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OUTLOOK PAPER 03 • SEPTEMBER 2026

Promised, Not Produced

Outlook 01 quantified how much Europe needs. Outlook 02 assessed where innovation could raise the ceiling. Neither counts until a plant is built and running. This paper measures the distance between the propellant capacity Europe has announced and the capacity it is likely to have, and what that distance means for the 155mm reserve.

CORE JUDGEMENT

Europe's output of usable large-calibre rounds is set by conventional gun propellant and the nitrocellulose behind it. Europe's established energetic-nitrocellulose producers make roughly **20,000 tonnes a year** between them, and each artillery round takes 6 to 7 kilograms of it on the industry's own planning figure. That material also serves small arms, medium calibre, mortars, tank rounds, rockets and the combustible cases modern charges are built in.

Of 34 dated capacity commitments made since 2022, **six were delivered on time**. The rest are late, far below rate, stalled or unfunded. Capacity that does get built is financed against offtake and is therefore committed before it runs: Eurenco's doubled Belgian powder capacity is reserved by its customers until 2032.

Europe makes about 2 million 155mm shells a year and has the powder to charge fewer than one million of them. The gap is about **14,000 tonnes of propellant a year** today and, on the delivery record, closes in about 2035 at best, about 2043 on the central case and not before 2050 at worst. On European powder alone, the 30-million-round reserve is charged in **2044, 2046 or 2051**. A full reserve then needs 10,000 to 26,000 tonnes a year of replacement for as long as it is held.

SERIES VSR DEFENCE INDUSTRIAL OUTLOOK - PAPER 03

VERSION 1.3 • 29 SEPTEMBER 2026 BASIS PUBLIC-SOURCE ANALYSIS

STANDING BASELINE OUTLOOK 01 (JULY 2026) AND OUTLOOK 02 (AUGUST 2026)

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Basis

Everything in this paper comes from public sources: government and NATO documents, audit and inspector-general reports, permits and planning records, company disclosures, technical literature and reputable trade reporting. It contains no classified material, no national stockpile figures, no formulations and no manufacturing parameters. Where a planning conversion is used, such as tonnes of propellant per round, it is a strategic conversion for arithmetic, not a description of any charge.

Capacity figures are as the operator or the authority published them; they are indicative rather than audited. Every number is marked **sourced** where a document states it, **derived** where it is calculated from stated figures, and **estimated** where it has been reasoned to. Where a figure is estimated, the reasoning is shown so that it can be challenged. Superscript numbers resolve to the source register at Annex C.

The subject is **traditional propellant**: single-, double- and triple-base powders made from nitrocellulose, the charges built from them, the double-base rocket grains that share the same chemistry, and the feedstocks behind all of them. High-explosive fill and the European RDX and TNT window were assessed in Outlooks 01 and 02 and are referred to here only where they touch the propellant chain.

ESTIMATIVE LANGUAGE

Probability describes how likely something is. Confidence describes how good the evidence is. The two are independent: a judgement can be highly likely and still rest on thin evidence.

PROBABILITY TERM		CONFIDENCE
Remote chance	≤ 5%	High Several credible sources agree, or the issuing authority states it directly
Highly unlikely	10–20%	
Unlikely	25–35%	Moderate Credible sourcing with gaps; another reading is possible
Realistic possibility	40–50%	
Likely / probably	55–75%	Low Thin or single-source evidence; treat as a planning input
Highly likely	80–90%	
Almost certain	≥ 95%	

Key judgements

THE QUESTIONS THIS PAPER ANSWERS

QUESTION	WHERE IT IS ANSWERED
How much of the capacity announced since 2022 has turned into output, and why not the rest?	Section 2
What is the ceiling on traditional propellant today, and who owns it?	Section 3
Will the capacity now coming loosen the market for anyone outside the financier's own order book?	Section 4
How large is demand once other calibres, rockets and live consumption are counted, not only the 155mm reserve?	Section 5
Which feedstocks sit above the powder, and which of them can be sized?	Section 6
How large is the shortfall in tonnes, and for how many years does it last under best, central and worst cases?	Section 7
What does keeping an ageing stock of propellant and rocket motors serviceable require?	Section 8

Seven judgements, each stated in full with its confidence. The standing judgements of Outlook 01 are carried forward; where this paper revises one, Section 10 says so.

- 1
- Announced capacity is not delivered capacity. The gap between the two is the central fact of Western ammunition rearmament, and it is widest in the chemical stages.**

HIGH CONFIDENCE

Of 34 dated commitments across propellant, nitrocellulose, explosives, charges, bodies and filling, six were delivered on time. Four were built but run far below rated output, thirteen are late, seven are stalled, unfunded or announced only, and four are too early to judge (Annex A). The United States set itself 100,000 155mm rounds a month by October 2025 and was producing about 36,000 in March 2026¹. The European Union promised Ukraine a million shells by March 2024; a third had been delivered on the eve of the deadline, with the Commission itself projecting just over half². Poland's nitrocellulose and powder line at Pionki was announced in 2018 for 2020 and produced its first qualified powder in July 2026^{3,4}. Bulgaria's government states that the Rheinmetall powder joint venture at Sopot was never constituted^{5,6}.

- 2
- Traditional propellant, and the nitrocellulose it is made from, is the ceiling on usable rounds. Measured in rounds, that ceiling sits close to the number of shells Europe already makes, which leaves no headroom for a reserve.**

HIGH CONFIDENCE

Colt CZ's analyst presentation lists the West's established energetic-nitrocellulose producers at about 30,500 tonnes a year in total, of which Europe's share is roughly 20,500 tonnes (derived), and gives the industry's planning figure of 6 to 7 kilograms of energetic nitrocellulose per

artillery round⁷. Charging the two million 155mm shells Europe makes each year would take 12,000 to 14,000 tonnes of that material, 60 to 70 per cent of everything Europe's established producers make for every calibre and use combined. Europe's large-calibre powder lines are tighter still: roughly 12,000 tonnes a year for 155mm, enough to charge about 0.9 million rounds fully (Section 3). The two ceilings coincide by 2028–29, when the announced powder additions outrun the nitrocellulose behind them.

3 **New European nitrocellulose is being created inside the groups that will consume it, largely by converting civil plants. None of it has a published tonnage and none of it reaches an independent buyer.** MODERATE CONFIDENCE

The EU's ammunition production programme targeted more than 10,000 tonnes a year of new powder⁸ and Rheinmetall plans to take group propellant output from about 12,000 tonnes in 2027 to 20,000 in 2030⁹. Against that, the only new European nitrocellulose with a published size is Synthesia's expansion of about 1,000 tonnes⁷. The remainder comes from civil plants being converted (Hagedorn for Rheinmetall; MSM Walsrode for CSG, which reports its German plant on target for 2027¹⁰) and from integrated complexes in Romania and Slovakia, all captive. Every project outside those groups (Verkan in Sweden, CellCore in Canada, Grupa Azoty in Poland, PGZ's Canadian proposal, the Radford modernisation) is dated 2028 or later and has either moved right or lacks committed money^{11,12,13,14,15}.

4 **New capacity is committed before it runs. It does not loosen the market for anyone outside the financier's own order book.** HIGH CONFIDENCE

Eurencos doubled its Belgian powder capacity and states that "all of this future capacity has already been reserved by EURENCO's customers until 2032"¹⁶. The Valleyfield expansion in Quebec, taking modular-charge propellant from 6 to 16 million pounds a year, is funded entirely by the US Army, which will buy the output^{17,18}. Forcitra signed a €189m Finnish offtake running 2028 to 2037 before its plant produced anything¹⁹. Germany signed a framework of up to €8.5bn for artillery ammunition with Rheinmetall in 2024, ahead of the Unterlüß plant's first delivery²⁰; the group's weapon and ammunition backlog stood at €25.3bn at 30 June 2026 and its 155mm capacity plan runs from about 1.1 million rounds in 2027 to 1.5 million in 2030^{21,9}. Explosia, the Czech state producer, reports that demand still exceeds its production capacity after a 169 per cent rise in nitrocellulose propellant output²². Capacity that gets financed is capacity that is already spoken for.

- 5 **The 155mm reserve is the smallest defensible measure of demand, not the whole of it. Other calibres, rockets and live consumption draw on the same chain, and the guns already in the field could fire far more than industry can supply.** MODERATE CONFIDENCE

Russia fires about 27,000 artillery rounds a day on Ukraine's own figures, against roughly 15,000 for Ukraine (derived from the stated 1.8 to 1 ratio)²³. A 122mm artillery rocket carries about 20 kilograms of double-base propellant made from the same nitrocellulose and nitroglycerine as a gun charge²⁴. Closing the gap between Ukrainian and Russian fire alone would take roughly 4.4 million more rounds a year; at 13 kilograms a full charge that is about 57,000 tonnes of propellant, more than three times Europe's entire large-calibre output (Section 5).

- 6 **Europe's shells are not the constraint; its powder is. The propellant gap is about 14,000 tonnes a year today and persists for nine, seventeen or more than twenty-five years depending on the case. The 30-million-round reserve cannot be charged with European powder before the mid-2040s.** MODERATE CONFIDENCE ON DIRECTION
LOW CONFIDENCE ON THE YEAR

Europe makes about 2 million 155mm shells a year; charging all of them fully takes about 26,000 tonnes of propellant. European plants supply about 12,000 tonnes for 155mm today. With announced capacity delivered at the rates the record supports, European powder covers Europe's own shell output in about 2035 on the best case, about 2043 on the central case and not before 2050 on the worst. The reserve is charged on European powder in 2044, 2046 or 2051. Against the pace Outlook 01 modelled, filling the reserve by 2032, the gap is 30,000 to 50,000 tonnes a year, and no announced project addresses it (Section 7).

- 7 **A full reserve is a standing liability, not a completed task. Propellant and rocket motors must be surveyed, reworked and replaced for as long as they are held.** HIGH CONFIDENCE ON THE MECHANISM MODERATE ON THE SIZE

The UN's international ammunition guidelines give most propellants a shelf life of at least 15 to 40 years at a constant 30°C, with the rate of chemical deterioration approximately doubling for every 10°C above that^{25,26}. On a reserve of about 390,000 tonnes of propellant, that is 10,000 to 26,000 tonnes a year of replacement once the reserve is full (derived). The US Army's missile reliability programme has extended average missile shelf life from 7.9 to 22.6 years, through surveillance and component replacement rather than by leaving stock alone²⁷.

Executive summary

Outlook 01 established the arithmetic: a cautious floor of thirty million 155mm rounds and a European industrial base that cannot fill it inside the 2029–30 threat window. Outlook 02 located the narrowest stage in the chain: the charge, and the nitrocellulose behind it. This paper answers the question beneath both. Of everything announced to widen that stage, how much is being produced, and when does the gap close?

Announcement and production have diverged. Across the chain, the record since 2022 shows targets met at a half or a third, lines built that run far below rate, plants held at permit, court or objection stage, and joint ventures that were never constituted. Poland's nitrocellulose and powder line took eight years from announcement to first qualified powder; its machinery sat in storage until the warranties expired^{3,4}. The US Army's Inspector General found that a \$469m metal-parts line in Texas had not delivered a single conforming part¹. The cause is structural rather than a matter of good faith: an industry that contracted for thirty years has been asked to double in three, and money has arrived faster than sites, permits, qualified people and qualified processes.

The ceiling is chemical and small. The West's established makers of energetic nitrocellulose fit on a single line, and Europe's share of their output is about 20,000 tonnes a year. On the industry's own planning figure of 6 to 7 kilograms per artillery round, Europe's two million shells a year would take 60 to 70 per cent of that material before small arms, medium calibre, mortars, tank ammunition, rockets and combustible cases take theirs⁷. The new nitrocellulose Europe is adding comes almost entirely from civil plants being converted inside the groups that will use it, and the cellulose behind it, cotton linters, is sourced predominantly from China on the estimate of Rheinmetall's chief executive²⁸.

Capacity that gets built is committed before it runs. Energetics capacity is financed against offtake, so it is sold before the first batch leaves the line. Eurenco's doubled Belgian powder capacity is reserved until 2032¹⁶; the US Army is paying for the Canadian propellant expansion it will then buy from^{17,18}; Germany's €8.5bn artillery framework was signed before Unterlüß delivered a round²⁰. A buyer entering the market in 2027 or 2028 will not find spare capacity appearing. Every new line is already allocated.

The shortfall is measured in tonnes and decades. Europe's powder charges fewer than half the shells it makes; the balance depends on powder from outside Europe or leaves with lighter charges. The gap is about 14,000 tonnes a year today. With announced capacity discounted for the delivery record, European powder covers Europe's own shell output in about 2035 at best, about 2043 on the central case and not before 2050 at worst. The 30-million-round reserve is charged on European powder in 2044, 2046 or 2051. Against the pace Outlook 01 modelled, a filled reserve by 2032, the gap is 30,000 to 50,000 tonnes a year. The years are soft; the direction held across every sensitivity tested (Section 7).

Demand does not end when the reserve is full. Propellant and rocket motors age. The international guidelines give most propellants 15 to 40 years at 30°C, less in heat; motors are surveyed, re-motored and re-cast to stay in service. A reserve of the size NATO planning implies becomes a permanent replacement market of 10,000 to 26,000 tonnes a year, and ageing stocks already held, including rocket motors now being returned to service, compete for the same nitrocellulose, test ranges and qualified staff.

THE ONE FACT THAT WOULD MOST CHANGE THESE JUDGEMENTS

A European army funding the qualification of a nitrocellulose-free gun propellant before 2028. It would not change the arithmetic before 2030, but it would begin a second industrial cycle that removes the cotton dependency and shortens the tail. No public record of such a programme exists in any European army, and the paper judges it highly unlikely inside the period.

01 The traditional chain

A shell carries two energetic products that are routinely confused. The **fill** is the explosive inside the body. The **charge** is the propellant behind it that drives it down range. This paper concerns the charge and everything that must exist before a charge can be made.

Almost all Western gun propellant is built on nitrocellulose (NC): cellulose from cotton or wood treated with a mixture of nitric and sulphuric acid. The cellulose most propellant makers specify is cotton linter, the short fibre left on the cottonseed after ginning. It is a by-product of the cotton crop, it has no public price index of its own, and Europe draws most of it from China. Nitrocellulose is made into powder in one of three families.

FAMILY	WHAT IT ADDS TO NITROCELLULOSE	WHERE IT IS USED	ADDITIONAL DEPENDENCY
Single base	Nitrocellulose alone, with stabilisers and additives	Small arms, medium calibre, low-zone modular-charge increments	Nitrocellulose and stabiliser only
Double base	Nitroglycerine (NG)	Mortars, some gun charges, extruded rocket grains such as the 122mm artillery rocket	Glycerine and nitration capacity for NG
Triple base	Nitroglycerine and nitroguanidine (NQ)	Large-calibre high-zone charges including 155mm: cooler burning, less barrel wear and flash	Nitroguanidine, which has very few Western producers

Powder is then built into a charge. For 155mm that is now usually a set of modular increments in combustible cases, and the combustible case is itself made largely from nitrocellulose: a second, generally uncounted demand on the same material. It is not small. Rheinmetall's Aschau expansion adds over five million combustible components a year alongside its new powder²⁹, and Lithuania's planned propellant centre is specified around combustible cartridge cases and modular-charge assembly³⁰. Legacy bag charges use a cloth bag, so their nitrocellulose sits in the powder rather than the container. A charge is not a commodity: it is qualified to a particular gun and projectile family and written into that gun's firing tables, so a buyer cannot change supplier or chemistry without requalification.

Three consequences follow for anyone counting capacity. The chain is only as wide as its narrowest stage. The stages do not add: a plant that assembles modular charges consumes powder, and a powder plant consumes nitrocellulose, so counting charge plants, powder plants and nitrocellulose plants together counts the same tonne three times. And the narrowest stage on current evidence is nitrocellulose and the multi-base powder made from it, which is where this paper counts.

HOW THIS PAPER COUNTS

Capacity is counted at the narrowest stage. Charge-assembly plants such as the modular-charge ventures in Poland, Slovakia and Latvia are recorded as demand on powder, not as supply.

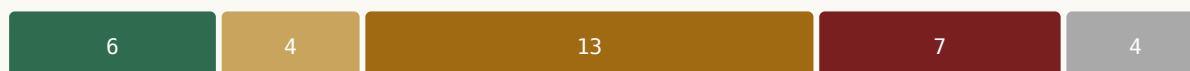
Powder is counted in tonnes. Rounds are converted at **13 kilograms of propellant per 155mm round**, a full high-zone charge: six high modules of the bi-modular charge system carry 13.8 kg of propellant³¹, the US M203A1 bag charge about 12.7 kg³², and the US modular system stacks five high-zone modules at full charge³³. Outlook 01 used 8.5 to 10.5 kg, an average across the zones actually fired; a reserve held for long-range fire has to hold full charges. This is a strategic conversion, not a statement about any particular charge.

02 Promised, not produced: the feasibility gap

Since 2022 Western governments and companies have announced more ammunition and energetics capacity than at any point since the Cold War. The relevant question is how much of it has become output. This paper compiles 34 dated public commitments across nitrocellulose, propellant, charges, explosives, bodies and filling and compares each with what happened. The register is at Annex A.

EXHIBIT 1 Outcome of 34 dated capacity commitments, 2022 to September 2026

■ Delivered (6)
 ■ Far below rate (4)
 ■ Late (13)
 ■ Stalled, reset or announced only (7)
 ■ Too early to judge (4)



Source: project-level public sources at Annex A. "Delivered" means the stated capacity or milestone was reached by the stated date or within a quarter of it. The file is not a random sample; it over-represents large, publicly announced European projects.

Roughly one commitment in six was delivered on time. The projects that delivered share three characteristics: they extended an existing licensed site, the operator already made the product, and an order was in hand. Eurenco's new powder line at Bergerac and its third charge line there³⁴, the automated 155mm assembly line at Kansas Army Ammunition Plant³⁵ and Eurenco's Belgian doubling¹⁶ all fit that description. The projects that did not deliver fall into five patterns.

2.1 Five ways a plant fails to happen

The money was never committed. Rheinmetall and Bulgaria's VMZ announced a powder and shell complex at Sopot: about 1,300 tonnes of propellant a year, charges for 150,000 rounds and around 1,000 jobs. On 23 July 2026 Bulgaria's deputy prime minister said no founding agreement and no joint venture existed, no budget provision had been made and the site was unsuitable; talks restart from scratch^{5,6,36}. The EU's defence loan instrument covers perhaps 10 to 15 per cent of the roughly €400m need (derived from reporting). PGZ's proposed Canadian plant for TNT and nitrocellulose has no financing, no site and no partner¹⁴. Grupa Azoty set out in November 2025 to return Poland to nitrocellulose, nitroglycerine and nitroguanidine by 2029, with a decision due by early 2026; banks were reluctant to lend because of losses elsewhere in the group, and in September 2026 financing was still being negotiated^{13,37}. An industry tracker dated 3 August 2026 still listed Sopot as fully funded³⁷: announcements outlive the projects they describe.

The site, the permit or the neighbours. Chemring Nobel's greenfield explosives site at Hurum, in forest beside the Oslo Fjord, has drawn more than 800 mostly negative consultation responses, activists have occupied a building on the site, and there is no final investment decision or approved planning

programme; the target is operation by 2030^{38,39}. Forcitra's Finnish TNT plant had to withdraw and refile its permit applications after a change in the law before laying its foundation stone in September 2026⁴⁰. Verkan's Swedish powder and nitrocellulose plant is an upper-tier major-hazard site whose permit is before the Land and Environment Court, with production targeted for 2028^{41,42}, construction reported for 2027, a build of up to four years and a power demand of up to 300 megawatts on trade-press reporting⁴³. Canada's Valleyfield propellant expansion drew objections from 23 civil-society groups and over 100 residents before Quebec's environmental review found it justified, with conditions, in June 2026^{44,45}. Rheinmetall's Lithuanian propellant centre, agreed by memorandum in November 2025 for the Baisogala site, had no published construction contract ten months later³⁰.

Politics and the host government. Rheinmetall's artillery ammunition plant in Ukraine, contracted in July 2024 to produce within 24 months, had not broken ground by May 2026 as the stated reasons moved from bureaucracy to a change of site to regulatory issues; production is now expected in 2027⁴⁶. Rheinmetall's Latvian forge-and-fill joint venture missed its spring 2026 construction start with the site still unpublished⁴⁷.

Technology, transfer and qualification. Poland decided in 2018 to build a nitrocellulose and powder line at Pionki for about PLN 400m, to run in 2020. The date slipped to 2024 and was missed again. Machinery was bought and stored in the absence of buildings until its warranties lapsed, and according to one Polish trade report the defence ministry's own control department recommended halting the programme and referring it to prosecutors^{3,4}. The first powder batch to pass qualification came in July 2026, on technology transferred from the Czech group CSG^{4,48}. At Mesquite in Texas the US Inspector General found that the contractor "did not deliver on schedule any metal projectile part that met the technical requirements" after a \$469m investment^{1,49}.

Built, but far below rate. The US target of 100,000 155mm rounds a month by October 2025 stood at about 36,000 in March 2026 and has been reset to 140,000 by December 2027¹. The EU's million-shell pledge for March 2024 had delivered about a third by February 2024². Rheinmetall's Unterlüß plant, advertised at 350,000 rounds a year by 2027, made its first delivery in July 2026 in a "low five-figure" quantity, with the charges supplied from other Rheinmetall sites⁵⁰. MESKO's Kraśnik plant targets 150,000 bodies a year once its investment completes in 2027 and has published no current output figure⁵¹. BAE's new filling facility at Glascoed, re-scoped in 2025 to double its capacity, was reported six months behind schedule in early 2026 and was still unopened in September⁵².

Incidents. KNDS's powder-pressing department at Colleferro caught fire on 13 August 2026; a prosecutor is investigating and no restart has been reported⁵³. Bulgaria's EMCO has lost warehouses to repeated fires and explosions, with sabotage suspected⁵⁴. In September 2026 a fire broke out in an ammunition warehouse at Romania's Cugir arms factory⁵⁵, and workers at Eurenco's Karlskoga propellant site in Sweden reported weeks of exposure to about a tonne of leaked nitroglycerine paste before a stop-work order, which the Swedish work-safety authority then lifted over the objection of the union safety representative who had raised it⁵⁶. Each incident at an energetics site raises the permitting, vetting and insurance bar for the next one.

2.2 What the record implies for the forward numbers

The delivery record allows a rate to replace an assumption. Every forward project is scored by the stage it has reached, and each stage carries a probability of delivery and an expected delay. The bands below

are calibrated against the 34 projects at Annex A. The sample is small and the bands should tighten as the record lengthens; they are shown as ranges for that reason.

STAGE REACHED, ON PUBLIC EVIDENCE	PROBABILITY OF DELIVERY	EXPECTED DELAY	EXAMPLES TODAY
Announced only: memorandum, letter of intent, "understandings"	20–30%	3+ years	PGZ Canada; Sopot; Grupa Azoty; Lithuanian propellant centre; Nitro-Chem/BAE UK TNT
Funded and sited	~50%	~2 years	Hanwha Pine Bluff; Strážske charge plant; Victoria powder plant
Permitted and under construction	75–80%	~1 year	Aschau expansion; Forcit Pori; Synthesia expansion
Commissioning or first output	~90%	0–1 year, then ramp	Pionki; Unterlüß
Ramp from first output to rated output	–	2–3 years	US 155mm programme at 36% of target

These are estimates, not measurements, and they are conservative against the record: they assume a permitted plant under construction delivers three times in four, when the record for large new-build projects in the file is worse. They underpin the three delivery assumptions in Section 7: 80, 60 and 50 per cent of announced capacity delivered, with delays of one, two and three years.

Headline claims warrant the same discount. In September 2026 the US President told the UN General Assembly that 18 new munitions plants were under construction by the largest US defence companies⁵⁷. No list was published and none can be scored. The United Kingdom's energetics programme, which funded 22 firms to return feasibility studies by the end of September 2026 ahead of site selection and construction starts by the end of the year, had published no returns at the date of this paper^{58,59}.

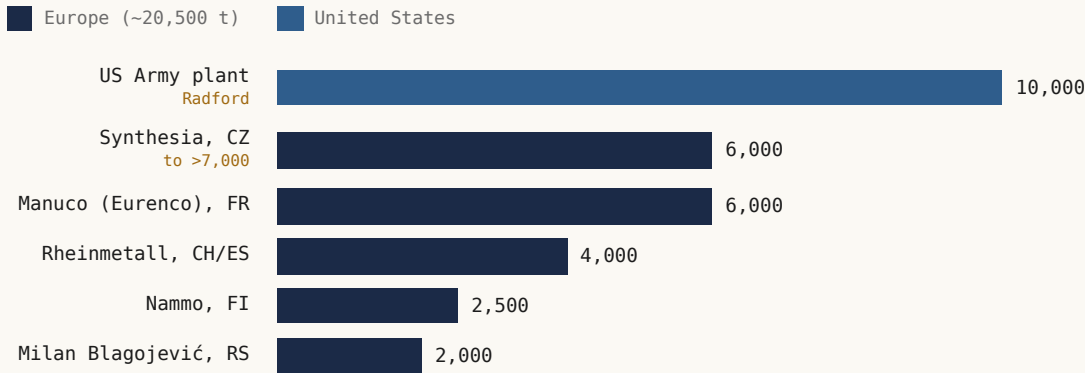
ADVERSARIAL VIEW: THE RECORD IS A WARTIME RAMP, AND RAMPS LOOK WORSE THAN THEY ARE

The case. Every industrial ramp looks like failure in its first three years. Unterlüß and Kansas are running, Pionki has qualified powder, and US output has tripled since 2022. Judging capacity by the missed dates of 2024–26 understates what will exist in 2028–30. **What would have to be true:** ramp-to-rate times fall below two years and non-starts become rare. **What would show first:** plants reaching rated output within a year of first output. **Why the paper does not hold it:** the failures recorded are not mostly slow ramps. They are non-starts, with no money, no site or no permit, and those do not recover with time.

03 The ceiling today: supply, and who owns it

Almost nobody publishes propellant tonnage. The best single public view of the stage that matters most, energetic nitrocellulose, comes from an interested party. That is a reason to use it with care rather than a reason to set it aside.

EXHIBIT 2 Eligible Western energetic-nitrocellulose capacity, tonnes a year



Source: Colt CZ Group, Synthesia Nitrocellulose acquisition presentation to analysts, 29 August 2025⁷. Company figures, not audited; the 30,500-tonne total is this paper's sum. The US plant is listed as a US Army plant operated by BAE, which is Radford. Rheinmetall's 4,000 tonnes covers its Swiss and Spanish sites. Colt CZ states that only European and North American producers are eligible suppliers of energetic nitrocellulose "due to security and quality concerns".

Four features of this base matter for the rest of the paper. It is small: about 30,500 tonnes a year across the eligible West, about 20,500 of it in Europe (derived). It is concentrated: six established producers, one of them outside the EU and NATO. It is shared: the same presentation gives end uses of 6 to 7 kilograms per artillery round in "low units of millions" of rounds a year, about 150 grams per medium-calibre round in "tens of millions" of rounds a year, and grams per small-arms round in tens of millions more⁷. And it is increasingly owned by the groups that consume it.

The list is of established producers, and some familiar names are absent for a reason. BAE makes no nitrocellulose in the United Kingdom, where propellant production at Bishopton and Bridgwater closed in the early 2000s⁶⁰, but it operates the US Army plant that heads the list. Rheinmetall's Spanish production is within its 4,000 tonnes. KNDS in France buys powder rather than making nitrocellulose; French nitrocellulose is Eurengo's. What the list does not show is capacity now being converted: two German civil nitrocellulose plants, Hagedorn (bought by Rheinmetall in 2025) and MSM Walsrode (CSG), are being moved to military grade, the second reported by CSG as on target for 2027, with no tonnage published for either^{61,10}. Producers in Türkiye, Korea and India exist but fall outside a comparison that treats only European and North American suppliers as eligible.

PRODUCER	OWNER AND CHANGE SINCE 2025	IMPLICATION
Synthesia Nitrocellulose, Pardubice	Colt CZ took 51% in January 2026, with an option on the rest ⁶²	Czech nitrocellulose-to-propellant chain owned end to end

PRODUCER	OWNER AND CHANGE SINCE 2025	IMPLICATION
Manuco (Eurengo), Bergerac	Eurengo, supplying its own powder lines	Captive
Rheinmetall (Switzerland, Spain)	Rheinmetall; also bought Hagedorn-NC in 2025 ⁶¹	Captive, and acquiring
Hagedorn-NC, Lingen (DE)	Bought by Rheinmetall, 2025; civil plant converting to military grade ⁶¹	New military nitrocellulose, captive from the start
MSM Walsrode (DE)	CSG; civil plant converting to military grade, on target for 2027 ¹⁰	New military nitrocellulose, captive from the start
Nammo, Finland	Nammo (Norwegian and Finnish state)	Captive
MESKO, Poland	Long-term energetic-nitrocellulose supply agreement with Eurengo, 2026 ⁶³	Polish powder tied to French nitrocellulose
EKOCHM, Pardubice (engineering)	Sold to a US holding company, June 2026 ⁶⁴	Western nitrocellulose design capability being acquired
AlzChem (nitroguanidine)	CSG holds about 20% ⁶⁴	Triple-base ingredient moving towards an integrated group

The pattern is vertical integration. The independently traded market in nitrocellulose, the market a new powder maker or a government outside the large groups would buy from, is contracting as producers are absorbed by their largest customers. That is rational for them. For a buyer, the question is not only whether capacity exists but whose order book it sits in.

3.1 Powder and charges

Published powder figures are fragmentary. Aschau makes about 1,700 tonnes a year and 300,000 charge modules today and is adding 2,500 tonnes, over a million modules and over five million combustible components a year from 2027, with full capacity in 2028²⁹; trade reporting puts the site's triple-base output at up to 4,500 tonnes from the third quarter of 2027⁶⁵. Bergerac is at 1,200 tonnes rising towards 1,800³⁴. Rheinmetall's group propulsion plan runs from about 12,000 tonnes in 2027 to 20,000 in 2030, a figure that includes small and medium calibre and a rocket-motor propellant line of up to 3,500 tonnes a year from the first quarter of 2027⁹. Outlook 02 put Europe's announced gun-propellant output at roughly 12,000 to 20,000 tonnes a year⁶⁴. This paper holds a planning figure of about 16,000 tonnes for all large calibres (estimated), of which roughly three-quarters is available to 155mm. That figure sits below the Commission's capacity target of two million shells a year⁸, in line with lower independent estimates of actual output, and is consistent with the nitrocellulose base once small and medium calibre take their share (estimated).

Outlook 01's figure of about 30,000 tonnes a year is not a contradiction. It was defined there as propellant capacity "by ~2030" on a generous reading of every announced project including undisclosed tonnage³⁴. Today's ~16,000 tonnes plus the ~14,000 tonnes a year of additions announced for 2027–30 is that 30,000, provided every project delivers in full and on time, which Section 2 shows they do not.

3.2 Two ceilings: powder lines now, nitrocellulose next

Europe makes about two million 155mm shells a year: the EU's objective, reported as achieved in early 2026, and the EU Defence Commissioner's own "more than two million shells a year"⁶⁶. Two independent checks show how far Europe's own energetics fall short of that number.

The powder-line check. Charging two million rounds fully at 13 kg takes about 26,000 tonnes of powder. Europe's roughly 12,000 tonnes of 155mm powder charges about 0.9 million (derived). The remaining 1.1 million or so shells a year are charged with powder or charges from outside Europe, supplied with fewer modules, or leave without charges, as the Estonian shells did⁶⁷.

The nitrocellulose check. At the industry planning figure of 6 to 7 kilograms of energetic nitrocellulose per artillery round⁷, two million rounds take 12,000 to 14,000 tonnes: 60 to 70 per cent of everything Europe's established producers make. Medium calibre alone, at about 150 grams a round across tens of millions of rounds, takes several thousand tonnes more; mortars, tank ammunition, rockets and combustible cases take the rest (derived). On the nitrocellulose base alone, Europe could charge roughly 2 to 2.5 million artillery-class rounds a year if nothing else drew on it. That is the ceiling the announced powder lines will meet: the ~14,000 tonnes of powder additions to 2030 need on the order of 7,000 tonnes more energetic nitrocellulose (derived at the same planning figure), against about 1,000 tonnes of published new European capacity and two conversions of unknown size.

EXHIBIT 3 Two ceilings against Europe's shell output, million 155mm-equivalent rounds a year



Derived. Powder line: ~12,000 t of 155mm powder at 13 kg a round. Nitrocellulose base: ~20,500 t of European energetic nitrocellulose at 6-7 kg a round⁷, before small and medium calibre, mortars, tank rounds, rockets and combustible cases. Announced powder additions: ~14,000 t gross to 2030 at face value (Section 4.1). Shell output: EU Commissioner, February 2026⁶⁶.

FINDING

The headline "two million rounds a year" counts shells. The number of full rounds Europe can charge from its own powder is under half of that, and the nitrocellulose base would be fully consumed by artillery alone at about the same output. Both ceilings are close to the shells Europe already makes, which leaves no European headroom for a reserve. The gap is filled today by suppliers outside Europe, including the United States, South Korea, Türkiye, India and South Africa, who also supply Ukraine's own shell production and their own forces.

North America's position is more exposed, not less. Rheinmetall's US leadership states that the United States relies on "a single plant in Canada" for modular-charge propellant and that Radford is its only domestic producer of single-, double- and triple-base propellant, on processes "dating back more than 50 years"; an interested party's claim, but one the US has not disputed⁶⁸. The Canadian plant is being expanded with US Army money^{17,18}; Radford's nitrocellulose modernisation is at the design stage, on a design contract running to March 2028¹⁵; and two smaller US firms in Arkansas, Regulus Global and D&M Holdings, have announced nitrocellulose and nitroglycerine plans with no money or dates disclosed³⁷. US demand does not fall on Europe's plants directly. It absorbs the North American capacity that might otherwise have relieved Europe.

04 What is coming, and why it will not loosen the market

New capacity is coming. The question is whether any of it will be available to a buyer who is not already in the queue. On the evidence, very little will.

4.1 More powder than nitrocellulose

ADDITION	STAGE	STATED SIZE	STATED DATE	ASSESSMENT
Aschau powder, DE	Under construction	+2,500 t/yr	From 2027; full 2028	Likely; Rheinmetall's own books
Bergerac powder, FR	Ramping	1,200 – 1,800 t	2027	Likely; Eurenco's own books
Victoria powder, RO	Funded, sited	~300,000 charges/yr	2028	Realistic possibility on time
Pionki powder, PL	First qualified output	Not published	Charges mid-2028	Eight years from announcement
Skarżysko-Kamienna charges, PL (Eurenco-MESKO JV)	Shareholders' agreement June 2026	Not published	Launch summer 2028	Consumes powder and nitrocellulose; not a supply addition
Wimmis, CH	Prioritised permit	Not published	Not published	Cannot be counted
Strážske, SK (nitrocellulose, nitroglycerine, charges)	Funded	Not published	By 2028	CSG's own chain; captive
Sopot powder, BG	Reset	~1,300 t/yr	–	Count at zero
Synthesisia nitrocellulose, CZ	Under construction	6,000 – >7,000 t	2026–27	The only firm new European nitrocellulose
Hagedorn-NC and MSM Walsrode, DE (civil plants converting)	Converting	Not published	End-2026; 2027	First new European military nitrocellulose; captive to Rheinmetall and CSG
Verkan, SE (nitrocellulose and powder from wood pulp)	Permitting	>1,000 t/yr powder (trade press)	Construction 2027; output 2028	Highly likely to slip past 2028 (estimate: 80%)
Grupa Azoty, PL (nitrocellulose, nitroglycerine, nitroguanidine)	Seeking finance	Not published	2029	Announced only; financing unresolved

ADDITION	STAGE	STATED SIZE	STATED DATE	ASSESSMENT
CellCore, Canada	Pre-construction	6,000 t/yr powders	Late 2028 / Q1 2029	Company timeline moved right during 2026 (this paper's observation)
Valleyfield, Canada	Approved with conditions	6 – 16m lb/yr	Not published	Funded by and for the US Army
Radford modernisation, US	Design	Not published	2030s	Design contract to March 2028

Sources: 5, 7, 9, 10, 12, 13, 15, 29, 34, 37, 41, 43, 44, 48, 65, 69, 70. Highlighted rows are nitrocellulose.

Set against each other, the imbalance is clear. More than 10,000 tonnes a year of new powder was targeted under the EU's ammunition production programme alone⁸, and Rheinmetall adds roughly 8,000 tonnes across its group by 2030⁹. The only new European nitrocellulose with a published size is Synthesia's 1,000 tonnes. Everything else is a civil plant being converted inside Rheinmetall or CSG, a new integrated complex owned by the same groups, or a project outside them (Verkan, Grupa Azoty, CellCore) that lands in 2028 or later and has already slipped or lacks money. The conversions matter: they are the first new military nitrocellulose Europe will see. But they arrive inside the groups that will use them and, on this paper's reading, they move nitrocellulose out of the civil paints and coatings market rather than adding nitration capacity to the world. New powder lines will either run below capacity for want of nitrocellulose or draw it from the existing base and from other calibres. Neither adds rounds at the rate the headlines imply.

Europe has begun to hedge the cotton dependency, through wood pulp and recycled cotton rather than a different propellant chemistry. Verkan will make nitrocellulose from pulp at Kristinehamn¹¹; in the same town Eurenco and Biosorbe are piloting nitrocellulose from recycled textile cotton under a Swedish state research grant running to November 2026⁷¹. Outlook 02 judged that a composite charge was the only published way out of the cotton dependency. That is corrected here: wood-pulp nitrocellulose is a second route, and it is the one European capital is taking. It lands in 2028–29 at the earliest.

4.2 Committed before it runs

New energetics capacity is financed against signed offtake, because a hazardous chemical plant is not financeable without a buyer. The consequence is that capacity that gets built has already been sold.

CAPACITY	EVIDENCE THAT IT IS COMMITTED
Eurenco, Clermont (BE): doubled propellant capacity	"All of this future capacity has already been reserved by EURENCO's customers until 2032" ^{16,72} . Small and medium calibre; it demonstrates the mechanism rather than adding 155mm supply
GD-OTS Valleyfield (CA): modular-charge propellant, 6 – 16m lb/yr	Expansion funded 100% by the US Army, the buyer of its output ^{17,18}

CAPACITY	EVIDENCE THAT IT IS COMMITTED
Rheinmetall, Unterlüß (DE): 155mm rounds	Framework of up to €8.5bn with the German armed forces signed June 2024, two years before first delivery ^{20,50}
Forcit, Pori (FI): new TNT plant	€189m Finnish offtake agreed for 2028–2037 before first output ¹⁹
Nitro-Chem, Bydgoszcz (PL): TNT	18,000 tonnes committed to the United States for 2027–29 from the current base, before the planned doubling exists ³⁴
Chemring Nobel (NO): HMX	15-year supply agreement with Northrop Grumman; 12-year framework with Diehl; a £23m Nammo order delivering 2027–2037; ~95% order cover for FY26 in the Countermeasures and Energetics segment at November 2025 ^{73,74,75,76}
Rheinmetall: weapon and ammunition	Order backlog €25.3bn at 30 June 2026; 155mm capacity plan ~1.1m rounds in 2027 rising to ~1.5m in 2030; division margin guided to 29–31% by 2030 ^{21,9}
Explosia (CZ): propellant	Nitrocellulose propellant output up 169% in 2025; the company states that demand still exceeds its production capacity ²²
CSG: group	Backlog €17bn at 30 June 2026 (€8bn firm, €8bn frame, €1bn soft) with a further €29bn pipeline; German nitrocellulose plant and Slovak charge venture both pre-allocated within the group ¹⁰
Nammo: group	Backlog NOK 55bn at end-2025, up 38%, on revenue up 32% ⁷⁷
Hanwha, Pine Bluff (US): charges and base-bleed units	\$2.2bn campus on a US Army arsenal for US Army and foreign-military-sales demand; construction complete 2030, operations 2031 ^{78,79}

Two of these are explosives rather than propellant and are included because they show the same mechanism in the neighbouring lane. The judgement does not rest on them. It rests on the Belgian, Canadian and German cases, where propellant or round capacity was reserved or paid for by its buyer before it existed, and on the behaviour of Europe's largest supplier, which is growing its order book faster than its output and guiding investors to margins near 30 per cent to the end of the decade. A supplier expecting spare capacity by 2028 would not guide that way.

IMPLICATION FOR A BUYER OUTSIDE THE QUEUE

The market does not ease when new lines open. It eases when new lines open faster than the orders already signed against them are filled. On the evidence in this section, the first uncommitted tonnes from the new European capacity are an event of the 2030s, and each year of delay in the forward projects in Section 4.1 moves them further out.

05 Demand: the 155mm reserve is the floor, not the total

Outlook 01 set a deliberately cautious floor: thirty million 155mm rounds of European reserve, worked up from consumption data, the barrel park and adversary output. At 13 kilograms of propellant for a full charge, that floor alone requires about 390,000 tonnes of propellant to be laid down (derived). Everything in this section sits on top of it.

5.1 Live consumption comes first

A reserve grows only when output exceeds what is fired, donated, used in training and exported. Ukraine's armed forces put Russian fire at about 27,000 artillery rounds a day in mid-2025, at a ratio of 1.8 to 1 against Ukraine, which implies roughly 15,000 Ukrainian rounds a day across all calibres (derived)²³. Earlier in the war Russian fire exceeded 40,000 a day⁸⁰. At 15,000 a day Ukraine fires about 5.5 million rounds a year (derived), several times Europe's output. While the war continues, European output goes to the front before it goes to a depot. Outlook 01 reached the same conclusion from the other direction: the layer of demand that current production overwhelmingly serves is direct consumption.

SUPPLY-LIMITED, NOT REQUIREMENT-LIMITED

Ukraine fires roughly 15,000 rounds a day against Russia's 27,000 on Ukraine's own figures. Closing that gap, 12,000 rounds a day, would take about 4.4 million more rounds a year (derived). At 13 kg a full 155mm charge that is roughly 57,000 tonnes of propellant, and still about 31,000 tonnes at a lower average for a mixed fleet of 122mm, 152mm and 155mm guns (estimated): two to three-and-a-half times Europe's entire large-calibre output. The guns are consumed as well: a US reprogramming document put Ukraine's need for M777 tubes alone at over 30 a month, more than the sole US tube plant could make⁸¹. Demand in this war is capped by supply, not by requirement.

5.2 Other calibres draw on the same nitrocellulose

The thirty-million-round floor counts only 155mm. The same nitrocellulose goes into 152mm and 122mm for the Soviet-pattern guns still in service across the eastern flank and in Ukraine, 120mm and 81mm mortars, 105mm light guns, tank ammunition, and small and medium calibre. The industry's own planning figures size the draw: 6 to 7 kilograms of energetic nitrocellulose per artillery round in low millions of rounds a year, about 150 grams per medium-calibre round in tens of millions, and grams per small-arms round in tens of millions more⁷. Modular charges add a draw of their own: the combustible cases the increments sit in are made largely from nitrocellulose, and Aschau alone is adding over five million combustible components a year²⁹. No producer publishes the tonnage this takes. This paper holds a planning assumption that 20 to 30 per cent of Europe's large-calibre propellant output goes to calibres other than 155mm (estimated). A lower share would shorten the shortfall; nothing in the public record suggests it is lower.

5.3 Rockets share the chain

Artillery rockets are the part of this demand most often left out of the arithmetic. The 122mm rocket, the Grad family and its Western successors, uses an extruded double-base grain of nitrocellulose and nitroglycerine, the same chemistry as a double-base gun charge. A Czech 122mm rocket carries 20.45 kilograms of propellant²⁴, so a hundred thousand rockets is about 2,000 tonnes (derived). Europe is buying rocket artillery at pace: Poland has ordered 290 Chunmoo launchers; the Netherlands, Spain, Denmark and Germany have bought PULS or EuroPULS; Italy, Norway and the Baltic states have bought HIMARS⁸². A Danish plant plans up to 10,000 122mm rockets a year from 2026⁸³. Guided rockets of the GMLRS family use composite propellant rather than nitrocellulose, and Lockheed Martin is ramping to 14,000 a year⁸⁴; they do not draw on nitrocellulose, but they do draw on the same test ranges, magazine licences, cast-cure skills and qualified chemists.

5.4 Competing pulls on the same base

Interceptors and missiles matter here only for what they take out of the shared industrial base. Rheinmetall's rocket-motor propellant line, up to 3,500 tonnes a year from the first quarter of 2027, sits inside Europe's largest 155mm supplier⁹. US Patriot inventory fell from about 2,330 to between 759 and 827 interceptors on CSIS estimates, with recovery measured in years⁸⁵. Rebuilding that stock occupies propulsion sub-tiers, qualification slots and test time for most of the decade. None of this displaces 155mm demand. It lengthens the queue in which 155mm charges and rockets stand.

06 Feedstocks: the chain above the powder

A powder plant is the visible end of a chemical chain that no defence ministry controls. Its inputs are by-products of agriculture and petrochemicals whose supply, price and export rules are set by industries and governments with no interest in ammunition. This section sizes each input where the public record allows, and says so where it does not.

6.1 Cellulose: cotton linters and their substitutes

Energetic nitrocellulose is made from purified cellulose, and the grade most European producers specify is cotton linter. The draw can be sized from the base in Section 3. Nitration adds mass: in theory 1.5 to 1.76 tonnes of nitrocellulose per tonne of cellulose, and in practice about 1.45 to 1.5 once losses are allowed for⁸⁶. Europe's roughly 20,500 tonnes of energetic nitrocellulose therefore consumes on the order of **14,000 tonnes of chemical-grade linter pulp a year** (derived), and the announced additions to 2030 would add around half as much again.

Supply of that pulp is concentrated. Rheinmetall's chief executive told the Financial Times in April 2024 that "more than 70 per cent" of the cotton fibre for European propellant comes from China, and that Rheinmetall had built a three-year stock as protection; the same report cited International Trade Centre data putting China at just under half of global linter trade²⁸. The 70 per cent figure is one executive's estimate and is cited here as such, but the market's own behaviour is a price on the risk: the largest European producer is holding three years of feedstock. China's dual-use export-control regulation, which brought nitrocellulose under licence, took effect on 1 December 2024⁶¹. Linters are a by-product with no published index; fewer bales ginned means fewer linters whatever the lint price does, and the August 2026 world agricultural estimates put cotton ending stocks at their lowest since 2011–12⁶⁴.

Two substitutes are in development, both in Sweden and both dated 2028 or later: Verkan's wood-pulp nitrocellulose at Kristinehamn¹¹ and the Eurenco-Biosorbe pilot on recycled textile cotton, funded to November 2026⁷¹. Neither has a published tonnage. Until they run, every tonne of new European propellant capital committed in 2026 still depends on the linter supply chain.

6.2 Nitrating acids: sulphur, sulphuric acid and nitric acid

Nitration uses a mixture of concentrated nitric and sulphuric acid. Sulphuric acid became the priced constraint in 2026. The Strait of Hormuz has been closed to normal traffic since 28 February 2026, and the Middle East supplies nearly half of the world's seaborne sulphur; global sulphur exports fell about 45 per cent below end-February levels in the months that followed^{87,88}. On 10 April China replaced its 700,000-tonne sulphuric acid export quota with a halt, in force from 1 May, to protect domestic supply; China exported 4.6 million tonnes in 2025 and the halt removes about 2.8 million tonnes from world trade in 2026^{89,87}. CRU reads the halt as running to the end of 2026; Kpler reported it as running through August, and electronic-grade acid is exempt^{89,87,88}. The price moves were large: sulphur delivered to Brazil rose from \$525 to \$1,150 a tonne between late February and early May, and sulphuric acid delivered to the US Gulf from \$155 to \$400⁸⁸.

Concentrated nitric acid is the other half of the mixture and is the less visible of the two. It is made inside chemical groups from ammonia, and no public price exists for the concentrated grade; this paper found no published European capacity figure for it either. It is recorded here as unpriced and unsized rather than as unconstrained. Freight is not what binds at this stage: bulk sulphur, ammonia and acid do not travel in containers, and acid that China will not export cannot be shipped at any price.

6.3 Ammonia and gas

Nitric acid is made from ammonia, and ammonia in Europe is made from natural gas. Europe holds about 17.7 million tonnes a year of ammonia capacity against a defence requirement of well under half a per cent of it⁶⁴, so the exposure is price rather than volume. That price is moving: EU gas storage stood at 68.5 per cent on 15 September 2026 against 80.8 per cent a year earlier, and the benchmark TTF gas price reached €81 a megawatt-hour on 16 September, up 187 per cent since January⁹⁰. A cold winter raises the cost of every nitrated product; it does not remove supply.

6.4 Nitroguanidine

Nitroguanidine is what makes a triple-base propellant, and the high-zone charges that give 155mm its range are triple base. Western production is concentrated in one company, AlzChem of Trostberg in Germany, and AlzChem's own disclosures show the capacity being added is committed before it runs. The company received a €34.4m grant under the EU's ammunition production programme in March 2024, announced in October 2024 that it would double nitroguanidine capacity with defence customers co-financing the investment and commissioning scheduled for the second half of 2026, and reported €31.9m of customer grants in defence in its 2025 accounts^{91,92}. In July 2026 it selected Bushy Park, South Carolina, for a \$150m US plant under a US government contract, with construction in 2027 and operations in 2029⁹³. No tonnage has been published for either. The US Department of Defense's own position is that current nitroguanidine supplies are imported, and in November 2024 it awarded \$5.1m under the Defense Production Act to establish recrystallisation of "the large existing DoD inventory" so that old material can be reused⁹⁴. Nitroguanidine is therefore not hidden; it is a single European producer whose expansion is spoken for and a US programme that reprocesses stock rather than adding new supply.

6.5 Nitroglycerine, glycerine, stabilisers and DNT

Glycerine, the feedstock for nitroglycerine, is a biodiesel by-product with no reported constraint. The constraint on nitroglycerine is nitration capacity and its incidents: the Karlskoga leak in September 2026⁵⁶, and the fact that the only announced European nitroglycerine addition is CSG's plant at Gnaschwitz in Saxony, at over €100m and inside CSG's own chain¹⁰. Nitroglycerine is also being recovered from demilitarised stock in Italy⁵³. For stabilisers (diphenylamine, ethyl centralite, akardite) and for the dinitrotoluene used in some single-base powders, this paper found no public evidence of constraint and no public sizing; they are recorded as unassessed rather than as secure.

INPUT	EUROPE'S ANNUAL DEFENCE DRAW	WHO CONTROLS SUPPLY	2026 PRICE SIGNAL	RELIEF
Cotton linter pulp	~14,000 t (derived)	China: over 70% of Europe's supply on Rheinmetall's estimate; just under half of global trade (ITC) ²⁸	No index; cotton stocks lowest since 2011–12	Wood pulp and recycled cotton, 2028–29
Sulphur / sulphuric acid	Not sized	Middle East ~half of seaborne sulphur; China halt from 1 May 2026 ^{88,89}	Sulphur \$525 – \$1,150/t; acid \$155 – \$400/t (Feb–May)	Hormuz reopening; end of Chinese halt
Concentrated nitric acid	Not sized	Captive inside chemical groups	No public price	None visible
Ammonia and gas	<0.5% of 17.7 Mt EU capacity ⁶⁴	European gas market	TTF +187% since January; storage 68.5% ⁹⁰	Seasonal; cost not volume
Nitroguanidine	Not published	AlzChem (DE), expansion customer-funded; US reprocessing stock ^{91,94}	No public price	AlzChem H2 2026 (captive); US plant 2029
Glycerine / nitroglycerine	Not sized	Nitration capacity: Karlskoga, Bergerac, Aschau; Gnaschwitz coming ¹⁰	No shortage reported	–
Stabilisers, DNT	Not sized	Not assessed	–	–

WHAT CARRIES INTO THE SHORTFALL

Two points. The dependency Europe can least fix quickly is the cellulose, which every euro of new European propellant capital committed in 2026 still requires, and whose only substitutes are unbuilt Swedish plants. And the one feedstock that moved in price in 2026, sulphur, moved by a factor of two in ten weeks because of a strait and an export rule, neither of which any propellant maker controls. The shortfall model in Section 7 carries this as a 10 per cent loss of today's output in the worst case; it does not model feedstock prices.

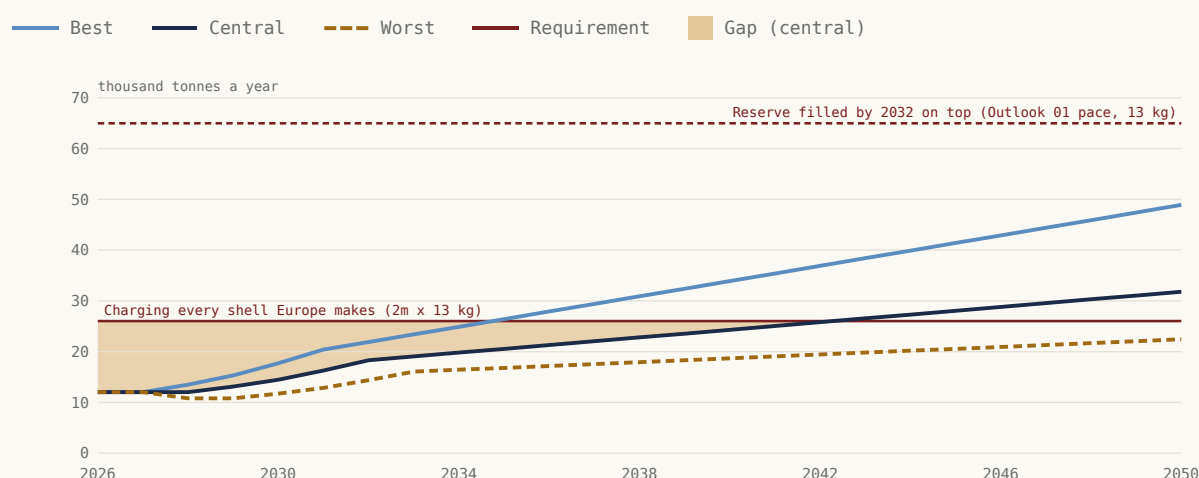
07 The shortfall: how large, and for how long

Europe makes about two million 155mm shells a year and will keep doing so. While the war lasts they go to Ukraine; when it ends they can go to the reserve. Two questions follow. How much propellant is Europe short of charging the shells it already makes, and for how long? And when can Europe hold thirty million charged rounds?

The model is deliberately simple, and every input is set out beneath the exhibits and at Annex B. European plants make about 12,000 tonnes of 155mm powder a year today, enough to charge about 0.9 million rounds fully (Section 3.2). Charging every shell Europe makes takes about 26,000 tonnes. New European capacity raises supply year by year at the delivery rates and delays the record in Section 2 supports. Every shell that European powder cannot charge needs powder from outside Europe.

7.1 The gap in tonnes

EXHIBIT 4 European 155mm propellant supply against requirement, 2026–2050



Derived, VSR Outlook 03 model v3. Supply: ~12,000 t of 155mm powder today (75% of ~16,000 t of large-calibre output), plus announced additions delivered at 80 / 60 / 50% with one / two / three-year delays, plus 2,000 / 1,000 / 500 t a year of capacity not yet announced from the 2030s; worst case loses 10% of today's output to feedstock from 2028. Requirement: 2 million shells at 13 kg. The upper line is the additional 65,000 t a year that filling a 390,000 t reserve by 2032 would take. Shading is the central-case gap.

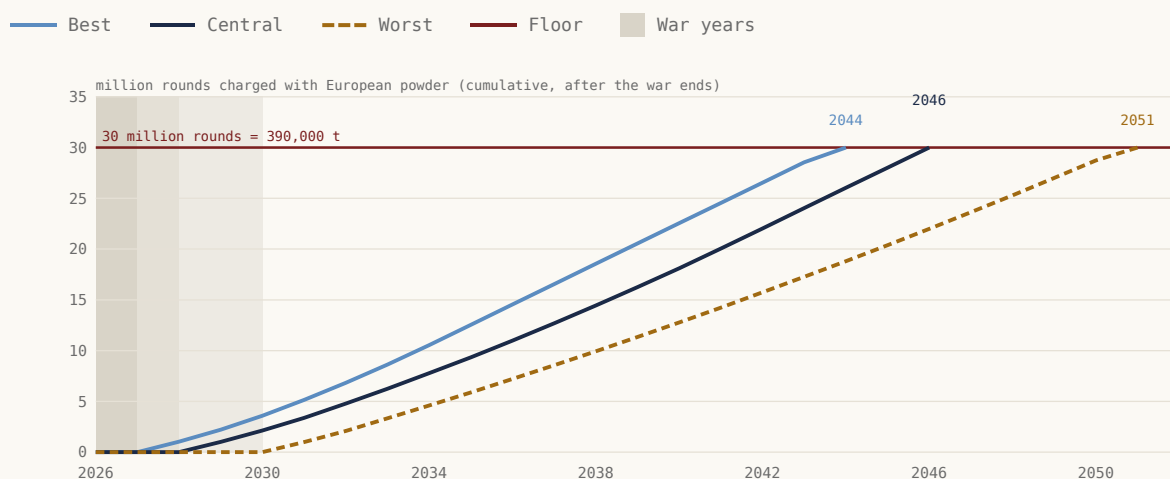
CASE	WAR ENDS	2026–30	2031–35	2036–40	2041–45	SUPPLY COVERS 2M SHELLS	YEARS OF SHORTFALL	CUMULATIVE GAP TO 2045
Best	2027	12	3	—	—	2035	9 years	73
Central	2028	13	7	3	—	2043	17 years	120
Worst	2030	15	11	8	6	After 2050	25+ years	198

Average annual gap in thousand tonnes of 155mm propellant against charging 2 million shells a year, European supply only, no imports counted. "Years of shortfall" is counted from 2026. Cumulative gap in thousand tonnes.

Three results follow. The gap today is about 14,000 tonnes a year on every case, because it is set by the plants that exist, not by the plants that are planned. Announced capacity, discounted for the delivery record, closes that gap in about 2035 on the best case, in about 2043 on the central case, and not before the 2050s on the worst: nine, seventeen and more than twenty-five years from now. And the gap measured here is only the gap to keep charging what Europe already makes. Filling the reserve at the pace Outlook 01 modelled would require a further 65,000 tonnes a year at a full charge, or 42,500 to 52,500 tonnes at Outlook 01's 8.5 to 10.5 kg³⁴; no announced project approaches that line, and the model does not attempt to reach it.

7.2 The reserve on European powder

EXHIBIT 5 Reserve charged with European powder against the 30-million-round floor



Derived, VSR Outlook 03 model v3. All European output goes to Ukraine while the war lasts (to 2027 / 2028 / 2030, shaded) and to the reserve afterwards; rounds charged each year are capped at the ~2 million shells made. With outside powder allowed, thirty million shells are reached in 2042 / 2043 / 2045, but only with 45,000 / 78,000 / 125,000 tonnes of outside powder; those dates are set by shell output and the war-end date rather than by powder, and are not headline results.

On European powder alone the reserve is charged in 2044 on the best case, 2046 on the central case and 2051 on the worst. In the best and central cases the date is set by the two-million-shell cap almost as much as by powder: once European powder covers Europe's own shell output (2035 and 2043 respectively), fifteen years of post-war output are needed to reach thirty million rounds regardless. Raising shell output does not change the European-powder dates (2043 / 2046 / 2051 at 2.5 million shells a year) because powder then binds alone. Shells are not the constraint in either reading; powder is, and the tonnage gap in 7.1 is the measure of it.

7.3 Sensitivities

VARIED	BEST: COVERS 2M	BEST: 30M	CENTRAL: COVERS 2M	CENTRAL: 30M	WORST: COVERS 2M	WORST: 30M
Base case	2035	2044	2043	2046	After 2050	2051
No unannounced capacity after 2030	—	2047	—	2050	—	2055
Today's powder output 20,000 t rather than 16,000 t	2033	2044	2039	2045	After 2050	2049
Today's powder output 12,000 t	2037	2045	2047	2048	After 2050	2054
10.5 kg per round (Outlook 01 high-zone case) rather than 13 kg	2032	2043	2036	2045	2047	2048
70% of large-calibre output to 155mm rather than 75%	2036	2045	2045	2047	After 2050	2052
Only 1.5m of the 2m shells go to the reserve after the war (training, exports)	—	2048	—	2049	—	2052
2.5m shells a year after the war	2040	2043	After 2050	2046	—	2051
Target lowered to 20m rounds	2035	2039	2043	2041	After 2050	2045

Derived, VSR model v3. "Covers 2m" is the year European 155mm powder first equals 2 million full charges (26,000 t; 21,000 t in the 10.5 kg row; 32,500 t in the 2.5m-shell row). "30m" is the year the reserve is charged on European powder; imports are not counted in any cell.

The year the gap closes is most sensitive to capacity nobody has yet announced and to the charge weight assumed. The year the reserve is complete is least sensitive to anything, because the shell cap and the war-end date dominate it. The two measures answer different questions: the first is how long Europe's powder makers face more demand than they can meet; the second is when the reserve exists. The first is the market question and it holds under every row.

RECONCILIATION WITH OUTLOOK 01

Outlook 01 judged that public programmes leave the floor unfilled until the mid-2030s, at 8.5–10.5 kg a round and on a generous reading of announced capacity, and gave the reserve as 255,000–315,000 tonnes on that basis. This paper uses a full 13 kg charge, which makes the reserve 390,000 tonnes; counts only the powder European plants make today and are likely to add; and starts the reserve when the war ends. Both charge weights are carried: the 10.5 kg row above gives the reserve on European powder in 2043 / 2045 / 2048. Outlook 01's timing is revised accordingly (Section 10).

FINDING

Europe will be short of 155mm propellant for as long as it makes more shells than it can charge, which on the central case is until the early 2040s, and short by a further 30,000 to 50,000 tonnes a year for as long as it also tries to build the reserve inside the threat window. Until then every tonne of qualified European powder will be bought, and outside suppliers will be asked for 45,000 to 125,000 tonnes more. After that, keeping a 390,000-tonne reserve serviceable needs roughly 10,000 to 26,000 tonnes a year of replacement before any use in training or conflict. The United Kingdom sits inside the European pool as a pure importer: it makes neither nitrocellulose nor gun propellant.

08 Ageing stocks and rocket motors

Every tonne of propellant laid down in a reserve begins ageing on the day it is made. This section sets out what the public technical record says about how propellant and rocket motors age and, as a clearly labelled hypothesis, what keeping an old stock of rocket motors serviceable is likely to involve.

8.1 How gun propellant ages

Nitrocellulose decomposes slowly in storage and releases oxides of nitrogen. If these are not removed, in the words of the UN's international ammunition guidelines, they "will catalyse further degradation", and "this autocatalytic decomposition of propellants is a serious safety issue, as it is known to lead to spontaneous ignition during storage, usually resulting in the loss of one or more explosive storehouses"²⁵. Stabilisers absorb those gases and are consumed in doing so. The same guidelines state that most propellants "have a shelf-life of at least 15 to 40 years when stored at a constant 30°C", falling to 3.75 to 10 years at 50°C, with the rate of chemical deterioration approximately doubling for every 10°C rise above 30°C²⁶.

NATO manages this by surveillance rather than by date. Two standards do most of the work: one tests the depletion of stabiliser (STANAG 4620, AOP-48), the other measures the heat a sample gives off (STANAG 4582), and both are designed to show that a propellant will remain chemically stable for at least ten years at 25°C^{95,96}. The UN guidelines direct armies not to assign an overall shelf life from a single test but to set the next surveillance date from the stabiliser remaining and the storage temperature²⁵. Surveillance is a recurring cost, and it identifies lots that must be destroyed. The US Army destroys lots whose effective stabiliser falls below 0.20 per cent, and recorded five self-ignitions of propellant at its installations between 1984 and 1989, with others in 1996 and 1997⁹⁷. Auto-ignition of propellant is a recognised cause of unplanned explosions at munitions sites worldwide, and many fires of unknown cause are thought to begin that way⁹⁸.

The implication for demand is direct. A reserve is not a warehouse of finished goods; it is a population of lots on individual surveillance clocks, some of which fail every cycle and must be replaced. Hot storage, and stock that has been moved and cycled through a war, ages faster. That is why a full reserve still requires thousands of tonnes a year of new propellant.

8.2 How rocket motors age

Double-base rocket grains, the extruded sticks in a 122mm rocket, age in the same way as gun propellant: stabiliser depletion, nitroglycerine migration and cracking from temperature cycling. Composite motors, made from ammonium perchlorate in a rubber binder, age differently. The published literature finds that "oxidative cross-linking of the binder was the predominant degradation mechanism", making the propellant "harder, stiffer" and reducing how far it can stretch before it cracks; plasticiser migrating between the grain and the liner weakens the bond between them; and moisture breaks the binder down⁹⁹. A common minimum requirement is ten years after casting⁹⁹.

Both kinds can be kept in service far beyond their original rating, but only through work. The US Army's missile stockpile reliability programme raised average missile shelf life from 7.9 to 22.6 years²⁷. Its Stinger life-extension added ten years to 2,594 missiles by fitting "new rocket motors, warheads, and gas generator and desiccant cartridges"¹⁰⁰, and a later programme at McAlester restored 1,900 unserviceable Stingers at about \$50,000 less per round than buying new¹⁰¹. The Minuteman III programme remanufactured and replaced all three solid-rocket stages on 607 missiles "before age-out occurs", at about \$1.8bn in procurement¹⁰². The United States also holds a large demilitarisation backlog, 430,987 tons of munitions in 2017, of which 28,153 tons were rockets and missiles, much of it stock that aged out rather than being fired¹⁰³.

8.3 Hypothesis: what returning old rocket motors to service involves

HYPOTHESIS: NOT YET EVIDENCED FOR ANY SPECIFIC PROGRAMME

No public record was found of a European programme to refurbish 122mm rocket motors, and no public cost comparison with new build for that calibre. The following is reasoning from the general record above, set out so that it can be tested.

STAGE	DOUBLE-BASE GRAIN (E.G. 122MM ROCKET)	COMPOSITE GRAIN (AMMONIUM PERCHLORATE)
Triage	Lot records, storage history, visual and X-ray inspection for cracks and voids	X-ray or computed tomography for bond-line separation and voids
Chemical test	Remaining stabiliser and heat flow, to the NATO surveillance standards	Hardness and strain capability of propellant samples; burn-rate check
If the grain passes	Extend life by analysis; replace igniters, seals and perished parts; re-test on a shorter interval	As for double base
If the grain fails	Remove and dispose of the grain; fit a new grain into the existing case, nozzle and fins	Wash out the propellant, recover the case and possibly the oxidiser, and re-cast
What it consumes	New nitrocellulose-nitroglycerine grain; test and range time	New composite propellant; cast-cure capacity; test and range time

Two conclusions follow even at hypothesis level. Most refurbishment of double-base rockets is a demand for new propellant in the shape of the old motor: the case and fins are reused, the energetic part largely is not. And the scarce parts of the job are the same parts that are scarce for new production: qualified propellant, test ranges and qualified people. Refurbishment extends a stock more cheaply than buying new, as the Stinger record shows, but it does not step outside the propellant chain. It adds to the demand on it.

09 The case against

Five arguments against this paper's central claims, each put as strongly as the evidence allows. For each: what would have to be true, what would show first, and why the paper does not currently hold it.

1. GOVERNMENTS WILL QUIETLY LOWER THE TARGET

The case. Thirty million rounds is a planning figure, not a law. If the war ends, finance ministries will cut reserve targets and the shortfall shrinks with them. Hungary and Italy have already asked for about €17.9bn less from the EU's defence loan instrument than expected. **What would show first:** NATO capability targets reduced at the 2029 review; ammunition lines cut from national budgets. **Why the paper does not hold it:** NATO's 5 per cent commitment runs to 2035, and a US troop drawdown from Europe, now being weighed by the Pentagon, pushes more of Europe's defence onto its own industry. The target does not change the tonnage gap in Section 7.1 at all, because that gap is the cost of charging the shells Europe already makes; even at a 20-million-round target the central case cannot be charged with European powder before 2041.

2. IMPORTS WILL FILL THE GAP

The case. Korea, Türkiye, India, Pakistan and South Africa all make 155mm and propellant, and Europe already buys from them. **What would show first:** large multi-year European contracts for complete rounds or charges from outside Europe. **Why the paper does not hold it:** the EU's defence loan instrument restricts spending to European production; Estonia's loss of about €70m on shells delivered without fuzes, charges or primers has raised the diligence bar on non-European supply⁶⁷; and imports already charge about half of Europe's shells, so the reserve would add a further 45,000 to 125,000 tonnes to a demand that Ukraine's own shell production and the US Army are also placing on the same suppliers.

3. A NEW CHEMISTRY WILL BYPASS THE COTTON

The case. Nitrocellulose-free propellants and continuous-flow manufacture could leapfrog the whole chain. **What would show first:** a European army funding qualification of such a charge. **Why the paper does not hold it:** no public record of a qualification programme exists in any European army, and every euro of new European propellant capital committed in 2026 is nitrocellulose chemistry. A bypass is a second cycle for the 2030s, not a remedy for this one.

4. THE WARTIME SURGE IS ALREADY FADING

The case. Czech-led deliveries to Ukraine are reported down sharply for 2026, with fewer donor countries; container freight is falling; Rheinmetall's 155mm output is not rising ahead of its capacity plan. **What would show first:** contract prices falling towards €2,000 a round; lines idled. **Why the paper does not hold it:** falling donor volume with rising supplier margins is not a glut. Colt CZ's ammunition margin rose to 33.2 per cent on lower revenue in the first half of 2026¹⁰⁴, Explosia reports demand above capacity²², and Rheinmetall guides its ammunition division to 29–31 per cent margins to 2030⁹. Suppliers behave as if capacity, not demand, is the limit.

5. THE MODEL IS BUILT ON ESTIMATES

The case. Nobody publishes Europe's large-calibre propellant output, so the base, the other-calibre share and post-2030 capacity are all this paper's estimates, and the feasibility register is a sample this paper chose. **What would show first:** a credible published tonnage well above 16,000, or a run of announced plants reaching rated output on time. **Why the paper still holds the judgement:** every estimate was varied across a wide range (Section 7.3), and no single change closes the central-case tonnage gap before the late 2030s. The year is uncertain; the direction is not.

10 What would change these judgements, and what to watch

10.1 Revisions to the standing judgements

STANDING JUDGEMENT (OUTLOOK 01)	REVISION
The binding constraint has shifted from projectile bodies to energetic materials and filling	Confirmed and sharpened: within energetics, traditional propellant and the nitrocellulose beneath it are the ceiling on usable rounds, and the industry's own planning figure of 6–7 kg of nitrocellulose per round puts that ceiling at about the shells Europe already makes
Precursor dependencies are an unpriced single point of failure	Relieved on the 2028-plus horizon by wood-pulp nitrocellulose and civil-plant conversions; unchanged before it. Sulphur became a priced dependency in 2026. Every new Western nitrocellulose tonne is owned by its financier
A second wave of private and public-private capacity is highly likely to be required	Confirmed. The gate is offtake and delivery, not demand, and the delivery record means announced second-wave capacity should be discounted by stage
Public programmes leave even the 30m floor unfilled until the mid-2030s	Revised later: the propellant gap to charge Europe's own shells closes in ~2035 / ~2043 / after 2050; the reserve is charged on European powder in 2044 / 2046 / 2051
Demand survives a ceasefire	Held at likely, upper band; strengthened by the storage-life replacement liability in Section 8

10.2 What to watch

INDICATOR	WHEN	WHAT IT WOULD SHOW
UK energetics factory feasibility returns and first front-end engineering awards	Due 30 Sep 2026; none published at 29 Sep	Whether the UK programme moves from paper to sites ^{58,59}
China's sulphuric acid export halt: extended, lapsed or narrowed	Aug–Dec 2026	Whether the nitrating-acid squeeze outside China eases ^{89,87}
AlzChem nitroguanidine expansion commissioning	H2 2026	Whether the one Western triple-base ingredient expansion lands on time, and whether any of it is uncommitted ⁹²
CellCore groundbreaking; Verkan first-instance permit	Q4 2026; 2027	Whether any new Western nitrocellulose lands before 2029
Rheinmetall Q3 results and Aschau first output	5 Nov 2026; 2027	Whether the largest addition delivers on time

INDICATOR	WHEN	WHAT IT WOULD SHOW
Latvia's Iecava charge plant opening	Due 2H 2026	Whether state-led charge plants open on schedule
Radford operating-contract changeover	End-2026	Continuity at the only US multi-base propellant plant
Hagedorn and MSM Walsrode conversions to military nitrocellulose	End-2026; 2027	Whether the first new European nitrocellulose arrives on time, and how much
Grupa Azoty financing decision	Overdue	Whether Poland's nitrocellulose and nitroguanidine return has money behind it
Sopot and the Lithuanian propellant centre	Ongoing	Whether announced-only projects revive or lapse
Any published order-book cover or "reserved until" date from a propellant maker	Ongoing	How far forward capacity is already sold
Any European qualification programme for a nitrocellulose-free charge	Ongoing	The start of a second industrial cycle

Three additions to the standing indicator set are proposed: announced versus actual capacity for every tracked plant, with an actual-rate field that will usually be empty; nitrocellulose ownership, recording each change of control; and a bulk-precursor indicator for sulphur, acids and ammonia, which sit below the current indicator set entirely.

A Annex A: Feasibility register

Thirty-four dated public commitments across the chain, classified by outcome against what was promised. "Delivered" means the stated capacity or milestone was reached by the stated date or within a quarter of it. Classes are this paper's judgement on public evidence at 29 September 2026.

PROJECT	LANE	PROMISED	WHAT HAPPENED	CLASS
Eurencó Bergerac, FR: new powder line	Propellant	New large-calibre powder line	In service January 2025 ³⁴	Delivered
Eurencó Bergerac, FR: third charge line	Charges	1.2m charge units/yr	Inaugurated 4 July 2026	Delivered
Eurencó Clermont, BE: propellant doubling	Propellant (small calibre)	Double output within a year of July 2025	Reported complete; reserved to 2032 ¹⁶	Delivered
Kansas AAP, US: automated 155mm line	Filling	New automated M795 line	Opened 13 April 2026 at 12,000/month ³⁵	Delivered
NPGM Niewiadów, PL: filling lines	Filling	Lines accepted 2026	Technical acceptance August 2026 ¹⁰⁵	Delivered
FMG Linares, ES: storage	Storage	Storage for >1m projectiles	Opened 28 May 2026	Delivered
US Army 155mm programme	Complete rounds	100,000/month by Oct 2025	~36,000/month in March 2026; reset to 140,000 by Dec 2027 ¹	Far below rate
GD-OTS Mesquite, US	Metal parts	100,000 bodies/month	No conforming parts delivered on schedule after \$469m ^{1,49}	Far below rate
EU million-shell pledge	Complete rounds	1m to Ukraine by March 2024	About a third delivered by February 2024; 52% projected ²	Far below rate
Rheinmetall Unterlüß, DE	Complete rounds	350,000/yr by 2027	First delivery July 2026, "low five-figure" ⁵⁰	Far below rate (early)
MESKO Kraśnik, PL	Bodies	150,000/yr from 2027	Investment completing 2027; no current output published ⁵¹	Too early
MESKO Pionki, PL: nitrocellulose and powder	Propellant	Running 2020 (PLN 400m, 2018)	Missed 2020 and 2024; first qualified powder July 2026 on CSG technology ^{3,4,48}	Late
Rheinmetall Várpalota, HU: RDX	Explosive	From 2026	Now 2027 ⁶⁵	Late

PROJECT	LANE	PROMISED	WHAT HAPPENED	CLASS
SWEBAL Nora, SE: TNT	Explosive	Full output 2028	Construction slipped to late 2026 / early 2027 ¹⁰⁶	Late
Nitro-Chem doubling, PL: TNT	Explosive	2028	2029–30 per PGZ's deputy chief executive ¹⁴	Late
CellCore, CA: nitrocellulose powders	Propellant	Ground broken Q3 2026; output late 2028	Company timeline moved to Q4 2026 and Q1 2029 without announcement (this paper's observation) ^{12,69}	Late
Nalagx / Eurenco Belledune, CA: TNT	Explosive	2029	2030, before construction ¹⁰⁷	Late
Hanwha Pine Bluff, US: charges	Charges	Groundbreaking 30 Sep 2026	Not reported; construction complete 2030, operations 2031 ^{78,79}	Late
BAE Glascoed, UK: filling	Filling	Opening 2026	Six months behind early 2026; unopened September ⁵²	Late
Rheinmetall Ukraine plant	Complete rounds	Production within 24 months of July 2024	No ground broken May 2026; now 2027 ⁴⁶	Late
Rheinmetall / Latvia forge and fill	Bodies and filling	Construction spring 2026	Missed; site unpublished ⁴⁷	Late
Iecava, LV: charge plant	Charges	Production 2H 2026	Unopened at end-September ¹⁰⁸	Late
Radford, US: energetic waste incinerator	Propellant support	July 2025	Moved to June 2026 ¹⁰⁹	Late
Rheinmetall Baisogala, LT	Complete rounds	Production 2026; qualified by end-2026	Construction reported behind schedule; no delivery figure ^{30,110}	Late
Rheinmetall / VMZ Sopot, BG: powder and shells	Propellant	~1,300 t/yr powder; charges for 150,000	No joint venture ever constituted; talks reset ^{5,6,36}	Stalled / reset
Rheinmetall Lithuania: propellant centre	Propellant	Combustible cases, propellant components and modular-charge assembly	Memorandum only (November 2025), sited at Baisogala; no construction contract published ³⁰	Announced only
Grupa Azoty, PL: nitrocellulose, nitroglycerine, nitroguanidine	Propellant	Production by 2029; decision by early 2026	Banks reluctant; still negotiating financing in September 2026 ^{13,37}	Announced only

PROJECT	LANE	PROMISED	WHAT HAPPENED	CLASS
PGZ Canada: TNT and nitrocellulose	Propellant / explosive	Plant sized like the UK project	No financing, site or partner ¹⁴	Announced only
Nitro-Chem / BAE Systems UK: TNT	Explosive	~2,000 t/yr plant (letter of intent, 27 Jul 2026)	Feasibility study only; no site, funding or build date ¹¹¹	Announced only
Chemring Nobel Hurum, NO: greenfield explosives	Explosive	New plant, operation by 2030	800+ mostly negative responses; site occupied by activists; no investment decision ^{38,39}	Stalled
Upytë, LT: RDX	Explosive	Protocol October 2024	No visible progress ¹¹²	Stalled
Verkan Kristinehamn, SE: nitrocellulose and powder	Propellant	First deliveries 2028	Before the environmental court; construction 2027; up to four-year build ^{41,43}	Too early
Forcit Pori, FI: TNT	Explosive	Production 2028	Permits refiled; foundation stone September 2026 ⁴⁰	Too early
GD-OTS Valleyfield, CA: propellant	Propellant	6 – 16m lb/yr	Approved with conditions June 2026; no completion date ^{44,45}	Too early

Totals: delivered 6; far below rate 4; late 13; stalled, reset or announced only 7; too early to judge 4. Highlighted rows are nitrocellulose or propellant.

B Annex B: Model and conversions

Structure. For each year from 2026, Europe makes about two million 155mm shells. While the war lasts they all go to Ukraine; once it ends they all go to the reserve. European 155mm powder is today's large-calibre output, less the share taken by other calibres, plus the share of announced and later capacity actually delivered. The number of shells European powder can fully charge is that powder divided by 13 kg, capped at the shells made; the rest need outside powder. The annual gap is the difference between the powder needed to charge every shell made and European supply. The reserve is complete when thirty million shells have been charged with European powder. Model: T00L-PropellantShortfallModel-v3.py.

ITEM	VALUE	BASIS
Propellant per 155mm round	13 kg (full high-zone charge)	Six BMCS high modules carry 13.8 kg of propellant ³¹ ; US M203A1 bag charge ~12.7 kg ³² ; US MACS stacks five M232A1 modules at full charge ³³ . Outlook 01's 8.5–10.5 kg is an average of charges fired and is carried as a sensitivity
30m-round floor	~390,000 t	Derived: 30m × 13 kg (255,000–315,000 t at Outlook 01's 8.5–10.5 kg)
Energetic nitrocellulose per artillery round	6–7 kg	Industry planning figure, Colt CZ analyst presentation ⁷ ; used for the nitrocellulose check in Section 3.2, not in the model
155mm shells made in Europe	~2 million a year	EU objective reported as achieved early 2026; "more than two million" (EU Defence Commissioner) ⁶⁶
Requirement to charge every shell made	~26,000 t/yr	Derived: 2m × 13 kg
War ends	2027 / 2028 / 2030	Estimated, best / central / worst
Large-calibre propellant output today	~16,000 t/yr	Estimated; Outlook 02 range 12,000–20,000 ⁶⁴ ; consistent with the nitrocellulose base (Section 3)
Share to 155mm	75% (~12,000 t today)	Estimated; the rest to other calibres and rockets; 70% carried as a sensitivity
Outlook 01's ~30,000 t	capacity by ~2030	Outlook 01 Annex B: "generous reading of announced projects incl. undisclosed tonnage" = today's ~16,000 t + ~14,000 t announced ³⁴
Announced additions, gross	+2,500 (2027), +3,000 (2028), +4,000 (2029), +4,500 (2030) t/yr	Estimated phasing of Aschau, Bergerac, Victoria, Pionki and Rheinmetall group growth ^{29, 9} ; ASAP powder target >10,000 t ^{8, 113}
Delivery of announced capacity	80% / 60% / 50%; 1 / 2 / 3 years late	From the delivery record, Section 2 and Annex A

ITEM	VALUE	BASIS
Further capacity from the 2030s	+2,000 / +1,000 / +500 t a year, each year	Estimated; not yet announced
Worst-case feedstock loss	-10% of today's output from 2028	Estimated linter or acid squeeze (Section 6)
Reserve-build pace, Outlook 01	42,500–52,500 t/yr at 8.5–10.5 kg; ~65,000 t/yr at 13 kg	Fill by 2032 ³⁴ ; shown as a reference line in Exhibit 4, not modelled
Storage life	15–40 years	IATG 07.20 at 30°C ²⁶
Replacement at full floor	~10,000–26,000 t/yr	Derived: 390,000 ÷ 40 and ÷ 15
Closing the Ukraine–Russia fire gap	~4.4m rounds/yr; 31,000–57,000 t	Derived: (27,000 – 15,000) × 365, at 7–13 kg a round ²³
Cellulose to nitrocellulose	~1.45–1.5 t NC per t cellulose in practice	Industry reference; theoretical 1.5–1.76 ⁸⁶
Canadian national programme	C\$355.7m nitrocellulose; C\$57.9m charge loading	Sourced ¹¹⁴

What the model does not do. It does not deduct existing European stocks, which are not public (as in Outlook 01). It does not deduct storage losses or training use from the reserve. It does not model nitroguanidine, acid or linter supply explicitly beyond the worst-case reduction, and it does not model price. It treats Europe and the United Kingdom as one supply pool, within which the United Kingdom is a pure importer of nitrocellulose and gun propellant.

c Annex C: Source register

Sources are numbered in order of first citation. Tier 1 sources (governments, companies, standards bodies, auditors) are used for every capacity, date and money figure where one exists; trade and general press are used where no primary source was found and are identified in the text where they carry a number alone. Access date for all web sources: September 2026.

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