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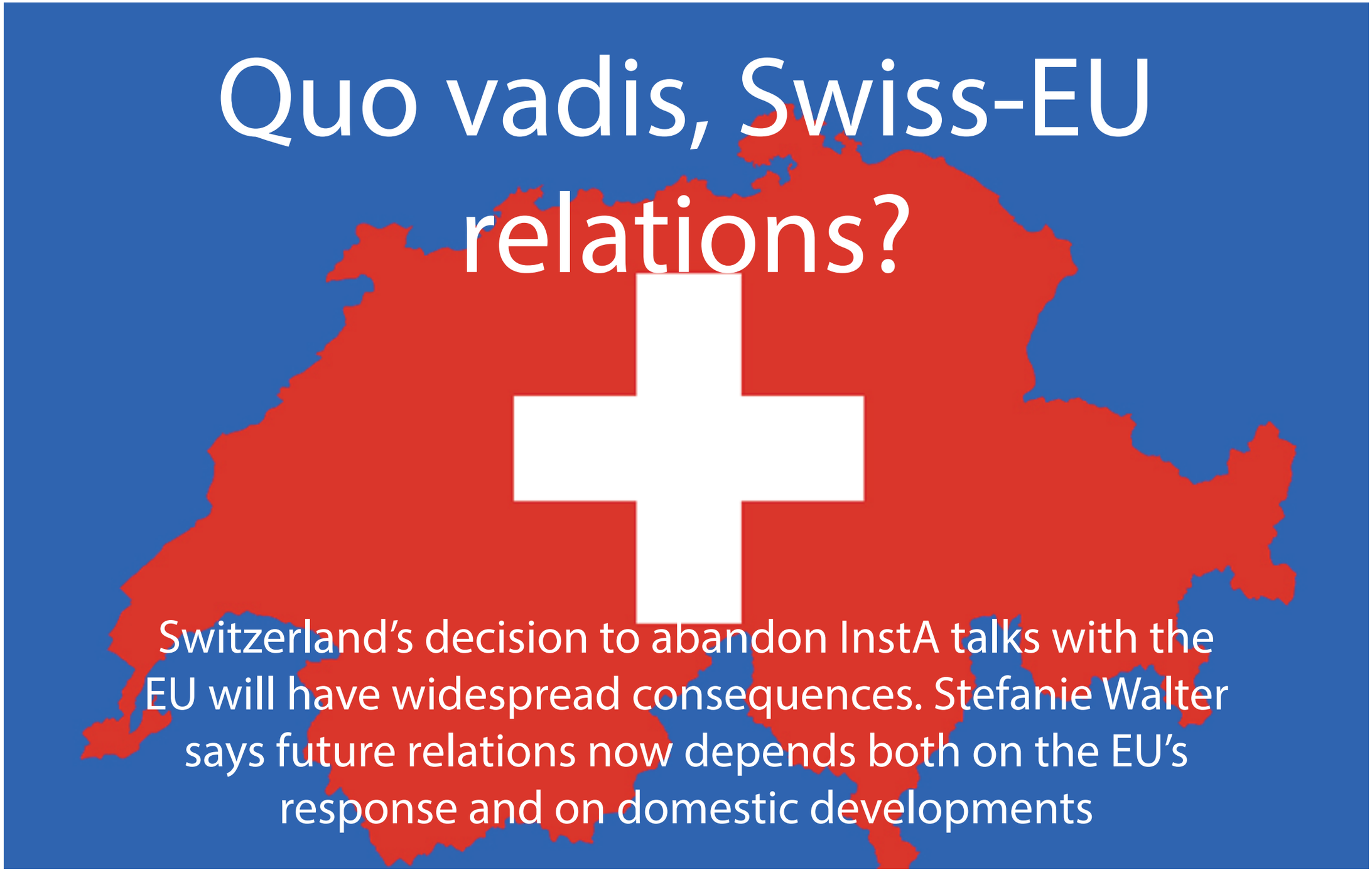

Switzerland's decision to abandon InstA talks with the EU will have widespread consequences. Stefanie Walter says future relations now depends both on the EU's response and on domestic developments

Switzerland and the European Union have a close and unique relationship, but it is a relationship that hangs in the balance after the Swiss government decided on 26 May to abandon negotiations on a so-called institutional framework agreement (InstA) with the EU. What is the agreement, why did the Swiss reject it, and where do relations go from here?

What is the institutional framework agreement?

In 1992, Swiss voters rejected European Economic Area membership. Subsequently, Switzerland and the EU created a tight web of over 120 bilateral treaties that allow for close cooperation on issues as diverse as market access, research cooperation and free movement.

While close, Swiss-EU bilateral relations are therefore complicated, not least because the multiple treaties need to be updated continuously as EU law evolves. To put the relationship on a more institutionalised footing, Switzerland and the EU in 2014 started negotiations on a broader institutional framework agreement.

The institutional framework agreement's goals were in particular to allow for easier updating of the bilateral market-access agreements and to provide a dispute settlement mechanism for any conflicts over the application and interpretation of the bilateral agreements. The objective of the institutional framework agreement was thus to consolidate and further develop the bilateral path taken by Swiss-EU relations.

Why did the Swiss side abandon the agreement?

The InstA has been contested in Swiss politics since the start of negotiations but became more politicised in 2019, when the Swiss government launched a domestic consultation on the text of the framework agreement negotiated with the EU (and which the EU at that time considered a finalised agreement).

In those consultations, three issues of contention emerged: guaranteed protection for Switzerland's traditionally high wages, state aid rules which created problems for the Swiss cantons, and the question of whether to accept the EU citizens' rights directive (2004/38/EC) and give EU immigrants access to Swiss welfare.

After further negotiations to try and resolve these issues, the Swiss government decided at the end of May that these they could not be resolved and abandoned negotiations altogether.

It will take a few months for the dust to settle and for the contours of the new Swiss-EU politics to emerge

Critics of this decision have pointed out that these three issues weren't insurmountable. But what made them politically problematic was that they split up the traditional pro-EU alliance in Switzerland. While the left has traditionally supported closer relations with the EU, the wage protection issue alienated trade unions who adamantly opposed the framework agreement.

This new opposition emerged next to the staunch, longstanding resistance from the right who fundamentally opposed the InstA from the start (especially any role for the ECJ in the dispute settlement mechanism) as well as growing criticism from business, who have traditionally supported bilateral cooperation with the EU.

Although public opinion polls have repeatedly shown a majority of voters support the InstA, the widespread criticism from both left and right made it increasingly difficult for the government to win a referendum on the framework agreement.

However, the fundamental reasons for the failure of the InstA negotiations go deeper. They are rooted in a strong Swiss unease about giving up sovereignty in a direct democracy in which voters are used to being given the final decision on issues as diverse as tax reform and the dehorning of cows, as much as on international treaties.

They are also rooted in a strong preference for bilateral relations to remain as they are today. Support for the bilateral treaties is exceptionally strong in Switzerland.

In a survey from February 2021, two thirds of respondents said that the bilateral treaties were very or somewhat positive, compared with only 16% who viewed them somewhat or very negatively. For many Swiss, the status quo is the ideal scenario for Swiss-EU relations.

Where are Swiss-EU relations headed?

Against this backdrop, it is not surprising that the Swiss government wants to consolidate and expand existing relations on a bilateral, case-by-case basis.

The government's immediate strategy consists of three elements: first, it will try to convince the Swiss parliament to approve the payment of the 'cohesion billion', money intended for cohesion measures in central Europe that was put on hold in 2019 when the EU declined to grant the stock market equivalence.

Second, it will go over all areas covered by the bilateral treaties to unilaterally update and align domestic legislation with EU standards where no domestic opposition exists. Third, it plans to 'engage in a political dialogue with the EU'.

Whether these measures will safeguard the status quo is uncertain. The EU has said that it is unwilling to update any existing agreements or conclude new ones until a framework agreement is in place. For Switzerland this is problematic because the status quo can only be maintained if both parties pursue this path.

If the EU follows through on its threat of refusing to update existing agreements, then the status quo of bilateral relations will slowly erode. In the short to medium term this means new certification hurdles for the medtech and machinery industries, reduced electricity security and a relegation of Swiss researchers to third-country status in Horizon Europe. In the long run, Swiss-EU cooperation could fall far below current levels.

While proponents of the InstA in Switzerland warn against this scenario, the dominant view among Eurosceptics, and it seems the government, is that this is an empty threat. President Guy Parmelin argued in a newspaper interview that *"the EU would damage itself by torpedoing trade relations with one of its most important trading partners."*

Many believe that the EU is bluffing because it benefits equally from close relations with Switzerland. Commenting on the government's decision, Daniel Lampart, chief economist of the Swiss trade union federation claimed 'the EU Commission would be stupid' to put good and regulated economic relations with Switzerland at risk.

InstA sceptics also point to the 1992 experience, where despite concerns of a deterioration of Swiss-EU relations, the rejection of EEA membership ultimately resulted in a favourable and tailor-made agreement with Switzerland. Thus, there is a widespread expectation Switzerland will be able to continue on its bilateral path with the EU.

Meanwhile, the government's decision has led to considerable domestic debate. Swiss-EU relations has turned into a cross-cutting cleavage with several key parties, most notably the liberal democrats and the social democrats, torn between a Europhile and a Eurosceptic camp.

Unsurprisingly, reactions have varied widely: views are divided on whether Switzerland should pay into EU Cohesion Funds, on the extent to which a substantial updating of domestic legislation is possible and on the merits of a new political dialogue.

More generally, there has been a range of proposals of where to go from here. Some argue that the decision to abandon negotiations was not the governments but parliament's prerogative.

Indeed, a motion is pending in parliament urging the government to continue negotiations (the government acted before the motion could be voted on). But it is unclear whether the government's decision could and would be overturned by parliament. Others have proposed collecting signatures for a popular initiative that would force the government to reengage with the EU.

Some have gone further, arguing that Switzerland now needs a fundamental discussion about its relationship with the EU, including EU accession (an option that is deeply unpopular among Swiss voters) or EEA membership. On the conservative side of the political spectrum, there is a push for domestic reforms and more deregulation to offset the loss of EU market access with a more competitive Swiss business environment.

What future Swiss-EU relations will look like will depend both on the EU's response and on domestic developments. A non-accommodating EU response may highlight the risks associated with an erosion of the bilateral treaties, but it may also harden feelings towards an EU that is already seen much more negatively in Switzerland than in EU countries.

Domestically, new alliances may form, and the two main parties that are not represented in Switzerland's consensus government, the Greens and the pro-EU Green Liberals, may benefit politically. But the move could also strengthen Eurosceptics, most notably the Swiss People's Party. It will take a few months for the dust to settle and for the contours of the new Swiss-EU politics to emerge. ■

Stefanie Walter is a Non-Resident Fellow at Bruegel. She is also a Professor for International Relations and Political Economy at the Department of Political Science at the University of Zurich and Director of the Center for International and Comparative Studies

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The Dutch elections and 'populism'

Fleur de Beaufort and Patrick van Schie interpret the results of the Dutch elections, and consider the growth in the support for the alternative 'populist' parties

The background to the elections in the Netherlands

In March 2021 the scheduled elections were held for the Second Chamber, which is the more important of the two chambers comprising the Dutch parliament. As many as 37 parties sought a seat in the new Second Chamber. The elections were remarkable for various reasons and the run-up to them proceeded more messily than ever before.

On the left, where three political parties – the Partij van de Arbeid [Labour Party] (PvdA), GroenLinks [Green-Left Party], and the Socialistische Partij [Socialist Party] have been talking in vain about combining their forces for many years now, they again beat about the bush as is customary in relation to the contentious issue of 'greater cooperation'. On the right, conflicts ensued in the weeks preceding the elections, which resulted in splits and the birth of new competitors.

In the meantime, the existing government coalition of four centre-right and centre-left parties (the third cabinet of Prime Minister Mark Rutte) fell on 15 January in the wake of a social allowance affair which saw the Tax and Customs Administration office wrongly accuse and prosecute the recipients of childcare allowances as frauds over a lengthy period of time.

The fall of the Rutte III government was accompanied by the demise of the odd key political player and the social democrats were urgently compelled to seek a new leading candidate (because their current one had been responsible in his capacity as a minister in the previous government), while others explicitly secured the ongoing support of their rank and file, and remained.

Even the Christian democrats changed their leading candidate during the contest due to circumstances. At the outset the media sought to elicit statements from the leading candidates as to their potential coalition partners – and apparently more interestingly – their exclusion of specific parties.

In particular, this had already been the fate of the explicit right-wing flank on more than one occasion, while extreme left-wing viewpoints invariably went unchallenged.

At a more practical level, the elections also proceeded differently from what was customary. As a result of the coronavirus crisis, it had been decided to stagger the elections over three days to ensure that the polling stations would not be excessively busy.

... there is a good chance that a Rutte IV government will emerge, because it is impossible to form a stable government without the VVD

In addition, those voters who were older than 70 years of age had the option of casting a postal vote. Nevertheless, many failed to observe the procedure properly, with the result that even then their vote was declared invalid.

It was reported that some 65,000 votes (of the total of 10,462,677 ballots cast) were not counted for the purposes of the final outcome. In spite of what were extraordinary circumstances, the turnout of 78.7% could be termed 'average' by Dutch standards.

The results interpreted

What is of course more interesting is to examine a number of striking aspects of the election results. First of all, 17 parties managed to obtain a sufficient number of votes to secure a seat in the Second Chamber, which comprises a total of 150 seats.

This meant that a post-war record was achieved in terms of the number of parties represented. This large number is partly due to the fact that the Netherlands has one of the purest systems of proportional representation in the world with merely one seat in the Lower House (representing 0.67% of the votes cast) serving as an electoral threshold[1]. As such, it is relatively simple for a new party to gain access to the Second Chamber.

Partly as a result of this, the trend toward so-called single-issue parties gaining access to parliament is persisting. In 2006 the Netherlands was the first European country in which a political party focusing on animal welfare managed to secure a seat in parliament (Partij voor de Dieren).

Since then parties which specifically focus on the elderly (50PLUS)[2], rural interests (BoerBurgerBeweging), the promotion of a federal Europe (VOLT), and anti-discrimination (BIJ1) have come to be represented in the Second Chamber. In a number of cases newcomers are actually breakaways from existing parties, such as JA21, whose

founders turned their backs on their existing party, Forum voor Democratie [Forum for Democracy], following internal division.

The 'traditional' major currents of social and Christian democracy have been exhibiting a decline in their number of seats for years now, a trend which is also occurring at the international level[3]. Between 1956 and 1998 the social democrats (PvdA) usually won in excess of 40 seats, with peaks of more than 50 and the odd decline to 37 seats.

In the last two elections they have failed to win more than nine seats. In the case of the Christian democrats (the CDA [Christian Democratic Party]), which always achieved an absolute majority between 1922 and 1967, the decline initially began somewhat earlier with a provisional trough of 29 seats in 1998.

A brief revival featuring scores in excess of 40 seats was followed by a drop to a low point of 13 seats in 2012, and the party failed to advance further than 15 seats in 2021. A survey of voters has also revealed that these traditional parties have to contend with supporters who are ageing the most[4].

What is also remarkable is that the left has also failed to emerge as the largest presence in any single Dutch municipality. Even the last left-wing bastions, such as north-east Groningen (in the extreme north-east of the Netherlands) changed their colour to dark blue (VVD) [People's Party for Freedom and Democracy] or light green (D66 [Democrats 66] in 2021.

The Christian democrats, which were still in the majority in most municipalities in 2002, managed to retain their relative majority in several rural municipalities, especially in north-east Friesland and the Twente region (in the north and east of the country respectively), although they were forced to acknowledge the VVD as their superior in

other municipalities. The original social and Christian democrat predominance in the large cities and the north and the Catholic south respectively has dissipated in its entirety.

This is because the parties designated liberal (the VVD and D66) together obtained more than 58 seats, although the question remains as to whether this may really be celebrated as a genuine victory of liberalism. The victory of the right-wing liberal VVD is predominantly due to the persistent popularity of Prime Minister Mark Rutte as a crisis manager.

As such, the party largely centred its campaign on the person of Rutte in the absence of any explicit liberal message. In addition, Rutte headed a government which has pursued a policy that was hardly liberal in that it imposed strict restrictions on liberty during the coronavirus pandemic.

Moreover, the fall of the government in January this year seems to have failed to yield any grounds for a reduction of Rutte's popularity. While it is true that D66 is usually viewed as liberal in international terms, and profiles itself using the vague adjective, 'progressive', it has adopted few liberal positions.

For instance, this party took the initiative to introduce legislation on organ donation which conflicts with the constitutional right to the inviolability of the individual's own body, and it opts for more state intervention with persistent frequency.

In addition, during the last elections most voters turned their backs on the traditional left in favour of D66 as a 'left-wing alternative'. This too occasions doubt about the concept of a 'liberal victory'.

More to the left the traditional left-wing parties together failed to advance further than 26 seats. If one adds the minor, left-wing, single-issue parties of PvdD, VOLT and BIJ1, the left has failed to advance further than 36 seats.

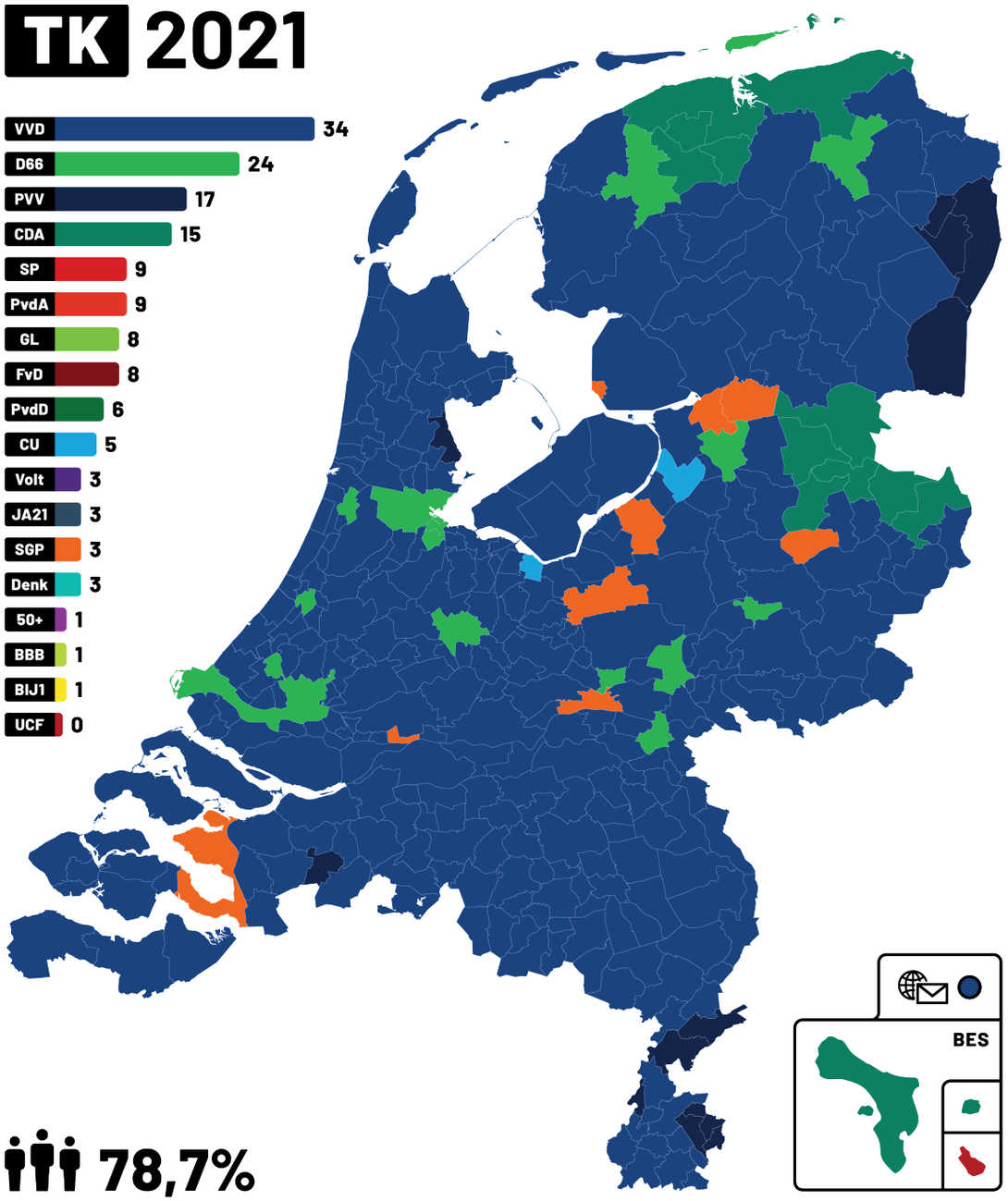
As such, the left wing in the Dutch parliament is smaller than ever, not even managing a quarter of all of the seats. This outcome is even more striking in view of the allegedly 'neo-liberal' yoke that is frequently cited and under which the country is said to be suffering.

It is precisely on the right that a collection of parties is growing – the Partij voor de Vrijheid [Freedom Party] (PVV), Forum voor Democratie (FvD)[5], JA21, Staatkundig Gereformeerde Partij [Reformed Political Party] (SGP) – which is good for 31 seats and, as such, is larger than the traditional left.

Most of these parties are tagged as 'populist', a description which is then eagerly applied in the foreign media. However, this is misleading in many respects.

'Populism' on the explicit right?

In order to ascertain whether there is any question of 'populism' amongst these parties, one first needs to determine what it entails. This is not the place to proceed with a discussion of the matter, although the aspects which are attributed to it and are frequently cited are (a) playing up to dissatisfied voters, (b) presenting matters as though such dissatisfied voters comprise the real people whom the 'elite' no longer serves but cheats, (c) a strong leader (or this is how the party leader is at any rate presented) who would do everything differently if they were to seize power, and (d) an appeal to and/or ties with a body of thought sourced from a 'brown' or 'black' past.



The first three aspects are mainly sourced from the relevant academic literature[6], while the fourth aspect is frequently cited in left-wing circles in order to align them with a questionable tendency. In this respect we would merely like to note that the first two aspects almost always apply in the case of new political movements or parties.

All of the established parties or their predecessors once started out from dissatisfaction (whether justified or not) with matters which the dominant political regime neglected or mismanaged in the eyes of the newcomers.

In this sense the social and Christian democrats, the parties which are now on the wane, were the 'populists' of their time more than a century ago, even though they developed an ideology based on their dissatisfaction.

If we examine the above-mentioned parties on the right in the Netherlands in the light of these criteria, one must immediately treat the SGP as an exception. Established in 1918, the SGP is now the oldest political

party in the Netherlands. While it is true that the three traditional tendencies of liberalism, and Christian and social democracy are older, the parties that currently espouse them are younger.

The SGP is a typically Dutch party: extremely orthodox Calvinistic, anti-papal for many decades, and formerly more inclined to testify as preachers from the pulpit than as politicians operating in the political arena. Its support base is one of the most stable in the Netherlands, consistently amounting to more than 2% of the voters.

It also espouses a highly distinctive ideology sourced from a strict, Calvinistic interpretation of the bible coupled with a distrust of state intervention in the socio-economic field. In parliament the SGP has started to operate 'more politically', albeit constructively.

The party is probably the only one that has never been represented in a government but which does not in itself serve as opposition and is disposed to accommodating governments, albeit critically.

Still always representing more than 10% of the electorate, Geert Wilders' PVV is the largest party on the explicit right and the one which is always categorised as 'populistic and right-wing' in the foreign media. This party has been quite simply set up around a single leader.

More importantly, voters cannot become a member of the party, as Wilders is its sole member[7]. More so than in any other party, Wilders also personally helps to select all of his fellow parliamentary members. This desire for control has its origins in the fear of the conflicts with which new parties are almost always afflicted.

Wilders is relatively flexible in relation to various issues and his party appears to listen to a potential support base comprising socially and economically disadvantaged or neglected voters. Yet Wilders is uncompromising when it comes to his primary concern.

He views Islam as an ideology that is hostile to Dutch values and would therefore like to reduce the number of highly religious Muslims. It is this essential aspect of his beliefs which causes many of his opponents to brand him as discriminatory or even 'racist'.

The question as to whether this description is justified is closely associated with one's own assessment of Islam and the presence of large groups of Muslims in Western European countries. Wilders is vehement and explicit, something which Muslims sometimes perceive to be provocative and insulting.

His links to extreme right-wing parties and his admiration for 'strong leaders', such as Orban and Putin, cause one to consider the fourth of the above-mentioned criteria.

However, Wilders definitely distinguishes himself from traditionally extreme right-wing parties in two respects. Firstly, he is not anti-Semitic and is even explicitly pro-Israel. Secondly, his argument contends that Islam constitutes a threat to traditional Dutch freedom, in respect of which he explicitly refers to the rights of women and homosexuals. Traditionally, the extreme right, has little sympathy for these two groups.

For approximately five years there has been a newcomer on the right-wing flank, namely, Forum voor Democratie (FvD) and its leader, Thierry Baudet. Its original agenda was twofold. The other parties were characterised as 'cartel democracy' and the remedy was supposed to be more direct democracy.

This component of its agenda is very similar to what D66, a party that is viewed as an eminent example of anti-populist sentiment, brought with it when it entered the Dutch political arena 55 years ago. The second component of its agenda lies in FvD's view that European integration has gone too far, with the result that the nation state has come to be under threat.

In this case too direct democracy is the remedy that is offered. The voters must be able to express their views on EU matters through referendums, including the question as to whether the Netherlands should remain a member of the EU.

A third issue which FvD has used to profile itself emerged at a later stage: opposition to climate targets and, closely associated with this, to sensitive matters, such as the erection of increasingly more wind turbines in the countryside and policy to reduce those farming activities which are deemed to be polluting.

Whatever conclusions one wishes to draw in this respect, they are legitimate positions and in them the party is expressing concerns which are clearly shared within the Dutch electorate.

The fact that there was a breeding ground for a party which expressed such concerns is also an indication that the 'established parties' devoted insufficient attention to them in the eyes of part of the electorate at any rate and that the Netherlands' open system of democracy – featuring pure proportional representation – offers scope for the representation of voters who are 'not heard'.

However, FvD is frequently portrayed unfavourably in the news because of three factors and the party has already had to contend with a major breakaway on three occasions in its brief history. The person of its leader, Thierry Baudet, is the first factor.

He does not tolerate opposition, which nevertheless occurs more often in politics, and he does not have the wherewithal to secure the loyalty of fellow party members who do not admire him uncritically. The situation is more difficult, because Baudet is somewhat capricious.

Related to this – the second factor – is that racist statements regularly occur within the party and Baudet does not distance himself from them. More to the point, on more than one occasion he has also made statements which suggest a belief in a superior white race, provided that its conduct is deemed to be 'masculine'.

A third factor lies in his undisguised admiration for Putin and his tendency to deny or condone aggressive Russian behaviour. The most distressing within the Dutch context is that Baudet constantly raises doubts as to whether Flight MH-17, an aircraft with mainly Dutch passengers which was shot down above eastern Ukraine in the summer of 2014 was indeed brought down by pro-Russian rebels.

Baudet is sympathetic to Russian propaganda which ascribes this crime to Ukraine. According to leaked internal electronic messages, this position is (also?) linked to Russian funding of FvD. For a party that claims to support the national interests, it is remarkable that it is so casual in its dealings with the interests of the survivors of the almost 200 deceased Dutch citizens who were on board Flight MH-17.

Aversion to the first two of the above-mentioned factors led to a breakaway from FvD to establish JA21 several months before the Lower House elections in March 2021. This party claims that it wishes to highlight FvD's original agenda without making any wild statements and to do so in a way in which it hopes to exert influence on its policy.

This newcomer relies on a 'conservative, liberal' body of thought. It explicitly claims that it wishes to provide a home for those voters who are of the opinion that the liberal right-wing VVD and the Christian democratic CDA are inclined too much to the left.

It awaits to be seen to what extent this party, many of whose members were also a member of FvD until recently, is able to live up to this claim. Nevertheless, within a brief period of time it has managed to convince enough voters, most of whom have come from the VVD and CDA rather than FvD and the PVV, to enter the Lower House with three seats.

According to some polls, it already commanded double the number of seats two months after the elections. It says a great deal that other parties have not precluded this party at the outset. As such and in so far as it is already possible to say this now, JA21 is a potentially non-populist outlet for dissatisfied voters on the right. Time will tell whether this party will be able to live up to this.

Towards a new government

Three months after the elections a new government is still a far-off prospect. This is not unusual in the Netherlands. The formation of a new government can take a long time, because increasingly more parties are required for this purpose.

Since the Second World War the formation of a new government has taken more than three months on average. The formation of the Rutte III government took a record number of 225 days.

What is unusual is that the first two months elapsed before the formation involved any substantive matters and – up until know – without there being any clarity as to which parties would constitute part of the new coalition.

An unfortunate leaked statement made by Prime Minister Rutte occasioned extensive debates in the Lower House, where parties that are rival to the VVD sought to settle scores with Rutte, who won the elections.

Nevertheless, there is a good chance that a Rutte IV government will emerge, because it is impossible to form a stable government without the VVD, while polls reveal that new elections, which some losers in March may be seeking, will again result in Rutte's VVD trumping its competitors by a large margin.

Voters are beginning to tire of politicians who have been preoccupied with holding each other to account instead of addressing the major issues facing the country, as in the case of other Western nations. ■

Dr Fleur de Beaufort is Researcher and Dr Patrick van Schie is Director of the Dutch liberal think tank TeldersFoundation

Endnotes

1. By way of comparison, most of the European countries which have a system of proportional representation have an electoral threshold varying from 2% (Denmark) to 5% (Germany, Belgium, Poland, most others).

2. It is no longer formally represented in the Lower House, albeit still locally and in the Senate, after the departure of its leading candidate, Liane den Haan, on 6 May 2021 following a conflict.

3. As it happens, the membership of all of the political parties amounted to more than 780,000 members when taken together, whereas that figure had shrunk to 310,000 in 2021. The minor (new) movements are performing relatively better than the traditional parties.

4. 'TK2021 naar demografische en andere kenmerken' [The 2021 Lower House based on demographic and other

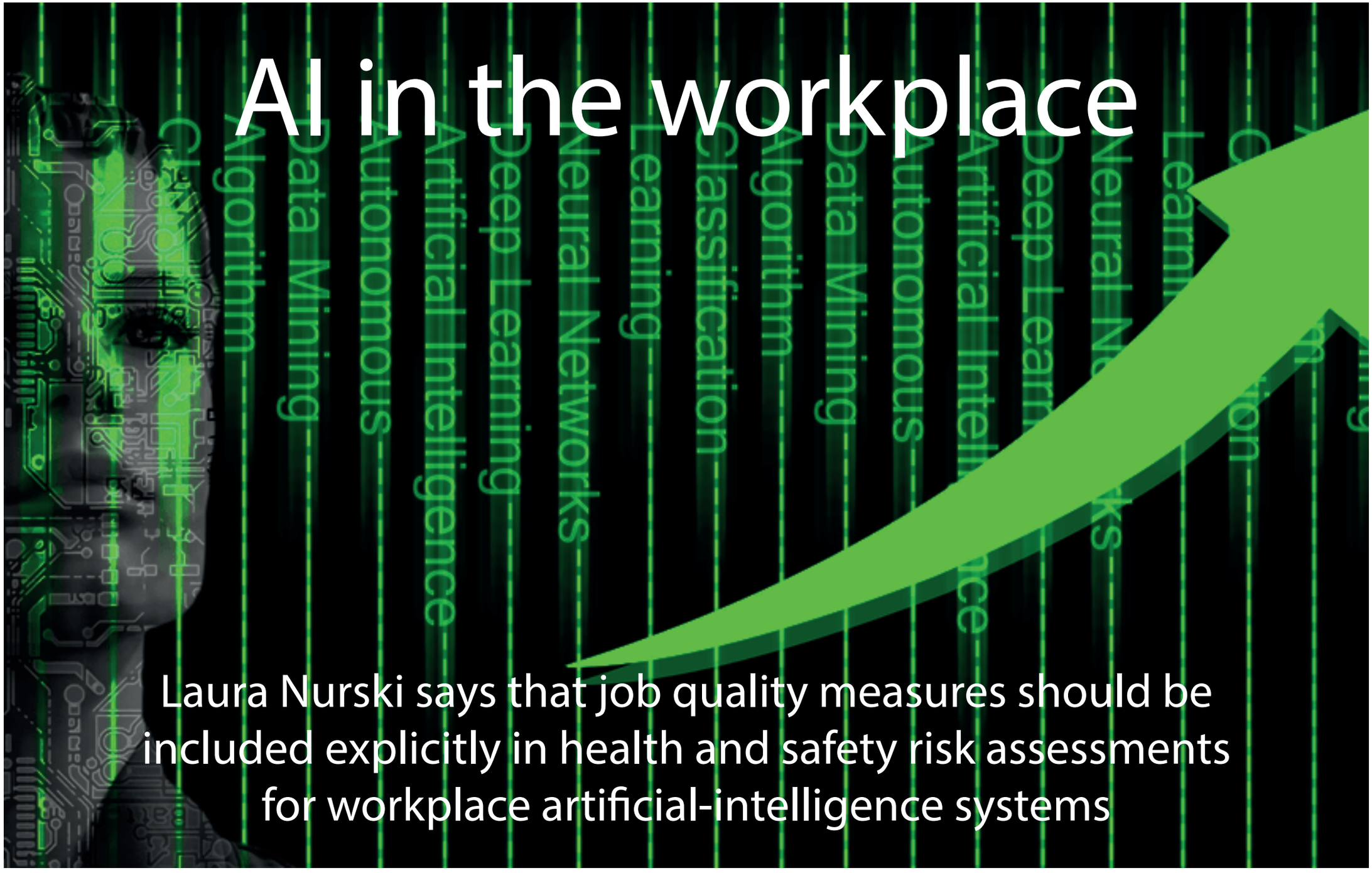
characteristics], which was consulted at https://maurice.nl/peilingen/2021/04/11/tk2021-naar-demografische-en-andere-kenmerken/

5. On 13 May 2021 FvD again had to contend with a breakaway, as a result of which three of the five seats will continue as the Haga Group and the FvD leader, Thierry Baudet saw his party shrink to five seats in the Lower House.

6. See numerous publications, eg. Cas Mudde and Rovira Kalwasser, Populism: A Very Short Introduction (Oxford, 2017) and Jan-Werner Müller, What is populism? (Philadelphia, 2016).

7. In formal terms there are two 'members: the individual, Geert Wilders, and also a foundation whose executive board consists of ... Wilders.

AI in the workplace



Laura Nurski says that job quality measures should be included explicitly in health and safety risk assessments for workplace artificial-intelligence systems

AI in the workplace: what's at stake?

The use of artificial intelligence in the workplace has been hailed as both the future of work and its destruction. Worker-friendly applications of AI in the workplace include the automation of dangerous, dirty and dull tasks, strategic workforce planning and learning and reskilling.

However, applications that might harm rather than help workers are also emerging. AI algorithms in hiring and promotion have been shown to discriminate, for example. Equally worrying for workers is algorithmic management (AM).

AM is the use of AI to assign tasks and monitor workers. It includes continuous tracking of workers, constant performance evaluation and the automatic implementation of decisions, without human intervention. These algorithms are designed to optimise the efficient allocation of resources in the production of goods and services, helping organisations reduce costs, maximise profits and ensure competitiveness in the market.

However, optimising efficiency can come at the expense of worker wellbeing. Deteriorating job quality is often a side effect of scheduling and allocation algorithms.

In warehouses, robots are not yet replacing workers, but algorithms are optimising jobs to make workers more like robots and to minimise workers' idle time (to the point that they skip bathroom breaks).

In retail, scheduling algorithms present workers with long and unpredictable hours, making it next to impossible to balance personal life with work. No longer confined to digital labour platforms, AM is now pervasive throughout the whole economy, particularly in retail, call centres, hospitals and warehouses.

None of this is new, however. We need not look far to find evidence of the harmful effects of such optimisation practices. Frederick Taylor's *Principles of Scientific Management*, written in 1911, reads like a twenty-first century guide to data-driven management: data collection and process analysis, efficiency and standardisation, and knowledge transfer from workers into tools, processes and documentation.

The digital transformation that organisations have gone through in the past decades has left them with mountains of data and cheap technology for storing and analysing that data. With the rise of workplace AI, Taylor's dream of perfectly optimised work processes might finally become a reality.

The digital transformation that organisations have gone through in the past decades has left them with mountains of data and cheap technology for storing and analysing that data

However, that would come with a price. The Ford factories adhering to Taylor's principles had a staff turnover rate of over 350% (meaning the entire staff had to be replaced 3.5 times per year). It is not hard to see that job quality was extremely bad on the Ford assembly lines.

There is a large body of evidence on the effect of job autonomy on workers' wellbeing and health. Jobs with low autonomy or control have been shown to lead to negative health outcomes and mental strain. Acute conditions, cardiovascular risk, musculoskeletal disorders, mental health problems, functional disabilities and self-assessed health problems are also associated with low-autonomy jobs among older workers.

Data on observable health outcomes confirms the self-assessed effects: coronary heart disease and even cardiovascular mortality have been found to be impacted by job control over time. These long-term effects on workers' health could be felt years after they have been exposed to low-autonomy jobs.

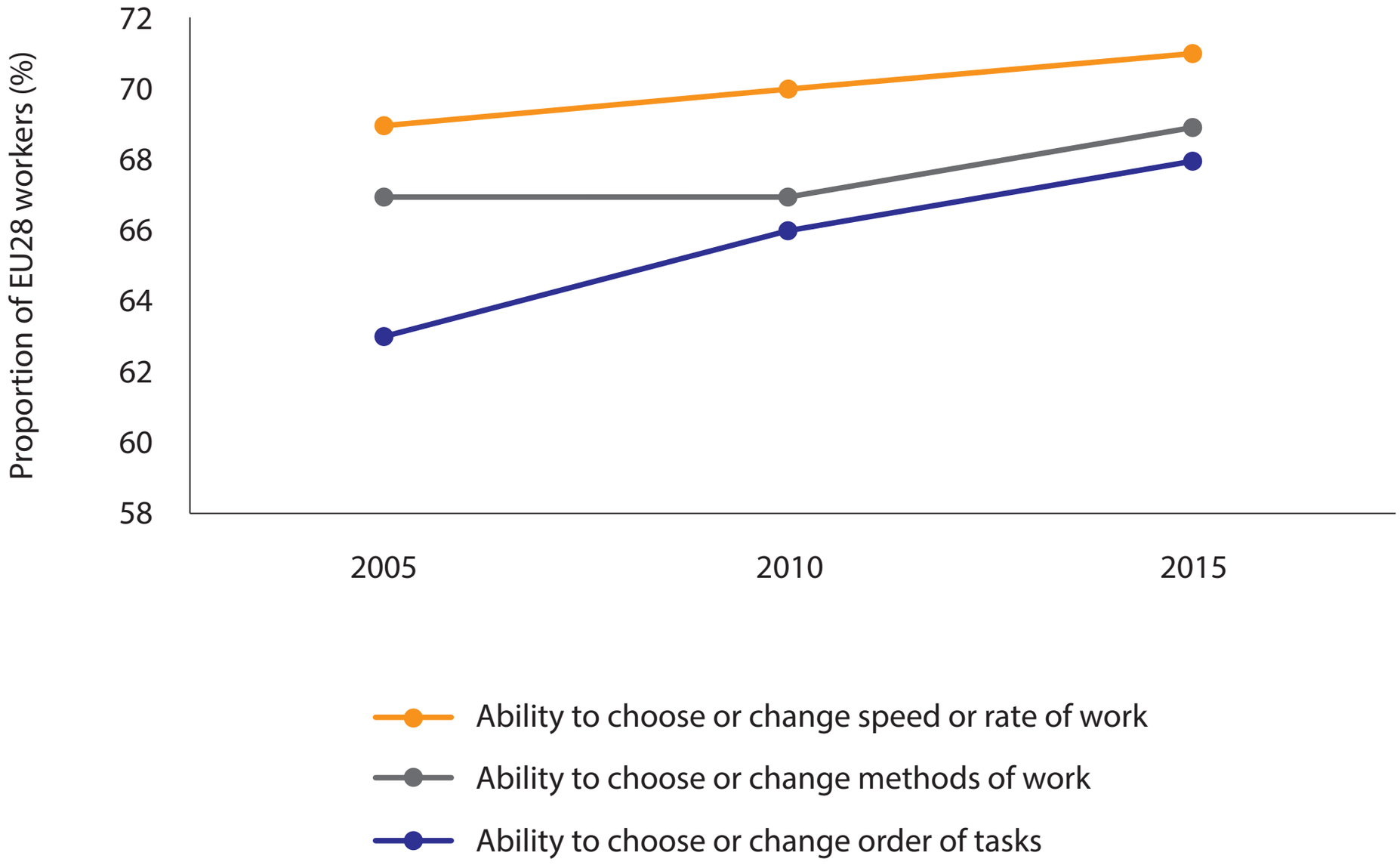
Indicators of job quality developed by Eurofound (the European Foundation for the Improvement of Living and Working Conditions) include the ability to change the order of tasks, the ability to choose or change the speed or rate of work and the ability to change or choose methods of work.

All three measures increased in Europe between 2005 and 2015 (Figure 1). Given AI's specific impact on automating exactly those types of decisions, there is a real risk that these forms of workplace AI could reverse that evolution and set worker wellbeing back 100 years.

AI regulation versus labour regulation

Some protection for European Union workers against excessive AI-based optimisation might come from European Commission proposals on ensuring trustworthy AI, published on 21 April. The Commission's goal is to guarantee the

Figure 1. Decision latitude increased among EU28 workers



Note: Includes the United Kingdom
Source: Bruegel, based on Eurofund (2017, p. 80)

health, safety and fundamental rights of people and businesses, while promoting AI adoption and innovation. The proposal identifies eight areas of AI application considered high risk for health and safety.

Rightly, the commission includes among these the use of AI in employment and workers' management. The Commission specifically mentions algorithms for assigning people to jobs (recruitment, selection, promotion and termination) and algorithms for scheduling and productivity (task allocation, monitoring and evaluation).

According to the Commission, these systems *"may appreciably impact future career prospects and livelihoods of workers"* by *"perpetuating historical patterns of discrimination,"* and violating *"rights to data protection and privacy."*

However, as we have shown, concern about AI in the workplace should extend beyond career prospects and livelihoods into job quality and worker wellbeing. Besides AI regulation, EU workplace regulation could help mitigate the health risks associated with low job control stemming from algorithmic management.

At European level, two main bodies of legislation are relevant in this context: labour law (covering working conditions such as working hours, part-time work and posting of workers, as well as informing and consulting workers about collective redundancies and transfers of companies) and the Occupational Safety and Health (OSH) Framework Directive (89/391) (creating a legal obligation for employers to protect their workers by avoiding, evaluating and combating risks to their safety and health)[1].

But neither body of legislation seems geared for the large-scale impact and fine-tuned precision of workplace AI systems, because employers have been found to use AI in ways that erode labour laws. Law professors Alexander and Tippett call this *"the hacking of employment law"*, describing practices in which employers use software to *"implement systems that are largely consistent with existing laws but violate legal rules on the margin."*

However, the main legislative shortcoming related to the undermining of workers' autonomy (and long-term health) is that the specification of workplace risks or criteria for assessing them are left too vague.

While the European Agency for Safety and Health at Work's (OSHA) practical guide addresses psychosocial factors, the OSH directive doesn't mention any specific risks.

The terms 'stress' and 'psychosocial risks' are not mentioned explicitly in most of the legislation, leading to a lack of clarity or consensus on the terminology used. This leaves room for employers to pick and choose which risks to consider, let alone how to measure, address and mitigate them. The Commission's proposed AI regulation also leaves the definition of risks insufficiently specified.

Shortcomings and suggestions

Under the Commission's proposal, since employment and workers' management is included in the eight high-risk areas, workplace AI systems would be subject to strict obligations before they can be put on the market, including requirements for risk assessments and mitigation systems, data quality checks to minimise the risk of discrimination, logging of activity to ensure traceability, and transparency measures including detailed documentation and user information.

This is insufficient to protect workers adequately. Workplace AI systems will only be subject to risk assessments carried out by the employer or provider of the AI system. To strengthen worker protection, social partners could be given a role in overseeing AI systems at work. Workers opposing the outputs of high-risk AI systems could be given protection against disciplinary measures imposed by employers. Indeed, worker participation in the implementation and assessment of AI could partially mitigate the psychosocial risks of autonomy-reducing AI systems.

But besides the issue of who should assess the risks of workplace AI systems, there is the issue of which risks should be included in the mandatory assessment. The Commission's proposed AI regulation lists requirements for risk-management systems for high-risk AI systems in Article 9, with as a first step *"identification and analysis of the known and foreseeable risks associated with each high-risk AI system"* (our emphasis).

The emphasis throughout the proposal on safety, health and human rights leaves the interpretation of these *"known and foreseeable risks"* too broad, with too much room for picking some risks over others.

While employers will consider obvious immediate safety risks (for example, the risk that a robot accidentally hurts a worker with its robotic arm), they might not equally consider the long-term health risks associated with taking away workers' autonomy.

Given the link between job quality and health, job control measures are a more responsive indicator to assess whether an AI system poses a risk to workers' wellbeing in the long run.

Job quality (and autonomy in particular) should therefore be explicitly included as a measure in the risk assessment of workplace AI, and processes should be put in place to mitigate any residual impact of AI on job quality and worker wellbeing.

The need for more tools and guidance on psychosocial risk management is clear, but in order to be binding the best place to address this risk definition is in the OSH legislation itself. The proposed AI regulation could then refer to psychosocial risks as defined in OSH legislation to be included in the required risk assessment and mitigation systems for the high-risk area of employment and workers' management.

Eurofound's job-control indicators – the ability to choose the order of tasks, the speed of work and the methods of work – provide a starting point for developing measures for psychosocial risk assessment. Given AI's specific impact on automating exactly those types of decisions, it is important to understand how different forms of autonomy relate to wellbeing at work.

Not all autonomy is the same and different aspects of job control have different effects on wellbeing. Current research suggests that scheduling autonomy (choosing the order of tasks) could be stress-reducing, while learning autonomy (experimenting with methods of work) could be motivating.

Only by understanding the distinctive impact of different types of autonomy on stress and engagement at work can the risks of AI for worker wellbeing be correctly assessed and mitigated. In an increasingly digital world of work, careful job design matters more than ever. ■

Laura Nurski is a Research Fellow at Bruegel

Endnote

1. Specifically on the potential discriminatory effects of AI, another relevant body of legislation deals with tackling discrimination at work.

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Vaccine diplomacy: soft power lessons from China and Russia?

Michael Leigh discusses the rocky start to the EU's vaccination rollout that has allowed Moscow and Beijing to score political points in the Balkans and Central and Eastern Europe

As COVID-19 continues to rage throughout Europe, China and Russia seem to be giving the European Union lessons in soft power on its home ground. Several EU members and countries nearby are turning to Beijing and Moscow for additional supplies of COVID-19 vaccines, faced with discontent at the slowness of the EU's own vaccination rollout, supply shortages, delivery bottlenecks, poor communication and concerns about vaccine safety.

China's vaccine deliveries come with soft-power messages. Beijing is providing its vaccine free to Chinese citizens and to 53 countries while, in parallel, seeking to counter critical views, following harsh Chinese repression in Hong Kong and Xinjiang, by vaunting its economic success, scientific and medical achievements, culture and language.

Beijing is completing Europe's largest Confucius Institute in Serbia, an early recipient of Chinese vaccines. The institute is located on the site in Belgrade where the Chinese embassy once stood before being bombed by NATO in 1999.

Heavy symbolism

Meanwhile, Russia's Sputnik V vaccine is gaining increasing acceptance in Europe. The European Medicines Agency (EMA) is reviewing its efficacy and it has won plaudits from the head of Germany's standing commission on vaccination.

Germany's health minister has discussed overcoming supply shortages in the EU with Chinese and Russian vaccines, once they have been approved. Bavarian Prime Minister Markus Söder has announced a preliminary purchase order for 2.5 million doses of Sputnik V, to be produced in Bavaria. Chancellor Merkel said in March there were *"good data"* on Sputnik V and that all vaccines were welcome once they receive the green light.

Merkel and French President Emmanuel Macron have discussed joint production of Sputnik V with Russian President Vladimir Putin. This is despite heightened tensions with Moscow following the imprisonment of opposition leader Alexey Navalny and Russia's recent troop build-up near Ukraine.

Russia misses no chance to accompany offers of vaccine or joint production to Eastern Europe and the Balkans with soft-power messages, dwelling on European failures and highlighting Russian support for countries covered by the EU's enlargement and neighbourhood policies.

Unstinting support in fighting the pandemic is the most tangible way for the EU to demonstrate its commitment to the wellbeing of neighbouring countries, which look to Brussels for solidarity

Over fifty countries have ordered the Sputnik V vaccine. Russia has made a show of vaccine deliveries to Serbia and Montenegro, while Croatia has begun talks with Russia about acquiring the Sputnik V vaccine. Croatia's health minister is reported to have asked its health regulator to authorise the vaccine without waiting for EMA approval.

The Czech Republic and Slovakia have also turned to Russia for supplies of Sputnik V. But Slovak Prime Minister Igor Matovic resigned in March after failing to obtain the governing coalition's agreement for his personal decision to purchase 2 million doses of the Russian vaccine.

Hungary became the first European country to administer Sputnik V in February 2021, after issuing emergency authorization, and plans are afoot to produce the vaccine in Italy.

Austria has held talks with Moscow about acquiring the Russian vaccine once it has been evaluated by EMA. Austria's Chancellor Sebastian Kurz accused EMA of being too slow to approve the vaccine.

Beijing meanwhile is targeting low and medium-income countries for early vaccine deliveries. It has supplied vaccines to EU member Hungary and EU candidate countries Serbia and Turkey.

Hungarian Prime Minister Viktor Orban posted a photo of himself being inoculated with a vaccine from Chinese manufacturer Sinopharm. China had shipped 115 million doses worldwide while the EU had exported 58 million by the end of March.

Recently, however, concerns have grown about the relatively low protection rates given by Chinese vaccines and about their availability. Trust in the reliability of Russian data and the comparability of its tests is still wavering.

EU countries are entitled to acquire vaccines approved by their regulatory authorities from suppliers not involved in the EU's centralised scheme. But a senior EMA official condemned this as *"somewhat comparable to Russian roulette,"* a remark that prompted calls for an apology from the Sputnik V manufacturer and criticism from the Kremlin.

Alarmed at member countries breaking ranks, European Council President Charles Michel launched a fierce defence of the EU's response to COVID-19. He wrote in his newsletter: *"We should not let ourselves be misled by China and Russia, both regimes with less desirable values than ours, as they organise highly limited but widely publicised operations to supply vaccines to others."*

A geopolitical open door

Nonetheless, the late rollout of the EU's vaccine purchase and delivery scheme handed Beijing and Moscow a commercial and diplomatic opportunity that fitted their strategic narratives.

For China, supplying vaccines to Europe forms part of its 'Health Silk Road', a rhetorical extension of its Belt and Road Initiative (BRI), intended to showcase the prowess of China's medical sciences and its devotion to global public goods.

China promotes the BRI in Central and Eastern Europe through 17+1, a loose network launched in Warsaw in 2012. At the start of the epidemic, China and Russia stepped in to provide masks and personal protective equipment to European countries amid severe supply shortages.

Moscow, too, seeks to convey the impression that its medical science is prevailing over the West's, despite low vaccination rates in Russia itself. The name Sputnik V mirrors that of the world's first artificial satellite, launched by

the Soviet Union in 1957. Russia rushed to become, on 11 August 2020, the first country whose COVID-19 vaccine was approved by national authorities.

China and Russia are pushing at an open door in Eastern Europe because of the EU's faltering strategies in the Balkans and eastern partnership countries (Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine). The EU promised membership to Balkan countries at the Thessaloniki summit in 2003.

Since then, only Croatia has joined the EU, and there are scant prospects for others to follow in the foreseeable future. Persistent governance problems in the Balkans and enlargement fatigue in the EU are responsible for the stalemate.

Despite repeated assertions that the region is destined for EU membership, the EU lacks a credible geopolitical strategy for the Balkans, an area surrounded by EU members that are its major donors and investors.

The EU has provided €70 million from existing funds to Balkan countries to acquire vaccines and a €3.3 billion package to tackle the health crisis, support investment and stimulate recovery. Balkan and eastern partnership countries are eligible for vaccines under the World Health Organisation's global COVAX scheme for low- and medium-income countries.

The EU recently doubled its contribution to COVAX to €1 billion. But these efforts fall far short of neighbouring countries' needs and of the COVID-fighting programmes deployed within the EU itself.

In March 2021, the European Commission ended the exemption of Balkan countries from the EU's vaccine export controls, reducing the credibility of its soft-power outreach to the region.

Foreign ministers from nine EU countries on 11 March 2021 called on the Union *"to take a strategic look at the Western Balkans."* They asserted that the pandemic had exacerbated existing trends, with their geopolitical implications, and that *"other actors are ready to step into regional affairs, often at our expense."*

Despite huge EU support for the region, *"other actors were more effective in presenting their support and thus undermining our reliability, credibility and perception of our solidarity."* Earlier, in January 2021, a group of foreign ministers, mainly from the EU's new member states, made a similar plea on behalf of Ukraine, Moldova, Georgia, Armenia and Azerbaijan.

Vaccine diplomacy and soft power

But despite the diplomatic and commercial agility with which China and Russia have moved to fill the vaccine and geopolitical gaps to the EU's east and south-east, their soft-power appeal to the countries concerned is limited.

Soft power derives from the attractiveness of a political, economic and social model and whether others aspire to emulate it. Despite China's success in containing the pandemic domestically and the early availability of its vaccines, few in Europe and its eastern periphery seek to emulate the Chinese model of society.

Russia, too, holds little appeal to populations in Europe's east whose main preoccupations are unemployment, living and governance standards and, in some cases, corruption. Disinformation, domestic repression and cyber-attacks do little to endear the Chinese and Russian regimes to public opinion in Europe.

Some 59% of respondents across the Balkans to the June 2020 *Balkan Barometer* survey consider that EU membership would be a good thing, up from 42% in 2014, the baseline year. The benefits of EU membership cited most often are greater prosperity and freedom to travel for work and study.

Serbia, where state television regularly presents the EU in a negative light while depicting China and Russia positively, is an outlier, with less than a third favouring EU membership. However, there is growing pessimism in the region about the prospects for joining the EU.

In Eastern Partnership countries, where the most recent regional survey was conducted in 2019 before the pandemic, just over half the respondents had a favourable view of the EU; 80% associated it with economic prosperity and human rights. Setbacks in fighting the pandemic have dented but not destroyed the EU's soft power in the Balkans and Eastern Europe.

Strategic choices

Chinese companies are engaged in public works in European countries, especially in Serbia. But infrastructure projects promoted by China's BRI have provoked environmental protests, created few jobs for local workers and raised debt levels to unsustainable levels, particularly in Montenegro.

Some major projects have been cancelled or remain incomplete. Six EU countries that are part of the 17+1 initiative were represented only by lower-rank officials at a virtual summit hosted by President Xi Jinping in February 2021, a setback that may herald the demise of this tenuous grouping.

If some governments in the Balkans and Eastern Europe appear to be prioritising vaccines from China and Russia, it is less on geopolitical grounds than as a response to delays in delivery by western suppliers. President Aleksandar Vucic of Serbia and Prime Minister Orban in Hungary exemplify this opportunistic, tactical approach. Vucic takes pride in achieving a high vaccination rate by using European, Chinese and Russian vaccines, claiming that he remains equidistant from all three. He has announced an agreement to produce Sinopharm vaccines in Serbia.

Chinese and Russian vaccine diplomacy might offer a partial workaround in the face of EU delays, but not a strategic choice. The aspirations of strengthening democracy and closer EU links remain strong in the Balkans and in Georgia, Moldova and Ukraine. Sabre-rattling by Moscow over Ukraine and the ongoing Russian absorption of Belarus will reinforce the tilts to the west of EU partner countries.

The EU should reinforce its position in the region with more inclusive policies, clearer signalling and robust measures to counter disinformation. Vaccine deliveries through COVAX should be accelerated and supplemented by additional donations from EU countries, as their own vaccine rollouts gather pace. The Western Balkans should be exempted from the EU's vaccine export control mechanism.

At the same time, EU representatives should push back firmly when Serbian President Vucic conveys the misleading impression that the Balkans can rely as much on China and Russia as on the EU, or when he poses as a regional benefactor, making small well-publicised donations of European-supplied vaccines to North Macedonia and Bosnia-Herzegovina.

The population should be reminded that the EU has done far more than China or Russia to modernise the Balkans' healthcare sector, providing over €450 million in grants and loans during the past twenty years to Serbia alone.

Unstinting support in fighting the pandemic is the most tangible way for the EU to demonstrate its commitment to the wellbeing of neighbouring countries, which look to Brussels for solidarity. ■

Michael Leigh is a Senior Fellow at Bruegel

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Is the EU's investment agreement with China underrated?

Uri Dadush and André Sapir argue that the CAI binds China to an international treaty that includes improvements on subsidies, SOEs, technology transfer and transparency

The European Union is very open to foreign direct investment. By comparison, despite considerable liberalisation in the past two decades, foreign investors in China's markets still face significant restrictions, especially in services sectors. Given this imbalance, the EU has long sought to improve the situation for its companies operating or wanting to operate in China.

After eight years of negotiations, the EU and China concluded in December 2020 a bilateral Comprehensive Agreement on Investment (CAI). The text awaiting ratification aims to give foreign investors greater market access, enforceable via state-to-state dispute settlement.

It does not yet, however, cover investor protection (such as against expropriation). Meanwhile, investor protection is covered by bilateral investment treaties between EU countries and China, which remain in force.

The CAI has been met in some quarters with scepticism on economic and geopolitical grounds. The main criticism is that it provides little new market access in China, and that this small economic gain for the EU comes at the price of breaking ranks with its main political ally, the United States.

Our assessment, which focuses on the economic implications, is different. It is true the CAI provides only modest new market access in China, but this is because China has already made progress in recent years in liberalising its foreign investment regulations unilaterally.

The CAI binds this progress under an international treaty, marking an improvement for EU firms insofar as their market access rights can be effectively enforced.

Most important, the CAI includes new rules on subsidies, state-owned enterprises, technology transfer and transparency, which will improve effective market access for EU firms operating in China. These bilateral new rules could also pave the way for reform of the multilateral rules under the World Trade Organization, with the aim of better integrating China into the international trading and investment system – a goal shared by the EU, the United States and other like-minded countries.

From an economic viewpoint therefore, the CAI is an important agreement, and one worth having. However, its ratification by the European Parliament is unlikely while China continues to apply sanctions against some members of the European Parliament and other critics of China's human rights record.

The CAI demonstrates the EU's capacity to negotiate successfully and independently with China; the EU has signalled clearly that it has no intention to decouple from China

The Comprehensive Agreement on Investment

Since its beginning, the European Union has maintained a treaty-based policy of openness towards foreign direct investment (FDI), though this varies slightly from EU country to EU country since members retain some prerogatives over FDI.

By comparison, China remains restrictive, despite having liberalised its FDI regime in recent decades. Restrictiveness is most notable in the services sector. Investment in China's manufacturing sector is now quite free, though still less than in the EU.

Given the imbalance between the EU and China in terms of investment openness, the EU has long sought to improve the situation for its companies operating or wanting to operate in China. After eight years of negotiations, the EU and China concluded in December 2020 a bilateral Comprehensive Agreement on Investment (CAI)[1].

Foreign firms wanting to invest in China have always needed to respect the country's prevailing Foreign Investment Law (FIL), which sets out the general principles applicable to foreign investment. The latest FIL was adopted on 15 March 2019 and entered into force on 1 January 2020[2].

Under the FIL, foreign investment in China in certain industries is explicitly encouraged, while it is prohibited or restricted in others. A typical restriction limits foreign ownership and requires foreign firms to form joint ventures (JV) with local partners.

Another typical restriction forbids investment in new capacity in sectors such as steel and cement where overcapacity exists. Although there are many situations in which foreign firms may be treated less favourably than domestic firms, the most recent FIL mandates that Chinese government procurement at all levels of government

shall not discriminate between foreign and domestic firms. The FIL also forbids, in principle, forced technology transfer.

Importantly, the FIL specifies that when international agreements to which China is a party contain provisions more favourable to the admission of foreign investors, those pro- visions will take precedence over the existing Chinese FDI regulations.

International agreements signed by China that include investment provisions include the World Trade Organization agreements and in particular China's schedule of commitments under the General Agreement for Trade in Services (GATS) schedule; the Regional Comprehensive Economic Partnership (RCEP) agreement between China and 14 other Asia-Pacific countries; and the Phase One US-China agreement.

The CAI is the first investment-only liberalisation agreement to which China is a party. The text agreed in December 2020 does not cover investor protection against discrimination, expropriation or denial of justice in the host country.

It specifies, however, that China and the EU will complete negotiations on investment protection (and the related investor-to-state dispute settlement) within two years of the signature of the current agreement. In the meantime, bilateral investment treaties (BITs), which cover only investment protection, between individual EU countries and China remain in force.

This paper assesses the gains that EU firms planning to invest in China, or that have already done so, will derive from CAI in terms of better market access. We do not mean to overlook the potential economic implications of increased investment in Europe by Chinese firms in the wake of the CAI, but we recognise that, since EU markets are already

largely open to Chinese investment, the most likely and largest source of gains for the EU will derive from the new opportunities in China.

Another purpose is to evaluate whether and how CAI could help better integrate China into the rules-based multilateral system – an important goal for EU trade and investment policy.

We focus on the economic aspect of the agreement and leave aside geopolitical considerations. This does not mean, however, that we do not appreciate strategic issues and how they relate to the workings of the world economy. EU-China relations are, by essence, of systemic importance given that the two parties are the world's second and third largest economic blocs.

At the same time, we are obviously aware that recent clashes between the EU and China over human rights violations in China cast a deep shadow over the agreement. Indeed, ratification of the CAI by the European Parliament is very unlikely while China continues to apply sanctions against some members of the European Parliament and European researchers who have criticised its human rights record.

The economic implications of the agreement are themselves the subject of considerable controversy. The CAI has been presented by the European Commission as a major success but has been met with considerable scepticism on the grounds that it does not go far enough[3].

Our assessment is different. We recognise that the CAI is an imperfect agreement which – in contrast to some of the Commission's claims – provides only modest new market access in China.

However, this is in no small measure due to the progress that China made over the last several years in liberalising its foreign investment regulations unilaterally. The CAI binds this progress under an international treaty, an improvement for EU firms insofar as their market access rights can be effectively enforced.

Most important, the CAI includes new rules on subsidies, state-owned enterprises (SOEs), technology transfer and transparency, all of which are of significance for the world trading system and which – with some caveats – increase the likelihood that European investors can operate in China successfully and sustainably.

Our overall conclusion is that the CAI is far from a perfect deal, but – from the economic viewpoint – is an important agreement worth having.

The impact of CAI on EU FDI in China

To what extent does CAI improve effective market access for EU firms already operating in or wishing to operate in China?

In principle CAI could improve market access by allowing EU firms to invest in more sectors and/or with less stringent conditions – no longer needing to participate in joint ventures with Chinese firms, for example. Or, the CAI could include rules, such as on subsidies, which will allow EU firms to compete on a more equal footing with Chinese firms in their home market. We look at these two issues in turn.

Does CAI improve market access for EU firms in China?

Two decades ago, China had a very restrictive investment regime. In 1997, it scored 0.625 on the 0 (open) to 1 (closed) scale of the Organisation for Economic Co-operation and Development's FDI Regulatory Restrictiveness Index[4].

By 2019, it scored 0.244, a huge improvement, though China was still the eighth most restrictive out of a sample of 83 countries, including 45 non-OECD members[5]. Compared to its fellow BRICS, China's FDI regime is about as restrictive as India's and Russia's, but far more than Brazil's and South Africa's.

It should be borne in mind that the recent revisions to the FIL may not be fully reflected in the 2019 OECD index. For the record, all EU countries have scores near zero (Figure 1 and Table 1).

China's substantial investment liberalisation during the past two decades is attributable to a combination of unilateral and multilateral measures. Consider first China's manufacturing sector, which is about 60 percent larger than the EU's and is growing faster, and where most EU FDI is presently directed.

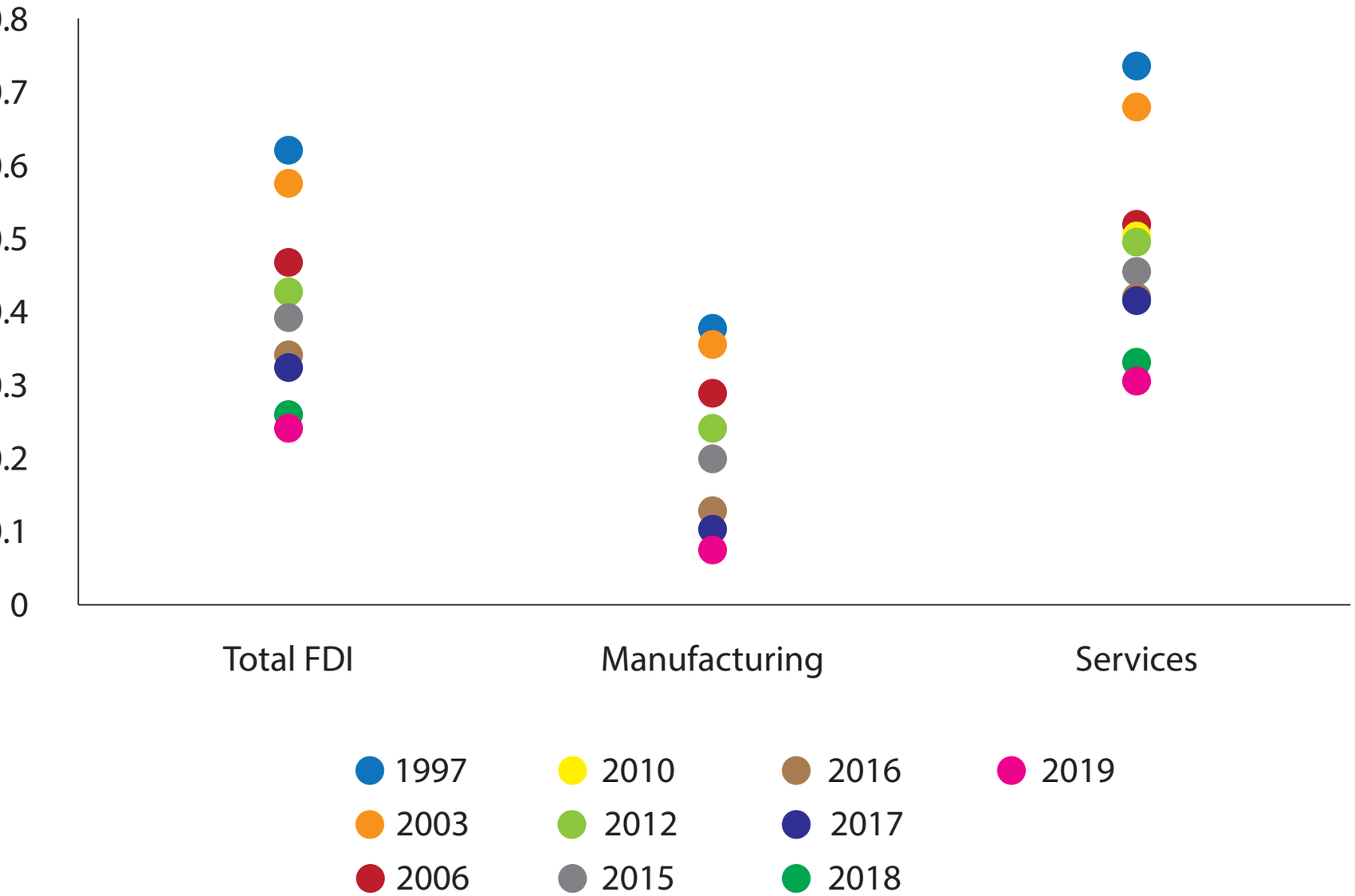
According to a 2019 McKinsey study (Woetzel *et al*, 2019), Chinese manufacturing is already highly integrated into global value chains, using global standards 90 percent of the time, while importing many advanced components.

Multinational firms have greater penetration in Chinese consumer markets than they do in the United States (Woetzel *et al*, 2019). According to UNCTAD, in 2020 China became the world's largest FDI destination, passing the United States.

Shifting the focus from outcomes to regulations, China's FDI Restrictiveness Index in manufacturing decreased from 0.379 in 1997 to 0.073 in 2019. This means that China's investment regime in the manufacturing sector is now close to being completely liberalised.

For example, according to this OECD statistic, China's regulations on inward FDI in manufacturing are now more liberal than those of Australia, Canada and Mexico (with scores in the 0.08 to 0.1 range), although not as liberal as

Figure 1. The OECD's FDI Regulatory Restrictiveness Index for China, 1997-2019



Note: a score of 0 equals completely liberalised. A score of 1 indicates closed.
Source: Bruegel based on OECD.

Table 1. OECD's FDI Regulatory Restrictiveness Index for China and selected countries, 2019

Country	Total FDI	Manufacturing	Services
China (People's Republic of)	0.244	0.073	0.306
France	0.045	0.000	0.033
Germany	0.023	0.000	0.022
Italy	0.052	0.000	0.057
Spain	0.021	0.000	0.038
Brazil	0.082	0.025	0.099
India	0.207	0.035	0.311
Russia	0.261	0.161	0.350
South Africa	0.055	0.010	0.101

Note: a score of 0 equals completely liberalised. A score of 1 indicates closed.
Source: Bruegel based on OECD.

Portugal or Morocco, for example, where inward FDI in manufacturing is completely liberalised (score of 0). China's liberalisation of foreign investment in manufacturing was achieved on a purely unilateral basis, through successive FILs[6].

By contrast, in the services sector, investment liberalisation has taken place through a combination of unilateral and multilateral measures, since the WTO covers liberalisation of investment in services but not in manufacturing[7].

Also in contrast to manufacturing, investment liberalisation in services is far less advanced. From 1997, China's FDI restrictiveness score decreased from 0.739 to 0.306 in 2019 – still much higher than the average score of less than 0.06 in the three biggest EU countries.

Like other WTO members, China made multilateral commitments in its GATS schedule under Mode 3 (commercial presence of foreign services companies), when it acceded to the WTO.

Among the 162 services sectors listed by the WTO in its Services Sectoral Classification List (SSCL)[8], and after a transition period ranging between two and six years after its WTO accession, China made full market access commitments under Mode 3 (meaning that foreign firms can invest freely in China) in only 26 sectors; partial commitments (meaning that foreign firms wishing to invest in China must form a joint venture with a local partner or are subject to other forms of market access limitations) in 71 sectors; and no commitments (meaning that foreign firms are not free to invest in China, unless they obtain specific authorisation) in 65 sectors[9].

Considering China's limitations on national treatment, which imply that foreign firms are subject to certain requirements that do not apply to local firms, only 22 of the 162 services sectors are completely free of market

access and national treatment limitations under Mode 3 in China's WTO commitments, a much lower figure than in most other countries' WTO commitments[10].

In addition to its multilateral commitments, China has also liberalised some of its services sectors unilaterally through successive FILs. Like in the manufacturing sector, however, liberalisation undertaken unilaterally through national law is, by definition, not bound by a treaty obligation, and can therefore, be revoked at the stroke of a pen.

Although important for foreign investors, such unilateral liberalisation is therefore less valuable, because it is less predictable than liberalisation enshrined in an international treaty or agreement.

So, what can we say about the CAI? Does it create fresh market access opportunities for EU investors in China compared to the 2019 FIL and China's WTO commitments?

In the manufacturing sector, the CAI binds China's unilateral liberalisation for the benefit of EU firms. Examination of the commitments in the CAI's Annex 3 (the positive list) shows that investment in 30 manufacturing sectors is liberalised. Of these, 20 are free of any limitations, including any joint-venture or ownership requirements.

These sectors cover a vast array of manufacturing, including food processing, apparel and textiles, chemicals (except for explosives), pharmaceuticals (except for certain types of vaccines), aircraft and spacecraft manufacturing, electrical machinery and equipment, computers and instruments.

In the ten sectors for which limitations on market access remain, there are no joint-venture requirements, and the limitations are justified mainly by concerns about overcapacity. For example, in printing, and in petroleum refining China's schedule in Annex 3 states *"increasing production capacity for oil refining shall be in line with the planning."*

In sectors including cement, steel, aluminium and shipbuilding, adding production capacity is forbidden for foreign firms as it is for Chinese firms. This means that foreigners can still invest in those sectors, for example by acquiring a Chinese firm or by retooling to adapt their product mix, but they cannot expand overall plant capacity.

Examination of CAI Annexes 1 and 2, which contain various exceptions to national treatment, shows no significant provisions on manufacturing, except in the automotive sector.

The automotive sector deserves special attention because it is important for EU companies, representing about 30 percent of their total FDI in China. Here there are some access limitations (such as 50 percent Chinese ownership), though these apply only until 2022, in line with the 2019 FIL. There are no joint-venture requirements after 2022.

Establishing new production capacity in electric vehicles is allowed but is subject to limitations that apply if there is overcapacity in the designated province. Most important, reflecting China's intention to promote electric vehicles, China's schedule in Annex 3 states that *"the establishment of new traditional fuel-powered motor vehicle enterprises is prohibited"* and increasing capacity in traditional vehicles is subject to model and geographical restrictions related to overcapacity.

In the services sector, the CAI needs to be compared to China's WTO commitments under Mode 3. This comparison shows three main improvements from the CAI.

First, China completely opens to foreign investment in eight sectors that were previously closed in its WTO schedule: veterinary services, services related to management consulting, placement and supply services of personnel, telephone answering services, money broking, motor-vehicle financing by non-bank financial institutions, sporting services, and supporting services for rail transport.

Second, China partially opens to foreign investment in 11 sectors that were previously closed in its WTO schedule: database services, R&D services for natural sciences, interdisciplinary R&D services, printing and publishing, market research and public opinion polling services, trading of derivative products including futures and options, asset management, hospital services, entertainment services, passenger air transportation services, and freight air transportation services. In these activities, China retains some limitations on market access, such as joint-venture requirements.

Third, in most other sectors for which China had previously made only partial commitments, the obligation to form joint ventures has been removed. The main exceptions are some audio-visual services, most telecommunications services and all educational services, where China's concern seems to be more political than economic[11].

A detailed comparison of China's services commitments with those already available to foreign investors under the FIL lies beyond our scope. It is worth noting, however, that in some sectors for which the European Commission claims significant progress on market access, such as telecommunications services, joint-venture requirements remain, and, in the case of hospital services, so do geographical limitations. There is also a complete prohibition on the provision of internet access services.

In conclusion, the CAI appears to give only modest new market-access opportunities to EU investors in China compared to the current situation. What it does, however, is to give them the certainty that the big improvements of recent years in market access and national treatment, as reflected in successive FILs, will not be reversed unilaterally by China.

The removal of the obligation to form joint ventures in most sectors is of special importance, as it is related to the thorny issue of forced technology transfer, which we discuss in the next section.

Does CAI improve rules and the level playing field for EU firms in China?

Being able to access the Chinese market in the framework of an international treaty is obviously important for EU investors, but often they face additional problems in China that the CAI tries to remedy. We focus on four important issues: forced technology transfer, state-owned enterprises, subsidies and standard setting.

CAI bans forced technology transfers in covered sectors

European and other foreign companies established or seeking to establish in China have long complained that China uses foreign ownership restrictions, including joint-venture requirements, to force them to transfer technology (TT) to Chinese entities. China's WTO commitments have been of limited help in tackling this.

In goods sectors, WTO rules apply to trade but not FDI. Hence, in these sectors, China is free to apply ownership restrictions to foreign companies that may lead to unfavourable TT arrangements for foreign investors. In services sectors, WTO rules apply to FDI, but only to the extent that WTO members have assumed specific obligations under GATS Mode 3.

As discussed above, China has assumed some Mode 3 obligations in the schedule of concessions for services attached to its Protocol of Accession to the WTO, but some major sectors are excluded, and in some covered sectors, the establishment of foreign firms is conditional on entering into a joint-venture arrangement with a Chinese entity, which may lead to forced TT.

Given the limited ability of current WTO rules and commitments to deal with the problem of forced TT in China, some of its trade and investment partners, primarily the United States, China's Asian neighbours and the European Union, have sought bilateral or regional solutions.

It is important to note that in the 2019 FIL, China responded to these concerns by outlawing forced TT. As in the case of many market-access provisions, however, this falls short of a commitment enforceable under an international treaty.

The CAI agreement comes on the heels of efforts to impose disciplines on forced TT on China under the Trans-Pacific Partnership/Comprehensive and Progressive Agreement for Trans-Pacific Partnership (of which China is not a member but which had China in mind), and the China-US Phase One agreement. CAI contains the strongest language yet in that regard.

Specifically, CAI contains an obligation for the parties not to *"impose or enforce any requirement or enforce any commitment or undertaking … to transfer technology, a production process, or other proprietary knowledge to a natural person or an enterprise in its territory."*

As noted by Mavroidis and Sapir (2021), the words 'impose' or 'enforce' are crucial. They imply that states (the parties to the agreement) cannot impose TT requirements on foreign firms that want to invest in their jurisdictions and that, in case such firms decide to do business in their jurisdictions through a joint venture, the local partner will not be able to enforce any commitment for TT that it may have extracted from the foreign partner as a condition for the joint venture.

In principle, therefore, even when joint-venture requirements continue to apply, Chinese companies will no longer be able to force unwanted technology transfer on their EU partners. If enforced properly, this measure, which applies to permitted investment in both goods and services sectors, would be a major advance for EU firms investing in China.

CAI makes headway in dealing with the problem of unfair competition from (SOEs)

For the first time in an international agreement to which China is a party, CAI contains a precise and comprehensive definition of SOEs, by applying rules to SOEs at all levels of government, including local government, and by improving transparency.

State-owned enterprises are omnipresent in the global economy and the WTO agreement places no restriction on their operation, provided they operate on a commercial basis. However, well before China's WTO accession, and increasingly since, concerns about the competitive distortions caused by China's large and opaque SOE sector have been prevalent.

At the time of China's WTO accession, SOEs accounted for a large share of economic activity in China They still account for between 23 percent and 28 percent of GDP in China today (Zhang, 2019), compared to about 15 percent in the EU.

Surprisingly, given these concerns, China's accession protocol to the WTO (henceforth 'the protocol') includes only a few paragraphs that relate to SOEs.

The main thrust of China's commitments were: a) SOEs would buy and sell only based on commercial considerations and the government would not directly or indirectly influence SOEs' commercial decisions; b) any subsidy to a SOE would be considered specific, hence actionable; c) SOEs would be responsible for their own profits and losses; d) China will notify any subsidy given to an SOE.

A notable omission from the protocol was a definition of an SOE, which proved a cause of confusion and major disputes. The CAI refers to SOEs as 'Covered Entities', and establishes criteria to recognise them. These criteria

go beyond full or majority ownership to include the power of the state to appoint directors and to control the decisions of the enterprise through *"any other ownership interest"* or even without *"any ownership stakes."*

Firms granted monopolies by the state are also defined as SOEs. The definition applies at *"all levels of government"*, which includes the operation of SOEs owned by local and regional government.

Under Section 2 Article 3 of the CAI, covered entities must *"act in accordance with commercial considerations in the purchases and sales of goods or services in the territory of the Party …"* and not discriminate.

The CAI does not include specific provisions on notification of subsidies to SOEs (or by SOEs). Instead, subsidies to SOEs are covered under the new notification requirement (services) and under 'Consultations' in the Article on Transparency of Subsidies (for goods and services), which apply to all enterprises.

However, the CAI establishes a procedure through which a party can demand information about a subsidy, or on an entity that is believed to be subsidising, where it believes its interests are being adversely affected.

The information that the requested party must provide is detailed in CAI Section 2 Article 4, and it includes information on ownership, the entity's revenue, the size of the subsidy and its purpose.

Compared to recent trade agreements involving China, the CAI section on covered entities is an improvement. Neither the China-US Phase 1 Agreement nor RCEP includes disciplines on SOEs. China was not a party to the negotiations of the US-led and subsequently abandoned Trans-Pacific Partnership (TPP).

However, Chapter 17 of that agreement covers SOEs and was designed partly with China in mind. It is sometimes referred to as the gold standard on SOE disciplines. Thus, it is no mean achievement that the scope of SOE commitments under the CAI is similar and compares quite favourably with those of the TPP's successor agreement, the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP).

In fact, whereas the TPP's provisions apply only to central government, the CAI's apply to all levels of government, a significant improvement given the importance of China's province- and local government-owned enterprises. Moreover, the CAI definition of SOEs is more encompassing than that of the TPP, including SOEs for which the government can control decision-making. However, the TPP demands more transparency than the CAI, since it obligates the parties to provide a list of all SOEs within two years of ratification of the agreement.

CAI provides new disciplines on subsidies in the covered service sectors

The CAI's disciplines on subsidies in services represent a major improvement since the WTO only covers subsidies in goods trade.

Overseas investors in China have long complained of a lack of transparency and unfair competition from subsidised Chinese entities. Subsidy disciplines under the Agreement on Subsidies and Countervailing Measures (SCM) and China's accession protocol date back to when China was a relative minnow in global trade.

As China rose to be the world's largest trading nation, dissatisfaction with aspects of these agreements grew. The dissatisfaction is heightened by the increasing importance of services in global economic activity and trade, since WTO disciplines do not cover subsidies in services, only goods. The intention to negotiate disciplines on subsidies in services was included in Article XV of GATS, but these negotiations never took off.

The most important innovation of CAI is to cover subsidies in the eligible services sectors covered by the CAI. However, the CAI's enforceable provisions relate only to transparency (notification) and consultation relating to subsidies.

If a subsidy above a certain size is found to exist, the subsidising party is not required to remove the subsidy or to accept the complainant's countervailing measures, only to use its best endeavours to find a solution. The relevant paragraphs in section 3 (Regulatory Framework), Article 8 (Transparency of Subsidies) read:

> *Paragraph 7. If the requesting Party, after the consultations have been held, considers that the subsidy concerned has or could have a significant negative effect on the requesting Party's investment interests under this Agreement, the requested Party shall use its best endeavours to find a solution with the requesting Party. Any solution must be considered feasible and acceptable by both Parties.*

And,

> *Paragraph 10. Paragraph 7 shall not be subject to Section X (State to State Dispute Settlement).*

Neither the China-US Phase 1 nor RCEP include new provisions on subsidies, so the CAI is a step forward.

It is also instructive to compare the CAI to the WTO subsidy reforms proposed in January 2020 by the EU as a member of the Trilateral Group, which includes Japan and the United States. The Trilateral Group does not mention China specifically, but the group's proposals have China very much in mind[12].

The Trilateral Group proposals relate only to industrial subsidies, not services, but most of the proposals could be directly applied in services as well.

In addition to calling for a clear definition of SOEs, which the CAI provides, the Trilateral Group proposed a set of far-reaching subsidy reforms, none of which are envisaged in the CAI, at least explicitly.

For example, the Trilateral Group proposals would extend the list of prohibited subsidies to cover state guarantees. The Trilateral Group also proposed that subsidies that are not notified are deemed illegal if they are counter-notified and no written explanation is forthcoming.

The implicit reference to China is clearest in the Trilateral Group's proposal to change the way subsidies are calculated, namely, to replace the use of domestic prices with appropriate benchmarks when the market of the subsidising member is distorted.

In conclusion, while the CAI includes important steps forward in subsidy disciplines, deeper reforms, such as those envisaged by the EU and its partners in the Trilateral Group, remain a work-in-progress.

CAI helps EU firms participate in Chinese standard setting in covered sectors

Technical regulations and standards are important features of modern economic life, which can constitute barriers to international trade and investment. An important condition for foreign firms to have effective access to domestic markets is therefore participation in standard-setting bodies.

In the European Union, as elsewhere in the OECD, foreign companies have the same right to participate in standard-setting bodies as EU firms. The situation is different in China.

According to a report submitted in 2018 by the US authorities to the WTO[13], US companies and other foreign companies operating in China face two types of problems with respect to standard setting.

First, Chinese government officials in some cases reportedly have pressured foreign companies that want to participate in the standard-setting process to license their technology or intellectual property on unfavourable terms.

Second, China has continued to pursue unique national standards in several high-technology areas where international standards already exist, such as in telecommunications, wireless networks and information security.

So far, dealing with this problem has proved difficult. China's protocol of accession to the WTO contains no obligation on China regarding its standard-setting process. Nor does the US-China Phase One trade agreement. Only the RCEP agreement mentions standard setting, but simply to encourage the exchange of information between the relevant national bodies.

The CAI is clearly innovative here. It commits the two parties to allow foreign enterprises that are covered by the agreement *"to participate in the development of standards by [their] central government bodies, including related standardisation working groups and technical committees at all levels, on terms no less favourable than those it accords to its own enterprises, including its covered entities."*

This commitment is much more valuable to EU firms operating in China than to Chinese firms operating in the EU, since the former currently face much more difficulty than the latter in participating in standard-setting bodies. But it is also a guarantee for Chinese firms that they will continue to be treated like EU firms by government bodies in the EU.

It should be noted, however, that the obligation to treat foreign firms no less favourably than domestic enterprises only applies to government standard-setting bodies. In the case of local and non-governmental bodies, the parties have only an obligation to recommend that they provide such treatment.

Enforcement

Obviously, commitments are only worthwhile if they can be enforced. The CAI's market-access and level playing field commitments are enforceable via a state-to-state dispute resolution mechanism, as in the EU's trade agreements with other nations.

In case of a dispute, and if the parties fail to reach an agreement through consultations, the complaining party may request the establishment of an arbitration panel. If the panel rules in favour of the complainant and the respondent fails to abide by the decision of the panel and remove the disputed measure within a reasonable period of time, the complaining party may retaliate by adopting an equivalent measure.

No international treaty is fool proof, of course, and all treaties depend on the willingness and ability of contracting parties – sovereign nations – to abide by their terms.

China's record on compliance with its trade treaty obligations, notably in the WTO, is no better or worse than that of other nations. It is worth noting, however, that China has been the subject of many WTO disputes and it has a strong record of compliance with decisions of panels and the Appellate Body when they ruled against it.

The impact of CAI on the global trading and investment system

China is now the world's largest trading nation in goods, and among the fastest growing. The main systemic implication of the CAI is that it strengthens disciplines on China's idiosyncratic economic system in important areas.

As the European Commission has claimed, the CAI is sui generis, an entirely new type of bilateral investment agreement which covers market access in both the goods and services sectors. Previous bilateral investment agreements – of which there are currently over 2000 in force – cover only investor protection (for example, against expropriation and prohibitions on profit repatriations), not market access.

As mentioned, market access through foreign investment in the goods sector is not covered under the WTO, and nor is it covered in China's accession protocol.

In contrast, market access through foreign investment in the services sector is governed under GATS Mode 3 (foreign establishment), negotiated in the Uruguay Round. As discussed in the previous section, China made modest services commitments under Mode 3 in its Protocol, which the CAI deepens and extends.

Thus, a notable systemic implication of the CAI is that it may pave the way for new types of bilateral agreements that make international investment in goods and services more open and predictable. This may include progress in the stalled investment negotiations between the US and China.

The CAI covers many, but not all, services sectors, and excludes treatment of trade under Modes 1 (cross-border), 2 (consumption abroad) and 4 (presence of natural persons).

Therefore, it does not conform to the conditions allowing for an exception to the non-discrimination principle, envisaged for regional trade agreements under GATS Article VI (parallel to GATT Article XXIV).

It follows that China's and the EU's commitments in services must be extended to all WTO members, under the MFN provision (GATS Article II). Thus, another notable systemic implication of the CAI is that it not only binds and

enhances liberalisation of foreign establishment in two of the world's largest economies, but this is to the benefit of all WTO members, not just the EU.

However, since investment in goods is not covered by the WTO, CAI provisions on market access in the goods sector are not MFN, and only benefit the EU.

From a WTO perspective, the CAI has some negative and some positive features. The negative feature is that the CAI, because of its bilateral rather than multilateral nature, favours EU over other foreign investors in China, since some of its provisions only apply to EU firms.

The most important positive feature is that it advances disciplines in transparency, subsidies, technology transfer and SOEs among two of the world's largest economies, disciplines which could potentially be incorporated at some stage in the WTO, based on plurilateral or multilateral negotiations involving other WTO members besides the EU and China.

Also potentially important for the WTO are the CAI's sustainable investment provisions, which cover labour and environmental standards. Such provisions are commonly included in the EU's and the US's bilateral or regional agreements.

However, this is the first time that they have been adopted by China, which has been among the leaders of the developing country resistance against including these disciplines in WTO agreements.

Other systemic implications of CAI can be seen from the perspectives of the world's three largest economies: China, the United States, and the EU.

China

By adopting the CAI, China has shown that it is willing to consolidate (bind) its progress on investment liberalisation under its FILs into an international treaty, and that it intends to continue to confront Chinese firms with world-class competition on their own turf.

In the covered services sectors, the liberalisation is far from complete but affects all foreign investors, not just those from the EU. In goods sectors, the liberalisation has been far-reaching but is internationally bound only as it concerns European firms.

However, since these include many of the world's largest multinationals, the competitive effects on Chinese goods markets could be far-reaching.

Moreover, by agreeing to disciplines on transparency about subsidies, SOEs and forced technology transfer, China has taken another step towards promoting 'competitive neutrality' between firms that are state-owned (or state-influenced) and private firms, including both Chinese and foreign firms[14].

Considering the commitments that China made on technology transfer and intellectual property protection in its Phase One deal with the United States, with the CAI China is also signalling, both at home and abroad, that it wants to deal with the major concerns raised by foreign firms competing in China or with Chinese firms on overseas markets.

Although China gains little in new market access in the EU (in the market for renewable energy equipment, for example) it scores other important wins. At a time of great trade tensions, the EU binds its commitment to receive Chinese foreign investment with very few limitations.

This would not, however, prevent the EU from restricting market access to a Chinese company in case an arbitration panel found that it received state subsidies or acted not in accordance with commercial considerations.

In combination with the conclusion of the RCEP negotiations with Asia-Pacific partners, China is showing through the CAI that it is becoming more integrated in global markets and will not be isolated even in the face of potential continued US hostility.

China's unilateral liberalisation and level playing field reforms, consolidated in the CAI, send an important signal to foreign investors that they are welcome, and that China sees their contribution as important for its continued development.

The United States

There is an assumption[15] that the CAI pre-empts EU cooperation with the Biden administration in striking a tougher bargain with China. But it is far from certain, considering thorny China-US relations, that such a bargain was there to be had.

As it happens, by agreeing to a temporary suspension of tariffs under the Airbus-Boeing dispute, and in various other ways, the Biden administration has already signalled that it is keen on intensifying its collaboration with the EU on trade matters.

More importantly, the CAI clearly furthers US economic interests. The US benefits directly from China's services liberalisation under the CAI, including the elimination of joint-venture requirements in many sectors.

Even though the CAI's many provisions on transparency, including in subsidies, the definition of what constitutes an SOE, and the strong ban on forced technology transfer apply only to the sectors covered and only to the EU, they directly or indirectly address some of the United States' most important demands on China.

The Biden administration intends to hold China to its Phase One commitments, and – when and if it decides to embark on Phase 2 negotiations – will have the opportunity to coordinate with the EU its position on the outstanding level playing field issues.

The EU

The EU's new commitments under the CAI are limited, since its market is largely open and disciplines on subsidies, for example, are already strict. Moreover, as the European Commission has stressed, the EU retains its instruments to screen inward investment from China and elsewhere for any violation of its competitive neutrality criteria.

The CAI does, however, demonstrate the EU's capacity to negotiate successfully and independently with China. In concluding the CAI negotiations, the EU has signalled clearly that it has no intention to decouple from China, a course that some radical factions in the United States and elsewhere advocate.

The CAI is both innovative and supportive of the world trading system, in a manner that the highly discriminatory 'managed trade' Phase One deal was clearly not. This result was achieved even though the EU had little to give that is new to China beyond binding its investment liberalisation.

Since the entry into force of the Lisbon Treaty in December 2009, EU trade and investment policy must 'be guided' by fundamental EU principles, including human rights, labour rights and environmental protection.

The CAI's sustainable investment clauses are an important victory for the EU and a major concession by China since – as mentioned – none of the trade agreements it has signed so far, including the RCEP, contains a sustainability clause. The SI chapter legally obliges the parties to the CAI to *"effectively implement the ILO Conventions it has ratified and …[to] make continued and sustained efforts on its own initiative to pursue ratification of the fundamental ILO Conventions No 29 and 105 [on forced labour], if it has not yet ratified them."*

In case of disagreement between the parties regarding the fulfilment of their sustainable-investment obligations (which cover not only labour, but also corporate social responsibility, the environment and climate change) the matter will be referred to an independent expert panel.

The sanction for not respecting sustainable-investment obligations is not retaliation like with market access commitments, but naming and shaming through the publication of the expert panel's report. This may help China enforce its sustainable-investment obligations, to the extent that it cares about its international image and standing.

Conclusion

The CAI is far from a perfect deal, but from an economic viewpoint, it is an important agreement, and one worth having. The CAI falls short of the high expectations set at the time the negotiations were launched in 2014. It is a work in progress, and its provisions relating to investment protection, which were intended to replace the BITs between China and EU member states, remain to be negotiated over the next two years.

In contrast to some of the Commission's claims, the CAI makes only modest advances in new market access relative to that established under China's succession of FILs.

However, it consolidates that level of access in an international treaty. Under the CAI, EU firms will have predictable and, in principle, largely unfettered access for investment in goods and more predictable access in services, where many impediments remain.

Joint-venture requirements are eliminated in goods and in many service sectors, thus largely reducing the possibility of forced technology transfers. Also, new rules on subsidies, SOEs and transparency – though still incomplete – level the playing field for EU firms and improve their ability to achieve sustained profitability in China.

As the first liberalisation investment-only agreement, the CAI is innovative and of considerable systemic significance, as it tightens the disciplines on China's socialist market economy and improves the chances that it will become better integrated into the world trading system. The CAI opens new avenues for improving WTO rules on SOEs and subsidies, and for negotiating bilateral investment agreements that include market access.

The CAI addresses fundamental concerns about Chinese behaviour shared with the United States, the EU's most important ally, and directly promotes the United States' economic interests by consolidating its market access in China's services sector.

If divisions over human rights and geopolitical competition can be bridged, both the EU and China will derive considerable economic benefits from the agreement, and the prospects for sustaining an open and predictable world trading system will improve. ■

Uri Dadush is a Non- Resident Fellow, and André Sapir a Senior Fellow, at Bruegel

Endnotes

1. The text of the agreement and its annexes can be found here: https://trade.ec.europa.eu/doclib/press/index.cfm?id=2237

2. For an extensive discussion of the 2019 FIL, see World Bank (2020).

3. Some of the sceptics are Beattie (2021), García-Herrero (2021), Godement (2021) and Gros (2021).

4. According to the OECD's website, the FDI Index measures statutory restrictions on foreign direct investment in 22 economic sectors. It gauges the restrictiveness of a country's FDI rules by looking at the four main types of restrictions on FDI: foreign equity limitations, discriminatory screening or approval mechanisms, restrictions on the employment of foreigners as key personnel, and other operational restrictions, such as restrictions on branching and on capital repatriation or on land ownership by foreign-owned enterprises. Restrictions are evaluated on a 0 (open) to 1 (closed) scale. The overall restrictiveness index is the average of sectoral scores.

5. The seven countries with a higher FDI index than China are: Libya (0.713), Algeria (0.587), Philippines (0.374), Indonesia (0.345), Thailand (0.268), Russia (0.261) and Malaysia (0.252).

6. The only manufacturing sector for which China made a multilateral commitment at the time of its entry to the WTO in 2001 was the automotive sector, with China granting limited market access. Foreign firms still needed authorisation to invest in the automotive sector in China and were required to enter a joint-venture arrangement with a local partner, but they were given freedom to choose the categories, types and models they wanted to produce.

7. A partial exception is the Agreement on Trade Related Investment Measures (TRIMS) which forbids setting conditions on inward FDI such as local content or export requirements. The TRIMS agreement covers only goods.

8. See WTO Document MTN.GNS/W/120/ of 10 July 1991.

9. See Protocol of Accession of the People's Republic of China (WT/L/432), and the People's Republic of China Schedule of Specific Commitments (GATS/SC/135).

10. In terms of broad economic sectors, the 22 fully liberalised sectors under Mode 3 in China's accession protocol include: 9 business services, 6 transport services, 3 distribution services, 2 financial services, and 2 tourism and travel services. At

the other extreme of the spectrum, the 65 sectors with no commitments under Mode 3 in China's GATS schedules include 23 transport services, 15 business services and 9 financial services; there are also no WTO commitments under Mode 3 by China in health services, and recreational services.

11. China will also continue to apply joint-venture requirements in three financial services sectors and three transport services sectors.

12. The EU's announcement of the Trilateral Group proposals is available at: https://trade.ec.europa.eu/doclib/docs/2020/january/tradoc_158567.pdf

13. See WTO Document WT/GC/W/746 of 16 July 2018.

14. See García-Herrero and Ng (2021) for a discussion of SOEs and competitive neutrality in China.

15. Including on the part of those who view the deal sceptically (see footnote 3); see also, for example: https://asiatimes.com/2020/12/europe-hurried-to-sign-china-pact-to-preempt-biden/

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A new template for the European fiscal framework

The European fiscal rules have been suspended to enable member states to combat the COVID crisis. Martin *et al* argue this is an opportunity for ambitious reform of a now clearly outdated fiscal framework

This column, part of the Vox debate on euro area reform, argues that the reactivation of the rules, now foreseen in 2023, should be made contingent on a political agreement on reforming the fiscal framework, and proposes a comprehensive reform in which the new European fiscal framework would prioritise externalities arising from debt sustainability risks and demand spillovers.

Fiscal targets should be differentiated depending on country vulnerabilities and implemented in a more decentralised way.

We propose a comprehensive reform in which the new European fiscal framework would prioritise externalities arising from debt sustainability risks and demand spillovers. Fiscal targets should be differentiated depending on country vulnerabilities and implemented in a more decentralised way. We provide a detailed economic and institutional roadmap for this reform.

We are no longer in the world of Maastricht

Since the Maastricht Treaty, the European fiscal rules have been constantly revised (without significant Treaty changes) but overall, the underlying framework has remained the same. Even before the COVID-19 crisis, many economists and officials were calling for its reform (eg. Bénassy-Quéré *et al*. 2018, Darvas *et al*. 2018, Feld *et al*. 2018, Thygesen *et al*. 2018).

The post-COVID context results in a disconnect between these rules and four new facts: higher public debts, very low or even negative interest rates, limited effectiveness of monetary policy in the vicinity of the effective lower bound, and common debt issuance with the adoption of the European recovery plan in 2020.

In this context, the role of fiscal policy in reducing both temporary and persistent demand deficits must be reassessed. This has strong implications for the euro area, where this role has been codified on a premise that now appears to be obsolete. Echoing Mario Draghi's 2014 call for a *"greater role"* for fiscal policy alongside monetary policy (Draghi 2014),

ECB Executive Board member Isabel Schnabel recently advocated rethinking the relationship between monetary and fiscal policy when interest rates can no longer be reduced, saying that *"effective macroeconomic stabilisation in the vicinity of the lower bound requires both unconventional monetary and fiscal policies"* (Schnabel 2021).

The case for a comprehensive overhaul of the fiscal rules

In a recent French Council of Economic Analysis paper (Martin *et al.* 2021), we argue that to be effective, an overhaul of the rules should address two main fiscal externalities. The first, which was at the heart of the euro area crisis,

We believe that the European economic policy system must learn all the lessons of the new economic and financial environment

is the risk to the area's financial and monetary stability posed by sovereign insolvency and, even more so, by the possible exit that could follow.

The rules should tackle the insolvency risk resulting from excessive debt, not the threats resulting from self-fulfilling expectations, which are and should remained addressed by the ECB (Farhi and Martin 2018).

The second externality, which was largely neglected in the design of the EMU, pertains to aggregate demand. As long as fiscal support to aggregate demand is called for and no central budget exists to take on this role, the impact of national fiscal policies on partner countries must be considered.

This externality was long considered secondary because of opposite spillover effects through the goods and capital markets, yet it is significant when the central bank's policy rate can no longer be reduced due to the effective lower bound.

While the need for reform is increasingly recognised, its nature remains fiercely debated. Blanchard *et al*. (2021) call for replacing budgetary rules by qualitative standards. They propose to get rid of all numerical criteria, to replace them with the sole principle that member states *"ensure that their public debts remain sustainable with a high probability"* and (in the most streamlined version of their proposal) to replace the mechanism of gradual sanctions by the standard EU procedure of action by the Commission before the Court of Justice.

We agree on the focus on sustainability and on removing the multiple numerical criteria that have accumulated in the European fiscal framework. However, we consider a complete break with the Pact as unrealistic.

Country-specific debt targets

We do not propose to rewrite the central provisions of the Treaty on the Functioning of the European Union (TFEU). This applies first of all to Article 126 (*"Member states shall avoid excessive government deficits"*), including the gradual pressure its procedures entail and the possibility – never used – of financial penalties. We regard a gradual peer pressure mechanism as appropriate in a context where excessive public debt may have adverse effects on partner countries.

Similarly, we do not propose to eliminate the central provision of Article 121 (*"Member states shall regard their economic policies as a matter of common concern and shall coordinate them within the Council"*) on which the preventive arm of the Stability Pact was built. Neither the spirit nor the letter of this article prejudges the nature of externalities or the desirable direction of national policies.

However, we believe it is essential to at least de facto (and in time de jure) remove the uniform numerical thresholds for the debt (60% of GDP) and the deficit (3% of GDP) indicated in the Protocol 12 annexed to the TFEU. The debt threshold sets a target that is too far removed from reality and lacks analytical foundations.

Uniform numerical criteria are misplaced because debt sustainability depends fundamentally on the differential between the interest rate and the growth rate and on a state's capacity to maintain a sufficient primary surplus. These determinants of debt sustainability are all very much country-specific.

We therefore propose that each government sets a medium-term debt target, the appropriateness of which would be first assessed by the domestic independent fiscal institution (IFI) on the basis of a common methodology, monitored by the EFB, and second endorsed (or rejected) by the EU.

This target should be explicitly based on estimates of the maximum primary balance and the risks to the interest rate–growth rate differential.

Once debt targets have been set, they should serve as anchors for expenditure rules. The path for primary nominal expenditure net of new discretionary tax measures (and excluding automatic stabilisers on the expenditure side) would be determined accordingly.

Our proposal would change the hierarchy of objectives. So far, the deficit criterion has in most cases been given priority over the debt criterion. We would instead give priority to a country-specific debt target and de-emphasise the primacy of the deficit criterion.

Legally speaking, the reference value for public debt mentioned in Article 126 would need to be interpreted as country-specific rather than uniform. Ultimately, this would require amending Protocol 12, which can be done by unanimous agreement.

We do not favour introducing a golden rule that would treat investment expenditures differently from other public expenditures, as the distinction between investment expenditures and other growth-enhancing expenditures would raise endless discussions.

Nevertheless, it will be the role of the IFIs and of the EU to take into account the impact on potential output of public investment in a broad sense. The assessment of public finance sustainability should also consider the time profile of climate investments in order to ensure they are not postponed.

Space for discretionary policy

Because discretionary fiscal policy has an important role to play in a regime of low interest rates and as long as the sustainability objective is not at risk, the fiscal framework should leave room for active demand management. A possibility would be to apply a common flexibility factor to national expenditure rules. However, this would not prevent member states from running excessively tight fiscal policies in a slump.

The Recovery and Resilience Facility (RRF), introduced in 2021 to respond to the pandemic shock, could serve as a template for a new European fiscal instrument. It would not be a budget, and the stabilisation of business cycles would continue to rely on monetary policy and on the member states' fiscal policies.

Nevertheless, the experience with the RRF could serve as a basis for taking joint fiscal initiatives in response to crises leading to prolonged demand shortfalls or to a structural lack in public investment. This could take the form of a European instrument to finance specific public investment programmes by means of mutualised debt.

A new institutional framework

We propose a redefinition of responsibilities of both the IFIs and of the European Fiscal Board (EFB). We recommend strengthening the resources, independence and surveillance capacities of the national IFIs, in order to further anchor the culture of fiscal responsibility in domestic institutions. We propose that:

- the EFB defines a common methodology to assess national fiscal sustainability, and controls its implementation by the IFIs;

- each government sets a debt target and expenditure rule over a five-year horizon;

- the IFI assesses whether the government's debt target is compatible with the EU sustainability standards, and its detailed assessment is made public;

- the Commission recommends to the Council whether or not to endorse the national debt target and expenditure rule;

- the Council (in euro format) endorses or rejects the member state's fiscal targets; and

- the Commission monitors the implementation of the country-specific fiscal rule.

A detailed map of the institutional geography is given in Figure 1.

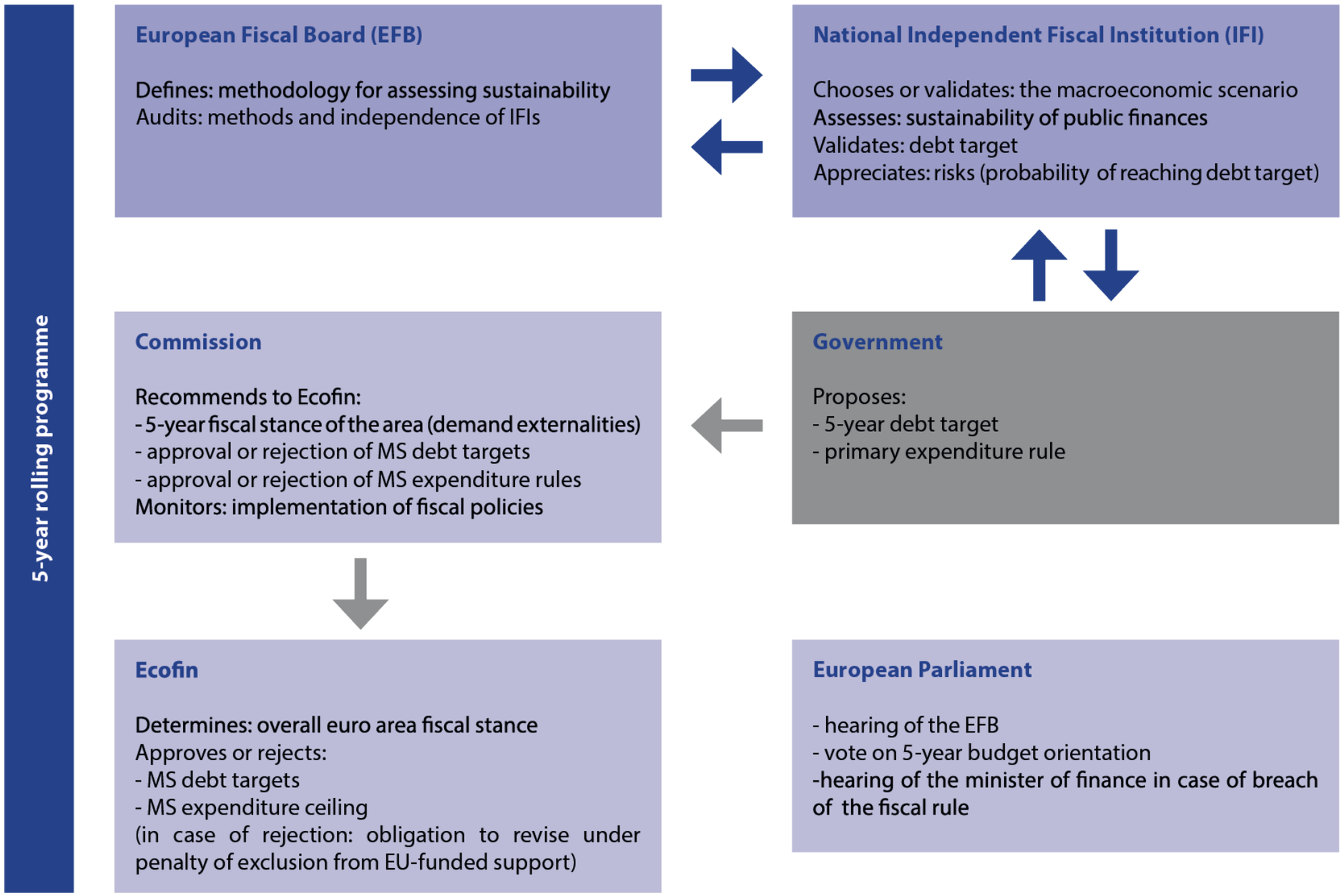
Enforcement

To remain effective, a more adaptable oversight system must rely on credible sanctions for violation of the sustainability requirement. On top of the approval of the debt target and the expenditure rule by the Council, we propose the excessive deficit procedure be triggered by a manifest violation of the country-specific expenditure rule.

Moreover, if the Commission assesses that the budget for the following year risks materially violating the expenditure rule, it should refer it to the Eurogroup, which would make its opinion public.

Finally, an adjustment account should be introduced that would keep the memory of past spending slippages (or past under-spending) and contain or permit future spending overruns.

Figure 1



On top of being legally powerful, analyses and pronouncements by the IFIs, the Commission and the Council will carry weight because these informed judgements on potential risks to debt sustainability would have financial consequences through impacting borrowing costs.

For the management of demand externalities, we propose that the Commission make a recommendation to the Council on the overall fiscal stance of the euro area, both at a one-year and five-year horizon, and that it recommend the reorientation of a fiscal policy (be it too restrictive or too expansionary) of a member state that would aggravate current account imbalances within the zone.

The Commission should also be entrusted with the responsibility of proposing the activation of exceptional support through the to-be-constructed common fiscal instrument.

Conclusion

The reforms we propose are substantial but compatible with the essential provisions of the European treaties. They aim to avoid policies that would endanger the stability of the euro area, whether through excessive debt or lack of fiscal support.

We believe that the European economic policy system must learn all the lessons of the new economic and financial environment. The reforms of the fiscal framework that we are proposing aim to make states both more autonomous in their fiscal choices, and more responsible. ■

ABOUT THE AUTHORS

Philippe Martin is Professor of Economics at Sciences Po, Chair French Council of Economic Analysis, and CEPR Vice

President and Research Fellow, Jean Pisani-Ferry is Tommaso Padoa-Schioppa chair at the EUI in Florence, Senior Fellow at Bruegel and the Peterson Institute and professor of economics at Sciences Po in Paris, and Xavier Ragot is CNRS Director and Professor at Sciences Po, Paris, and is currently President of the French Economic Observatory (Observatoire Français des Conjonctures Economiques, OFCE)

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Towards a green capital markets union

Christine Lagarde considers the European Union's transition towards a sustainable economy that will be backed by the growth of sustainable finance

When technology and finance unite around a common purpose, the consequences for monetary unions can be far-reaching. Let me borrow an example from US history. The economic and financial integration of the United States in the late 19th century owed a great deal to the new technology of railroads.

With a fragmented local banking system, the huge amount of financing needed for this project could only be mobilised via capital markets, notably in the form of railroad bonds. This, in turn, laid the foundations for the development of the US-wide financial system[1]. The railroads ended up linking not only the far-flung corners of the union, but also its capital markets.

If you allow me the analogy, I see some parallels between this period of US history and the EU's transition today towards a sustainable economy, backed by the growth of sustainable finance.

The shift to net zero emissions, together with an adequate digital backbone, will require major investments across Europe in technology, infrastructure and networks. Fragmentation between national financial markets might constrain our ability to finance future investments. But if green finance continues to emerge to fund this transition, the consequences for Europe's financial system could be sweeping.

In fact, I believe that the green transition offers us a unique opportunity to build a truly European capital market that transcends national borders – or what I would call green capital markets union (CMU).

And, like the railroads in the past, this could have ramifications for our monetary union that reverberate more widely. Integrating green capital markets could play a part in addressing two of the wider challenges we face today.

First, we face the challenge of making our monetary union more resilient to cyclical shocks. To achieve this, we must do better at reducing risks, and also at sharing risks across countries.

And second, we need to transform our economies as structural changes speed up around us. We must redirect activity towards the green and digital sectors as quickly as possible, which will help raise Europe's growth potential[2].

Addressing these challenges is important for the ECB, as they affect the transmission of our monetary policy across the euro area. They require parallel efforts on many different fronts. But a common thread is the need to enhance

Green CMU not only gives us a tremendous opportunity to craft something genuinely European and with immediate impact, but it also has the potential to transform the EU as a whole

the contribution of the financial sector, in particular by taking significant steps towards a capital markets union in Europe.

Integrated capital markets are at the heart of building resilience, because they encourage Europeans to invest in debt and equity irrespective of home country considerations. That, in turn, helps share the costs of local recessions, because financial losses in one part of the Union can be offset by gains in another. Scale and depth matter, as does a common regulatory framework.

At present, however, financial markets are less integrated in the euro area than in other large economies. Only around 20% of shocks in the euro area were mitigated through cross-border debt and equity holdings between 1999 and 2016, compared with at least 60% in the United States[3].

Capital markets are also vital to fund the transformation of our economies. We need to see investment of around €330 billion every year by 2030 to achieve Europe's climate and energy targets[4], and around €125 billion every year to carry out the digital transformation[5].

While banks can and should provide a good share of this funding, capital markets can provide innovative tools to close the investment gap. Capital markets are better suited to financing projects with a defined purpose, directly linking investors to the impact they intend to achieve. And they are also better at drawing retail investors towards supporting transformative activities[6].

Although we are making progress, thanks to the work of the Commission, completing a fully-fledged CMU will take time. Capital markets have developed nationally, so we first have to open them up and harmonise those markets in order to integrate them further.

This begs the question: how do we deepen capital markets faster? Are there market segments where fewer obstacles exist and where we can achieve high levels of integration quickly, but that also encourage the funding of future-oriented projects?

Developing European green capital markets

To my mind, Europe's green capital markets meet all these criteria. Green capital markets are dynamic and growing in Europe, and they are already relatively well integrated. This means that as they deepen further, so will Europe's resilience.

Europe is established as the location of choice for green bond issuance, with around 60% of all green senior unsecured bonds issued globally in 2020 originating here. And the market is growing rapidly – the outstanding volume of green bonds issued in the EU has grown almost eight-fold since 2015.

Environmental, social and corporate governance (ESG) investment is also concentrated in Europe. The assets under management of investment funds with ESG mandates have almost tripled since 2015, and over half of bond funds are domiciled in the euro area[7].

In addition, the euro has taken the lead as the global currency of green finance. Last year, around half of the green bonds issued worldwide were in euro. There is immense potential for this role to grow once the green transition takes off worldwide and we see a generational transfer of wealth to millennials who are bound to be concerned about the future.

Crucially, the green bond market has already achieved greater pan-European scale. Holdings of green bonds within the EU have, on average, half the home bias of conventional bonds.

And this means deepening the market is a different type of challenge. We do not need to undo the past – we need to create a new framework that did not exist before. So we have a real opportunity to build a genuinely European capital market from the outset.

Green capital markets could also act as a catalyst for the overall structural transformation of Europe, ensuring that it happens both quickly and evenly across EU countries.

These capital markets would not just add debt into the green finance mix, they would also add equity, which – as ECB research demonstrates – typically leads to more green innovation and a faster reduction in carbon emissions[8].

And they could spark the take-up of digital technologies such as smart urban mobility, precision agriculture and sustainable supply chains, which are crucial to the green transition[9].

With their pan-European reach, green markets could also help all countries to access the capital they need to finance economic transformation – not only those with the most sophisticated financial markets. That would support convergence within Europe, enabling capital to flow to regions that are currently lagging behind in the transition to a more sustainable economy.

In order to build momentum, the 'public sector dimension' should be part of the picture. The issuance of green bonds by governments will be key to funding major infrastructure projects, which in turn helps create a pipeline of projects for the private sector to invest in. As part of the Next Generation EU fund, the European Commission will shortly be placing €225 billion of green bonds, making it by far the world's largest issuer.

Towards Green CMU

I must stress, however, that the continued growth of green capital markets will not happen by itself. We will at some point hit the same limits that now restrict the integration of our broader capital markets – missing cross-border infrastructures and national constraints.

If the EU cannot provide the services that foreign investors and issuers are looking for, they will go elsewhere. In fact, we know from history that deep and liquid capital markets are key to a currency gaining global status. If others move faster than we do, the euro's advantage as the global green currency could fade and be lost. The euro would miss an opportunity to strengthen its international role.

So in my view we should reinforce the CMU agenda by supporting the development of Green CMU. Specific initiatives under the CMU action plan should be fast-tracked – even if they are applied only to sustainable finance for now.

A key element is indeed the Commission's proposal on corporate sustainability disclosures. I strongly welcome this proposal and believe it can finally address the main data gaps currently afflicting the EU's sustainable finance landscape.

It will also be a key pillar of the Commission's forthcoming proposal for a European single access point. By integrating sustainability disclosures with financial data, we would create a 'one-stop shop' for all critical information about a company, including its green credentials, which would be immensely useful for investors. But more fundamental reforms will also be necessary.

We need proper European supervision of green financial products with official EU seals such as the forthcoming EU Green Bond Standard[10]. This is key to ensuring compliance and to identifying systemic links and associated risks within the cross-border market.

We also need harmonised tax treatment of investments in sustainable finance products, so as to prevent fragmentation of green investments along national lines. And we need further convergence in the efficiency of national insolvency frameworks, even carving out special procedures for green investments.

These initiatives can be seen as an engine for the CMU project generally, testing and putting in place some of the measures that are needed to advance wider capital market integration. If we succeed, there will be very positive knock-on effects for European capital markets.

In short, Green CMU not only gives us a tremendous opportunity to craft something genuinely European and with immediate impact, but it also has the potential to transform the EU as a whole.

It would allow us to make our economy more resilient to shocks and fit for the future, all while avoiding the worst scenarios for climate change. To my mind, that is too good an opportunity to pass up. ■

Christine Lagarde is the President of the ECB

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2. After five years, the estimated multipliers associated with green spending are about two to seven times larger than those associated with spending on non-eco-friendly projects. See Batini, N, di Serio, M, Fragetta, M, Melina, G and Waldron, A, (2021), "Building Back Better: How Big Are Green Spending Multipliers?", Working Paper No. 2021/087, March 2021.

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6. Brière, M and Ramelli, S (2021), "Can responsible investing encourage retail investors to invest in equities?", ECMI Commentary, No 73, European Capital Markets Institute, March.

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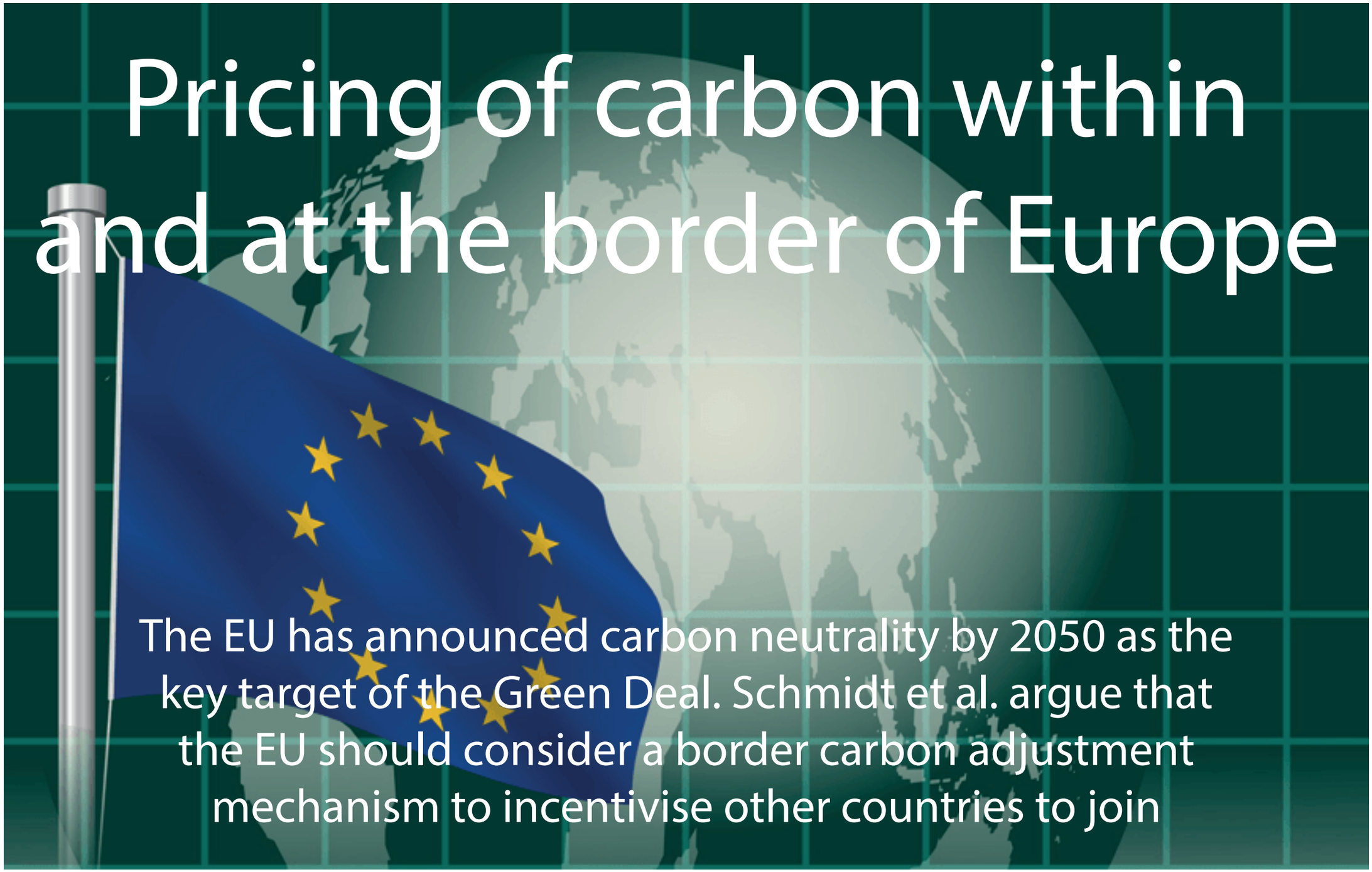
8. De Haas, R and Popov, A (2019), "Finance and carbon emissions", Working Paper Series, No 2318, ECB, September; Popov, A (2020), "Does financial structure affect the carbon footprint of the economy?", Financial Integration and Structure in the Euro Area, ECB, March.

9. In 2017, Europe had 76% more patents in the digital-green domain than the United States and over four times more than China. European Investment Bank (2021), Investment Report 2020/2021: Building a smart and green Europe in the COVID-19 era.

10. See the European Commission's website.

This article is based on a speech delivered at the European Commission's high-level conference on the proposal for a Corporate Sustainability Reporting Directive, Frankfurt am Main, 6 May 2021

Pricing of carbon within and at the border of Europe



The EU has announced carbon neutrality by 2050 as the key target of the Green Deal. Schmidt et al. argue that the EU should consider a border carbon adjustment mechanism to incentivise other countries to join

The EU has announced reaching carbon neutrality by 2050 as the key target of its Green Deal strategy. The best coordination signal in this endeavour would be a uniform and encompassing price on carbon. To ascertain that all goods consumed in the EU face the same carbon price, it would be sensible to credibly prepare the implementation of border carbon adjustments applied to imported goods.

This column argues, however, that the EU should refrain from exempting exports from carbon pricing, and should consider a border carbon adjustment mechanism only after having established a credible uniform carbon-pricing mechanism within its jurisdiction. This could provide incentives to other countries to join a far-reaching international alliance for carbon pricing.

The EU can become the world leader in the energy transition. It should be the explicit aim of this effort to provide the path towards an effective global approach to climate policy. To tap into a fruitful division of labour, research and investment projects entailing high European value added and policy instruments for setting incentives for the greening of the European economy should be coordinated at the European level.

Previous work by the French Council of Economic Analysis (CAE) and the German Council of Economic Experts (GCEE) (GCEE 2019, CAE and GCEE 2019), as well as the interdisciplinary work of the German national academies of science (acatech *et al*. 2020), advocated the pricing of carbon as the leading instrument of European climate policy.

Uniform carbon pricing: a cornerstone of European climate policy

As explained, for example, by Schlögl and Schmidt (2020), in the diverse and decentralised economic system that characterises the EU, the best coordination signal corresponding to this principle would be a uniform price on carbon that encompasses all actors, sectors, regions, and technologies. Separate pricing systems for different sectors or for different countries can only be interim solutions.

Correspondingly, while separate target values for sectors and member states can serve as important gauges of actual developments, it is not advisable to interpret them as binding restrictions. Voluntary participation by all member states in the uniform pricing mechanism might require financial transfers to member states whose energy systems still rely more heavily on fossil resources.

In principle, several pricing mechanisms could be employed to implement a uniform European carbon price – both price (taxes or surcharges) or quantity (emission certificates) schemes. As this already provides a functional and effective system, the best strategy would be widening the scope of the European Emissions Trading System (EU-ETS).

The EU can become the world leader in the energy transition. It should be the explicit aim of this effort to provide the path towards an effective global approach to climate policy

Currently, the EU-ETS only covers the industry and energy sectors, and it is pursuing a joint European reduction target for these sectors. For other sectors, the burden-sharing agreement instead stipulates a set of national target values for 2030. With this compartmentalised approach, the EU is foregoing any possibility to enact the principle of division of labour in emissions reduction.

It might be sensible to fortify the EU-ETS with a minimum price floor over an extended time horizon, and also to engage in an extensive reform of national energy taxes and surcharges to support the uniform carbon pricing.

In practice, it will take time to integrate EU-ETS and non-EU-ETS sectors; the aim should be to form an integrated EU-ETS well before 2030 and, in parallel with this, to dismantle the multiple national climate policies. The longer the implementation of a uniform coordination signal by a fully integrated EU-ETS takes, leaving the coordination of transformation efforts in the non-EU-ETS sectors to separate (national) pricing schemes, the higher the overall cost of transition.

As long as carbon prices remain too low and limited in scope[1] the EU should regularly estimate and make public the shadow price of carbon that supports its climate ambition[2].

It should be used in the cost-benefit analyses that need to be conducted on its portfolio of existing non-price climate policies, such as bans, norms, standards, and subsidies. By providing additional public revenue, moving to carbon pricing will also help alleviate the regressivity inherent in climate policy.

This is a national responsibility of the member states (CAE and GCEE 2019), and this revenue would enable member states to fund redistribution schemes[3], energy price reforms and infrastructure investments, according to their individual preferences and institutions.

Arguably, Europe will only be able to contribute to the objective of reaching global climate neutrality if it manages to design its own transition path in a way that combines climate neutrality with unimpeded prosperity growth.

Taking action unilaterally is endangering the international competitiveness of energy-intensive European firms, which are facing serious competition from outside the realm of European climate policy ('carbon leakage').

So far, the EU-ETS has not led to serious carbon leakage problems, but the carbon prices emitters hitherto had to pay were moderate (aus dem Moore *et al*. 2019). It seems likely that this innocuous result will change at the higher carbon prices that will correspond to the ambitions of the Green Deal.

Climate neutrality and the European Green Deal: great ambitions

In December 2019, the European Commission proclaimed the European Green Deal as its principal growth strategy, announcing as its key target reaching carbon neutrality for the EU by 2050 (European Commission 2019).

This ambitious long-term objective has important repercussions for the EU's climate target for 2030; Europe is set to pledge to cut emissions by some 55% compared with their 1990 levels, a substantial accentuation of the previous target of 40%. The Green Deal comprises a wide range of measures to cut emissions in areas such as energy systems, mobility, heating, and agriculture. Most importantly, the Commission is considering the implementation of an encompassing carbon-pricing mechanism covering all relevant sectors.

To implement uniform carbon pricing, the Commission announced its intention to widen the scope of the EU-ETS by 2021 to beyond the industry and energy sectors (European Commission 2020a). The ensuing uniform carbon price would serve as the desperately needed principal coordination signal for the massive public investment and, to an even larger extent, private investment needed to meet the more ambitious European climate targets by 2030.

Arguably, carbon prices will have to rise steeply over time in order to meet these targets (Gollier 2021). Moreover, their effect in incentivising investments today already stands and falls with the credibility of their installation as an unalterable coordinating signal.

Until a fully integrated EU-ETS is implemented, reducing emissions in the non-EU-ETS sectors will remain a national affair. France and Germany, in particular, have so far not pursued a joint strategy for the non-EU-ETS sectors.

In previous years, with less ambitious transition objectives, the losses in terms of prosperity from disregarding possible efficiency gains were limited. With the announcement of the European Green Deal, however, the setting has changed dramatically: member states will have to increase their efforts to reduce emissions in the non-EU-ETS sectors.

To avoid these efforts being prohibitively costly, it is highly advisable to speed up the process of integrating national pricing schemes into the EU-ETS.

Steeply increasing (shadow) prices of carbon will endanger the competitiveness of European companies vis-à-vis their competitors that do not fall under the realm of the EU's ambitious climate policy. As the costs of those emissions-intensive domestic producers who are trading on global markets increase ever further, they might relocate increasing shares of their production to sites outside of Europe.

This carbon leakage would be harmful to European jobs and economic prosperity, and it would also hurt the overall cause of climate change mitigation, countervailing the EU's ambitions. The issue of how to incentivise other countries to adopt ambitious carbon emissions reduction targets through carbon pricing is therefore of utmost importance.

Under the EU-ETS, the international competitiveness of domestic producers has so far been protected quite successfully by the free allocation of certificates to emissions-intensive firms facing international competition in, for example, the steel, cement and chemical industries, based on a benchmarking system.

Yet, with increasing carbon prices this might change. Outsourcing decisions motivated by rising cost differentials would be difficult to reverse ex post, due to the long investment cycles in the industry sector. Thus, the aim should be to avoid these decisions ex ante. A promising alternative to the cost-free allocation of certificates may be the installation of a border carbon adjustment (BCA) mechanism.

New challenges: towards reducing carbon emissions from imports

The principal idea behind the BCA mechanism would be to levy a charge on imported goods equivalent to the carbon payment of the same domestically produced good.

Ideally, all goods consumed in the EU would face the same carbon price, irrespective of globally diverging climate policies. As it seems far too complicated to impose the BCA on all imported goods, the system could instead be restricted to very energy-intensive and very tradable goods.

Limiting the BCA to applying only to imports would, however, not address the distortion caused by less stringent climate policies outside the EU to the competitiveness of EU companies in external markets and, accordingly, would induce the risk of carbon leakage.

Alternatively, the EU might opt to implement a full-fledged symmetric variant of the BCA, in which exporters would receive a corresponding remuneration. Consequently, goods consumed abroad would face the carbon price

determined by the country where they are consumed. The system would then be reminiscent of a value-added tax, where imports are taxed and exports are exempt.

This is not the route to take: by implementing a symmetric BCA, the EU would contradict its own communication and forfeit control over the extent of carbon emissions generated in the region, since EU carbon pricing would only curb emissions caused by the production of goods and services actually consumed in Europe.

To preserve the EU's self-conception of taking responsibility for the global climate, it will be necessary to present the BCA not as a trade, competition or industrial policy, but as an environmental policy. Its proclaimed ultimate objective should therefore be reducing global carbon emissions, not increasing the competitiveness of European industry.

Thus, it should be restricted to applying only to imported goods. This fundamental dilemma between climate protection and preserving competitiveness would be less prevalent if the international alliance for carbon pricing were to grow, obviating the need to impose a BCA on products being imported from (and exported to) other members of this 'carbon club'.

Following the initiative of the French and German governments, the European Council has not only emphasised a BCA mechanism as an instrument to prevent carbon leakage, in contrast to our appraisal, but also announced in the conclusions of its meeting in July 2020 that starting from 2023, a BCA could be used as a source of revenue for the EU budget.

The explicit objective of the BCA should, however, be to induce a reduction of carbon emissions, not to serve as an instrument to raise public revenues. Contrary to a popular view, such a tax on imports would not be paid by foreign

producers; due to a high pass-through of import taxes, it is European consumers who would bear the majority of the burden.

While the principal idea of a BCA is reminiscent of the well-established concept of value-added taxes, a sizeable number of technical, regulatory, and legal challenges would have to be overcome (Mehling *et al*. 2019). Accurately measuring the carbon content of individual goods is far from easy (Droege and Fischer 2020), since one would have to capture all of the carbon emissions caused throughout the good's entire value chain.

This is costly, since for the same good there are many possible production processes with varying carbon intensities. Simply applying the benchmarks employed for the cost-free allocation of EU-ETS emission certificates is precluded, since those only measure the direct carbon emissions caused during the production process.

A related issue concerns the question of possible exceptions. Which exporting countries will be subject to the BCA – all countries outside the regulated area, or just countries with no 'equivalent' climate policy? If the EU opted to take the latter approach, it would have to make up its mind on how to define an equivalent climate policy.

While, in principle, this could be a policy inducing at least a shadow carbon price of similar magnitude as in the EU, in a real-world application it is very difficult to estimate the underlying carbon value of the wide range of implemented regulatory measures. It will therefore be difficult to prevent countries subject to the tax considering it as a political choice, and therefore contesting it.

Furthermore, if the EU would not only be levying charges on imported goods but also offering rebates to exporters, this might also endanger conformity with GATT rules and lead to protracted trade disputes. This risk would be all

the more grave the more openly the EU views the BCA scheme as a device to ascertain economic competitiveness, instead of for global climate protection (Droege *et al*. 2018)[4].

Irrespective of the sophistication with which any legal obstacle might be circumnavigated, EU trading partners might interpret any unilaterally introduced BCA as a protectionist measure anyway (GCEE 2020). Nevertheless, it could be possible to implement a BCA mechanism that is compatible with the existing body of law (European Commission (2020b).

The chances of avoiding a severe trade conflict would likely rise substantially if the EU, instead of introducing the BCA unilaterally, were to take this action in a joint effort with other trading partners, especially the US.

However, the EU should consider a BCA mechanism only after having established a clear and credible uniform carbon pricing mechanism within its jurisdiction. This credibility is key to provide incentives to other countries, the US and China in particular, to join a far-reaching international alliance for carbon pricing (Nordhaus 2015).

Most specifically, trade partners could be invited to join the EU-ETS mechanism. The chances of a successful courtship will increase as the number of countries pricing carbon grows. ■

ABOUT THE AUTHORS

Christoph Schmidt is President, RWI Essen and CEPR Research Fellow; Marcel Fratzscher is President, DIW Berlin, Professor of Macroeconomics and Finance, Humboldt-University Berlin, and Member of the Advisory Council, Ministry of Economy of Germany; Nicola Fuchs-Schündeln is Professor for Macroeconomics and Development, Goethe University Frankfurt and CEPR Research Fellow; Clemens Fuest is President, ifo Institute, Professor of Economics and Public Finance at the

University of Munich, Director, CES, Executive Director at CESifo, and Speaker, EconPol Europe; Christian Gollier is Director, Toulouse School of Economics; Philippe Martin is Professor of Economics at Sciences Po and Chair French Council of Economic Analysis, CEPR Vice President and Research Fellow; Isabelle Mejean is Associate Professor of Economics at École Polytechnique; Xavier Ragot is Director at CNRS, Professor, Sciences Po, and President, Observatoire Français des Conjonctures Economiques; Katheline Schubert is Professor of Economics at University Paris 1 Panthéon-Sorbonne, and Associate Chair at the Paris School of Economics; and Beatrice Weder di Mauro is Professor of International Economics at the Graduate Institute of Geneva, Distinguished Fellow at INSEAD Emerging Markets Institute, Singapore, and President of CEPR

Endnotes

1. This may be due to social acceptability issues in Europe, as shown by Oswald and Nowakowski (2020).

2. A shadow price associated to a collective constraint is defined as the price signal necessary to satisfy the constraint. It would have to be estimated by employing an integrated assessment model.

3. See, for example, the proposals by Dominique Bureau, Fanny Henriet and Katheline Schubert in CAE (2019).

4. Jakob et al. (2014) argue, however, that the climate impact of a BCA mechanism is itself rather uncertain, as it depends on its difficult-to-assess effects on global production and consumption patterns.

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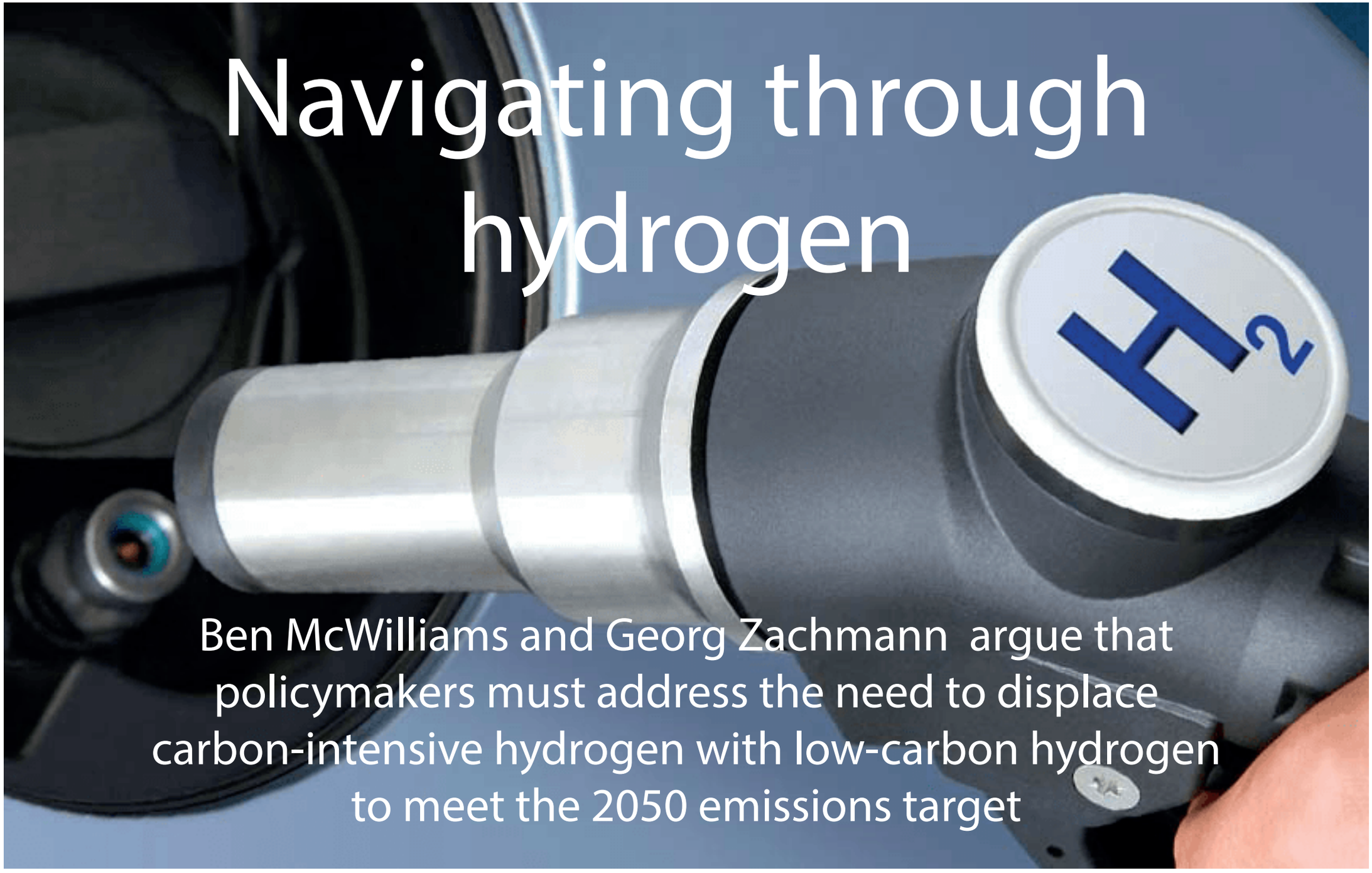
Navigating through hydrogen



Ben McWilliams and Georg Zachmann argue that policymakers must address the need to displace carbon-intensive hydrogen with low-carbon hydrogen to meet the 2050 emissions target

Hydrogen is seen as a means to decarbonise sectors with greenhouse gas emissions that are hard to reduce, as a medium for energy storage, and as a fallback in case halted fossil-fuel imports lead to energy shortages. Hydrogen is likely to play at least some role in the European Union's achievement by 2050 of a net-zero greenhouse gas emissions target.

However, production of hydrogen in the EU is currently emissions intensive. Hydrogen supply could be decarbonised if produced via electrolysis based on electricity from renewable sources, or produced from natural gas with carbon, capture, and storage. The theoretical production potential of low-carbon hydrogen is virtually unlimited and production volumes will thus depend only on demand and supply cost.

Estimates of final hydrogen demand in 2050 range from levels similar to today's in a low-demand scenario, to ten times today's level in a high-demand scenario. Hydrogen is used as either a chemical feedstock or an energy source. A base level of 2050 demand can be derived from looking at sectors that already consume hydrogen and others that are likely to adopt hydrogen. The use of hydrogen in many sectors has been demonstrated.

Whether use will increase depends on the complex interplay between competing energy supplies, public policy, technological and systems innovation, and consumer preferences. Policymakers must address the need to displace carbon-intensive hydrogen with low-carbon hydrogen, and incentivise the uptake of hydrogen as a means to decarbonise sectors with hard-to-reduce emissions.

Certain key principles can be followed without regret: driving down supply costs of low-carbon hydrogen production; accelerating initial deployment with public support to test the economic viability and enable learning; and continued strengthening of climate policies such as the EU emissions trading system to stimulate the growth of hydrogen-based solutions in the areas for which hydrogen is most suitable.

1 Introduction

In the European Union's decarbonisation drive, hydrogen is seen as a solution for sectors with greenhouse gas emissions that are hard to reduce, as a means of energy storage, and as a fallback in case halted fossil-fuel imports lead to energy shortages.

The attractiveness of hydrogen comes from the fact that no carbon dioxide is emitted when it is burned or used in a fuel cell to produce electricity. In sectors where it could be applied, hydrogen could displace fossil-fuel consumption and the associated carbon emissions.

Hydrogen is not a new fuel. Its ability to provide useful energy has been understood for well over 100 years. As recently as the early 2000s, a wave of public interest focused on its potential for powering automobiles (Lizza, 2003).

European policymakers should think about designing a framework for the international trade in clean hydrogen

Interest in hydrogen is now resurging in the EU, linked to the bloc's much more ambitious decarbonisation targets. On the demand side, hydrogen could be a solution for particularly hard-to-abate sectors, such as steel, providing a valuable argument that full decarbonisation is technically feasible.

On the supply side, the potential for large imports of low-carbon hydrogen is attractive when considered against the argument that the EU's clean energy potential might be too limited. Moreover, hydrogen offers one solution to the seasonal storage issue that while renewable electricity generation peaks in summer, demand peaks in winter.

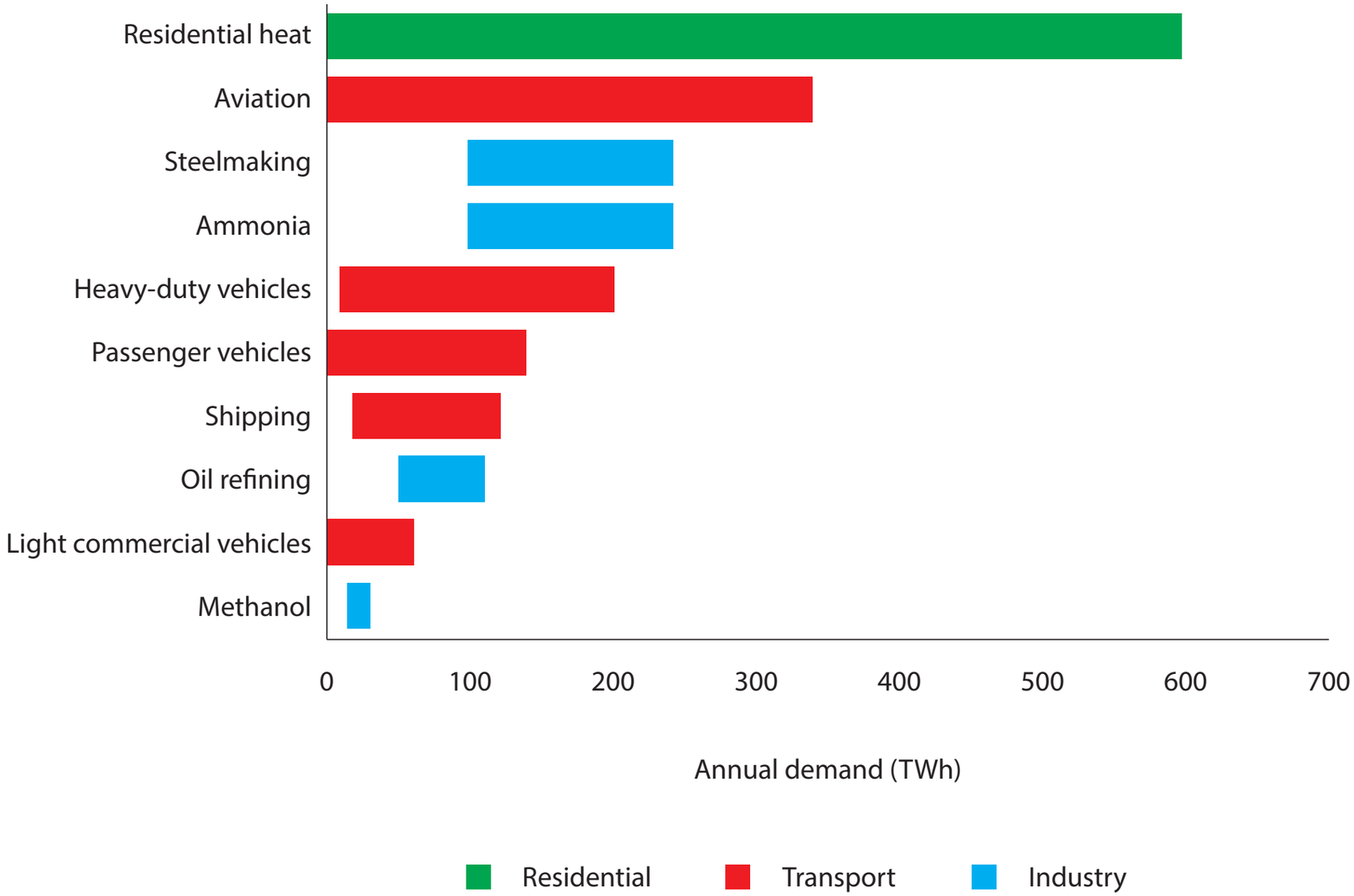
Notwithstanding this technical promise, hydrogen remains prohibitively expensive. Its use today in the European Union is thus far removed from the role optimists see it playing in a net-zero EU in 2050. It is currently used almost exclusively as a chemical feedstock for the production of ammonia and methanol and for crude oil refining.

Furthermore, the dominant production route for hydrogen – involving separation of hydrogen from methane – is highly carbon-intensive. But hydrogen can also be produced from electricity via electrolysis. The rapidly falling cost of electricity from renewables is creating excitement about low-cost, low-carbon hydrogen production.

The future role hydrogen will play in the sectors where it could be deployed depends upon the extent to which the necessary technologies reach commercial maturity. This will be driven by the complex interplay of capital costs, consumer preferences, policy decisions, and the relative performance of competing clean energy sources.

Because of these uncertainties, we estimate that in 2050, hydrogen could meet 20 percent of EU final energy demand – but it may meet only 3 percent (Figure 1). This is in line with more sophisticated modelling studies.

Figure 1. Estimated variation in hydrogen demand in 2050



Note: Horizontal bars represent the range of annual hydrogen demand between our highest and lowest assumptions (see section 3). The European Commission (2018) estimated total final energy demand in 2050 of 10,000 TWh. Some of the uses for hydrogen shown in the figure are as a chemical feedstock, not energy consumption, but the 10,000 TWh figure still provides a sensible order of magnitude. Our higher estimate (2,080 TWh) would see total hydrogen demand of approximately 20 percent of final energy demand in 2050, with the lower estimate (295 TWh) at 3 percent.
Source: Bruegel.

This Policy Contribution examines the gap between 3 percent and 20 percent. Our analysis supports the idea that decarbonisation will be driven mainly by electrification, while hydrogen will emerge to fill the niche for applications where electricity is either too expensive or complex.

We first explore the potential for hydrogen to evolve from today's highly polluting chemical feedstock to a key clean energy source in a decarbonised EU in 2050. The first fundamental step is the ability to produce significant volumes of clean hydrogen (section 2).

We then examine the main sectors in which hydrogen is currently being consumed or is considered an important pathway for future decarbonisation. To illustrate the uncertainty around future hydrogen demand we assess what 2050 hydrogen demand might be in ten significant sectors (section 3).

The difficulty for policymakers today lies in knowing exactly where the hydrogen niche lies. It could cover whole sectors, such as aviation, or might cover sub-sectors, such as hydrogen fuel cells for heavy vehicles travelling long distances. Or hydrogen might find a temporary niche, for example in heating of buildings.

Despite the uncertainty, hydrogen's current use as a chemical feedstock and highly likely adoption in the steel sector mean that at least some clean hydrogen will be required by 2050. Public policy, which we cover in section 4, should therefore focus on stimulating cost reductions for the production of clean hydrogen.

2 Hydrogen supply

Large-scale production of hydrogen can be done using six very different inputs: natural gas, electricity, biomass/waste, solar radiation, coal and oil. At least 16 different production methods generate hydrogen from at least one of these inputs. Production methods differ significantly in their associated greenhouse-gas emissions.

For example, for production via electrolysis (electricity is used to split water molecules into hydrogen and oxygen atoms), the origin of the input electricity determines whether the hydrogen is carbon-neutral (eg. when produced from renewable or nuclear-generated electricity) or highly polluting (eg. electricity from lignite power plants). Figure 2 provides a schematic overview of the low-carbon production pathways for hydrogen.

The cost-competitiveness of different hydrogen production processes depend on the capital costs of the required installations, their technological efficiency in transforming input fuels into hydrogen, the input fuel and carbon prices.

Hydrogen supply capacity in the EU is currently estimated at 339 terawatt hours per year[1], approximately 3 percent of EU final energy demand (FCH JU, 2019). Of this, over 95 percent is hydrogen produced from fossil fuels, and less than 5 percent is produced via electrolysis (Cihlar *et al* 2020).

Production of fossil hydrogen in Europe is mainly done by separation of hydrogen from a stream of methane, a process that generates significant carbon dioxide emissions. Box 1 compares these emissions to those from electrolysis, which depend on the carbon intensity of electricity.

The EU hydrogen strategy, published in July 2020, aims to set out a vision for *"how the EU can turn clean hydrogen into a viable solution to decarbonise different sectors"* (European Commission, 2020). It is centred on scaling up electrolysis production with renewable electricity input.

An alternative option would be to apply carbon capture storage (CCS) technology in the production of hydrogen from methane, capturing up to 90 percent of the CO_2 emissions generated[2] (IEA, 2019a). The strategy sees a role for CCS in hydrogen production in the short and medium terms, but not as a long-term priority.

Box 1. Carbon emissions associated with hydrogen from methane and electrolysis

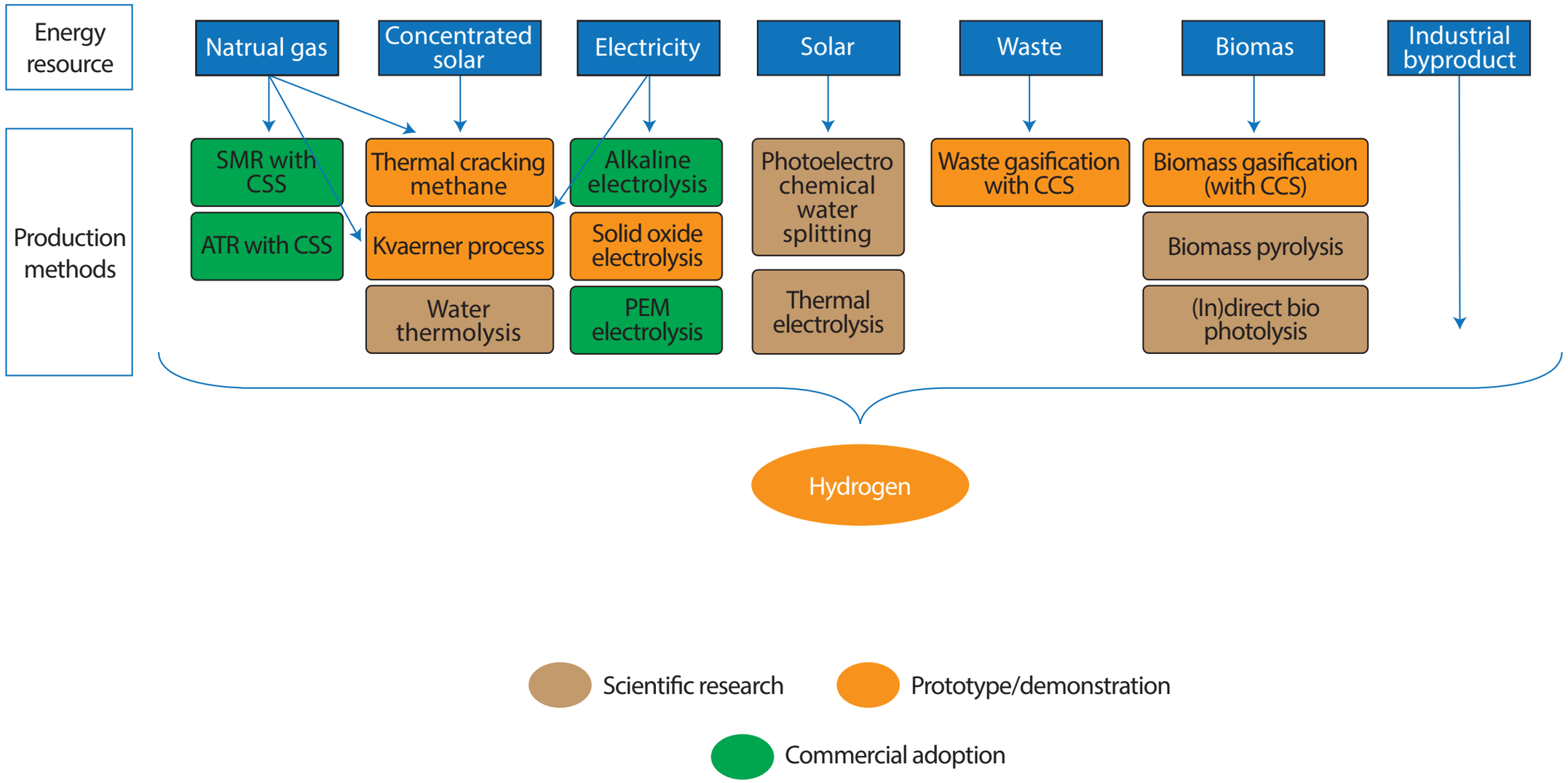
For hydrogen from methane without CCS, the carbon intensity of production is around 270g CO_2/kWh. For an electrolyser connected to the European electricity grid, average emissions will be 430g CO_2/kWh, based on current average electricity-related emissions of 285g CO_2/ kWh.

Therefore, electrolytic hydrogen will only result in better emissions performance than SMR when the average emissions intensity of European electricity is reduced to significantly below 200g CO_2/kWh. Extrapolation of current decarbonisation trends would see this happening around 2025. Production from electrolysis will become even cleaner over time as electricity is further decarbonised.

Very low carbon intensities can already today be achieved in many hours of the year, such as on sunny and windy summer weekends, or in certain EU countries, such as France and Denmark. But making hydrogen production 'low-carbon' by producing it from green electricity has no economic justification because it would only imply that other consumers would consume non-green electricity.

To ensure that domestic hydrogen production does not result in increasing emissions, the cap of the EU emissions trading system (which covers hydrogen production from electricity and natural gas) should be tightened enough to meet the EU climate targets.

Figure 2. Low-carbon hydrogen production



Notes: SMR = steam methane reforming. CCS = carbon capture and storage. PEM = polymer electrolyte membrane. ATR= autothermal reforming.
Source: Bruegel based on Hanley et al (2017), Nikolaidis and Poullikkas (2017), Piebalgs et al (2020) and IEA (2020).

The competitiveness of hydrogen from methane compared to electrolysis depends on the price of the inputs (natural gas or electricity) and the carbon price (Figure 3). Our estimates for methane production use a price of €20/MWh, while the range of electricity prices likely available to industrial producers is the vertical shaded grey area, around €40-€50/MWh[3].

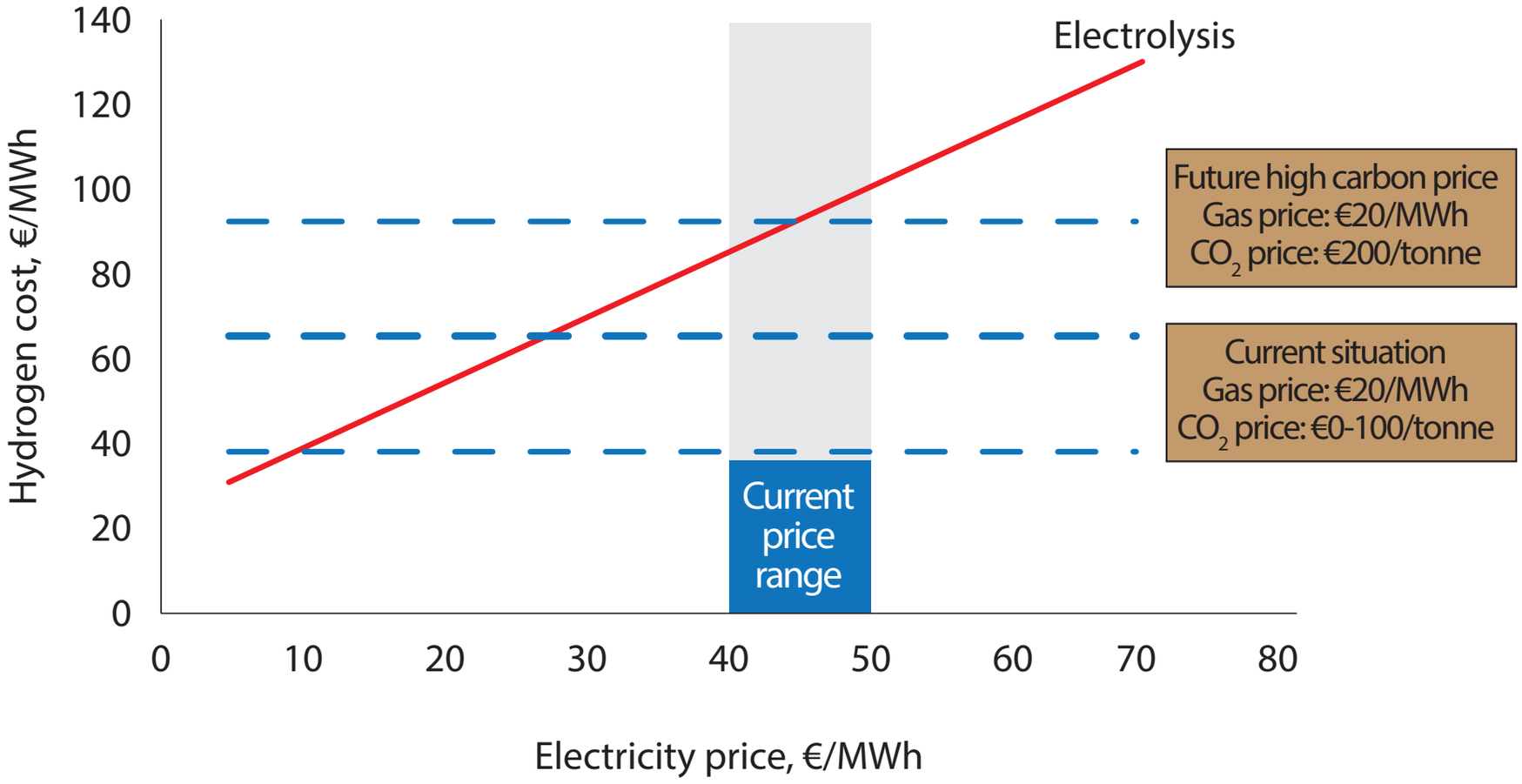
Figure 3 shows that at current natural gas, electricity and carbon prices[4], hydrogen production from methane without CCS is significantly cheaper than hydrogen production from electricity[5]. However, if electricity prices drop to about €20/MWh (for example because of cost reductions related to renewables), hydrogen produced from electricity would become cheaper than that produced from methane. On the other hand, increases in the carbon price would also affect the cost. An increase in the carbon price to €200/tonne would mean that electricity at current prices would become competitive with natural gas.

Furthermore, the capital costs of electrolysers could fall significantly in the near term, meaning that electrolysis would be competitive even if electricity prices do not drop to €25/MWh. Wood Mackenzie (2020), for example, forecast electrolysis-produced hydrogen becoming cost-competitive with methane-produced hydrogen between 2030 and 2040, depending on the region, because of shifting cost dynamics.

Commitments in hydrogen strategies published so far by the EU, its member states and other countries to deploy electrolyser capacity are set to stimulate cost reductions.

Moreover, our analysis is based on average EU values and cost assumptions. Differing tax rates, network costs and wholesale prices drive significant regional electricity price differences. The competitiveness of electricity versus gas will therefore vary between regions.

Figure 3. Hydrogen price for different electricity and carbon prices



Note: the graph shows the different hydrogen prices for different electricity prices using an electrolyser, where the cost of carbon is already internalised through the carbon price paid by electricity generators. For natural gas production, we assume a gas price of €30/MWh. The dashed lines represent different hydrogen costs for different carbon prices paid for a methane plant without CCS. Calculations based on IEA assumptions: for electrolysis, CAPEX - $900/kWe, efficiency – 64%, Annual OPEX – 1.5% of CAPEX. For natural gas reforming, CAPEX - $910/kW$H_2$, Efficiency – 76%, Annual OPEX = 4.7% of CAPEX, emissions = 8.9kgCO_2/kgH_2.
Source: Bruegel based on IEA.

And we base our analysis on an electrolysis plant behaving as a traditional baseload consumer of electricity, ie. demanding electricity with limited flexibility, which is the situation with electrolysers today.

However, developments in alternative electrolysis technology[6], the falling capital cost of electrolysers and the increasing variability of electricity prices (because of increasing shares of renewable energy generation) could increase demand for electrolysis as a source of flexible power demand.

Therefore, electrolysis could emerge as a significantly more competitive technology by: a) utilising close to zero (or occasionally even negative) electricity prices for a substantial number of hours, and b) providing flexibility services to the grid by consuming excess electricity at times of excess supply and helping to facilitate the over-deployment of renewable electricity sources (see section 3.4).

2.1 Alternative production pathways

Hydrogen production from natural gas and electricity are the most common methods, but there are others. Table 1 lists them, along with some rough cost estimates.

In sum, the global technical production potential of hydrogen exceeds demand by several orders of magnitude[7], meaning expansion of supply depends in principle only on the hydrogen production cost and demand at that cost level. National hydrogen production costs can differ depending on the differing availability and cost of inputs and capital, the availability of required infrastructure for transport, hydrogen storage and possibly carbon storage space.

2.2 Hydrogen imports

In optimistic scenarios, hydrogen could contribute a significant share of final energy demand within the EU by 2050. The EU hydrogen strategy works with a projection of 13 percent to 14 percent by 2050 (European Commission,

Table 1. Additional low-carbon hydrogen production methods

Production method	Energy source	Feedstock	Hydrogen cost estimate (€/MWh)
Autothermal reforming with CCS	Fossil fuels	Natural gas	50
Methane pyrolysis/thermal cracking	Internally generated steam	Natural gas	54 - 57
Biomass pyrolysis	Internally generated steam	Biomass	42 - 74
Biomass gasification	Internally generated steam	Biomass	60 – 69
Direct bio-photolysis	Solar	Water and algae	72
Indirect bio-photolysis	Solar	Water and algae	48
Dark fermentation		Organic biomass	87
Photo-fermentation	Solar	Organic biomass	96
Solar thermal electrolysis	Solar	Water	172-354
PEC process (photo-electrolysis)	Solar	Water	350
Nuclear thermolysis (thermal cracking of water)	Nuclear	Water	73-89
Solar thermolysis (thermal cracking of water)	Solar	Water	269-284

Note: CCS = carbon capture and storage.
Source: Kayfeci et al (2019).

2020). If hydrogen demand is to reach such levels, imports of hydrogen might also develop. The European Commission hydrogen strategy aims to develop 40 GW of hydrogen capacity in neighbourhood regions by 2030 – the same capacity the EU aims for within its borders. From countries with an abundance of renewable energy resources, green hydrogen could become an attractive export.

Installing renewables and electrolysers outside the EU and importing the hydrogen into the EU only makes economic sense when the renewables conditions in the exporting countries are significantly better, while capital costs are not substantially higher than in the EU.

Furthermore, the cost advantage must exceed the costs of delivery of hydrogen as a gas via pipelines. Alternatively, hydrogen can be transformed into, for example, ammonia, which can be more easily stored in liquid form and transported by ship.

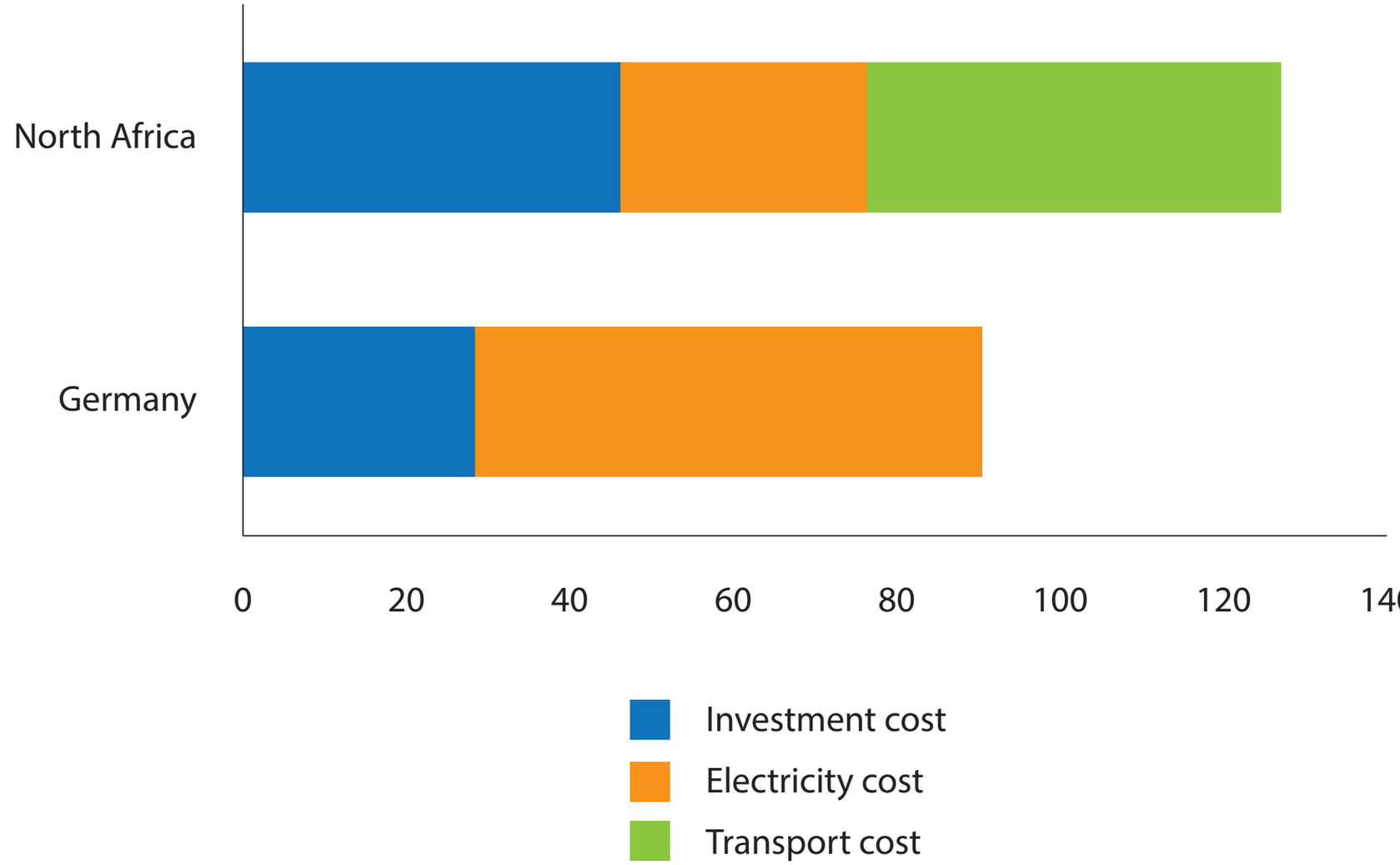
Based on IEA assumptions of current costs it seems hard to make a case for imports of hydrogen from solar energy from North Africa. If deployment of additional wind or solar units in Germany becomes difficult because suitable/acceptable land is already utilised, while investment costs in Africa decline, imports of hydrogen might become competitive.

However, consistent international rules would be needed to ensure that significant imports of hydrogen do not directly or indirectly increase net emissions in the producing country, for example through land-use change or replacement of renewable electricity for local populations by fossil fuels.

3 Hydrogen demand

The future evolution of demand for hydrogen in Europe is highly uncertain. Hydrogen has historically had a limited

Figure 4. Import vs domestic hydrogen (€/MWh)



Note: Key assumptions: CAPEX electrolyser: $900/kW, electricity price in Germany: $47/MWh, electricity price in North Africa: $23/MWh, interest rate in Germany: 5%, interest rate in North Africa: 10%, transport distance: 3,000Km, pipeline transport cost of $2/Kg.
Source: IEA (2019a).

role in influential global energy modelling studies (for example, Quarton *et al* 2020). In this section, we discuss the most likely sectors for future hydrogen demand, with calculations for high, medium and low hydrogen demand scenarios.

We thus provide a broad overview of what hydrogen demand might look like in three scenarios: one in which hydrogen technology and deployment is aggressively pursued by policymakers and costs continue to fall, one in which the exact opposite occurs, and one in the middle. Our numbers are not intended to be forecasts, but rather serve to highlight the significant uncertainty surrounding future hydrogen demand[8].

The evolution of competing or complementary decarbonisation options, including energy efficiency, biomass, electrification and carbon capture, will be significant for determining the role or niche for hydrogen. Hydrogen therefore cannot be considered in isolation but rather in combination with the development of others fuels and energy carriers within complex energy systems (Hanley *et al* 2017).

Our assessment of hydrogen demand focuses on three broad sectors: transport (section 3.1), industrial applications (3.2) and residential heating (3.3). We also discuss the role hydrogen may play in the power sector (3.4). Table 2 provides an overview.

3.1 Transport

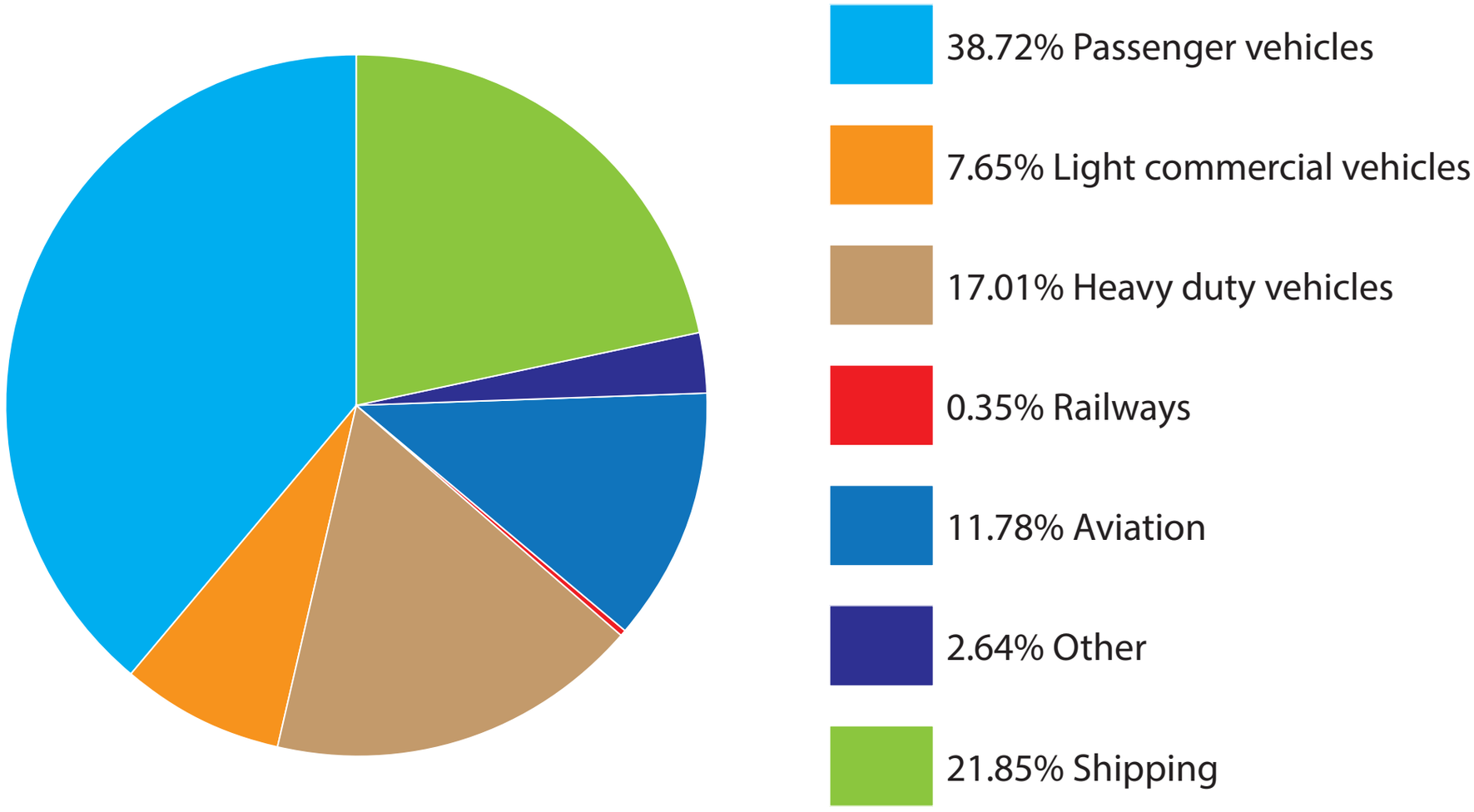
There are multiple options for hydrogen consumption in the road, rail, maritime and air transport. Pure hydrogen can be consumed directly through a fuel cell to produce electricity, or combusted. Alternatively, hydrogen can be transformed into ammonia before use in a fuel cell or by combustion. Finally, hydrogen can also be used as a building block for renewable synthetic fuels (e-fuels).

Table 2. Sector scorecard

Sector	Emissions (% of EU total)	Hydrogen potential	Note
Ammonia & methanol	14%*	★★★★★	Already using hydrogen produced from natural gas/ industry by-product
Oil refining	2%	★★★★	Already using hydrogen produced from natural gas/ industry by-product
Steelmaking	4%	★★★★★	High potential to replace coal
Passenger vehicles	12%	★	Electric vehicles hold first-mover advantage in low carbon market
Light commercial vehicles	2%	★★	Electric vehicles likely to be strong competitors
Heavy duty vehicles	5%	★★★	Hydrogen more suited to heavier vehicles
Shipping	7%	★★★★	Potential additional demand via use as ammonia
Aviation	4%	★★★	Synthetic fuels; fuel cells
Residential heating	12%	★★	Competing with electricity

*Note: *emissions include all chemical sector, not only ammonia and methanol.*
Source: Bruegel.

Figure 5. GHG emissions share in transport sector



Source: Bruegel.

Transport: road

Passenger vehicles

- Hydrogen potential: ★
- Upper demand: 140 TWh. Medium demand: 50TWh. Lower demand: 0 TWh[9]
- 12 percent of EU greenhouse gas emissions

In road transport, hydrogen faces direct competition from electricity. Increasingly, the decarbonised future of passenger vehicles looks to be one of battery electric vehicles (BEVs). The price of batteries has rapidly dropped while range per charge is increasing.

As a result, the global stock of fuel cell (hydrogen) vehicles is just 11,200 compared to more than 5 million BEVs (IEA, 2019). BEVs now enjoy a first-mover advantage as the conventional low-carbon passenger vehicle. They attract significantly more government and private-sector funding, particularly for charging infrastructure.

Nonetheless, there may be some scope for hydrogen if limitations arise because of raw material shortages, technological limitations of batteries or excess strains on electricity grids arising from too many poorly managed BEVs. Moreover, certain companies (Hyundai, Honda) are still actively developing fuel-cell electric vehicles (FCEV), ie. hydrogen passenger vehicles.

As markets grow and prices decrease, it is possible that FCEVs will one day compete more seriously with BEVs. Large-scale deployment of hydrogen refuelling networks would be fundamental to this, but these currently still face the problem that while FCEV take-up is low, investment in refuelling networks is not attractive. As other economic

sectors begin to demand more hydrogen, the roll-out of hydrogen refuelling networks may become economically more attractive.

Hydrogen offers quicker refuelling than battery charging, making it potentially more suited to vehicles in constant use, such as taxis and buses.

Heavy-duty vehicles

- Hydrogen potential: ★★★
- Upper demand: 200 TWh. Medium demand: 120 TWh. Lower demand: 10 TWh[10]
- 5.2 percent of EU greenhouse gas emissions (including buses)

Hydrogen appears to have greater potential for the heavy-duty road transport sector because hydrogen is able to store more energy in a smaller space and at lower weight than a lithium-ion battery. A challenge for manufacturers of battery electric vehicles has been producing batteries which contain sufficient energy but are not too heavy.

For example, to provide the same range as a 1,000 litre diesel truck, the battery of an electric truck would have to weigh about 14 tonnes. As the capacity and range of lithium batteries has expanded, this problem is gradually being overcome for small, passenger vehicles. However, hydrogen fuel cells could be deployed in heavier vehicles for which greater range and higher power output are required.

In this market segment, hydrogen would compete against biofuels and the use of electrically-derived fuels (via hydrogen). The speed of battery improvements has been rapid so far, and it is still very possible that innovations will allow battery-driven electrification to dominate heavy-duty transport. Overhead transmission lines may also play a limited role.

The most optimistic EU 2050 scenarios see approximately a 15 percent share of hydrogen FCEVs in the heavy goods vehicle stock (European Commission, 2018). Least optimistic scenarios would see 0-3 percent FCEV deployment. Some additional indirect hydrogen demand might occur through electrically derived fuels.

Light-commercial vehicles

- Hydrogen potential: ★ ★
- Upper demand: 60 TWh. Medium: 15 TWh. Lower: 0 TWh[11]
- 2.3 percent of EU greenhouse gas emissions

Vans and light commercial vehicles occupy the middle ground between passenger vehicles and heavy-duty vehicles. They tend to be slightly larger than passenger vehicles, giving hydrogen an advantage because of its higher energy density, but not comparable to heavy-duty vehicles, meaning it is still very possible that this market will be dominated by BEVs.

Currently, over 90 percent of light commercial vehicles in the EU are diesels (European Commission, 2018). The deployment of hydrogen fuel cells in this sector may likely depend on the initial success of hydrogen fuel cell deployment elsewhere (particularly in heavy-duty vehicles). However, similarly to passenger vehicles, current market dynamics would still suggest that BEVs will dominate this market.

Transport: rail

- Hydrogen potential: ★
- Demand: likely to be very close to zero
- 0.11 percent of EU greenhouse gas emissions

The strongest decarbonisation opportunities are in electrifying rail tracks, shifting away from diesel consumption. Electrifying tracks implies significant upfront fixed costs. Tracks electrified so far are those which are the most heavily used in order to increase the ratio of returns to a fixed investment.

For less-used tracks, the returns are not large enough to justify the significant upfront capital costs of electrification. On these tracks, hydrogen fuel cells are an attractive option (IEA, 2019).

The potential scope is still relatively small as approximately 50 percent of European tracks have already been electrified (Donat, 2020). Take up of hydrogen for trains on non-electrified tracks can be aided by falls in the costs of fuel cells, driven by deployment elsewhere. Battery electric trains are another option. Overall, rail is not likely to be a leading candidate sector for large volumes of hydrogen consumption.

Transport: shipping

- Hydrogen potential: ★ ★ ★ ★
- Upper demand: 120 TWh. Middle demand: 70 TWh. Lower demand: 20 TWh[12]
- 6.6 percent of EU greenhouse gas emissions

The maritime-fuel mix in the EU and globally is dominated by heavy fuel oil. Policy restrictions on sulphur emissions and planned controls on greenhouse gas emissions mark an attempt to move beyond heavy fuel oil. The European Commission is considering including shipping in the EU emissions trading system.

Hydrogen fuel cells may work for short-distance light shipping, for which power requirements are not too large. This is likely to be in competition with battery electric ships. Liquefied hydrogen, synthetic fuels derived from hydrogen and ammonia (Middlehurst, 2020), have greater potential in terms of decarbonising longer distance shipping.

Like hydrogen, ammonia can be used to produce energy either by combustion within an internal combustion engine, or by producing electricity through a fuel cell. Biofuels are likely to be another competitor for hydrogen in the maritime sector.

A challenge will be to transform bunkering, or fuelling, facilities, which currently store heavy fuel oils, so they can store hydrogen or hydrogen-derived fuels. Here, a global coordination problem arises as ships must refuel in multiple locations, normally in different countries.

For this reason, it is quite likely that one or two fuels will become dominant. Hydrogen might be boosted by other uses in port operations. Forklift trucks are already a big adopter of hydrogen, with 25,000 deployed globally, for example. Port hydrogen storage and distribution infrastructure will become economically more efficient with multiple end-use cases.

Transport: aviation

- Hydrogen potential: ★★★
- Upper demand: 340 TWh. Middle demand: 180 TWh. Lower demand: 0 TWh[13]
- 3.60 percent of EU greenhouse gas emissions

For short-distance flights of less than 3,000 kilometres (encompassing most European flights; Madrid to Helsinki is about 2,950km, for example), electricity and pure hydrogen could make a significant contribution. This may be through battery or fuel cell (hydrogen) electric planes, or through direct combustion of hydrogen. Hybrid options, combining the two (electricity and hydrogen combustion) are also possible.

Airbus has released three concept designs for hydrogen planes which they state could enter service by 2035 (Airbus, 2020). The proposed planes are of a hybrid nature, combusting hydrogen in modified gas-turbines and producing electricity through fuel cells.

Longer distance flights require fuels with higher energy densities. Advanced biofuels and synthetic fuels[14] derived from hydrogen are the most promising decarbonisation options.

Synthetic jet fuel can be a drop-in replacement for current jet fuel. However, options are today far too expensive[15]. Significant policy support and cost reductions would be required for synthetic fuels to be a realistic decarbonisation option.

For longer distance flights, the evolution of biofuels will be a key determinant for the potential of hydrogen fuels. Biofuel production is constrained by land availability[16] and any constraints on biofuel production will provide a stimulus for investment into hydrogen. A further influencing factor will be the extent to which biofuels are demanded by other economic sectors.

Therefore, there are two separate considerations for future hydrogen demand in aviation: directly through use in a fuel cell/combustion to power short-distance flights, or indirectly producing synthetic jet fuels which are then combusted during flight. We estimate an upper bound of 210 TWh of direct hydrogen use in aviation, and 130 TWh indirect hydrogen use for producing synthetic fuels.

However, aviation remains firmly in the hard-to-decarbonise box, with technologies at a very immature stage of development. It will take many years of research and development before the potential of hydrogen relative to alternatives is clarified.

Moreover, as one of the hardest sectors to decarbonise, aviation is a strong contender for residual emissions in a net-zero 2050 scenario that involves significant use of negative emissions technologies. Aviation may therefore to some extent carry on burning conventional fossil fuels and emitting greenhouse gases.

3.2 Industry

Currently, over 90 percent of hydrogen produced in Europe is used as a feedstock in oil refining, ammonia and methanol production (Cihlar *et al* 2020). The possibility of substituting hydrogen for fossil fuels used in steel production is one of the most commonly discussed future uses for hydrogen. These four sectors together account for up to 41 percent of the EU's industrial emissions[17].

Chemical sector: ammonia and methanol

- 3.2 percent of EU greenhouse gas emissions[18]

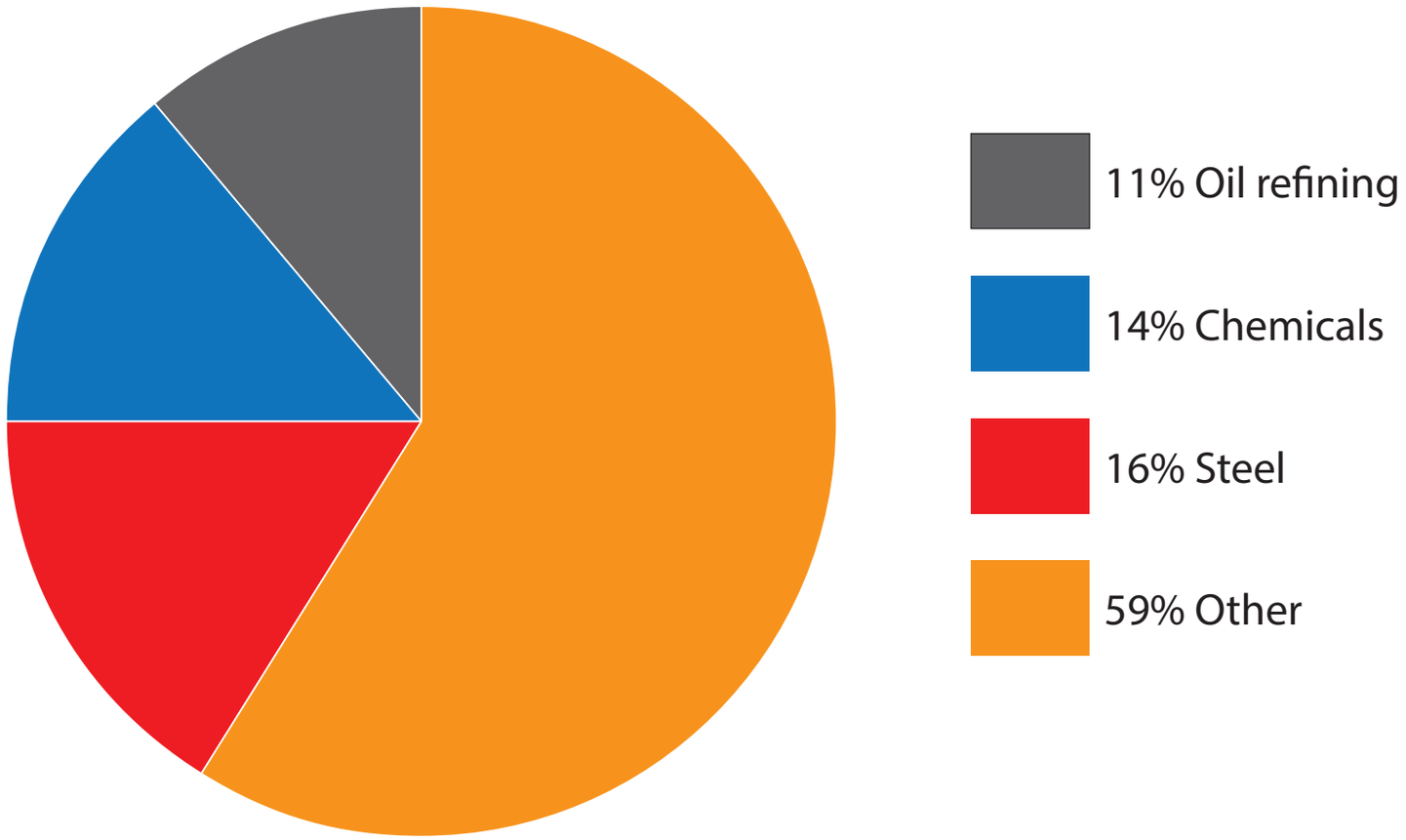
The ammonia and methanol sectors both require hydrogen as a feedstock. The most convenient and cost-effective source is fossil-fuel derived hydrogen.

Ammonia production

- Hydrogen potential: ★★★★★
- Upper demand: 240 TWh. Medium: 160 TWh. Lower: 100 TWh[19]
- 2015 demand: 129TWh

Over 80 percent of ammonia produced worldwide is for the manufacture of fertilisers (Bazzanella and Ausfelder, 2017). Other uses are for nitric acid, pharmaceuticals and cleaning products.

Figure 6. EU industrial greenhouse gas emissions



Source: Bruegel.

In Europe, natural gas is the most important feedstock. Hydrogen is extracted from natural gas (methane) before being combined with nitrogen from the air to produce ammonia, or NH_3. Green hydrogen would therefore be able to directly reduce emissions from ammonia production by eliminating the need for production of hydrogen from methane[20]. Such green ammonia projects are already underway[21].

Europe currently produces 17 million tonnes of ammonia annually and the future evolution of demand is uncertain. As the global population increases, demand for ammonia-based fertilisers will increase; food production must become more efficient to feed an increasing number of mouths from the same amount of land.

However, public policy may drive out ammonia in favour of biological fertilisers or higher levels of organic production. The EU in 2019 updated fertiliser rules to promote fertilisers based on organic materials rather than chemicals[22].

Our analysis is based on traditional uses of ammonia, but ammonia demand could rise significantly if ammonia becomes a significant future energy carrier. Ammonia could be a preferable option for transporting the energy contained in a hydrogen atom (ammonia's physical properties make it easier to transport than hydrogen). Ammonia could help in transporting energy from areas of renewable energy abundance to areas of demand.

Moreover, non-traditional demands for ammonia may arise in shipping (section 3.1) and potentially even in the power sector[23]. Such a scenario would significantly increase hydrogen demand for ammonia production.

Methanol production

- Hydrogen potential: ★★★★★
- Upper demand: 30TWh. Medium demand: 25TWh. Lower demand: 15TWh[24]

- 2015 demand: 27 TWh

Similarly to ammonia, demand for hydrogen in methanol production is predominantly met by hydrogen from methane. The production of green hydrogen would reduce demand for hydrogen from natural gas and its significant carbon emissions.

Currently, EU methanol production (1.5Mt/annum) as a share of global production is much lower than for ammonia. Assuming similar trends, final demand for hydrogen in this sector is likely to be significantly lower than in the ammonia sector within the EU.

Oil refining

- Hydrogen potential: ★ ★ ★ ★
- Upper demand: 110TWh. Medium demand: 90TWh. Lower demand: 50TWh[25]
- 2015 demand: 153 TWh
- 2.4 percent of EU greenhouse gas emissions

A major use of hydrogen today is in oil refining: turning crude oil into commercially attractive end-use products. Hydrogen is used in hydrotreating and hydrocracking. Hydrotreating refers to the removal of sulphur impurities from crude oil, necessary because sulphur is an air pollutant. Hydrocracking is used to transform heavier residual oils into lighter and more commercially attractive fuels.

Future demand for hydrogen in this sector will be determined by future demand for crude oil products, which in Europe is set to decrease. Meanwhile, sulphur restrictions are progressively being tightened, increasing the hydrogen demand per barrel of crude oil[26].

Ironically, sulphur restrictions on crude oil products such as jet fuel have in recent years likely increased the sector's greenhouse emissions because of the current carbon intensity of hydrogen (Catalá *et al* 2013, Figure 4.5.5). In 2050, there will likely still be demand in the oil refining sector because of the use of hydrocarbons in certain chemical products.

Steelmaking

- Hydrogen potential: ★★★★★
- Upper range: 240TWh. Middle range: 150TWh. Lower range: 100TWh[27]
- 3.8 percent of EU greenhouse gas emissions

The EU produces 177 million tonnes of steel a year, 11 percent of global output[28]. Significant emissions are associated with the steel sector and hydrogen is widely regarded as fundamental to decarbonising the sector.

Most steelmaking greenhouse gas emissions are associated with the turning iron ore into iron prior to its processing into steel. Steel can be produced in blast oxygen furnaces (BOF) (60 percent of EU production; European Commission, 2018) and electric arc furnaces (EAF).

The BOF route produces steel using coal and has little future in a decarbonised world, though efforts are being made to reduce emissions by improving efficiency, replacing some coal with hydrogen and retrofitting plants with carbon capture technology.

However, unless carbon capture can be done at levels of emissions far above capabilities today, there will always be significant emissions associated with BOF.

Decarbonisation of steel production therefore relies on switching to the EAF (currently 40 percent of EU production). Here, the primary energy input is electricity[29], making green steel possible if the electricity is decarbonised. Two different feedstocks can be used with EAF: scrap steel and direct reduced iron (DRI), or a combination.

Globally, scrap steel contributes to about 25 percent of steel production. Increasing the use of scrap steel would be a welcome shift toward the circular economy[30], but is limited by availability of high-quality scrap[31].

Meanwhile, producing DRI for use in EAF involves reacting iron ore with a reducing agent, currently a mixture of hydrogen and carbon monoxide. This is already a technologically proven route, with deployment particularly in the Middle East where industry has access to low-cost natural gas, which is used for producing the stream of hydrogen and carbon gases for reduction.

All major European steelmakers are currently building or testing hydrogen-based reduction for use in EAF[32]. The target is to use pure hydrogen rather than a hydrogen/carbon mixture for reduction of iron ore. Using both scrap steel and DRI produced using hydrogen in electric arc furnaces is considered the most viable decarbonisation option for the sector within the EU (Hoffmann *et al* 2020).

A related question is whether the move to DRI-EAF will affect the location of steel production from close to coal/iron resources to close to cheap green-energy resources.

One issue is the long lifespan of steel plants – approximately 35 years. The production of steel through DRI-EAF using hydrogen is not yet economically mature. However, the industry must be wary of locking in any further BOF capacity, with such facilities likely to become stranded assets by 2050.

Residential heating

- Hydrogen potential: ★ ★
- Upper demand: 600 TWh. Medium demand: 300 TWh. Lower demand: 0 TWh[33]
- 12.5 percent of EU greenhouse gas emissions

Natural gas is currently the most common primary fuel used for household heating in the EU, accounting for 44 percent of demand. Coal, oil, and biomass are the other significant contributors (Bertelsen and Vad Mathiesen, 2020).

Energy efficiency is the main tool for ensuring decarbonisation of the buildings sector. The EU's long-term roadmap sees energy demand for residential heat halving in a baseline scenario (European Commission, 2018, Figure 39).

Demand reductions will be achieved through a combination of rules for new build and existing households. From 2021, new buildings must comply with requirements in the Energy Performance of Buildings Directive 2010/31/EU: new buildings must be nearly zero energy consumption. Old buildings must be renovated, and heating demand reduced through better insulation. The EU's *2020 Renovation Wave* strategy is intended to address exactly this issue[34].

Domestic heating can also become more electrified. Electrically powered heat pumps, with an efficiency of 300 percent, are able to draw three times more heat energy from outside air than they consume in terms of electric energy. Currently, the share of electricity in final residential heating demand is approximately 5 percent but European Commission scenarios forecast a growth in this share to between 22 percent and 44 percent by 2050 (European Commission, 2018, Figure 43).

Nonetheless, as a temporary solution, blending natural gas with hydrogen in gas grids is being discussed. Technically, this can be done up to a certain proportion (roughly 5 percent to 20 percent).

In the short run, the blending of hydrogen into gas grids allows for incremental reductions in emissions while creating an early demand market for green hydrogen.

To achieve concentrations of hydrogen in gas grids above 20 percent, pipes and grid appliances must be retrofitted. This is not an impossible task; grids in the United Kingdom were retrofitted in the 1960s to move away from town gas (a mixture with a high hydrogen concentration) to natural gas.

Switching a gas distribution grid to hydrogen would be organised top-down and would require less significant investments on the user side to decarbonise residential heating, while moving to electric heat pumps will in principle be more efficient and allow for gradual switching of users at their convenience.

But it will be more difficult to push individual users to make the necessary substantial investments – one might consider this in light of the difficulties faced with smart meter roll-outs across Europe[35]. Moreover, the required strengthening of electricity distribution grids would also have to be financed.

Under a scenario in which electrification is pursued as the primary residential heating technology, hydrogen may still play a complementary role. Decentralised provision of hydrogen (ie. gas bottles) could supplement residential heating on the coldest days to prevent excessive strain on local electricity distribution grids.

A final option involves keeping the natural gas network much as it is today but injecting biomethane[36] or synthetic methane produced by combining hydrogen with carbon dioxide.

An obvious advantage is minimal disruption to the grid. However current levels of supply of biogas fall far short of demand, and synthetic methane is an inefficient source of energy and is very expensive.

3.4 Hydrogen as an enabler of renewable electricity deployment

In addition to deployment in end-use sectors, hydrogen could be used for energy storage, enabling the integration of increasing shares of variable renewable generation into electricity systems.

Historically, electricity grids have operated on the basis of volatile aggregate demand from end-users being met by a mix of inflexible baseload (nuclear, lignite, run-of-river) and peak-load power that is dispatched on demand (for example gas or hard coal), with relatively little storage.

Increased adoption of variable renewable electricity sources is changing this model. A challenge for grid operators is to maximise the uptake of renewable electricity that is produced when the sun is shining and the wind blowing. A number of options, beyond the scope of this Policy Contribution, are under consideration, including the use of hydrogen produced from electrolysis.

Short-term flexible demand

Hydrogen production via electrolysis could be increased during times of excessive renewable power generation and reduced when supply is weak, allowing more efficient balancing of the electricity market. Kopp *et al* (2017) showed that already in 2016, a 6 MW electrolyser in Mainz, Germany was deployed with economic benefit to the German control reserve market.

Whether electrolysers can be competitive as providers of grid-balancing services will depend on technological and regulatory developments in the next few years.

In particular, battery storage systems that already feature much lower storage losses than hydrogen will likely see their capacity costs drop dramatically as more batteries are produced and deployed. They may therefore be better suited than electrolysis to managing intra-daily or even intra-weekly fluctuations on electricity grids.

Long-term seasonal storage

Hydrogen could be a more useful option for managing fluctuations in renewable electricity produced in different seasons. Hydrogen could be produced during months of excess renewable electricity production, stored geologically, and then converted back into electricity during months of lower renewable electricity supply.

Compared to batteries, hydrogen is a more plausible solution for seasonal storage because investment costs are almost independent of storage volume[37] and 'self-discharge' is low (Parra *et al* 2019).

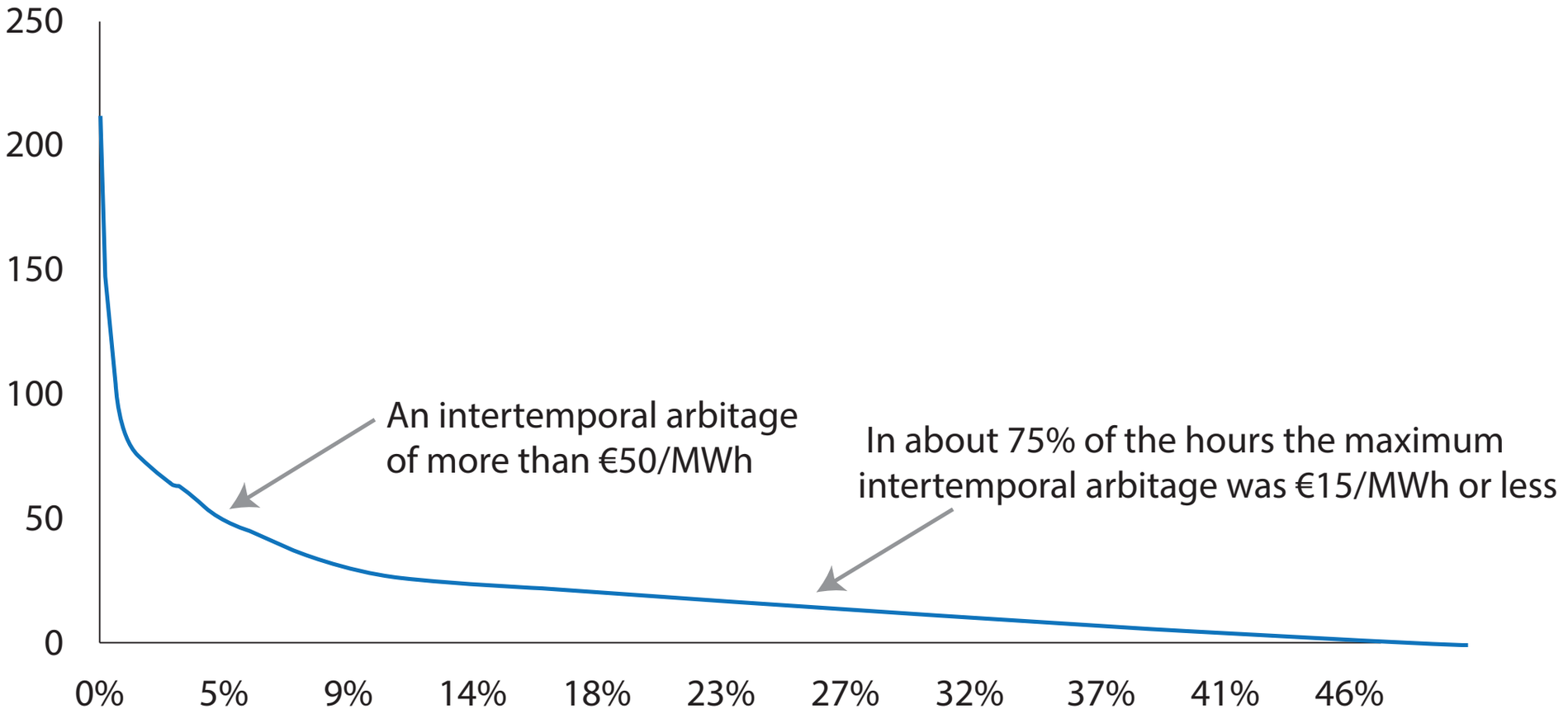
From an economically efficient perspective, whether hydrogen emerges as a seasonal storage mechanism will depend on the relationship between seasonal price differentials and the capital costs of deploying electrolysers along with storage.

German electricity price differentials show that currently only for 5 percent of the time does the price differential (arbitrage gain) exceed €50/MWh. The evolution of this potential for arbitrage gain will inter alia depend on the deployment of renewable electricity generation sources and on the deployment of flexible demand side resources.

4 Overview of market dynamics

The current cost structure of hydrogen is based on its production from natural gas (methane). But, as we have discussed, this supply is expected to be considerably transformed.

Figure 7. Price differential, lowest vs highest hourly prices in Germany, 2019



Source: Bruegel based on SMARD.

The market consensus is that the price of low-carbon hydrogen will decrease over the coming years, largely driven by falling electrolyser costs (which can be reinforced by deployment policies that allow economies of scale and learning).

The extent of this cost decrease will determine the competitiveness of low-carbon hydrogen for each end-use sector (Figure 8).

A further fundamental driver of supply costs will be the cost of fuel inputs – electricity in the case of electrolysis. Expectations are that, unless there are breakthroughs in terms of more flexible power demand/storage, there might be more hours with very high and very low prices (Bossmann *et al* 2018).

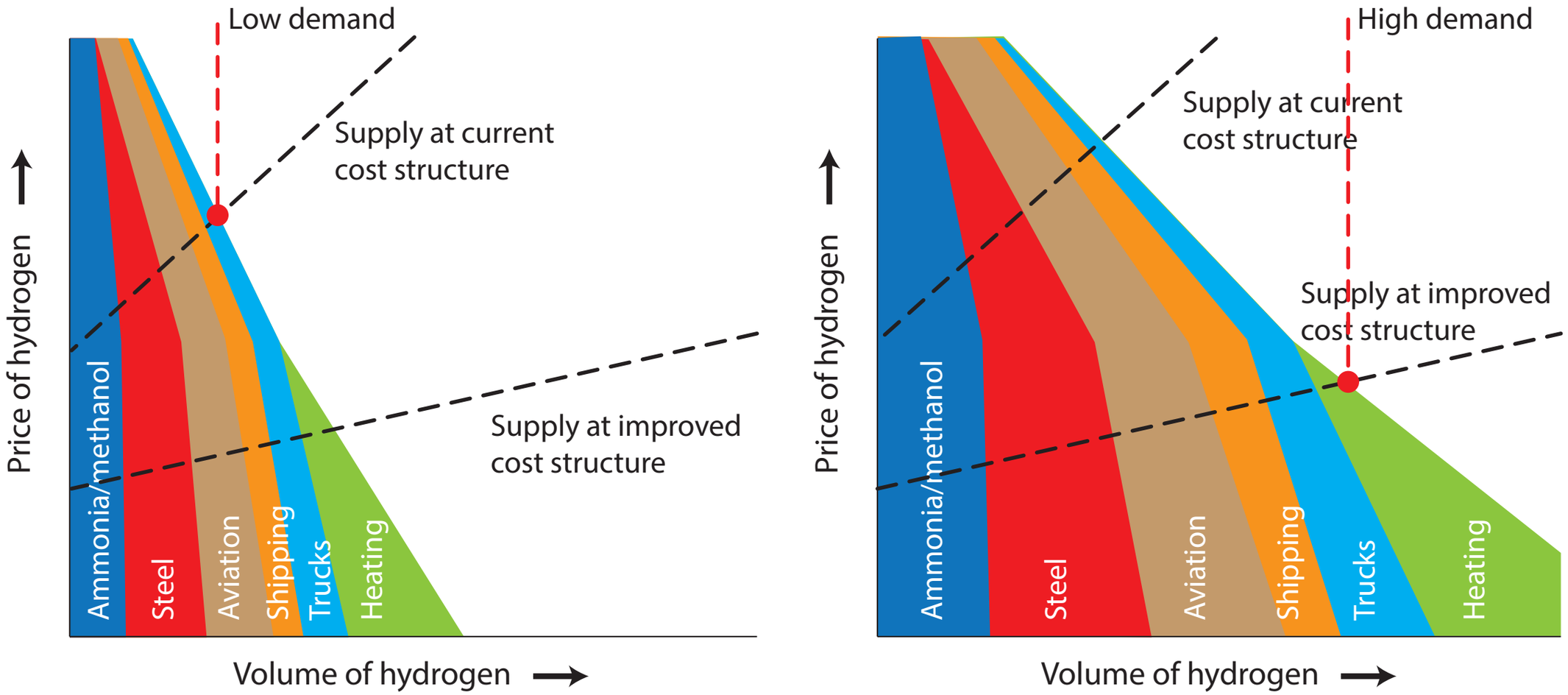
Thus, there is potential for hydrogen costs to be further lowered by running electrolysers only in hours when – thanks to abundant power from renewables and/or low demand – electricity is particularly cheap.

However, while the investment cost of electrolysers remains high, they will have to run most of the year to justify their fixed costs.

Only when the fixed costs of electrolysers reduce enough will their use be economic in part-load. But then they will start to push up electricity prices during exactly those hours where it is economic to operate them. This will make additional renewables investments economically viable and an equilibrium could develop.

Electrolyser capacity in this equilibrium will be determined not only by the cost of renewables and electrolysers, but also by the cost of competing flexibility providers (eg. batteries, demand-response). Thus, if batteries continue their

Figure 8. Stylised hydrogen demand scenarios



Note: left panel shows a scenario with limited technological/commercial development on the demand side; right panel shows a scenario with significant breakthrough in all demand sectors.
Source: Bruegel.

rapid pace of technological advancement, and/or innovation sees electricity demand become increasingly flexible, it is still possible that the capital costs of electrolysers will be too high to justify their part-load operation.

Non-EU countries are also investing in hydrogen production capacity. In some cases, this involves cooperation with Europe, such as between Germany and Morocco (BMZ, 2020).

In other cases there is no European cooperation and hydrogen will potentially be traded on international markets. The ability of third countries to produce hydrogen under more favourable conditions may exert downward pressure on European prices, although transport costs would have to be factored in, as discussed in section 2.

The evolution of hydrogen demand within Europe is highly uncertain (section 3). But whatever happens, a certain level of hydrogen demand is almost certain to remain, the extent of which will depend on the demand for the end products: ammonia, methanol, crude oil-derived products. In other sectors, demand for hydrogen will depend if hydrogen-utilising technologies reach commercial maturity.

5 Policy options

The future prospects of hydrogen are highly uncertain. Currently, it is a chemical feedstock but significant breakthroughs in production and end use could mean hydrogen might even contribute 20 percent of the EU's final energy demand in 2050.

The challenge for policymakers today is to assess the correct level and type of policy support in the context of this uncertainty. We conclude with a discussion of some of the policy measures that could support hydrogen deployment currently being debated.

Meaningful price on all greenhouse gas emissions

Tightening/extending the EU emissions trading system and re-thinking the design of energy taxation systems

Higher prices on the use of fossil fuels help the competitiveness of all low-carbon technologies relative to fossil-fuel alternatives. In 2021 the European Commission will propose to extend and tighten the EU emissions trading system (ETS) in line with tougher emission reduction targets.

Addressing the current taxation discrepancy between electricity and natural gas prices would be another no-regret option. From a carbon emissions standpoint, the European taxation system currently biases consumption away from electricity and toward natural gas[38]. The European Commission can address such discrepancies by reforming the EU Energy Taxation Directive (2003/96/EC), which is also scheduled for 2021.

Supporting low-carbon hydrogen production

State support for the production of hydrogen with low carbon emissions

We classify this as a no-regret policy option. Decarbonising the production of current hydrogen demand would already avoid approximately 100 Mt of CO_2 emissions in the EU per year.

The wide range of sectors which could potentially use clean hydrogen suggests that the benefits of decarbonising hydrogen production are likely to exceed those from current demand only.

Moreover, until a low-carbon hydrogen source at scale is secured for Europe, there is limited value in stimulating a massive ramp up in additional hydrogen demand, which would be met by carbon-intensive production methods[39]. Supporting low-carbon hydrogen should therefore be a policy priority.

The deployment of a significant volume of electrolysers should be supported to reduce their cost. This could be done using tools that proved successful for wind and solar technology (auctioning of feed-in premia).

Policies to support the deployment of renewable electricity generation to fuel growing demand from electrolysers would also be a no-regret option. The deployment of other low-carbon hydrogen production should also be phased in when industry is willing to share some of the remaining technology risk.

From a geopolitical standpoint, developing commercial know-how in technologies used to produce clean hydrogen is likely to make Europe's exports more competitive in a decarbonising world.

Supporting green products

State support for the production of low-carbon products, particularly in markets currently dominated by emissions-intensive production

Focusing public support to the demand for low-carbon products and intermediate goods (such as low-carbon steel) has the advantage of being technologically neutral.

Markets would be allowed to decide the most cost-efficient manner for production. Public revenue would be spent only for products for which a clear carbon-emissions reduction has been achieved.

This would allow policymakers to adopt a neutral standpoint regarding the applicability of hydrogen technologies, and to avoid public money being spent on projects that eventually do not significantly reduce emissions. The EU already has a tool for defining low-carbon benchmarks in the ETS product benchmarks[40]. A challenge would be choosing which products to support, and how much to support each product.

One drawback to this solution may be that one or two technologies are over-supported, while other options are ignored. The question then arises of whether the state is able to predict accurately which products and technologies should be supported.

This is because an explicit focus on decarbonising one sector prioritises technologies that are suitable for that sector while not necessarily taking into account that support for a different technology may have wider benefits for the rest of the economy. For example, a focus on decarbonising heavy transport today might boost the competitiveness of new fuel cells and hydrogen tanks that then could be used in light vehicles, trains and aircraft, while a focus on decarbonising light vehicles today might instead extend the head start batteries have to all other modes of transportation.

Supporting R&D

Support for hydrogen research and development

Europe invests too little into R&D in general (D'Andria *et al* 2017). Public support for low-carbon R&D is a no-regret option. However, prioritising support for different areas is more controversial.

Many potential hydrogen applications would benefit from R&D investment. On the supply side, a range of potential production pathways could be explored. Public support for increasing the number of potentially viable decarbonisation options would make the low-carbon transition more resilient (eg. if other technologies fail unexpectedly).

Increased technology competition is also important to exert pressure on dominant technologies (eg. electric vehicles) to invest in innovation based on specific criteria where alternative technologies still have a lead (eg. limited range).

There is a strong case for Europe to significantly scale up R&D for all decarbonisation options. But, in a scenario of limited R&D budgets the value of hydrogen R&D must be weighed against R&D in competing technologies or energy carriers.

A consistent and predictable support mechanism at the European level would be beneficial. It could periodically allocate R&D funding to areas that appear most attractive according to decarbonisation criteria and priorities. The mechanism would adapt to technological evolution in order to avoid institutional lock-in[41].

It could take the form of an independent public body, a European Energy Agency, which could provide policy advice to the European Commission and interested member states. For example, future bottlenecks in the shift to a low-carbon economy could be identified as a basis for today's public R&D support. Such a mechanism would help identify which hydrogen technological applications justify public R&D.

Finally, in the context of the current economic crisis, a focus on creating jobs and high multipliers might lead to an under-appreciation of the merits of R&D for long-term economic development.

Retrofitting natural gas networks

Public infrastructure investment to adapt the natural gas grid to make it suitable for transporting hydrogen

The natural gas grid constitutes a significant infrastructure asset, capable of holding large volumes of energy. At reasonable cost it could be repurposed for a low-carbon economy.

The necessity of repurposing the gas grid depends upon the size and geographic dispersion of demand clusters. If households are to consume significant volumes of hydrogen, clearly repurposing is necessary and investment should slowly begin.

However, it is not clear if household-level hydrogen demand will ever materialise (section 3). Instead, our demand analysis points to the likelihood of relatively significant hydrogen demand emerging in a series of large industrial clusters ('hydrogen valleys') across Europe.

In each cluster, hydrogen-using industries (eg. ammonia, steel, carbon storage) would co-locate and share the costs of hydrogen production or transmission.

Therefore, a planning perspective would not place much importance on building out a hydrogen distribution grid to the scale of anything like that resembling the current natural gas infrastructure. Instead, a few transmission pipelines connecting large demand and supply sources would be the priority investment.

Therefore, while it is technologically possible that hydrogen could satisfy household energy demand, it is not a first-best solution. The challenge in the transition between two network-based systems (eg. gas-based heating to electricity-based heating) is, that at one stage in the transition, the incumbent network will lose so many subscribers that its remaining subscribers will bear too much of its fixed cost, leading them to unsubscribe at increasing speed.

Such a disorderly transition (which was seen for some central heating networks in eastern Europe) can be inefficient and might need to be publicly managed.

In addition, policymakers should focus short-term planning (5-10 years) and regulatory activity on enabling industry to build the infrastructure necessary for a system of large industrial hydrogen clusters. Decisions over whether to retrofit natural gas grids at a more granular level should be postponed until clearer evidence emerges of the capacity of electrical solutions to fully satisfy household energy demand.

Current market dynamics do not yet suggest that retrofitting natural gas grids to carry hydrogen is a sensible public policy.

Roll-out of hydrogen vehicle charging stations

State support for the deployment of hydrogen vehicle charging stations

Hydrogen vehicle charging stations are an enabling infrastructure. Providing the means to refuel and operate hydrogen vehicles should stimulate private investment in the production and purchase of hydrogen vehicles. Some pilots have already been supported (fewer than 100 in Germany).

However, significant public support for hydrogen charging stations would likely not be sensible. As discussed in section 3, the case for a transition of most transport sectors to hydro- gen appears weak when compared to the case for battery electric technology.

There is a risk that public support for hydrogen refuelling stations would be at the expense of public support for electric charging stations.

European policymakers should continue to increase the stringency of decarbonisation policies for the transport sector. As discussed, with higher carbon prices or tougher policies, hydrogen solutions may be viable for heavy vehicles.

In such a future scenario, private investment could cover the required charging stations (at either end of a trucking route, for example). If private consortia come forward with co-financing options for publicly available hydrogen charging stations, policymakers might consider offering small incentives, but this should not be a landmark policy. Hydrogen vehicle charging stations are not today a priority for public support.

Certification scheme for low-carbon hydrogen

Developing a system for robust classification of the carbon content for each MWh of hydrogen

Knowing the carbon emissions associated with the production of each MWh of hydrogen will be an issue for future hydrogen consumption. Within Europe, calculations should not be necessary because hydrogen production falls under the ETS, and so carbon emissions are already priced in. But certification may be necessary for certifying the 'greenness' of hydrogen imports.

Designing a robust classification system will be difficult. For electrolysis, this would involve certifying the electricity input. When electricity for electrolysis is taken from the public grid its carbon content is more a matter of definition/accounting, than an objective value[42].

But even certifications of dedicated supplies from renewable electricity often do not pass the additionality test: has new renewable electricity capacity been built exclusively for hydrogen purposes, or has existing or already planned renewable capacity simply been 'assigned' to hydrogen production?

While a difficult task, European policymakers should think about designing a framework for the international trade in clean hydrogen. The extent to which hydrogen will become an internationally traded commodity remains to be seen, but if such a scenario emerges, Europe is likely to be a significant net importer. It would be wise, therefore, to start the conversation about how Europe can be sure its hydrogen imports are low carbon.

Competition policy/regulation holidays

Providing breaks from the rules of competition policy or regulation to encourage targeted investment

Providing some temporary exemptions from strict competition/network regulation rules designed for mature markets can be a tool for encouraging private sector buy-in. Horizontal and vertical coordination are both crucial

during the earlier stages of building a new network. For example, initial investments in the production, transmission and consumption of hydrogen need to be well synchronised.

Without the ability to ensure the provisioning of the complementary elements of the hydrogen value chain (through vertical integration or binding agreements), private investment may be discouraged in some areas.

There is a coordination problem, with investment into all elements needing to be synchronised because each individual investment (eg. an electrolyser) is only worthwhile if all other parts of the new value chain (eg. a hydrogen pipeline, storage or steel-plant) also work.

Additionally, regulatory breaks can help encourage breakthrough R&D and investment. This is particularly the case for testing new technologies, such as the correct protocols for using hydrogen in households.

In both cases, such exemptions must be temporary and well targeted so they encourage investment in areas with high benefits. ■

Ben McWilliams is a Research Analyst, and Georg Zachmann a Senior Fellow, at Bruegel

Endnotes

1. In this paper we transfer all energy units (electricity, hydrogen, natural gas, etc) into terawatt hour (TWh) for easier comparability. One TWh is about 0.03 million tonnes hydrogen or 92 million cubic meters of Russian natural gas.

2. 90% is a technical maximum. The range of carbon captured is likely to be in the range of 60-90%. Capturing carbon

between 60 and 90% is relatively more expensive.
3. See https://www.eex.com/en/market-data/power/futures where futures at the Belgian energy exchange frequently settle at around €50, and https://www.powernext.com/futures-market-data where an index of European natural gas prices stays around €20.
4. In fact, we consider a carbon price of €50 a likely upper bound for the next three years.
5. Estimates using IEA data. This illustrative example assumes that the required installations for hydrogen production from methane and from electrolysis are available.
6. The EU is in particular supporting the development of proton electron membrane (PEM) electrolysers. For example, the REFHYNE project (https://refhyne.eu/) will install and operate the world's largest hydrogen PEM electrolyser with 10MW capacity. This is important because PEM electrolysers are able to more quickly adjust demand in response to fluctuating electricity supply compared to conventional electrolysers.
7. Solar potential of some 600,000 TWh/year from Korfiati et al (2016) alone would enable around 12,000 Mt of hydrogen production.
8. Our calculations are predominantly built on interpretations of the European Commission's 'Clean Planet for all' strategy (European Commission, 2018). Additional sources are used to complement our analysis in many cases. A footnote below each set of numbers briefly explains the underlying calculations.
9. Figures estimated using the growth rate in passenger vehicles assumed by European Commission (2018). Upper demand based on 15 percent of the vehicle stock in 2050 being hydrogen fuel cell, 5 percent for medium, and 0 percent for lower.
10. Figures estimated using the growth rate in heavy duty trucks to 2050 from European Commission (2018). Upper bound assumes 25 percent hydrogen fuel cell composition of 2050 heavy duty fleet, medium and lower bounds assume 15 percent and 1 percent respectively.
11. Figures estimated using the growth rates in light commercial figures to 2050 from European Commission (2018). Upper bound assumes 20 percent hydrogen fuel cell composition for 2050 light-duty fleet, medium and lower bounds

assume 5 percent and 0 percent respectively.
12. Figures estimated on the basis of hydrogen-optimistic and hydrogen-pessimistic scenarios for final energy demand in the shipping sector from European Commission (2018). These figures exclude indirect demand for hydrogen that would arise if ammonia were used as a fuel.
13. Total energy demand for aviation sector in EU taken from European Commission (2018). Upper demand assumes 30 percent of demand met by direct hydrogen (ie. fuel cell + combustion). Of the remaining 70 percent, jet fuel or equivalent substitutes are used. Of this demand, 20 percent is assumed to be met by synthetic fuel production from hydrogen. Lower demand is zero in the case that hydrogen technology does not develop. Medium is midpoint.
14. Synthetic fuel broadly refers to the concept of a chemical fuel synthesis in which hydrogen is reacted with carbon from carbon dioxide in order to produce hydrocarbons with a significant commercial value (eg. methane). When hydrogen is produced from green electrolysis and carbon dioxide is captured from the air, this can theoretically be a zero-carbon emission fuel.
15. The implied mitigation cost of using power-to-liquid to produce synthetic jet fuel would be in the order of €800/tonne CO_2 (Pavlenko et al 2019).
16. Biofuels from seaweed could address this issue but are not yet commercially proven (Bellona Europa, 2020).
17. Up to 41 percent with chemical sector emissions used to represent methanol and ammonia.
18. For the whole chemical sector, not just ammonia and methanol.
19. Based on the assumption of a 178 kilogramme hydrogen requirement per tonne of ammonia. The variation arises from different final demands for ammonia in the EU in 2050.
20. Production of hydrogen from methane emits 1.83 tonnes of CO_2 per tonne of ammonia (Bazzanella and Ausfelder, 2017).
21. For example, a 100MW wind-powered renewable hydrogen production plant in the Netherlands developed by power company Ørsted and fertiliser company Yara (Durakovic, 2020).
22. See https://www.consilium.europa.eu/en/press/press-releases/2019/05/21/eu-adopts-new-rules-on-fertilisers/

23. Ammonia can be combusted to produce electricity. On a small scale, it is currently co-fired in coal plants to produce electricity with lower emissions.
24. Based on assumption of 189 kilogrammes hydrogen per tonne of methanol. Variation arises from differences in EU final methanol demand in 2050.
25. Our estimations first take IEA trends for a slight decrease in hydrogen requirements in oil refining from 2020 to 2030 while assuming constant demand for oil refining. The scenarios then differ depending on assumptions on the decrease in demand for oil refining.
26. See for example the International Maritime Organisation's IMO 2020 rule: https://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx
27. Demand assumed constant at today's level. Upper assumes all demand met from electric arc furnaces (EAF) with 60 percent direct reduced iron (DRI)/40 percent scrap steel feedstock. Lower assumes 50 percent EAF, and feedstock 50 percent DRI/50 percent scrap steel. Medium assumes 75 percent EAF and feedstock of 50 percent DRI/50 percent scrap steel.
28. See https://ec.europa.eu/growth/sectors/raw-materials/industries/metals/steel_en
29. Electric arc furnaces can also be rapidly started and stopped. A shift in steel production towards electricity could therefore have positive spillover effects for demand response in electricity grids with lots of variable renewable power.
30. As well as removing the majority of emissions which are associated with the reduction of iron ore.
31. Recycled steel can be contaminated with other elements, most commonly copper. This reduces the quality of steel.
32. HYBRIT in Sweden is a well-known example. See https://www.ssab.com/company/sustainability/sustainable-operations/hybrit
33. Based on modelling results from European Commission (2018). Upper demand is taken from the H_2 scenario – this scenario achieved an 80 percent reduction in emissions. We assumed a slightly increased hydrogen demand to reach a 100 percent reduction. Medium and lower linearly extrapolated to zero.
34. See https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en

35. In 2014, it was estimated that the penetration of electricity smart meters in the EU in 2020 would be 72 percent. Most recent estimates suggest that the actual figure is about 43 percent. Lack of consumer acceptance, often for privacy reasons, has been a main reason for delay (Tounquet and Alaton, 2020). While heat pumps should not present privacy issues, the example clearly illustrates the challenges associated with a policy that requires the agreement of individual households.

36. Refined from biogas, which is produced through anaerobic digestion of waste or organic matter from a variety of sources.

37. Most of the investment cost is related to the capacity (ie. the MW) of the appliances that transform electricity into hydrogen and back – while the size of the storage tanks/aquifers (ie. the MWh) does not drive cost that much.

38. This DG ENER factsheet shows the discrepancies in taxation rates: https://ec.europa.eu/energy/sites/ener/files/qmv_factsheet_on_taxes.pdf

39. There is an argument that it is still worthwhile pursuing demand cases today and that clean hydrogen supply will eventually 'catch up'. There is clear reason to this argument, but we believe that a clearer route must first be established for the decarbonisation of hydrogen supply within Europe. Supplying the volume of clean hydrogen suggested by our highest demand case would currently be very difficult for Europe.

40. Product benchmarks have been calculated for a range of emission-intensive products under the ETS. This benchmark is based on the average greenhouse gas emissions associated with the best performing 10 percent of installations. They can therefore be thought of as the best-practice emissions associated with production of a particular product.

41. See Zachmann et al (2012) p 99, for further discussion.

42. For electrolysis, it would require defining the carbon content of the used electricity and three very different values can be used for each hour in which the electrolyser was used: cleanest power plant; average power plant; dirtiest power plant or last (marginal) power plant required to meet the demand. In the short-term, the last option seems most plausible, but in the longer term, additional demand from electrolysis might be met be increasing supply, potentially from renewable sources.

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Virtual EBACE connected our industry

Ed Bolen considers how the business aviation community adapted to new forms of communication, and looks ahead to the return of in-person gatherings post-pandemic

Even more than one year later, I remain amazed and humbled by the tremendous innovation and resilience our industry displayed in responding to the COVID-19 pandemic, including by how quickly the business aviation community adapted to new forms of communication.

At NBAA, we revamped our entire model for connecting with our members to utilize the virtual environment. With our world and our industry *"locked down"* around the globe, NBAA's News Hour webinars, our NBAA Insider Daily summary of the latest news in our industry and immersive virtual convention platforms all proved to be vital and highly-effective tools as we navigated the COVID environment.

As *World Commerce Review* readers know, the 2020 edition of the European Business Aviation Convention & Exhibition (EBACE) was one of the first major industry events to be cancelled last year as the full scope of the pandemic became known. However, I'm pleased to note we've recently wrapped a successful virtual edition of the event for 2021, EBACE Connect.

Held 18-20 May and presented by the European Business Aviation Association (EBAA) and NBAA, this online exhibition soared beyond expectations and demonstrated the global business aviation community's eagerness to embrace the future, focus on new opportunities and fire the imagination.

EBACE Connect served to bring the business aviation community together to share a common vision for the future and to plan for our post-pandemic world. The event made clear that business aviation is focused on much more than just returning to a *"new normal"*; our industry is evolving, coming back stronger, more adaptive and more innovative than ever.

More than 1,600 attendees participated in EBACE Connect, which featured keynote discussions with aviation leaders and visionaries. Famed pilot and philanthropist Erik Lindbergh opened the program by sharing personal insights on the next great era in aviation, while day two featured a Lightning Round session with the CEOs of all the major business aircraft OEMs highlighted their perspectives.

The future was in focus throughout EBACE Connect's roster of panel sessions and 'Thought Leadership' discussions, covering advanced air mobility, safety regulation for new technologies, growing beyond COVID, market trends and sustainability. Major OEMs and leading service providers announced exciting new products and offerings to an audience that included nearly 100 international journalists registered to cover the event.

I believe NBAA and our entire industry are confident of much brighter days ahead, as business aviation stakeholders worldwide embrace a promising, innovative and sustainable future

Joining together once again as an industry

While EBACE Connect was an unquestionable success, our industry eagerly anticipates meeting together once again, in person, and we certainly look forward to the return of an in-person 2022 EBACE to Geneva Airport and Palexpo in Switzerland, scheduled to take place 23-25 May.

NBAA is also working to bring an exciting, in-person 2021 edition of our Business Aviation Convention & Exhibition (NBAA-BACE) to Las Vegas, NV from October 12-14. Interest in this event has been strong from exhibitors and attendees alike, and we're close to selling out the Exhibit Floor at the all-new, state-of-the-art West Hall of the Las Vegas Convention Center (LVCC).

Featuring 600,000 square feet of exhibit space and the equivalent of 80 new meeting rooms, the LVCC West Hall also features an expansive, 14,000 square foot outdoor terrace for receptions. NBAA-BACE attendees will further appreciate that all exhibitors will be hosted in a single area, unlike past years in Las Vegas that split the exhibit floor between the Central and North Halls.

In keeping with its unique importance this year in bringing our industry together again, NBAA-BACE will feature an unprecedented roster of impressive, dynamic and forward-looking keynote speakers and session presenters, as well as hundreds of prominent business aviation OEMs, industry stalwarts and first-time exhibitors alike.

Attendees will also experience several new features of NBAA-BACE, including a dedicated Maintenance Pavilion on the show floor highlighting the very latest resources available to the aviation maintenance technicians (AMTs) and airframe and powerplant (A&P) mechanics who have kept our industry flying safely throughout the pandemic.

Details of this and other new offerings will be available in the months ahead at nbaa.org/bace.

NBAA has also partnered with leading medical services consulting firm CrowdRX to ensure NBAA-BACE meets the highest standards for attendee safety, without losing the character and camaraderie for which the event is known. Additionally, the LVCC has earned Global Biorisk Advisory Council (GBAC) STAR facility accreditation by ISSA, the world's leading trade association for the cleaning industry.

In marked contrast to the uncertainty we all felt this time last year, I believe NBAA and our entire industry are confident of much brighter days ahead, as business aviation stakeholders worldwide embrace a promising, innovative and sustainable future. We look forward to welcoming you to a truly one-of-a-kind experience in Las Vegas. ■

Bolen is President and CEO the National Business Aviation Association (NBAA)