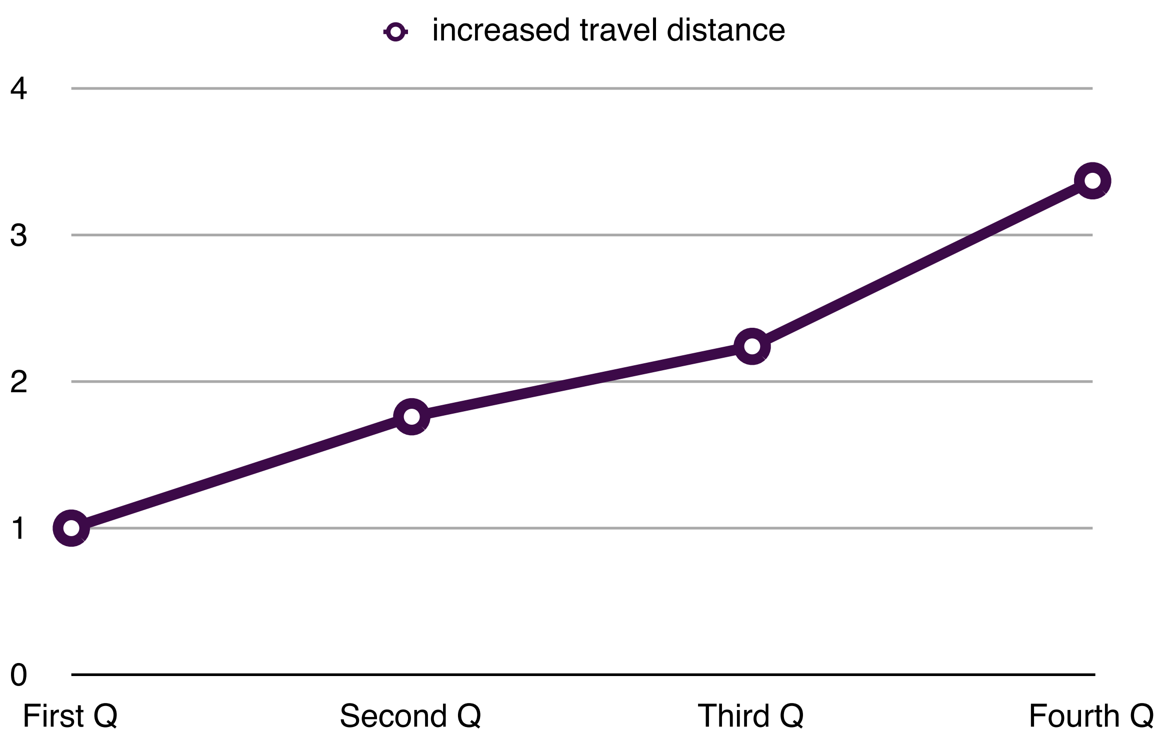
Average Distance Traveled for Feedstock to a Centralized Biomass Processing Facility as a Function of Doubling and Quadrupling the Feedstock.

Abstract: One of the limiting factors of viable biomass processing for energy, is that the biomass feedstock has a low energy density when compared with petroleum products. Thus the petroleum energy that is needed to transport the feedstock by truck, very quickly exceeds the energy return from the processed feed stock. This low EROEI makes the project non-viable. In this study we are looking at an ideal landscape so as to draw general conclusions as to what happens to transport distances as total feedstock is doubles and quadruples. When the feedstock is doubled, the further half of the feedstock has to travel 1.77 times as far as the closer half. However when the feedstock is quadrupled, the furthest 25% has to travel 3.37 times as far as the closest 25%.

Graph A: Increased Travel Distance As Feedstock Quadruples



Imagine a perfect landscape for biomass harvesting. It has a flat topography, ideal roads for transport directly to the processing facility and a consistent amount of harvestable biomass per area of land. Because we are asking what happens to the ratio, the units of area and mass cancel. Similarly, road issues based on radial or

Cartesian grid road systems do not effect the analysis as long as the system stays constant over the scale of the biomass harvest area.

Now imagine imposed on that landscape a series of concentric circles of increasing radius centered around the biomass processing facility.   Each with a radius = (n)R. The area of harvest, and thus the mass of feedstock is proportional to π R^2. As radius increases, the cumulative distance for each new radius is the area at that largest radius times the radius to the central processing plant.

Table B: Cumulative Increases in Transport Distance as Area Doubles.

Radius	Area	Area at largest radius	(Area at radius) x radius
(n)	π R^2	Area(n) - Area(n-1)	
1	π 1	π 1	1
2	π 4	π 3	6
3	π 9	π 5	15
4	π 16	π 7	28
5	π 25	π 9	45
6	π 36	π 11	66
7	π 49	π 13	91 partial sum 252
8	π 64	π 15	120
9	π 81	π 17	153
10	π 100	π 19	190
			partial sum(2) 463

When we compare areas for radius of 7 and 10 units, the area goes from Pi 49 units^2 to Pi 100 units^2. This is effectively doubling the area and thus the mass of feedstock.

For the 7 unit radius the average distance traveled = 252 distance mass units / 49 mass units = average 5.14 distance units.

For the mass harvested between the 7 and 10 unit radius, the average distance traveled = 463 distance mass units / 51 mass units = average 9.08 distance units.

The ratio is thus 9.08 average distance units / 5.14 average distance units = a ratio of 1.77.

Thus when the mass of feedstock mass is doubled, the further half of the feedstock has to travel 1.77 times as far as the initial amount.

By similar analysis, if the mass of feedstock quadruples, the furthest out 25% has to travel 3.37 times as far as the closest 25%. These calculations were done by comparing the average distance traveled for a radius of 10, 14, 17 and 20, with corresponding areas of 100 π, 196 π, 289 π and 400 π. This progression increases the area by approximately 100 π units at each interval.

Table C: Cumulative Increases in Transport Distance as Area Quadruples.

Radius	Area = π R^2	Area at Largest Radius Area (n) - Area (n-1)	(Area at Radius) x Radius (units are π distance ^3)	Average distance traveled for each quarter	Ratio of each quarter to first quarter
10	100 π	19 π	Total sum 715 for area 100	715 / 100 = 7.15	7.15/7.15 = 1
11	121 π	21	231		
12	144 π	23	276		
13	169 π	25	325		
14	196 π	27	378 partial sum 1,210 for area increase of 96	1,210 / 96 = 12.60	12.60/ 7.15= 1.76 **
15	225 π	29	435		
16	256 π	31	496		
17	289 π	33	561 partial sum 1,492 for area increase of 93	1,492 / 93 = 16.04	16.04/ 7.15 = 2.24
18	324 π	35	630		
19	361 π	37	703		
20	400 π	39	780 partial sum = 2,674 for area increase of 111	2,674 / 111 = 24.10	24.10/ 7.15 = 3.37

** Note that the doubling ratio is the same (1.76) with in rounding error for both Table A and Table B

The area of radius 10 is 100 π, with a total (area at radius) x radius of 715, for an average of 7.15.

The area at radius 20 is 400 π, or quadruple the area of radius 10. The partial (area at radius) x radius for the furthest 25% of area is from radius 17 outwards. This partial sum is 2,674 for an area of 111π. This has an average of 24.09.

24.09/7.15 = 3.37 This indicates that the furthest quarter has to travel 3.37 times as far as the closest quarter feedstock.

Thus when the area of harvest quadruples, the furthest out 25 % of the harvest has to travel 3.37 times further than the closest 25%.

In conclusion: When centralized biomass processing facilities are scaled upwards, the area of harvest must increase in proportion to the mass of feedstock. However, the increased distance traveled does not increase in a linear fashion to the increased feedstock. There is a mathematical “cliff” beyond which it is not economically viable to transport low density feedstock. At this distance from the plant, the energy needed to transport the material is greater than the energy provided by the processed material.

Other impacts include: the energy density of the feedstock, the road configuration, the harvestable percentage of the land area, etc. However, it is important to realize that, if a processing facility is economically viable in one area, that does not mean that the same operation will necessarily be viable in a new geography at the same scale. The furthest transported feedstock has to travel considerably further than the closest, and this can make or break an operation.

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