HyDelta

WP8 – Admixing

D8.5 – Mandatory blending of hydrogen: summary for policy makers

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Abbreviations

CCS	*Carbon Capture and Storage*
(EU) ETS	*(European) Emission Trading Scheme*
EU	*European Union*
GoO	*Guarantee of Origin*
OPEX	*Operational Expenses*
RED (II)	*Renewable Energy Directive*
RES(-E)	*Renewable Energy Source(s) (-Electric)*
RFNBO	*Renewable Fuel of Non-Biological Origin*
RPS	*Renewable Portfolio Standards*
SAF	*Sustainable Aviation Fuel(s)*
SMR	*Steam Methane Reforming*
TGC	*Tradable Green Certificates*

1. The context and relevance of mandatory blending

During the first decades of the energy transition much of the focus has been on the introduction of renewable energy sources such as wind and solar. This EU strategy has been successful so far, although the amount of subsidies supporting the built up of renewable capacity has been very significant, i.e. hundreds of billions of euro's since the year 2000 as a cumulative amount [1]. The result of this strategy has been that meanwhile some 38% of the electricity produced in the EU is green, i.e. RES-based. By contrast, something similar has not yet taken place with respect to the energy molecules. Some policy initiatives have been taken to introduce biobased gases in the natural gas system, but on a voluntary bases only. Also, mandatory blending has been introduced in part of the fuels for mobility, but in still relatively limited percentages. Despite such policy initiatives the percentage of the energy molecules that can be labelled 'green' so far remained limited to probably less than 5% only. Also, energy carriers that are used as feedstock in, for instance, the chemical industry, such as hydrogen and the derived products, so far have not been subject to any mandatory greening. As a result virtually all feedstock carriers are still 'grey', i.e. produced with a fossil footprint.

This difference in greening that has been implemented in the EU energy/feedstock system between electrons and molecules has recently contributed to the notion across the EU that greening the energy and feedstock molecules should be given serious attention. Without such greening it is impossible to get to a decarbonized economy by 2050. The pressure on decarbonizing the molecules is building up because energy molecules traditionally and worldwide have dominated the energy system: still some 80% of the energy system is based on molecules, and it seems likely that this percentage will come down – even in a completely green energy system – to around 50%. For technical and economic reasons most experts expect molecules to remain a significant part of any future energy system.

Turning the massive flows of fossil liquids and gases currently used as the backbone of our energy system into a system substantially based on green molecules both for energy and feedstock purposes, is probably by far the biggest challenge the energy transition is facing. Given the timeline of the EU energy transition – almost complete decarbonization by 2050 – this challenge implies a revolutionary turnover of much of the energy system in less than 30 years.

During the last 20 years a vivid discussion has taken place on the potential role of biomass as a source of green energy molecules. In fact, the mandatory blending scheme for fuels introduced by 2009 across the EU as a start to green mobility, was based on the expectation that there would be sufficient biomass available to gradually and stepwise turn the fossil fuels for mobility into green fuels. During the last decade, however, heavy discussions emerged on the risks of large-scale introduction of biomass to replace fossils. Arguments that would question such massive use of biomass have been that this would risk massive deforestation not only in Europe, but also elsewhere, and that it would crowd out biomass used for other, and better, purposes such as food, thereby raising food prices up to the point of enhancing poverty. This caused the high expectations of the role of biomass to replace fossils to be lowered significantly. It also meant that alternative options would need to be explored to replace fossil molecules by others. In this discussion much attention switched towards hydrogen as an alternative source of green molecules assuming hydrogen can eventually be produced without a carbon footprint.

In this spirit the EU turned relatively recently towards an active hydrogen strategy searching how to replace fossil molecules by hydrogen without a carbon footprint, and realising that such a strategy will need to be implemented soon in order to be sufficiently successful in time. Given the formidable size of the energy revolution it will involve, it is clear that this transition: will not occur just like that, will face serious lead times, and will need extensive and intelligent policies and measures to take place.

Also, the hydrogen strategy may sometimes be complex because it will gradually replace the fossil energy production system which as a consequence will have to be closed down. This may conflict with vested investment interests.

Theoretically the EU could choose to use a similar strategy as has been followed during the first decades of the energy transition when subsidies were used as the main instrument to get renewable energy capacity off the ground. To introduce hydrogen at a large scale in Europe, subsidies are most likely needed as well, especially to get the various technologies through the 'valley of death'. Moreover, clearly both CAPEX and OPEX subsidies will need to be provided to achieve the necessary scaling up and speeding up of carbon neutral hydrogen production capacities, although introducing OPEX subsidies for the production of green hydrogen as widely as has been implemented towards wind and solar to guarantee power prices to investors does not seem to be likely given the subsidy volumes it would require. Stimulating carbon neutral hydrogen supply is, however, not enough to get to mature hydrogen value chains. Launching demand is equally important. Here, the option of mandatory blending of hydrogen[1] into the current, predominantly fossil, gas system comes into the picture, because such mandatory blending will immediately get carbon neutral hydrogen demand off the ground.

Mandatory blending consists of prescribing that a *certain* percentage of the traditional fossil gases or fuels is replaced by carbon neutral alternatives via hydrogen, or derived products such as ammonia or methanol. Introducing such policies, although a logical next step in the energy transition of the EU, is a considerable challenge, because if such introduction is done not successful, it in fact may slow down the process of introducing hydrogen, and ultimately the energy transition itself up to the point that the 2050 mitigation targets turn out to become impossible to achieve. In other words, introducing strategies of mandatory blending needs to be done very carefully in order not the frustrate its own progress. In four deliverables (D8.1 [2], D8.2 [3], D8.3 [4] and D8.4 [5]) produced in a framework of the HyDelta 1 hydrogen research program the issue has been explored and the complexities one may face when introducing mandatory blending have been addressed. Below, we will systematically summarize the main challenges that are foreseen and have been assessed from various policy perspectives in this research.

2. The key challenges of mandatory blending

Introducing mandatory hydrogen blending schemes will anyhow require a good preparation in order not to be overwhelmed by hick-ups and pitfalls that have been insufficiently anticipated. In assessing the blending literature we encountered a number of fundamental challenges that seemed to characterize virtually all blending schemes that have been introduced in practice. A first challenge is to strike the right balance between the mandatory physical blending and virtual blending based on that. It seems to be important to coordinate this balance carefully in order to guarantee that the certificate trading practices from virtual blending are socially well accepted. A second challenge is whether or not different quota are specified upfront for energy carriers that have been produced with different technologies. Such differentiation may be introduced to support specific production technologies, but does assume that governments will be able to foresee which technologies will eventually be the clear winners in the market. Because that assumption is not always taken for granted, a technology neutrality position can equally well be defended. A third challenge, when introducing virtual trading and therefore certificate trading as an option, is to make the certificate system watertight and

[1] Other terminologies than mandatory blending schemes are: mandatory quota, quota obligations, binding quota targets, admixing schemes, renewable portfolio standards (RPS), or tradable green certificate schemes (TGCs).

completely reliable. This holds not only for the quality of the certificates themselves but also for the transparency and liquidity of the process of certificate trading. Without guarantees that the system is completely reliable, there are risks that the system will be perceived as having low integrity up to the point of introducing greenwashing. A fourth challenge is to somehow control the inherent volatility of certificate prices, especially during the stages of certificate markets to getting mature. Practice of volume-driven instruments such as mandatory blending have learned that prices, which are determined by the market interaction between supply and demand, may easily fluctuate strongly especially if supply and demand elasticities are low as is often the case in energy markets. A final challenge for policy makers may be to strike the right balance between using clean hydrogen flows that are generated domestically, against the option of using such flows that have been produced abroad and thus imported. The issue then can be if the blending scheme needs to contain incentives in favour of domestic production, or not.

In the following sections these five challenges will be discussed shortly; for a more detailed discussion the reader is referred to the HyDelta deliverables D8.1-D8.4.

2.1 Virtual vs physical blending

A fundamental conceptual issue with respect to blending is the distinction that can be made between physical blending on the one hand and virtual blending on the other hand. Physical blending speaks for itself; it literally means that carbon neutral hydrogen is admixed into the existing flows of fossil gases or liquids; virtual blending means that physical blending is not necessary, but that the blending obligation is fulfilled with the help of certificates that prove that carbon neutral hydrogen has been introduced into the energy system anywhere else.[2] It is important to understand that if a consuming party under a quota obligation wants to comply with certificates only (i.e. no physical consumption), this is only possible if other parties in the scheme will consume more than required, because otherwise there would be double counting or greenwashing. The option of compliance via virtual blending therefore can only work if a trading scheme of certificates functions properly, and if a certificate scheme has been designed that can guarantee that the certificates are backed up by true decarbonization activity.[3] This requires lots of rules and regulations but this is necessary for a scheme to be perceived by society as a reliable, watertight and secure. If it works, however, it could generate a number of advantages as compared to a scheme accepting physical blending only, because it potentially prevents technical issues of system adjustment to new gas specifications, and it contributes to the cost effectiveness of compliance, because blending will be concentrated there where it can be done most cost effectively.

A virtual blending scheme therefore is by definition the mirror image of a physical blending scheme. Virtual blending is impossible without physically introducing an equivalent volume of clean hydrogen anywhere into the gas grid (either blended, or purely), but physical blending is indeed possible without virtual blending. In the latter case, the scheme does not include certificate trading based on blending, which on the one hand makes it simpler because all complexities related to certificates can be left aside. The major backdrop, however, is that for a mandatory scheme target compliance should be book kept and that the scheme becomes less cost efficient if every party can comply physically only. That is why in actual practice most mandatory blending schemes are likely to be a combination of physical and virtual blending. An extreme case of a virtual and physical blending combination is when a specific

[2] See D8.1 [2] for a literature review on both physical and administrative/virtual blending, including its background information, challenges and potentials.
[3] See D8.2 [3] chapters 2.2.3, 3.2.3, 4.2.3, 5.2.3 and 6.1 for a more detailed description of issues with certification systems experienced in the past.

part of a current fossil energy system is completely replaced by a carbon neutral hydrogen system, whereas the surplus of certificates from that switch is used to completely decarbonize another part of the energy system.[4] For instance, all hydrogen transported towards a number of chemical plants is replaced by carbon neutral hydrogen, while the certificates from that switch are sold to owners of tank stations to comply with their obligation to green the fuels they are selling.

It is up to the policy regime if and to what extent a complete distinction between physical and virtual blending would be accepted. In practice, it will be most likely that schemes will be introduced allowing some mixture of physical and virtual blending. For instance, one could introduce a generic mandatory blending of the natural gas grid for general use while at the same time accepting that part of the blending will be fulfilled with the help of certificates. An interesting aspect of physical blending of multiple gases in the public grid is to what extent technical adjustments are needed to guarantee the safety of the grid as well as the appliances linked to that grid.[5,6] The latter is a complex issue especially because the grid safety in itself is already quite a challenge if different gas mixtures need to be transported through it. The challenge, however, becomes even bigger if all possible appliances using the gas also will maintain the required safety in use as the gas mix alters. In practice this may mean that if the hydrogen admixed to the natural gas surpasses some limits, costs to adjust the grid itself and the connected appliances to ensure safety levels may rise exponentially, or safety levels may be surpassed. This can be a reason to limit the accepted physical blending percentage to a predetermined maximum, e.g. 20%, and to continue more progressive blending policies by way of virtual blending only. Another point related to physical blending in the distribution grids is the measurement and billing of gas. Currently measurement is done by volume of gas. However hydrogen and natural gas differ in energy density per volume. The number of studies on the relation between physical blending percentages; blending volumes in relation to the fluctuating gas flow; the related gas system adjustment costs; and safety limits has remained limited so far, but more information on this is urgently needed to shed more light on the issue what the optimal mix between physical and virtual blending will need to be.

2.2 Quota differentiation

A specific design issue with respect to mandatory blending quota is whether a generic quota will be introduced leaving it to the market with what gas specifications the quota will be filled in, or instead a differentiated quota scheme in which specific production technologies of hydrogen are distinguished by the policy maker.[7] This issue typically relates to the fact that carbon neutral hydrogen can be produced with the help of different technologies. One option is the production of so-called green hydrogen where electrolysers are used to turn RES-based power into hydrogen; another option is the so-called blue hydrogen where mostly steam methane reforming is used to split natural gas into hydrogen and carbon and oxygen components, and whereby the carbon is stored usually underground. Other ways of producing carbon neutral is with the help of pyrolysis possibly combined with carbon capture and storage (CCS), or using nuclear power rather than RES-based power as an input. Policy makers can take the position of technology neutrality by arguing that through their quota specification the only thing they want to impose is a specific carbon mitigation impact, while leaving it to the market

[4] However, see also a detailed analysis on the risks and considerations as described in D8.1 Part II [2] subchapter 'Market participants with a quota obligation' within section 3.3 and 4.3.
[5] See D8.1 Part I [2] chapter 2, 3 and 4 for an overview of the technical and safety aspects of physical blending.
[6] In other HyDelta WPs the topics of 'hydrogen safety' (WP1A, WP1E, WP2 and WP3) and 'hydrogen in the gas grid' (WP1B, WP1C, WP1D, WP1F and WP4) are investigated in detail as well.
[7] See D8.1 Part II [2] sections 3.2 and 3.3, D8.3 [4] section 2.2 on whether or not to include certain technologies in the scheme, and D8.4 [5] sections 3.5, 4.6-4.8 and 5 on how differentiation can be implemented and what the pros and cons of the various options are (incl. no differentiation).

to determine how they can produce the hydrogen that satisfies such criterion in the most cost-effective manner. Within this view, there could still be chosen to value certificates differently in the quota related to the emissions of the production technology (e.g. for technologies using carbon capture, still not 100% of emissions can be captured). The technology neutral view will likely generate the most overall cost effective compliance regime. An alternative perspective for policy makers can be that it is deemed necessary to steer the technology in order to make sure that some specific technologies have a good chance to develop and not to be locked in, or, instead, remain limited in scope. The latter perspective will ask for a differentiated quota that, for instance, prescribes that *x* % should be fulfilled with the help of technology A, and *y* % with technology B, etc. Proponents of technology neutrality generally tend to argue that the market, not the government, knows best how to mitigate in a most cost effective way. Proponents of the alternative view, namely in favour of quota differentiation, argue that without further specification some promising green technologies will be locked out because of the time- and scale-dependence of technology development favouring the early cost-effective ones at the cost of other technologies.

2.3 Certificate market design

To develop a system of certificates that can be used for hydrogen blending quota compliance, as well as a trading market for such certificates, is a delicate issue. Experiences have learned that certificate trading may easily meet some public suspicion of representing something that may be easily abused by fraud, lack of control, or greenwashing:[8] Who guarantees that the certificate genuinely represents mitigation and that trade is not manipulated by a monopolized trading scheme? Governments therefore have to carefully see to it that the certificate and its trading scheme are reliable and carefully controlled, but also that the certificate market is functioning in a transparent manner. To achieve this requires institutions to carry out the checks and balances and the organisation of rules and regulations such that they guarantee the quality of the system. Testing how a system functions in practice will require time and money, so that the risk can emerge that it could slow down actual blending practices to quickly mature. Sellers of the certificates generally are reluctant to comply with too much paperwork and to deal with related costs; traders typically want to generate acceptable trading margins and do not want to face all kind of restrictions to promote market transparency and liquidity.[9] The challenge therefore is to speed up market maturity fast enough for blending to become a successful strategy, while not frustrating private stakeholders to step in. Pilots are helpful tools in trying to find the right balance between good systems but at the same time systems that develop smoothly in practice.

2.4 Volatility of certificate prices

The largest challenge from an economic perspective of any mandatory blending scheme of any substance is to create the right convincing and effective incentives to potential investors, such that they will actually raise the volumes of hydrogen supplied. The difficulty of blending quota is that they represent essentially a volume-based incentive which means that the volume is controlled by policy, but that the price is left to the market forces.[10] In other words, upfront it is not known how hydrogen certificate prices will behave. Model simulations are helpful in trying to predict future certificate prices, but experiences from e.g. the EU ETS, another volume driven scheme, has learned that it is very hard to make predictions that from hindsight turn out to be quite right. Most investors in new hydrogen production technology might want to reduce risks as much as possible. Uncertainty about future

[8] See, D8.1 Part II [2] chapter 6.3 and 6.4, and, again, D8.2 [3] chapters 2.2.3, 3.2.3, 4.2.3, 5.2.3 and 6.1.
[9] For more detailed information about these dilemma's, see D8.4 [5] chapters 3.4, 4.1 and 5.
[10] See D8.1 Part II [2] chapter 3.1, D8.2 [3] whole document, summary in chapter 6.7 and D8.4 [5] chapter 2 for the main differences between price-based and volume-based schemes.

certificate prices and a fortiori uncertainty about future certificate price volatility act as a disincentive to invest in hydrogen production capacity at all. For the policy makers in setting up mandatory blending quota, the challenge therefore is to somehow provide upfront (some) certainty on the likely price trend of certificates as well as the potential volatility ranges.[11] This is inherently problematic because it implies that policy makers somehow have to intervene in the market process which introduces risks of intervention costs inviting speculation and introducing regulatory uncertainties. Yet, this challenge will need to be covered if mandatory blending is going to be part of the massive future policy mix in the spirit of the energy transition.

The experience with various volume driven policy instruments implemented in the past, including those implemented in the energy system, have learned that it is not easy to steer certificate prices and to reduce their volatility in a straightforward manner without introducing new risks either for the policy makers or for the market. It seems that a balanced system of minimum and maximum prices for certificates, some quota allocation flexibility, the introduction of some market stability reserve facility and possibly some kind of buffer fund, are all ingredients of such an indispensable mix to try to stabilize the certificate market.[12] A sufficient incentive for potential investors in hydrogen production capacity obviously can often not be achieved by hydrogen and certificate price expectations only, but is likely to also require funding and subsidies especially for pioneering investors and for dealing with the so called 'valley of death'.[13]

2.5 Import of hydrogen (related carriers)

If blending is to be seriously picked up as one of the strategic policy measures to get to the massive volumes of green energy molecules that are needed to achieve the 2050 mitigation target of the EU, and if much of this blending ultimately will be based on green hydrogen, i.e. produced with the help of renewable energy, it is clear that enormous amounts of green power will be needed as well as very considerable electrolyser capacities to turn that electrons into green hydrogen. Renewable electricity produced in the EU will, however, also be needed for other purposes.[14] It will be needed where electricity is used in industry, the private sector, the built environment, for datacentres and so on, next to being needed as a source of green hydrogen. Rough estimates of the future need for green power across the EU so far seem to suggest that the EU itself will not be able to generate enough of it to fulfil all needs including the massive need for green hydrogen. This means that just as in the past, also in the future part of the energy molecules will need to be imported to allow for a green energy future system of the EU. This puts blending also in the perspective of the imports of carbon neutral hydrogen that most likely is going to be part of the European energy reality of the future. The issue therefore becomes if hydrogen imported from outside the EU can be included for commitment of EU blending schemes.[15] So far little attention has been given in the literature to this option, but a priori it seems

[11] See D8.4 [5] chapter 3.3 for a detailed analysis of this issue.
[12] See D8.4 [5] chapter 4.2, 4.3, 4.4, 4.5 and 5 for a detailed analysis of the potential measures.
[13] Of course accumulation of support should be prevented (see also EU Guidelines on State aid for environmental protection and energy (2014/C 200/01) [11], chapter 3.3 number 114; new guidelines are expected to be implemented in January 2022). See D8.1 Part II [2] subchapter of 4.1 'Anti-cumulation' for an explanation of this topic. See D8.1 Part II [2] chapter 5, D8.2 [3] chapter 6.3, D8.3 [4] chapter 3.3 and D8.4 [5] 4.10 on how subsidies can be used before, and/or in the initial phase, to help starting up mandatory quota.
[14] See D8.1 Part II [2] subchapter 3.2 'Temporal correlation' and 'Additionality of installations' and D8.4 [5] chapter 3.6 for a brief analysis of the impact of potential additionality criteria, and D8.2 [3] for the impact of the fuel blending obligation crowding out biomass resources in the past.
[15] For dilemma's on imports, internationalization of certificate markets and leakage of support, see: D8.1 Part II [2] subchapter 3.2 'Geographical criteria for production', and D8.2 [3] chapter 6.2. For the required aspects to trade certificates internationally (and intercontinentally), see D8.1 Part II [2] subchapter 4.1 'REDII' and 4.3, and Article 19 of RED-II [9] [6].

questionable why imported hydrogen could somehow not be accepted for compliance. To give clear answers, this point will, however, need to be further sorted out by future research. To the extent that imported hydrogen can be used for blending purposes, it will also need to be researched how this will work out in incentives for investors to develop EU hydrogen production capacities, etc.

3. The introduction of mandatory hydrogen blending schemes

The ultimate introduction of hydrogen as the main new carbon neutral feedstock and energy carrier with the help of mandatory blending has implications for the industry and end users that are far-reaching, so any introduction of such policies will need to be prepared very carefully. For all mandatory blending schemes therefore pilots will be needed to assess how such schemes work out in practice.[16] Obviously a lot can be learned from comparable mandatory blending quota schemes that have been introduced in the past in other sectors,[17] but nothing can replace real-life testing of to be introduced policy measures simply because the market conditions for all market segments are different and make the functioning of policy instruments unique. That is why mandatory blending pilots are crucial in dealing with all kinds of obstacles, hick-ups and behavioural complexities that may show up in actual practice.

In designing pilots one therefore has to carefully select quota schemes such that pilots have best chances of being realistic, effective and ultimately successful. Also, pilots need to be prepared well, because it takes time for the various stakeholders involved to prepare themselves for the new opportunities of replacing fossils by carbon neutral alternatives.

A first pilot: Industrial. Our analysis suggests that mandatory blending quota pilots can relatively easily be initiated for those cases in which the number of stakeholders is relatively small, and where a tradition of directly using hydrogen does exist, i.e. in the chemical industry. So, one could as a start and in close communication with the main industrial and other stakeholders investigate how an increasing percentage of hydrogen,[18] currently still grey, can stepwise be replaced by carbon neutral hydrogen, while assuring that such volumes can indeed be delivered and that the transport system to do so is in place. Such a pilot is not simple – and may in fact be preceded by a pilot 'on paper' – because the complete value chain of hydrogen needs to be sufficiently developed and in the same timeframe. However, if it works for a number of showcases, it will show the rest of the industry that it is indeed possible and doable to green the hydrogen typically used as a feedstock for chemical products. The mandatory quota pilot will need to be made sufficiently attractive for the first firms to join and will also need to be closely monitored. Thereby, the effect of the pilot on the public opinion should not be underestimated, both a successful and failing result can frame the public perception of the instrument's effectiveness.

A second pilot: Fuels. Another option of what could develop into early successful experiments are pilots in which already existing mandatory blending schemes are extended to include hydrogen. The only mandatory schemes currently functioning in the EU are based on RED II and prescribe that fuels for mobility will need to be greened up to a certain percentage and in one way or another. Introducing carbon neutral hydrogen or derived products into the fuel mix, next to biobased fuels, on a mandatory basis could be a way to extend the greening of fuels without fundamentally altering the existing incentive scheme.[19] That is why it is proposed to introduce mandatory blending pilots in mobility by

[16] In D8.3 [4] specific attention is paid to designs of pilots to introduce mandatory blending.
[17] In D8.2 [3] a general assessment is done of two mandatory and two voluntary schemes. In D8.4 [5] the economic aspects of mandatory blending schemes are analysed based on experiences in the past.
[18] See D8.3 [4] section 2.3 and 3.3 for a more detailed description of this scheme and pilot.
[19] See D8.3 [4] section 2.5 and 3.5 for a more detailed description of this scheme and pilot.

extending the fuel mix by including hydrogen under the 'advanced' sub quota, but this does not guarantee hydrogen will come off the ground. Therefore, a stronger option is to create a dedicated hydrogen sub quota including both hydrogen delivered purely and via the so called 'refinery route'.

A third pilot: Generic gas mix. A final pilot option with good chances of success relates to locally switch parts of the distribution grid to 100% hydrogen, and gradually add small percentages of hydrogen to the natural gas mix where this can be an in-between step towards full conversion.[20] Such pilots obviously will be somewhat more delicate than the ones mentioned before, because the number of end users and their appliances will be much larger, and the volumes of hydrogen that need to be fed into the grid possibly too. The advantage of such a pilot, however, may also be that it shows that greening gas for public use is possible.

The three suggested pilots mentioned above all have different characteristics as has also been summarized schematically in the table below.

Proposed schemes			
Proposed scheme	**1: Industrial**	**2: Fuels**	**3: Generic gas mix**
Market sectors	Chemical industry	Mobility	Public gas delivery
Obligated parties	End-user: industries using hydrogen	Suppliers: fuel suppliers delivering sufficiently large volumes[21]	Suppliers: gas suppliers
Base of the quota	% of total H2 used in processes	% of total taxed fuel volumes (GJ) sold	% of total gas delivered
Accepted quota energy carriers	• Renewable H2 • (Low-carbon H2)	• Renewable H2 • Currently accepted renewable fuels	• Renewable H2 • (Biomethane) • (Synthetic methane)
Proposed pilots for schemes			
Scheme	**1: Industrial**	**2: Fuels**	**3: Gases**
Type of pilot	(Virtual) pilot	Pilot by adapting existing regulations	Pilot in specific region
Main challenges / points of attention	• What industries/processes included? • How/if to include import? • Speed of quota size adjustment	• Hydrogen in separate quota or not • Quota compatibile with demand • Which certificates can be used?[22]	• Safety and grid integrity • Testing local grid conversion • Social aspects incl. safety of appliances
Indicative year of pilot finalization and introduction full scheme	2026	2022*/2025	2028

Note: For an extensive description of the detailed characteristics of the proposed pilot schemes, see D8.3 'Pilots for introducing hydrogen blending quota' [4].

[20] See D8.3 [4] section 2.4 and 3.4 for a more detailed description of this scheme and pilot.
[21] E.g. similar to existing fuel blending obligation: >500.000 litres, kg or Nm3 of fuel annually.
[22] This point also relates to a discussion in the Netherlands on whether certificates from refinery processes can be used for fuel blending purposes.

In fact, the above three examples of typical first candidates for pilot options do match with some recent proposals that have been made by the European Commission and some national governments to introduce mandatory blending schemes. More specifically, the following blending measures are currently considered/implemented:

- Proposed amendment of RED II (2021/0218) [6], article 22a:
  ''Member States shall ensure that the contribution of renewable fuels of non-biological origin used for energy and non-energy purposes shall be 50% of the hydrogen used for final energy and non-energy purposes in industry by 2030.'' (excluding *''hydrogen used as intermediate products for the production of conventional transport fuels.''*)
- Proposed amendment of RED II (2021/0218) [6], article 25b:
  A sub-target for RFNBOs used for transport is introduced: *"…, and the share of renewable fuels of non-biological origin is at least 2.6% in 2030."*
- Proposed amendment of ReFuel EU (2021/0205) [7], article 4 and annex I:
  "Aviation fuel suppliers shall ensure that all aviation fuel made available to aircraft operators at each Union airport contains a minimum share of sustainable aviation fuel (SAF), including a minimum share of synthetic aviation fuel in accordance with the values and dates of application set out in Annex I." (*"From 1 January 2030, a minimum share of 5% of SAF, of which a minimum share of 0.7% of synthetic aviation fuels."*)
- Proposal amendment of the gas markets and hydrogen regulation (2021/0424) [8], article 20.1:
  ''Transmission system operators shall accept gas flows with a hydrogen content of up to 5% by the volume at interconnection points between Union Member States in the natural gas system from 1 October 2025, subject to the procedure described in Article 19 of this Regulation.''
- Revised (as of January 2022) Dutch national blending obligation of transport fuels based on RED II (2018/2001) [9] by including Renewable Fuels of Non-Biological Origin (RFNBO) under the 'advanced renewable fuel entity' category [10]. So legally introducing the proposed fuel pilot is already possible.

Considering the above analysis, it seems advisable for the Netherlands' authorities to set-up the suggested pilots at short notice, and to prepare for a timely hydrogen blending regime compatible with the ambitions to develop a mature hydrogen system as part of the energy transition and in the spirit of the 2030 and 2050 national and European mitigation targets.

Overview of deliverables

D8.1 'Admixing literature review'

This deliverable provides a state of the art literature overview of both physical and administrative blending. In Part I an overview of the technical, safety, legislative and economical aspects of physical admixing is given. Part II provides an overview of the background, design choices, the related policy framework and implementation aspects of administrative admixing.

D8.2 'Assessment Admixing Schemes'

This deliverable assesses two voluntary (the Dutch RES-E GoO's by CertiQ and Dutch green gas GoO's by Vertogas) and two mandatory (the Dutch fuel blending obligation and the Norwegian-Swedish electricity quota) admixing schemes based on their general, legislative, economic and environmental characteristics in order to conclude generic lessons that can be taken into account for schemes related to hydrogen.

D8.3 'Pilots for introducing hydrogen blending quota'

This deliverable is an explorative study based on interviews and literature how the first steps towards mandatory blending can be taken via pilots. The study developed suggestions for three type of blending schemes that can be implemented separately or next to each other. For each scheme, concrete actions for pilots are described, which can be started tomorrow, if there is political willingness to move towards mandatory blending schemes.

D8.4 'Economic aspects of Mandatory Hydrogen Blending Quota Schemes'

Based on literature and experiences with quota obligations in the past, potential adverse developments and mitigation measures from an economic perspective are analysed. The deliverable mainly focusses on issues related to the early stages of certificate markets developing towards maturity, and provides insights in the key dilemma's that should be dealt with very carefully.

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