CBE research referenced: Karras, 2010 (http://pubs.acs.org/doi/abs/10.1021/es1019965)
Karras, 2012 (http://pubs.acs.org/doi/abs/10.1021/es301915z)

Hirshfeld and Kolb's response[1] to my comment[2] on their paper[3] now asserts that they "neither critiqued nor rejected" the public domain ("PD") refinery emissions model I reported.[4] This is a useful clarification of their analysis, given the following problems.

Their response ignores a clearly identified error, and that carries forward an invalid comparison of the PD model and their linear programming ("LP") model results. Both models estimate increasing emissions from refining lower quality crude.[3,4] Thus, a valid comparison of these models' emission results must account for crude quality. Their comparison does not do so. Therefore, their comparison of LP and PD results is invalid.

My comment clearly identifies this error, stating that their comparison "excludes PD results for crude feeds similar to those they analyze" and instead "selects PD results for much denser, higher sulfur oils."[2] This is a serious error of selective data exclusion. Their response fails to acknowledge this serious error and compounds the problem by repeating this error: Their revised assertion that PD emission results are "3–4 times higher (per barrel of crude) than our estimate"[1] is spectacularly erroneous because of this selective data exclusion. Fortunately, independent reviewers can confirm their error by comparing the LP results, and the PD results for similar-density and similar (or lower) sulfur crude feeds, given in the tables cited in the caption of my comment's Figure 1. Relevant results from those tables are excerpted for reference in Table 1 below.

Table 1. Comparison of refinery emission model results for crude quality scenarios S2–S4

	Crude feed quality		CO_2 emission/vol crude	
Model (result)	(spec. gravity)	(sulfur % wt.)	(kg/m^3)	LP Δ from PD[a]
PD (PADD 3, 2005)[b]	0.878	1.64	323.7	3–5%
PD (PADD 3, 2008)[b]	0.879	1.70	324.6	3–5%
LP (Scenario S2)[c]	0.885	1.60	306.9–313.9	—
PD (PADD 5, 2007)[b]	0.885	1.25	328.4	4–6%
PD (PADD 5, 2006)[b]	0.888	1.23	332.9	6–8%
PD (PADD 5, 2004)[b]	0.889	1.26	336.3	5–7%
PD (PADD 5, 2005)[b]	0.889	1.28	336.5	5–7%
LP (Scenario S3)[c]	0.889	1.76	312.6–319.5	—
PD (PADD 5, 2003)[b]	0.889	1.23	337.0	5–7%
PD (PADD 5, 2002)[b]	0.890	1.22	338.2	5–8%
PD (PADD 5, 2002)[b]	0.890	1.22	338.2	4–7%
PD (PADD 5, 2008)[b]	0.890	1.36	338.9	5–7%
LP (Scenario S4)[c]	0.892	1.76	313.9–323.3	—
PD (PADD 5, 2001)[b]	0.894	1.23	347.1	7–10%
PD (PADD 5, 1999)[b]	0.895	1.24	349.9	8–10%

(a) The difference of the LP result for similar-density crude feeds from each PD result, in percent.
(b) Public domain model results from ref 4, Supplemental Information Table S8 (PD results for the four crude feed densities most similar to each LP scenario).
(c) Linear programming model results for scenarios S2–S4 from ref 3, Table 3 (the high end of the emission ranges shown assume more stringent future fuel standards in the year 2025).

Equally troubling, they blame the difference between their results and observed data on differences between their scenario S4 model inputs and similar-density (PADD 5) observations with respect to (i) refined product specifications; (ii) gasoline and light liquids yield; and (iii) crude sulfur content[1] but they fail to support this claim. Their response presents no data comparing their modeling of these factors with the observed (PADD 5) data. Moreover, other information appears to contradict this claim:

(i) Their paper reports modeling current (2010) and potentially more stringent (2025) refined product specifications.[3] This should result in refinery energy intensity due to product specifications that is equal to or greater than that observed across PADD 5 refineries during 1999–2008, not the lower modeled energy intensity that they report.

(ii) Gasoline and total light liquids (gasoline, distillate, kerosene and naphtha) yields calculated based on the scenario S4 modeling they report are similar to or higher than those observed at similar crude feed density (see Table 2 below). This too should result in refinery energy intensity equal to or greater than that observed at similar crude feed quality, not the lower modeled energy intensity that they report.

(iii) Finally, the crude feed sulfur content they model in scenario S4 (1.76 % wt.) is greater than that observed at similar crude feed density (1.22–1.36% wt.; see Table 2 below). This too should result in refinery energy intensity greater than that observed at similar crude feed density, not the lower modeled energy intensity that they report.

Table 2. Crude feed sulfur content and light liquids yields modeled by Hirshfeld and Kolb in their scenario S4 vs. those observed for similar-density crude feeds

	Crude feed quality		Light products yield (%)	
	(spec. gravity)	(sulfur % wt.)	(gasoline[a])	(light liquids[a])
Observed (PADD 5, 2002)[b]	0.890	1.22	47.4	82.7
Observed (PADD 5, 2008)[b]	0.890	1.36	45.7	84.8
Modeled (Scenario S4)[c]	0.892	1.76	46.9–47.2	86.9–87.4
Observed (PADD 5, 2001)[b]	0.894	1.23	45.6	81.1
Observed (PADD 5, 1999)[b]	0.895	1.24	44.8	79.4

(a) Gasoline includes aviation gasoline. Light liquids include gasoline, distillate, kerosene and naphthas.
(b) Observed data from USEIA for crude quality (www.eia.gov/dnav/pet/pet_pnp_crq_dcu_nus_m.htm) and yields (www.eia.gov/dnav/pet/pet_pnp_pct_dc_r50_pct_a.htm). These data are also reported in ref 4, Supplemental Information Table S1.
(c) Modeled data for LP Scenario S4 from ref 3, Table 3 (crude feed quality) and Table SI-12 (inputs and outputs for products yield); yield calculated as defined by USEIA by CBE. The yield ranges shown reflect modeling for current (2010) and potential future (2025) refined product standards.

In sum, the discrepancy between their results and observed data suggests that their model underestimates impacts of refining denser crude (see ref 2, Figure 1B), and available data do not support the claim that the other factors they cite explain this discrepancy.

Further, they appear to rely on this unsupported claim instead of exploring other possible reasons for the widening discrepancy between LP results and observed data as crude density worsens. My comment describes a possible reason for the discrepancy—which is consistent with their caution that the LP model may assume ideal processing conditions, thereby understating energy used in real-world refining—and points out that data disclosure could allow this possibility (and others) to be confirmed or rejected.[2] Their failure to respond to this point is a specific example of a broader scientific issue.

Crucially, Hirshfeld and Kolb recommend their proprietary refinery emissions model for use in making public policy choices about climate.[3] But when estimates can be based on publicly verifiable science, as can be done here,[4] it is not appropriate from a scientific or public policy view to estimate potentially irreversible pollution (such as that from investments in processing lower quality crude) based on secret data and modeling. Their response does not respond to my comment on this point. Instead, they state that: "The client community [oil industry] vets proprietary refinery LP models because they are used in applications of practical consequence."[1] The "practical consequence" of applying an unverifiable estimate of potential emissions from refining lower quality petroleum could—if it underestimates that pollution—have serious public impacts. Ultimately, the proprietary interest in the private effort to develop their LP model that they assert[1] might accentuate the need for a publicly verifiable "check" on that proprietary model's estimate, but it does not address or resolve a fundamental problem: Data secrecy undermines scientific progress and could allow otherwise preventable hazards to develop.[2,5]

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(1) Hirshfeld, D. S.; Kolb, J. A. Response to comment by Karras on "Analysis of energy use and CO_2 emissions in the U.S. refining sector, with projections to 2025." *Environ. Sci. Technol.* **2012**, DOI: 10.1021/es302393w. (http://pubs.acs.org/doi/abs/10.1021/es302393w)

(2) Karras, G. Comment on "Analysis of energy use and CO_2 emissions in the U.S. refining sector, with projections to 2025." *Environ. Sci. Technol.* **2012**, DOI: 10.1021/es301915z. (http://pubs.acs.org/doi/abs/10.1021/es301915z)

(3) Hirshfeld, D. S.; Kolb, J. A. Analysis of energy use and CO_2 emissions in the U.S refining sector, with projections to 2025. *Environ. Sci. Technol.* **2012**, *46,* 3697–3704, DOI: 10.1021/es204411c. (http://pubs.acs.org/doi/abs/10.1021/es204411c)

(4) Karras, G. Combustion emissions from refining lower quality oil: What is the global warming potential? *Environ. Sci. Technol.* **2010**, *44,* 9584–9589, DOI: 10.1021/es1019965. (http://pubs.acs.org/doi/abs/10.1021/es1019965)

(5) Edsall, J. T. Scientific freedom and responsibility: Report of the AAAS Committee on Scientific Freedom and Responsibility. *Science* **1975**, *188* (4189), 687–693.