The impact of biofuel on fuel prices and the environment: a multiproduct noncompetitive set-up

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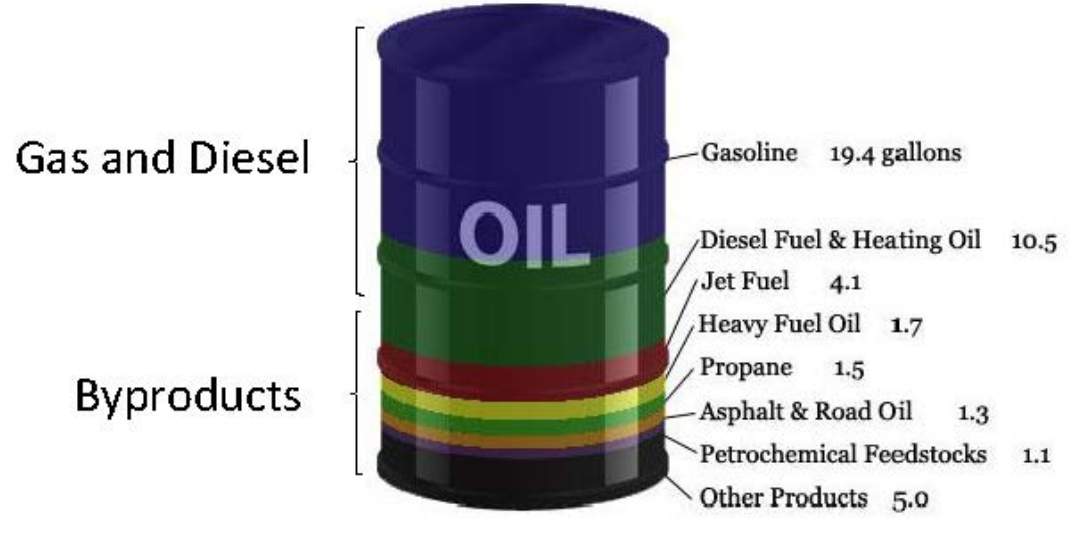
Motivation

- Regulation of biofuels is based on estimates of the impact of biofuel on greenhouse gas emission, using lifecycle analysis.
- Most of the literature conducting such assessments assumes perfectly competitive fuel markets and ignores the fact that fossil fuels are a result of a multiproduct process, whereby gasoline and diesel are derived from crude oil together with other petroleum products.

But …

- crude oil is used to produce gasoline and diesel, as well as other petroleum products such as liquid-petroleum-gas and asphalt.



Putty-clay structure

- The petroleum refining process is a capital-intensive process, whereby once a refinery is configured and the capital investment made short-term decisions are constrained by existing technologies.
  - This is an industry whose response to market fundamentals is limited in the short-run but becomes much more flexible in the long run.

Not a competitive environment

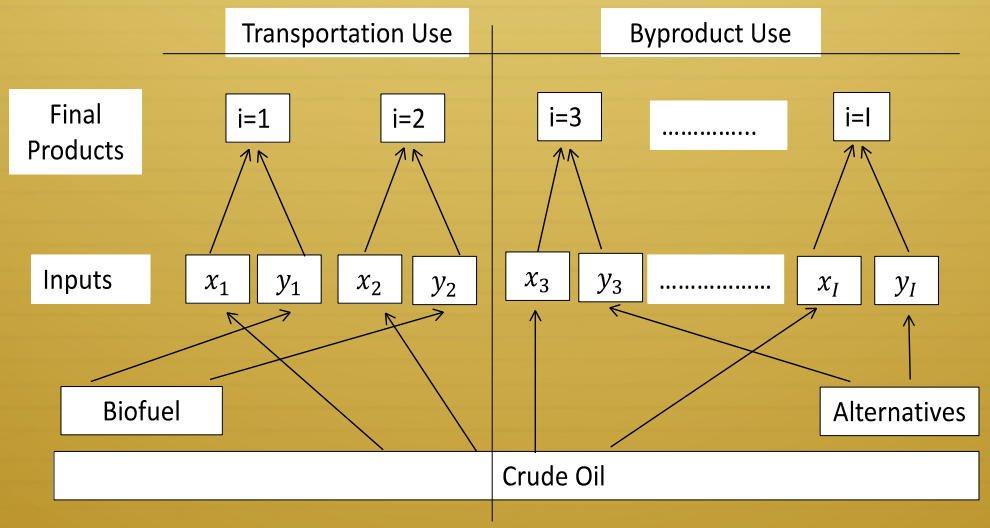
- The refining industry is an oligopolistic industry
- The petroleum refineries respond to the introduction of biofuels, and this effect is different than what is implied under competition.
- This leads to differences in
  - Environmental side effects
  - Dynamics of the introduction and adoption of alternatives energy sources
  - Pricing of various petroleum products
  - Distributional implications

A simple numerical model

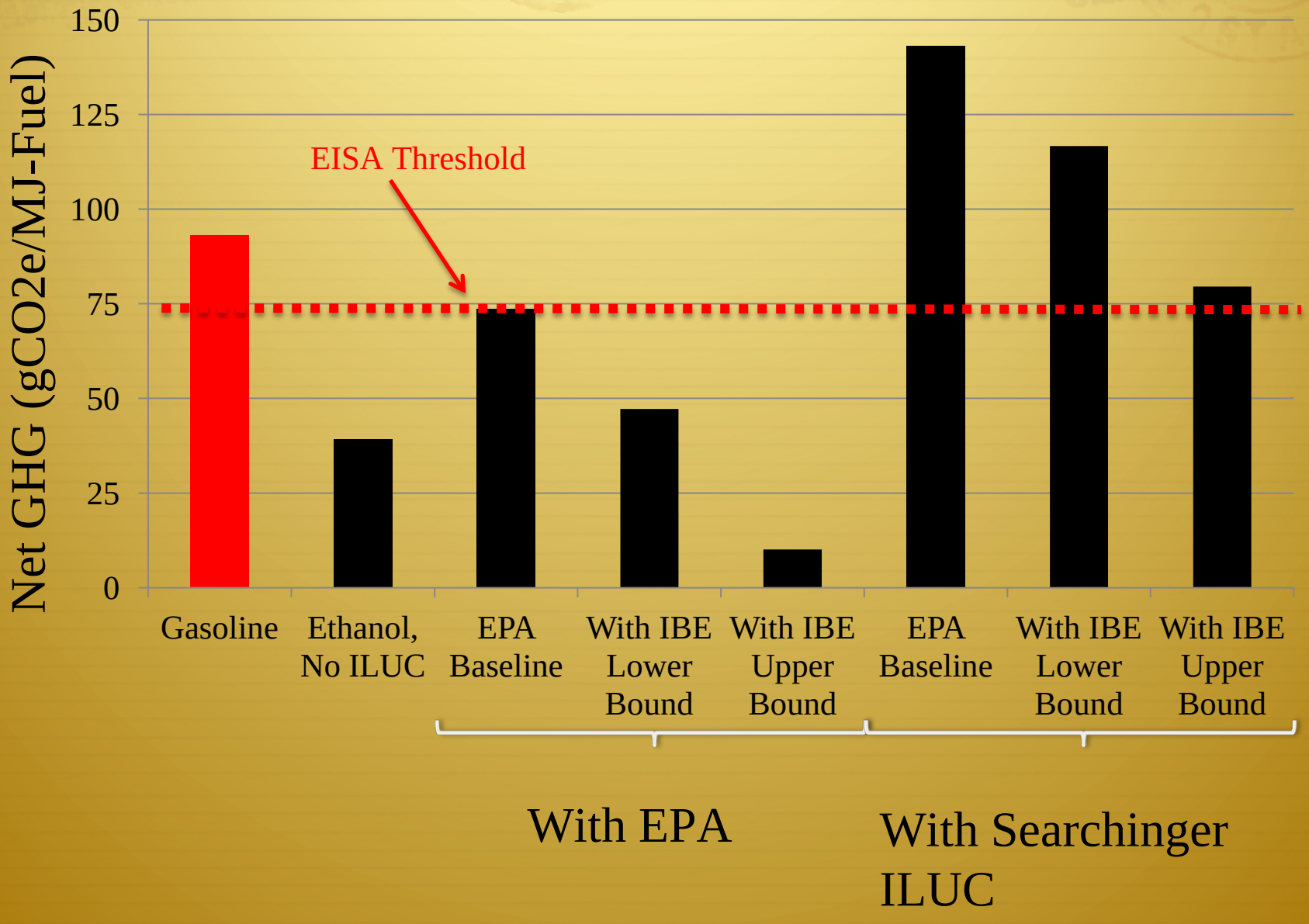
The indirect co-product effect

- The indirect co-product effect is defined as the change in GHG emissions associated with changes in petroleum co-product supply resulting from increased biofuel use.

- **Production system**



Annualized Emissions for Corn-Based Ethanol



Indirect co-product effect

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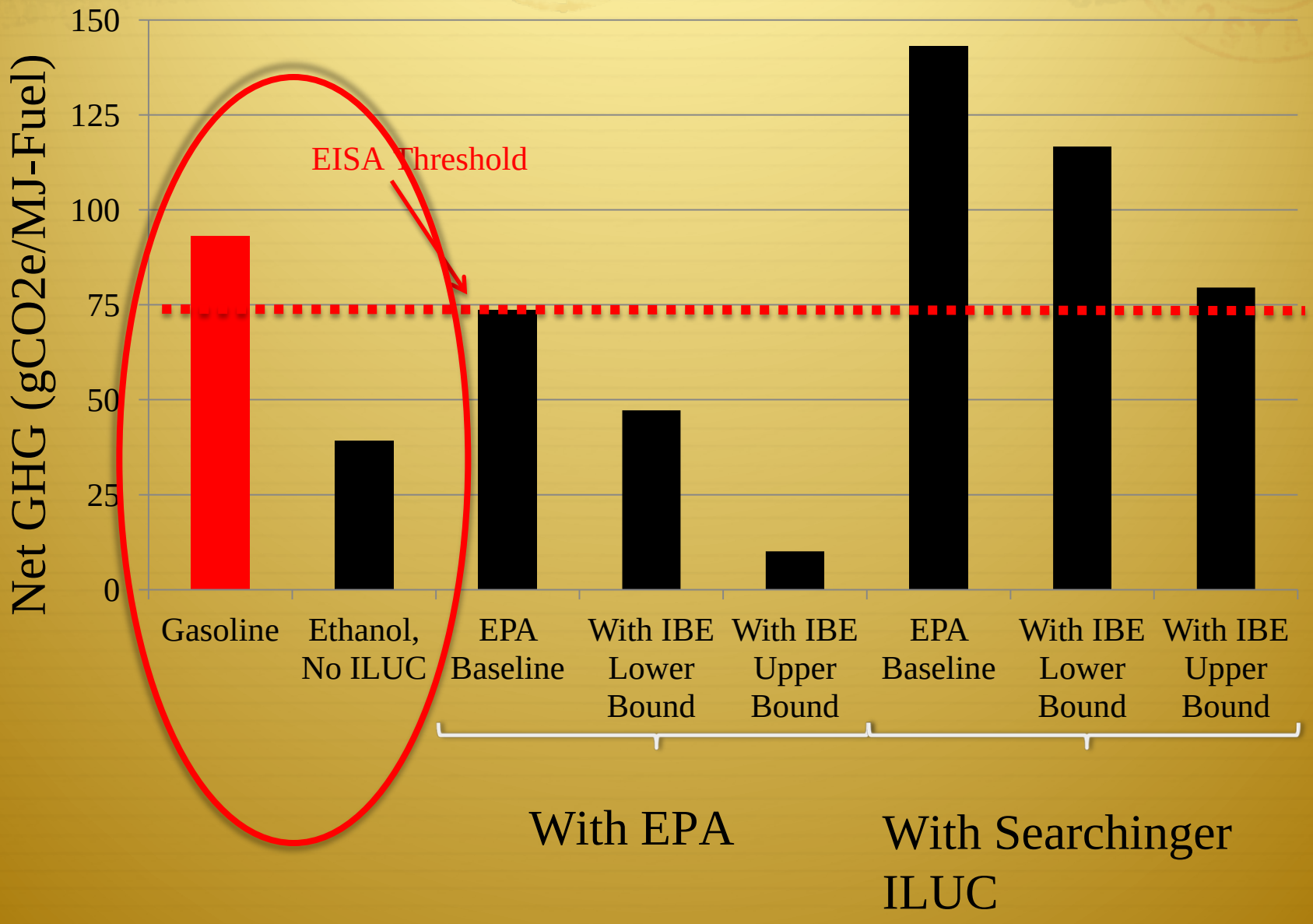

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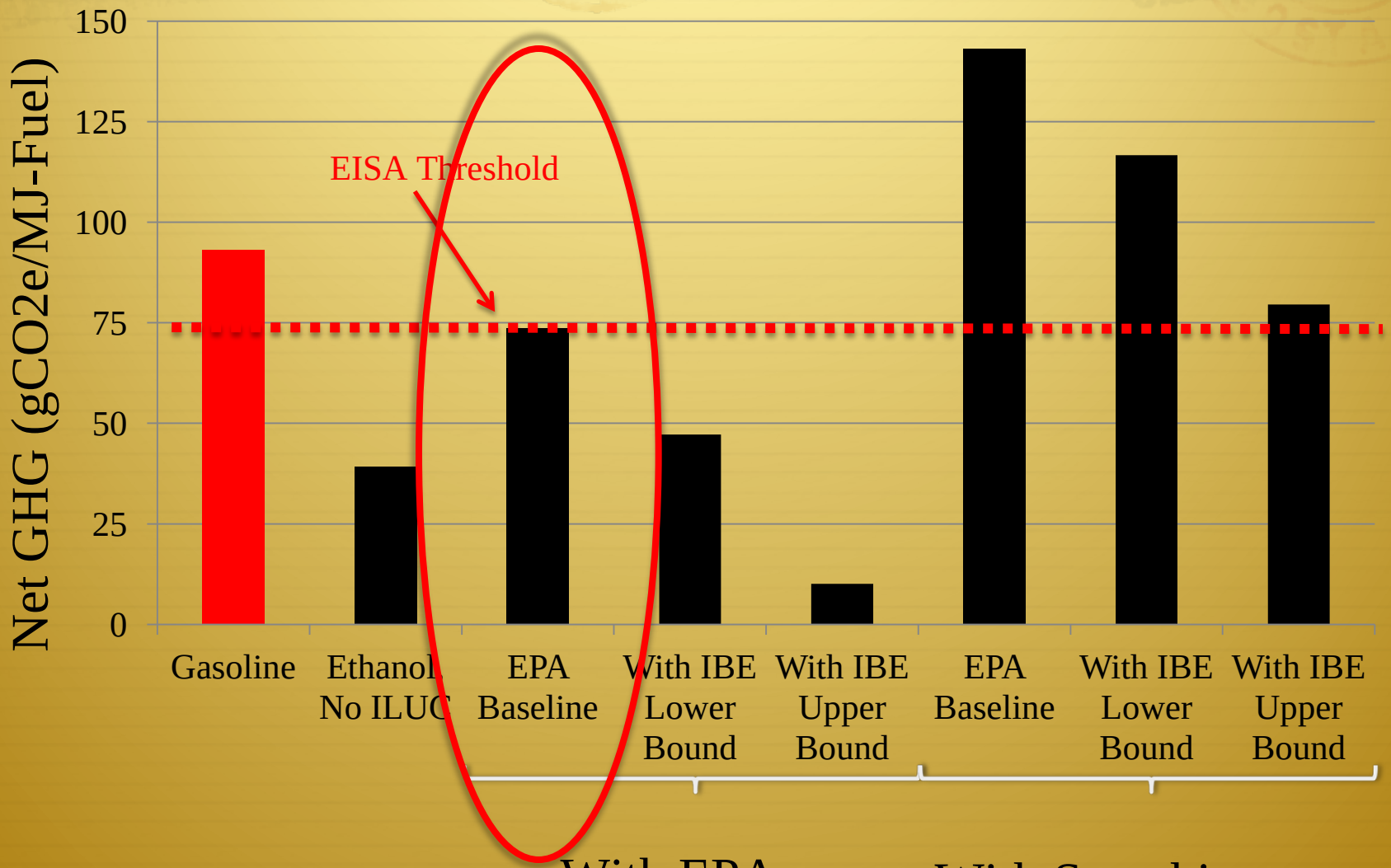

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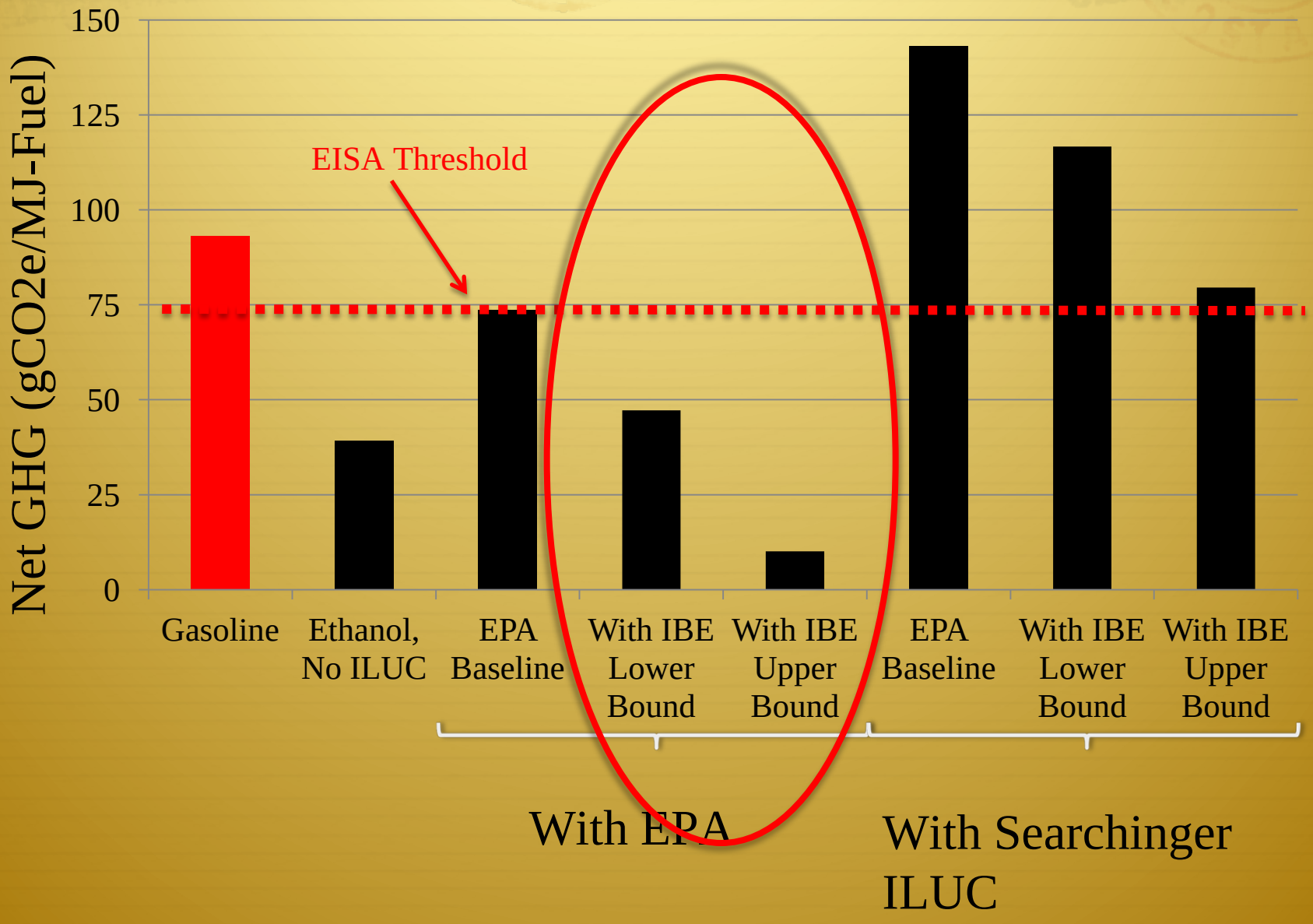

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- Using the Searchinger et al. estimates, without including indirect co-product effect, corn-based ethanol emits 143 gCO2e/MJ, or 54% more GHGs than gasoline (column 5). Including the IBBE estimate under fixed proportion assumption, corn-based ethanol emits 97 gCO2e/MJ (column 6).

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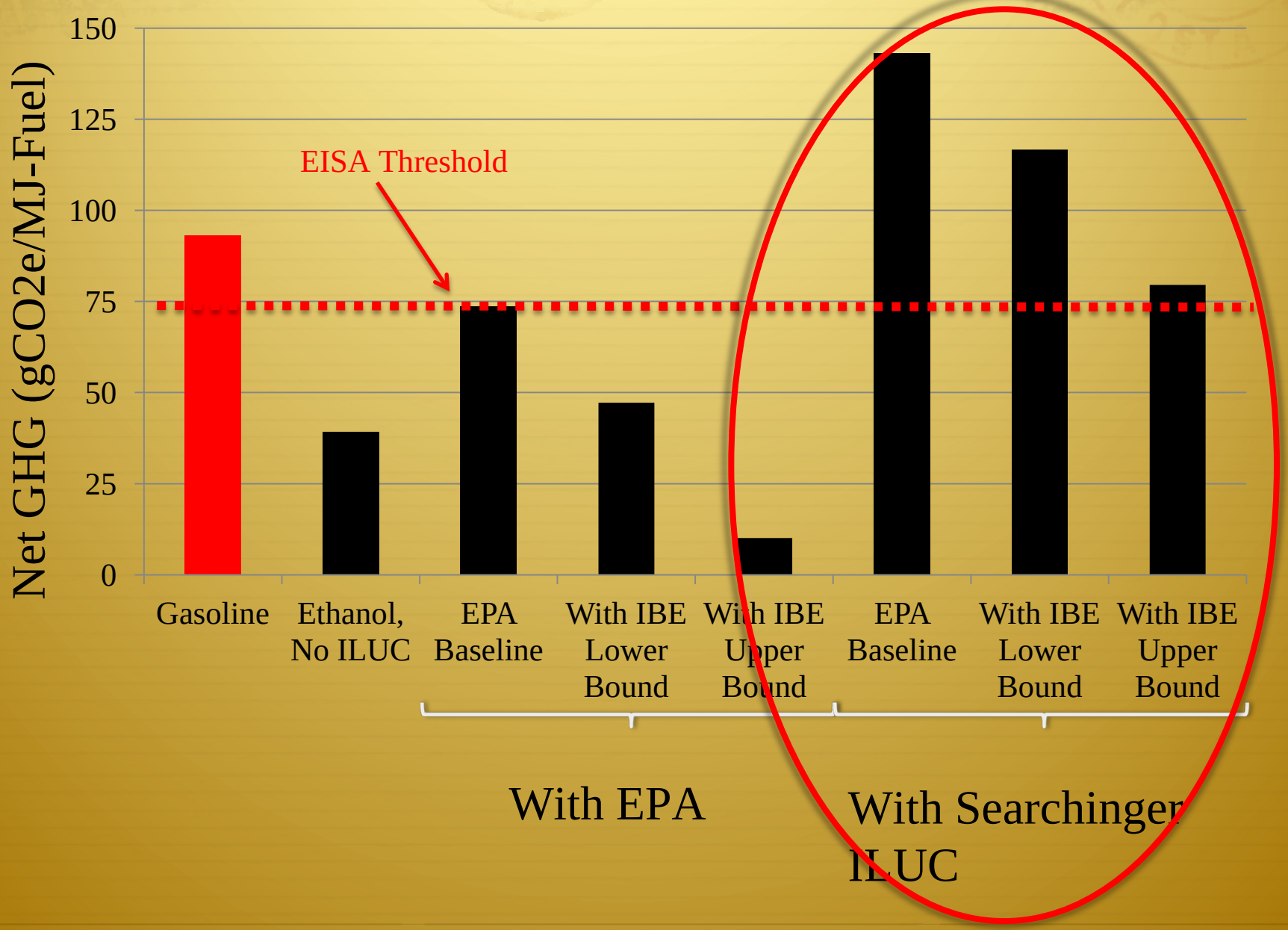
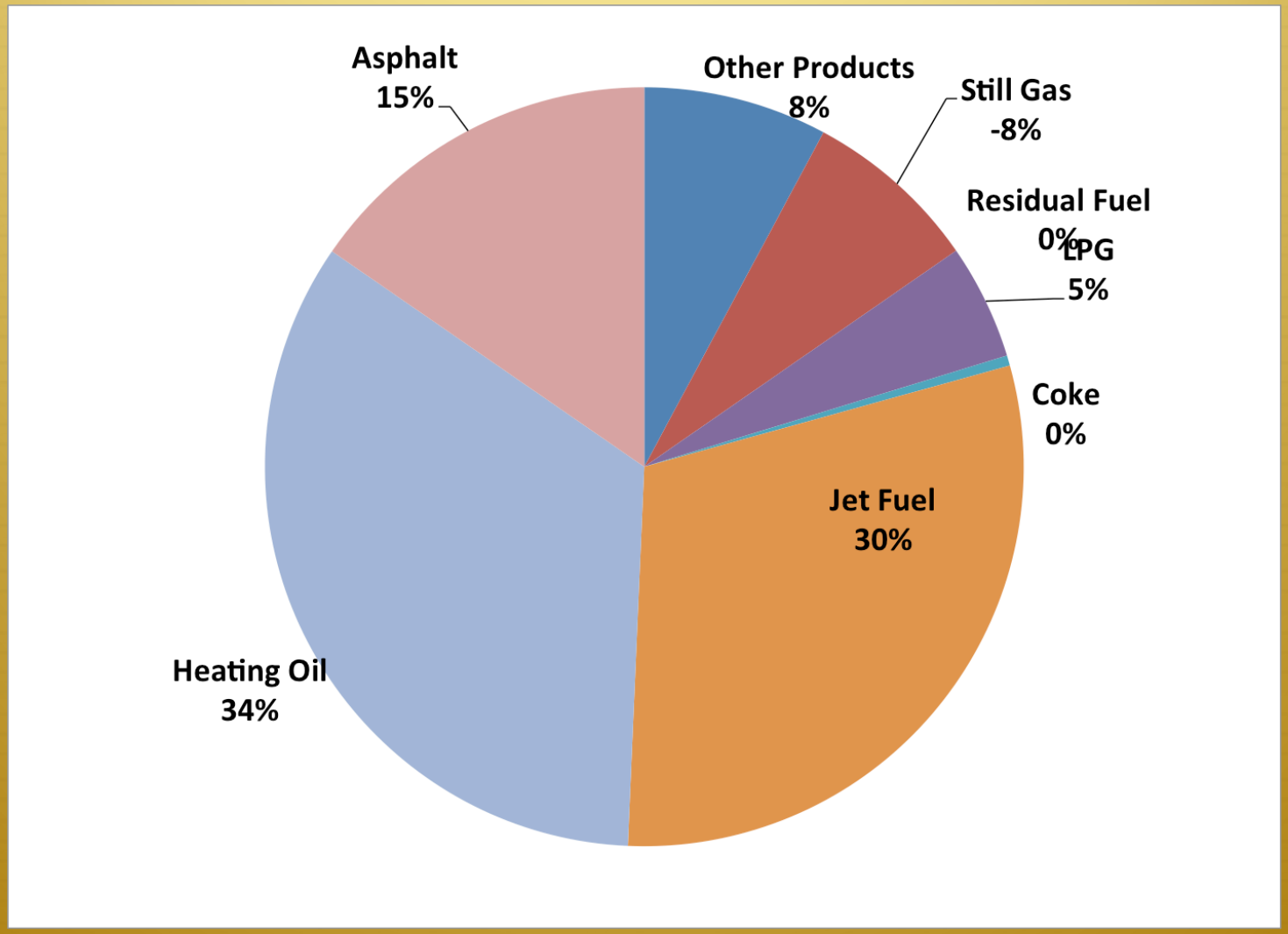
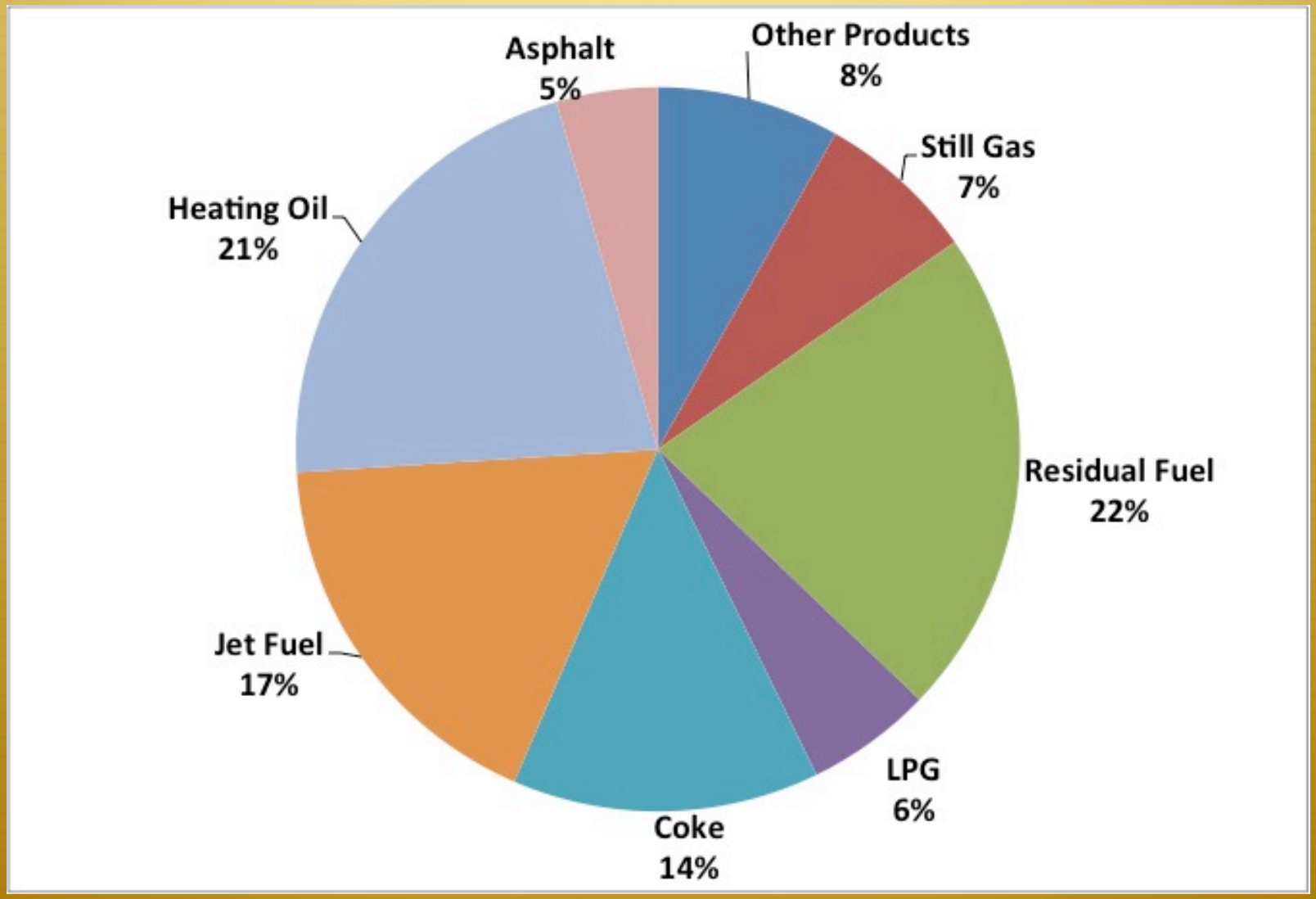


Co-product contributions to GHG savings under *full replacement*



Co-product contributions to GHG savings under *no* replacement



Comparing the two outcomes

- The reason for the more even distribution under the assumption of no replacement, is that the emissions differentials are all on the same order of magnitude, unlike in the full replacement case, in which we assume the emissions differential from jet fuel and heating oil to be much larger than the differentials associated with the remaining co-products.

Reintroducing non-competitive behavior

The short run: With the introduction of the non-petroleum sector

- Amount of gasoline supplied to the market declines, but so does the amount of asphalt.
- The price of gasoline declines (the rebound effect) *but* the price of asphalt increases.
- The petroleum refinery response results in a larger decline in amount of gasoline supplied to the market, and thus a lower decline in prices, than in competition.
- Assuming non-competitive behavior results in a larger indirect fuel and co-product effect, than in competition.

The long run: Intensive and extensive margins

- The introduction of alternative to gasoline results in inefficient refineries exiting the industry, and active refineries adjusting the technology and producing more of the petroleum co-products, relative to the short-run.
- But the introduction of an alternative results in less petroleum co-products produced, both in the short-run and in the long run.

concluding remarks: The implications to greenhouse gas accounting

- The fall in supply of fossil fuels affects production of other petroleum products resulting in an indirect effect, namely, the indirect co-product effect, where under plausible scenarios may be larger than the biofuel indirect land use effect.
- The rebound effect is substantially smaller than in previous studies that assumed competitive behavior.

Implications to advance biofuels

- The feedstock for advance biofuels offer significantly higher yields and do not compete with the food supply, which means the indirect effects on land-use change will be much smaller. However, the indirect co-product and fuel effects on GHG reductions is the same regardless of the biofuel technology replacing gasoline and diesel, which suggests that advance biofuels may carry even larger environmental benefits than are currently believed.