
| Sulfuric acid                 | 0.075        |
| Ammonia                       | 0.495        |
| Hydrogen                      | 10           |
| Raney-nickel                  | 2.6          |
| Carbon dioxide                | 0.0098       |
| $\text{AlCl}_3$               | 0.0006       |
| Ionic liquid                  | 3.56x10^{-5} |
| Ethyl acetate                 | 0.7          |
| NaOH                          | 0.7          |
| $\text{SO}_2$                 | 0.0015       |
| Glucose                       | 0.0015       |
| CNUTR                         | 1.267 x10^{-5} |
| Oil                           | 6            |

| Product                       | Price ($/kg) |
|-------------------------------|--------------|
| Xylitol                       | 4.05         |
| Levulinic acid                | 8.28         |
| Succinic acid                 | 2.6          |
| Guaiacol                      | 1.6          |
| Vanillin                      | 20           |
Table S4. Economic results for 75 ton/hour of dry empty fruit bunch

| Component               | Dilute acid | Enzyme | Saccharification | Xylitol | Levulinic acid | Succinic acid | Guaiacol | Vanillin |
|-------------------------|-------------|--------|------------------|---------|----------------|---------------|----------|----------|
| Capital investment      | 5.2         | 58.2   | 3.4              | 31.4    | 7.7            | 42.6          | 52.2     | 18.8     |
| Operating cost          | 13.4        | 20.8   | 1.2              | 122.9   | 4.1            | 70.1          | 42.6     | 115.2    |
| Sales Revenue           | -           | -      | -                | 626.96  | 838.5          | 191.75        | 73.57    | 385.36   |
| Profit (M$/year)        | -           | -      | -                | 335     | 823            | 313           | 25       | 74       |

2. **Life cycle assessment**

Figure S1 reveals the global warming potential of each production process involved.
3. Inherent safety

Table S5 presents results of inherent safety assessment for five upgrading processes involved.

| Process  | Chemicals                                | Type of hazards  | FEDI  | TDI  |
|----------|------------------------------------------|------------------|-------|------|
| Xylitol  | Hydrogen, xylitol                         | Flammable        | 118   | 87   |
| Levulinic acid | Hydroxymethylfurfural, formic acid, levulinic acid | Toxic/corrosive | 163   | 285  |
| Succinic acid | Succinic acid                              | Toxic/corrosive  | 144   | 341  |
| Guaiacol  | Hibert kethon, guaiacol                   | Toxic/corrosive  | 172   | 325  |
| Vanillin  | Vanillin, sulfureic acid, ethyl acetate    | Toxic/corrosive  | 195   | 204  |

B. Multi-objective optimization code

The developed model equations of all responses/outputs of all processes are given below. Interaction between the parameters were obtained and correlated with the output as shown in following Equations.

1. Objective function (@Biorefinery)

Max annual profit = -(11012.84 + 0.23x₁ - 226.11x₂ + 0.06x₁x₂ - 2.59x₁⁻⁹x₂² + 1.16x₂⁻² - (x₃)(-204.03 + 0.304x₁ + 5.69x₄ + 0.14x₁x₄ - 1.1x₁⁻¹¹x₂² - 0.039x₄²) - (1 - (x₃))(1743.27 - 0.29x₁ - 46.15x₅ + 0.069x₁x₅ + 4.5x₁⁻⁵x₂² + 0.3x₅²) - (x₆)(49.11 - 0.63x₁ - 1.402x₇ + 0.04x₁x₇) - (1 - (x₆))(547.12 + 0.063x₁ - 149.27x₆ + 0.32x₆x₆ + 9.13x₁⁻⁷x₁² + 10.17x₅²) + (43.53 + 0.0039x₁ - 0.88x₂ + 1.18x₁⁻⁴x₁x₂ - 1.4x₁⁻⁴x₂² + 4.5x₁⁻³x₂²) + (x₃)(0.27 + 5.24x₁⁻³x₁ - 1.24x₁⁻⁴x₄ + 4.11x₁⁻⁵x₃x₄) + (1 - (x₃))(15.46 - 0.032x₁ - 0.37x₅ + 3.74x₁⁻⁴x₁x₅ + 5.63x₁⁻⁴x₂² + 2.85x₁⁻³x₅²) + (x₆)(6.11 + 0.073x₁ - 0.32x₇ + 3.73x₁⁻⁴x₁x₇ - 1.43x₁⁻⁴x₂² + 4.42x₁⁻³x₇²) - (1 - (x₆))(-3.11 + 0.025x₁ + 1.02x₆ + 1.3x₁⁻⁴x₁x₆ - 7.95x₁⁻⁵x₂² - 0.068x₆²) + 0.32 + 0.038 - 1.056x₁ + 0.123x₁ + (62.53 + 1.63x₁ - 1.25x₂ + 1.8x₁⁻⁴x₁x₂ - 3.13x₁⁻⁴x₂² + 6.42x₁⁻³x₂² + (x₃)(0.77 + 0.037x₁ - 2.32x₁⁻⁴x₄ + 9.58x₁⁻⁵x₃x₄) + (1 - (x₃))(-3.22 + 0.69x₁ + 0.21x₅ + 1.34x₁⁻³x₃x₅ + 8.88x₁⁻⁴x₄² + (x₆)(3.09 + 0.58x₁ + 0.057x₇) + (1 - (x₆))(-7.23 + 1.59x₁ + 1.38x₈ + 1.76x₁⁻⁴x₁x₇ - 3.12x₁⁻⁴x₇² - 0.086x₈²) + 0.968 + 0.166x₁ - 0.667 + 0.32x₁
Min $GWP = 6.99 + 0.48x_1 - 0.15x_2 + 4.22 \times 10^{-5}x_1x_2 - 1.06 \times 10^{-4}x_1^2 + 7.92 \times 10^{-4}x_2^2 + (x_3) \left( -1.58 + 0.064x_1 + 0.044x_4 + 6.05 \times 10^{-4}x_1x_4 + 8.87 \times 10^{-7}x_1^2 - 3.03 \times 10^{-4}x_4^2 \right) + (1 - (x_3)) \left( -375.55 + 1.61x_1 + 10.2x_5 + 7.16 \times 10^{-3}x_1x_5 - 3.27 \times 10^{-4}x_1^2 - 0.069x_5^2 \right) + (x_6) \left( 11.31 + 0.72x_1 - 0.32x_7 + 9.8 \times 10^{-3}x_1x_7 \right) + (1 - (x_6)) \left( 0.37 + 0.54x_1 - 0.1x_8 + 2.25 \times 10^{-4}x_1x_8 - 4.96 \times 10^{-6}x_1^2 + 7.09 \times 10^{-3}x_8^2 \right) + 0.0083 + 0.051x_1 + 0.705 + 0.2694x_1$

Min $FEDI = 724.22 + 0.78x_1 - 13.73x_2 + 1.2 \times 10^{-3}x_1x_2 - 2.43 \times 10^{-3}x_1^2 + 0.071x_2^2 + (x_3) \left( 58.44 + 1.13x_1 + 0.59x_4 + 1.51 \times 10^{-3}x_1x_4 - 3.29 \times 10^{-3}x_1^2 - 2.67 \times 10^{-3}x_4^2 \right) + (1 - (x_3)) \left( 232.03 + 0.85x_1 - 4.53x_5 + 3.12 \times 10^{-3}x_1x_5 - 2.9 \times 10^{-3}x_1^2 + 0.033x_5^2 \right) + (x_6) \left( 399.28 + 0.52x_1 - 17.46x_7 + 0.025x_1x_7 - 4.18 \times 10^{-3}x_7^2 + 0.24x_7^2 \right) + (1 - (x_6)) \left( 171.76 + 0.96x_1 - 12.59x_8 + 0.012x_1x_8 - 2.95 \times 10^{-3}x_1^2 + 0.97x_8^2 + 62.943 + 0.4396x_1 \right)$

Min $TDI = 909.22 + 0.59x_1 - 18.10x_2 + 2.16 \times 10^{-3}x_1x_2 - 1.95 \times 10^{-3}x_1^2 + 0.094x_2^2 + (x_3) \left( 46.54 + 2.18x_1 + 1.57x_4 + 5.56 \times 10^{-3}x_1x_4 - 6.34 \times 10^{-3}x_1^2 - 7.21 \times 10^{-3}x_4^2 \right) + (1 - (x_3)) \left( 635.56 + 2.2x_1 - 14.1x_5 + 0.012x_1x_5 - 7.54 \times 10^{-3}x_1^2 + 0.101x_5^2 + (x_6) \left( 61.04 + 1.87x_1 + 3.33x_7 + (1 - (x_6)) \left( 122.95 + 1.84x_1 - 12.53x_8 + 0.015x_1x_8 - 5.14 \times 10^{-3}x_1^2 + 0.95x_8^2 \right) + 77.893 + 0.8216x_1 \right)$

2. Demand constraint (@Bconstraint)

$xylitol\ demand = -(339.902 + 0.00713x_1 - 6.979x_2 + 0.00184x_1x_2 - 7.99 \times 10^{-3}x_1^2 + 0.0358x_2^2) + 19$;

$levulinic\ acid\ demand = -(x_3)(-3.08 + 0.0459x_1 + 0.0858x_4 + 0.0021x_1x_4 - 1.66 \times 10^{-13}x_1^2 - 0.000596x_4^2) + 1.9$;

$succinic\ acid\ demand = -(1 - (x_3))(-1.1344 + 0.00169x_1 + 0.0144x_5 + 0.0031x_1x_5) + 88.75$;

$guaiacol\ demand = -(x_6)(-0.1344 - 0.0556x_1 + 0.000304x_7 + 0.0022x_1x_7) + 5.6$;

$evulinic\ acid\ demand = -(1 - (x_6))3.419 + 0.00039x_1 - 0.9329x_8 + 0.0021x_1x_8 + 5.71 \times 10^{-9}x_1^2 + 0.0635x_8^2) + 4.7$;

3. Solver
options = optimoptions('gamultiobj','Display','iter',...
    'MaxGeneration',1000,...
    'PopulationSize',100,...
    'CrossoverFraction',0.8,...
    'MigrationFraction',0.2,...
    'PlotFcns',@gaplotpareto);

fitness = @Biorefinery;
nvars = 8;
ConsFcn = @Bconstraint;
LB = [50 96 0 67 73 0 33 7];
UB = [100 99 1 77 80 1 37 7.7];
[x,fval] = gamultiobj(fitness,nvars,[],[],[],[],LB,UB,[],options);

%pareto front
figure(1);
scatter3(fval(:,1),fval(:,2),fval(:,3).');
xlabel('Annual profit($Million/year');
ylabel('GWP (kg CO2 eq)');
zlabel('FEDI');
view(40,35)

C. Multi-criteria decision making

1. Fuzzy Analytical Hierarchy Process

Table S6. Decision maker attribute

| Decision maker 1 | Economic Viability | Environmental Performance | Safety Index |
|------------------|--------------------|---------------------------|--------------|
| Economic Viability | 1 1 1             | 1 1 1                     | 1 1 1        |
| Environmental Performance | 1 1 1          | 1 1 1                     | 1 1 1        |
| Safety Index     | 1 1 1             | 1 1 1                     | 1 1 1        |

Decision maker 2
| Economic Viability | Environmental Performance | Safety Index |
|--------------------|---------------------------|--------------|
| Economic Viability | 1 1 1                     | 1 1 1 0.179 0.333 0.667 |
| Environmental Performance | 1 1 1                     | 1 1 1 0.179 0.333 0.667 |
| Safety Index | 1.5 3 5.6 1.5 3 5.6 | 1 1 1 |

**Decision maker 3**

| Economic Viability | Environmental Performance | Safety Index |
|--------------------|---------------------------|--------------|
| Economic Viability | 1 1 1                     | 3 5 7.9 3 5 7.9 |
| Environmental Performance | 0.127 0.2 0.333 1 1 1 | 0.179 0.333 0.667 |
| Safety Index | 0.127 0.2 0.333 1.5 3 5.6 | 1 1 1 |

**Decision maker 4**

| Economic Viability | Environmental Performance | Safety Index |
|--------------------|---------------------------|--------------|
| Economic Viability | 1 1 1                     | 3 5 7.9 1.5 3 5.6 |
| Environmental Performance | 0.127 0.2 0.333 1 1 1 | 0.179 0.333 0.667 |
| Safety Index | 0.179 0.333 0.667 1.5 3 5.6 | 1 1 1 |

**Decision maker 5**

| Economic Viability | Environmental Performance | Safety Index |
|--------------------|---------------------------|--------------|
| Economic Viability | 1 1 1                     | 0.313 0.5 0.833 1.5 3 5.6 |
| Environmental Performance | 1.2 2 3.2 1 1 1 | 1.5 3 5.6 |
| Safety Index | 0.179 0.333 0.667 0.179 0.333 0.667 | 1 1 1 |
GROUP (GEOMETRIC MEAN)

| Economic Viability | Economic Viability | Environmental Performance | Safety Index |
|--------------------|--------------------|----------------------------|-------------|
| 1                  | 1                  | 1.23                       | 1.04        |
| 1                  | 1                  | 1.66                       | 1.72        |
| 1                  | 1                  | 2.20                       | 2.78        |
| 0.45               | 0.60               | 0.81                       | 0.39        |
| 0.81               | 1                  | 1                          | 0.64        |
| 0.39               | 0.64               | 1.11                       |             |
| 0.36               | 0.58               | 0.96                       | 1           |
| 0.58               | 0.96               | 2.59                       | 1           |
| 0.96               | 2.59               | 1                          |             |

2. Technique for Order Preference

Table S7. TOPSIS key calculation information for profit, GWP, and FEDI

| Profit (F1) | GWP (F2) | FEDI (F3) | Normalized Weighted F1 | Normalized Weighted F2 | Normalized Weighted F3 | S   | S - Relative Closeness |
|-------------|----------|-----------|------------------------|------------------------|------------------------|-----|------------------------|
| 931.8       | 284.0    | 594.7     | 0.09289                | 0.03296                | 0.05194                | 0.00233 | 0.01660 | 0.8771 |
| 925.4       | 285.3    | 594.1     | 0.09226                | 0.03312                | 0.05189                | 0.00240 | 0.01595 | 0.8693 |
| 918.7       | 287.7    | 592.1     | 0.09159                | 0.03339                | 0.05172                | 0.00258 | 0.01526 | 0.8553 |
| 915.7       | 285.3    | 592.3     | 0.09129                | 0.03311                | 0.05174                | 0.00269 | 0.01499 | 0.8478 |
| 914.0       | 288.9    | 591.4     | 0.09111                | 0.03353                | 0.05165                | 0.00285 | 0.01477 | 0.8382 |
| 905.7       | 290.0    | 590.2     | 0.09029                | 0.03366                | 0.05155                | 0.00340 | 0.01395 | 0.8038 |
| 896.2       | 285.7    | 589.9     | 0.08934                | 0.03316                | 0.05152                | 0.00406 | 0.01306 | 0.7628 |
| 894.3       | 283.0    | 589.1     | 0.08915                | 0.03284                | 0.05145                | 0.00416 | 0.01292 | 0.7562 |
| 887.9       | 296.9    | 586.0     | 0.08851                | 0.03446                | 0.05118                | 0.00502 | 0.01214 | 0.7075 |
| 884.5       | 286.9    | 588.4     | 0.08818                | 0.03329                | 0.05139                | 0.00508 | 0.01189 | 0.7007 |
| 882.3       | 280.4    | 586.8     | 0.08796                | 0.03255                | 0.05125                | 0.00519 | 0.01181 | 0.6948 |
| 875.9       | 297.6    | 583.7     | 0.08732                | 0.03454                | 0.05098                | 0.00607 | 0.01096 | 0.6436 |
| 870.1       | 296.2    | 579.3     | 0.08674                | 0.03437                | 0.05060                | 0.00649 | 0.01044 | 0.6168 |
| 866.4       | 283.4    | 584.3     | 0.08637                | 0.03289                | 0.05103                | 0.00668 | 0.01020 | 0.6043 |
| 860.8       | 281.6    | 584.0     | 0.08581                | 0.03268                | 0.05101                | 0.00721 | 0.00970 | 0.5738 |
| 855.3       | 287.3    | 581.4     | 0.08526                | 0.03334                | 0.05078                | 0.00776 | 0.00906 | 0.5388 |
| 851.4       | 290.2    | 580.3     | 0.08488                | 0.03368                | 0.05068                | 0.00816 | 0.00865 | 0.5144 |
| 842.3       | 288.5    | 579.5     | 0.08397                | 0.03349                | 0.05061                | 0.00902 | 0.00781 | 0.4640 |
| 839.0       | 289.7    | 579.5     | 0.08364                | 0.03362                | 0.05061                | 0.00936 | 0.00746 | 0.4435 |
Table S8.: TOPSIS key calculation information for profit, GWP, and TDI

| Profit (F1) | GWP (F2) | TDI (F3) | Normalized Weighted F1 | Normalized Weighted F2 | Normalized Weighted F3 | S   | S -   | Relative Closeness |
|------------|----------|----------|------------------------|------------------------|------------------------|-----|-------|-------------------|
| 931.3      | 284.1    | 956.9    | 0.08721                | 0.03403                | 0.05096                | 0.00055 | 0.00538 | 0.9079 |
| 929.5      | 284.2    | 956.8    | 0.08704                | 0.03403                | 0.05095                | 0.00057 | 0.00521 | 0.9018 |
| 927.4      | 283.8    | 956.2    | 0.08684                | 0.03399                | 0.05092                | 0.00061 | 0.00502 | 0.8912 |
| 925.3      | 283.7    | 955.8    | 0.08664                | 0.03397                | 0.05089                | 0.00073 | 0.00482 | 0.8683 |
| 923.3      | 283.6    | 955.6    | 0.08646                | 0.03396                | 0.05089                | 0.00087 | 0.00463 | 0.8416 |
| 922.9      | 283.5    | 955.5    | 0.08642                | 0.03395                | 0.05088                | 0.00090 | 0.00460 | 0.8367 |
| 920.8      | 283.3    | 955.0    | 0.08622                | 0.03393                | 0.05085                | 0.00106 | 0.00440 | 0.8054 |
| Processes | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 | T11 | T12 |
|----------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| 919.6    | 283.2 | 954.9 | 0.08611 | 0.03391 | 0.05085 | 0.00116 | 0.00429 | 0.7871 |
| 916.8    | 282.9 | 954.3 | 0.08585 | 0.03388 | 0.05082 | 0.00140 | 0.00403 | 0.7414 |
| 915.9    | 282.8 | 954.1 | 0.08577 | 0.03387 | 0.05081 | 0.00148 | 0.00395 | 0.7278 |
| 914.6    | 282.7 | 953.9 | 0.08564 | 0.03386 | 0.05079 | 0.00159 | 0.00383 | 0.7060 |
| 912.1    | 282.5 | 953.4 | 0.08540 | 0.03383 | 0.05077 | 0.00182 | 0.00359 | 0.6631 |
| 912.1    | 282.5 | 953.4 | 0.08540 | 0.03383 | 0.05077 | 0.00182 | 0.00359 | 0.6631 |
| 910.0    | 282.3 | 953.0 | 0.08521 | 0.03381 | 0.05075 | 0.00201 | 0.00340 | 0.6283 |
| 909.1    | 282.2 | 952.9 | 0.08513 | 0.03380 | 0.05074 | 0.00209 | 0.00332 | 0.6131 |
| 906.9    | 282.3 | 952.8 | 0.08492 | 0.03380 | 0.05074 | 0.00230 | 0.00311 | 0.5746 |
| 905.7    | 281.9 | 952.2 | 0.08481 | 0.03375 | 0.05070 | 0.00240 | 0.00301 | 0.5556 |
| 903.9    | 281.8 | 952.1 | 0.08464 | 0.03375 | 0.05070 | 0.00257 | 0.00284 | 0.5252 |
| 901.6    | 281.7 | 951.7 | 0.08442 | 0.03373 | 0.05068 | 0.00279 | 0.00256 | 0.4853 |
| 900.4    | 281.5 | 951.4 | 0.08432 | 0.03371 | 0.05066 | 0.00289 | 0.00253 | 0.4666 |
| 897.2    | 281.5 | 951.1 | 0.08401 | 0.03371 | 0.05065 | 0.00320 | 0.00223 | 0.4110 |
| 895.4    | 281.2 | 950.6 | 0.08384 | 0.03367 | 0.05062 | 0.00336 | 0.00208 | 0.3816 |
| 893.3    | 281.3 | 950.5 | 0.08365 | 0.03369 | 0.05062 | 0.00356 | 0.00189 | 0.3464 |
| 892.5    | 281.2 | 950.4 | 0.08357 | 0.03368 | 0.05061 | 0.00364 | 0.00181 | 0.3328 |
| 890.6    | 281.4 | 950.2 | 0.08339 | 0.03370 | 0.05060 | 0.00382 | 0.00164 | 0.3007 |
| 888.3    | 281.4 | 950.2 | 0.08318 | 0.03370 | 0.05060 | 0.00402 | 0.00144 | 0.2639 |
| 887.3    | 281.3 | 950.0 | 0.08309 | 0.03369 | 0.05059 | 0.00412 | 0.00136 | 0.2477 |
| 885.2    | 281.5 | 949.9 | 0.08289 | 0.03371 | 0.05058 | 0.00432 | 0.00117 | 0.2138 |
| 882.6    | 281.5 | 949.6 | 0.08265 | 0.03371 | 0.05056 | 0.00456 | 0.00096 | 0.1746 |
| 882.5    | 281.5 | 949.6 | 0.08263 | 0.03371 | 0.05056 | 0.00457 | 0.00096 | 0.1729 |
| 879.2    | 281.8 | 949.4 | 0.08233 | 0.03375 | 0.05056 | 0.00488 | 0.00070 | 0.1257 |
| 877.9    | 281.8 | 949.3 | 0.08221 | 0.03375 | 0.05055 | 0.00500 | 0.00063 | 0.1113 |
| 875.3    | 282.1 | 949.2 | 0.08196 | 0.03378 | 0.05055 | 0.00524 | 0.00050 | 0.0873 |
| 873.8    | 282.1 | 949.1 | 0.08183 | 0.03378 | 0.05054 | 0.00538 | 0.00049 | 0.0828 |
| 873.8    | 282.1 | 949.1 | 0.08183 | 0.03378 | 0.05054 | 0.00538 | 0.00049 | 0.0828 |
|                | Value 1 | Value 2 | Value 3 |
|----------------|---------|---------|---------|
| Positive Ideal | 0.08721 | 0.03367 | 0.05054 |
| Negative Ideal | 0.08183 | 0.03403 | 0.05096 |