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Centralized versus decentralized biorefinery configurations for cellulosic ethanol: Can we reconcile environmental sustainability and profitability?

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GREAT LAKES BIOENERGY RESEARCH CENTER

MICHIGAN STATE UNIVERSITY

RESEARCH OBJECTIVES

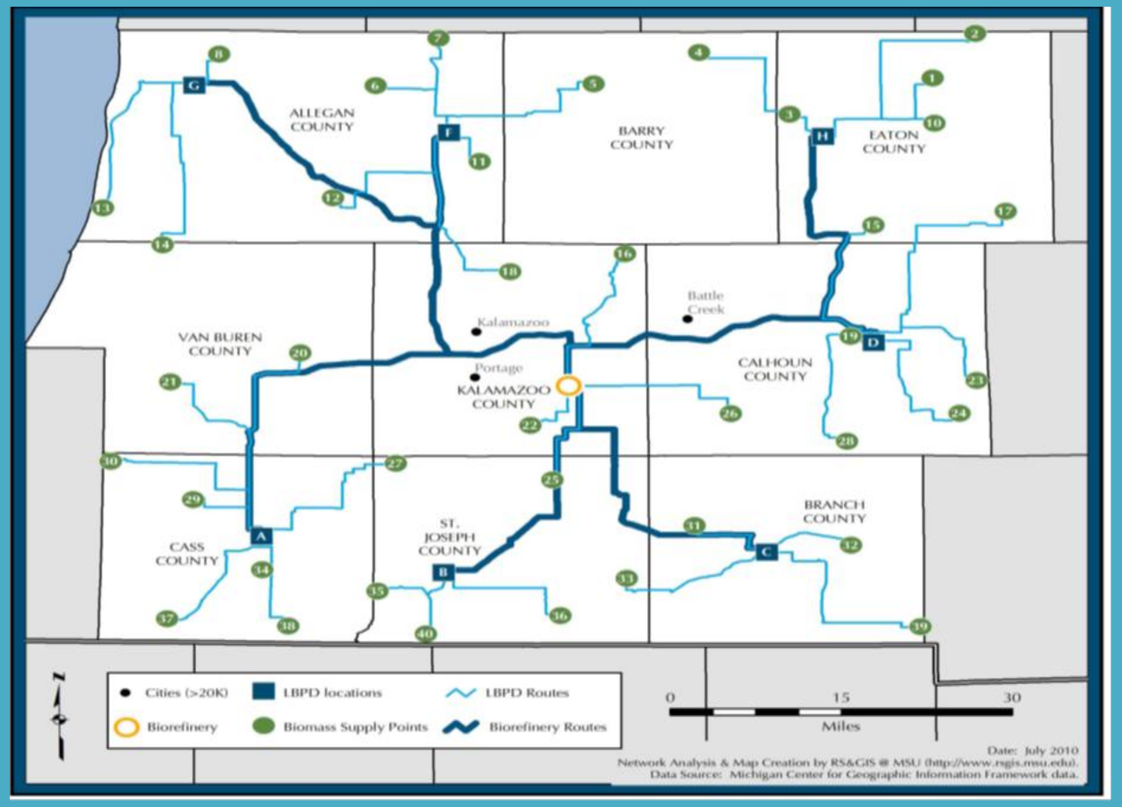
Compare spatial configurations of Central Biorefinery versus dispersed Local Biomass Processing Depots (LBPDs), focusing on:

1) Profitability of biomass production, transport, pretreatment and final processing;
2) Environmental impacts in terms of soil nutrient runoff, soil erosion, greenhouse gas (GHG) emissions, and land use change;
3) Technological change impacts of improved ethanol yields on system profitability and environmental outcomes.

RESEARCH QUESTIONS

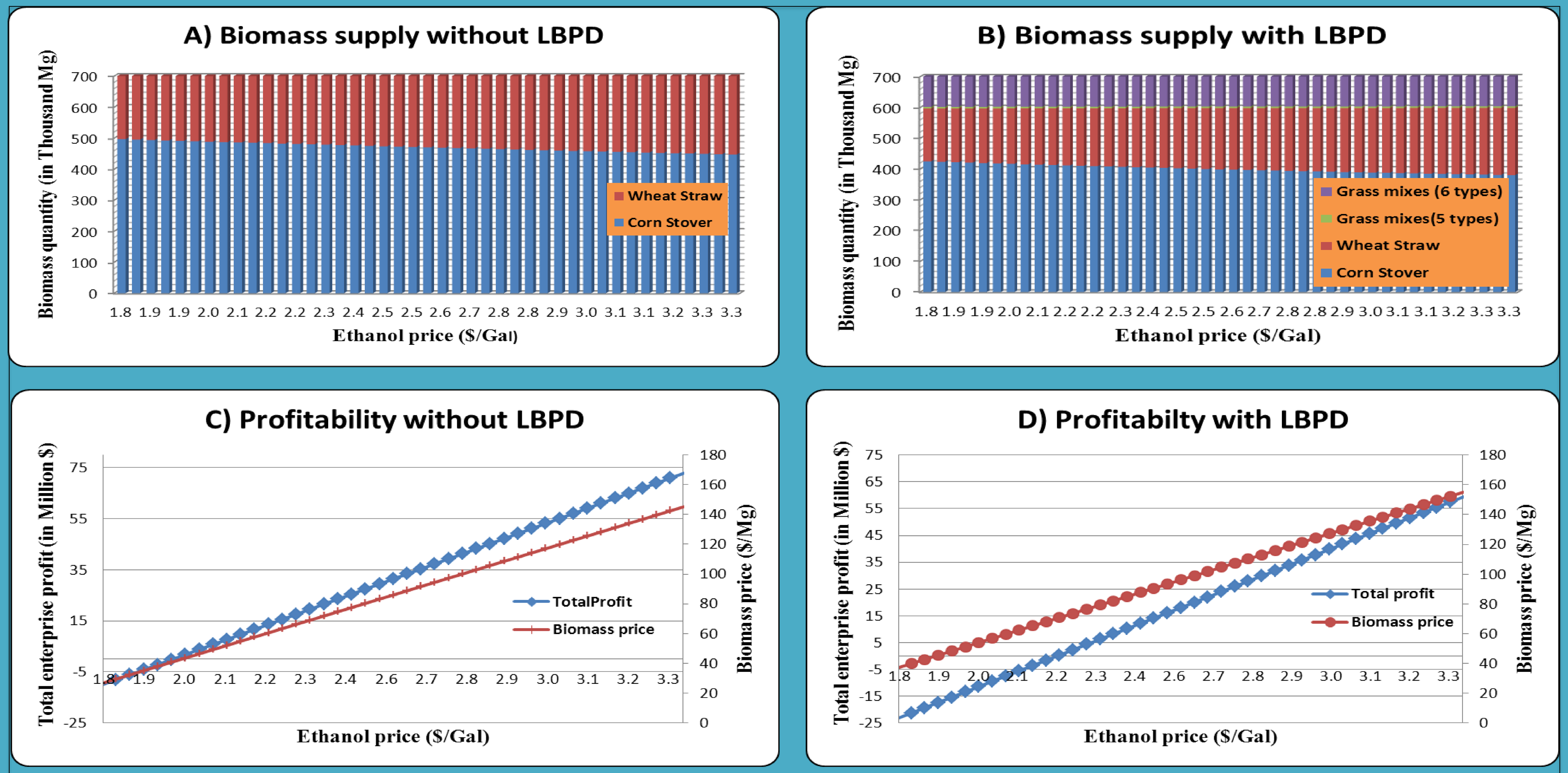
1. What parameters drive the profitability of the two biorefinery spatial configurations?
2. What land use changes and environmental costs ensue from each spatial configurations of ethanol refining (nutrient runoff, GHG emissions, land use change and soil erosion)?
3. How does more efficient processing of a perennial grass affect biorefinery profitability and environmental impacts?

SPATIAL REFINERY CONFIGURATION



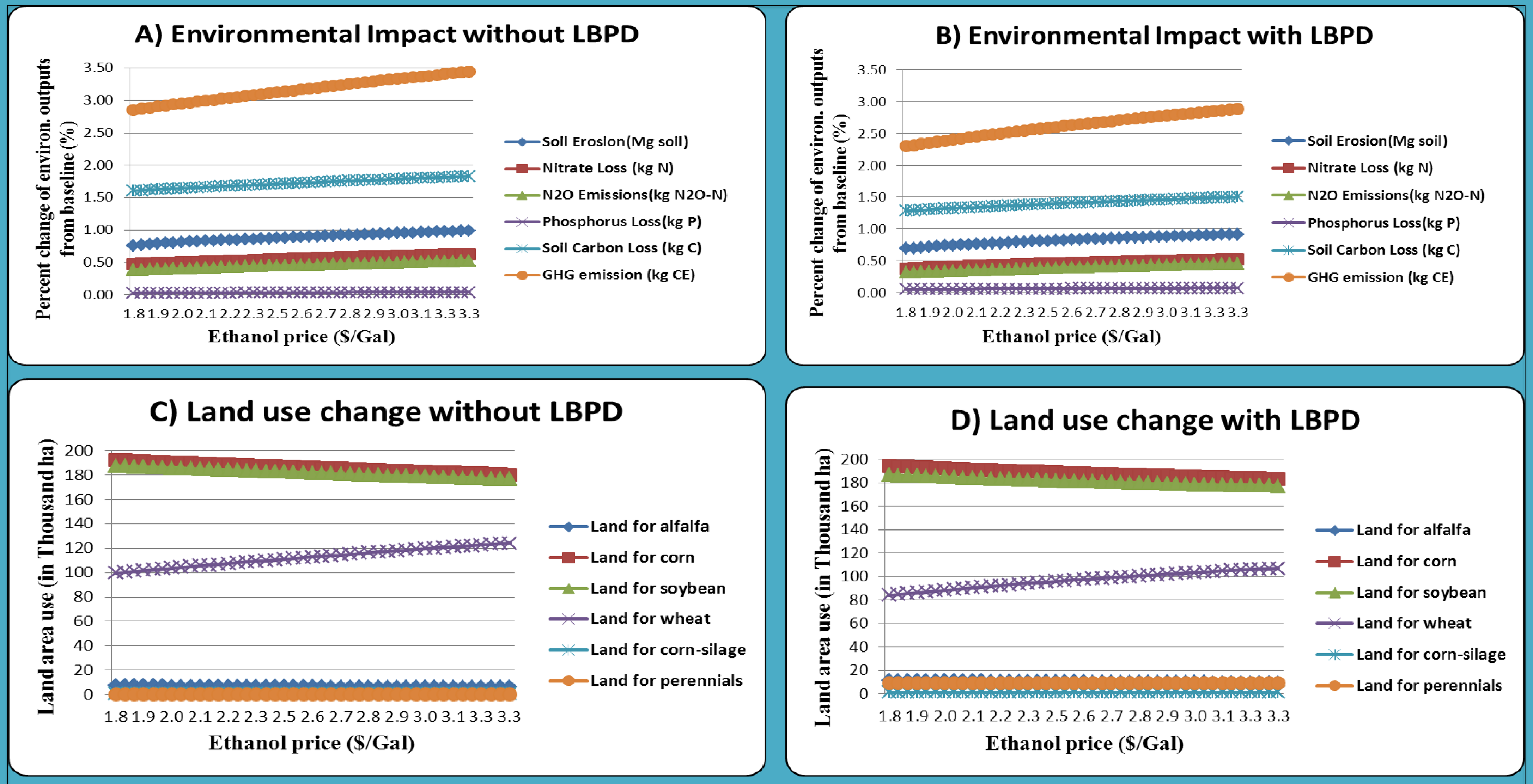
Biomass is moved either directly to the refinery or pretreated at the LBPDs before it get to the refinery.

BIOMASS SUPPLY AND PROFITS WITH LBPD AND WITHOUT LBPD



Without LBPDs, corn stover and wheat straw are the only feedstocks and the system is profitable with ethanol at $2.00/gal. With LBPDs, mixed perennial grasses join the annual crop residues and system profitability requires an ethanol price of $2.20/gal.

ENVIRONMENTAL IMPACT AND LAND USE CHANGE



Spatially dispersed LBPDs reduce environmental impacts due to more perennial grass production. Crop land use with LBPDs has 3% more area under perennials.

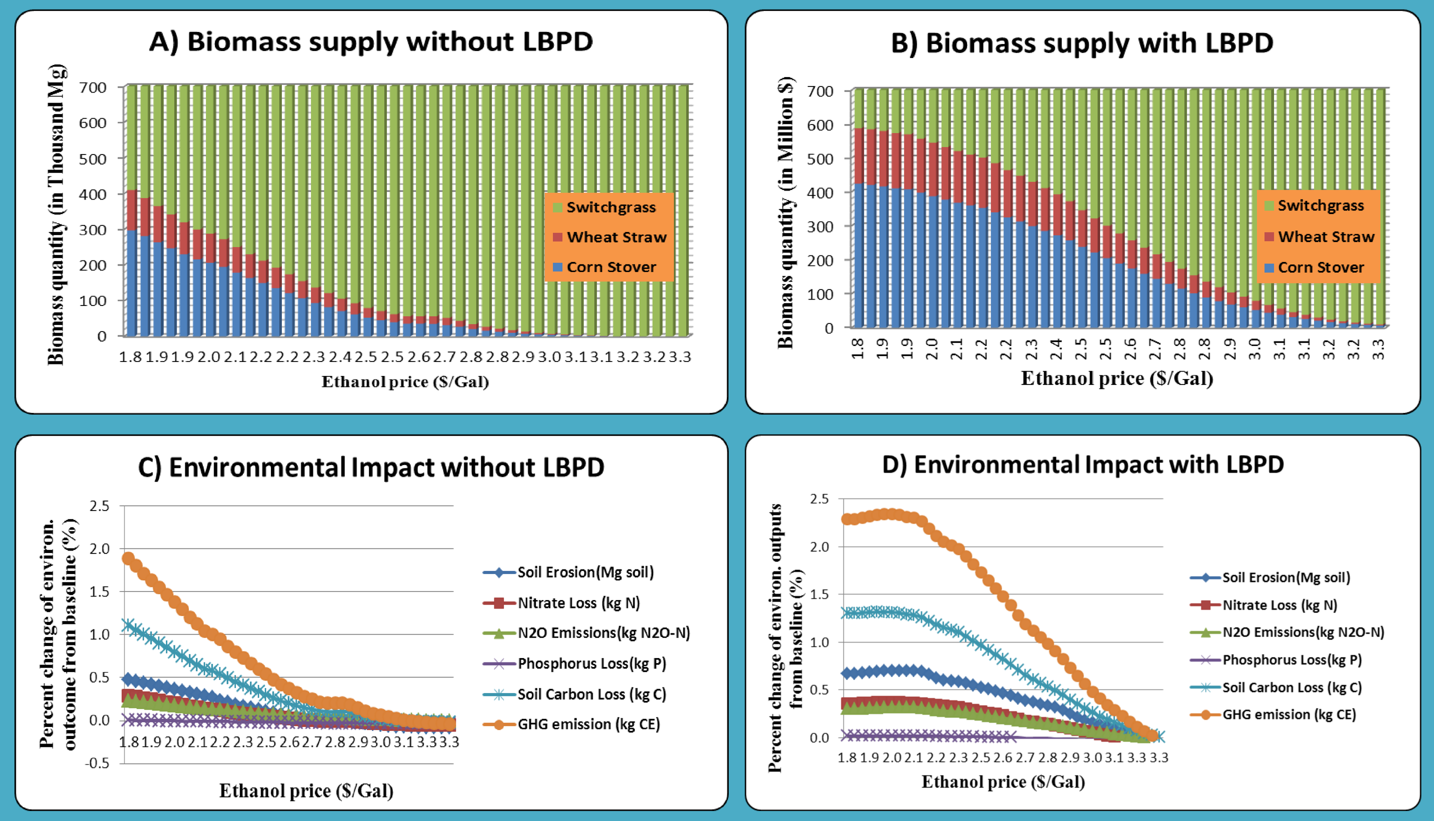
For details, see: Egbendewe-Mondzozo, A. et al.. 2011. "Can Dispersed Biomass Protect the Environment and Cover the Bottom Line for Biofuels." MSU Staff Paper 2011-15. (http://purl.umn.edu/119348).

METHODS

The bioeconomic model uses mathematical optimization to maximize gross margin (profitability) from crop production and ethanol biorefining. Biorefining activities include the case of 8 local biomass processing depots (LBPDs) compared to a centralized biorefinery operation.

- The Environmental Policy Integrated Climate (EPIC) model simulates yield and environmental outcomes from 82 cropping systems in 37 watersheds across 9 counties in S.W. Michigan.
- Transport costs of biomass from each watershed centroid to the biorefinery or to each LBPD with concentrated briquets moved to biorefinery.
- Prices of crops & fertilizers and production costs for each cropping system are calculated using data from Michigan State University Extension and the U.S. Department of Agriculture.
- A techno-economic model of the LBPDs and biorefinery provides fixed and variable costs for biomass pretreatment and final conversion into ethanol and byproducts.
- These component models generate parameters that drive the constrained optimization model that calculates the most profitable way to produce ethanol at the capacity of the biorefinery.

HIGHER ETHANOL YIELD FROM SWITCHGRASS



Higher ethanol yield triggers more switchgrass use, improving environmental quality.

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