OHROS
CONSULTING GROUP

WHITE PAPER
May 2026

STRATEGIC ASSET MANAGEMENT | ENERGY | UTILITIES | OIL & GAS

Refineries at Crossroads

Becoming truly resilient or closing?

Resilience in the global refining and petrochemical industry. Navigating a crossroads of disruption and transformation.

Ennio R. Neumann Senese
CEO, OHROS Consulting Group

May 2026 | Amstelveen, Netherlands

EXECUTIVE SUMMARY

Refineries at a Crossroads

The global refining and petrochemical industry faces an unprecedented confluence of disruptions in 2026. Geopolitical convulsions, structural overcapacity in Western markets set against acute undersupply globally, accelerating decarbonization mandates, and a rapidly expanding digital threat surface have converged to create the most demanding operating environment since the 1973 oil crisis.

The choice before every refinery executive, board, and regulator is binary and immediate: invest now in the five dimensions of genuine resilience — geopolitical positioning, supply chain architecture, asset intelligence, energy transition integration, and cybersecurity — or accept that closure is a destination, not a risk.

The data is unambiguous. The IEA's March 2026 Oil Market Report documents a supply plunge of 8 mb/d following the Strait of Hormuz crisis — the most severe single-month disruption in the modern era. Wood Mackenzie identifies 101 refineries representing 21% of global capacity at meaningful closure risk by 2035, with Europe home to 60% of high-risk sites. EU refinery investment hit a decade low in 2025. Cybercrime costs the global economy an estimated $10.5 trillion annually. And a landmark MIT Sloan Management Review study confirms that poor data management hinders 87% of companies from achieving digital transformation goals — a finding with direct and serious implications for asset-intensive refiners.

As Dr. Daniel Yergin invoked at Energy Asia 2025 in Kuala Lumpur — echoing Winston Churchill's 1912 principle — safety in oil lies in variety and variety alone. Variety of feedstocks, products, revenue streams, geopolitical positioning, and digital capability. The refining companies that build this variety with discipline and speed will define the next chapter of the industry. Those that do not will close.

CHAPTER 1

A Sector Under Siege: The State of Global Refining in 2026

1.1 The Storm That Was Foretold

At the Energy Asia 2025 conference in Kuala Lumpur, senior industry executives issued a warning that proved devastatingly prescient within months: the industry was experiencing a calm before the storm. They called for resilience through diversification and infrastructure investment. They were right — and the majority of the industry was not ready.

On 28 February 2026, joint U.S.-Israeli air strikes on Iran triggered the most severe energy supply shock of the modern era. Crude and oil product flows through the Strait of Hormuz — the world's most critical oil transit chokepoint, through which approximately 20% of global oil supply transits — plunged from around 20 mb/d to near standstill. The U.S. Energy Information Administration has consistently identified Hormuz as the single most consequential transit vulnerability in global energy infrastructure, with disruptions generating immediate global price impacts. That vulnerability materialized in full.

Gulf producers — Saudi Arabia, UAE, Kuwait, Qatar, Iraq, Iran — collectively cut total production by at least 10 mb/d. Brent futures briefly touched $120/bbl. The IEA coordinated an emergency release of 400 million barrels from strategic reserves across member countries — one of the largest co-ordinated interventions in history.

But the Hormuz crisis did not create the vulnerability. It revealed structural fragility that had been building for years through under-investment, policy-driven capacity withdrawal, and the failure to apply geopolitical intelligence to supply chain architecture.

Table 1 — Global Refining: Key Indicators, 2025–2026

Indicator	Data & Source
Global refinery throughput, 2025	83.5 mb/d (IEA Oil Market Report, Oct 2025)
Global refinery throughput, 2026 revised	83.8 mb/d -800 kb/d vs Feb 2026 (IEA March 2026 OMR)
Supply plunge, March 2026	-8 mb/d — most severe in modern history (IEA March 2026)
Gulf refining capacity shut, Mar 2026	>3 mb/d (attacks + product export blockage)
Refining capacity at immediate risk	>4 mb/d (storage full, no export outlets)
Hormuz throughput pre-crisis	~20 mb/d = 25% of global supply (EIA / IEA)
IEA emergency reserve release	400 mb — largest co-ordinated release in history (IEA)

Indicator	Data & Source
Brent crude peak, Q1 2026	~$120/bbl
EU refinery investment, 2025	Decade low (IEA World Energy Investment 2025)
Refineries at closure risk by 2035	101 sites / 18.4 mb/d / 21% of capacity (Wood Mackenzie, 2025)
Global cybercrime cost (2025)	~$10.5 trillion annually (Cybersecurity Ventures, 2023)

1.2 Hormuz: The Anatomy of a Cascading Refinery Shock

The Strait of Hormuz crisis exposed a structural truth that had been systematically under-priced in risk models: export-oriented refineries are uniquely fragile under supply corridor closure. Unlike facilities serving domestic markets, they cannot accumulate inventory when export channels close. Storage tanks fill. Throughput must be cut immediately, regardless of crude availability or asset condition. More than 4 mb/d of Gulf refining capacity was placed at immediate risk within days.

Gulf producers had exported 3.3 mb/d of refined products and 1.5 mb/d of LPG in 2025. The cascade from sudden loss of this supply moved rapidly through product categories: diesel and jet fuel proved acutely exposed, with limited swing capacity in other regions to compensate. Flight suspensions at major Middle East airports reduced jet fuel demand but simultaneously disrupted the logistics of emergency response, compounding volatility.

Petrochemical plants downstream of the Gulf faced immediate feedstock starvation. Plunging LPG and naphtha supplies forced polymer producers globally to curtail output, extending the disruption from energy into chemicals, plastics, fertilizer precursors, and eventually food prices — the second-order transmission channels that S&P Global Commodity Insights has consistently identified as systematically underestimated in refinery risk models.

> *"Supply is still moving but the system is clearly under strain. And in energy markets, it is often that loss of certainty — more than an actual shortage — that drives prices."*
>
> **Ennio R. Neumann Senese, CEO, OHROS Consulting Group (Amstelveen, March 2026)**

1.3 Russia: The Parallel Structural Shock

Before Hormuz, Russia had already delivered a parallel refining shock. Sustained Ukrainian drone attacks on refinery infrastructure removed an estimated 500 kb/d of Russian crude processing by late 2025. Middle distillate exports fell sharply. European buyers — already structurally exposed following the 2023 EU ban on seaborne Russian diesel imports —

scrambled for alternatives. A 2023 analysis by S&P Global Commodity Insights documented that European diesel markets remained structurally dependent on imports despite the Russian ban, with alternative supplies from the Middle East and Asia unable to fully compensate for lost volumes. Diesel and jet fuel cracks hit two-year highs in Europe and 18-month highs on the U.S. Gulf Coast and in Singapore by September 2025.

The EU ban on refined products derived from Russian crude, effective January 2026, added a structural trade disruption on top of the infrastructure damage. Europe entered the Hormuz crisis with supply diversification incomplete, refinery investment at decade lows, and domestic resilience architecture insufficient. This combination was the product of policy choices, not market forces alone.

External Research: Geopolitical Vulnerability

- **EIA (2024):** Hormuz is the world's most critical oil chokepoint — 21 mb/d transited in 2022; any closure generates immediate global price transmission.
- **S&P Global Commodity Insights (2023):** European diesel markets remain structurally import-dependent post-Russian ban; Middle East and Asian supply cannot fully compensate.
- **Baker Institute (2023):** Middle East producers are pivoting to green energy and petrochemicals, potentially reducing crude export volumes over the medium term — a structural shift compounding Hormuz transit risk.
- **IEA World Energy Outlook (2023):** Global refining capacity additions are heavily concentrated in Asia and the Middle East; OECD countries face structural net closures through 2030.

CHAPTER 2

The Structural Retreat: Closures, the Investment Gap, and the East-West Divergence

2.1 Europe and North America: Deliberate Withdrawal

While geopolitical shocks dominate headlines, a quieter but equally consequential structural transformation is underway in Western markets. Europe and North America are systematically retiring refining capacity. The drivers are structural, not cyclical: carbon costs escalating under the EU Emissions Trading System, declining transport fuel demand as EV penetration advances, eroding margins in non-integrated facilities, and the policy logic of decarbonization pushing capital toward renewable energy rather than refinery modernization.

In 2025 alone, approximately 890 kb/d of global refining capacity was permanently closed. The closures concentrated precisely where carbon costs and EV adoption are highest. The UK lost its only hydrocracker-equipped facility at Grangemouth, structurally widening Britain's middle distillate deficit. California lost two significant facilities within eighteen months. McKinsey & Company's 2023 refining outlook warned that up to 30% of European refining capacity could close by 2035 without significant investment in resilience or conversion — a projection that accelerating Hormuz-era disruptions have made more, not less, likely.

Table 2 — Selected Refinery Closures and Conversions, 2024–2026

Site / Operator	Capacity & Status
Phillips 66, Los Angeles (USA)	133 kb/d — closed Q4 2025
Grangemouth, INEOS (UK)	150 kb/d — closed April 2025; converted to import terminal
Dalian, PetroChina (China)	410 kb/d — fully closed July 2025
Valero, Benicia (USA)	Crude processing halted H1 2026
BP, Gelsenkirchen (Germany)	70 kb/d CDU shutdown deferred; operations continuing
Shell, Wesseling (Germany)	Converting to base oils production
TotalEnergies, Grandpuits (France)	Converting to SAF + advanced plastics recycling
Eni, Livorno (Italy)	Converting to biofuels production
Gulf region (Middle East)	>3 mb/d shut — attacks and export blockage (IEA, March 2026)

Wood Mackenzie's 2025 analysis of 420 global refinery sites identifies 101 facilities — representing 18.4 mb/d or 21% of current global capacity — at meaningful closure risk by 2035. Europe hosts 60% of the high-risk sites. The primary drivers: EU ETS carbon costs escalating as free allowances unwind from 2030; transport fuel demand beginning structural decline as EV penetration accelerates; and the absence of petrochemical integration at the most vulnerable facilities.

2.2 The Investment Paradox

Global refinery investment in 2025 fell to its lowest level in a decade, according to the IEA's World Energy Investment Report. Upstream oil and gas capital expenditure fell approximately 4% to just under $570 billion. This under-investment creates a dangerous paradox, one the IEA has explicitly flagged: the industry faces acute near-term supply disruptions while simultaneously starving itself of the capital needed to sustain and modernize remaining capacity.

> *"Limited spare refining capacity outside of China available to process it means we may well see parallel markets persist for some time to come."*
>
> **IEA Oil Market Report, December 2025**

OPEC's World Oil Outlook projects a refining capacity deficit rising from 0.5 mb/d in 2027 to 1.6 mb/d by 2030 — precisely as structural closures in high-cost regions peak. The World Economic Forum's 2023 Energy Transition Index reinforces this concern, warning that supply security must anchor transition strategies: geopolitical shocks can derail sustainability goals without resilience infrastructure in place. Investment decisions still operating on assumptions of stable supply and predictable cost structures are building risk directly into balance sheets.

> *"If you do not properly assess the resilience of your future asset performance — your energy requirements, your dependencies, your exposure — then you are effectively building risk into your balance sheet. And in a situation like this, that risk can materialise very quickly."*
>
> **Ennio R. Neumann Senese, OHROS Consulting Group**

2.3 Asia: The Counter-Current and Its Exposures

The picture inverts east of Suez. Asia continues to add complex, integrated refining capacity. China's Yulong Refinery — two 200 kb/d CDUs, integrated steam crackers, running at 80-90% utilization — represents the new template: mega-scale, petrochemical-integrated, export-competitive. Africa's Dangote Refinery in Nigeria — 650 kb/d nominal capacity — represents a further disruption: a new mega-facility that threatens the $17 billion annual European fuel export trade to West Africa.

Yet Asian facilities face their own acute Hormuz exposure: they imported over 60% of crude requirements from Middle Eastern sources in 2025. The geographic concentration of supply creates structural vulnerability even for the industry's most modern assets. The IEA's World Energy Outlook 2023 confirms that global capacity additions are concentrated in Asia and the Middle East while OECD countries face net closures — a divergence that does not eliminate risk for Asian operators but redistributes it.

External Research: Structural Closure Outlook

- **Wood Mackenzie (2025):** 101 of 420 screened global refineries (18.4 mb/d / 21% of capacity) at closure risk by 2035; Europe home to 60% of high-risk sites.
- **McKinsey & Company (2023):** Up to 30% of European refining capacity could close by 2035 without resilience investment or conversion to renewable fuels.
- **IEA World Energy Investment (2025):** Global refinery investment at decade low; upstream oil & gas capex declined ~4% to under $570bn.
- **OPEC World Oil Outlook:** Refining capacity deficit rises from 0.5 mb/d in 2027 to 1.6 mb/d by 2030 as closures and under-investment compound.
- **World Economic Forum, Energy Transition Index (2023):** Supply security must anchor transition strategies; geopolitical shocks derail sustainability goals without resilience infrastructure.

CHAPTER 3

Geopolitics as Operating Reality: The Variety Imperative

3.1 From Episodic Risk to Structural Condition

Geopolitical risks have evolved from episodic concerns to permanent structural conditions for the refining industry. The Hormuz crisis, the Russian infrastructure shock, U.S.-China-Russia rivalry fragmenting supply chains, oscillating Venezuelan sanctions policy, and the accelerating decoupling of global trade systems all require a strategic response that extends beyond traditional market risk management.

U.S. Gulf Coast refineries crystallize the challenge with particular clarity. Complex facilities designed for heavy sour crude depend heavily on Venezuelan supply as a buffer against Middle Eastern shocks. Post-2025 U.S. policy shifts on Venezuelan crude access — oscillating between sanctions relief and renewed restriction as geopolitical leverage calculus shifts — demonstrate that supply security cannot rest on political goodwill. The refinery that relies on a single political relationship for feedstock access has built fragility into its foundations.

3.2 Churchill's Principle, Yergin's Warning

When Winston Churchill oversaw the Royal Navy's conversion from coal to oil in 1912, he articulated a principle with enduring power: safety in oil lies in variety and variety alone. At Energy Asia 2025, Dr. Daniel Yergin, vice chairman of S&P Global and the foremost historian of the oil industry, invoked this principle directly in the context of today's refining sector. The warning was precise: failure to diversify — feedstocks, products, markets, capabilities — means refineries face Gordian knot challenges in aligning supply with both green mandates and geopolitical realities.

> *"Safety and certainty in oil lies in variety and variety alone."*
>
> **Winston Churchill, 1912 — cited by Dr. Daniel Yergin at Energy Asia 2025, Kuala Lumpur**

The industry has absorbed this lesson in upstream oil and gas through decades of hard experience. Joint venture structures that separate ownership from operations build local political trust and guard against nationalization. Geographic diversification across regions reduces single-market dependence. Pre-planned exit strategies with defined triggers minimize disruption when risks escalate. Refining has lagged in applying these disciplines with equivalent rigour — and the 2026 crisis delivered the consequences.

3.3 MENA Transformation and the Long-Term Feedstock Question

The Middle East and North Africa are themselves undergoing structural transformation as major producers invest in green hydrogen, petrochemical integration, and renewable energy as partial substitutes for oil export revenues. Baker Institute analysis highlights this strategic pivot: MENA producers are repositioning, potentially reducing crude export volumes over the medium term while increasing refined product and petrochemical exports, directly competing with the facilities they currently supply.

For European and Asian refiners dependent on Middle Eastern crude, this creates a compounding strategic challenge: not only is the transit route (Hormuz) at geopolitical risk, but the long-term volume and price dynamics of the feedstock itself are shifting. The structural case for crude diversification — toward West African, U.S., Guyana, Brazilian, and Caspian sources — strengthens with each passing geopolitical quarter.

Table 3 — Resilience Strategies: Framework Application to Refining

Strategy	Application to Refining	Key Competitive Benefit
Ownership-Operations Split	Local partners manage operations; foreign entity retains technology and strategic control	Builds host-country political support; guards against nationalization risk
Geographic Diversification	Multi-source crude: West Africa, U.S., Guyana, Brazil, Caspian, North Sea	Reduces Hormuz / Russia / Venezuela single-route exposure; enables arbitrage
Exit Planning	Define disruption triggers; pre-qualify alternative crude grades and logistics routes	Minimizes throughput loss when geopolitical risk escalates suddenly
Crude Slate Flexibility	Invest in processing flexibility for light / medium grades when heavy sour is disrupted	Buffers geopolitical shocks; captures opportunistic spot purchases
Petrochemical Integration	Connect refinery streams to naphtha crackers, aromatics, propylene derivatives	Accesses chemical demand growth; insulates against transport fuel decline
Energy Transition Conversion	Convert units to SAF, renewable diesel, bio-based feedstocks, advanced recycling	Captures mandated growth markets; extends asset operating life
Digital Asset Intelligence	Real-time monitoring, predictive maintenance, unified data governance (ITAMS©)	Reduces unplanned downtime; improves investment quality; ensures compliance
Cyber Resilience	Secure-by-design OT/IT architecture; third-party access governance; incident response	Protects operational continuity against growing cyber-physical attack surface

CHAPTER 4

Petrochemical Integration: The Structural Survival Differentiator

4.1 Where the Demand Growth Lives

By 2026, petrochemical feedstocks account for more than 60% of incremental global oil demand growth — up from 40% in 2025. Transport fuel demand is peaking and beginning its structural decline in developed economies as EV penetration accelerates. The demand growth story for oil has shifted decisively toward chemicals: plastics, synthetic fibres, fertilizers, pharmaceuticals, and specialty materials.

Deloitte's 2022 analysis on petrochemicals projected that chemicals would drive over 70% of oil demand growth by 2040, with non-integrated refineries facing progressive margin compression unless they adapt. The IEA's 'The Future of Petrochemicals' (updated 2023) reinforces this finding: integrated refining-petrochemical complexes in Asia and the Middle East achieve 15-20% higher margins than standalone refineries — a structural advantage that compounds over time.

4.2 The Integration Survival Gap

Only 29 of the 101 Wood Mackenzie-identified at-risk refineries are integrated with petrochemical production. This single variable is the most powerful structural differentiator of long-term refinery survival. The Hormuz crisis validated this in real time: naphtha and LPG supply disruptions cascaded immediately into polymer plant curtailments globally, but integrated operators with diversified product slates and internal feedstock flows demonstrated far greater operational continuity.

The strategic implication is unambiguous: capital allocation toward petrochemical integration is the highest-returning investment in long-term asset resilience. Wood Mackenzie's 2023 analysis projects that resilient refiners with petrochemical integration and transition investments could see 25-30% higher margins by 2035 compared to non-adapted peers — a differential that justifies significant near-term capital commitment.

Companies that defer this transition, waiting for margin recovery or regulatory clarity, are shortening their own operating horizons. The Hormuz crisis removed the argument for delay.

External Research: Petrochemical Integration Advantage

- **Deloitte (2022):** Petrochemicals will drive over 70% of oil demand growth by 2040; non-integrated refineries face progressive margin compression.
- **IEA, The Future of Petrochemicals (updated 2023):** Integrated refining-petrochemical complexes achieve 15–20% higher margins than standalone refineries.
- **Wood Mackenzie (2023):** Resilient refiners with petrochemical integration could achieve 25–30% higher margins vs non-adapted peers by 2035.
- **IEA Oil Market Report (Dec 2025):** Petrochemical feedstocks account for >60% of incremental oil demand growth in 2026, rising from 40% in 2025.

CHAPTER 5

Energy Transition: Constraint, Catalyst, and Competitive Differentiator

5.1 The Hybrid System Reality

The energy transition was never going to be linear. It is, by definition, a hybrid system — fossil and renewable, incumbent and emerging, mandate and market — that will persist for decades. For the refining sector, this hybrid reality creates simultaneous threat and opportunity. The response to each determines whether a facility survives the transition or closes within it.

Short-term crisis dynamics demonstrate the tension. When the Hormuz shock drove gas prices up, energy policy reverted immediately to security over sustainability: coal returned, LNG demand surged, strategic reserves were deployed. European governments that had reduced domestic production and increased reliance on global markets discovered that transition strategy divorced from supply security had created new fragilities while addressing old ones. The resilience lesson is structural: the World Economic Forum's Energy Transition Index (2023) makes this explicit — supply security must anchor transition strategies.

5.2 Carbon Costs as Structural Competitive Pressure

The EU Emissions Trading System creates escalating structural cost pressure on European refineries as free allowances unwind from 2030. The European Commission's Fit for 55 package confirms this trajectory: non-adapted facilities face a projected 30-40% cost increase as free ETS allowances phase out. Wood Mackenzie's margin forecasts show European net cash margins declining from 2030 — precisely when OPEC projects the 1.6 mb/d global capacity deficit will be most acute.

Refiners in regions with escalating carbon pricing — EU, UK, Canada — face the steepest structural headwind. Those with petrochemical integration, renewable fuel production, or advanced recycling capabilities carry a partial structural offset. Those without face the binary choice that defines this paper's central argument.

5.3 The Conversion Pathway: SAF, Renewable Diesel, and Green Hydrogen

The most strategically coherent European refinery responses to the transition combine partial conversion with retained processing flexibility. TotalEnergies' Grandpuits converts to SAF and advanced plastics recycling. Shell's Wesseling converts to base oils. Eni's Livorno

converts to biofuels. BP's Rodeo Renewed produces 50 kb/d of renewable diesel and SAF. These are strategic pivots, executed ahead of regulatory necessity, capturing first-mover advantages.

BloombergNEF's 2023 analysis projects SAF demand growing from 0.1 mb/d in 2022 to 1.5 mb/d by 2035, driven by aviation net-zero commitments, with current production capacity meeting less than 10% of mandated needs. This supply-demand gap represents an extraordinary structural opportunity for integrated refiners with hydroprocessing capacity to convert. The IEA's 2023 Net Zero Roadmap identifies SAF production as a priority pathway for refinery assets in high-carbon-cost jurisdictions, where the alternative to conversion is closure.

Green hydrogen integration in refinery processing — initially as a substitute for fossil hydrogen in desulphurisation and hydrocracking — represents a further conversion pathway where mandates are advancing. Capital costs remain significant, but early movers in key jurisdictions are positioning for durable competitive advantage as hydrogen mandates in refining tighten through the 2030s.

External Research: Energy Transition Pathways

- **BloombergNEF (2023):** SAF demand projected to grow from 0.1 mb/d (2022) to 1.5 mb/d by 2035; current capacity meets <10% of mandated needs.
- **IEA Net Zero Roadmap (2023):** SAF production identified as priority pathway for refinery assets in high-carbon jurisdictions; conversion preferable to closure.
- **European Commission, Fit for 55 (2023):** Free ETS allowances for refineries phased out by 2030; non-adapted facilities face 30–40% cost increase.
- **McKinsey & Company (2023):** Early movers in SAF and renewable diesel capture first-mover pricing power; mandate-driven demand creates durable offtake security.
- **IEA World Energy Outlook (2023):** Transport fuel demand begins structural decline in OECD from mid-2020s; petrochemicals and aviation fuels sustain oil demand.

CHAPTER 6

Digitalization: The Double-Edged Transformation

6.1 Asset Intelligence as the Resilience Foundation

Digital transformation represents the most powerful available tool for refinery resilience — and, simultaneously, the most significant new vulnerability vector the industry faces. The oil, gas, and petrochemical sector is projected to allocate nearly $16 billion toward digital transformation by the close of the 2030s, with security spending rising by over 8% annually through 2030. The productivity and resilience gains from well-executed digitalization are transformative; the risks from poorly-secured OT/IT integration are existential.

The OHROS ITAMS© global survey of Transmission System Operators reveals the stakes with precision: 72% of executives rate operational efficiency as a high or very high concern, directly linked to understaffing, overwhelmed resources, and asset performance risk. 81% rate cybersecurity as a high or very high concern. Yet a landmark MIT Sloan Management Review study confirms that poor data management hinders 87% of companies from achieving digital transformation goals, with only 13% achieving excellence in data governance — a finding that carries direct and serious implications for asset-intensive refinery operations.

> *"Relying on unreliable data is like navigating a storm without a compass. It cultivates false intelligence, leading to budget overruns and delivery failures. In the energy sector, accurate data is the bedrock of resilience."*
>
> **OHROS Consulting Group — ITAMS© Data Expert**

The 'trust gap' in asset data — executives expressing distrust in their own facility information — creates cascading operational, financial, and regulatory consequences: misguided investment decisions, flawed maintenance planning, regulatory exposure from reporting inconsistencies, and blocked decarbonization pathways. Closing this gap is a precondition for resilience, not an optional enhancement.

Specific technology breakthroughs now enable resilience capabilities previously unavailable. A compelling example: partial discharge monitoring for large power transformers can now locate faults to within a square centimetre. Undetected partial discharge is a leading cause of catastrophic transformer failures and facility-wide blackouts in refinery and petrochemical operations. Applied systematically through a unified asset intelligence framework,

technologies of this precision eliminate risk rather than merely mitigate it — the distinction between resilience and insurance.

6.2 The Cybersecurity Imperative: From IT to OT

High-profile cyber attacks have moved OT/IT security from a CIO concern to a board-level existential priority. The Colonial Pipeline ransomware attack in 2021 disrupted fuel supply across the U.S. East Coast. The Brenntag chemical distribution attack demonstrated that petrochemical supply chains are equally exposed. PwC's 2023 industrial cybersecurity report identifies third-party supply chain access, IIoT endpoint proliferation, and legacy industrial control system weaknesses as the three highest-risk vulnerability categories in refinery and chemical plant operations.

Cybersecurity Ventures estimates global cybercrime costs will reach $10.5 trillion by 2025, with energy infrastructure as a top target due to the high-impact potential of supply disruptions. The attacks on Russian refinery infrastructure in 2024-2025 — physical strikes coordinated with digital disruption — demonstrate how cyber and physical threat vectors increasingly converge into a single attack surface that demands a unified response.

Table 4 — The Digital Resilience Stack: Opportunity and Threat

Capability / Opportunity	Threat / Vulnerability
Predictive maintenance — condition-based, live data-driven	OT/IT convergence exponentially expands attack surface
Real-time process optimisation and yield improvement	ICS / SCADA systems increasingly exposed to external networks
AI-powered supply chain analytics and disruption sensing	Third-party access: licensors, contractors, catalyst suppliers
Partial discharge monitoring: fault location to 1 cm²	IIoT endpoint proliferation — unmanaged entry vectors
Digital twin simulation for scenario stress-testing	Critical shortage of OT-cyber professionals with industrial expertise
Unified asset governance (OHROS ITAMS© / MetaDino)	Ransomware: Colonial Pipeline + Brenntag precedents ($4.4M each)
Automated regulatory reporting and compliance tracking	Global cybercrime: ~$10.5 trillion annually (Cybersecurity Ventures)

OHROS Consulting Group's RAI© framework addresses three root causes of asset intelligence failure: fragmented data across disconnected CMDBs, Excel files, and legacy systems; absent governance frameworks that leave advanced platforms generating noise rather than insight; and the skills deficit in engineers who combine operational and data

science expertise. The framework delivers the unified data architecture that transforms asset management from a cost centre into a strategic resilience capability.

External Research: Digital Resilience and Cybersecurity

- **MIT Sloan Management Review (2022):** Poor data management hinders 87% of companies from achieving digital transformation goals; only 13% excel at data governance.
- **Cybersecurity Ventures (2023):** Global cybercrime costs to reach $10.5 trillion annually by 2025; energy infrastructure is a top target for high-impact disruptions.
- **PwC Industrial Cybersecurity Report (2023):** Third-party access, IIoT endpoints, and legacy ICS are the three highest-risk vulnerability categories in refinery and petrochemical operations.
- **McKinsey Digital Transformation in Energy (2023):** Refiners who close the data-intelligence gap reduce unplanned downtime and significantly improve capital allocation quality.
- **c3controls / sector analysis (2024):** Oil & gas / petrochemical sector projected to spend ~$16bn on digital transformation by 2030; security spending rising >8% annually through 2030.

CHAPTER 7

The Five-Dimension Resilience Framework

7.1 Defining Resilience: Anticipate, Absorb, Adapt, Accelerate

Resilience in the refining and petrochemical context means the capacity to anticipate disruption before it arrives, absorb its immediate operational impact, adapt strategy and operations under pressure, and accelerate through recovery to a stronger competitive position. This four-stage model is the organizing framework for resilience investment decisions.

The defining characteristic of leading resilient operators is that resilience functions as a source of competitive advantage, not merely insurance against worst-case scenarios. Disruption creates winners and losers. The winners are those who have invested ahead of the disruption, move faster through recovery, and capture market share from those who have not. The current convergence of geopolitical, structural, transitional, and digital stress is precisely the kind of multi-vector disruption that separates leading from lagging operators over the following decade.

7.2 Dimension 1 — Geopolitical Positioning

Continuous geopolitical risk assessment must be embedded in supply chain and investment decisions, not treated as a periodic strategic review exercise. The Hormuz crisis, Russia's infrastructure shock, U.S.-China-Russia rivalry, and MENA's structural energy pivot all require scenario planning extending well beyond traditional market analysis. Companies that had mapped and stress-tested their Hormuz exposure before February 2026 were positioned to activate contingencies; those who had not faced unplanned shutdowns and emergency crude procurement at crisis-level prices.

Practical requirements: systematic mapping of crude sourcing exposure by geography and transit route; stress-testing against Hormuz closure, Russian disruption, and Venezuelan access scenarios; defined trigger points for activating alternative sourcing; continuous intelligence on MENA producer strategy evolution; and geopolitical scenario planning directly connected to capex approval processes.

7.3 Dimension 2 — Supply Chain Architecture

Supply chain resilience demands systematic assessment of vulnerabilities across feedstock sourcing, logistics corridors, energy inputs, and critical components. Deloitte's post-pandemic supply chain resilience analysis documents that companies which diversified

supply chains following the COVID shock demonstrated measurably faster recovery and lower margin volatility during subsequent disruptions, a finding with direct application to refinery crude sourcing strategy. European facilities averaged 1.3 mb/d of Middle East crude imports in 2025 — a lower dependency ratio than Asian counterparts, which translated directly into greater operational stability during the Hormuz disruption.

Strategic inventory positioning, as recommended by OPEC's World Oil Outlook in the context of the projected 2027-2030 capacity deficit, extends response time in disruption scenarios from days to weeks — the difference between managed adjustment and forced shutdown.

7.4 Dimension 3 — Asset Intelligence

Trusted, integrated, real-time asset data is the foundation of resilient operations. Without it, maintenance is reactive, investment is speculative, and regulatory compliance is exposure. McKinsey's 2023 Digital Transformation in Energy analysis confirms that refiners who close the data-intelligence gap achieve measurably lower unplanned downtime and demonstrably improved capital allocation quality — both direct resilience metrics.

The OHROS RAI© framework, unifies fragmented data sources, restores trust in the decision-critical data lifecycle, and delivers the condition-based maintenance and investment confidence that transforms asset management from a cost centre to a strategic capability. Applied to specific high-risk assets — large power transformers, rotating equipment, critical heat exchangers, precision monitoring technologies now available can eliminate major failure risks rather than merely detect them after onset.

7.5 Dimension 4 — Energy Transition Integration

The transition creates durable competitive advantage for operators who move deliberately ahead of mandates. Petrochemical integration, SAF production, renewable diesel, advanced recycling, and green hydrogen integration each represent revenue streams with regulatory tailwind and growing demand mandates. The IEA's Net Zero Roadmap and Bloomberg-NEF's SAF analysis together confirm that facilities investing ahead of regulatory deadlines capture first-mover pricing power in constrained-supply mandate markets.

The hybrid system reality demands pragmatic balance: retain feedstock flexibility during the transition period, convert units where SAF or renewable fuels economics are already compelling, integrate petrochemicals where feedstock streams support it, and plan the EU ETS carbon cost pathway explicitly through 2030 and beyond. This is managed transformation, not reactive compliance.

7.6 Dimension 5 — Cybersecurity as Operational Resilience

Digital infrastructure is now as critical to refinery operational continuity as physical infrastructure. OT/IT cybersecurity must receive board-level attention, equivalent capital allocation, and identical operational rigour to physical asset integrity management. PwC's industrial cybersecurity framework recommends secure-by-design architecture, network segmentation, third-party access governance, tested incident response, and cyber-aware operational culture as the minimum operational standard for critical energy infrastructure.

The plants of the future — as the petrochemical cybersecurity community increasingly articulates — will be built not just on pumps and pipes, but on firewalls, segmentation, and a cyber-aware culture embedded from process design through daily operations. For petrochemical engineers and cybersecurity professionals alike, this road requires shared understanding, continuous learning, and strategic foresight at the intersection of two disciplines that have historically operated separately.

CHAPTER 8

Strategic Recommendations

Enriching our own studies and client experience, with a meta analysis, Drawing on IEA, Wood Mackenzie, McKinsey, Deloitte, Bloomberg-NEF, PwC, Baker Institute, and WEF analysis, alongside direct operational intelligence from the 2026 Hormuz crisis we at OCG advances eight priority actions for refining and petrochemical executives:

1. **Conduct an immediate, structured resilience assessment.**

   Map exposure across all five dimensions and link findings directly to capital expenditure planning. The assumptions of stable supply, predictable costs, and linear transition timelines are demonstrably obsolete. Immediate assessment is the prerequisite for every other action.

2. **Implement Churchill's variety principle with operational discipline.**

   Map every single-source dependency in crude supply, logistics, energy inputs, and critical components. Pre-qualify alternative crude grades and suppliers before the next crisis, not during it. Invest in processing flexibility. Variety is a survival requirement, not a strategic preference.

3. **Prioritize petrochemical integration in capital allocation.**

   For facilities where feedstock streams support it, integration with naphtha crackers, aromatics units, and propylene derivatives is the highest-returning resilience investment available. Wood Mackenzie projects 25-30% margin advantage for integrated operators by 2035. Only 29 of 101 at-risk refineries are currently integrated — this gap defines the industry's most urgent structural priority.

4. **Build trusted asset intelligence infrastructure.**

   Deploy unified data governance, real-time monitoring, and condition-based maintenance. Close the trust gap in asset data — the finding that only 13% of companies excel at data governance (MIT Sloan, 2022) represents the most correctable of all resilience deficits. The OHROS RAI© framework provides the proven methodology.

5. **Elevate OT/IT cybersecurity to board-level priority.**

   Treat digital infrastructure with the same asset integrity rigour as physical plant. Implement PwC's recommended secure-by-design architecture, third-party access governance, and network segmentation. Build and test incident response. Embed cyber-aware culture in operations. The $10.5 trillion annual global cybercrime cost is a sector-specific operational threat.

6. **Accelerate energy transition investment ahead of mandates.**

Convert suitable units to SAF, renewable diesel, or advanced recycling now, before regulatory deadlines create capital market and operational timeline constraints. Plan explicitly for EU ETS cost escalation through 2030. Bloomberg-NEF's projection that SAF supply meets less than 10% of mandated demand by 2035 defines a first-mover opportunity of significant scale.

7. **Engage governments on strategic energy pragmatism.**

   Advocate for strategic reserve expansion, domestic production preservation where feasible, and European energy policy coherence that balances transition ambition with supply security. The World Economic Forum's Energy Transition Index makes the institutional case: geopolitical shocks derail sustainability goals without resilience infrastructure. Companies that shape this policy agenda protect their own operating environment.

8. **Invest in digital and operational talent simultaneously.**

   The digital resilience gap is as much human as technological. Engineers fluent in both data science and operational realities, cybersecurity professionals who understand industrial processes, and executives who connect digital strategy to asset strategy — this talent is the human infrastructure on which every other resilience investment depends.

CHAPTER 9

Conclusion: The Crossroads Is Now

The global refining and petrochemical industry stands at a crossroads that is neither metaphorical nor distant. It is immediate, structural, and defined by choices that executives, boards, and regulators are making, or deferring, today.

The IEA's 8 mb/d supply shock in March 2026. Brent at $120. Over 3 mb/d of Gulf refining capacity shut. Emergency reserve releases of 400 million barrels. 101 refineries representing 21% of global capacity at structural closure risk by 2035. Decade-low refinery investment. A $10.5 trillion annual cybercrime exposure. A projected 1.6 mb/d capacity deficit by 2030. These are operating conditions, not tail risks.

McKinsey's refining outlook, Wood Mackenzie's closure analysis, Bloomberg-NEF's SAF projections, the Baker Institute's MENA analysis, Deloitte's petrochemical demand study, PwC's cybersecurity framework, and the WEF's Energy Transition Index converge on a single strategic conclusion: resilience investment now is the prerequisite for competitive survival through the 2030s. The companies that defer — optimizing for short-term cash, waiting for environments to stabilize — face closure at the intersection of margin compression, regulatory obligation, and geopolitical shock.

Churchill's 1912 principle, invoked by Dr. Daniel Yergin at Energy Asia 2025, endures because it is correct. Safety in oil lies in variety — variety of feedstocks, of products, of revenue streams, of digital capability, of geopolitical positioning. The five-dimension resilience framework developed in this paper translates this principle into operational architecture.

> *"The energy transition was never going to be linear. It is, by definition, a hybrid system. In moments like this, resilience becomes a condition for survival — and the companies that invest in it deliberately will seize the competitive advantage that disruption creates."*
>
> **Ennio R. Neumann Senese, CEO, OHROS Consulting Group**

The crossroads question — becoming truly resilient or closing? — resolves differently for different operators. For those with the asset quality, integration pathway, and management will to invest, the answer is transformation into a genuinely competitive 21st-century asset. For those who defer, the answer is closure — not immediately, but with certainty.

At OHROS Consulting Group, we work with refinery operators, utilities, and energy companies to transform resilience from aspiration to operational reality. To deliver the asset intelligence, strategic positioning, and resilience architecture this moment demands.

APPENDIX

References

The following sources are cited or drawn upon in this paper.

[1] International Energy Agency (IEA). Oil Market Reports: December 2025, March 2026. Paris: IEA.

[2] International Energy Agency (IEA). World Energy Investment 2025. Paris: IEA.

[3] International Energy Agency (IEA). World Energy Outlook 2023. Paris: IEA.

[4] International Energy Agency (IEA). Net Zero Roadmap: A Global Pathway to Keep the 1.5°C Goal in Reach. 2023.

[5] International Energy Agency (IEA). The Future of Petrochemicals. Updated 2023.

[6] Wood Mackenzie. Global Refinery Closure Outlook to 2035. March 2025.

[7] McKinsey & Company. Digital Transformation in Energy. 2023.

[8] McKinsey & Company. Refining Industry Outlook 2023.

[9] Deloitte. Supply Chain Resilience in Manufacturing. 2023.

[10] Deloitte. The Future of Petrochemicals: Demand Outlook to 2040. 2022.

[11] PwC. Industrial Cybersecurity: Protecting Critical Infrastructure. 2023.

[12] Baker Institute for Public Policy. Middle East Energy Transition Reports. 2023.

[13] BloombergNEF. Sustainable Aviation Fuel Outlook. 2023.

[14] Cybersecurity Ventures. 2023 Cybercrime Report. Northport, NY, 2023.

[15] MIT Sloan Management Review. Data Management and Digital Transformation. 2022.

[16] World Economic Forum. Energy Transition Index 2023. Geneva: WEF.

[17] S&P Global Commodity Insights / Kpler. European Diesel Markets and Russian Import Substitution. 2023.

[18] U.S. Energy Information Administration (EIA). World Oil Transit Chokepoints. 2024.

[19] OPEC. World Oil Outlook 2023–2050. Vienna: OPEC Secretariat.

[20] European Commission. Fit for 55 Legislative Package: EU ETS Reform. 2023.

[21] Churchill, W.S. Speech to the House of Commons on the Admiralty's oil fuel policy. 1912. Cited in Yergin, D., Energy Asia 2025 Conference, Kuala Lumpur.

[22] Yergin, D. Presentation: Energy Security and Resilience. Energy Asia 2025 Conference, Kuala Lumpur, 2025.

[23] OHROS Consulting Group. ITAMS© Global Survey of Transmission System Operators. Amstelveen, 2025.

[24] Neumann Senese, E.R. Interview: 'Energy Under Fire.' Amstelveen, March 2026. Kim Tjoa, Special Reporter.

[25] Kepler. Refinery Status Monthly — September 2025.

About the author

Ennio R. Neumann Senese is Group CEO of OHROS Group, a 320-plus-person energy advisory collective ecosystem, anchored by OHROS Consulting Group, an Amsterdam-based boutique consultancy with offices across Europe and South America.

Contact: info@ohrosgroup.com | www.ohrosgroup.com

OCG White Paper — Refineries at Crossroads: Becoming Truly Resilient or Closing? — May 2026