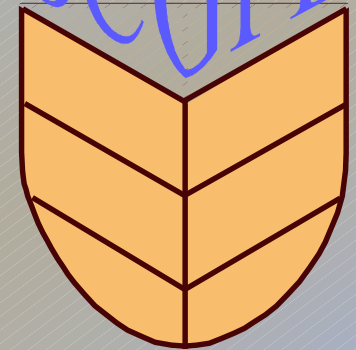


UMIST



SCGPE



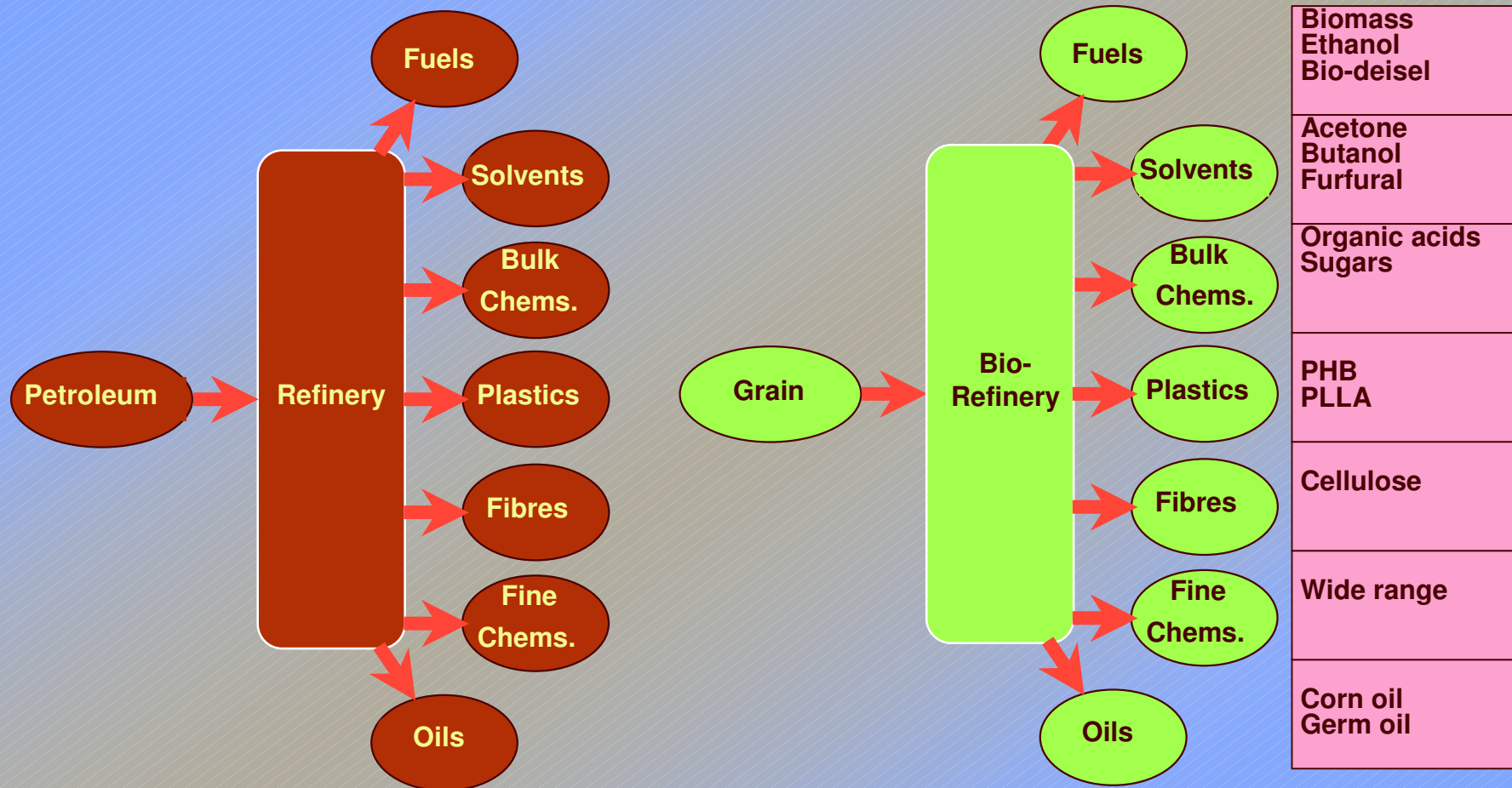
EVALUATION OF WHEAT AS GENERIC FEEDSTOCK FOR CHEMICAL PRODUCTION

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Most types of chemical produced from petroleum can be produced from cereals



Many of these can be produced through bioprocessing (fermentation) of the grain.

OPPORTUNITIES FOR BIOPROCESSING OVER CHEMICAL SYNTHESIS

DIRECT SUBSTITUTION
(single step microbial fermentation of carbohydrates)

INDIRECT SUBSTITUTION
(combined multi-step chemical/biochemical processing)

FOOD INDUSTRY
(e.g. amino acids and organic acids)

CHEMICAL INDUSTRY
(e.g. bioethanol and polymers)

TWO-STEP REACTIONS
(enzymatic/microbial conversion of chemical intermediates)

MULTI-STEP REACTIONS
(combination of conventional catalyst, microorganism and cell-free enzyme biocatalyst)

e.g.

FERMENTATIVE PRODUCTION OF ETHANOL

ETHYLENE

PROPYLENE

BUTADIENE

e.g.

MICROBIAL CONVERSION OF CARBOHYDRATES TO METHANE

METHANOL PRODUCTION FROM METHANE

CONVERSION OF METHANOL TO FORMALDEHYDE

CURRENT FEEDSTOCKS FOR CHEMICAL PRODUCTION

CHEMICAL INDUSTRY

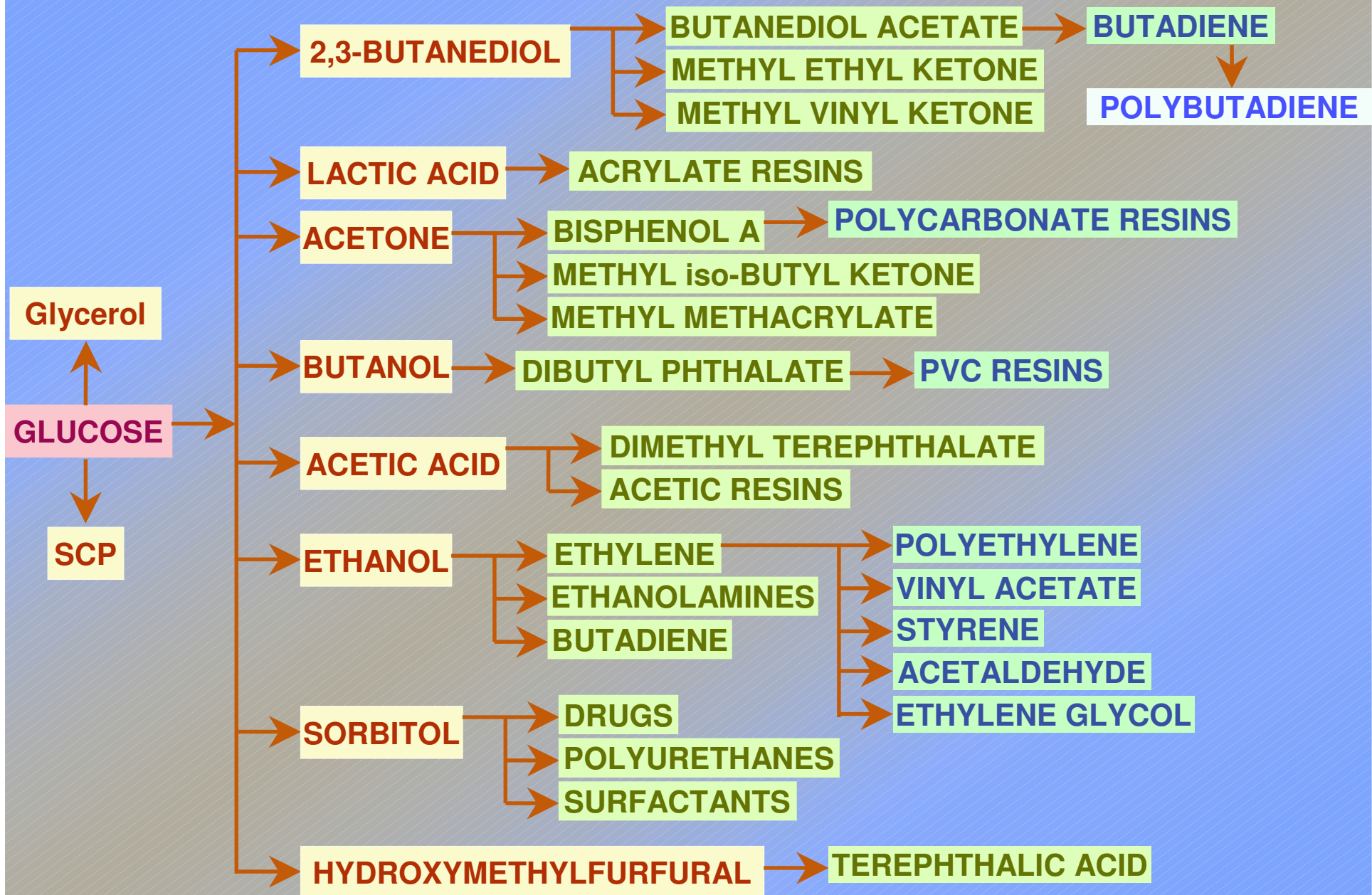
- Ethylene
- Propylene
- Butadiene and butenes
- Benzene and toluene
- Xylenes (ortho, meta and para)
- Methane

FERMENTATION INDUSTRY

Various by-products of the food industry

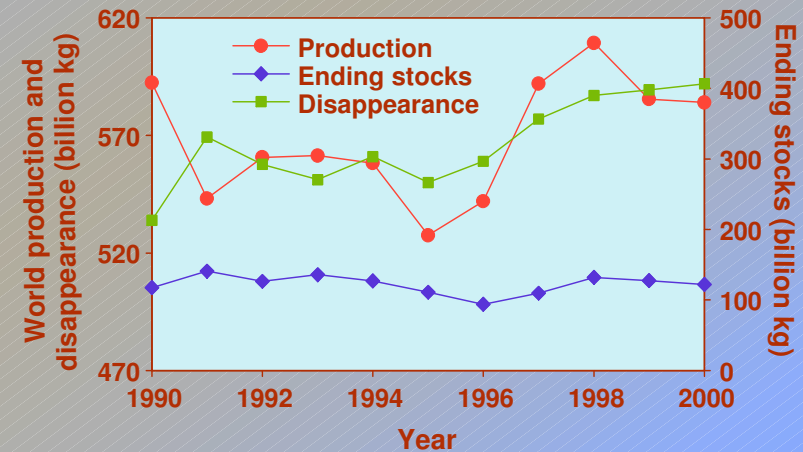
- Molasses
- Sugar derivatives
- Starch derivatives

CHEMICAL PRODUCTION FROM GLUCOSE

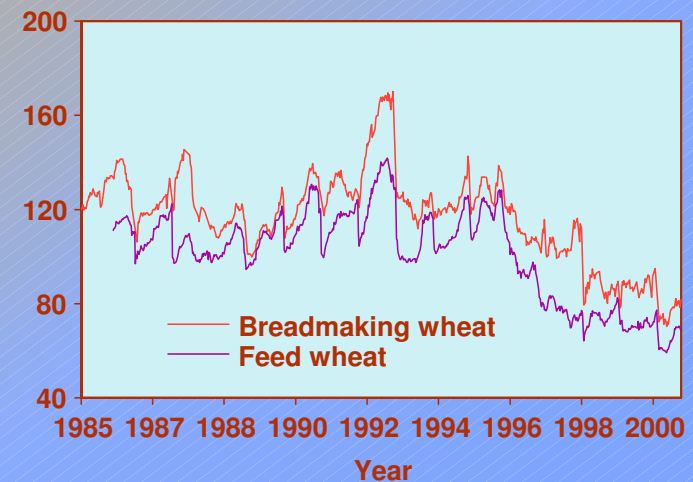


FACTORS AFFECTING WHEAT UTILIZATION AS A GENERIC FEEDSTOCK

- Wheat primary consumption in the food industry and secondary for feed purposes

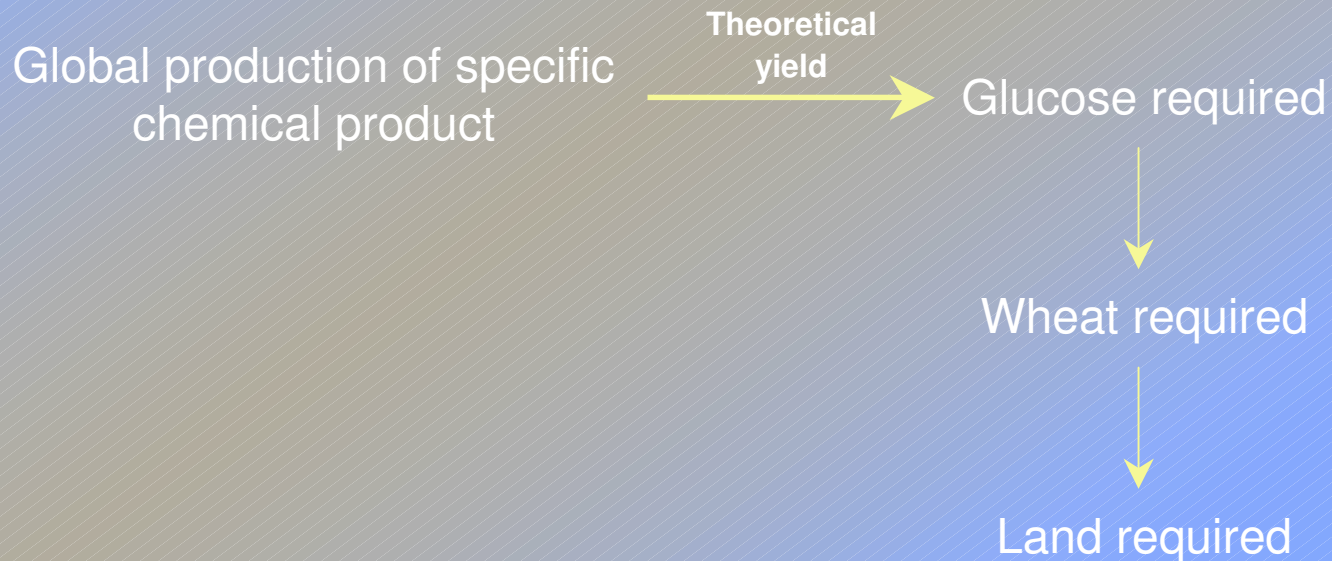


- Extensively fluctuating wheat purchase price



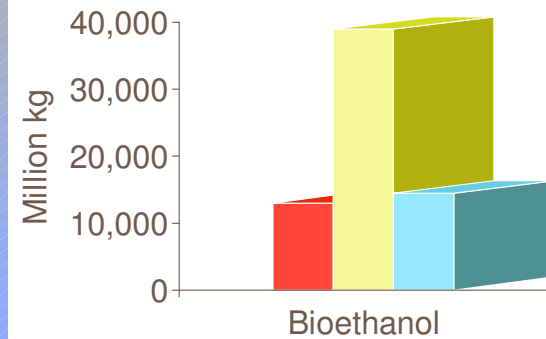
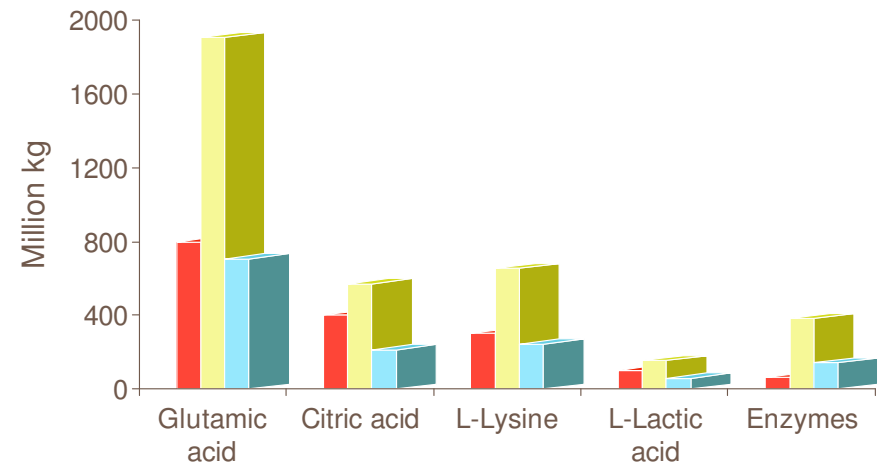
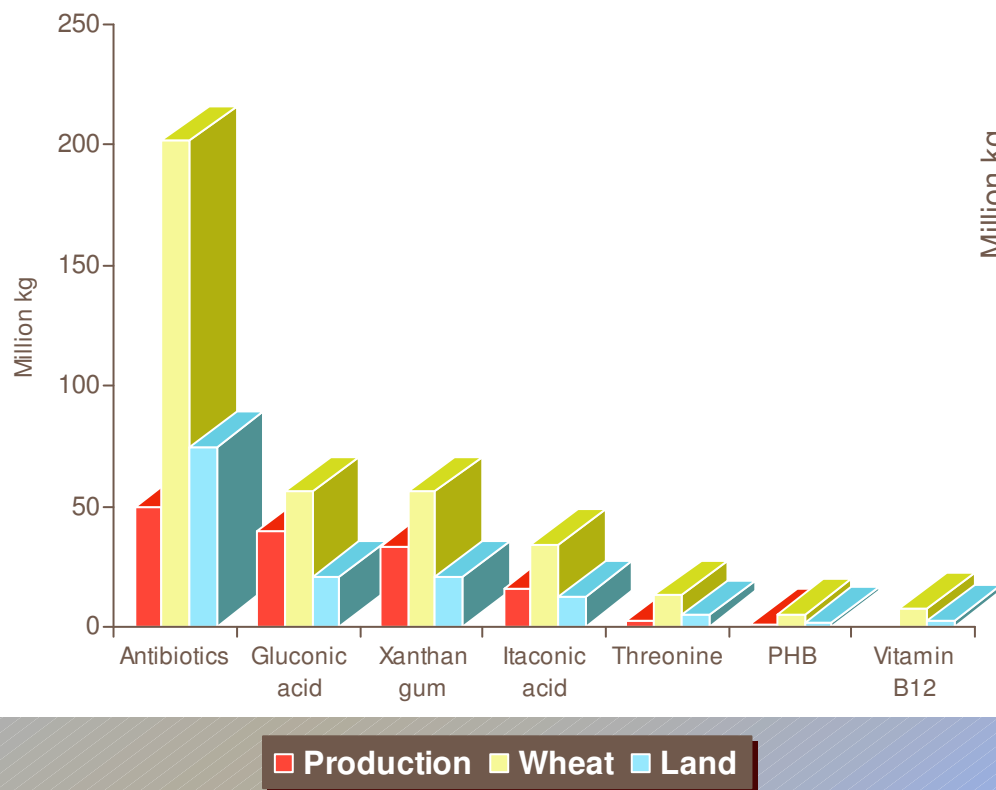
DOES WORLD WHEAT PRODUCTION PERMIT ITS UTILIZATION AS FERMENTATION FEEDSTOCK?

THEORETICAL SCENARIO - EFFICIENCY

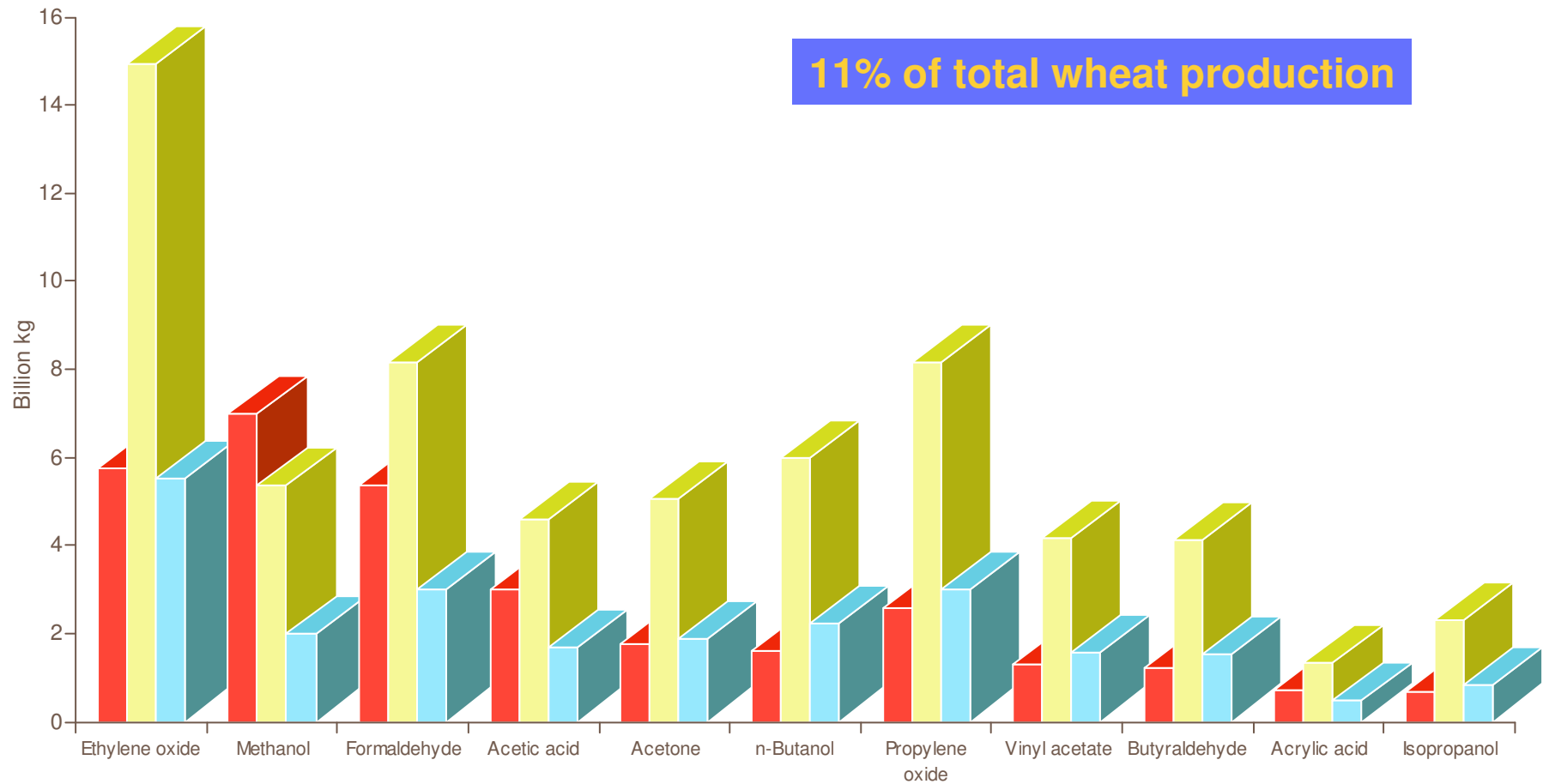


LAND AREA AND MAGNITUDE OF WHEAT REQUIRED FOR THE PRODUCTION OF MAJOR FERMENTATION PRODUCTS

7.35% of total wheat production



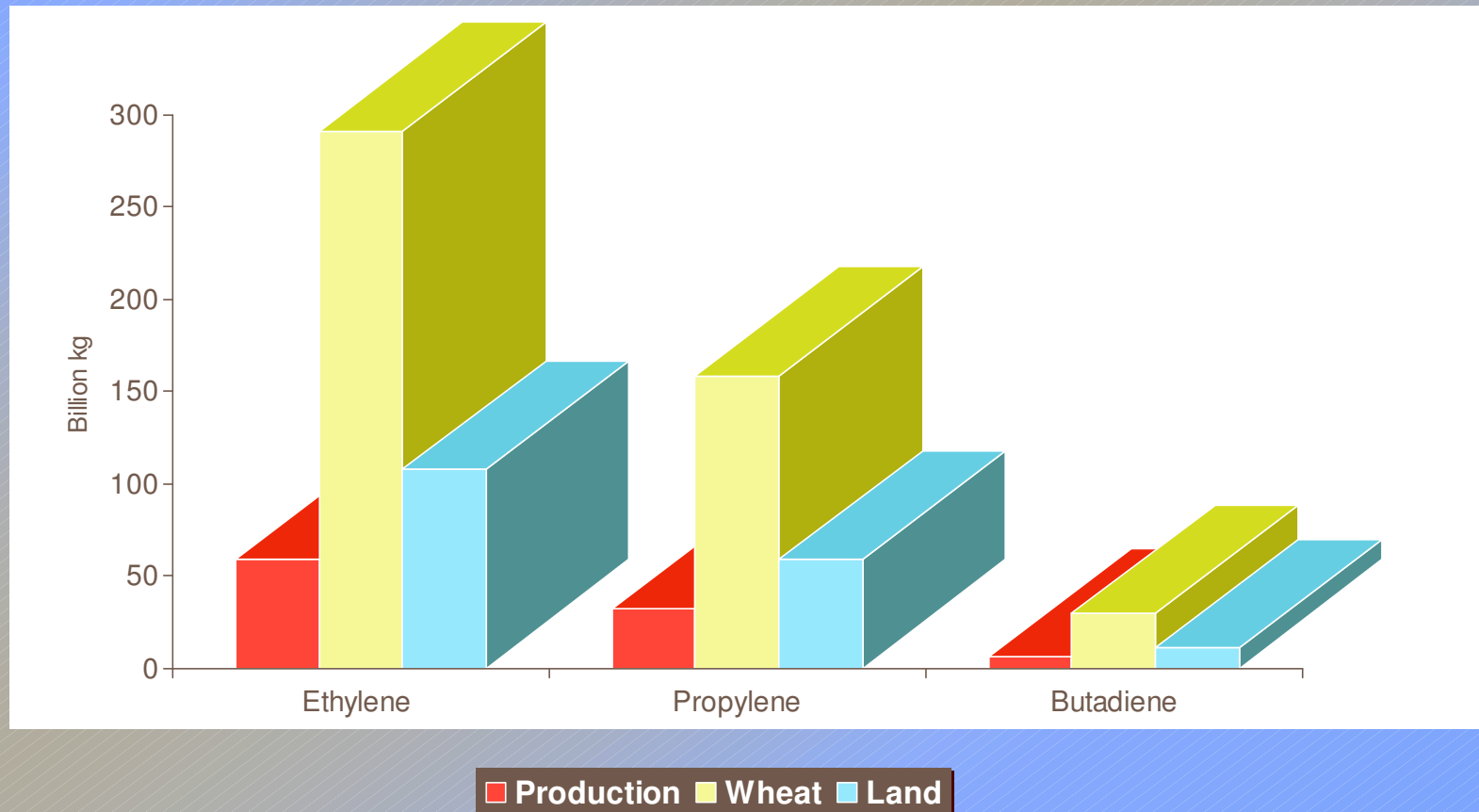
LAND AREA AND MAGNITUDE OF WHEAT REQUIRED FOR THE PRODUCTION OF SOME INTERMEDIATE PETROCHEMICAL PRODUCTS



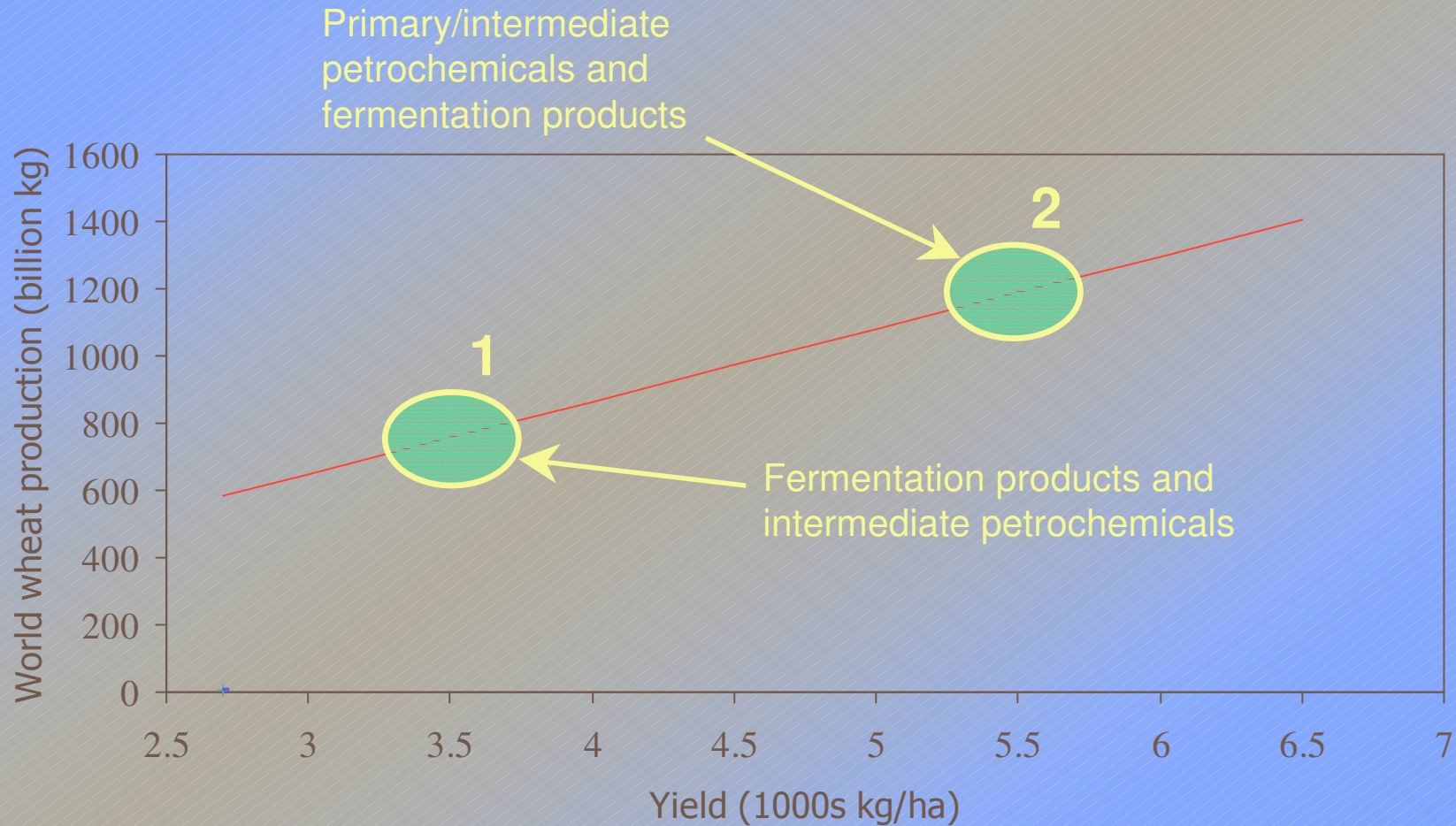
Production Wheat Land

LAND AREA AND MAGNITUDE OF WHEAT REQUIRED FOR THE PRODUCTION OF THE PRIMERY PETROCHEMICALS – ETHYLENE, PROPYLENE AND BUTADIENE

82.1% of total wheat production



WHEAT PRODUCTIVITY SHOULD BE INCREASED



PRELIMINARY ECONOMIC EVALUATION

EQUATION 1: FRACTION OF REVENUE FROM FEEDSTOCK (FRF)

$$\text{FRF} = (\text{Cost of feedstock} / \text{Value of products})$$
$$= (C_f / \sum x_i \beta_i y_i \alpha_i V_i)$$

i = component i of the feedstock (for wheat: carbohydrates, gluten and bran)

C_f = unit cost of the feedstock, (\$0.145/kg wheat)

α_i = fraction of maximum theoretical yield of product derived from component i (taken as 95% in this study)

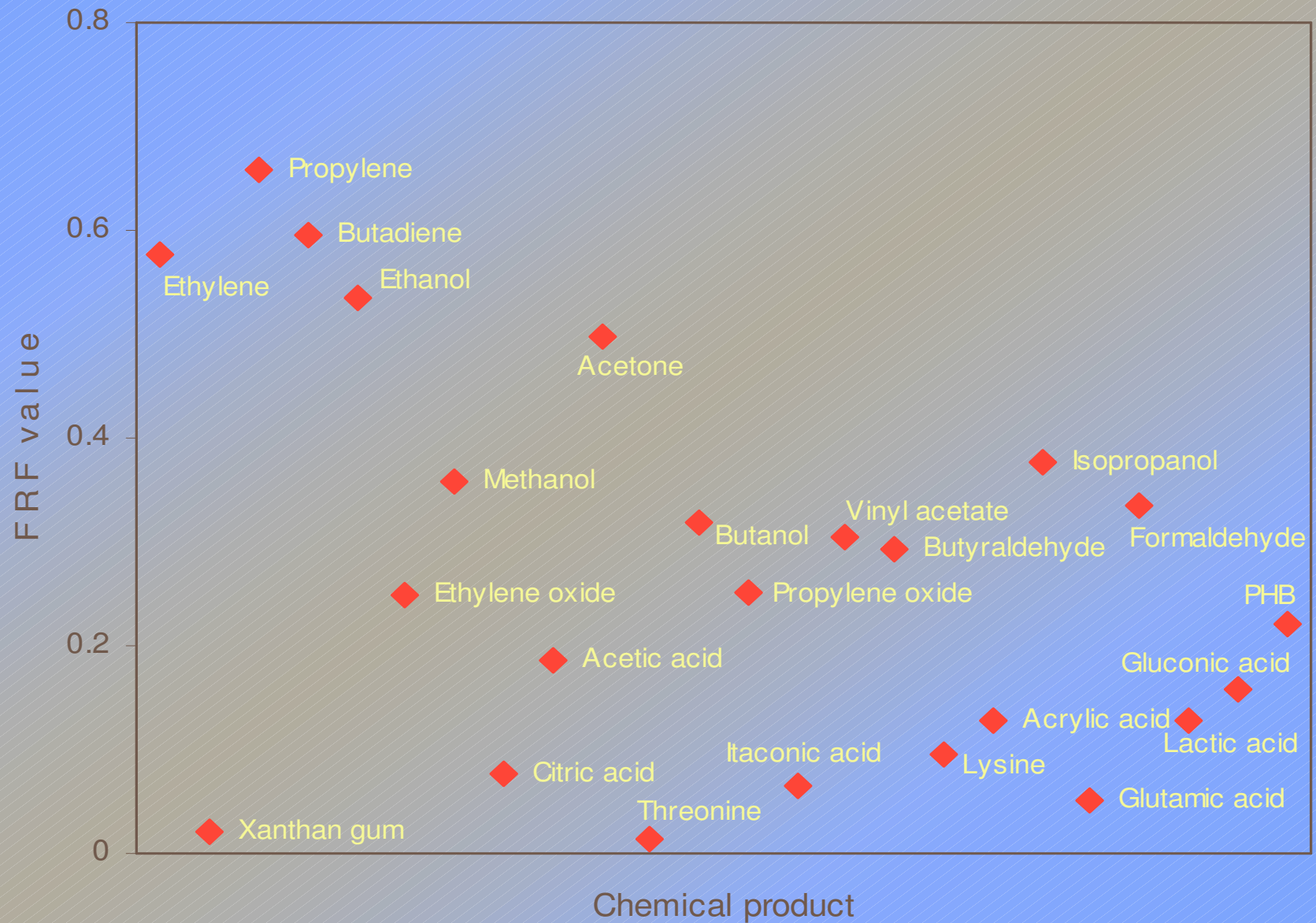
y_i = theoretical yield of product derived from component i

V_i = value of the product derived from component i

x_i = fraction of component i in the feedstock

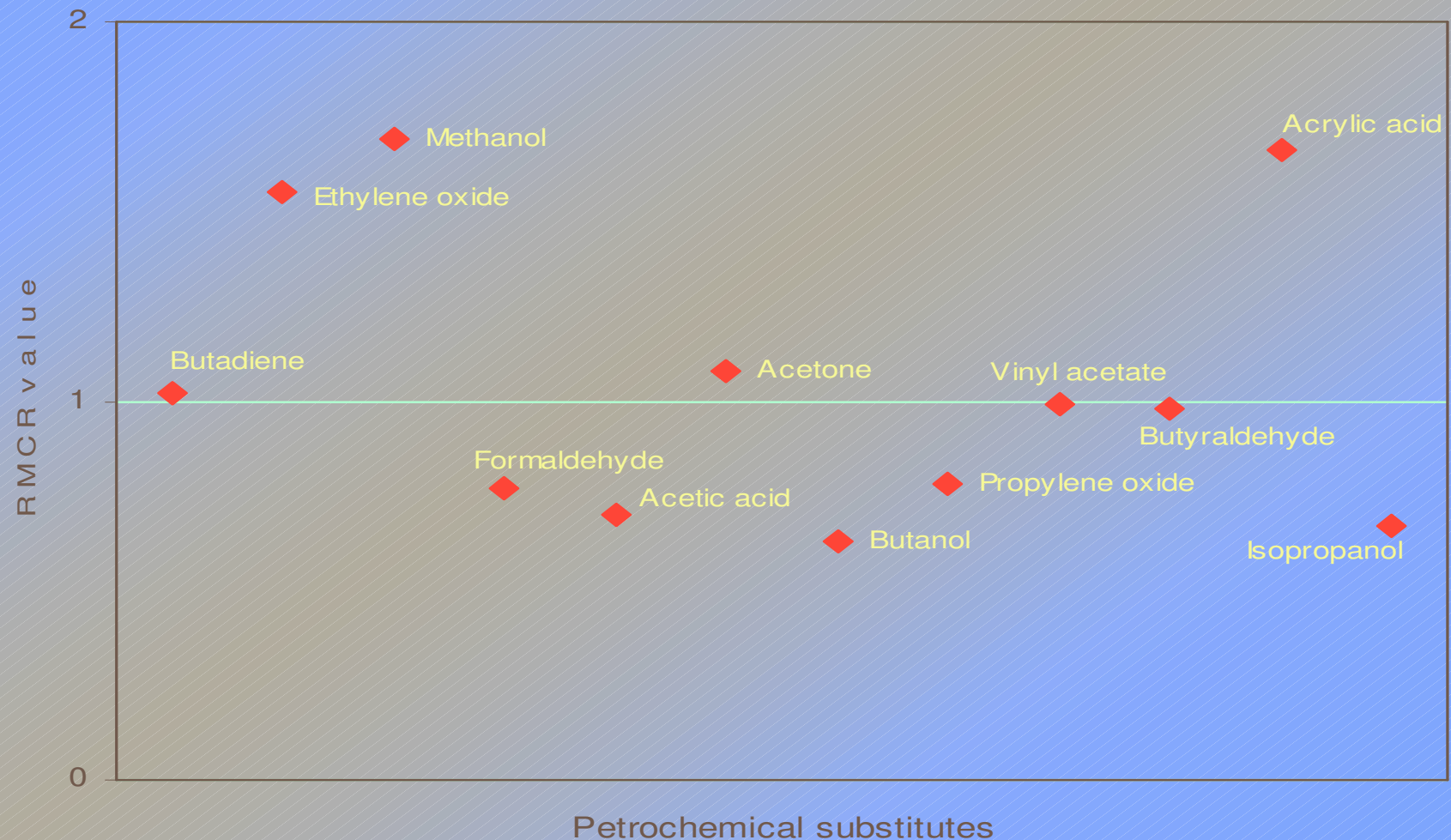
β_i = hydrolysis weight gain conversion factor (1.11 from starch to glucose)

The lower the FRF value for a specific chemical product, the higher the prospects for wheat utilisation as a generic feedstock for its production



EQUATION 2: RAW MATERIAL COST RATIO (RMCR)

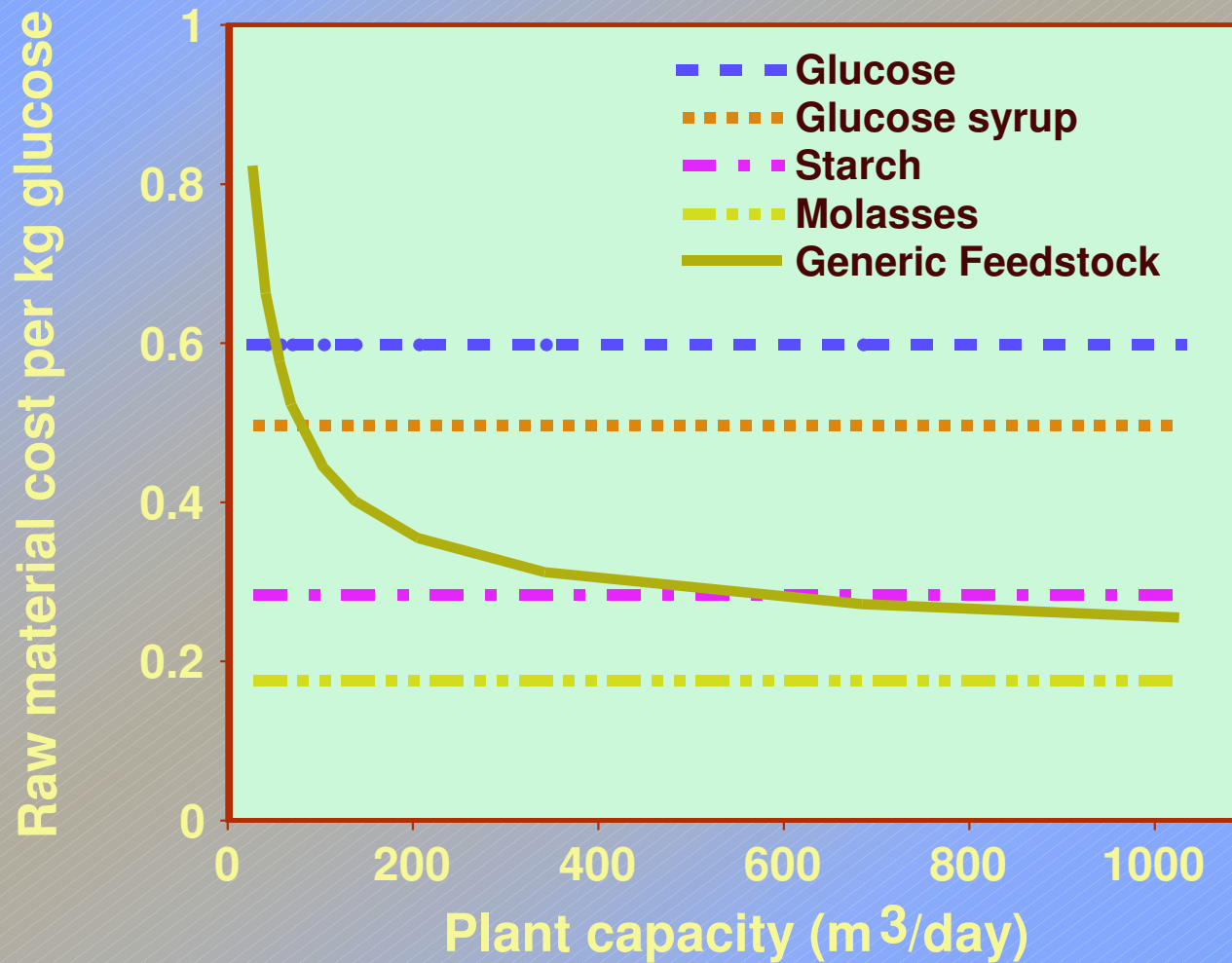
$$\text{RMCR} = \left(\frac{\text{Estimated cost of feedstock for conventional process}}{\text{Estimated cost of wheat for intended bioprocess}} \right) \times \left(\frac{1}{\text{Risk factor}} \right)$$



The higher the RMCR value than unity for a specific bioproduct, the more cost-competitive wheat can be in comparison to conventional feedstock



INFLUENCE OF PRODUCTION CAPACITY ON OPERATING COST



CONCLUSIONS

- An increase of the wheat yield from 2.65 to 5.5 tonnes per hectare cultivating land could permit the production of major petrochemicals and fermentation products using wheat as feedstock
- Wheat as fermentation feedstock could be more economical than current feedstocks in the case of fermentation products and specific intermediate petrochemicals
- Other cereal grains could provide a more cost-competitive renewable source for feedstock production

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