Koninklijke VEMW

Kenniscentrum en belangenbehartiger van zakelijke energie- en watergebruikers

Industrial flexibility is a key building block for a reliable and affordable grid

Position paper

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1. Purpose of this paper

This position paper put forward by TenneT and VEMW aims to provide a rationale and a motivation to advance flexibility from industrial demand response and energy storage in The Netherlands. It presents a background on the need for CO_2 free flexibility to secure an affordable electricity supply in a system increasingly dominated by renewable energy sources, and distinguishes various uses and sources of industrial flexibility. It also points out why industrial flexibility presents opportunities for industries to make money in increasingly volatile electricity markets. Important hurdles are discussed as well. The paper ends with a call to action to all stakeholders across industrial sectors and clusters, government, and grid operators, to put industrial flexibility high on the agendas and to promote it vigorously.

2. Capitalise on industrial flexibility

A more flexible electricity demand offers opportunities for both the basic industries (producing commodities) and the manufacturing industries. It may help to significantly reduce energy bills by responding to fluctuating electricity prices on the spot, balancing and reserve markets. A company may choose to offer fast support to TenneT on the market for ancillary services during balancing problems, either using regulating reserve (aFRR), incident reserve (mFRRda) and/or Frequency Control Reserve (FCR). It may also sell its flexible capacity for a fixed fee to balance responsible parties (BRPs).

Next to this, making good use of price fluctuations on the spot markets may help to build business cases for demand response and energy storage by concentrating electricity consumption in time windows with cheap electricity, and by avoiding consumption when electricity prices are high. Additionally, increased demand e.g. from energy storage may support business cases for renewable energy by supporting the electricity price during periods of high production from renewables.

Market parties such as metal producers, waste incinerators or horticulture entrepreneurs already offer their capacity for tuning up or down electricity demand on the balancing market for emergency power, but also on the spot market. Whenever the spot price is low, market parties may benefit by increasing demand. As soon as the spot price increases, industries can make money by using stored electricity themselves or by feeding it into the grid.

Industries can also reduce energy bills temporarily by turning off electricity-intensive processes, if the benefits from compensation outweigh the costs, including those from reduced output. In its study of industrial demand response options DNV (2020) found most current opportunities available in the chemical, packaging, paper, food, glass and metal industries. Today only a minor part can compete with dispatchable natural-gas fired capacity, but this may change as the CO_2-price increases steeply towards 2030. Identifying cost-competitive demand response opportunities is thus essential. Suitable industrial processes are flexible , and capable of being ramped up or down easily.

The search for feasible options in process designs will require a serious effort by industry in close cooperation with power system operators. In this examination of options, new and cost-effective potential can arise, while at the same time other options may turn out to be unattractive. Currently, there is no strong business case for many industrial applications to invest in flexible capacity, because price spreads do not (yet) justify the investment. Once significant, predictable and sustainable spreads occur there could be a strong drive to utilize such opportunities, and anticipation thereof is key.

Industries that have electrified to a large degree could make their processes more flexible wherever business cases are positive. In addition, interesting additional potential for flexibility can be unlocked as industrial electrification progresses, provided sufficient efforts are made. Electrification will enable options for electrified heating with electric boilers or heat pumps in combination with heat buffers, motor drives, battery storage and electrolyses. Business cases for each of these assets can be supported by offering their capacity and energy on the spot, unbalance and reserve markets. The 'Routekaart Elektrificatie' by TKI Energie & Industrie (2021) provides insight in the maximum potential of industrial electrification, both for the direct use of electricity and for the production of green hydrogen ("indirect electrification"). This roadmap also suggests an implementation agenda to progress industrial electrification up to and beyond 2030.

Box 1 Opportunities today for industrial demand response from existing processes

A recent study by DNV (2020) provides insight in the potential for temporarily reducing industrial electricity demand in The Netherlands, based on a study of demand response potentials in individual companies. Processes and costs for temporarily switching these off were analysed to make more precise estimates of – potential – availability for various time spans. The study identified a potential of 3.4 GW, which is expected to grow to 4.0 GW in 2030. Including this potential in an electricity market model showed that in 'extreme' weather scenario's the demand for industrial demand response is maximum 1.9 GW for the most extreme hour. To put this in perspective, total demand response in the Netherlands is estimated to be in the range of 0.7-2.0 GW according to the TenneT Flexibility Monitor (2020).

A range of options may reduce demand from existing industrial processes to cover prolonged shortages (hours to weeks). A key element in the price of industrial demand response is the impact on revenues. Demand response will need to generate additional income to compensate for lost earnings or costs for any hardware (metering devices) installed. Several examples of industrial processes that could provide flexible capacity were found:

- Packaging processes in the food industry do not need to run continuously and may provide flexible demand
- The production of certain chemicals is continuous, for instance the production and purification of metals on the basis of electrolysis. If lost earnings can be covered by sufficiently high electricity prices, these processes may be interrupted temporarily.
- In the metal industry various processes with a high electricity demand can be switched off easily for one or several hours.

Most industrial consumers can offer flexible capacity through DSR at a price higher than conventional gas-fired plants. Increasing CO_2-prices and increasingly volatile electricity prices may shift this situation and make industrial demand response options more competitive.

The study identified some bottlenecks for further developing the potential for demand response, including

- Limited knowledge of opportunities for additional earning by offering demand response to the electricity market
- Limited insight into the investments required to unlock the available potential
- Limited 'sense of urgency' for developing the potential in the short run with policy makers and industries. For many companies energy management is not core business and energy makes up a minor proportion of operational costs. For highly electrified companies energy does make up a significant proportion of operational costs, and they may represent quick wins.
- Lack of consensus on how to tap into the potential – through the market, or more centrally regulated.

Importantly, offering flexibility services will need to be integrated with other business processes, for instance in sales and marketing. In B2B sales, a normal way of working for industries is to ensure they can live up to agreements with customers, taking into account a reasonable degree of possible surprises. This could include the provision of flexibility services. Furthermore, smart marketeers will want to use the provision of flexibility services to their advantage in branding their firms as active contributors to the energy transition.

Box 2 Overview of electrification technologies and potentials. Source: Routekaart Elektrificatie (TKI E&I, forthcoming)

Electrification of industry in The Netherlands will have to result in 4.2 Mton CO_2 reduction by 2030. Based on the current rate of efficiency improvement, the potential for green gas and geothermal energy, and the subsidy ceiling for CCS laid down in the Climate Agreement, at least 40% of the reduction in industry by 2050 will have to be realized via direct or indirect electrification. The potential is much higher though. Currently, industry needs around 560 PJ of heat every year, as well as 140 PJ electricity (20% of the total final industrial energy requirement). Around 40% of the required heat is used for low temperatures (LT, <200 °C) and 60% for high temperatures (HT >200 °C). The technical potential for industrial electrification is approximately 130 TWh/y (or 470PJ/y) in 2050, which is well above the current national electricity consumption of around 110TWh/y. This calculation assumes an annual efficiency improvement of 1% and a two-thirds drop in demand for refining products. This does not take into account new production of synthetic fuels that are even more energy-intensive than the fossil routes. Unlocking this potential can take place in several steps.

Before 2030 it is technically possible to take major steps with electric compressors, electric boilers and low-temperature heat pumps. These have a combined technical potential of approximately 70TWh (or 250 PJ) in final demand for electricity or green hydrogen, excluding the loss of production of existing industrial CHP. With flexible use of electric boilers in a hybrid set-up with gas-fired boilers or CHP, the demand can be about 40TWh (or 150 PJ) lower. When green hydrogen is used in boilers in continuous operation, the demand for electricity is about 30 TWh (or 100 PJ) higher due to conversion losses. In the first few years, however, green (or blue) hydrogen used in industry will probably mainly replace the current use of grey hydrogen.

Between 2030 and 2040 it may become technically possible to apply direct industrial electrification for higher temperatures on a large scale using high temperature heat pumps, but also ovens and stoves. These options provide a potential of 40 to 50 TWh (about 140 to 180 PJ) in final consumption. Green hydrogen production via electrolysers can be greatly scaled up in this phase, especially when the potential for more cost-effective alternatives such as electric boilers has been saturated. This provides an additional technical potential of 70 TWh (or 250 PJ) in demand for renewable electricity for the production of green hydrogen. In addition, a start with direct or indirect electrification of very energy-intensive processes such as cracking and steel production is expected.

From 2040 onwards full direct and indirect electrification of energy-intensive processes is expected to be feasible, so that the industry can operate its processes completely CO_2 neutral. This leads to large-scale application of electricity as an energy source for industry with an additional demand potential of 50 TWh (or 180 PJ) for direct or indirect electrification in steel production.

3. More grid stability and less congestion

While flexible electricity use may offer an opportunity to lower energy bills for individual industrial customers, greater flexibility is vital for the energy transition to succeed. Flexible resources include options covering short term (day-night) variations, options for prolonged periods of high or low production from wind and/or solar, and options needed only sporadically on occasions when security of supply is at risk. As a result, flexible sources can support supply security in various ways.

Firstly, it is common practice for TenneT to purchase system services from flexible assets to stabilize to the grid. Such system services are offered on the different balancing capacity and/or energy markets. On these markets TenneT purchases system services with different characteristics in terms of capacity, availability, duration and ramp rates to ensure grid stability.
Secondly, flexible assets can also help to reduce local congestion that regional grid operators need to deal with progressively more, and reduce the costs for managing this congestion. Increasing congestion hampers the connection of new market parties to the grid. VEMW has already called for an effective collaboration between grid operators and connected parties to use limited transport capacity efficiently, thus reducing economic damage.
Thirdly, flexible electricity use is essential for matching supply and demand in a system increasingly dominated by renewable resources, thus ensuring the adequacy of CO2-free resources. This implies that balance responsible parties make flexible resources a normal and indispensable part of their portfolios at day ahead or futures market.

Natural gas
Thus far natural gas-fired power plants have been the dominant resource for providing all kinds of flexibility . Gas-fired power plants are particularly capable of quickly adjusting their production when compared to other conventional power plants (i.e. coal, oil, nuclear). Furthermore, in contrast to renewable energy sources, conventional power plants, including gas-fired power plants, are synchronous production installations: the physical connection between the frequency of the generator and the grid frequency supports grid stability by design. The role of natural gas will change in a zero-emission energy system. Both the Netherlands and the EU have committed to the Paris Agreement and aim to limit global warming to 1.5°C by 2100, which implies virtually phasing out net greenhouse gas emissions in 2050 – less than 29 years from now. As part of ambitious EU climate policy (Green Deal, Fit for 55) CO_2 price levels are projected to increase up to and above 80-100 euro/t in 2030 (Pietzker et al, 2021; BNP Parisbas, 2020). This is bound to make natural gas plants more expensive. As a result the economics of conventional natural gas-based generation capacity will be affected by a progressive reduction of operating hours (Gasunie and Tennet, 2021). It is as yet unclear to what extent existing flexible generation capacity will be operated using green or low carbon hydrogen, but this will be more costly than natural gas based operations today. Large scale CO_2 capture from gas-fired plants would compete with CO_2 capture from basic industries, which have few short term alternatives for decarbonization. In the Climate Agreement CCS is not part of the agreement for the electricity sector. So while flexibility from natural gas-fired capacity today comes very early in the merit order of flexibility options, this may well change. This may well improve business cases for industrial flexibility.

Net-zero gases

Dispatchable capacity based on sustainable gases (green gas and hydrogen) will have a growing role in providing flexibility beyond 2030 and towards 2050, but initial supply is scarce. Gasunie and TenneT (2021) explored this in their joint study on the energy system of the future. Based on four scenarios total costs for operating flexible capacity were estimated between 6 and 10 billion euros per year. Up to three quarters of these costs are for power-to-gas (up to 50 GW) and green gas-to-power (~ 35 GW) facilities, while the remainder would be for system batteries. Dispatchable capacity based on green gases will play a role mostly after 2030, and will require major investments in the development of electrolysers and gas storage facilities. For example, storing just ~0,25 TWh hydrogen in a salt cavern will cost 100-150 mln euros, and up to 60 of these caverns would need to be filled for seasonal storage, i.e. for electricity production from hydrogen in periods with limited supply from wind or solar. While investments and operations of such hydrogen capacity may be costly, it is difficult to fully grasp the dynamics of the hydrogen market. These will likely be more unpredictable than forces in today's market for natural gas, which is used for domestic heating too and thus mostly follows seasonal demand patterns. Price levels and volumes in the hydrogen market will be driven by demand in North-Western Europe on the one hand, and national production plus import of green hydrogen on the other hand.

The joint Gasunie/TenneT study does not anticipate large scale use of natural-gas fired capacity combined with CO_2 capture and storage. This would require connecting natural gas-fired capacity across the country with a CO_2-infrastructure, which would be a costly undertaking. Additionally, CCS is not part of the electricity chapter in the Climate Agreement.

Industrial flexibility for congestion management

The electricity grid is currently facing congestion; a lack of transport capacity leading to refusal of third party access. The various causes of congestion are not a part of this paper. To bridge periods of grid expansion, system operators use congestion management to ensure optimal use of the scarce capacity available. Short term CO_2-free flexibility may help to mitigate ceaselessly increasing costs for congestion management, thus contributing to a reliable and affordable energy system. Relevant options are available in all sectors and combined they offer indispensable potential. Particularly industry, as a major energy consuming sector can help to reduce grid management costs by unlocking its flexibility potentials. Industrial batteries, flywheels and demand response options are market ready technologies that can play a role today in balancing the grid and managing congestion, provided they are either necessary due to lack of an alternative, or desirable due to itself being more cost-efficient than alternatives.

4. Remove hurdles

Much of the earning potential from industrial flexibility reside in options that still need to be identified. An important point of departure should be how flexibility can be supported. While industrial flexibility offers an opportunity and can support business cases for electrification, for some companies it may add a layer of complexity. Offering industrial flex capacity is **relatively unknown** and apart from a business opportunity may involve financial risk. Companies will need a degree of security to embark on this, and support would clearly be helpful. Successful examples of business cases for industrial flexibility could play a key role in raising interest, ideally across a variety of technologies and subsectors. For these examples to manifest, hurdles which currently hamper the unlocking of industrial flexibility must be removed.

To demonstrate the viability of business cases insight is needed into whether electricity price levels will be able to make up for CAPEX and operational costs, including CO_2 prices and grid tariffs, or if additional public support would be needed. Furthermore, uncertainty about the timely availability of sufficient **grid capacity** may slow down investments in options for further industrial electrification and hence potential flexibility. TenneT has initiated a study to shed light on business cases for flexible electricity demand in five industries in the so-called sixth industrial cluster. This and similar studies may help to reduce perceived risks of grid investments on both ends.

In some cases **grid tariffs** represent a hurdle to a greater of deployment of industrial flexibility (

*Box **3***). For a start, in today's tariff structure an important component is the maximum grid capacity demanded by a user in a given year, which used to be a key driver for grid costs. Exceeding this value for an occasional peak is a hurdle to temporarily increasing demand, also in periods when this would help to manage congestion and thereby effectively reduce grid costs. Additionally, producers are not charged for their use of the grid. (OTE, 2018). Reforms to the tariff structure may help to reduce current barriers to the deployment of industrial flexibility, while preserving a level playing field. Such a level playing field must be guaranteed through a combination of transparent, non-discriminatory and reasonable grid tariffs, energy price levels, and fiscal measures. A working group on large-scale consumption tariffs of Netbeheer Nederland has started a process to investigate obstacles in the current tariffs for large consumers in a broad stakeholder dialogue. This may include barriers to industrial flexibility. If the working group sees sufficient reason from this investigation to adjust the tariff structure, the network operators will work towards an amendment proposal that can be submitted to the ACM.

In broad terms, strict **product specifications** hinder the supply of greater volumes of flexibility. Relaxation of product specifications should, under conditions, be permitted. Possible conditions include a relaxing of specifications being permissible if, as a form of compensation, volumes supplied are increased. Another possibility is coupling higher or lower prices to products with longer or shorter availability, respectively. Specifications of aFRR and mFRR must be industry-friendly, and need to be communicated clearly. TenneT currently demands that flexible capacity be available 24 hours, but for many industries this is too long. Contracts that would allow shorter availabilities (i.e. 4 hours of even less) would greatly improve the flex potential that can be offered to TenneT. Furthermore, IT Tools are key for this development and require investments (in time, processes and money). Likewise, information on hardware and software to install on assets must be readily available, including repercussions on cybersecurity.

These abovementioned hurdles hamper exploiting the flex potential from CHP installations particularly. For instance, the introduction of electric boilers may compete with existing CHP installations (Box 4). It would also be helpful for companies to have a better **understanding of flexibility markets** and options to offer flexible capacity at these markets, without excessive risks of penalties discouraging participation.

Box 3 Summary 'Hurdles in grid tariffs' (OTE, 2018)

In 2018, the *Overlegtafel Energie* reported on obstacles in the current grid tariffs for an efficient, reliable and sustainable energy supply. The working group also proposed a number of solutions that meet criteria of cost, feasibility and robustness, These may have importance to unlocking industrial demand management and energy storage, and are discussed below.

An uneven playing field in the flexibility markets for electricity extraction and production
In the current tariff structure, a transmission-dependent tariff is only charged to customers who extract electricity. It is important that the required flexibility is realized at the lowest cost, among other things through smart use of the electrification of transport and heat. The best market outcome will not be achieved without a level playing field on the flexibility market.

Costs of a higher kW contract and higher kW max month when temporarily purchasing more
In the current tariff structure, users on the high and medium voltage grid, in addition to one or sometimes two other tariff carriers, are subject to the kW contract for charging the transmission tariff. The kW contract value is determined for a whole year on the basis of the statement of the consumer and/or the maximum capacity used in a year in kW. The maximum consumption of a user in a year is seen as the main cost driver of the high-voltage grid. The costs of the high and medium voltage grid are driven by the maximum capacity that a user purchases at any time of the year. The increase in kW contract value for an incidental peak is experienced by market parties as an obstacle to temporarily purchasing more, in periods when the electricity system could possibly benefit from an increase in use and there is sufficient available grid capacity.

Calculation methodologies
More in general, methodologies for establishing grid tariffs or taxes are usually based on annual figures (for instance methodologies for establishing the 600 hour tariff, kWmax and kW contract, emission requirements, or for estimating profitability as required by Treasury). As renewable sources and flexibility fluctuate on much shorter time spans such methodologies will need to be reconsidered. Remunerations would need to consider the extent to which consumers can be flexible, rather than constant, in their electricity consumption. Baseload must no longer be confused with net stability.

Box 4 Specific hurdles for Combined Heat and Power generation

Many industries make use of Combined Heat and Power generation. Several barriers hamper exploiting the flexibility potential held by CHP installations fully.

Efficiency requirement - Utilization of CHP is incentivized by exempting natural gas consumption from energy taxes if efficiency is higher than 30%. This efficiency requirement hampers exploiting the full flex potential of CHP installations. In addition, new e-boilers may in certain cases with existing CHP capacity and jeopardize this tax exemption.

Emission requirement – CHP installations must meet CO_2-emission standards. Offering flexible capacity however implies running at low loads temporarily. As a result, emission limits are exceeded. The strict emission requirements therefore hinder the maximum flex potential of CHP.

600 hours tariff requirement - Sites with CHPs often use the 600-hour scheme for the tariffs of network operators. If CHPs are operated more than 600 hours in order to provide flexibility, the applicable grid tariff will be higher. These additional costs must also be bridged in order to be able to "unleash profitable flex to the market".

5. Take action

Industrial flexibility is thus important for helping to improve supply security and to make or electricity supply more sustainable while safeguarding/maintaining a reliable and affordable system. Yet it is new to many companies. Promoting the introduction and upscaling of energy storage and demand response, needs to be assisted in several ways.

1. Industrial companies should be supported in developing a detailed **understanding of their flexibility potential**, including new options resulting from further electrification and alternative process designs. The focus has so far been mostly on options that are known. Insight into new options is useful for cost-effective energy management by companies in years to come. Subsidized company scans may encourage market parties to conduct such assessments. Insights into the deployment, potential and costs at the level of companies may furthermore inform estimates at the sector or cluster level. The economic viability of such technical solutions should simultaneously become better understood by government and industry representatives through an analysis of the **revenue models**. A combined analysis of technical feasibility and economic viability clarifies the viability of demand side response From July to September 2021 a short assignment commissioned by EZK was conducted to explore business cases for flexibility across the economy. However, more time is needed to fully grasp opportunities until 2030 for energy storage and demand side response in different industrial subsectors.The economic analysis should include electricity price levels required, CO_2 prices, network tariffs or other price incentives. Building on these insights, government can propose measures that may help improving business cases for industrial flexibility.
   - **Action**: A scheme needs to be set up to help industries identify their technical flexibility and the

earning potential of such flexibility. This requires insight into price levels for electricity, CO_2 prices and grid tariffs. The technical potential and value to be unlocked shall be clarified through individual company scans.

- **Action by**: RVO with help of EZK, industry, energy companies and TenneT
- **On agenda**: Uitvoeringsoverleg Industrie and Elektriciteit

2. Industry representatives, government and grid operators need to prioritize flexibility in the **national dialogue** on the energy transition in industry. The recently published Integrated Infrastructure Outlook 2030-2050, which is important for this dialogue, for instance barely takes into account the potential for industrial flexibility. While currently ample resources are spent on developing CCS and hydrogen, targeted efforts are needed now to decarbonize industrial processes and build a CO_2-free electricity system in which renewable energy production and flexible demand are complementary.
   - **Action**: Industrial flexibility must be placed explicitly on the agenda of both the Uitvoeringsoverleg Industrie and the Uitvoeringsoverleg Elektriciteit. In concrete terms, we propose that an action agenda be drawn up that focuses on barriers that now hold back the use of flexibility in industry. Flexibility should also become a fixed item on the agenda.
   - **Action by**: TenneT and VEMW, supported by NVDE and EZK
   - **On agenda**: Uitvoeringsoverleg Elektriciteit en Industrie
3. TenneT, government and industry representatives need to grasp how and to what extent industrial flexibility is necessary for **security of supply** towards 2030 and beyond. This requires insight into existing industrial flex capacity and in potentials at the level of companies and regional clusters. An annual survey set up by TenneT and/or for instance RVO could help to collect this information and feed it into future editions of the TenneT Monitor Security of Supply.
   - **Action**: The implications of a (lack of) industrial flexibility for supply security must be understood. This can be done by considering industrial flexibility in the annual Monitor Supply Security from TenneT.
   - **Action by**: TenneT and RVO
   - **On agenda**: Uitvoeringsoverleg Elektriciteit
4. Government must put flexibility of industrial electricity demand on the **national policy agenda**. Context and urgency of industrial flexibility as explained above need to be pointed out by the Ministry of EZK, and tangible measures for identifying and exploiting industrial flexibility potentials must be proposed, such as subsidized company scans to identify flex potentials, an electrification bonus or fiscal measures affecting prices for electricity and gas.
   - **Action:** Market parties attending the Uitvoeringsoverleg will develop proposals to advance implementation of flexibility across industries.
   - **Action by:** energy companies, industries and TenneT
   - **On agenda:** Uitvoeringsoverleg Elektriciteit en Industrie

5. The working group on large-scale consumption tariffs of Netbeheer Nederland has started a process to investigate obstacles in the current tariffs for large-scale consumers in a broad stakeholder dialogue. This may include barriers to industrial flexibility. If this investigation shows sufficient reason to adjust the tariff structure, the network operators will work towards an amendment proposal that can be submitted to the ACM.
    - **Action:** investigate obstacles in the current tariffs for large-scale consumers and possibly develop an amendment proposal for ACM
    - **Action by:** working group on large-scale consumption tariffs of Netbeheer Nederland including grid operators, producers, consumers
    - **On agenda:** Uitvoeringsoverleg Elektriciteit
6. TenneT and industrial representatives should map out the barriers incorporated in **product specifications** for the balancing markets to participate in one of these markets.
    - **Action:** barriers for industrial flexibility to participate in one of the flexibility markets should be mapped out and, to the extent possible be incorporated in product specifications for different flexibility products.
    - **Action by:** TenneT
    - **On agenda:** TenneT

Taking action is urgent. Decarbonising our energy system will require flexible demand to complement renewable energy sources, and Dutch industry not only is a large energy consumer, but also has the opportunity to contribute to such flexible demand. In the next few years, industries will need to decide on their decarbonisation pathways, and substantial investments in electrification are foreseen. Flexibility potentials that have not been examined cannot be capitalised on, leading to unnecessarily high energy costs.

6. Collaboration

To advance options for demand response and energy storage in industry, a range of parties will need to collaborate, including as a minimum

- The six industrial clusters that are each developing a Cluster Energy Strategy (CES) in close collaboration with the grid companies, which participates in the Infrastructure for a Sustainable Industry Program (PIDI).
- The Association for non-domestic energy and water consumers (VEMW) as an advocate for (bulk) consumers of energy in industry.
- FME, representative of the technology industry, notably its Energy Storage NL platform
- The Ministry of Economic Affairs and Climate, which is currently looking into options for CO_2-free flexibility.
- The Dutch Enterprise Agency (RVO) which implements financial support schemes for decarbonizing industry and the Dutch energy system.

- The TKI Energy & Industry (programming) and the Institute for Sustainable Process Technology ISPT (executive), which are responsible for part 8 (Electrification and radical innovation) in the Multi-Year Mission-Driven Innovation Program.
- Academia, including TUD and TUe, where research into Industrial Flexibility has started.
- TenneT, which recently initiated a Program Industrial Flexibility to better understand options and business cases and implications for supply security.

Tabel 1 Stakeholder roles for advancing industrial flexibility

	identify flex potentials	clarify / support business cases	engage in dialogue	clarify supply security effects
Clusters, NBNL CES team, PIDI	●	●	●	●
VEMW	●	●	●	
Energy Storage NL	●	●	●	
Ministerie EZK		●	●	●
RVO		●	●	
TKI Energie & Industrie / ISPT	●		●	
Academia (TUe/TUD..)	●		●	
TenneT	●	●	●	●

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