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Energy Stockpiling as A China Strategic Warning Indicator

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Executive Summary

- Energy production and stockpile buildups often precede great power industrial wars. Nazi Germany increased its coal production nearly two-fold between Hitler's taking power in 1933 and the invasion of Poland in 1939.
- China is building surge production capabilities for coal and storage capacity for oil that each could be interpreted as exceeding "normal" commercial parameters. The NDRC seeks the capacity to rapidly augment coal production at the rate of 300 million tonnes per year by 2030, with a lesser amount operational by 2027.
- PRC policymakers greenlighted a coal mine capacity expansion of an additional 300 million tonnes in 2022—almost the annual production of the entire European Union. That's enough coal to fill a train of standard rail hopper cars that would wrap around the entire Equator, plus enough left to stretch from Washington DC to Los Angeles.
- China's total crude storage tank capacity is now somewhere a bit north of 1.8 billion barrels—about 30% larger than total U.S. storage capacity, even though the US still consumes about 25% more oil than China does.[2]
- Between 2016 and early 2024, China's total observed aboveground crude oil inventory has ranged from 850 million to a bit over 1 billion barrels.
- This number includes multiple aboveground strategic petroleum reserve sites with a total storage capacity of approximately 200 million barrels of crude oil.[3] China also has operational underground crude oil storage facilities at Huangdao, Jinzhou, Zhanjiang, and Huizhou, which between them could store at least 100 million additional barrels.[4]
- China could have nearly 300 million barrels of additional "headroom" across its oil storage complex if it chose to maximally stockpile ahead of an expected contingency.
- Sections IV and V of this Testimony outline specific warning signals to watch for, as well as recommendations for Congress. Creating an effective China-focused Energy Strategic Warning system would likely cost less than $25 million per year and could be scaled to monitor other regions as well for a range of climate, energy, and national security issues.

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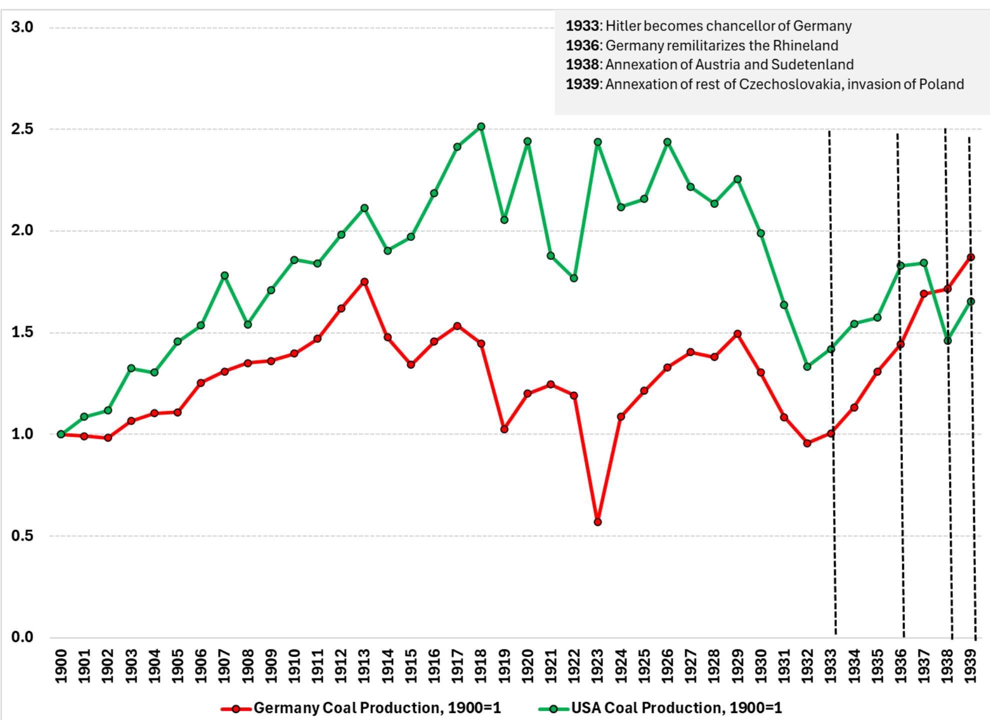
I. Introduction: Beans, Bullets, Black Oil, and Modern Warfare

Energy production and storage trends are an important signal that a country may be preparing to engage in warfare. Such data often hide in plain sight. Pinpointing "*where to look, how to look at it, and how to assess what we see*" is therefore critical. This analysis looks through the lens of "*how might a war initiator prepare its energy system and stockpile energy goods in advance of kinetic conflict or activities that materially raise the risk of kinetic war*?" It seeks to identify energy stockpiling activities that offer the most reliable strategic warning indicators and how those might be tracked.

Consider the case of Nazi Germany, which increased its coal production nearly two-fold between Hitler's taking power in 1933 and the invasion of Poland in 1939 (**Exhibit 1**). During the same period, the world's largest industrial economy, the United States, operated on market principles and its coal output trajectory significantly lagged that of an increasingly belligerent Third Reich. Energy activities showed that Berlin was on war economy footing years before it marched troops into the Rhineland, annexed Austria and the Sudetenland, and invaded Poland.

Exhibit 1: German and US Coal Production, Index (1900 = 1)



Source: NBER, Federal Reserve Bank of St. Louis, Author's Analysis

Similarly, the behavior of Chinese energy producers, traders, and transporters, who operate under increasingly intensive state supervision, could yield clues about the PRC's intent to

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potentially engage in armed conflict. Prospective belligerents may augment energy production and stockpile energy resources for several reasons. First, if they are significantly import-dependent--as China is for crude oil and natural gas--they need a cushion to help them sustain their industrial metabolism during a blockade or embargo. Second, even if they have abundant domestic resources (coal, in China's case) the rate of consumption at the intense, high-maneuver early phases of a war can exceed the ramp rate of domestic producers and logistics networks.

Third, under either scenario, the greater the stockpile relative to expected demand, the more resilient the party's supply position is. "Just in time" peacetime inventory management strategies please investors for their financial leanness but mean that even a handful of enemy strikes can seriously crimp supply. Finally, pre-conflict stockpiling is also likely to favor operational locations such as ports and airbases nearest the expected fight. As an illustrative example, if the PRC is preparing to invade Taiwan, it likely would stage diesel, gasoline, and jet fuel in Southeast China, not in Xinjiang or along the Bohai Gulf. Similarly, crude stockpiles would likely build nationwide, but with special intensity near refineries with the most robust product pipeline linkages to areas nearest the physical battlespace.

I. Energy & Modern Warfare

Energy matters greatly in a new era of industrial warfare. Russia's massive strike campaign against Ukraine's electricity and gas systems affirms their strategic importance to Kyiv's warfighting capacity. The Ukraine War's combat dynamics also suggest that past and present share more similarities than one might expect. Killing technologies have evolved dramatically over the past 80 years, but the physical raw material balances needed to sustain industrial war have not changed substantially.

In the maritime domain, a modern DDG-51 destroyer consumes approximately as much fuel as a similarly sized World War II light cruiser under many operating regimes.[5] Other machines have become far more fuel intensive. A P-51 Mustang takes off at a fuel flow rate of 120 gallons per hour, while an F-16 Viper with afterburner engaged for the same takeoff could burn approximately 130 gallons in a single minute.[6]

Platforms sailing, flying, or driving in the battlespace are only part of the equation. The energy demands of an economy at total war can be phenomenal. Energy is vital to produce metals and materials to arm warriors, to grow the food that sustains them, to move goods around, and to fuel the overall homefront economic activity necessary to stay in a prolonged fight. In summary, while energy abundance does not by itself ensure victory, it is an essential prerequisite. Snapshots of German war material needs in 1942 (when its material position was peaking) and US raw material usage in 1944 as its war effort reached full swing illustrate energy's comprehensive importance (**Exhibit 2**).

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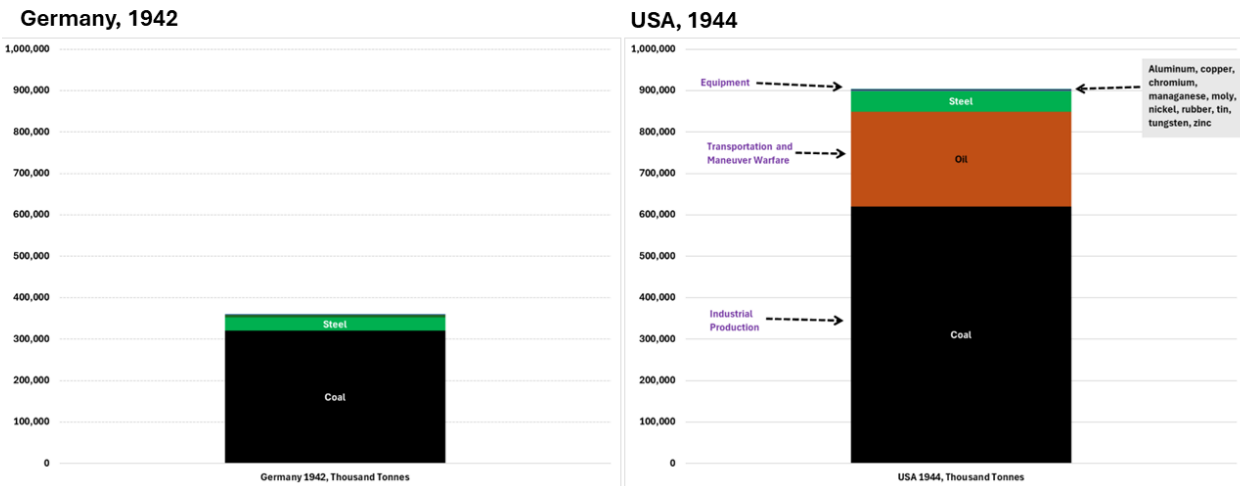
It bears noting that coal deliveries to consumers in Germany rose from 189 million tonnes in 1938/1939 to a peak of 250 million tonnes in 1942/1943.[7] German Armaments Minister Albert Speer captured the core issue well with his 1944 remark that "*coal is the starting point for everything necessary in war*."[8]

Exhibit 2: German and American Consumption of Key Raw Materials During Year of Peak War Production Effort ('000 Tonnes)



Source: Rohstoffverbrauch 1942 : Vergleich. 1943. 1 p. NARA T78 R146; DEIGHTON, Len. Blood, Tears and Folly : An Objective Look at World War II. New York, NY : Castle Books, 1999. 653 p. ISBN 0-7858-1114-1 (via Panzerworld); USGS, Author's Analysis

II. How is China Stockpiling Energy Resources?

China relies upon three import-exposed energy commodities for approximately 80% of its total primary energy usage. Coal underpins China's massive, world-leading energy system (1.6 times larger than that of the United States), accounting for about 56% of primary energy use (**Exhibit 3**). Oil follows at approximately 17% of total primary energy use—and propels most of the country's goods transportation activity aside from the rail system. Natural gas comes in third place, at about 9% of the total energy used in China.

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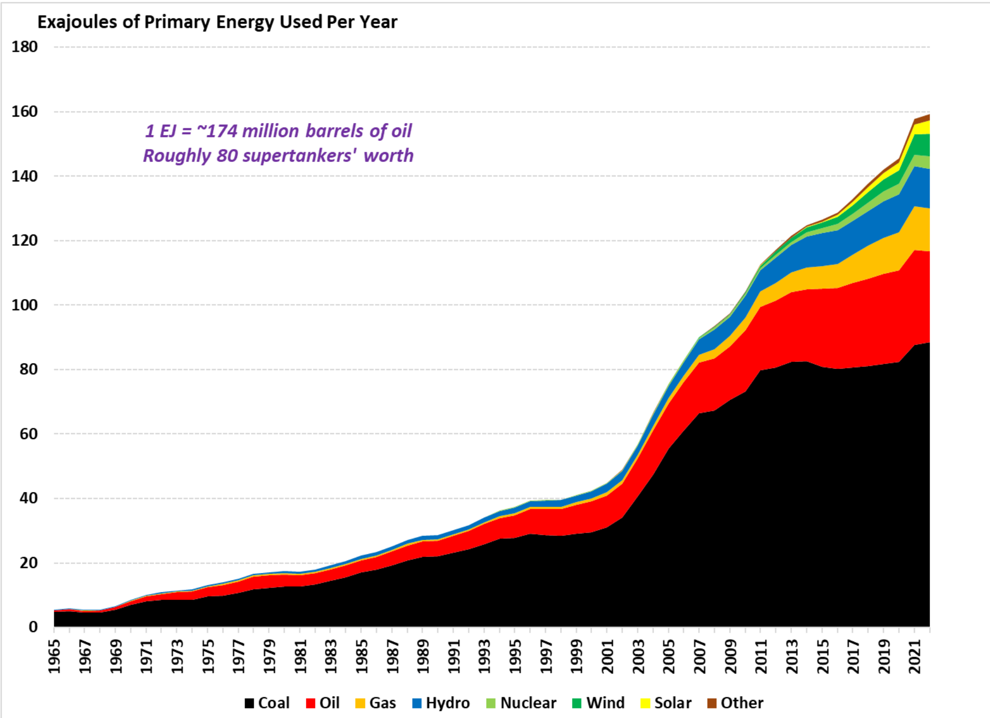
Exhibit 3: China Primary Energy Usage, By Source (Exajoules)



Source: Energy Institute Statistical Yearbook of World Energy 2023, Author's Analysis

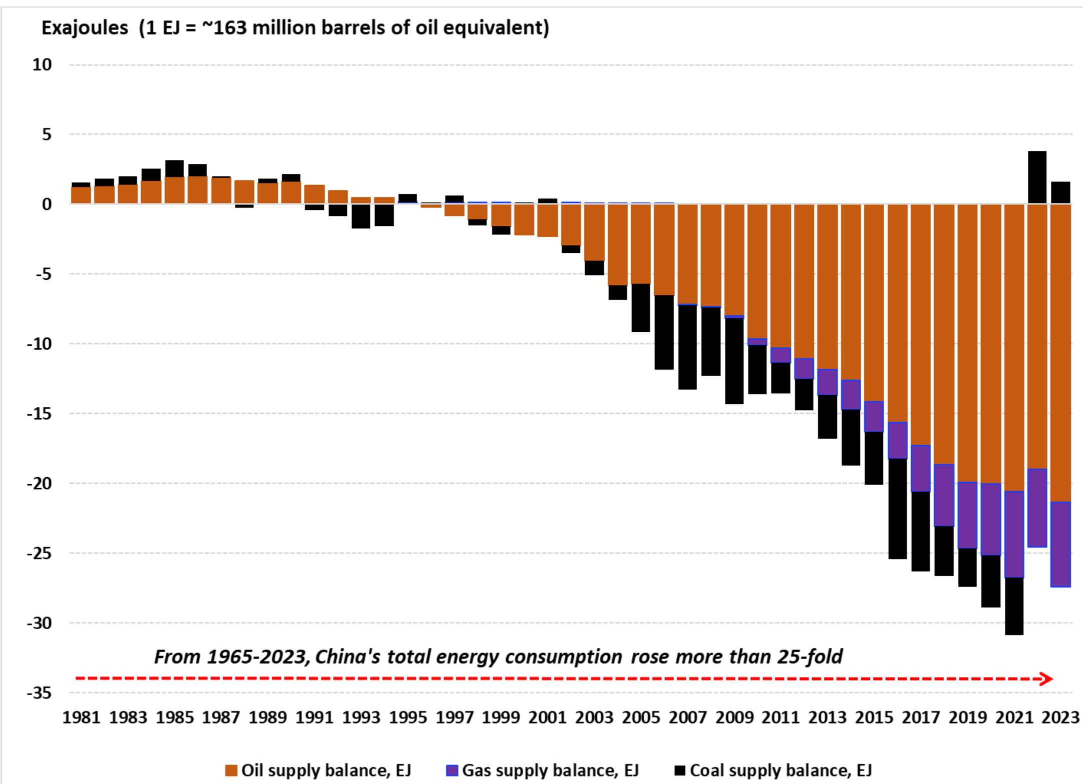
Chinese firms have over the past decade engaged in a massive energy infrastructure buildout implicating all three core hydrocarbon energy resources. Yet of the three, oil provokes the deepest concerns. As such, I will briefly engage coal and natural gas, along with the inventory management measures Beijing supports for those two resources, and then delve deeper into oil, the item for which PRC energy security anxieties are most acute and the energy source which powers the fighting instruments of a modern industrial war machine.

A. Coal Strategic Reserve Initiatives

The Chinese government's approach to coal stockpiling is production oriented. China's rich domestic coal reserves allow it to throttle production up in response to energy supply shortfalls, as it did with an approximately 25% production increase between early 2021 and early 2023. Such strategically transformational expansions of energy production are rare in the modern world. The only globally-impactful examples I could locate in the past century were (1) Nazi Germany's explosive expansion of coal production as it girded for war in the mid-to-late 1930s, (2) Saudi Arabia's oil ramp up from 1965 into the 1973 Oil Embargo, (3) the United States during the mid-2010s Shale Oil & Gas Boom, and (4) China's post-COVID coal production increases.[9]

China's domestic coal production juggernaut has been the country's primary fossil energy bright spot, with a turn to net supply surplus relative to demand over the past two years (**Exhibit 4**). Oil import dependence has risen sharply in the past 20 years. Natural gas import exposure is significant but has been held in place by aggressive domestic drilling efforts and perhaps most importantly, the fact that gas is secondary to coal as a source of process heat and can be substituted with coal, hydro, nuclear, and renewables (to some degree) as an electricity generation resource.

Exhibit 4: China Self-Sufficiency For Coal, Gas, and Oil (*Consumption – Production)*



Source: Energy Institute Statistical Yearbook of World Energy 2023, Author's Analysis

China in some months now stockpiles around 200 million tonnes of coal at major power plants, an approximately 30-day supply. Recognizing coal's foundational importance to the country's energy supply, social stability, and industrial production, the NDRC in April 2024 published a strategy for establishing a system of "dispatchable coal reserves."[10] While the idea's parameters are still taking shape, the NDRC seeks the capacity to rapidly augment coal production at the rate of 300 million tonnes per year by 2030, with a lesser amount

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operational by 2027. General Secretary Xi Jinping has said in the past that China seeks to have coal consumption peak around 2025-2026.[11] How much higher that figure will be than the 2023 level of more than 4.6 billion tonnes of domestic coal consumption remains to be seen.

The number is huge, but the predicate steps are already underway. PRC policymakers greenlighted a coal mine capacity expansion of an additional 300 million tonnes in 2022—almost the annual production of the entire European Union. That's enough coal to fill a train of standard rail hopper cars that would wrap around the entire Equator, plus enough left to stretch from Washington DC to Los Angeles.[12]

B. Natural Gas Stockpile Strategic Initiatives

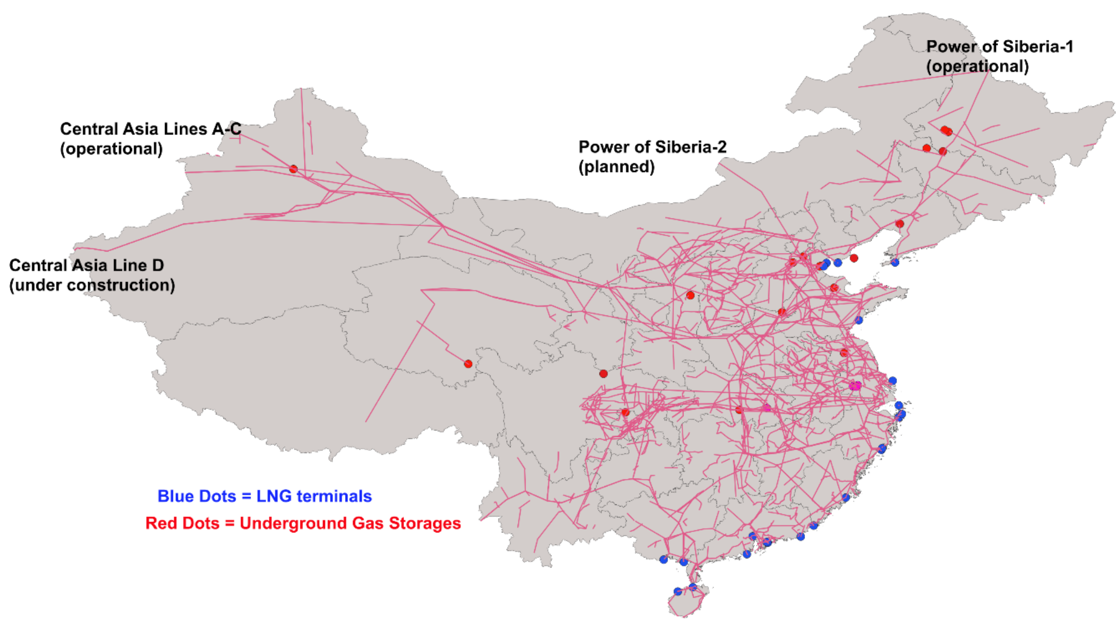
China is rapidly expanding its natural gas storage capacity. Cedigaz's latest Underground Gas Storage in the World report estimates that Chinese firms operate 21.3 billion cubic meters (BCM) of working underground gas storage capacity plus an additional 8.1 BCM of tank storage at liquefied natural gas import facilities. Cedigaz forecasts that the country's gas storage capacity could rise to 80 BCM of working gas capacity by 2030. As such, China gas storage could increase more than 2.5-fold, while overall gas consumption grows by something closer to half (from just under 400 BCM in 2023 to a range forecasted between 550 and 600 BCM in 2030).[13]

For comparison, Russia's Gazprom, the world's single largest gas producing firm operates approximately 75 billion cubic meters of working UGS capacity.[14] EIA data show that as of November 2023, the US had about 125 BCM of working underground gas storage capacity relative to nearly 900 BCM of annual gas consumption—the world's largest.[15]

Chinese policymakers appear to perceive natural gas storage as more of a market management tool than an explicit security instrument the way crude oil stocks are sometimes viewed. For instance, the Party's "2023 Energy Work Guiding Opinion" (2023年能源工作指导意见) emphasizes the importance of developing LNG import facilities and underground gas storage at key locations including Daqing, Chongqing, Henan (Pingdingshan), and Jiangsu (Huaian) but places these activities under a subheading of "bolstering energy system regulation capacity" (提高能源系统调节能力).[16]

To put the market management incentives in perspective, consider the following example: for much of the past decade, China has increasingly turned to spot market LNG imports to help balance the load in winter and avoid gas shortages. Spot LNG in Asia can cost $15 or more per MMBTU during the winter months.[17] Pipeline gas from Turkemenistan costs closer to $8.45/MMBTU while that from Russia in 2022 priced at approximately $7.30/MMBTU.[18] As such, by storing up gas volumes during warmer months (facilitated by renewable and coal use) allows China to potentially halve the cost of meeting spikes in gas demand during cold snaps that drive up gas demand.

Exhibit 5: China Gas Storage Map vs. National Gas Pipeline Network



Source: CEDIGAZ, GADM, GEM GGIT, GEM Wiki, Author's Analysis

C. Oil Strategic Storage Initiatives

Highly energy-dense liquid fuels offer the only means to reliably power aerial and ground combat systems on a sustained basis and at a high-performance level. The same holds for naval platforms unless they are nuclear-powered. Simple chemistry and physics underpin these realities: JP-5 jet fuel has more than 20 times the "usable" energy per kg of mass that a lithium-ion battery does.[19] While we may be able to eventually synthesize non-oil liquid fuels at acceptable cost and scale, crude oil is the only industrial-scale building block to

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produce the millions of barrels per day of fuels and myriad chemical items needed to sustain modern economies and industrial warfare.

History illuminates the stakes.[1] After World War I, the head of Great Britain's upper house of Parliament quipped that the Allies "*floated to victory on a wave of oil*."[20] World War II similarly saw Allied oil abundance help overwhelm and defeat the oil-starved Axis Powers. For its part, China lacks domestic resources, cannot create new ones through application of its industrial prowess, cannot control events abroad in producing regions, and is vulnerable to naval blockades that could curtail its oil imports and in a worst case, crimp the country's transport system and industrial base.[21]

Interviews conducted around a decade ago highlight the different views of oil within the PRC relative to other energy sources. PRC energy technocrats noted that electricity supply "*problems can be solved by ourselves*," but that "*oil imports are different…If our oil imports are cut off, it affects the whole nation, not just certain provinces, and we no longer maintain zili gensheng* (self-reliance)."[22] Reliance on oil imports appears to be especially jarring for a PRC leadership that appears to have concluded that the world is heading into a potentially prolonged period of chaos.[23] While the author has not yet located Chinese sources saying so, it is reasonable to believe that tightened U.S. export controls on semiconductors and related technologies plus emerging discussions of restrictions on LNG and refined products trade with China further stoke leaders' anxiety about the U.S. potentially exploiting Chinese oil import dependence.[24]

Beijing's oil security response to date emphasizes four core elements: (1) maintaining larger oil inventories, (2) intensified domestic drilling, (3) managing fuel demand through price, and (4) seeking to become an "electrostate" that substitutes electrons for oil (e.g., EVs for ICE cars).[25] This testimony will not further discuss Chinese firms' domestic drilling efforts because they appear to emphasize "running harder to stay in place" and do not appear poised to materially reduce China's substantial oil import dependency (on the order of 70% of consumption vice 30% for the United States). It will focus on stockpiling as well as the related measures of electrification, and potentially, the PRC's ability to use Russia and to a lesser extent, Kazakhstan, as "virtual stockpiles" from which cross-border pipelines could

[1] The next several paragraphs draw substantially upon the author's recent research essay for the National Bureau of Asia Research, Gabriel Collins, "Energy as a Strategic Space for China: Words and Actions Point to a Competitive Future," National Bureau of Asian Research, 28 February 2024, https://strategicspace.nbr.org/energy-as-a-strategic-space-for-china-words-and-actions-point-to-a-competitive-future/

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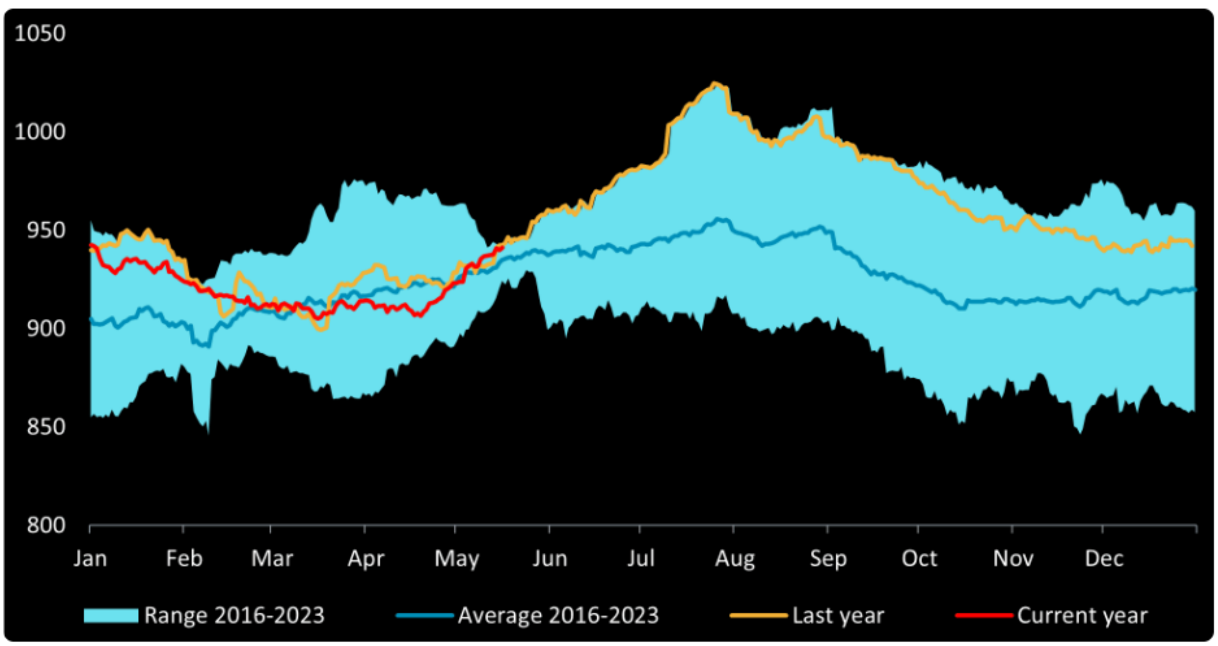
be rapidly expanded in a crisis to extend the coverage provided by oil already stored within the PRC.

i. China's Oil Storage Buildout

Commercial data provider BreakWave Advisors estimated that as of late May 2024, China had about 942 million barrels of crude oil stored in aboveground tanks onshore.[26] The company's data, which tracks with estimates the author has located from competitor firms Kayrros and Ursa Space Systems, suggest that between 2016 and early 2024, China's total aboveground crude oil inventory has ranged from 850 million to a bit over 1 billion barrels (**Exhibit 6**). This number includes strategic petroleum reserve sites with a total storage capacity of approximately 300 million barrels of crude oil.[27]

Exhibit 6: Estimated China Onshore Crude Oil Inventories (Aboveground Tanks Only), Million Barrels



China onshore crude inventories (aboveground tanks only, mb)

Source: BreakWave Advisors

The estimates cited above generally use synthetic aperture radar on satellites to measure the rise and fall of floating storage lids on large crude oil tanks and then base estimates of storage volumes on these observable tank levels. Kayrros data suggest that China's total crude storage capacity is now somewhere a bit north of 1.8 billion barrels—about 30% larger than total U.S. storage capacity even though the U.S. still consumes about 25% more oil than China does.[28]

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Combining commercial firms' data with our own Baker Institute China Energy Map shows that oil storage capacity tends to cluster around oil ports capable of accepting very large crude carriers (VLCCs).[29] Shandong, Zhejiang, Liaoning, and Guangdong provinces host the largest volumes of oil storage capacity. The Greater Shanghai Area and Shandong are the country's most critical oil import and storage zones, with more than 500 million barrels of storage capacity between them.

BreakWave's analysis indicates that over the past two years, China's Big 3 (Sinopec, PetroChina, and CNOOC), which control the lion's share of crude oil tank capacity, have typically utilized from 55% to 65% of their tanks' volume. Aboveground tanks can in many cases store 80% of their nameplate capacity, suggesting that China could have nearly 300 million barrels of additional "headroom" across its oil storage complex if it chose to maximally stockpile ahead of an expected contingency.[30]

China's outsized oil storage expansion rate—in which capacity roughly tripled since 2005 while the country's oil consumption doubled—has profound strategic implications. Consider the following simple model of how stocks + rationing + cessation of oil product exports + expanded overland imports + synthetic fuels can dramatically enhance China's ability to weather an oil blockade.[31] Key assumptions include:

- On the first day, China holds combined commercial and strategic crude-oil stocks of 1,440 million barrels in storage tanks and underground caverns (80% of 1.8 MB capacity and about 40% greater than peak storage used – Exhibit 6).
- The country's refinery runs of crude oil—a proxy for oil products demand--are 16 million bpd.
- Exports of refined products ceases
- Rationing rapidly reduces non-military demand for oil products relative to pre-conflict levels.
- China imports a baseline volume of six hundred thousand barrels per day of crude from Russia and four hundred thousand barrels per day from Kazakhstan by pipeline.
- The 440 kbd Myanmar–China pipeline is interdicted and unable to supply crude.
- Russia and Kazakhstan surge railborne crude supplies by a combined total of four hundred thousand barrels per day.
- In addition to pipeline and rail supplies, Russia and Kazakhstan provide 150 kbd of crude overland, by truck.
- Starting on Month-8 of the blockade/supply interruption, Russia acts as a "virtual stockpile" and surges crude oil supplies with additional pipelines bringing 1,000 kbd

of oil that enter service beginning in Month 8 of the crisis. (i.e. the flows now exported through the port of Nakhodka are instead directed south into China overland)

- The bottom line is that with a large stockpile, aggressive rationing, and secondary fuel supply measures, China could endure for between 2-to-4 years before crude oil stocks ran out (**Exhibit 7**). In terms of sensitivity, each incremental 100 million barrels of storage adds approximately 2 months of endurance time in the "no additional overland supplies" scenario and closer to 6 months when augmented with Russian overland pipeline expansions.

Exhibit 7: China Oil Blockade Endurance Model

					Implied Stockpile Life, Months
Beginning Crude Oil Stocks, '000 bbl	1,440,000		No Emergency Pipeline From Russia		
Baseline Refinery Runs, '000 bpd	16,000		Initial crude oil stockpile drawdown rate without seaborne imports and no rationing, '000 bpd	-9,229	5
Refinery Runs @ 35% Rationing, '000 bpd	10,400		Draw rate with 35% demand rationing, '000 bpd	-3,629	13
Refinery Runs @ 40% Rationing, '000 bpd	9,600		Draw rate with 40% demand rationing, '000 bpd	-2,829	17
Refinery Runs @ 45% Rationing, '000 bpd	8,800		Draw rate with 45% demand rationing, '000 bpd	-2,029	24
Methanol and Fuel Extenders, '000 bpd	971		Emergency Pipeline From Russia Enters Service on 8th Month of Blockade		
Domestic Production, '000 bpd	4,250		Drawdown rate with no seaborne crude imports once supplementary emergency pipeline built (no rationing), '000 bpd	-8,229	6
Existing Pipeline Potential Supplies From Russia & Kazakhstan, '000 bpd	1,000		Draw rate with 35% demand rationing, '000 bpd	-2,629	18
Rail and Truck-borne Supplies From Russia & Kazakhstan, '000 bpd	550		Draw rate with 40% demand rationing, '000 bpd	-1,829	26
Emergency Supplementary Pipeline from Russia, '000 bpd	1,000		Draw rate with 45% demand rationing, '000 bpd	-1,029	47

ii. Oil Stockpile Governance in China

China's SPR was born through roughly a decade of debate between "build" and "don't build" factions. As China's oil import dependency continued rising alongside skyrocketing oil demand in the early 2000s, the "builders" won the debate and construction of the first sites commenced in 2004.[32] The Phase I SPR sites—located at Zhenhai, Zhoushan, Huangdao, and Dalian—can collectively store about 103 million barrels of oil and were filled and operational by year-end 2009. Phase 2, which can store roughly 200 million additional barrels of crude, was filled and online by year-end 2019.[33]

Various Phase 3 SPR sites are under consideration across China amidst a crude oil storage buildout, that, as referenced above, has already made the country the world's largest single holder of oil storage capacity. **Exhibit 8** (below) shows existing SPR sites relative to overall

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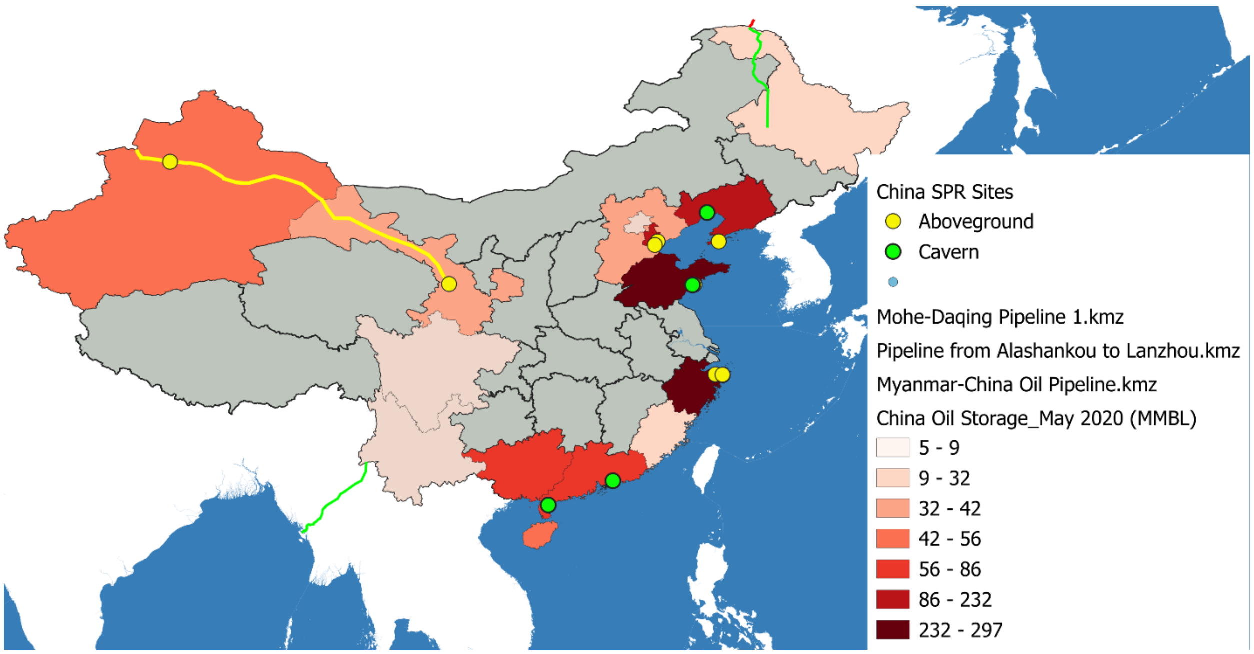
provincial oil storage capacity as of mid-2020. The map is constrained by data limitations, but provides a directionally accurate view, as the roughly 500 million barrels of incremental oil storage capacity added in recent years has tended to cluster around the storage zones that were dominant in 2020.

Exhibit 8: China SPR Sites vs. Total Oil Storage, By Province (*thick yellow and green lines are operational overland oil pipelines***)**

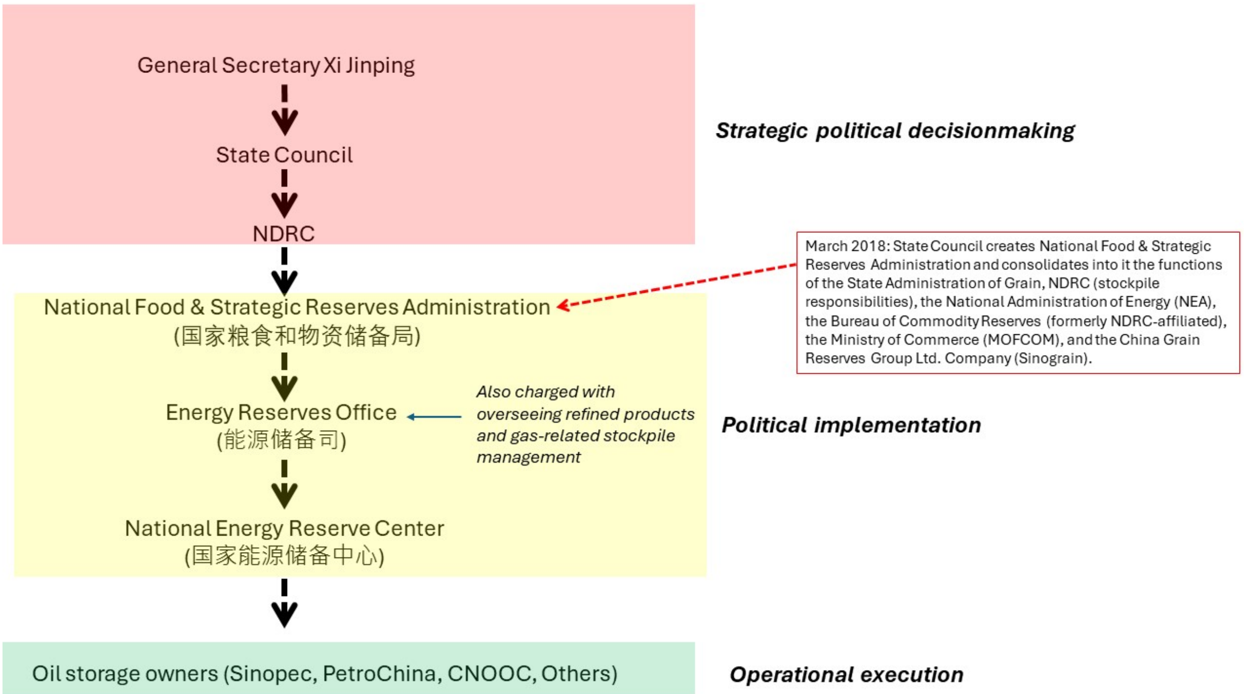


Source: Baker Institute China Energy Map, OIES, Reuters, Ursa Space Systems, Author's Analysis

China's SPR management incorporates three basic levels (**Exhibit 9**). At the highest level, strategic political decisionmaking, sits the National Development and Reform Council (NDRC), which is in turn subject to the State Council and General Secretary Xi Jinping.[34] The second level, political implementation, involves the National Food and Strategic Reserves Administration (**国家粮食和物**资储备局), within which the Energy Reserves Office (能源储备司) and National Energy Reserve Center (国家能源储备中心) sit.

The Energy Reserves Office oversees regular reserve operations, supervision, and data collection for crude oil, refined oil products, and natural gas.[35] The National Energy Reserve Center is classified as directly subordinate to the main National Food and Strategic Reserves Administration core divisions (直属联系单位), of which the Energy Reserves Office is one. Official PRC government websites do not conclusively show a specific direct command chain between the Energy Reserves Office and National Energy Reserve Center, but such a bureaucratic flow line likely exists. The third level of SPR management are the companies that manage storage and conduct operational execution.

Exhibit 9: China SPR Governance Structure



Source: NDRC, National Food and Strategic Reserves Administration

In 2018, China consolidated functions of several entities charged with energy, food, and materials stockpiling into the National Food and Strategic Reserves Administration.[36] Previously, the National Energy Administration (subordinate to the NDRC) oversaw China's SPR. The re-organization suggests that China's leadership may want to centralize strategic stockpile management. If this is indeed the case, it would fit with General Secretary Xi Jinping's broader proclivity toward centralization and consolidation of authority.

Energy stockpiling's new place may also reflect that the PRC government is, in relative terms, more preoccupied with food security than with energy, since the country has demonstrated the ability in recent years to surge coal production in response to energy shortages, is not facing acute gas supply shortfalls, and now, hosts the world's largest oil storage infrastructure. China also leads the world in transport electrification efforts designed to offset crude oil dependency.

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iii. Stockpile Management in Practice

Unlike the United States and other OECD countries, which generally clearly delineate between "commercial" and "strategic" crude oil storage, China's system has been ambiguous since its inception. Nine clearly demarcated SPR bases exist, but often sit adjacent to far larger commercial tank capacity. The stocks share access to common pipeline infrastructure and refineries. The "commercial" crude oil stocks also appear to be managed more conservatively than those in the US, where stock levels may swing 25% in the span of 18 months as participants react to market conditions—a fluctuation range nearly twice as large as that seen in PRC commercial crude oil stocks data published by BreakWave Advisors (**Exhibit 6, above**).

China has thus far largely operated its SPR under a "fill and hold" philosophy, conducting a single test sale of 7.38 million barrels from the Dalian SPR facility in September 2021.[37] Given this limited operational history and Chinese energy reserve operators' general secrecy (to the point that almost no employees have LinkedIn profiles), it is instructive to look at US SPR management practices to get a glimpse of how management practices could evolve moving forward.

For most of its history, the US has released oil from its SPR for three reasons: (1) periodic small test sales to keep operational mechanisms "well oiled", (2) smaller emergency releases to help ensure supplies to refiners in the event of logistical disruptions [ship collisions, pipeline problems, or hurricanes], and (3) responses to war shocks [Gulf War I and 2011 Libya War]. In 2022, the US SPR was for the first time used for large-scale price management as President Biden ordered a million barrel per day release of oil over a six month period.[38]

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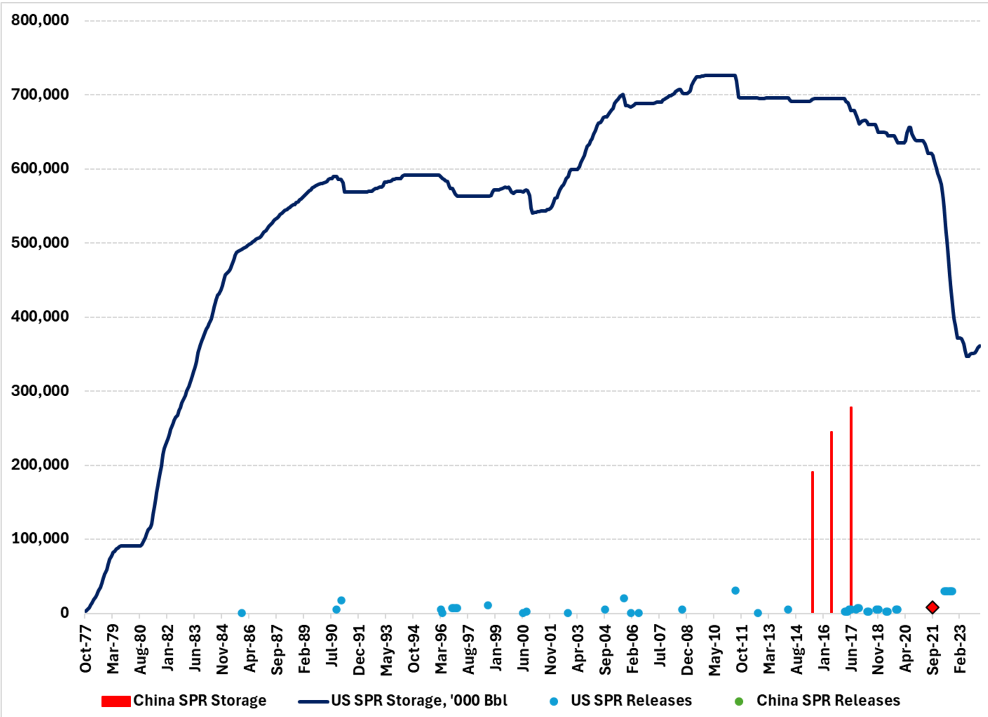
Exhibit 10: US and China SPR Levels and Releases

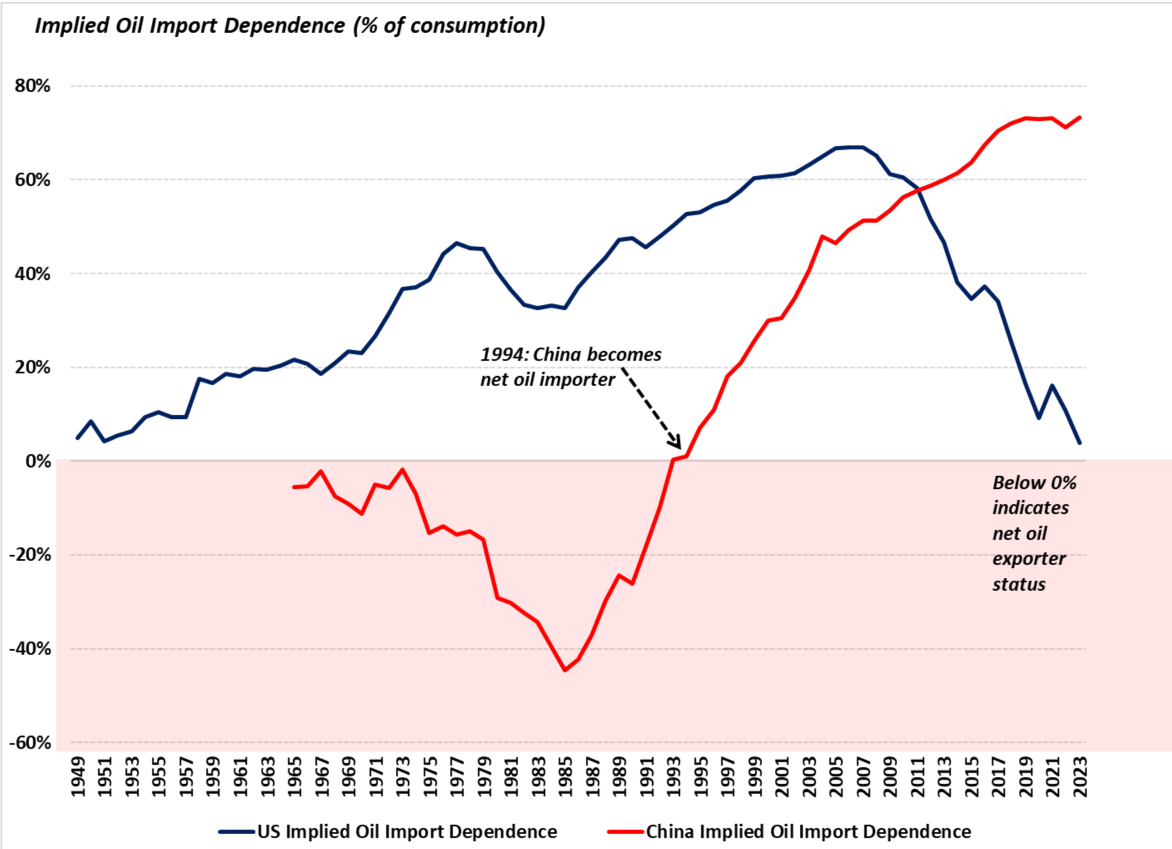


Source: EIA, OIES, Reuters, Author's Analysis

China's single small SPR release over its nearly 20-year operational history lends credence to PRC officials' 2006 statement that the country would not use the SPR for price management. Washington managed its SPR conservatively for much of the past 40 years, only shifting to more activist footing when a domestic production boom made the US nearly self-sufficient in crude oil (**Exhibit 11**).

One reasonable conclusion from the evolving American SPR management approach is that deep oil import dependence = conservative SPR management, while oil abundance = adoption of a more activist, trading mindset. In China's case, one could imagine a future in 15-20 years where electrification and other demand management efforts reduce oil dependence sufficiently that the country's massive oil storage and refining base becomes a global scale trading asset. But in the meantime, it is a strategic sector integral to the PRC's ability to compete economically during peacetime, and in a worst-case scenario, sustain the PLA during Great Power industrial warfare.

Exhibit 11: US and China Implied Oil Import Dependency (Proportion of Demand not covered by Domestic Production)



Source: EIA, NBS China, Author's Analysis

iv. Stretching the Stockpile: China's Emerging Electrostate

As the author stated in 2022:

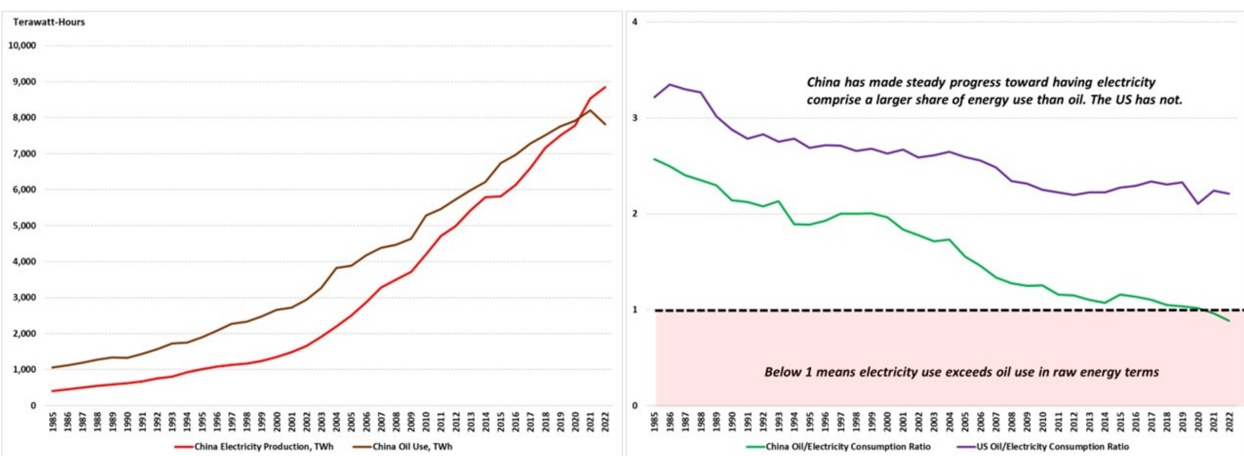
> *"...the past 20 years make one thing increasingly clear: unlike the United States, China is not going to drill its way to lower crude oil and natural gas import dependence. Between 2000 and 2013, China's "Big 3" (PetroChina, Sinopec, and CNOOC) ramped up their combined annual capital investment, which peaked in 2013 at about seven times the 2000 level and declined subsequently...But for both commodities, import dependency steadily deepened because domestic production simply could not keep pace with demand growth despite cumulative nominal expenditures of more than $1 trillion USD."*[39]

Chinese leaders have not given up on domestic drilling. But they are proportionally wagering much more on finding new technological pathways that leverage China's massive industrial base and human talent to redefine the country's energy reality. They are building an electrostate where oil usage is increasingly supplanted by electrical locomotion able to derive power not just from oil and gas, but instead from coal, uranium, hydro, wind, solar, and any other fuel that can spin a dynamo or displace electrons from a photovoltaic cell

Being a PetroState requires acceptance of deep exposure to global oil/nat gas commodity markets that can only be partially hedged with domestic output. Electrostates, in contrast, leverage techno-industrial excellence to create optionality between many fuels/power sources rather than dependence on a few. This is a key reason why China-Russia negotiations for a second pipeline from Siberia are proceeding slowly: Beijing does not acutely need Russian gas because it is one of many sources in the country's evolving energy portfolio (underpinned by abundant domestic coal).[40]

PRC-based firms are securing globally influential positions on both higher-value added industrial chains for alternative energy goods like batteries and electric vehicles (underpinned by of the world's largest coal-fired electricity generation infrastructure) while also exerting deep, intentional influence over physical supplies of energy raw materials. The PRC as a matter of high-level policy also simultaneously seeks commanding positions astride global energy data flows that can give PRC parastatal firms competitive advantages, stifle competitors, and improve strategic visibility into ally and adversary economies alike.[41]

Exhibit 12: China Electricity Production Versus Oil Consumption

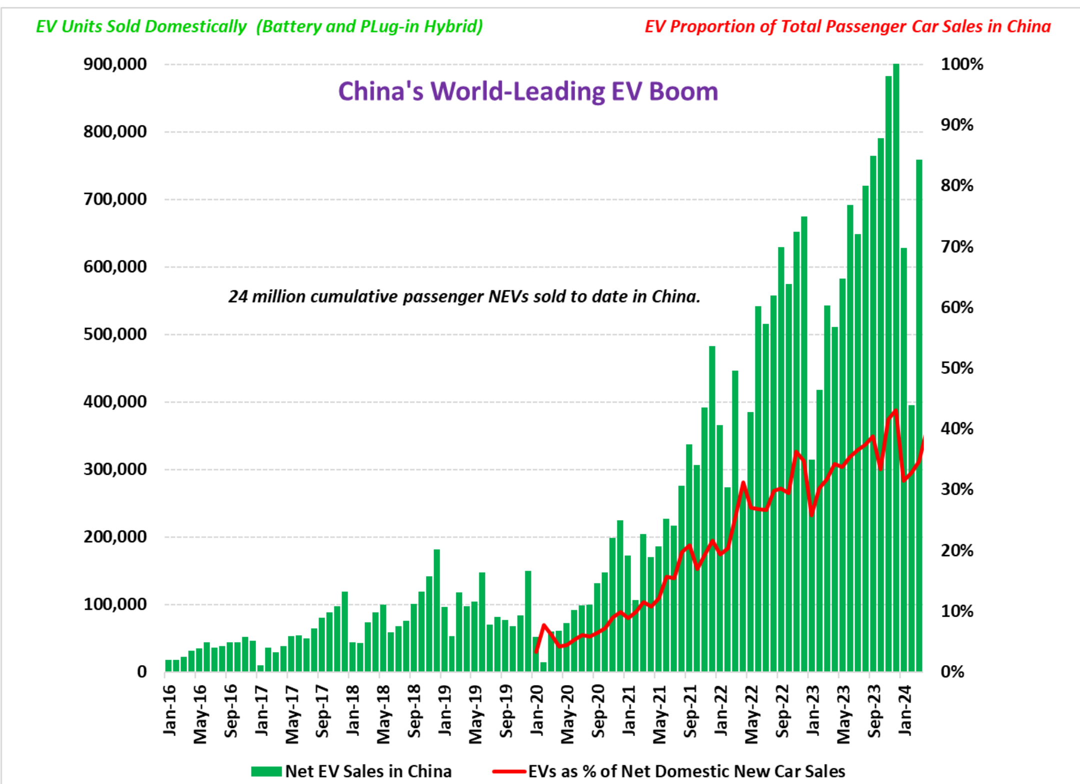


Source: Energy Institute Statistical Yearbook 2023, Gasunie (conversion), Author's Analysis

Transport electrification and the associated value chains are the product of decades of effort that after what are likely hundreds of billions of dollars in collective investments are now finally able to scale. EVs began to receive much more policy attention in China during the early 2000s, including from the 863 Program (State High-Tech Development Plan), presaging their role in the Made in China 2025 plan roughly a decade later.[42] Official focus intensified with the 2007 appointment of Wan Gang as Minister of Science and Technology. Dr. Wan was a German-trained former Audi executive who the New York Times characterized as "a passionate advocate of electric cars," was appointed by then-Premier Wen Jiabao, and attracted strong support from China's national security community, which perceived the country's rapidly rising oil imports as a strategic vulnerability.[43]

Bracketed by security actors concerned about oil import dependence and techno-industrialists seeking new economic advantages, China's EV sector has blossomed, with battery EVs and plug-in hybrids accounting for over 1/3 of new vehicles sold in China thus far in 2024, with more than 24 million passenger EVs sold to date (**Exhibit 13**).[44]

Exhibit 13: PRC Domestic Electric Vehicle Sales (Battery and Plug-in Hybrids)

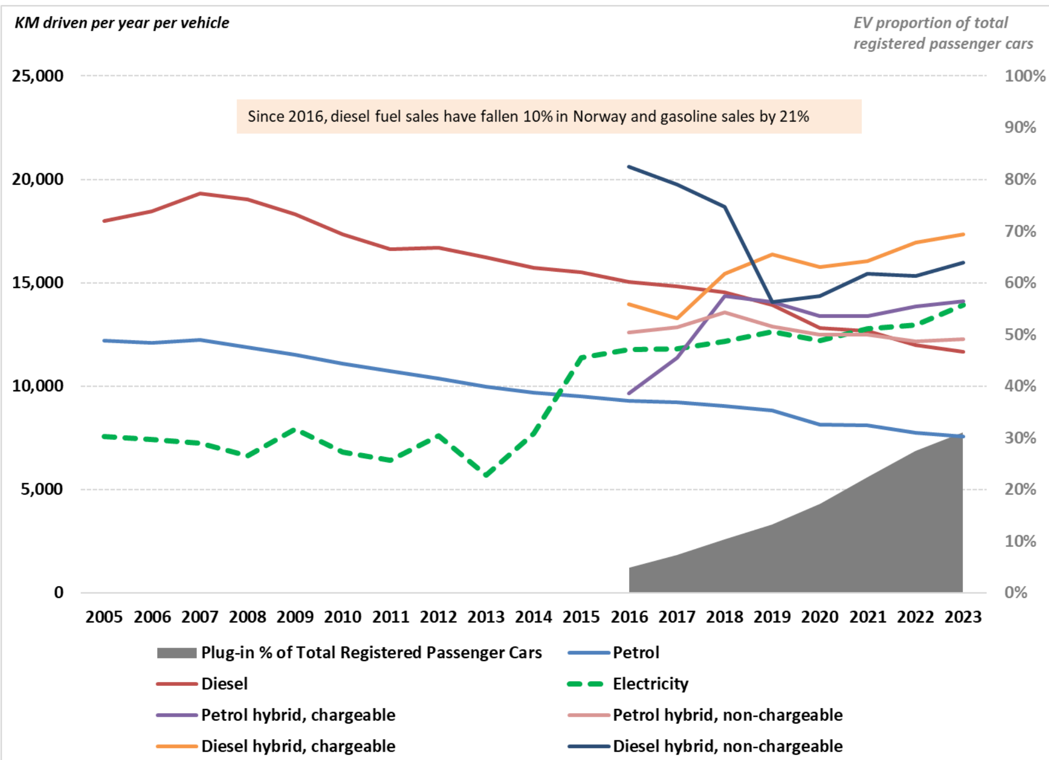


Source: CAAM, Author's Analysis

By the end of 2024, about 10% of China's passenger vehicle fleet is likely to be substantially electrified (either pure battery or plug-in hybrid). The existing fleet penetration of EVs and prospective growth rates moving forward suggest their growing presence is already reducing future motor fuel demand growth potential. How long until EVs potentially begin to outright reduce China's oil demand? Short answer: we do not know but can look to examples from markets like Norway with substantially larger EV shares to get a sense as to when tipping points could come.

Norway has one of the world's most aggressive EV subsidy programs, including disincentives to own standard internal combustion engine cars. In many months, EVs now account for 70-80% of new passenger car sales, twice the EV share in China. As a result, EVs have grown from about 5% of the registered passenger car fleet in 2016 to 31% in 2023 (**Exhibit 14**). EVs are also clearly evolving into true "daily driver" vehicles in Norway, with annual vehicle distance travelled now on par with legacy diesel and gasoline-powered cars.

Exhibit 14: Annual Distance Travelled For Passenger cars in Norway vs. EV Fleet Share



Source: Statistics Norway, Author's Analysis

The combination of greater fleet share plus rising use appears to be impacting transport oil usage in Norway. Between 2016 and 2023, diesel fuel sales declined by 10% while gasoline sales fell by 21%. While China would need to roughly triple EVs' fleet share to reach Norwegian levels and ensure that owners make them primary use vehicles, if it gets there, the Norwegian experience suggests gasoline and diesel fuel demand could be reduced meaningfully. But China's oil substitution efforts are chasing a moving target, because unlike Norway, China's vehicle fleet continues to grow and more than 60% of new vehicles sold each month are still gasoline and diesel-powered and thus build in future oil demand. The

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precise number of EVs needed to tip China onto a path of actual declines in oil usage remains unclear but is likely massive and could (depending on ICE vehicle fleet increases) exceed 80 million EVs. If China can move away from oil for heavier transport like trucks, ships, and aircraft via electrification or synthetic fuels, the impacts could be even larger.[45]

III. Lessons From Recent Wars

The Committee asks us about recent events and the lessons they might hold for PRC officials in charge of the energy security and energy stockpiling portfolios. Two primary lessons jump out. First, for energy storage infrastructure, underground = survivable. Russia's strike campaign against Ukrainian underground gas storage infrastructure has been far less impactful thus far than attacks on exposed power grid and generation assets. Second, in perhaps the most graphic display of how using the "fourth dimension" of underground facilitates wartime survival, Hamas has retained a meaningful degree of military capability and continues fighting despite an Israeli air campaign whose strike density is among the most intense in history.[46]

Chinese energy planners were already working to expand underground storage for both crude oil and natural gas and the two ongoing wars will likely intensify the push given the lesson that going underground supercharges survivability. Underground oil storage also frees up surface land for other uses in high value, crowded coastal zones, has lower operational costs over time, and enjoy longer service life and a lower maintenance burden. Chinese firms are working to build underground gas storage in salt domes near Jintan in Jiangsu Province. Chinese sources have previously discussed storing crude oil in that area but it is unclear whether firms are presently seeking to build underground salt dome crude storage there now.[47]

The war in Ukraine repeatedly demonstrates the vulnerability of aboveground oil and refined product storage tanks to strikes from drones, cruise missiles, and other munitions, where a warhead of even a few pounds' size can trigger catastrophic fires.[48] Some of China's already in service underground oil storages sit under as much as 100 meters of earth and rock, placing them below the reach of nearly every strike munition deployed by any military globally including the United States.[49] China already has operational underground crude oil storage facilities at Huangdao, Jinzhou, Zhanjiang, and Huizhou, which between them could store at least 100 million barrels.[50]

Efforts to take a greater proportion of oil storage underground are likely to accelerate. China National Petroleum Corporation (CNPC) announced the launch of a special "Mined Cavern Underground Oil Storage Laboratory" in 2023, pointing to a long-term commitment to expanding underground oil storage in China.[51] The June 2023 launch followed a roughly 4-

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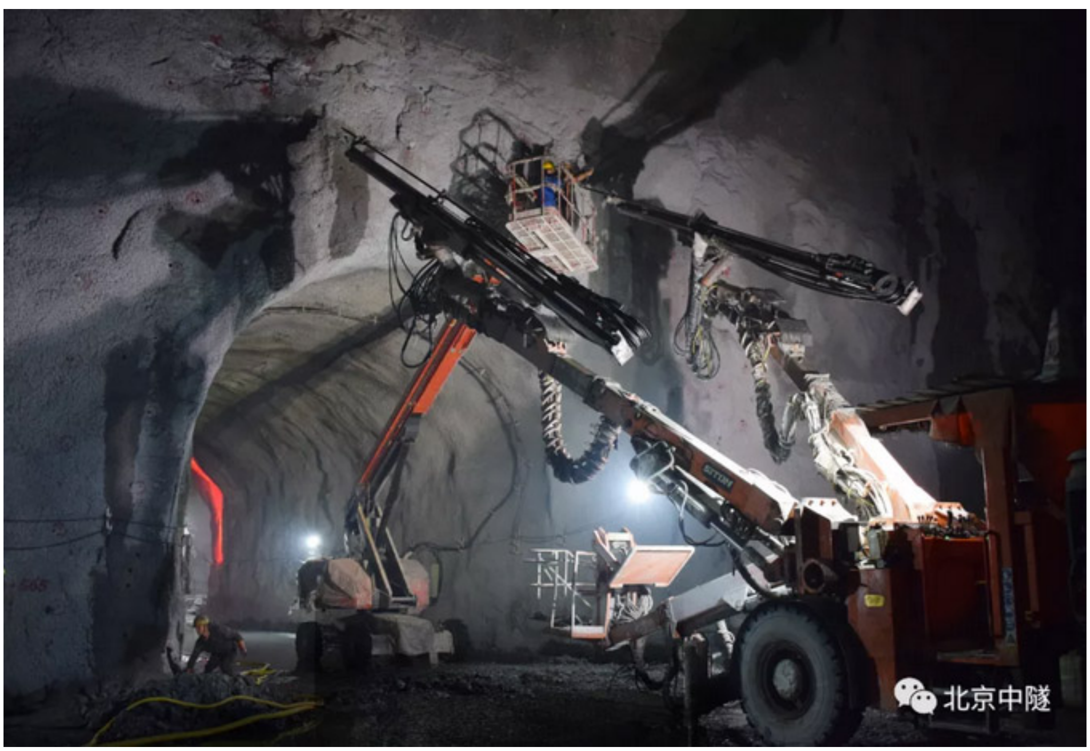
year creation period. Standing up such a dedicated laboratory during a time in which PRC energy policymaking has become increasingly securitized suggests underground oil storage construction may accelerate in coming years, including the possibility that as older above ground tank capacity is retired from service, it could be replaced by underground capacity. Indeed, at least one Chinese engineering journal notes that above ground crude oil tanks typically have a 25-year service life, meaning that several hundred million barrels of storage built between 2000 and 2005 could be nearing replacement age.[52]

Corporate actors to watch in the China underground oil storage construction space include Beijing Central Tunnel Engineering Corporation (北京中隧隧道工程有限公司), China Railway Tunnel Group Limited (中铁隧道集团), and Beijing New Oriental Star Engineering Investigation and Design Company Limited (北京东方新星勘察设计有限公司). Geographical areas to watch for underground storage facility construction center on existing areas where favorable topography (rock mountains) intersects with significant refining, pipeline, and oil import infrastructure. Areas fitting this description include Ningbo/Zhoushan, the Guangdong coastline, portions of Shandong near Rizhao and Qingdao, and Dalian.

Exhibit 15: Zhanjiang Oil Storage Caverns Under Construction in 2016



Source: Beijing Central Tunnel Engineering Limited Company

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Second, for a country with geographically constrained maritime approaches, being able to expand overland supplies facilitates strategic endurance. In Ukraine's case, Russia and Belarus (a Russian province in all but formal name) supplied over 60% of Ukraine's refined oil product imports prior to the 2022 invasion, accounting for a substantial proportion of domestic demand.[53] Once Russia started the war, these supply chains became physically and politically untenable. Furthermore, Russian forces sought to blockade Ukraine's Black Sea coast and deny maritime commerce, precluding a potential alternative supply pathway. In response, Ukraine had to rapidly re-orient its oil product procurement channels to obtain fuel from adjacent and nearby European Union members such as Bulgaria, Poland, Romania, and Slovakia.[54]

In China's case, its maritime oil imports are substantial, are geographically constrained by the First Island Chain, and could be interdicted more deeply and for a longer period than Ukraine's given that the U.S. and its allies field far more competent navies than Russia does. While Ukraine in the words of a local energy expert "*bought all the fuel tank trucks that were available in Europe*"[55] to rebuild fuel supply chains, China's much larger fuel needs would demand pipeline expansion to replace some quotient of lost seaborne crude oil imports.

So how might such a stratagem be executed?[56] China was able to build the initial Russia-to-China pipeline at an average rate of approximately 1.6 km per day, and has built crude oil pipelines in Western China at rates approaching 2.25 km/day.[57] The Jinzhou-Zhengzhou oil products line was welded at an average rate of 3.6 km/day.[58] In a time of national emergency, pipelines can potentially be built much more quickly as builders would likely marshal a much larger proportional share of their equipment and manpower for a select few "national priority" projects than would be the case under normal conditions.

Perhaps the closest historical analogy comes from the American construction of the "Big Inch" oil pipeline during WWII. The Big Inch enabled the secure overland movement of crude oil from Texas oilfields to East Coast refineries. Oil had formerly been moved from the Gulf of Mexico in coastwise tankers, but German submarine attacks jeopardized this maritime supply line and forced the U.S. to find alternative routes. At 1,254 miles long (2,000 km), the Big Inch covered roughly twice the distance a line from the Russian border to Daqing would and construction crews managed to complete it in just 350 days: an average construction rate of nearly 6km per day.[59] Against that backdrop, it is not inconceivable that a 1,000 km pipeline from Russia capable of moving as much as a million barrels per day into the Daqing area could be built in 6 months or possibly less.[60]

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IV. Strategic Warning Signals to Watch For

Warning Signal #1: Significant upward departure from the trailing 3-year and 5-year average aboveground crude oil storage utilization rates. Aboveground tank storage capacity utilization beyond 65% should be treated as a "yellow flag" justifying deeper scrutiny.

Warning Signal #2: Construction of more underground crude oil storage facilities. This will require techniques including monitoring of tunneling equipment firms' activities in the PRC, vehicle traffic observation in areas of interest using space-based synthetic aperture radar, and potentially, satellite-based gravimetric surveys, potentially facilitated by AI-driven data processing to bring down currently coarse spatial resolution. Volatile organic compound emissions in areas they would not normally be expected could also alert observers to the presence of underground oil storage caverns.[lxi]

Warning Signal #3: Greater levels of tanker activity than visible aboveground storage capacity would justify based on the trend of PRC refiners' and oil storage operators' typically conservative management practices. This is a proxy indicator of nearby underground facilities being filled.

Warning Signal #4: Construction of new overland oil pipelines from Russia and/or Central Asia or expansions of existing oil pipelines.

Warning Signal #5: Increased activity at refined product storage depots within 500 miles of Taiwan. One way to do this would be to use satellite monitoring of volatile organic compound emissions.[lxii]

Warning Signal #6: Expansion of coal inventories beyond their trailing 3-year and 5-year average levels. As more Chinese coal plants adopt covered coal sheds, this will require synthetic aperture radar monitoring of power plants' rail connections as well as stockpiles at coal mines themselves.

Warning Signal #7: PRC attempts to interfere with synthetic aperture radar measurement in the vicinity of known or suspected energy storage facilities.

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V. Policy Recommendations for Congress

1) Immediately fund intensified observation and analysis of current and suspected PRC energy storage locations, particularly for crude oil, but also coal and natural gas. Key agencies would include the National Geospatial-Intelligence Agency, Department of Energy, Department of Commerce, State Department, and Department of the Treasury.
    a. Maximize the use of commercial, off the shelf data and technology to accelerate the effort and ensure that it stays at the cutting edge of remote sensing technology while optimizing cost to taxpayers.
    b. A substantial part of the funds should support purchase of data from commercial entities with high-quality space-based energy data such as Ursa Space Systems and Vortexa, as well as synthetic aperture radar specialists such as Capella Space Systems. Planet Labs and Maxar provide high quality electro-optical imagery. Government-owned low earth orbit satellite networks could provide additional data.
    c. Congress should also fund UNCLASSIFIED efforts by academic researchers focused on Chinese energy infrastructure, how it is managed, and how it might be used to facilitate and prepare for intensified malign activities and in a worst case, warfare.
        i. Key action items should include: comprehensively mapping China's energy infrastructure, mapping the associated human decisionmaking network, and identifying points of maximum intelligence & warning value. The core objective should be maximal, frequently updated energy domain awareness across the PRC at the lowest possible classification level.
    d. Congress should also fund access to substantial AI compute capacity as well as funds to engage AI experts and data scientists from academic institutions and industry to help USG personnel working the energy warning issue wring maximum analytical value from their information streams.
2) Such efforts should feed an Economic Warning Fusion Center that provides advice across Cabinet-level agencies, the intelligence community, and the Defense Department, with particular focus on Indo-Pacific Command.
3) For an annual expenditure that would likely approximate the cost of a few missiles, the US Government would gain a set of insights into PRC energy stockpiling and strategic energy sector behaviors that would help it better anticipate coming kinetic conflict, should General Secretary Xi Jinping choose war.

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