**Viability of reclaiming municipal wastewater for potential microalgal based biofuel production in the U.S.**

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**Supporting Materials II**

1. **Algae pond area, biomass production and water demand estimate**

Algae biomass growth was simulated by using a pond temperature model and a microalgae growth model (Wigmosta et al. 2011). Pond temperature was obtained based on hourly time-series of meteorology at 1/8 degree spatial resolution from 1979 - 2012, a total of 33-years provided by NLDAS-2. Pond water temperature and evaporative loss were established hourly at a 15-cm pond depth. Pond size ranges from 100 or 200 m2 to 4,046,860 m2. A subset of the pond locations were selected based on land availability. The microalgae growth model predicts biomass productivity in outdoor ponds under nutrient-replete conditions, diurnally fluctuating light intensities, and water temperatures. A warm season freshwater strain Chlorella sorokiniana DOE-1412 was run for each potential site using the hourly pond temperature. Minimum average biomass production is set at 20g/m^2-day. Biomass are harvested when pond algae concentrations reached a density of 500mg/L. Nitrogen, ammonia, chemical nitrogen requirements were not limiting. Pond blowdown water is recycled. Water consumption in this study is expressed as the precipitation subtracted from evaporation loss in the pond during algae growth.

As algae growth rate is greatly enhanced by additional CO2 supply, the algae pond facilities were further screened for available external CO2 supply source within the conterminous U.S., resulting an estimated total of 7075 microalgae production facility sites and associated water demand and biofuel production. The CO2 sources include waste CO2 gaseous from coal-fired power plants, natural gas power plants, cement plants, fertilizer and ammonia plants, other chemical plants. Factors considered for CO2 supply include no compression transport for 30-40 miles to pond site and cost of $40 per ton of CO2 for CO2 capture and transport (Coleman et al. 2014).

We aggregated pond location and area, biomass production, and water demand at the county level, which is embedded in the file below.



**References:**

Wigmosta, A.M. Coleman, R.J. Skaggs, M.H. Huesemann, L.J. Lane. 2011. National microalgae biofuel production potential and resource demand: National Algae Biofuel Production. Water Resour. Res., 47 (2011), Article W00H04, 10.1029/2010WR009966.

Coleman, A.M., J.M. Abodeely, R.L. Skaggs, W.A. Moeglein, D.T. Newby, E.R. Venteris, M.S. Wigmosta, 2014. An integrated assessment of location-dependent scaling for microalgae biofuel production facilities. Algal Res., 5 (2014), pp. 79-94, 10.1016/j.algal.2014.05.008.

1. **Potential of reclaimed water available for algal biomass production**

Following geospatial analysis to identify production counties, we performed temporal analysis using monthly information - reclaimed water monthly flow and monthly algae productivity at the county level. Results from this analysis are used to identify qualified production counties. County level monthly analysis results were aggregated to annual total by state.

Table 2 presents the monthly reclaimed water use and biomass production analysis results under the three scenarios at the national level, Table 3 shows state annual total values for the scenarios, and Table 4 contains maximum, minimum, and average annual values in each state

**Table 2. Monthly reclaimed water use and biomass production under the three scenarios (states total).**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Jan | Feb | Mar. | April | May | June | July | Aug | Sept | Oct | Nov | Dec | Annual |
| RW OSW | 477 | 440 | 520 | 460 | 426 | 393 | 420 | 436 | 417 | 406 | 433 | 439 | 5,267 |
| Water RW | 120 | 113 | 160 | 245 | 282 | 283 | 302 | 310 | 276 | 254 | 210 | 139 | 2,694 |
| Water  RW50 | 29 | 31 | 36 | 56 | 59 | 49 | 48 | 58 | 50 | 70 | 63 | 34 | 584 |
| Water  RW100 | 36.0 | 29.6 | 36.3 | 50.0 | 40.6 | 51.2 | 67.2 | 70.7 | 53.0 | 51.0 | 79.4 | 47.3 | 612 |
| BM RW | 495 | 1,573 | 5,346 | 5,314 | 3,634 | 3,633 | 4,910 | 5,759 | 5,565 | 3,087 | 2,041 | 871 | 42,231 |
| BM RW50 | 191 | 647 | 2,314 | 1,900 | 960 | 1,006 | 1,179 | 1,818 | 2,006 | 817 | 816 | 336 | 13,990 |
| BM RW100 | 259 | 1,040 | 3,829 | 2,127 | 908 | 987 | 1,686 | 2,173 | 2,322 | 968 | 846 | 540 | 17,686 |

**Notes:**

1. Flow unit: BL/Yr
2. Biomass unit: Thousands MT/yr

**Table 3. Reclaimed water use and algal biomass production under scenarios RW, RW50, and RW100 in the 16 states.**



**Notes:**

BLY - billion liters per year

MT - metric tons

**Table 4. Average, maximum, and minimum values of reclaimed water use and biomass production in the 16 states.**



1. **Water use efficiency (WUE)**

We calculated weighted average, maximum, minimum, and state total of WUE for the 16 states compare with the freshwater-based baseline assessment (CW). Scenario values (RW, RW50, and RW100) were derived from county level water consumption and algal biomass production estimates generated from this study. Table 4show the statistics of WUEs under the three scenarios for the 16 states.

**Table 5. WUEs of the 16 states under RW, RW50, and RW100 scenarios.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **WUE** | Thousand MT BM/BL | |  |  |  |  |  |  |  |  |  |  |
|  | **CW** | | | **RW** | | | **RW50** | | | **RW100** | | |
|  | weighted ave | Max | Min | weighted ave | Max | Min | weighted ave | Max | Min | weighted ave | Max | Min |
| NC | **42.09** | 53.76 | 0.00 | 39.82 | 73.74 | 33.07 | 41.73 | 451.67 | 0.00 | 40.12 | 34.93 | 0.00 |
| SC | **25.85** | 34.21 | 0.00 | 34.63 | 99.61 | 22.20 | 42.37 | 770.41 | 0.00 | 52.62 | 0.00 | 0.00 |
| AL | **25.83** | 47.34 | 0.00 | 28.66 | 56.92 | 20.77 | 29.73 | 135.68 | 0.00 | 33.13 | 49.49 | 0.00 |
| LA | 25.34 | 49.07 | 0.00 | **42.29** | 122.32 | 18.28 | 48.55 | 901.26 | 0.00 | **67.88** | 44.50 | 0.00 |
| VA | 24.64 | 34.12 | 0.00 | 29.94 | 85.94 | 27.48 | 28.78 | 692.86 | 0.00 | 28.78 | 27.48 | 0.00 |
| MS | 24.08 | 42.91 | 0.00 | 39.18 | 124.01 | 16.85 | **56.12** | 610.69 | 0.00 | **62.73** | 42.91 | 0.00 |
| FL | 23.97 | 43.37 | 0.00 | **48.38** | 2,114.53 | 20.55 | **51.43** | 8,264.65 | 0.00 | 64.87 | 0.00 | 0.00 |
| GA | 22.08 | 30.68 | 0.00 | 30.16 | 191.39 | 15.92 | 31.98 | 375.49 | 0.00 | 36.72 | 30.68 | 0.00 |
| AR | 17.82 | 23.93 | 0.00 | **49.75** | 236.07 | 14.33 | **78.40** | 2,565.78 | 0.00 | **121.34** | 21.28 | 0.00 |
| OK | 9.07 | 21.38 | 0.00 | 14.16 | 81.71 | 4.02 | 17.19 | 202.42 | 0.00 | 20.04 | 10.15 | 0.00 |
| TX | 5.85 | 32.17 | 0.00 | 13.67 | 173.90 | 1.48 | 18.07 | 1,034.02 | 0.00 | 17.65 | 19.20 | 0.00 |
| OR | 5.76 | 7.21 | 0.00 | 7.90 | 7.90 | 7.90 | 9.26 | 9.26 | 0.00 | 16.97 | 0.00 | 0.00 |
| NM | 2.73 | 3.16 | 0.00 | 1.98 | 2.72 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| AZ | 2.67 | 2.91 | 0.00 | 2.27 | 2.41 | 1.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CA | 2.66 | 6.07 | 0.00 | 2.93 | 8.22 | 1.39 | 4.43 | 69.53 | 0.00 | 6.94 | 4.10 | 0.00 |
| NV | 2.01 | 2.34 | 0.00 | 1.67 | 1.67 | 1.23 | 0.87 | 0.87 | 0.00 | 0.11 | 0.00 | 0.00 |