Climate Impact of Oil Infrastructure Destruction in the Ukraine–Russia and Iran–Israel–US Wars

A Quantitative Assessment of Direct CO_2, Black Carbon, and Supply-Side Effects

Preliminary analysis — data as of May 2026

Abstract

We estimate the atmospheric impact of oil infrastructure destruction in two ongoing conflicts: the Ukraine–Russia war (2022–present) and the Iran–Israel–US war (2026). In the central scenario, direct fire emissions total **4.0 Mt CO_2**, representing roughly 3 hours of global oil combustion. Black carbon totals **71 kt** – a short-lived regional warming pulse lasting approximately one week. While airborne, BC absorbs solar radiation and causes regional warming; it is washed out by precipitation within days and leaves no lasting global signal. Assuming full and immediate market replacement (upper-bound for fire impact), the combined direct warming in CO_2-equivalent terms is approximately **28 Mt** (using conservative $GWP_{100} = 342$), dominated by BC. Under realistic supply-disruption assumptions, secondary demand destruction from the IEA-confirmed 10.1 Mbbl/day March 2026 supply shock easily exceeds fire emissions, yielding a net-negative CO_2 outcome in all but the full-substitution scenario.

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1 Introduction and Scope

Large-scale military conflict destroys oil infrastructure through two mechanisms with opposite atmospheric implications: fires that directly combust stored hydrocarbons, releasing CO_2 and black carbon; and destruction of refining or export capacity, which removes oil from the market and reduces eventual combustion.

Included in this analysis. Direct CO_2 from fires (with open-fire efficiency penalty); black carbon (BC) emitted; secondary demand reduction from supply disruption via price elasticity; and supply substitution sensitivity.

Excluded. Sulfate and other reflective aerosol cooling while airborne (real but partially cancels BC warming and is negligible at global scale, as demonstrated by Kuwait 1991); embodied carbon from reconstruction; long-run energy transition effects.

Why CO_2 and BC are reported separately. CO_2 persists in the atmosphere for centuries – it is a permanent stock addition. BC (soot) has an atmospheric lifetime of $\sim$1 week before being washed out by precipitation. Adding them using a Global Warming Potential (GWP) factor is technically possible and is done for reference in Section 3.2, but the resulting number conflates a permanent, cumulative warming agent with a transient, regional pulse. The two effects are reported separately throughout, and their sum is presented only as a worst-case direct estimate.

2 Oil Volume Estimates

2.1 Ukraine–Russia War

Russia's air campaign destroyed virtually the entire Ukrainian domestic refining sector by mid-2022 [11], forcing 100% fuel import dependency. Ukraine conducted a sustained long-range drone campaign against Russian refineries and export terminals from 2024 onwards [12]. The most comprehensive published volume measurement is the GHG Accounting of War project, which measured 686,168 tonnes of fuel burned on Ukrainian-controlled territory in the first ten months of the conflict [18]. By October 2025, facilities with ∼38% of Russia's nameplate refining capacity had been struck, with Carnegie estimating actual throughput reduction at ∼30% [13, 14].

Table 1: Ukraine–Russia War: oil/fuel fire events. Confidence: * moderate, ** low, *** very low (capacity-based estimate only).

Event	Fuel	Low (kt)	Central (kt)	High (kt)
Bryansk fuel depots (Apr 2022)*	Diesel	7	12	15
Feodosia oil depot, Crimea**	Crude	10	30	70
Russian refinery fires 2024–26***	Mixed	100	350	1,200
Ukrainian fuel depot losses 2022–26**	Diesel	350	650	1,000
Total		**467**	**1,042**	**2,285**

2.2 Iran–Israel–US War

The US–Israeli military campaign began 28 February 2026. Key events include strikes on Tehran fuel depots and the Tehran refinery (225,000 bbl/day) on 7–8 March 2026 [15], and Iranian retaliatory strikes on Gulf state facilities (Ras Tanura, Ruwais) [17]. Saudi Aramco officially described the Ras Tanura fire as "limited, from intercepted missile debris, quickly controlled." The Climate and Community Institute (QMUL) gives an aggregate estimate of 335–790 kt burned across all Iran conflict fires in the first 14 days [20]; our event-level estimates are consistent with this range.

Table 2: Iran–Israel–US War: oil/fuel fire events. All Iran entries *** (very low confidence – no public volume data).

Event	Fuel	Low (kt)	Central (kt)	High (kt)
Tehran fuel depots & refinery (Mar 2026)***	Mixed	50	120	250
Gulf state refinery fires (Mar–Apr 2026)***	Mixed	70	250	700
Kharg Island oil spill (May 2026)†	Crude	5	11	20
Total (excl. spill)		**120**	**370**	**950**

† Marine spill, not a fire. Excluded from emission totals.

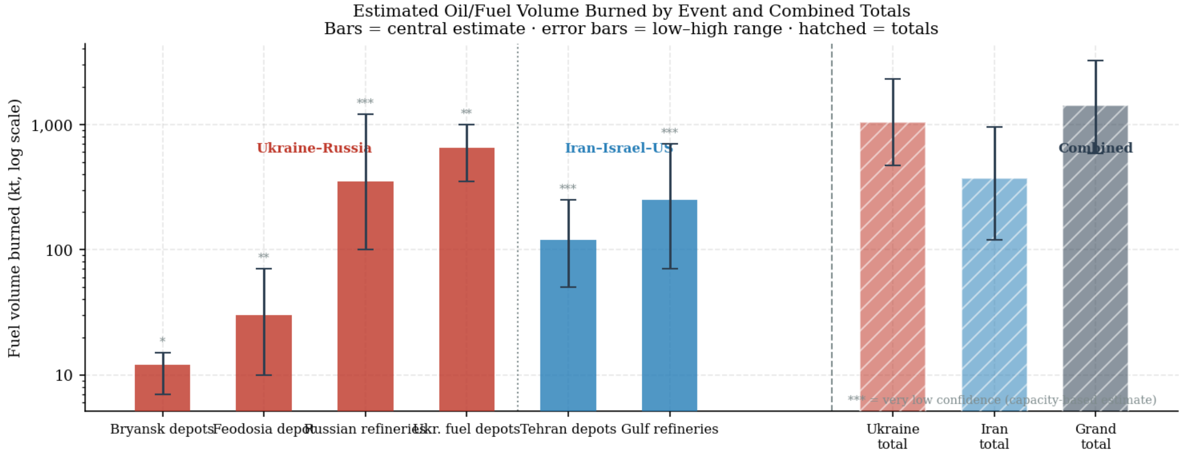

Figure 1: Estimated fuel volumes burned by event and combined totals (log scale). Solid bars = individual events; hatched bars = per-conflict and grand totals. Error bars = low–high range. Stars indicate confidence level.

2.3 Combined Fuel Volume

Table 3 aggregates the per-conflict totals from Tables 1 and 2.

Table 3: Combined fuel volume burned across both conflicts (kt).

Conflict	Low (kt)	Central (kt)	High (kt)
Ukraine–Russia War	467	1 042	2 285
Iran–Israel–US War	120	370	950
Grand total	**587**	**1 412**	**3 235**

The central estimate of **1,412 kt** is approximately 100× smaller in volume than the Kuwait 1991 fires (~136 Mt of oil over nine months), providing a useful calibration anchor: the Kuwait fires produced ~135 Mt CO_2, consistent with our central fire CO_2 estimate of ~4 Mt at 1/100 the volume.

2.4 Black Carbon Emitted

Open oil fires – particularly pool fires from storage tanks – produce significant black carbon through incomplete combustion. Laboratory and field measurements yield BC emission factors of 10–100 $\mathrm{g\,BC\,kg^{-1}}$ fuel, with a central estimate of ~50 $\mathrm{g\,kg^{-1}}$ [3, 4]. This is characteristic of pool fires burning at atmospheric pressure; well fires (such as Kuwait 1991) burn hotter and produce far less BC per unit fuel (~4 g/kg), so the Kuwait calibration is not directly applicable here.

In the central scenario, total BC emitted is **71 kt**: 52 kt from Ukraine-related fires and 19 kt from the Iran conflict. BC is removed from the troposphere within days to weeks by wet scavenging.

3 Direct Climate Effects

3.1 CO_2 Emissions from Fires

The CO_2 emission factor for crude oil under complete combustion is approximately 3.07 $\mathrm{kg\,CO_2\,kg^{-1}}$ fuel [5, 6]. Open fires are less efficient than engine combustion ($\eta \approx 0.90$ for large pool fires vs $\eta_0 \approx 0.99$ for engines); consequently fires emit *slightly less* CO_2 per tonne of fuel – the unoxidised fraction becomes CO, hydrocarbons, and black carbon. The total direct CO_2 from the fire is:

$$\mathrm{CO}_{2,\mathrm{fire}} = M_{\mathrm{fuel}} \times EF_{\mathrm{CO}_2} \times \eta \tag{1}$$

Table 4: Direct CO_2 from fires (Mt) and BC emitted (kt, central scenario)

	Direct CO_2 (Mt)			BC central (kt)
Conflict	Low	Central	High	
Ukraine–Russia War	0.7	2.9	4.6	52.1
Iran–Israel–US War	0.3	1.0	2.7	18.5
Grand total	**1.0**	**4.0**	**7.3**	**70.6**

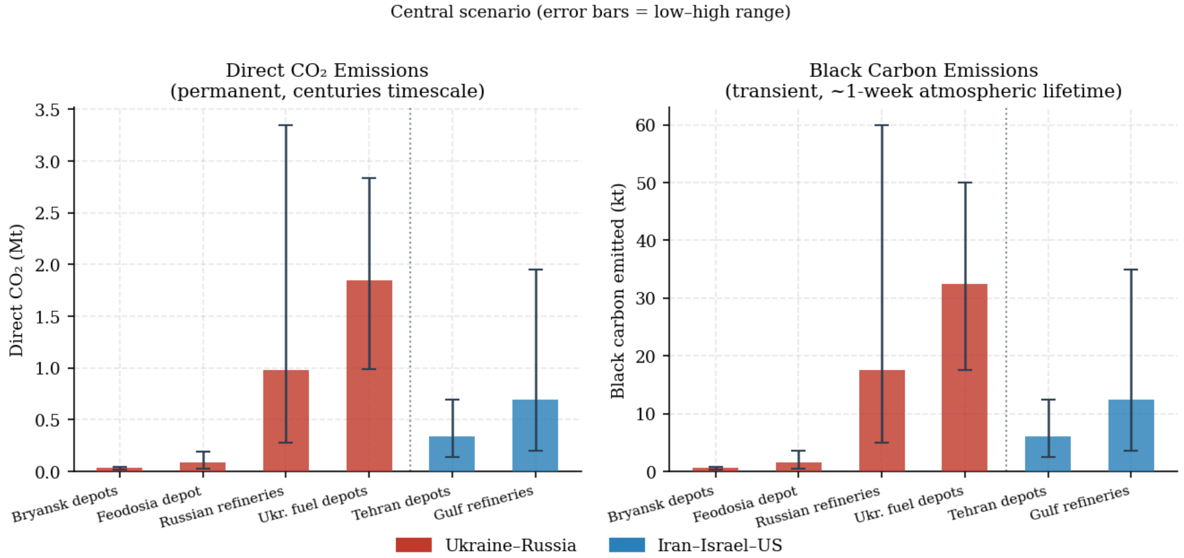

Figure 2: Direct CO_2 (left, permanent) and black carbon emitted (right, ∼1-week pulse) by event. Error bars show volume low–high range.

3.2 Black Carbon in CO_2-Equivalent Terms

As noted in Section 1, BC and CO_2 should not be aggregated for policy purposes. We nonetheless present GWP-based CO_2-equivalents for reference and cross-study comparison. The GWP expresses how much cumulative radiative forcing 1 kg of substance produces over a given time horizon, relative to 1 kg of CO_2. Because BC has a ∼1-week lifetime, its numerator in the GWP ratio is already fully "spent" by year 1, while the CO_2 denominator keeps growing at longer horizons – so the GWP decreases strongly with horizon length.

Table 5: Black carbon (central scenario, 70.6 kt total) expressed as CO_2-equivalent using NILU 2023 $GWP_{100} = 342$ (direct radiative effect only, conservative estimate [1, 5]). Note: IPCC AR6 GWP_{100} for BC spans −200 to +3,500 when uncertain indirect effects are included; 342 represents the lower end of the direct-forcing range.

	BC (kt)	GWP_{20} (2530)	GWP_{100} (342)	GWP_{500} (222)
			Mt CO_2-eq	
Ukraine–Russia War	52.1	132	18	12
Iran–Israel–US War	18.5	47	6	4
Total	**70.6**	**179**	**24**	**16**
Ratio to direct fire CO_2 (4.0 Mt)		45×	6×	4×

The dramatic reduction across horizons illustrates why the chosen time horizon determines whether BC looks dominant or minor. This report uses $\mathrm{GWP}_{100} = 342$ (conservative, direct forcing only) as the reference value: 71 kt of BC is equivalent to approximately **24 Mt $\mathbf{CO_2}$** CO_2-eq.

3.2.1 Short-lived Atmospheric Cooling While Airborne

The GWP calculation above captures the *warming* effect of BC. While the smoke plume is airborne, oil fires simultaneously emit sulfate and organic aerosols that *scatter* solar radiation, producing a short-lived regional cooling effect that partially offsets BC warming. This cooling is real but transient, operates on the same ∼1-week timescale, and is excluded from the GWP-based estimate above for the following reasons:

1. **Empirical precedent.** The Kuwait 1991 fires provide the definitive reference: ∼1 billion barrels burned over 10 months, emitting ∼3,400 tonnes BC/day at peak [2]. Despite predictions of severe regional cooling, the global temperature impact was **negligible**. Smoke reached only 3–6 km altitude (lower troposphere); both BC and sulfate aerosols rained out within weeks. Our central scenario BC total (71 kt) is approximately 1/35 of the Kuwait event – far below the threshold for measurable global effects.
2. **Partial cancellation.** Warming (BC) and cooling (sulfate) aerosols co-emit and partially cancel. Including only one sign would be misleading; including both adds noise without changing the policy-relevant conclusion that both are short-lived and regionally confined.
3. **Scope.** This report focuses on lasting atmospheric loading. The aerosol cooling effect disappears within weeks and leaves no long-term signal to account for.

3.3 Total Direct Effects

This section addresses the question: *what did the fires physically emit to the atmosphere, assuming the destroyed oil is immediately and fully replaced by equivalent supply elsewhere?* This full-replacement assumption gives the worst-case direct atmospheric loading from the fires. The secondary question – whether market substitution actually occurs – is addressed in Section 4.

Table 6: Total direct emissions under the full-replacement assumption. Fire CO_2 is permanent; BC CO_2-eq is a ∼1-week pulse ($\mathrm{GWP}_{100} = 342$, conservative direct estimate). The combined total should be interpreted as a worst-case direct figure, not a policy-equivalent permanent emission.

	Fire CO_2 (Mt)			BC (kt)			Combined CO_2-eq* (Mt)		
	Low	Central	High	Low	Central	High	Low	Central	High
Ukraine–Russia War	1.4	2.9	4.3	5	52	228	3	21	82
Iran–Israel–US War	0.4	1.0	1.8	1	18	95	1	7	34
Total	**1.8**	**4.0**	**6.0**	**6**	**71**	**324**	**4**	**28**	**117**

* Combined = Fire CO_2 + BC × $\mathrm{GWP}_{100}(342)/1000$.
Reference: global annual CO_2 from oil ≈12,000 Mt/yr.
4.0 Mt direct CO_2 = ∼3 hours of global oil combustion (4.0 ÷ 12,000 × 8,760 hr/yr).
28 Mt combined ≈ 3.7 years of Norwegian road traffic (7.5 Mt/yr).

The central combined figure (**28 Mt $\mathbf{CO_2}$-eq**) is dominated by BC: the BC contribution (24 Mt at $\mathrm{GWP}_{100} = 342$) is 6× larger than direct fire CO_2 (4 Mt). The ratio falls to 4× at the 500-year horizon ($\mathrm{GWP}_{500} = 222$) as BC's short atmospheric lifetime becomes increasingly diluted relative to the long-lived CO_2 denominator.

4 Secondary Effects: Supply Disruption and Demand Reduction

4.1 Mechanism

When oil production or refining capacity is *destroyed* – rather than merely blocked in transit – supply falls, prices rise, and demand falls. The CO_2 not emitted from this demand destruction is a genuine secondary benefit that does not revert when the disruption ends, because the fuel that was not refined and consumed during the outage cannot be "made up" retroactively: the trips not driven, the flights not taken, the industrial output not produced are permanently lost.

The CO_2 avoided equals the unsubstituted gap multiplied by the demand-destruction fraction and the standard emission factor ($430\,\mathrm{kg\,CO_2/bbl}$):

$$\Delta D = Q_{\mathrm{net\_removed}} \times \frac{|\epsilon|}{|\epsilon| + \epsilon_s} \quad ; \quad \mathrm{CO}_{2,\mathrm{avoided}} = \Delta D \times 430\,\mathrm{kg/bbl} \tag{2}$$

where $\epsilon = -0.10$ (range -0.04 to -0.20) [7, 8] is the short-run demand price elasticity, $\epsilon_s \approx 0.05$ is the short-run supply elasticity, and $Q_{\mathrm{net\_removed}} = Q_{\mathrm{disrupted}} \times (1 - s)$ is the unsubstituted supply gap after other producers partially fill the hole (substitution rate s, analogous to Libya 2011 where Saudi Arabia immediately replaced ∼27% of lost supply [9, 10]).

4.2 Ukraine: Sustained Refinery Capacity Destruction

Ukraine's drone campaign against Russian refineries and export terminals has reduced Russian refining throughput by an estimated ∼30% since mid-2024, cutting approximately **0.7 Mbbl/day** of refined product supply (central estimate) over a sustained period [14, 13]. This is a *capacity* disruption: individual refineries have been struck repeatedly, preventing sustained operations even after partial repairs. Russian crude is still extracted and exported (redirected to India and China), but the loss of domestic refining capacity creates a genuine, ongoing reduction in refined-product availability in European markets.

4.3 Iran War: Short-Term Demand Drop

The IEA Oil Market Report for April 2026 [16] confirmed that global oil supply fell by **10.1 Mbbl/day** in March 2026 due to the combined effect of the Strait of Hormuz blockade and conflict-related losses by Iran, Saudi Arabia, and Iraq. We model the demand reduction during the disruption window (central: 60 days) before OPEC spare capacity and SPR drawdowns compensate. The demand reduction during this window is treated as permanent: the consumption foregone (trips not taken, industrial output not produced) cannot be retroactively recovered once supply is restored.

We do *not* model the scenario where pent-up supply behind the Hormuz blockade flows back to markets after the strait reopens. That supply rebound would partially offset the avoided CO_2 estimated here.

4.4 Combined Scenarios

Table 7 brackets the combined outcome across both conflicts.

Table 7: CO_2-equivalent effects: both conflicts combined. Direct CO_2-eq = fire CO_2 + BC × GWP_{100} (342). Net CO_2-eq = direct minus avoided. Ukraine: 0.7 Mbbl/day for ∼18 months; Iran: 10.1 Mbbl/day for ∼60 days before OPEC compensation.

Scenario	Key assumptions	Direct CO_2-eq (Mt)	CO_2 avoided (Mt)	Net CO_2-eq (Mt)
LOW	Small disruptions; high OPEC substitution (80%/50%); low elasticity (−0.04).	3.8	−22	−18
CENTRAL	Best-estimate disruptions; 60%/25% substitution; elasticity −0.10.	28	−174	−146
HIGH	Large disruptions; low substitution (40%/10%); high elasticity (−0.20).	117	−597	−480

Direct CO_2-eq (central): fire 4.0 Mt + BC CO_2-eq 24 Mt = 28 Mt.

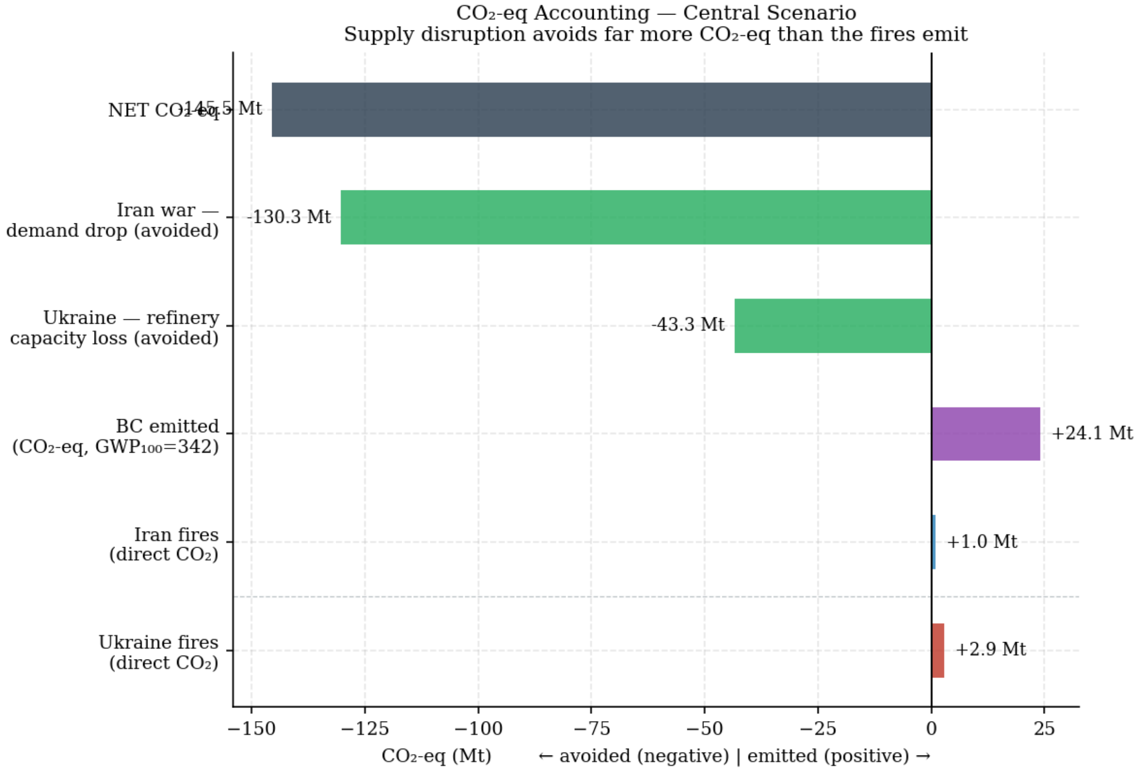

Figure 3: CO_2-eq accounting for the central scenario (both conflicts). Direct effects (fire CO_2 + BC × GWP_{100}) are dwarfed by demand reduction from the combined supply shock.

Comparison with direct effects. In the central case, demand destruction (−174 Mt) exceeds combined direct effects (fire CO_2 + BC CO_2-eq = +28 Mt) by a factor of ∼6. The net CO_2-eq is positive only if other producers fully compensate both disruptions simultaneously – a scenario without historical precedent at the magnitudes observed in 2024–2026.

4.5 Caveat: Supply Rebound Not Modelled

The estimates in Table 7 treat the demand reduction during the disruption window as permanent. If pent-up Hormuz supply flows back to markets after the strait reopens and is subsequently combusted, the Iran-side avoided CO_2 would be partially or fully offset. The true net CO_2-equivalent lies between +28 Mt (complete rebound: only direct fire CO_2 and BC × GWP_{100} remain; 4 Mt + 24 Mt = 28 Mt) and −146 Mt (complete demand destruction within the window; central estimate).

5 Key Uncertainties

Three parameters drive the net CO_2-equivalent result; two dominate (Table 8). Supply disruption scale and substitution rate together span a net range of more than 300 Mt. Demand price elasticity adds another 90 Mt of range. Fire volume estimates — the primary subject of Sections 2–3 — contribute only ±4 Mt: whether the fires burned 1,000 kt or 3,000 kt of fuel is almost irrelevant to the climate outcome.

Table 8: Key uncertainties and their qualitative effect on net CO_2. Each parameter varied independently from low to high; all others held at central.

Parameter	Range used	Net CO_2 range (Mt)	Main source of uncertainty
Supply disruption scale	±50% volume, ±2× duration	**Very large** (−47 to −390)	Duration before OPEC compensates; IEA data preliminary
Supply substitution rate	10–80% per conflict	**Very large** (−105 to −217)	OPEC spare capacity; political resolution
Demand price elasticity	−0.04 to −0.20	Large (−112 to −204)	Literature range; short-run vs. long-run
Fire volume estimates	3–7× central	Small (±4)	Operational secrecy; no satellite volume data
Combustion efficiency	60–96%	Negligible (±1)	BC/CO_2 split varies; total carbon fixed
BC emission factor	10–100 g/kg	Large on BC CO_2-eq; negligible on avoided	Pool fire vs. well fire; measurement scatter

6 Summary

Table 9: Summary of results: direct and secondary effects (both conflicts). Iran demand drop modelled for 60 days before OPEC compensation; supply rebound not modelled (see Section 4.5).

Scenario	Fire CO_2 (Mt)	BC CO_2-eq* (Mt)	Direct total (Mt)	CO_2 avoided (Mt)	Net CO_2-eq (Mt)	% global oil CO_2
LOW	1.8	2.0	3.8	−22.1	−18.3	−0.15%
CENTRAL	4.0	24.1	28.1	−173.6	−145.5	−1.21%
HIGH	6.0	110.6	116.6	−596.5	−479.9	−4.00%
No disruption	4.0	24.1	28.1	0	+28.1	+0.23%

* BC CO_2-eq uses $GWP_{100} = 342$ (NILU 2023).

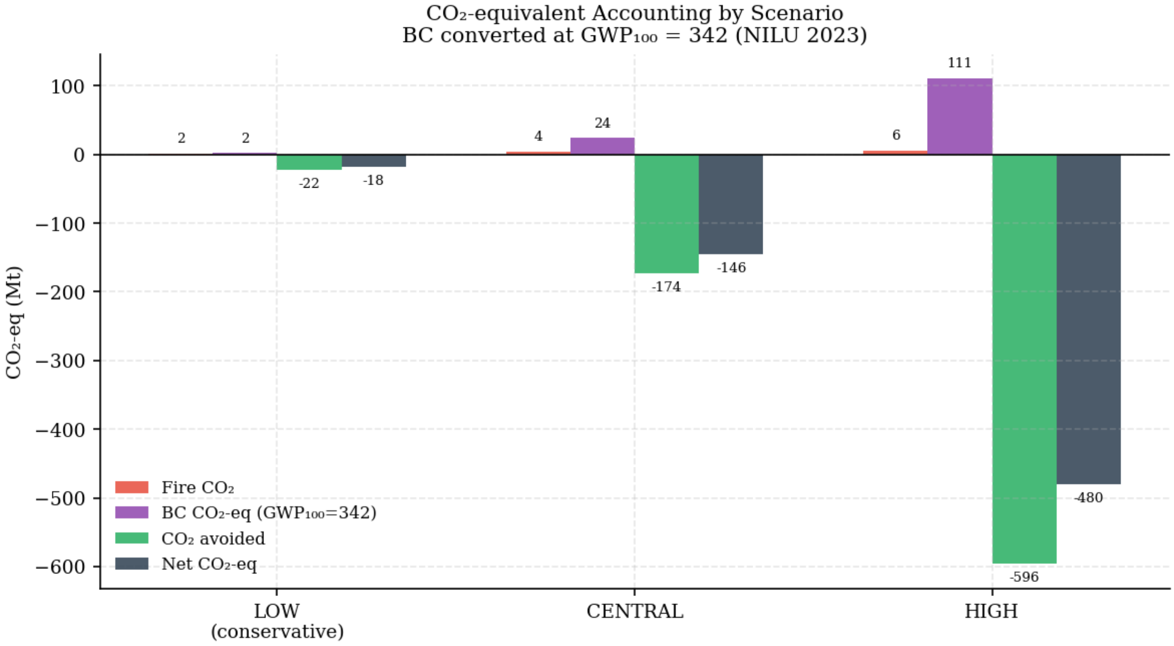

Figure 4: LOW / CENTRAL / HIGH scenario comparison.

Key conclusions.

1. **Direct fire CO_2 is globally negligible.** At 4.0 Mt central (range 1.8–6.0 Mt), fire emissions equal ~3 hours of global oil combustion. The fires are locally catastrophic but immaterial as a CO_2 source at global scale.

2. **Black carbon dominates the direct warming signal but is transient.** The 71 kt central BC estimate produces a warming pulse of ~24 Mt CO_2-eq ($GWP_{100} = 342$) — 6× direct fire CO_2 — but clears within ~1 week. Combined direct warming totals 28 Mt CO_2-eq under the full-replacement assumption (0.23% of annual global oil CO_2), of which 86% is the transient BC pulse and 14% is the permanent fire CO_2.

3. **Supply disruption reverses the sign.** Demand destruction from Ukraine refinery capacity loss (−43 Mt) and the Iran war supply shock (−130 Mt) totals ~174 Mt avoided CO_2 in the central case — 6× the combined direct effect. The central net CO_2-eq is **−146 Mt** (−1.2% of global annual oil CO_2). Net remains negative under all scenarios except full simultaneous market compensation by other producers.

4. **The Hormuz supply rebound is the critical unknown.** The Iran avoided CO_2 (~130 Mt central) assumes that demand foregone during the 60-day disruption window is not subsequently offset by pent-up Hormuz supply flowing back to markets. If full rebound occurs, the net converges toward +28 Mt (fires and BC only). Ukraine's contribution (~43 Mt) is more robust: physically destroyed refining capacity cannot retroactively produce the missing product.

5. **Fire data dominates neither the result nor its uncertainty.** Fire volume uncertainty spans ±4 Mt of net CO_2-eq. Supply disruption scale and substitution rate together span −47 to −390 Mt. Most volume estimates carry very low confidence: Ukraine withheld data for operational security; Iranian facility volumes have no public records.

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