

Defense-Industrial Bottlenecks: Gunpowder

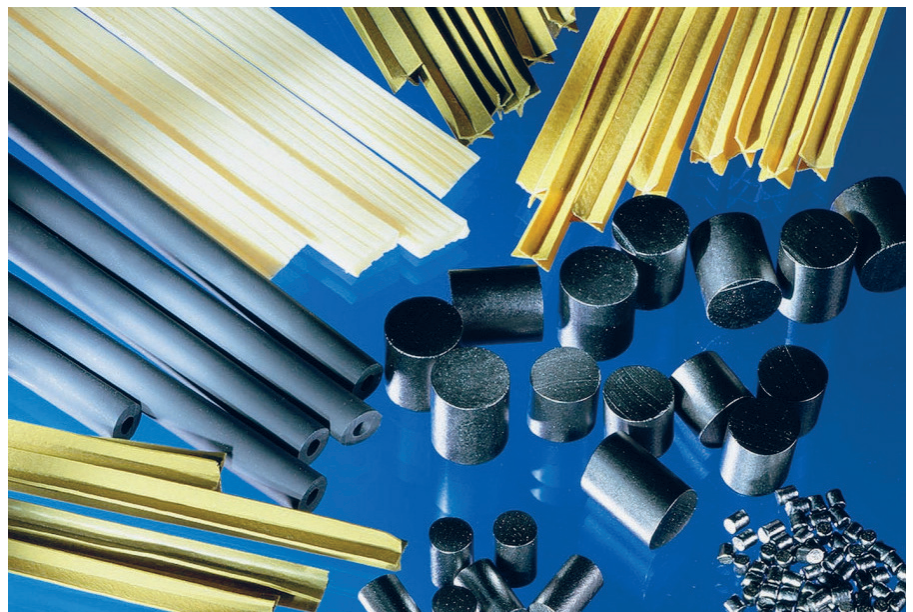
Supply shortages in gunpowder highlight the challenges that Europe currently is facing in its quest to regain basic defense-industrial capabilities. The product is in high demand, and there is a strong preference to source it domestically. The expansion of the European supply base, however, is restricted by momentous technical and structural factors. Numerous states therefore opt for industrial policy measures.

By Amos Dossi

The defensive capability of a state or alliance depends, to a large degree, on its access to sufficient defense-industrial capabilities. Even before the Russian attack on Ukraine, it was no secret that the capacities and, in some cases, competences of Europe's defense industry had dwindled considerably since the 1990s. However, a precise picture of the extent and implications of this loss of substance only becomes discernible now, against the backdrop of the current large-scale war. Two insights take center stage here.

First, to cover the new demands of European armed forces, the domestic industrial base is required not only to regain ground in prestigious high-tech fields such as military aviation and information technology, but also to reclaim basic skills. These relate, in particular, to weapons, ammunition, and energetic materials, most of which have been considered redundant and deliberately cut back in recent decades.

Second, it is especially in this "kinetic" field of application that the reclaim of industrial skills proves to be more challenging than its basic military character would suggest. In fact, this segment tends to be highly specialized and risky from both the techni-



Depending on the intended use, propellant charges are produced in a wide variety of forms.
Nitrochemie AG

cal and commercial standpoint. Respective industrial activities depend on expertise and complex infrastructures that are now rare in Europe and, beyond that, cannot be obtained in the short term through adaptation from the civilian sphere.

The present analysis examines this imbalance between demand and supply, its causes, and its implications for defense industrial policy using the example of gunpowder. This supposedly niche area is increasingly moving into the focus of political

and media interest. From a military point of view, gunpowder (or propellants, in more technical terms) is amongst the most elementary goods. From the point of view of industrial production, however, this chemical-technical product is extremely sophisticated and largely decoupled from other civilian as well as defense industrial activities.

In the following, the essential technical parameters determining the production pro-

The demand situation of European armed forces requires the industrial base to regain capabilities that, while basic, are all but “simple”.

cess of propellants as well as the product's military significance are outlined. Subsequently, the status and prospects of Europe's industrial recovery in this segment are examined, with a particular focus on Switzerland, which, *volens volens*, assumes a significant role here. Finally, the industrial policy implications of respective technological and market-related peculiarities are discussed.

Technical Parameters

Propellants are pyrotechnic charges that combine combustible and oxidizing substances, allowing them to react without an external supply of oxygen and thereby generate large volumes of combustion gases in a short time. These combustion gases can propel a projectile through the barrel of a pistol, a rifle, an automatic cannon, or a gun. They can also propel ground-, air-, or sea-launched solid-fuel missiles of both guided and unguided types. Nowadays, propellants for most types of weapons are based on nitrocellulose (NC). Until the end of the 20th century, nitrocellulose also found large-scale civilian use in the plastics and paint industries but it has now increasingly been replaced by other chemicals.

Producing NC propellants is a complex and delicate process. The base material is the natural product cellulose, that is, cotton or wood pulp. The cellulose is first prepared mechanically and chemically. Subsequently, it is “nitrated” in small batches in a mixture of sulphuric and nitric acid. After additional safety-critical cleaning and processing steps, the raw nitrocellulose is turned into a paste, optionally mixed with other chemicals, and then “extruded” into various shapes (strips, tubes, granules, and

others), a process resembling the production of pasta. This allows the burning rate and pressure as well as temperature development to be customized for specific types of weapons and ammunition. This is followed by drying and “phlegmatization”. The shelf life of the finished product is approximately 20 years.

This manufacturing method has remained essentially unchanged for around a century and is likely to remain so in the longer term. This is because it offers a satisfactory balance between safety and economy vis-à-vis the unchanging laws of physics and the largely mature state of chemical process technology. Notably, these framework conditions imply that scaling does not necessarily

mean increasing efficiency. The production of larger quantities of propellants implies a quasi-linear increase in the consumption of raw materials, energy, labor, and production space.

Apart from safety risks that cannot be ruled out completely, the technical parameters outlined above also entail commercial risks. When building a powder factory, investment costs in the three-digit million range can be expected, as well as extensive planning and construction periods. It is also worth pointing out the enormous space requirements, which can range from 50 to above 300 hectares. Depending on the type of propellant, the capacities of such installations, staffed by several hundred employees, are approximately 1,000 to 3,000 tons per year. If demand collapses unexpectedly, investments made can hardly be amortized by switching to civilian products due to the predominantly “single-use” nature of the product.

Military Significance

In conventional wars, artillery accounts for the bulk of propellant consumption. According to British estimates, Russian troops fired a total of around 20 million artillery and mortar shells in 2022 and 2023. The Ukrainian defenders' ammunition consumption is likely to have been around a quarter of this, although this is due not so much to the tactical advantages of the defense but rather to a shortage of supplies. With 12.5 million rounds per year and an assumed average propellant charge of 4 kilograms per round, this would correspond

to a total consumption of 50,000 tons of NC propellants per year – not including ammunition of smaller calibers and missiles.

To cover a demand of this magnitude, Ukraine would require around five medium-sized powder factories with an annual capacity of 2,000 tons, while Russia would need 20. Ukraine does not possess such a production base and is now even relying on Argentinian manufacturers in addition to European and North American ones. Russia, far better positioned in this industrial sector, is also increasingly turning to Chinese and North Korean suppliers.

However, the enormous consumption of propellants in the war in Ukraine, particularly on the part of Russia, cannot serve as a straightforward basis for the calculation of future European supply requirements. Generally speaking, Western concepts of land warfare – partly reflected in those of Ukrainian forces, which are increasingly equipped with Western weapons – are more heavily geared towards precision weapons than their Eastern counterparts. Generally speaking, they assume that they can achieve the same effect on the target with smaller quantities of ammunition. Furthermore, electrically powered drones and loitering munitions (LM) are likely to become increasingly important in fields of

The production of gunpowder is demanding. Besides safety risks, it also entails considerable commercial risks.

military application in which large-caliber guns and missiles were previously the weapons of choice.

For the time being, however, artillery is likely to experience a renaissance also in Western military doctrine. From Washington to Warsaw, the target stocks of artillery ammunition are being adjusted upwards significantly. Further, beyond respective planning cycles, it is not foreseeable to what extent advances in target detection and tracking as well as electric propulsion can contribute to the displacement of conventional artillery by drones and LM. Finally, it should be mentioned that artillery fire possesses several timeless and almost irreplaceable tactical advantages. These include, in particular, the short flight time of the projectiles, the practical impossibility

of intercepting them, and the psychological effect of their impact in large numbers.

Industrial Recovery Prospects

Until 1990, practically every Western European country – including smaller ones such as Sweden, Switzerland, Belgium, or the Netherlands – possessed at least one powder factory, which would typically be state-owned. These covered a large proportion of the domestic demand for artillery as well as smaller-caliber propellants and often also served export markets. Typical production capacities per plant were around 1,000 to 2,000 tons per year. Larger countries such as France, Great Britain, Italy, and West Germany would often operate more than half a dozen such factories.

This market situation, characterized by segmentation, nationalization, and high – after 1990 too high – capacities, quickly shifted into the opposite direction due to deregulation and a slump in orders. Since then, European powder production is becoming increasingly consolidated under the roofs of a few large multinational corporations. These firms shut down most of the older plants and satisfied the remaining demand based through a handful of the then more modern production facilities. Today, the European market leaders' (Rheinmetall, Eurenc, KNDS and Nammo) yearly output of artillery propellants (in tons) can be estimated to be in the high four-digit to low five-digit range.

According to available information, the recently initiated expansion of European capacities in propellants is aiming for an increase of around 10,000 annual tons. This objective is pursued along three main axes. The first involves the modernization, full utilization, and, if necessary, expansion of plants that have been operating according to Western standards to date. These include, for example, Karlskroga (in Sweden), Aschau (in Germany), Wimmis (in Switzerland), Pardubice (in Czechia), and Granada (in Spain). The second entails the construction of new plants or reactivation of decommissioned ones. New plants are currently planned in Hungary and Romania, among others. In Bergerac (in France), a historic facility is being reactivated on a large scale. The third axis concerns the conversion of plants in Eastern Europe, which previously produced according to ex-Soviet standards, to NATO standards. However, it should be noted that both Ukraine and some NATO allies still require ammunition of Eastern calibers and corresponding propellants.

The “Miracle of Wimmis”

It comes as a surprise even to industry experts that the Swiss Confederation is invested in powder production to this day. As the owner of RUAG MRO Holding AG, Switzerland holds 45 per cent of the shares of **Nitrochemie AG**. Nitrochemie AG is a joint venture founded in 1998 between the former Federal Powder Factory in Wimmis (Switzerland) and WNC-Nitrochemie Aschau (Germany) of the Rheinmetall Group, which holds the remaining 55 per cent. At its two complementary sites, Nitrochemie AG covers a major part of the range of NC propellants from raw materials to finished products. The combined capacity in 2022 was **2,500 tons per year** and is currently being increased significantly.

The origins of **state-run powder production** in Switzerland lie in the “gunpowder monopoly”, a legal provision enshrined in the Federal Constitution in 1849 and only abolished in 1998. It placed the previously private powder mills under state authority to safeguard the Swiss Armed Forces' powder supply both qualitatively and quantitatively. At the beginning of the 20th century, the Federal Powder Factory was in Worblaufen. In 1918 it moved to Wimmis and expanded considerably. Until the end of the Cold War, the 65-hectare site – with over 200 production and storage buildings and, at times, more than 500 employees – ensured **extensive national autonomy** in the field of propellants.

The question of how the expertise in propellant production, so much in demand again today, could be maintained over the lean spell of the last three decades is more difficult to answer than the question of how it was established in the first place. What seemed to be essential here was that the right balance was struck – whether by chance or foresight – between creating **commercial opportunities** and ensuring a minimum level of **government protection**. If the Swiss Government had not allowed its struggling powder factory to cooperate with Rheinmetall in the late 1990s, Swiss expertise in gunpowder would probably have been irretrievably lost. If, in turn, it had decided to sell its shares in Nitrochemie AG as part of the privatization push in the early 2020s, it would neither be able to reap the economic rewards of its more than one hundred years of investment in this critical industrial segment – nor to actively influence its future development according to domestic strategic preferences.

In these efforts, Western European suppliers in particular are faced with obstacles that go beyond the “endogenous” problems of high fixed and variable costs, as well as amortization. In addition to the general dependence on Chinese and Indian cellulose imports, these problems include high environmental regulations, energy, and labor costs as well as marked difficulties in finding suitable production sites and skilled workers. Furthermore, there is uncertainty in the industry as to whether Western European governments do really intend to

In their efforts to increase capacities, Western European suppliers face not only technical, but also structural and political obstacles.

utilize production capacities that are planned today and will only be available in a few years' time.

Against this backdrop, European governments are currently realizing that industrial recovery in propellants is not exclusively a supply-side responsibility. This is particularly the case if other strategic concerns that do not necessarily align with entrepreneurial logic are to be taken into consider-

ation. These concerns include short-term surge capacity regardless of (predicted) demand cycles, decentralization to mitigate the effects of accidents or sabotage and to keep supply lines short, and diversification in terms of ownership to prevent the formation of industrial monopolies.

This realization has given new priority and acceptance to defense industry policy. On the EU side, the Act in Support of Ammunition Production (ASAP) deserves particular mention. Based on this legal provision, almost 250 million EUR from the EU Commission's 2023 budget have been distributed to around a dozen projects aimed at boosting industrial capacity in propellants. Over the longer term, however, national measures appear to be more important as they are more granular and often more substantial. These include the negotiation of contracts linking longer-term purchase guarantees to supply-side commitments to domestic production, subsidies, as well as active governmental involvement as a shareholder of respective enterprises.

Industrial Policy Matters

Supply shortages in gunpowder highlight the challenges that Europe currently is fac-

ing in its quest to reclaim basic defense-industrial capabilities. This is not only because entrepreneurial incentives and military importance are particularly imbalanced here, but also because evasive strategies would have little traction. As discussed in this analysis, propellants are tailored to

If Europe's defense-industrial recovery is to be politically and strategically satisfactory, active demand-side involvement is required.

specific weapon systems, have a limited shelf life, and require highly specialized staff and equipment to produce. Consequently, outsourcing strategies, that is, the stockpiling of foreign armaments to be

used in the indefinite future, have limitations. So do on-demand strategies, that is, boosting capacities ad hoc by the conversion of civilian production lines.

If production capacities for propellants and related basic military goods are to be created in Europe within a reasonable timeframe, on a sufficient scale, and in line with political and strategic requirements, then the behavior of national governments will play a key role. As oligopolistic customers, it is up to them to offer companies the prospect of long-term sales opportunities so that they develop a willingness to make the necessary investments. As regulators, it is up to them to relativize the current ideas of an accelerated transformation towards a "green" high-tech and service economy to

the effect that strategic industrial activities of a more basic nature can also have a future in Europe. Ultimately, it is up to governments, as agents of their citizens and taxpayers, to decide whether and according to which model they want to participate in such industrial activities to actively shape them in the interest of national security and economic policy.

For more on military doctrine and arms procurement, see [CSS core theme page](#).

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