Overview: Whether processing can be widely distributed is not necessarily driven by economies of scale but rather depends on the conversion process which, in turn, depends on feedstock. The "Achilles' heel" of biomass processing and conversion is the issue of transporting and storing bulky cellulosic feedstocks. The most logical answer to this problem lies in distributed plants for several reasons but they need to be automated and economic to build. We will examine the benefits of distributed processing through three thermochemical pathways to producing bio-derived jet fuels (although similar arguments can be made for the case of biological pathways). (i) Conversion of bio-derived oils (triglycerides and fatty acids) to synthetic paraffinic kerosene (Bio-SPK), the UOP hydrotreated renewable jet process; (ii) Gasification of biomass followed by Fischer-Tropsch synthesis to liquids that can be formulated to paraffinic kerosene (FT-SPK), the Sasol process; (iii) The potential for biomass pyrolysis/liquefaction to bio-oils which could be upgraded to jet fuels (Py-SPK). Several studies have addressed the question of economic favorability of distributed processing over centralized plants. In the distributed model, farm-scale plants may produce fuel intermediates such as bio-oil, pressed oil, drop-in fuels, which can then be shipped to a central facility for final processing. In the centralized model, raw biomass is shipped to a central facility to be processed. The question is: Can any of the three processes be distributed? Of the three pathways identified, perhaps only direct gasification may not be distributed for the fact that the starting intermediate for the production of F-T liquids is a gas, one of the main drivers of economies of scale that has plagued gas-to-liquids (GTL) plants. The value chain for the production of Bio-SPK and Py-SPK are amenable to distributed processing. However they appear to be driven by economies of scale because the current economic models used intrinsically rely on capital expenditure.

The CapEx Factor: Reduction of capital expenditure favors concentrated production because construction costs are based on building unit operations individually with materials and labor at market prices. Hence several studies have favored economies of scale e.g., 550 ton per day (TPD) central biomass gasification plant was estimated to cost \$1.6 billion compared to \$4.1 billion for distributed pyrolysis[1], \$1.26/gal min. fuel selling price was estimated for a 500 TPD pyrolysis plant compared to \$1.74/gal for a 4.5 TPD plant[2]. 2000 TPD plant was considered optimal size in a DOE design case study[3], etc. However, modular systems that can be mass produced are seldom factored into these simulations. Other important cost factors, some hidden, that are not fully capitalized may include the following:

- *The Transportation Cost Factor:* Transportation costs for a distributed model could be less than half that of a concentrated model[4]. Although the difference may not be enough to offset the capital cost difference, fuel cost associated with shipping biomass from farm to plant is one cost factor that can change the economics[5], especially if the feedstock is to be grown on marginal lands and adaptable to regional differences.

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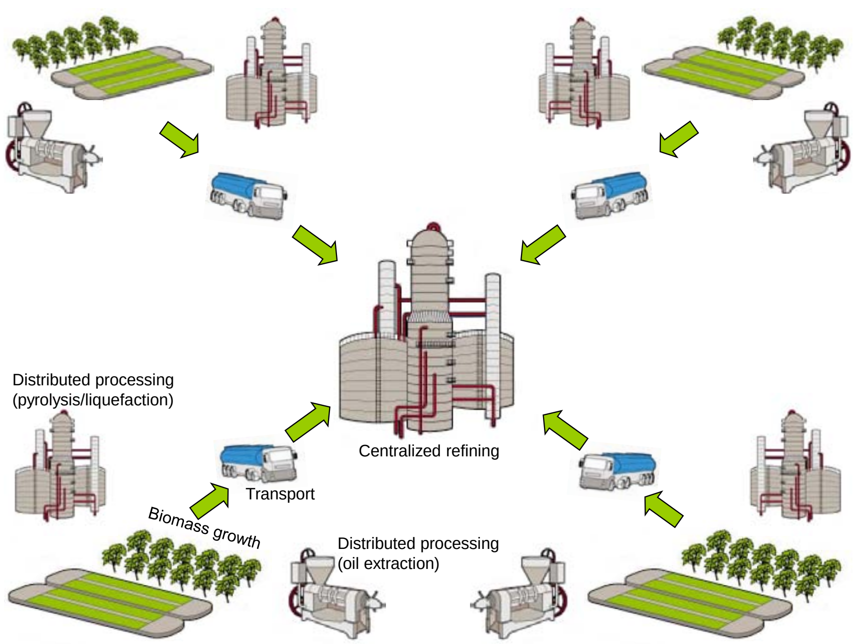
[1] MM Wright, RC Brown, AA Boateng. "Modeling and Analysis: Biomass to bio-oil for subsequent production of FTLs". *Biofuels, Bioprod. Bioref.* 2:229–238 (2008), p. 236
[2] Wright, M. Personal communication.
[3] SB Jones et al. "Production of Gasoline and Diesel from Biomass via Fast Pyrolysis, Hydrotreating and Hydrocracking: A Design Case", p. 3.1
[4] Wright et al., p. 235
[5] Ibid.

- *The Storage Factor:* Crops that can be stored for a long time without significant degradation may be amenable to centralized processing but second generation feedstocks for producing Bio-SPK (jatropha, camelina and algae) must be readily extracted without longer term storage. If feedstock constitutes 80% of processing cost[6] then distributed processing should be economically competitive if oil extraction and minor refining is done near or at the farm and the hydrogenation and formulation to jet fuels is done at a centralized location. For FT-SPK, gasifying liquefied biomass (py-oil) and biochar at site has been proposed as one measure to make GTL amenable to distributed processing, due to smaller transportation distances and avoidance of bulky biomass transport[7].
- *The Social implications:* The barrier to entry can be very high in a centralized model, making it likely that only a small number of corporations would control biofuel processing. Since a centralized model depends on dedicated energy crops for reliability, farmers would be beholden to this small group of corporations to buy their product, giving the bio-oil producers a disproportionate amount of economic power. This sort of economic asymmetry typically leads to instability.

Conclusion: It is undeniable that the capital and operational costs that have been calculated for a centralized production model are attractive in comparison to those for a distributed model. However, on closer examination, the centralized model has significant shortcomings. A distributed model allows for greater versatility, sustainability, and economic parity while having economic benefits that are not obvious. These important advantages make the distributed model attractive as a long-term option.



Distributed processing. Image credit ref (6)

[6] "Beginner's Guide to Aviation Biofuels". Available http://www.enviro.aero/Content/Upload/File/BeginnersGuide_Biofuels_WebRes.pdf 19 August 2009.
[7] "Novel Technology Could Produce Biofuel for Around $2.49/gal". Available http://www.sciencedaily.com/releases/2009/01/090129090004.htm 12 August 2009.