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Cefic Views: Understanding and Facilitating Industrial Flexibility in the Chemical Industry

Transitioning to climate neutrality requires fundamental changes in the way the EU power system functions: shifting generation from thermal baseload to low-carbon and renewable sources whilst electrifying end-uses necessitates additional grid capacity and balancing needs, as well as site adaptations. These add to the total cost of electricity for consumers. Yet, if total electricity costs are prohibitively high, large-scale electrification will not take off.

This is an inherent tension at the core of the electrification challenge: the balance between meeting the massive investment needs, while providing internationally competitive energy costs. Both are indispensable if the transition to climate neutrality is to succeed, and Europe is to retain a competitive industrial base.

Prioritising new projects for abundant and affordable low-carbon, renewable, and nuclear energy – including in baseload profile – will be a key enabler of industrial electrification and competitiveness. On the margins, sufficient flexibility capacity in the EU's electricity system might additionally help to lower total energy costs - including for industrial consumers - while generating positive externalities to the system.

Cost-efficient flexible capacity necessarily encompasses supply-side measures (such as ensuring back-up capacity, or combing intermittent generation with storage), as well as demand-side measures (meaning demand response through dynamic power purchasing/ producing and providing grid stability services, as well on-site energy storage). **This paper is to explore the role of flexibility for industry, its challenges and enablers.**

Expectations are high for EU industry to play a more flexible role in the EU power system. Still, the challenges of shifting the consumption profile of baseload users are considerable, as industry sites are capital intensive and traditionally optimised to run at maximal load with a stable energy supply. Flexibility will only be provided by industry if it improves industry's competitive position; it is not a substitute to competitive baseload supplies.

Yet, the possibility of industry to run flexibly are often viewed overly simplistically in the broader discourse, both in terms of technical feasibility and impact on production efficiency. To help inform the present discussion on industrial flexibility, this paper outlines:

1. **Understanding the flexibility potential of the chemical industry**
    a. Cascading linkages of processes
    b. Limits to safely storing chemical products on-site
    c. Inherent technical and safety limitations
2. **Economic barriers & political enablers of inducing greater flexibility in industry**
    a. Incentivise the development of flexibility potential in industry
        i. Market Access
        ii. Network Access & Tariffs
    b. Impact of increasing flexibility in industry on plant efficiency and emission
3. **Advancing industrial flexibility through on-site energy generation & energy storage solutions**

1. Understanding the flexibility potential of the chemical industry

The chemical industry is home to a variety of processes, some of them electrified, others relying on molecules for their energy needs. In total, the chemical sector is the largest industrial consumer of energy (1262 TWh in 2022 for both energy and feedstock[1]), the largest industrial consumer of electricity (157 TWh in 2022[1]), and operates in international competition.

Relevant for considering its potential for flexibility, the chemical industry principally operates in baseload – meaning in a flat consumption profile. It does so for reasons of costs, to optimise feedstocks yields, resource utilization and emissions, due to its capital intensity, as well as out of technical necessity and in the interest of sustainability. These consumption patterns and products, site specificities and economic considerations structure how dynamically a given industrial site can consume electricity.

The objective of this chapter is not to present a detailed quantification of the chemical industry's flexibility capacity, nor do we aim outline in any depth the technical capacity for flexibility on a chemical site[2].

Rather, the following categorisation is to provide an introductory overview of the technical limitations to increasing flexibility that may be found on a chemical site. For a more in-depth look at the flexibility potential of the chlor-alkaline industry specifically, refer to this paper[3].

Across the variety of industrial processes in the context of 'industrial flexibility' – meaning the capacity to dynamically adjust electricity consumption/ production – technical limitations generally fall into the following –non-exhaustive- categories:

a. Cascading linkages of processes

Processes on chemical sites don't operate in isolation; rather, different processes and technologies are often linked to one another in a cascading manner. This may include the linking of multiple processes that depend on one another for their raw materials and intermediary/ finished products. It may also include processes that rely on one another for their process heat through linked heat recovery.

The way multiple processes are linked can be specific to individual sites, meaning generalised statements about the flexibility potential of a given process are not possible. Because of these interlinkages, the flexibility limitations of one process can limit the flexibility potential of others, or even that of the entire site.

Pushing this interrelated system towards operating more dynamically should only be done by an informed expert on site to prevent any unintended effects on upstream and downstream

[1] Eurostat Figures

[2] For a more in-depth look, refer to this study (PDF) Electrical Flexibility in Chemical Industry: Technical Possibilities, Valorisation Paths and Ecological Benefits (researchgate.net), as well as: Study of electrical flexibility at the INEOS chemical sites in Belgium (FLEX) — Department of Electro Mechanical, Systems and Metal Engineering — Ghent University

[3] Eurochlor: Flexibility Fact Sheet

value chains and production and plant safety. For these reasons, we emphasise the importance of flexibility measures to be voluntary in nature.

b. Inherent technical and safety limitations

Chemical processes generally have a capacity utilisation limit under which the processed substances can no longer be handled safely, or the process be run economically. In addition, machines or motors that are integrated in a process may have limited ramping rates, sensitivity to ambient temperatures, and lengthy reaction times to adjust load safely. The number and interlinkages of these limitations on a given site can be substantial and will – again - be best known to the respective plant operators.

Completely turning off processes is possible in principle, but the chemical industry is not a start & stop industry. Sites are designed to stop under safe conditions, but any stop in production will necessitate a lengthy (and costly) shut-down and re-start of processes, wear and tear on equipment, higher energy consumption and additional emissions.

These interruptions may also have knock-on impacts on other processes and sites, given the deep integration of chemical sites and value chains. They further affect product quality, production and delivery deadlines, and can influence the fulfillment of contracts toward customers – and thus, the competitive position of the industry. This, again, places limits on the availability of flexibility potential in the chemical sector.

c. Limits to safely storing chemical products on-site

Where 'industrial flexibility' means taking energy from the grid during times of excess – provided that sufficient additional production capacity is available -, that energy will in effect be stored in chemical products and intermediaries.

The capacity of an industrial site to store additional product is limited both legally, in the case of hazardous or explosive substances, as well as physically (i.e. the availability of sufficient storage space).

For instance, chlor-alkaline electrolysis has – in principle – potential to offer flexible capacity on a day-ahead and even intra-day market/ balancing market, provided all the right conditions are in place. However, there exist limits to how much caustic soda, chlorine, and hydrogen (in the case of SEVESO sites) can be stored legally on a chemical site. This in effect limits the amount of energy a given site can absorb. Energy storage assets can potentially aid in alleviating some of these limitations (see chapter 3).

2. Economic barriers & political enablers of inducing greater flexibility in industry

In addition to the technical limitations outlined in the first chapter, politico-economic barriers can inhibit the scale-up of flexibility in industry. Flexibility can generate significant additional costs for companies including through production losses, investments in additional storage and/or production capacities, as well as adjustment costs. They may additionally entail higher personnel costs, lower feedstock yields, higher specific fixed costs, increased maintenance costs, higher demand for energy or chemical storage combined with a risk of reduced product quality due to changing process parameters. Furthermore, flexibility may also require similar flexibility on other input factors that may drive up costs and can negatively impact energy efficiency.

A voluntary increase in demand side response is therefore only economical if it is remunerated or incentivized accordingly. To that end, we put forward the following considerations:

a) Incentivise the development of flexibility potential in industry

i. Market Access

Accurate price signals provide invaluable incentives in favour of deploying flexibility efficiently. To broaden the exposure to price signals to all consumer groups, we recommend reducing existing barriers for industrial users to participating in flexibility markets, which may include day-ahead, intra-day, or capacity markets.

Besides removing legislative barriers, this encompasses also the development of new market services, e.g. help bundle the flexibility potential of smaller, non-traditional market players to improve system efficiency or flexibility services from slow-reacting load.

- **Recommendation**: Participation to flexibility markets should be voluntary, fairly remunerated, and open to all market participants.
- **Recommendation**: Service providers such as aggregators can help in facilitating flexibility market development and -access.
    - Their role should be strengthened and undue barriers to their formation and market participation be removed.

Note that exposure to the short-term wholesale market is an important driver of inducing greater industrial flexibility. This exposure runs counter to the dominant narratives of industrial energy procurement emerging from the recently revised Electricity Market Design (EMD). The EMD identifies long-term contracts, such as PPAs, as central for industrial players. There is an inherent tension between the push towards electricity procurement under long-term contracts and inducing greater industrial flexibility through exposure to short-term markets.

ii. Network Access & Tariffs

Network tariffs can provide another avenue to remunerate more flexible consumer behaviour and the deployment of storage assets. Importantly, incentivising flexibility through network tariff setting should not come at the cost of penalising baseload consumption. Even fully electrified processes may, due to the technical limitations described above, have limited to no potential for operating flexibly. Prohibitive network tariffs would undermine the business case for these baseload processes to electrify and should be avoided.

In view of the development of national transmission system operator (TSO) schemes to incentivise flexibility, we recommend:

- **Recommendation**: Non-firm connection agreements can facilitate grid access for industrial sites with flexibility potential, provided by demand response, storage, and/or on-site generation capacity.
- **Recommendation**: Time of use tariffs can provide signals in favour of scaling flexibility resources, however:
    - Baseload consumption with limited to no potential for flexibility should be exempted.
    - Given the specificity of their processes, it is important that industrial users be consulted in the development of TSO products that aim to facilitate greater flexibility and that the up-take of these products be voluntary.
    - In the interest of market integration, the roll-out of 'flexibility incentives' at TSO level should be coordinated as much as possible at EU level.
    - The up-take of relevant TSO products will hinge critically upon the visibility that consumers have of future flexibility needs at a local level.

b) Impact of increasing flexibility in industry on plant efficiency and emission

Most global manufacturing industry – the chemical sector included – operate principally in a baseload profile, often with high-capacity utilisation, for reasons of operational efficiency, cost competitiveness and technical necessity. Shifting towards a more dynamic consumption profile – even where technically feasible– will decrease the efficiency of industrial processes, leading to greater (relative) emissions and lower energy efficiency, lower feedstock yields, and higher overall costs to operate a given plant more dynamically, depending on the underlying process.

- **Recommendation**: Recommendations from energy audits and energy management systems under the Energy Efficiency Directive (EED) should not emerge as bottlenecks to scaling industrial flexibility.
    - Conversely, providing voluntary demand side flexibility should not have a negative impact on meeting the energy efficiency criteria within existing legislative and state aid frameworks.
- **Recommendation**: Fluctuations in run rates will result in changing emission loads that could lead to issues with IED operating permits. Where these fluctuations fall outside the normal operating ranges, they will have to be dealt with as OTNOC (other than normal operating conditions). For these, better controls will need to be defined.

3. Advancing industrial flexibility through on-site energy generation & energy storage solutions

Deploying on-site energy generation can provide potential for grid balancing services (through reduced or increased electricity production) whilst mitigating some of the challenges associated with demand response. Especially where on-site energy generation serves, at least in part, as a back-up, some capacity may be available for supplying the grid. These arrangements already exist today for some CHP plants, for instance, but may play an increased role in the future, depending on the development of on-site generation technologies[4].

The scale up of energy storage solutions on industrial sites can also be an attractive alternative or complement to more dynamic means of production. 'Energy storage' here may refer to means of storing electrical energy, be that in power-to-x (heat, hydrogen, chemical intermediaries), electrical battery, thermal energy storage, or mechanical storage (water, pressurised air).

These storage technologies may enable the respective industrial user to maintain more stable production even while also providing grid balancing services through reduced or increased electricity consumption. Thus, they avoid some of the negative side-effects of more flexible production patterns mentioned above.

However, high up-front investment costs prove prohibitive to their large-scale deployment on industrial sites. During the early phases of the market-ramp up of storage solutions, we recommend putting in place appropriate support measures that are harmonised as much as possible at EU level.

Similarly, higher production capacity deployment may also enable greater room for demand-response for industrial users - who could ramp up production commensurate with supply peaks, provided they can sufficiently store the manufactured products. In essence, this would enable 'energy storage' in the form of chemical products.

Same as with energy storage solutions, these investments in additional capacity and on-site generation face high up-front cost. In addition, running more dynamic production profiles in manufacturing industries is dependent on sufficient storage facilitates (and the right to store certain hazardous products) to absorb the increased production.

- **Recommendation**: State aid support should include capital funding for storage assets on industrial sites, as well as capacity expansions and on-site generation where these provide competitive balancing services to the grid. Support measures should be harmonised as much as possible on EU level.
    - Operational expenditure subsidies are also crucial to de-risk investments and lower the overall cost of storage solutions, especially to allow the technologies to develop and mature.
- **Recommendation**: Capacity renumeration schemes should be open to industrial users to offer both existing and new-built capacity to the market to help cover the operational expenditures associated with more dynamic manufacturing patterns.
    - "Behind the meter" storage should be treated equally to standalone storage facilities in the grid when it comes to qualifying to capacity mechanisms and delivering ancillary services to the grid (when technically feasible).

In addition to these, the recommendations under chapter 2 a) can similarly be applied to storage assets on industrial sites.

[4] Fact Sheet: Chemical Industry Views on Facilitating Industrial Small Modular Reactor (SMR) Deployment

We reiterate that industrial flexibility needs to be understood as one component in a broader context of designing an internationally competitive energy system. Supply-side measures that bring additional affordable low-carbon, renewable, and nuclear energy – including in baseload profile – to market are central to addressing the EU's energy needs.

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About Cefic
Cefic, the European Chemical Industry Council, founded
in 1972, is the voice of large, medium and small chemical companies across Europe, which provide 1.2 million jobs and account for 15% of world chemicals production.