SVENSKT NÄRINGSLIV
SWEDISH ENTERPRISE

The effects of the US Inflation Reduction Act (IRA) on EU competitiveness

EXPECTED IMPACT ON CLEAN ENERGY AND ELECTRIC VEHICLE VALUE CHAINS AND HOW THE EU SHOULD RESPOND

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A report by the Confederation of Swedish Enterprise, based on an analysis from Copenhagen Economics

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Copenhagen Economics CE

The Inflation Reduction Act (IRA), signed by US President Biden in August 2022, is the first major climate law ever approved by the US Congress. The IRA aims to radically increase the pace of decarbonisation in the US by offering subsidies, tax breaks, and government investment. In the EU, there are fears that investment will switch from the EU to the US and that transatlantic trade and investment will be distorted. This in turn calls for an immediate and ambitious response from the EU.

The Confederation of Swedish Enterprise (Svenskt Näringsliv) has commissioned Copenhagen Economics to examine the possible impact of the IRA on EU competitiveness, EU-US trade, and foreign direct investment (FDI). This report presents the findings from Copenhagen Economics and puts them into a wider policy context, with proposals from the Confederation of Swedish Enterprise on how the EU should, and should not, respond to the IRA. The analysis conducted by Copenhagen Economics can be found in the annex of this report.

Content

Preface

The Inflation Reduction Act (IRA) was signed into law by President Biden on August 16, 2022. Despite its name, the IRA has little to do with inflation and is rather a wide-ranging federal law aimed at cutting greenhouse gas emissions and fulfilling US climate targets. This is to be achieved through a range of investments, subsidies, and tax breaks aimed at incentivising American firms and consumers to change their production and consumption patterns.

The law has been described as a real game changer for the global fight against climate change. Different calculations suggest that the act will cut US emissions between 37.5% and 41% by 2030. This would not be enough to reach the US target of a 50% reduction in the same period, but it is a decisive step in the right direction.[1]

The question for businesses worldwide is whether the IRA is also a game changer for the global market economy. By rolling out an extensive subsidy programme, combined with earlier programmes for infrastructure and the production of data chips, the US appears to be moving towards a more state-oriented economic model. If that is the case, what does that mean for businesses elsewhere when they compete in a global context?

In Europe, judging by alarmist reports in the media, there are fears that a future wave of investment would switch from the EU to the US and that trade patterns would be distorted. This calls for an immediate and ambitious response from the EU. But are these fears well-founded, or are they based on anecdotes?

Policy, as always, needs to be based on facts, not fear. The Confederation of Swedish Enterprise found that there is a lack of thorough analysis of the expected effects of the IRA and therefore commissioned Copenhagen Economics (CE) to analyse the effects of the IRA on EU competitiveness. In this report, we summarise CE's findings and put them in a wider policy context, with our proposals on how the EU should, and should not, react.

The work at the Confederation of Swedish Enterprise has been coordinated by Henrik Isakson and Ingrid Serup, with contributions from, among others, Madeleine Johansson, Alexandra Leonhard and Stefan Sagebro.

The analysis from CE can be found in the annex to this report.

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[1] The Climate Impact of the Inflation Reduction Act (evergreenaction.com)

About the study

Part of the IRA analysed

The IRA has a total budget of USD 369 billion for the period 2023 to 2031. It is important to note that this is purely a budget and therefore, the actual sums spent may be larger or smaller. This depends, for example, to what extent various tax credits are used.

The IRA consists of several programmes, the vast majority of which relate to addressing climate change. A large part of the act is government investment, and with that comes various “Made in America” provisions, which discriminate against non-US suppliers in procurement processes. This is nothing new, but rather an expansion of existing, worryingly protectionist, policy in the US. These investments are not the focus of the debate, and they are not discussed further here.

The analysis conducted by CE, commissioned by the Confederation of Swedish Enterprise, focuses on programmes for the private sector to support (1) clean energy and (2) providing incentives for electric vehicles. The latter – electric vehicles – consists of direct support to consumers and support for manufacturers, while support included in the clean energy sections is directed at business.

Combined, these programs constitute USD 206 billion, or 56% of the IRA budget. CE finds that **8% of the IRA is for *setting up and/or expanding* clean energy powerplants and 44% for the running costs of *producing* clean electricity.** To limit the scope of the analysis, only wind and solar energy are studied[2]. **4% of the IRA budget is for electrical vehicles (EVs),** including commercial and passenger cars. It is in these areas that the competitiveness effects of the IRA are likely to be the greatest.

A value chain approach

The IRA did not appear in a vacuum. Subsidies existed in both the EU and the US before the IRA. The size of the subsidies, and their effects on the production costs, are assessed in the CE study. US subsidies (for these areas) are mostly at the federal level, whereas EU subsidies are mostly administered at member state level, although sometimes with funds originating from the EU budget, and always limited to what is compatible with the EU state aid rules. The US subsidies, which mostly take the

[2] The Inflation Reduction Act supports the facilities generating electricity from several resources – for example wind, biomass, geothermal, solar, hydropower, and current and new nuclear. CCUS for coal – and gas plants and storage. Source: https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf

form of tax breaks, are compared with European subsidies in six EU member states, namely Germany, France, Spain, Poland, Sweden, and Denmark. These six countries account for 60% of EU GDP and emit 56% of EU's greenhouse gas emissions. Therefore, these countries can be seen as representative of the EU27.

CE first compiled data on pre-IRA subsidies in the US and EU, then added the IRA subsidies and finally analysed the new total costs[3] of production and how these may affect relative competitiveness between the EU and the US in terms of investment and trade in the sectors considered. A value chain perspective has been used, which means that subsidies have been added along the various stages in the production chain to finally arrive at a total subsidy. This is a more useful way of analysing the effects of the IRA rather than simply studying the sums of money allocated to various programmes.

See below an illustration of the value chain for renewable energy products.

Two different scenarios have been analysed. The first one is a scenario in which IRA subsidies expire in 2031 as planned. The second scenario looks at the effect of extending the subsidies for the full life cycle of an investment. This would require a new decision in the US Congress, but as the subsidies are gradually dispersed and become popular, they may become hard to remove. As subsidies were also in place before the IRA, a fallback to zero subsidies seems unlikely.

[3] Total costs include labour, capital, taxes etc.

Clean energy

Prior to the IRA, EU member states' subsidies for clean electricity production were larger than those in the US. For example, in **2017, EU subsidies for renewable electricity production amounted to USD 80 billion compared to USD 10 billion in the US.** In recent years, however, subsidies in this area in EU member states have decreased as investment in renewable electricity production have become more profitable on market terms. In the EU, carbon emission pricing under the Cap-and trade-system (EU ETS) has also incentivised the expansion of renewable electricity production. **The EU has therefore been more active and used more carrots and sticks than the US.**

Clean energy power plants and production of clean electricity

The IRA subsidises investment to set up and expand clean energy power plants. The act also supports the manufacturing of components for these plants. CE's analysis shows that 8% of the budget is allocated to this purpose. Key components, including solar modules, wind turbine blades and wind towers must be "fully assembled" in the US to receive support.

Furthermore, **another much larger part of the IRA (44% of the budget) is technology-neutral support for the costs of producing clean electricity.** There are several complicated requirements that affect eligibility for support, including criteria related to when plants are built and local content requirements for iron and steel (which have to be increasingly sourced in the US, Canada or Mexico), which means that not all US clean energy plants will receive a full subsidy.

Based on CE's analysis, the effects of this on the EU are twofold. First, there is a *cost of energy effect* and then there is a *trade effect*. When it comes to the costs of producing electricity, it will be different depending on the technology. For wind, the effects will not be especially significant because the IRA mostly extends to existing subsidies. Costs will fall, but not significantly. For solar energy, the effects are far greater, with a massive reduction in costs.

If the IRA subsidies are extended, the effects on costs of production will be far greater. **The costs for wind power will fall and may approach zero or perhaps even fall below zero. As for solar, the effect is more certain and much more pronounced. The cost of producing solar power will fall by almost 100%, close to zero or, entirely feasibly, fall below zero.**

The trade effect has to do with the stated objective to create a US value chain for these products, which means fully supported US power plants must source their key components domestically. However, to what extent suppliers in other parts of the world can contribute to that value chain with *parts for components* is unclear to us. It is clear that **EU exporters will not be able to participate in a large part of this American value chain.** As for iron and steel producers in Europe, their ability to supply the expansion of clean energy in the US will be held back as those metals are key inputs, for example in wind turbines where they make up most of the mass of turbines.

The purpose of these subsidies is to rapidly roll out clean energy in the US. **Electricity, due to physical constraints, is not traded between the EU and the US today – which means that the direct effect on EU relative competitiveness is nil**. However, the indirect effect on other industries might be more considerable (see next section on hydrogen and refined electrofuels).

Moreover, **if the IRA reduces the *overall price* for electricity in the US, it might have a profound effect as it will provide energy-intensive US industries, such as chemicals, with a competitive edge.**

Clean hydrogen and refined electrofuels

As discussed above, it is not possible to trade electricity over long distances. However, electricity can be converted into hydrogen and in turn to refined electrofuels, which can be transported and traded globally.

Clean hydrogen and refined electrofuels are important products to enable the green transition throughout industry. Hydrogen is an energy carrier and can be used as fuel, electricity or heat, using an energy converter[4]. Production of clean hydrogen is covered under the IRA. Clean hydrogen can in turn be further refined into electrofuels such as green ammonia and green methanol. These fuels have the capability of reducing greenhouse gases in areas such as heavy transport, fertilizers, and manufacturing where emissions are hard to reduce.

IRA subsidies to clean hydrogen consists of a direct subsidy for production and indirect subsidies discussed in the section above on clean energy[5]. As much as 60-80% of the cost of producing clean hydrogen[6] is the cost of electricity, which means that the indirect impact of the subsidies is strong. The IRA subsidy is likely to push down costs in the US to below the cost of production in most EU countries. With the extended subsidy to both clean electricity and clean hydrogen, CE calculations

[4] Hydrogen is already produced today. A common way of producing hydrogen is by steam reforming of natural gas. The method creates carbon dioxide emissions, as natural gas is of fossil fuel origin.
Source: https://www.uniper.energy/sv/sverige/om-uniper-i-sverige/vatgas-i-sverige

[5] CE's analysis presents a scenario where the electricity used in the electrolysis is transmitted directly from an IRA-subsidised renewable energy source. Thus, the electricity used are not bought from the wholesale electricity market and are not affected by the market price for electricity.

[6] Costs mean the average production cost of hydrogen including all costs over a plant lifetime.

results in **hydrogen almost certainly becoming cheaper in the US. Production costs could reach zero or even become negative.** This is in particular concerning for EU member states with a natural comparative advantage in this area, such as those on the Iberian Peninsula and the Nordic countries.

Due to high transportation costs, markets for hydrogen are currently regional. Thus, the trade impact on clean hydrogen may be limited. However, CE finds that there are theoretical scenarios where the export of US-produced hydrogen could be sold at competitive prices on the European market, despite transportation costs.

Nevertheless, the CE analysis finds that the real impact may come in refined electrofuels[7]. CE's report highlights green ammonia, green LNG, and green methanol as examples of refined electrofuels. Electrofuels are easier to trade as they have lower transportation costs (non-green versions of ammonia, methanol and LNG are already traded today). Market costs to produce refined electrofuels are expected to gradually reduce and converge, so subsidies will gradually play a relatively greater role. **US-produced electrofuels are likely to be extremely competitive on the EU market.** EU tariffs on ammonia, LNG and methanol currently range from 0% to 5.5-% and will only have a marginal impact.

[7] Electrofuels is an umbrella term for fuels and chemicals made from combining hydrogen with carbon dioxide or nitrogen. The carbon dioxide can come from a variety of sources, for example from production of liquid biofuels or from the air. Nitrogen can be captured from the air. Source: Elektrobränslen | f3 centre

Automotives

Electric vehicles (EVs) were subsidised in the EU and US before the IRA. In the US, subsidies were mostly at federal level and on average a bit lower than EU member state subsidies[8], which may explain the prevalence of EVs in Europe today compared to the US.

With the IRA, electric vehicles will be supported in several ways along the value chain in the US. Consumers receive a tax credit[9] to a maximum of USD 7,500 a vehicle. If we take the case of a Volvo S60 EV, the total subsidies are doubled with the IRA, and the proportion of the retail price that is subsidised increases from approximately 10% to 20%. This is only applicable for cars sold in the US, so there is **no risk US-subsidised vehicles will penetrate the EU market.** In addition, the EU has a relatively high tariff on electric vehicles, 10%, while the US tariff is 2%. However, companies producing in the US may use the subsidised profits to lower their overall prices for EVs, including in the EU.

Hence, **the size of the subsidies to EVs themselves are not expected to affect trade,** at least not to a significant extent. Rather, **the problem is that the subsidies are subject to local content requirements**. EV assembly must take place in the USMCA[10] countries. Furthermore, batteries must be produced in the USMCA, and as much as 50% of battery components must be manufactured in the USMCA. This increases to 100% in 2029. Steel and aluminium are important battery production inputs, and exports from the EU could thus be affected. Critical minerals, which are essential for EV batteries, need to come from a country with which the US has a free trade agreement, for example, Australia or Chile. However, the term free trade agreement is not yet specified in the IRA as of March 2023.

Since the IRA is agnostic regarding the ownership of automotive facilities, any EU firm that opens or expands production in the US may benefit from the act if the local content requirements are fulfilled. And since automotives are mostly produced locally to be close to the market and avoid transport costs, this also means that European car sales in the US will be able to benefit, again if local content requirements are fulfilled. The question is what happens to cars and car parts produced in Europe, which are currently, or could in the future, be exported from the EU to the US? **Vehicles manufactured and assembled in the EU cannot receive the subsidy**, which is of great concern. The requirements for batteries are also of concern for the EU.

[8] EU member states' subsidies for EVs varies from country to country.

[9] Not applicable for premium cars or for high-income earners.

[10] The United States-Mexico – Canada Agreement, signed in November 2018

However, batteries are not traded to any great extent today due to the dangerous and bulky character of batteries. Firms will primarily use Foreign Direct Investments (FDI) to reach foreign battery markets.

The critical minerals are another matter. Such minerals are not mined in Europe today, but that might change with new deposits being found and exploited. The processing of such minerals could be a future EU industrial activity and potential export. The fact that **the IRA closes a large part of the US market for EU exports of critical minerals** is a matter of concern for the EU.

The automotive industry represents 5% of total EU exports. The question is what value will remain for European production after the IRA. Premium cars are not subsidised by the IRA and **components that are not part of batteries can be sourced from anywhere. These "other inputs" represent somewhere between 50% and 65% of inputs in the value chain.** Neither do local content requirements cover services. This means that all the various services, especially digital inputs of today's connected vehicles, are unaffected. Much of the growth in value added in the automotive sector in the coming years will be in this area.

It is also not clear how IRA will be implemented when it comes to subsidies for cars that are leased, as the US government has announced that the US will waive the local content requirements for leased cars. Considering the likelihood of a larger share of all cars being leased in the years ahead, this further reduces the impact on the European industry. Other waivers may follow too, as not all guidelines have been published yet.

Overall, the IRA will benefit EU producers in the US at the expense of EU exports. However, it is likely that a large proportion of EU exports will be unaffected by the IRA, such as premium cars, digital services, non-battery components and due to leasing arrangements.

Steel and aluminium

The markets for steel and aluminium can be affected to a considerable degree by the IRA because these products are essential inputs for clean energy and automotives. 2% of total EU exports to the US consists of these metals.

The local content requirements included in the IRA are likely to result in scarcity of domestic steel and, to a lesser extent, aluminium in the US, which will push up prices. The local content requirements mean that some parts of the US market might be closed to EU steel and aluminium exporters. However, other parts (the majority) will be open and perhaps even more profitable for EU exports.

Unlike the US, the EU does not only provide *carrots* in the form of subsidies for the green transition. It also provides *sticks* in the form of financial incentives to move away from non-green production. This takes the form of the ETS[11] and the soon-to-be-enacted CBAM[12]. Unless a recession reduces demand for emission rights, **ETS and CBAM will increase the cost of steel and aluminium in Europe and could thus make investment in clean energy power plants, and automotives, more expensive, which will make the EU less competitive**[13]. This effect will abate when green/fossil-free steel and aluminium are gradually introduced to the EU market, (either produced or imported), although this is still several years off.

The net effects on EU steel and aluminium trade are impossible to assess. However, it is important to note that something that is good for steel and aluminium producers is not necessarily good for the economy as a whole. Local content requirements will limit manufacturers and producers' choice, push up prices for vital inputs, and thus reduce US competitiveness. More specifically, **the investment and incentives the US provides in the IRA are undermined by local content requirements.**

[11] The EU Emissions Trading System.

[12] The EU's Carbon Border Adjustment Mechanism.

[13] CBAM will be fully implemented 1st of January 2026 and the phasing-out of free allocation under the EU ETS will take place in parallel with the phasing-in of CBAM in the period 2026-2034. The full effects on the EU economy are thus not immediate but will gradually increase.

Summary and policy conclusions

In this section, we summarise our conclusions and make policy recommendations based on the CE study, other information, and relevant data. All conclusions are to be attributed to the Confederation of Swedish Enterprise, as these go beyond the CE study.

Firstly, the **IRA is a manifest game changer for US ambitions to reduce greenhouse gas emissions**. As such, it is to be welcomed by the European business community that embraces **long-term predictability for climate-related investment, production and R&D**.

The best and most cost-effective solution to support the green transition would be to introduce market-based measures that price carbon dioxide emissions, such as the EU's cap-and- trade-system, ETS. For the sake of the climate and competitiveness, it would be desirable if the US also introduced a similar system. **The polluter pays principle is preferable to the subsidies route**. However, this does not seem to be a politically realistic option for the foreseeable future.

At present, the price of natural gas is also significantly lower in the US, which limits the market driven transition towards clean electricity. The natural incentives to deploy clean electricity, as in Europe, are thus not as significant. In light of this, the IRA subsidies could be considered necessary to achieve the climate goals. **They must therefore be considered legitimate and a "necessary evil"**, as subsidies are something that Swedish business is generally not in favour of. However, as the US is only using positive incentives (carrots)[14], whereas the EU uses positive and negative incentives (carrots and sticks), this puts the EU at a competitive disadvantage. On the other hand, **EU member states have for a long time subsidised the green transition more than the US has. For example, EU subsidies were eight times higher than the US's federal subsidies for renewable electricity production in 2017**. The recent changes to the state aid rules aims to further facilitate subsidies of this kind within the EU. The overall impact on competitiveness can therefore not be assessed but must be assessed for specific sectors, which was done in the analysis by CE.

[14] At least at the federal level.

Impact on trade and investment

IRA subsidies are set to mostly go to clean energy and this is where they are expected to have most impact. These subsidies are far larger than support given to electric vehicles. The economic effects on the EU of subsidies to electric vehicles outlined in the IRA are likely to be limited; (however, local content requirements are concerning, more on that below).

The calculations by CE show that the impact on the clean energy value chain is likely to be very substantial, particularly for solar energy and the production of hydrogen and electrofuels. If the IRA subsidies are extended, their effects will be even greater. Total costs for wind and solar power and production of green hydrogen will in some cases approach zero or even become negative. That means that the most effective US producers could be paid to produce clean energy before they sell it to customers. Needless to say, this creates extremely strong incentives for investment. It should however be noted that as we do not know if the IRA will be extended, such business cases are uncertain.

Even if subsidies are not an efficient way to build long-term competitiveness, the sheer size of the subsidies along with the fact that the US is already a highly competitive country means that IRA will have a big impact. **The US may become a clean energy superpower, with large scale subsidised clean electricity production and costs close to zero**. This will affect trade in certain energy products, such as hydrogen and electrofuels, and may cause distortions versus production in Europe. Less efficient European energy projects and firms may not be able to compete.

If the IRA reduces the overall price for electricity in the US, it could have a profound effect as this would provide US energy-intensive industries, such as chemicals, with a competitive edge. The effect on the general price of electricity depends for example on the cost of fossil fuel inputs (e.g. natural gas), and the increased demand that may follow electrification of the US industry and increased usage of electric cars, and the total effect is therefore hard to assess. The total impact on relative competitiveness between the EU and the US also depends on how energy prices in the EU develop. At present, prices for natural gas are however significantly lower in the US than in the EU.

The scale of subsidies is likely to increase investment in the US and ramp up production of clean energy products. This ***may*** **delay some investment in the sectors analysed in the EU as certain companies will revise their investment plans, prioritising investment in production facilities in the US to take advantage of the subsidies as soon as possible. This may limit production increases in the EU, as would a potential lack of capital and raw materials. However, it is unlikely to** ***stop*** **these investments as investment are not a zero-sum activity**. Firms can choose to invest in both the EU and the US, and many will do so. Companies will invest in the EU as long as it is profitable. In addition, there is evidence that production is becoming increasingly regionalised, a trend that started long before the IRA.

Neither the US nor the EU, are currently major producers of the critical minerals needed for the green transition. There is already a scramble for raw materials, and the IRA will cause increased US demand for these minerals. China is also ahead of the EU when it comes to accessing these minerals. In the short to medium term, this may lead to **the EU finding it harder to source critical minerals**. The EU has, however, just presented a strategy for securing the supply of lithium, rare earths and other key minerals under the Critical Raw Materials Act.

The local content requirements are a concern, as these put EU producers at a disadvantage in terms of qualifying for subsidies, and subcontractors may also be affected. They are, however, even more worrying from a systemic trade perspective. The EU's state aid framework, and previous US subsidy programmes, do not contain such discriminatory elements for the private sector. As such, they are a novelty – and a worrying development. They are likely to contravene WTO most-favoured-nation and national treatment principles, i.e. they discriminate against non-US businesses. There is also a risk that other countries follow suit. This weakens the multilateral trading system and the WTO over the longer term, which is a truly regrettable aspect of the IRA.

However, there are also more positive aspects of the findings. Decarbonisation in Europe might very well accelerate and become cheaper with the inflow of US-produced clean energy products. Firms in Europe that import clean hydrogen and refined electrofuels will indirectly benefit from the IRA. One possible conclusion is that **the IRA will be harmful for certain production of clean energy products in the EU, but positive for their consumption,** the latter at the courtesy of US taxpayers.

Winners in Europe will be firms investing in the US in the clean energy and automotive sectors entitled to the subsidies, and profits from this may be reinvested in Europe. However, there might also be winners in the European export sector, benefiting from greater economic activity in the US in areas where EU firms have expertise. Not least services exporters can gain from the green transition in the US as they, without any of the protectionist elements, can export services necessary for the manufactured goods. Services constitute 35% of EU exports to the US. Thus, **the IRA may result in upscaling of technology, increased diffusion of technology and research and innovation to the benefit of the climate and the economy. However, exporters of goods from the EU will face local content requirements that may limit their gains.**

The EU response

There has been an extensive debate in the EU on how the EU should respond to the IRA. First of all, one could argue that **we do not need a specific "answer" to the IRA**. Moreover, we do not need *one* answer **but rather need to focus on several factors to limit the potential negative effects** of the IRA on the EU, advance the green transition, and strengthen the EU's competitiveness.

If IRA subsidies are demonstrated to create trade distortions, the EU already has a unilateral toolbox in the form of countervailing measures against subsidised imports. The EU also has the new Foreign Subsidy Regulation as a tool to address the issue of subsidised firms operating on the EU internal market. We strongly believe that **no new defensive trade instruments are needed**.

Taking the US to the WTO to resolve a dispute would drag on, and potentially result in a decision that the US would not respect anyway. We have seen how the US has ignored a panel ruling from the WTO in the recent past. Rather, the EU and the US should attempt to solve the issues together. An important aspect of this is that, even though the IRA has been passed, not all guidelines have been put in place for its implementation. As an example, the term "free trade agreement" is not yet defined in the IRA as of March 2023. Therefore, **dialogue with the US is crucial to remove some of the discriminatory elements** of the IRA. In mid-March, the EU Commission President Von der Leyen, after meeting with the US President Biden, announced that the EU and the US would start talks on a critical mineral agreement. This might mean an opening for EU exports of these products to the US. However, according to the WTO, a free trade agreement should cover "substantially all the trade between the constituent territories in products originating in such territories"[15]. It is of concern if countries start to derogate from these common principles.

Many in Europe are calling for more subsidies at EU level to address the IRA, even though the EU already grants considerable amounts of state aid and has significantly eased its state aid regulations. The European Commission has very recently, and without any prior impact assessment on how the IRA would affect EU, presented several initiatives with the aim of supporting and accelerating investment particular in new technologies and clean energy:

- On 9 March 2023 the *Temporary Crisis and Transition Framework* to foster support measures in sectors which are key for the transition to a net-zero economy, in line with the Green Deal Industrial Plan.
- The Commission also endorsed a targeted amendment to the *General Block Exemption Regulation*. Both revisions aim to open up and simplify state aid rules for aid to investment and financing for clean tech production in Europe.
- Furthermore, on 16 March 2023, the Commission presented the *Net Zero Industry Act* which contains further measures that have the ambition to facilitate and speed up investments in this field.
- On the same day, the Commission presented the *Critical Raw Materials Act*, aiming to facilitating the extraction of raw materials in the EU, as well as improving the availability of raw materials in general to EU companies, and reducing the EU's dependence and vulnerability.
- Finally, the Commission also published two communications celebrating the 30th anniversary of the Single Market and setting out how to secure long-term competitiveness of the EU.

The EU response have been extensive, with a prominent focus on state intervention and paving the way for increased subsidies with the prominent exception of the communication on how to secure long-term competitiveness. Considering the recently loosening of state aid rules and the considerable amounts of funding that are available in the form of the Recovery and Rescue Facility and RepowerEU, it is reasonable to

[15] GATT Article XXIV.

assume that the amount of state aid in the EU for clean electricity production will increase significantly in the coming years. Whether this is necessary and appropriate is another question – much investment in clean electricity production is already profitable given high energy prices and low running costs of such installations – it is rather the permit processes that constitute obstacles to a faster expansion of clean energy. Imports of subsidised clean hydrogen from the US should not be considered in itself as a problem, and this could be a more reasonable option compared to subsidising EU production in countries and sites where conditions are less favourable.

While subsidies may be justified to address market failures, **more flexible state aid rules in general are problematic.** More state aid from member states **distort competition in the Single Market and can even counteract ambitions to increase long-term productivity growth. Less efficient projects could be enabled by the granting of state aid and more efficient projects in other countries that do not receive aid could risk failure**.

Furthermore, subsidies in the EU entail considerable amounts of administrative burden, and the expansion of the rules bring even more complexity and legal uncertainty to companies. Smaller firms often do not even bother to apply for subsidies as it is too complicated and expensive, which leads to an advantage for incumbents. Subsidies could therefore counteract a dynamic business environment. **Subsidies under the IRA, on the other hand, are easier for firms and households to obtain** as they come in the form of tax-cuts or direct grants based on the number of units produced. At the same time, IRA subsidies will be granted regardless of whether they are necessary and proportionate for a specific company, as they do not consider the actual need of a subsidy in the specific case to make an investment viable. Both models have their advantages and disadvantages. What can be said is that the EU needs to prioritise simplicity in future revisions of the state aid rules. That does not mean watering down rules in general but ensuring that overlapping and temporary rules are avoided as much as possible. Principles behind the modernisation of the regulatory framework must be safeguarded, so that bureaucracy and extended review processes do not become more frequent.

Trying to counteract the risk of fragmenting the single market through common EU funding in the form of a new, joint European sovereignty fund, also creates risks. **Subsidies risk leading to a global subsidy race**, where countries compete to subsidise their industries. A subsidy race does not benefit trade, businesses or consumers. When it comes to the climate, a subsidy race makes the green transition more expensive. Subsidies always need to be financed, either through increased taxation today or increased borrowing (which must be financed through increased taxation tomorrow). At a time where many EU member states' have strained state budgets, additional expenditures could be problematic, and should in any case be directed towards lowering costs in general for business.

In conclusion, investment is not a zero-sum game. Companies may choose to invest in both the EU and the US. However, for such investment to take place in the EU, we need to put long-term competitiveness on the agenda and do our homework[16].

[16] A competitiveness compass for the EU, the Confederation of Swedish Enterprise (2022).

Importantly, **we need to work towards an expanded, technology-neutral clean energy supply, incentivise the green transition with the ETS, shorten the amount of time to obtain permits and invest more in research and innovation and the diffusion of green technology. We should *refrain* from adopting local content requirements and instead continue to remove barriers in the Single Market and prioritise open trade with the rest of the world. We should make sure that European businesses benefit from those parts of the IRA that are open to EU but be assertive against US protectionism and deploy necessary tools when competition becomes unacceptably distorted.**

All these actions and measures have the potential to support the green transition whilst building our long-term competitiveness based on principles of market economy and open trade.

IMPACT OF THE INFLATION REDUCTION ACT

Assessment of the impact of the US Inflation Reduction Act on EU competitiveness

The Confederation of Swedish Enterprise (Svenskt Näringsliv)
February 2023

Preface

In August 2022, the US Congress passed the Inflation Reduction Act (IRA) with the aims to lower inflation and increase the speed of decarbonisation in the US by offering subsidies, tax breaks, and government investments. The IRA runs from 2023 to 2031.

The EU has criticised the IRA for containing distortionary elements such as requirements for local US or North American contents and production. The concern is that production, investments, and scarce natural resources will flow to the US, and the EU will lose competitiveness, which could lower investments in the EU, and lower EU exports in turn.

Copenhagen Economics has been commissioned by the Confederation of Swedish Enterprise (*Svenskt Näringsliv*) to examine the possible impact of the IRA on EU competitiveness, EU trade, and attraction of foreign direct investments (FDI).

Concretely, we analyse *EU economic strongholds and strategic industries* for **clean energy products** and **automotives**. In the IRA, these industries are subsidised by more than USD 200 billion, equivalent to 56 per cent of the IRA budget, see figure.

For the purpose of this report, clean energy products are defined as renewable energy, green hydrogen, and refined electrofuels production using renewable energy. Since many renewable energy assets have timelines exceeding 10 years, we consider a timeline that goes beyond the IRA period. We do not consider nuclear energy in this report, since nuclear reactors are not widely traded and is thus out of scope.

For automotives, we focus particularly on electric vehicles (EVs), as they are covered in the IRA.[1] In addition, we include key inputs in the value chains, i.e., iron, steel, aluminium, components for renewable energy, materials for batteries, and battery production.

Our methodology consists of four steps:

i. For both industries, we first examine the current **effective subsidy levels** in the US, the EU, and in selected US States and EU Member States.

ii. Then, we apply the **marginal effective subsidy** impact of the IRA in the US. This gives us a *marginal impact* on the total cost of production in the US, which we can compare to the total cost of production in the EU. In the total costs, we consider all cost related to producing a product, including input costs, labour costs and capital cost, but for the marginal impact, we only consider the impact from the subsidy.

iii. In turn, we discuss how IRA in conjunction with existing subsidies affect trade and FDI in the focus industries, taking into account the **tradability** of the affected products.

iv. At last, we discuss how EU's proposed expansion of the Emission Trading System (ETS), the Carbon Border Adjustment Mechanism (CBAM), and the upcoming Green Deal Industrial Plan may influence EU's competitiveness.

We cover different geographical areas in terms of political aspects, natural endowments, and economic strongholds, see map. The selection of individual US states and EU Member States examined is based on covering areas where:

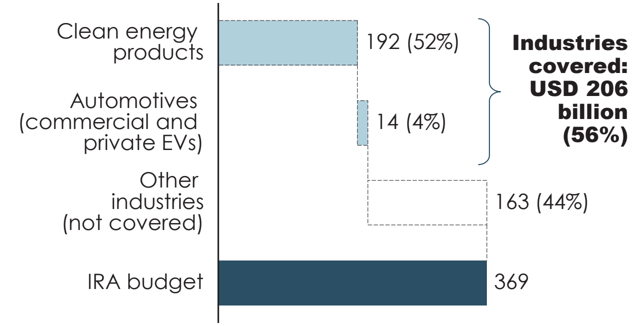
- There are (or have the potential to have) vast sources of renewable energy, which include California, Texas, Washington, Denmark, France, and Spain.[2]
- Automotive production is an important economic industry, which include Georgia, Michigan, Germany, and Sweden.[3]
- Key inputs are produced, which include Sweden.[4]
- Relatively limited efforts have been done to become less dependent on fossil fuels, which include Georgia and Poland.[5]

The selected US states cover 32 per cent of GDP and 27 per cent of greenhouse gas emissions in the US. The selected EU Member States cover 60 per cent of EU GDP and 56 per cent of emissions.[6]

The focus in the report is on the expected impact of regulation (subsidies and taxes) on the markets examined and not potential actions of *specific* companies, nor do we provide concrete policy recommendations for the EU and EU Member States.

US IRA budget categories for industries covered vs. not covered in report, 2023-2031

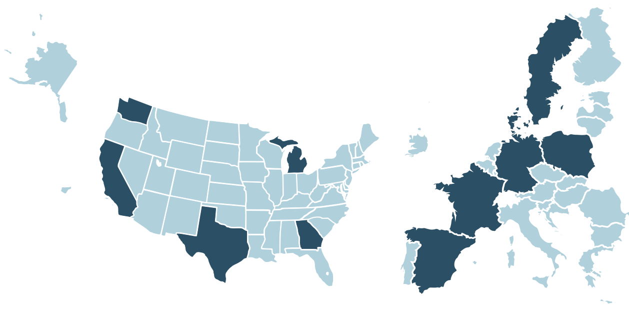
USD billion



Note: Clean energy products cover production of clean electricity, including nuclear power, and green hydrogen (44% of IRA budget). Clean energy manufacturing supports investments in facilities for renewable energy and manufacturing of components for these plants (8% of IRA budget), see appendix. .

Source: Committee on Finance (2022)

Geographical coverage of report



1) In some statistics, we show the conventional cars and electric cars together. The share of new light-weight EV registrations reached 17 per cent in Europe, 16 per cent in China, and 5 per cent in the US in 2021. Source IEA (2022, b) /// 2) Based on solar photovoltaic map potential from World Bank (2020), wind power density from DTU et al (2023), and hydropower potential from Hoes et al. (2017) /// 3) Based on higher share of value added than EU average from Eurostat and 2025 US car production capacity from Bui et. Al (2021), page 17 /// 4) Iron and steel are produced in Sweden. Based on higher share of value added from Eurostat than average /// 5) Based on research of subsidies in place. /// 6) Based on numbers from BEA, EPA, World Population Review, and Eurostat.

Disclaimer: New IRA and EU policy developments come forth while making the report. The report should be seen as the evaluation of the policies and announcements made the time of publishing (February 2023). In our research for examining existing subsidies in place, we cover the most important subsidies. We have not covered all subsidies in place as subsidies also exist on county, city, or project to project basis and are not always disclosed or possible to deduce from publicly available information.

Executive summary (1/2)

The IRA affects competitiveness through subsidies and requirements

Subsidies for renewable energy have historically been higher in the EU than the US, but in recent years, subsidies in EU Member States have decreased and for some new renewable energy projects, there are no subsidies. Competing electricity generation using fossil fuels is also taxed in the EU emission trading system (ETS). In the EU, subsidies are mainly administered by the Member States and the subsidy size typically differ for each project.

In the US, subsidies and tax breaks are mainly found on a federal level with fixed sizes, but there are state, county, and city subsidies for smaller projects, such as solar panels for households. Other US state subsidies are not possible to assess as they exist on a project-to-project basis and are often not disclosed.

Both the US and the EU Member States have effective subsidies for electric vehicles.

The IRA impacts competitiveness, trade and investment patterns through two channels; i) **subsidies** and ii) **requirements** to obtain the subsidy e.g., a certain share of US or North American content or production.

On one hand, the IRA *subsidies* lower the price of renewable energy, hydrogen, and (some) electric vehicles in the US. On the other hand, the IRA's geographical content *requirements* for minerals, metals, and other inputs may result in increasing cost of renewable energy and electric vehicles as producers may need to source more expensive material than they would without the requirements. The impact of the IRA requirements on US production costs is expected to be negligible compared to the impact from the IRA subsidies.

The impact of these subsidies is linked to the structure of value chains from raw materials to final products for producing clean energy and automotives.

Raw materials, intermediary inputs, and final products are traded globally. Some products are traded less, but instead companies invest in local production facilities in the market of interest; also called *foreign direct investments* (FDI). FDI is more common in "heavy" products and products where trade costs are high relative to geographical production cost differences, e.g., wind turbines.

In general, the decision for a company to invest in an area – whether domestically or abroad – depends on the total cost of production, i.e. all cost related to producing, deploying, and the tradability of the product to markets of interest. Subsidies throughout the value chain also affect the total costs of production. The total cost of production including subsidies and the tradability of the product are the key determinants for the costs competitiveness of a product on a market.

The IRA may lower EU competitiveness within green hydrogen and refined electrofuels

One of the expected future key products in global decarbonisation is green hydrogen which have applicability in several industries. Currently, there is a "race" between countries to become frontier green hydrogen producer.

Green hydrogen can further be refined into refined electrofuels, (including green ammonia, green methanol, and green LNG) which have potentials for decarbonisation in other industries.

Our analysis shows that **the largest risks from the IRA on EU competitiveness are in future production of green hydrogen and refined electrofuels**. The IRA makes the US an increasingly attractive location for investments in green hydrogen and refined electrofuels, which could **move future investments away from the EU** and other areas to the US.

With the IRA, there is a potential business case for green US hydrogen and refined electrofuels exports to e.g., Central and Eastern Europe. This means that **EU-based companies could lose future market shares on the EU market** for green hydrogen and refined electrofuels.

Concretely, we find that the *marginal impact* from the IRA subsidies is lower levelised costs of renewable electricity[7] with resulting production costs close to, or even below, zero. This means that some US producers in principle could be paid to produce renewable energy before they sell it to their customers.

The levelised cost of electricity is essential for future green hydrogen production as electricity currently constitutes 60-80 per cent of the total cost of producing green hydrogen. IRA direct and indirect subsidies reduce production costs of green hydrogen to around zero.

Today, markets for hydrogen are regional, as hydrogen has relatively high transportation costs. For green hydrogen to be produced in the US and exported to other markets, US production costs have to be USD 2.3 to 4.2 lower per kg than other markets (e.g., the EU) to cover transportation costs to these markets. In the lower cost ranges, **US green hydrogen is competitive on the EU market** due to the IRA subsidies.

US refined electrofuels are even more likely to become globally competitive since they have lower transportation cost than hydrogen and benefit from IRA subsidies for green hydrogen.

Lower cost of US clean energy products may also lower costs for other US energy-intensive industries, *if* the clean energy products can compete on price and applicability relative to traditional energy sources. This could be the case for renewable electricity.

7) Levelised cost of electricity is the average production cost for producing one MWh over a lifetime of an asset taking into account capital expenses, operational expenses, asset lifetime, annual estimated production, and depreciation.

Executive summary (2/2)

The IRA subsidies are not likely to have a large impact on EU exports of EVs, but the IRA requirements might

Electric vehicles (EVs) are currently a small part of the existing global car fleet, but the EV share of *new car registrations* have been increasing in recent years; particular in the EU and to some extent in the US.

The IRA *subsidies* are not expected to have a large negative impact on EU EV production, as subsidies and tax breaks are also present in the EU. However, the **IRA *requirements* for private EVs could lower EU automotive exports to the US**.

Currently, private EVs are only eligible for the subsidy if they are produced in North America. While several European car manufacturers already have US production facilities, some models are currently only produced in Europe and shipped to the US and thus not fulfilling the IRA requirements. Recent changes to the IRA has allowed for imported private cars for leasing to be covered by the subsidy, which lowers the potential trade impact of the IRA requirements.

The IRA subsidies and requirements will likely create an investment pull towards the US to ramp up battery production, and thus also create increased US demand for critical materials for battery production. Few countries have the majority of the known reserves of critical raw materials, and the **EU risks getting squeezed between the US and China in the "race" for these materials**.

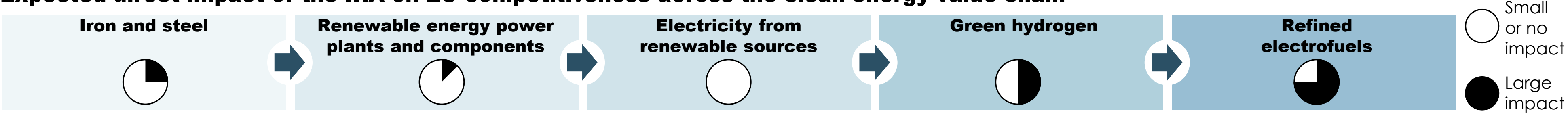
The IRA local content requirements may have some implications for **trade in iron, steel, and materials for batteries**. However, the industries covered in the IRA do not constitute the majority of the iron and steel markets. It is likely that the imports of iron an steel shift to other US domestic industries, when US clean energy and automotive companies source iron and steel locally to meet IRA requirements.

With the exception of the Green Deal Industrial Plan, EU policies are unlikely to curb the impacts of the IRA

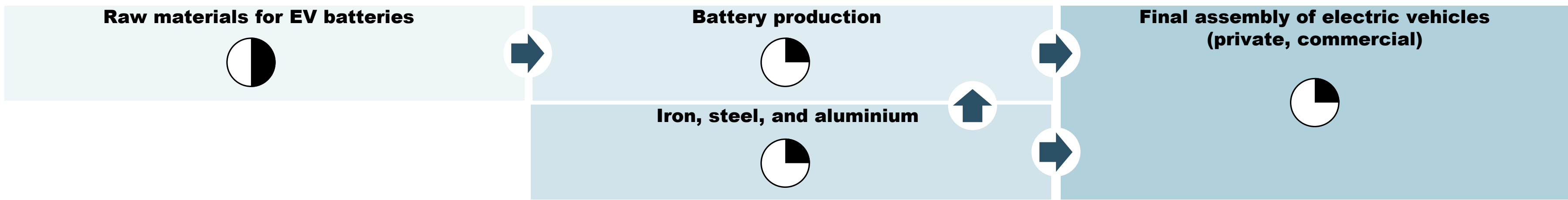
There is currently a debate whether the EU should temporarily open up for state aid as a response to the IRA in the upcoming Green Deal Industrial Plan. It is too early to say what effect this may have on the impact of the IRA.

The EU is currently in the process of expanding the ETS and has proposed a carbon border adjustment mechanism (CBAM). The CBAM will most likely not have a large effect on the impacts of the IRA, as these do not affect green products that benefit from the IRA. CBAM will increase the costs of imported (non-green) steel and aluminium on the EU market at least until domestic and/or imported green steel is supplied in large enough quantities on the EU market. In the expanded ETS system, it may be possible to receive free ETS allowances when producing green hydrogen. This could lower the impact of the IRA for green hydrogen.

Expected direct impact of the IRA on EU competitiveness across the clean energy value chain



Expected direct impact of the IRA on EU competitiveness across the electric vehicle value chain



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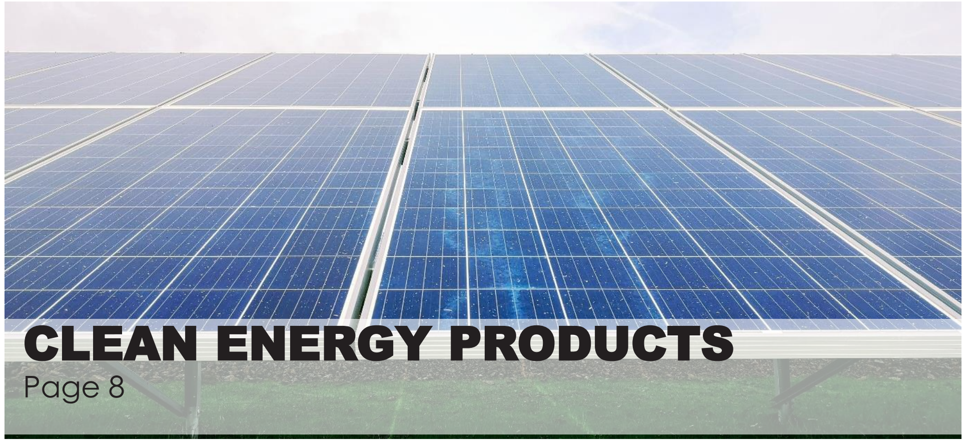



Introduction (1/2)

Our approach: A value chain perspective

To examine the impact of the IRA on EU competitiveness for clean energy products and EVs, we consider the *whole value chains* from raw materials to final product, as subsidies and taxes impact cost competitiveness *through each part of the value chain* (compounding impact). The effective subsidies for a product is thus the *direct subsidy and taxes* for the product itself **plus** the *indirect subsidies and taxes* upstream in the product's value chain. On each page in the report, we highlight what part of the value chain that we are examining.

Companies that are competitive in a foreign market has the option to export their product, or alternatively use FDI in production facilities in the local market. The decision to invest locally instead of exporting could be driven by low geographical production cost differences, high transportation costs, or security issues in the transportation of the good. FDI are therefore common for relatively "heavy" products such as wind turbines or automotives, and for battery production which is considered potentially dangerous in transportation.

In our assessment of the relative competitiveness between the US and the EU, we consider three main cost components:

1. Total cost of production covering all cost related to producing a product, including input costs, labour costs, and capital cost.
2. Effective subsidies and taxes throughout the value chain.
3. Tradability of the product, including transportation costs and other trade costs.

In this report, we focus on how **subsidies and taxes affect the cost levels**. We do not consider how *changes* in labour or capital costs affect the total cost of production. In addition, there are administrative compliance costs when applying for subsidies in both the US and the EU, which we do not cover. These costs cover internal administrative costs, legal costs, etc. For example with the IRA, companies are likely to have compliance cost for documenting that they fulfil the requirements to be eligible for the subsidy. These costs are likely affecting smaller companies (SMEs) more than large companies as the documentation costs constitute a larger part of the investment size for small investments than for larger investment.

In our research, we find several numbers for production costs, subsidies, and transportation costs in different sources. Therefore, we show total cost of production, subsidies, and transportation costs **in ranges**.

The cost ranges make comparisons between counties difficult. Therefore, we base our comparisons on scenarios, i.e., what the likely implications are for EU competitiveness in the lower or upper part of the cost ranges.

Introduction (2/2)

Subsidies pre-IRA

As a baseline, we examine the impact of effective subsidies *before the IRA* in the US and the EU. It is important to note that subsidies have to be financed via taxes, and while subsidies may lower costs in one industry, cost levels will increase in other parts of the economy.

The US and EU Member States have provided subsidies for renewable energy and electric vehicles years prior to the IRA. In the US, subsidies and tax breaks are mainly provided on a federal level. For smaller projects, such as household solar panels, there are state, county and/or city subsidies.

In our analysis of the subsidies, we may *underestimate* the actual subsidy levels for renewable energy, as we find that US states, US cities, and EU Member States sometimes offer additional subsidies on a project-to-project basis. These subsidies are often not publicly disclosed and they differ from each project, making them difficult to quantify. This also means that comparisons between effective subsidies in different countries are difficult. We only compare the subsidies that are possible to quantify.

EU Member States have historically provided large subsidies for wind and solar. In 2017, the total amount of subsidies for renewable energy generation in the EU were almost USD 80 billion, whereas it was less than USD 10 billion in the US.[8] However, total subsidies in the EU have declined in recent years due to more competitive renewable energy production.

Both the US and the EU Member States have direct subsidies and tax breaks for EVs. In the EU, subsidies for renewable energy projects and EVs are mainly administered by the Member States.

While EU subsidies are administered and sometimes financed by EU Member States, the EU also finance some of the subsidies through the EU Member States. This is for example the case in the EU Recovery Plan, Next Generation EU, and REPowerEU.

Subsidies post-IRA

For the post-IRA US subsidies, we consider the bill that the US Congress approved in 2022 and the guidelines and changes that have happened since, see fact box below. We also compare these to the EU subsidies. On each page in the report, we make a clear distinction as to whether the numbers are **pre-IRA** or **post-IRA**.

The Inflation Reduction Act

The budgeted USD 369 billion IRA offers tax breaks and direct investment support for several industries and households in the US from 2023 to 2031. In principle, there is no upper limit to the IRA budget, which is different from EU Member States that has to adhere to fixed budgets under EU's state aid rules. Some of the provisions in the IRA are amended or expanded subsidies that were in place before 2023, whereas other subsidies are new.

The IRA covers many areas outside our scope, including air quality, health care, and support for rural or disadvantaged areas. In this report, we focus the IRA provisions for clean energy products and EVs. The IRA affects competitiveness through two channels:

1. IRA *subsidies* lower production costs of renewable energy, green hydrogen, and electric- and plug-in hybrid vehicles in the US.
2. IRA *requirements* for local content, wage requirements etc. for companies to be eligible for the subsidy. These requirements cover for example sourcing of raw materials, metal inputs, and other inputs and may therefore result in increasing cost of renewable energy and electric vehicles as producers need to source more expensive material than they would without the requirements. In addition, content requirements effectively impact imports of certain products which US companies have to source domestically, or in some cases from specified countries, to be eligible for the subsidy, see appendix.

In the **clean energy value chain**, the IRA has implications for *steel* that has to abide by IRA's requirements, *renewable energy* receives IRA subsidies, and *green hydrogen* receives direct IRA subsidies and indirect IRA subsidies in renewable energy.

For renewable energy power plants at least *40 per cent of iron and steel inputs* (20 per cent for offshore wind) have to be sourced from North America to be eligible for the full renewable electricity production subsidy, increasing to 55 per cent in 2028. Iron and steel are key inputs for production of for example wind turbines as they make up the majority of the turbine's mass.

Key *components used in renewable energy power plants must be assembled in the US* to be eligible for the clean energy manufacturing subsidy. These components include PV cells, PV wafers, solar modules, wind blades, wind towers, nacelles, wind turbine foundations, and solar- and wind inverters.

In the **EV value chain**, the IRA has implications for *iron, steel and aluminium* that have to abide by IRA's requirements for batteries, *key raw materials for batteries* have to be sourced from a specified US trading partner, *battery components and manufacturing* receive direct IRA subsidies, and *final EV purchase* receives direct IRA subsidies and indirect subsidies in battery production.

The IRA requirements mean that critical materials for EV batteries have to be sourced from specified countries. Final EV assembly and 50 per cent of battery components and assembly must be produced in North America, increasing to 100 per cent in 2029.

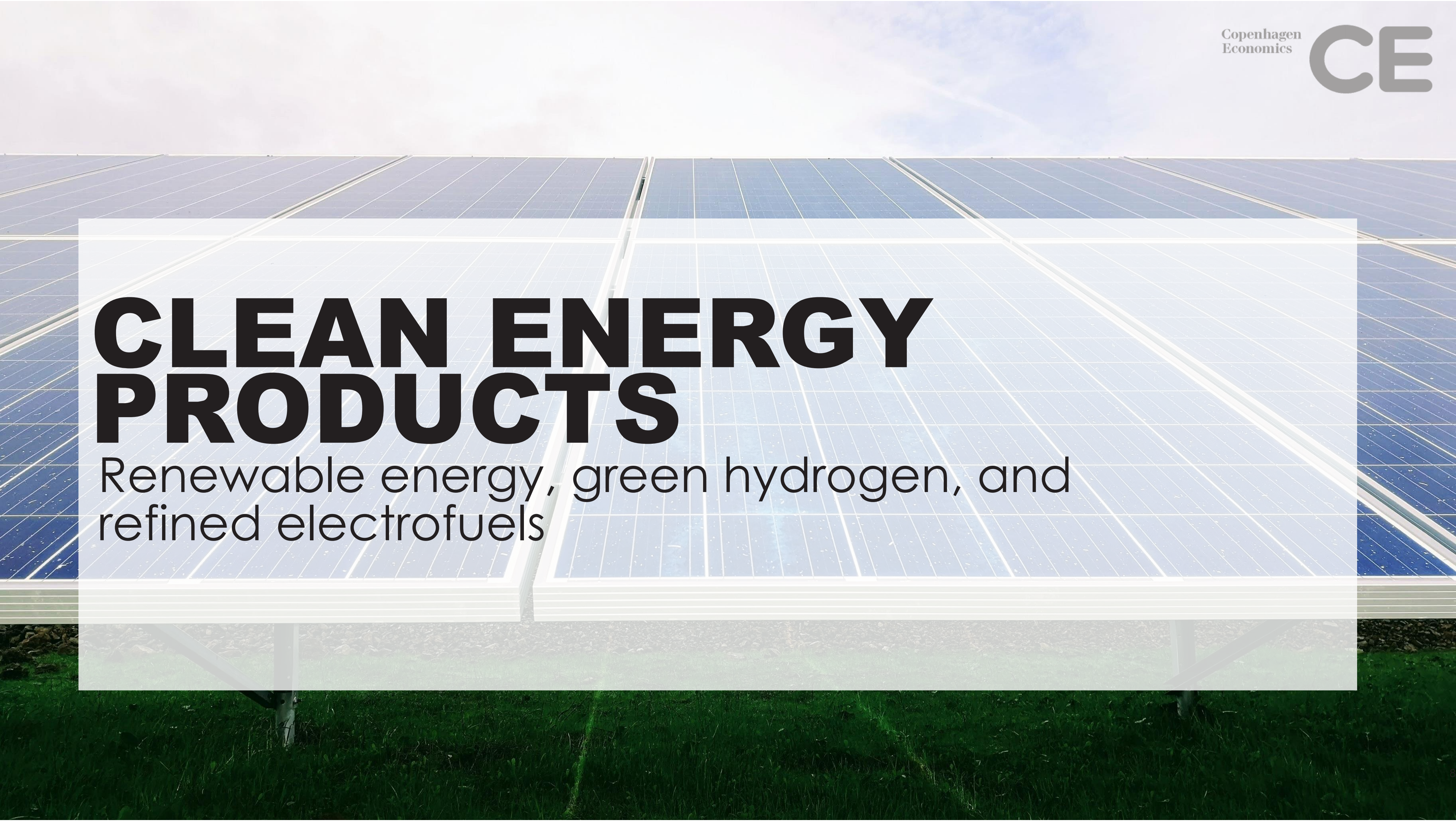
The USD 206 billion IRA budget allocated for clean energy products and EVs is thus directly or indirectly influenced by IRA content requirements, see appendix.

The IRA runs for nine years, and many renewable energy assets, have a lifetime longer than that. Therefore, we calculate two different scenarios to estimate an effective subsidy from the IRA:

1. **Extended subsidy** considers that subsidies are extended past the 2031 timeline covering the full asset lifetime of renewable energy. Considering that there were US subsidies in place pre-IRA, it is not unlikely that there will be (some) subsidies after the IRA period, although the subsidy size and scope may change.
2. **Current subsidy** considers that the subsidies end in 2031.[9]

The renewable energy assets considered in this report have a longer lifetime than the IRA (some 30 years+), and therefore there is a difference in the amount of subsidies that an investor would receive over the full asset lifetime for the two estimation methods. We calculate both IRA subsidy scenarios in the report.

8) Irena (2019), figure 5. /// 9) We include a conservative discount factor to account for this, see appendix for a description of how we calculate these subsidies.



CLEAN ENERGY PRODUCTS

Renewable energy, green hydrogen, and refined electrofuels

Chapter introduction

In this chapter, we deep dive into the clean energy value chain to examine the impacts of the IRA. First, we outline the clean energy value chain from iron and steel inputs to refined electrofuels, see figure, and we show that products in the value chain are traded between the US and the EU.

Second, we investigate the renewable energy subsidies in place *pre-IRA* in the US and the EU, and how these subsidies lower the cost of renewable energy in the US and in the EU.

Third, we examine the marginal impact of the new IRA subsidies on renewable energy costs in the US, and how the IRA subsidies affect the total cost of production of green hydrogen in the US. We find that these costs are lower than EU production costs.

This allows us to discuss the competitiveness of US green hydrogen and refined electrofuels on EU markets. The total IRA subsidies for green hydrogen and refined electrofuels are so large that the US may become globally cost competitive, which could lower future investments in the EU.

EU exports of iron, steel, and renewable energy power plants to the US may also be affected by the IRA content requirements.

Green hydrogen and refined electrofuels

Green hydrogen is produced using electricity from renewable sources and water in an electrolysis. The electrical energy is then ‘transferred’ to the green hydrogen molecule.

Green hydrogen is a key component of refined electrofuels, which include (but is not limited to) green ammonia, green methanol, and green liquefied natural gas (LNG). Green hydrogen is part of a refinement process (synthesis, catalyst) for producing these electrofuels. The different electrofuels have different applications.

Green methanol and green LNG use CO_2 as input and also emit CO_2 in their use. It is therefore important that the CO_2 input is from a renewable source for the fuel to be considered ‘green’.

There is an energy loss in the production of the fuels, meaning that more input energy is used in production than what is inherent in the final fuel product.

Fuel uses

Green hydrogen and refined electrofuels are important products for decarbonisation of industries where the emitted greenhouse gasses are hard-to-abate.

Green hydrogen has uses in manufacturing to replace natural gas in industry processes, in heavy road transportation, and for short-distance maritime transportation.

Green ammonia has uses in fertiliser production and potentially for long-haul maritime transportation.

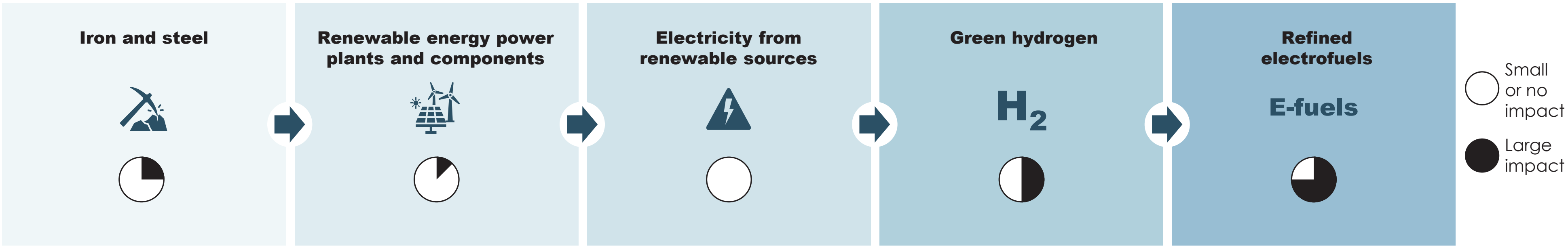
Green methanol and green LNG have uses in manufacturing processes and in maritime transportation.

Other refined electrofuels have uses in for example aviation.

The use of ‘green’

When we say ‘green’, we mean production of hydrogen with low-carbon lifetime emissions as defined by the EU.[10]

Expected impact of the IRA on EU competitiveness in the clean energy value chain and potential direct impact of the IRA



10) The EU has recently published their assessment of what needs to be true for hydrogen and related fuels to be considered ‘green’ in the EU Delegated Acts on Renewable Hydrogen. This is a complex assessment covering a multitude of conditions that become stricter over time. See European Commission (2023)

International value chains are key for producing renewable energy, green hydrogen, and refined electrofuels

The global renewable energy market

The global renewable electricity market was USD 1 trillion in 2022 and is expected to grow 8.6% annually towards 2030.[11] There are two key drivers of this market growth, namely *direct electrification* and *indirect electrification*. Direct electrification stems from local electricity demand, including traditional demand (households, manufacturing, etc.) and increasing demand for electric vehicles, electric heating etc. Indirect electrification include products where the energy from the electricity is 'transferred' onto other products. The key products are green hydrogen, green ammonia, green methanol, and green LNG.[12] Unlike direct electrification, indirect electrification products have the property that they can be traded over long distances.

International value chains

To produce the vast amount of renewable energy needed for these products, international value chains play an important role, from the extraction or recycling of iron and steel, to production of components and renewable energy power plants producing electricity to use in electrolysis for green hydrogen production and at last refinement to other electrofuels, see figure.

Several products are tradable along the value chain from iron and steel to refined e-fuels, whereas direct electricity is not.

Conceptual illustration of the clean energy products value chain from raw materials to final products

Product	Iron and steel	Renewable energy power plants and components	Electricity from renewable sources	Green hydrogen (H_2)	Refined Electrofuels (E-fuels)
Key inputs	• Reserve availability	• Wind: Steel (66-79% of mass), iron (5-17%), and plastic (11-16%).	• Renewable energy power plants.	• Electricity (60-80% of costs).	• Green hydrogen.
Demand drivers	• Manufacturing. • Construction. • Renewable energy power plants.	• Direct electrification (traditional demand and increased electrification). • Conversion from fossil fuels to renewable energy. • Green hydrogen.	• Decarbonisation of energy system • Energy independence	• Manufacturing. • Transport. • Refined e-fuels.	• Green ammonia: fertiliser, shipping. • Green LNG and methanol: industry, shipping. • Other: transport, manufacturing.
Tradability	• Traded commodities, standardised products, and specialised products.	• Some trade, especially solar panels. Heavy products are less traded and FDI is more used. Some components are traded.	• No trade over large distances due to expensive cables and grid loss.	• Currently, there is little trade in hydrogen. • Transport costs are relatively high.	• Currently, there is trade in (non-green) ammonia and LNG. • Transport costs are lower than for hydrogen.

11) Precedence Research (2022). /// 12) There are other ways to produce some fuels 'green' without using electricity, for example bio-methanol and bio-LNG.
Source: Copenhagen Economics based on data from Comtrade, Orbis, Amadeus and NREL (2015), table 30

The US and the EU are large markets for clean energy, and clean energy products and renewable energy investments flow across their borders

Iron and steel inputs

Iron and steel products are globally traded commodities, including in renewable energy plants. Aluminium products are also globally traded but to a smaller extent.

The US and the EU also trade these products, and in 2021, the US imported iron and steel products worth USD 88 billion, while the EU imported USD 110 billion (not including intra-EU trade). While the US has steel production and is recycling scrap steel, the US is still a net importer of steel worth USD 53 billion in 2021.[13]

In 2021, the EU exported worth USD 12 billion iron and steel products to the US, equivalent to 1.6 per cent of total EU exports of goods and services to the US.

Similarly, the US imported USD 29 billion in aluminium products of which USD 2.8 billion came from EU countries, equivalent to 0.4 per cent of EU exports to the US.

Some of these imports went to production of clean energy, but many other industries also demand these metals, especially construction and manufacturing.[14]

Renewable energy and fuels

In 2022, the market for renewable electricity was USD 124 billion in the US and USD 335 billion in Europe.[15]

While many fuels are not today produced using green production methods, this will change going forward. Therefore, we include non-green alternatives to green hydrogen, green ammonia, green methanol, and green LNG in the figure.

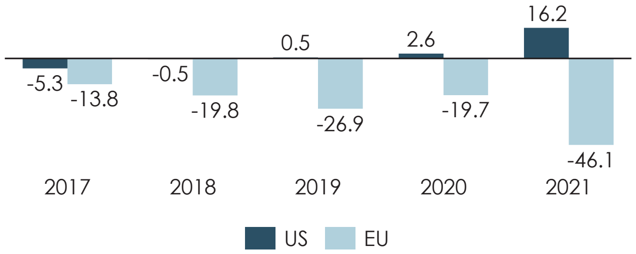
The EU is a *net importer* of these energy products with net imports of more than USD 46 billion in 2021, whereas the US has become a *net exporter* in recent years, see figure. The main driver of this trade is liquefied natural gas (LNG), the majority of which is currently not produced using green technologies.

Both the US and the EU are net importers when it comes to renewable energy products such as wind and solar plants. Especially, imports of solar panels from China drive this trend. There is some trade in products for geothermal and hydro plants, but in general, these products are not traded to a large extent.

The EU exported USD 700 million worth of wind turbines and solar panels to the US in 2021, equivalent to 0.1 per cent of EU exports to the US.

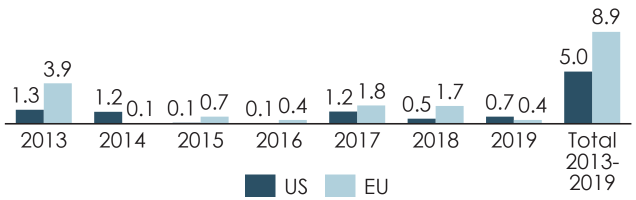
From 2013 to 2019, the US had an inflow of USD 5 billion in FDI in clean energy, whereas the EU received almost USD 9 billion in FDI (not including intra-EU FDI), see figure. For both areas, the average annual FDI inflows are not large compared to the industry size, suggesting that most investments come from domestic US and EU investors.

Net export of clean energy products*, 2017-2022
Billion USD



*Note: *Including fuels that are not yet produced green. Includes wind turbines, solar panels, and fuels. Fuels include liquefied natural gas (LNG), hydrogen, ammonia, and methanol. Intra-EU trade is not covered. Source: UN Comtrade data covering clean energy products outlined in the methodology section.*

Inflow of FDI in the clean energy, 2013-2019
Billion USD



Note: Covers greenfield investments. Intra-EU FDI is not covered. 2019 covers the first 6 months. No investments in green hydrogen and electrofuels were identified. Source: Orbis Crossborder.

13) Goods and services trade data for 2021 is from Comtrade and Eurostat. /// 14) It is not possible to distinguish which industries imported these products in detail. Based on numbers from Comtrade covering HS codes 2601, 72, and 73. /// 15) Precedence Research (2022).

Renewable energy subsidies vary between countries, and can be decisive for where energy companies invest in renewable energy

Effective taxation in steel and aluminium production

The US and the EU have different systems for *taxation of greenhouse gas emissions (GHG) from products* that are also used as inputs for renewable energy power plants. Iron and steel production is part of the EU ETS and companies operating in the EU have to buy quotas for their GHG emissions in production.[16] There is no similar system on a federal level in the US.[17]

The *direct* ETS cost of producing (non-green) steel in the EU is around USD 170 per tonne, equivalent to 25-30 per cent of the steel price.[18] ETS quota costs are around USD 160-220 per tonne to cover *direct* CO_2 emissions in (non-green) aluminium production, equivalent to 7-9 per cent of the aluminium price.[19]

With the ETS, the EU intends to incentivise green behaviour by making non-green alternatives relatively more expensive. By taxing emissions in, e.g., steel production, EU steel manufacturers have incentives to invest in green steel production.

EU-based companies can avoid these indirect taxes if they import steel and aluminium from non-EU producers. However with a future EU implementation of a Carbon Border Adjustment Mechanism (CBAM), imported steel and aluminium would face the same taxes as the EU ETS. In a situation with increasing ETS prices, EU producers would have increasing costs from both domestic and imported iron, steel, and aluminium. It is important to note that this is only the case *until* green steel and green aluminium can supply the EU demand for these products.

Carbon border tariffs, import tariffs, local content requirements and other trade barriers affect trade between countries. The US steel import tariffs under the Trump administration and the subsequent retaliation had negative effects on the US cost level, US trade, and were found to lower US real GDP by to USD 6 billion.[20] Similar conclusions were found on the Bush administration's steel tariffs in 2002.[21]

Renewable energy subsidies in the US and the EU

Pre-IRA, US subsidies for on- and offshore wind was about the same as the EU average, and it was lower for solar PV. US federal subsidies for wind were USD 10-17 per MWh and USD 5-7 for solar, see figure. The US subsidies shown are provided on a federal level.

While EU subsidies for renewable energy historically have been high, EU Member State subsidies have been declining in recent years. Now, energy companies partake in competitive public auctions to bid for a price (and thus implicitly a level of subsidy) to produce renewable energy for a specific project in a specific location.

As of 2022, several new renewable energy projects are now without subsidies in the EU, including offshore wind projects in Denmark and Germany.[22]

Renewable energy subsidies in Europe vary depending on the technology and location, see figure. Additionally, competing production of electricity using fossil fuels is covered in the ETS and thus pays taxes for their emissions, which benefits the roll-out of renewable energy in the EU.

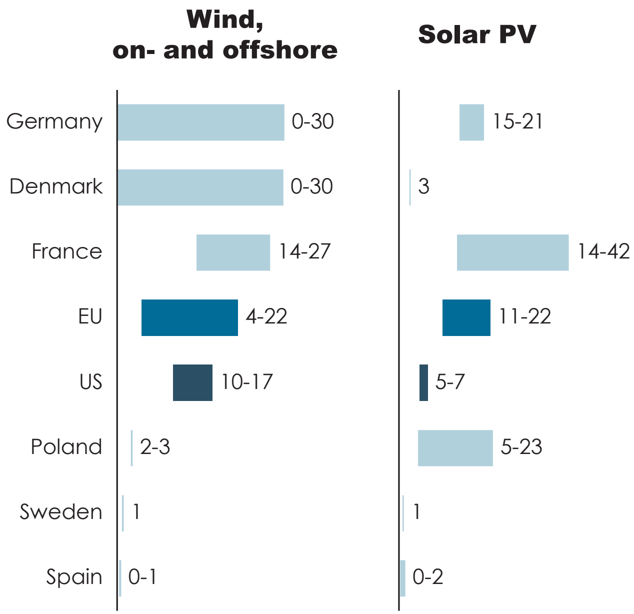
Example: Calculation of DK wind upper subsidy of USD 30 per MWh

We calculate the effective subsidy as the difference between the awarded (secured) price of wind auctions and the actual relevant spot price for the period 2018-2020, avoiding the extreme electricity prices 2021-2022.

The highest awarded price in Danish wind auctions were USD 67 per MWh and the average relevant spot price was USD 37 per MWh from 2018-2020. The maximum subsidy is then USD 30 per MWh (67 *minus* 37) for wind in Denmark.

Direct effective subsidy (pre-IRA), 2022

USD per MWh



Note: EU subsidies are the GDP weighted average of the six EU Member States. EU Member State subsidies are the average computed market premium awarded at auctions for 2018-2022 based on 2018-2020 electricity prices to exclude temporary extreme effects of high electricity prices in 2021-2022. For Sweden, there were no auctions available. Instead. we use the 2022 average renewable electricity certificate price. Additional local subsidies may apply.

Sources: AURES II (2022), EC-DGE (2020), Netztransparenz (2023), Energidataservice (2023), ESIOS (2023), PSE (2023), NECS (2023), Eurostat; Department of Energy (2022), and Lazard (2021).

16) EU manufacturing sectors receives so-called free-allowances which were 30 per cent of emissions in 2020. These are gradually phased out until 2026. For certain industries (including steel) the free allowances end in 2030, as these industries are considered at risk of carbon leakage due to high global competition and high tradability, see European Commission (2023) /// 17) Some systems do exist on a state level (for example California and Washington), see Center for Climate and Energy Solutions (2023). /// 18) Calculated based on an estimate of 1.89 tonnes CO2 per produced tonne of steel, from World Steel Association (2021), EU ETS price as of December 19, 2022 from Ember (2023) and steel prices as pf December 19 from Trading Economics (2023). /// 19) Calculation based on Aluminium France (2023), EU ETS price as of December 19, 2022 from Ember (2023), and aluminium prices as pf December 19, 2022 from Markets Insider (2023). /// 20) Based on Flaaen & Pierce (2019), Ciuriak & Xiao (2018), Salotti & Rocchi (2019), Cox (2022) /// 21) Lake & Liu (2022), Qiu & Tao (2001), Stone et al (2015), Flaig and Stone(2017) /// 22) Based on numbers from the AURES auction database.

The subsidies lower the levelised cost of electricity and increase incentives to invest in renewable energy

Cost levels for producing renewable electricity

As we have LCOE numbers for the US, Germany, and Denmark for onshore wind, offshore wind, and solar photovoltaic (PV), we compare their respective LCOE for onshore wind, offshore wind and solar in the figure.

Excluding subsidies, it is more cost-efficient to produce onshore wind and solar power in the US than in Germany, whereas offshore wind is more cost-efficient in Denmark compared to the US and Germany, see figure.

The competitiveness of different renewable energy sources for power production depends on the location of the asset. In areas with abundance of wind, like offshore wind in Denmark, the cost of wind power is relatively low, and in areas with abundance of sun, cost of solar power is relatively low.

Germany has higher LCOE for wind than the US and Denmark, and several other EU Member States due to less access to wind and open water.

Renewable energy subsidies

When including full *pre-IRA* subsidies, the LCOE decreases for all three technologies in all three countries. Now, the low-cost technologies are onshore wind in the US and in Germany, and offshore wind in Denmark.

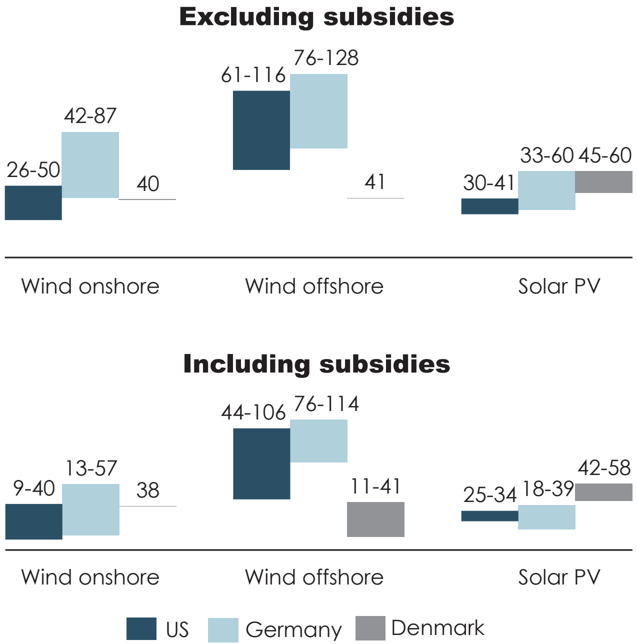
Overall, the subsidies have large impacts on the cost levels, and several technologies have LCOEs much closer to zero, and the subsidies therefore increase the incentives to invest in renewable energy.

Although Germany becomes more competitive with the subsidies all three technologies, there is no clear tipping point in terms of competitiveness between the three countries when including subsidies. This changes with the IRA subsidies, see next page.

Renewable energy investment determinants

Power prices, electricity production costs (so-called *LCOE*), access to demand, and public subsidies are four key determinants for where energy companies choose to invest in renewable energy.[23] Subsidies have historically driven investments in renewable energy, as wind and solar power were more expensive than traditional power production using fossil fuels. In the last decades, the cost of renewable energy has decreased so much that renewable energy are now competitive with fossil fuels in many locations.

Levelised cost of electricity in the US, Germany, and Denmark, 2021
USD per MWh



Note: LCOE is calculated without subsidies. For Germany the ranges show the minimum and maximum LCOE for a given technology reported by Fraunhofer (2021). US offshore wind is the 5th and 95th percentile of costs from Department of Energy (2022). US onshore and solar follow Lazard (2022). For offshore wind, US subsidies are assumed to have similar absolute effect as for onshore wind. Subsidies are based on numbers in the previous slide. The upper subsidy bound is subtracted from the highest LCOE and lower subsidy bound is subtracted from the minimum LCOE to reflect that higher support is assumed to be awarded at for less attractive LCOE locations, e.g. offshore wind in the Baltic Sea rather than the North Sea. We removed an outlier for solar PV in Germany. For Denmark wind onshore and offshore LCOE follow IRENA, which only gives a point estimate. Danish solar PV is assumed to be equivalent to northern Germany.
Sources: IRENA (2019, 2021), OECD (2023), European Commission (2020), Department of Energy (2021), Fraunhofer (2021), Lazard (2021), and Aures II (2022).

23) See e.g. Tu et al (2022).

The IRA lowers the price of renewable energy in the US resulting in LCOE around zero, which is lower than in the EU

The IRA subsidies

While US federal subsidies for renewable energy were in place pre-IRA, the new IRA subsidies increase the amount of subsidies provided and lowers LCOE in the US. For the extended IRA subsidy, the IRA marginally increases the effective subsidy by up to USD 11-18 per MWh for onshore wind and USD 28-30 per MWh for solar PV, resulting in lower US LCOE, see figures. This means that some US producers in principle could be paid to produce renewable electricity before they sell it.

The subsidies comprise of two parts: a subsidy for *electricity production* and a subsidy for the *manufacturing of the renewable technology*.[24] The electricity production subsidy is USD 26 per MWh for all technologies. The manufacturing subsidy varies among technologies but requires that components are manufactured in the US.

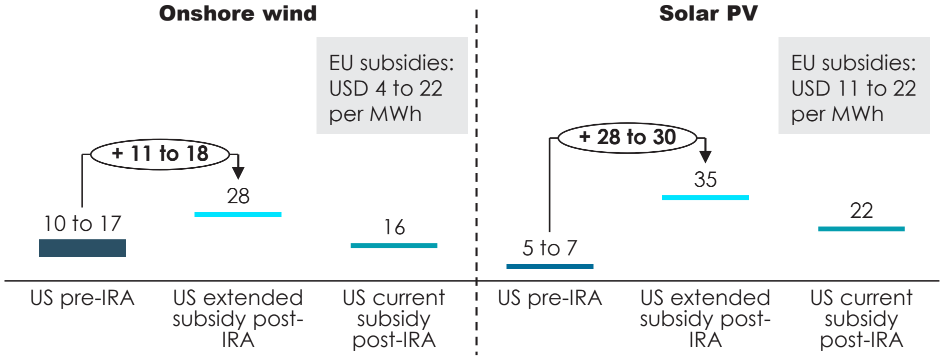
The *extended subsidy* reduces the cost of onshore wind by additional 46 to 122 per cent, and solar PV by 83 to 120 per cent.[25] For the *current subsidy*, the marginal impacts on LCOE are lower and close to the level of the pre-IRA subsidy for wind, but lower for solar PV. The IRA content requirements means that a certain amount of inputs for renewable energy is sourced from North America, which may affect prices and trade in iron and steel.

Potential impact on clean energy products

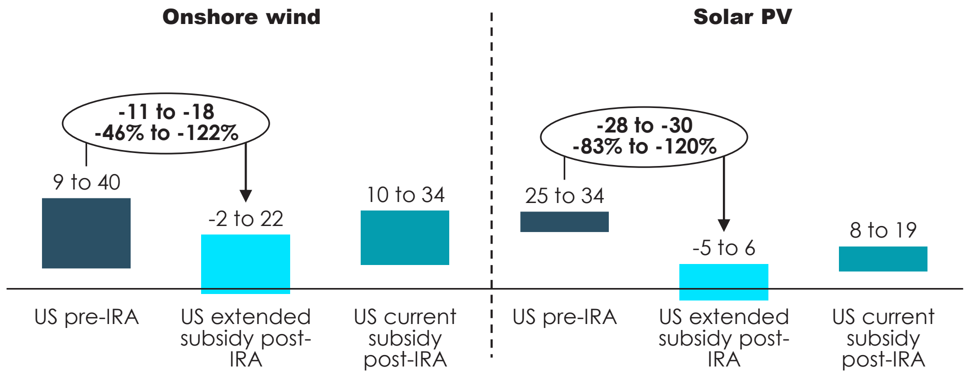
Renewable energy investments are expected to increase in the US because of the IRA subsidies. The combination of declining EU subsidies and increased US subsidies will increase the relative attractiveness of investing in renewable energy in the US compared to the EU. However, as power cannot be traded over long distances due to physical constraints, the US will not improve their international competitiveness for *direct electrification* products. The potential impact of the IRA on EU competitiveness primarily arises through indirect effects, e.g., for green hydrogen and refined electrofuels, see next page.

US industries with high electricity consumption (e.g., aluminium) will also benefit indirectly from IRA subsidies in renewable energy and will be able to have more competitive prices on the global market. As an example, if an US aluminium producer indirectly benefits from the extended subsidy for renewable energy, they can lower their costs by *up to* USD 600 per tonne produced relative to a no-subsidy scenario.[26]

Total effective subsidies in the US
USD per MWh, 2021-values



Levelised cost of electricity including subsidies in the US
USD per MWh, 2021-values



Note: The initial starting point for our calculation is the upper bound of LCOE as shown on previous slides. Subsidies may contain local content requirements for the production of components and sourcing and refinement of materials. See appendix. The main interest of the effect of the IRA on LCOE is through indirect effects. As offshore wind is high cost in the US per prior slide, we have not included it in the above for simplification. Instead focus is on onshore and solar, where through main impacts are to be expected.
Sources: EU current subsidies follow from page 12, Department of Energy (2021) and Sidley (2022).

24) See appendix. /// 25) Producers benefiting from the subsidies have to abide to the local content requirements and will likely have to accept higher input prices for their materials and workers, which could increase the LCOE (not covered in figure). ///
26) USD 600 per tonne is equivalent to 25 per cent of the current world price. Depending on the efficiency of the production and the renewable energy technology used. In reality, the benefits will not be passed on 100 per cent for on-grid solutions as prices are determined on the power market. Aluminium prices as of December 19, 2022 from Markets Insider (2023).

US green hydrogen production costs drop to around zero from IRA subsidies which is lower than the production costs in EU Member States

Green hydrogen

Green hydrogen is a large future demand driver within clean energy as green hydrogen has applicability to reduce hard-to-abate greenhouse gas emissions in manufacturing industries and transport.[27] Green hydrogen can be further refined to other electrofuels which have applicability to reduce greenhouse gas emissions in other areas, such as fertilisers and heavier transport.

The key input in green hydrogen production is electricity from renewable energy sources, which today make up 60-80 per cent of the *levelised costs of producing green hydrogen* (*LCOH*).[28] Future cost reductions in renewable energy will lower this share. Subsidies throughout the value chain will also lower the LCOH.

Impact of the IRA

In the figure, we show LCOH ranges in different locations, excluding and including subsidies. Excluding subsidies, the US production costs of USD 4.2 to 6.4 per kg are on par with several EU Member States, but Spain has lower LCOH.

Including the *extended IRA subsidies* for the US and the subsidies in the EU Member States, it is more cost efficient to produce green hydrogen in the US than in the EU.[29] US producers *both* receive a direct subsidy when producing green hydrogen *and* benefit from the indirect subsidies for the renewable electricity in the value chain. The IRA subsidies for green hydrogen cover three parts, see below. This means that some US producers in principle could be paid to produce green hydrogen before they sell it.

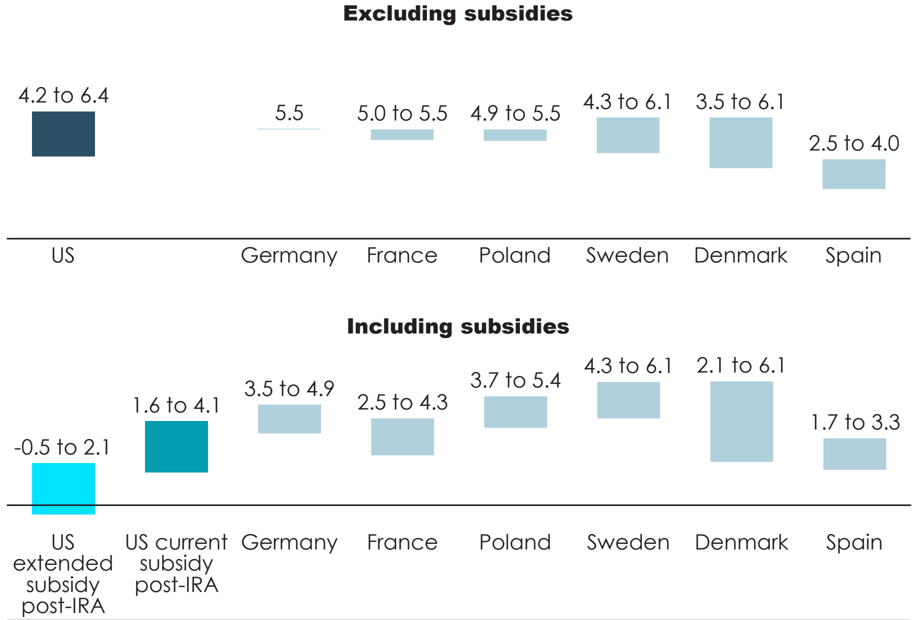
With the *current IRA subsidies*, the US LCOH is on par with the subsidised cost levels in France, Denmark, and Spain.[32] Spain and Denmark have the lowest cost of producing green hydrogen among the EU Member States covered.

Going forward, not all areas in Europe can compete in producing green hydrogen, as some areas have high production costs, or may not be able to ramp up production fast enough in the short run to meet surging demand. In particular, Central and Eastern European countries may have to import green hydrogen and refined electrofuels due to fast demand increases and potential resource constraints in production.[33] Northern Europe, Iberia, and the British Isles are more likely to become European producers due to abundance of low-cost renewable energy.

Three IRA subsidies constitute the *extended subsidy* of USD 4.3-4.7 pr kg

1. The direct subsidy for hydrogen is USD 0.6 USD per kg but with certain requirements fulfilled there is a 5x multiplier mechanism, resulting in a subsidy worth **USD 3.0 per kg hydrogen**.[29]
2. Indirect renewable energy production subsidy is worth **USD 1.2 per kg hydrogen**.[30]
3. Indirect renewable energy manufacturing subsidy is worth **USD 0.1-0.5 per kg hydrogen**.[31]

Levelised cost of green hydrogen
USD per kg hydrogen, 2022-values



Effective current subsidies (USD/kg)							
4.3-4.7	2.3-2.6	0.6-2.0	1.2-2.5	0.1-1.2	0.0	0.0-1.4	0.7-0.8

Note: Based on ranges of estimates found in literature for off-grid solutions in Europe. US estimates are a mix of on-grid and off-grid solutions. Subsidies include direct subsidies for hydrogen production and indirect through power production and investments. For Sweden, no budget were given in the hydrogen strategy. Production costs the Nordic Countries are included for Denmark and Sweden, and Iberia for Spain.
Source: Fuel Cells and hydrogen observatory (2023), International council on clean transportation (2023), ICCT (2023), Goldman Sachs (2022), national hydrogen plans, AURES database, and IRA legislation.

27) The only 'waste' product of burning hydrogen is water. /// 28) LCOH is the average production cost of hydrogen including all costs over a plant lifetime. Hydrogen production can either be on-grid as traditional power consumption, or it can be off-grid in its own closed system. In on-grid solutions, you pay transmission and distribution tariffs, and the power produced is not 100 per cent renewable at all times. Therefore, we use off-grid costs, where available. /// 29) These requirements cover certain wage, apprenticeship, and other requirements. /// 30) Based on a subsidy of USD 26 per MWh and 70 per cent electrolyser efficiency for producing one kg. hydrogen, which contains approximately 33 kWh energy. /// 31) The subsidy components are calculated into watt production capacity and are averaged out based on expected lifetime production. We assume 1,000 full load hours for solar PV and a lifetime of 32 years (USD 0.5 per MWh), and 3,678 hours for onshore and 4,167 hours for offshore wind with a lifetime of 25 years (USD 0.1 per MWh). /// 32) See appendix /// 33) Goldman Sachs (2022), pages 62-65.

Case: US green hydrogen may be able to compete on some EU markets even when considering transportation costs

Pre-IRA | Post-IRA
Green hydrogen H_2

Supply of green hydrogen in Germany

One potential business case that arise from the IRA is exports of US produced green hydrogen to other parts of the world; including to the EU. For the business case to make sense economically, the transportation costs of hydrogen have to be lower than the cost differences between EU and US producers, such that the total cost of delivering US green hydrogen on the EU market is the same or lower than competing producers.

Below, we explore a stylised case for increased green hydrogen demand in Germany, and we compare the price from three sources of supply

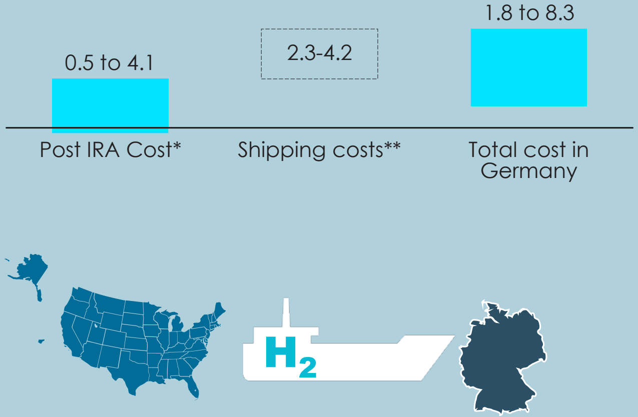
- Option 1: Produced in the US and shipped to Germany
- Option 2: Produced in Denmark and transported via pipeline to Germany
- Option 3: Produced in Germany next to the demand with no transportation costs

For the high range IRA subsidy and the low range transportation costs, the US can deliver green hydrogen in Germany at a cost of USD 1.8 per kg, whereas the lowest cost from Danish production via pipeline is USD 2.3 per kg, and German own production is USD 3.5 per kg.

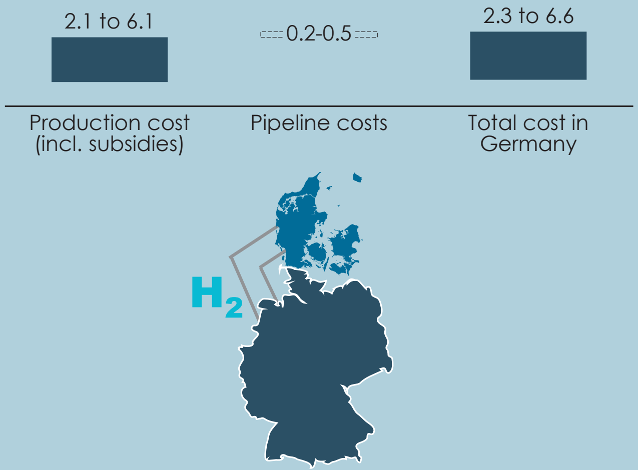
In the low range scenario, the US is competitive on the German market, but estimates for hydrogen transport costs via ship vary greatly and are key for the profitability of the US business case, as the US is not competitive in the medium or high range scenarios for transportation costs.

We do not include import tariffs in the figures for import of US green hydrogen to Germany, as these are related to the price of hydrogen, not the production and transportation cost. In the EU the MFN import tariff is 3.7 per cent for hydrogen.

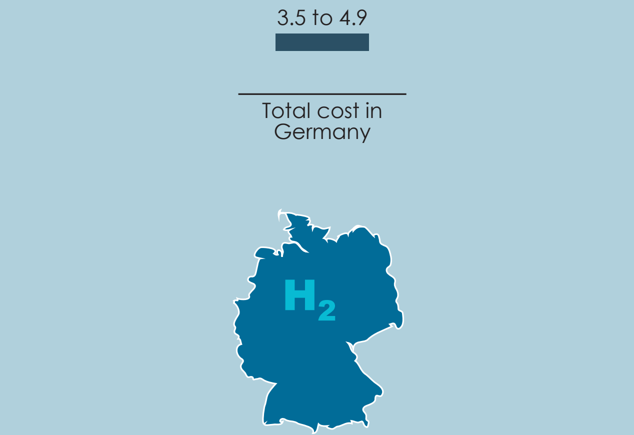
Option 1:
US H_2 shipped to Germany
USD per kg hydrogen



Option 2:
Danish H_2 via pipeline to Germany



Option 3:
German H_2 production, no transportation



Note: This is a stylised example, not considering resource constraints of other hydrogen supplied in the different markets. The pipeline from Denmark to the industry in Germany is assumed to be 500 km, equivalent to a cost of approximately USD 0.2-0.5 per kg. (read off graphs). *For US, we use the lower limit from the extended subsidy scenario and the upper limit for the current subsidy scenario. ** We do not take into account import tariffs. The EU MFN import tariff for hydrogen (ad valorem) is 3.7 per cent of the price (not the cost). Therefore, we cannot meaningfully include this in the figure, but the tariff would be a small part of the final price.
Source: For production costs and subsidies, see previous pages. Shipping transportation costs: IRENA (2022), IEA (2019), Agora (2021), EDISON (2021), McKinsey (2021). Johnston et.al (2022). Pipeline costs: IEA (2019), figure 29, EWI (2020), figure 7.

US refined electrofuels are more competitive than green hydrogen on the world market as transportation costs are lower

Refined electrofuels

Future global competition for green fuels does not only extent to green hydrogen, but also refined electrofuels such as green ammonia, and green LNG.

Transportation costs for ammonia and LNG are lower than for hydrogen, see figure, and these fuels are already traded globally. (Non-green) ammonia is currently used in fertiliser production, and LNG is used in the natural gas networks. For both hydrogen and ammonia, around 75 per cent of the total transportation costs are in the conversion and re-conversion of the fuels in the departure and arrival harbours, including cost from energy losses in the conversion and re-conversion processes. The actual transportation cost via ship is therefore a smaller part of the total costs and the additional cost of a longer voyage is relatively small.[34]

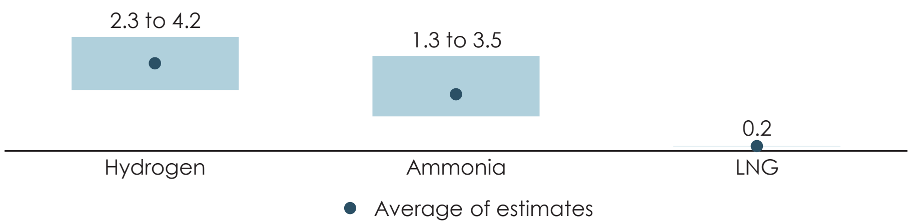
As the additional cost of refining green hydrogen into green ammonia largely extends to ammonia synthesis costs, which are not expected to be vastly different in different locations, the lower transportation cost of ammonia relative to hydrogen makes an even better business case for US exports of green ammonia, see the calculation example below. This could also be the case for green LNG, as the transportation costs are low, and US producers still benefit from the IRA subsidies for green hydrogen which is a key cost component in the value chain for green LNG. The EU MFN import tariff is 5.5 per cent for ammonia and 0 per cent for LNG.

Looking ahead, the levelised cost of hydrogen (excluding subsidies) is expected to drop and to some extent converge in absolute numbers due to declining costs of renewable energy and increased efficiency in electrolysers. This means that subsidies and transportation costs become relatively more determining for where green hydrogen and refined electrofuels are produced. Therefore, the IRA subsidies could have an greater impact on EU competitiveness later in the IRA-period, especially if transportation costs also decrease.

Case: Green ammonia production costs to supply demand in Germany, USD per kg H_2	**Produced in US**	**Produced in Denmark**	**Produced in Germany**
Hydrogen costs, including subsidies	-0.5-4.1	2.1-6.1	3.5-4.9
Ammonia synthesis[35]	1.0	1.0	1.0
Transportation to Germany (US via ship, Denmark via pipeline to Germany)	1.3-3.5*	1.1	0.0
Ammonia price in Germany, USD per kg H_2	**1.8-8.6**	**4.2-8.2**	**4.5-5.9**

Transportation cost of shipping hydrogen, ammonia, and LNG

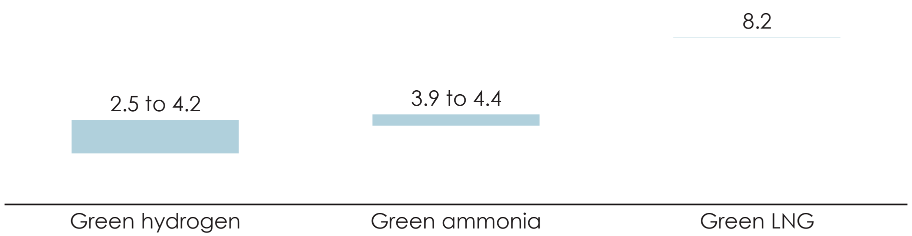
USD per energy content of one kg hydrogen



Note: Transport above 5,000 km via ship. Hydrogen and ammonia is a mix of estimates for 2022 and 2030 and LNG is 2023. We only have only one uncertain point source for methanol and do therefore not include it. Sources: EIKON (2023), IRENA (2022), IEA (2019), Agora (2021), EDISON (2021), McKinsey (2021). Johnston et.al (2022)

Global low range levelised cost of green fuels, excluding subsidies

USD per energy content of one kg hydrogen



Note: Numbers are from 2020-2023. For hydrogen, the costs are based on a range of the lowest estimates in 10 low-cost areas, and for ammonia the number is based on 3 low-cost areas. We only have a point source for green LNG. Sources: Data points from IEA, IRENA, Goldman Sachs (2022), FCH Observatory, the ICCT

34) Based on averages from EDISON (2021), IEA (2019), Goldman Sachs (2022) /// 35) Ammonia synthesis constitute approximately 20 per cent of average total production costs, and green hydrogen is 80 per cent, see Salmon et al (2021). With a green hydrogen input price of USD 4 per kg, this amounts to ammonia synthesis costs of USD 1 per kg hydrogen. For simplification, we assume same costs of ammonia synthesis/catalyser in different locations.
*We do not take into account import tariffs. The EU MFN import tariff for ammonia (ad valorem) is 5.5 per cent of the price.

Conclusion: The IRA may reduce EU's relative competitiveness against the US within refined electrofuels which could lower FDI and trade in the EU

Chapter conclusion

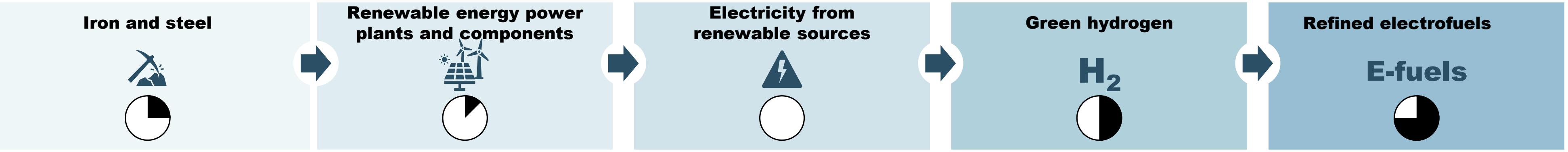
Previous EU subsidisation of renewable energy have led to a large uptake of renewable energy in many EU countries, and now renewable energy can compete against electricity produced by fossil fuels in many locations.

Historically, the US has not subsidised renewable energy to the same extent as the EU, but with the IRA, the orders of magnitude have changed so now the US provides more subsidies, and we will likely see in an influx of renewable energy investments to the US. The EU and EU companies will still invest in decarbonisation of the EU economy, but less capital may be available in the short run.

The IRA subsidisation of US green hydrogen and refined electrofuels may end up benefitting and speeding up EU decarbonisation as US tax payers effectively support green products on the EU market if these are exported to the EU. Thus, EU industries demanding green inputs will be able to source more low cost inputs from the US for their decarbonisation.

Potential impact on EU trade, FDI and competitiveness

Small or no impact — Large impact



For *renewable energy* in the US, the IRA requirements will, in isolation, lower US imports of iron and steel, for example from the EU, and US-based companies would have to pay a higher price for these metals.

However, considering the full market, *other* US industries will likely take over the import of these metals that clean energy used to import as they are not bound by the requirements.

Therefore, the total impact on EU exports of iron and steel to the US are not expected to be severely hit.

As there currently is limited trade in renewable energy power plants and no electricity trade, no large direct impact is expected from the IRA. The IRA subsidies will spur investments in renewable energy in the US. This could in the short run divert some investments in renewable energy from the EU to the US. Investments in transforming existing US electricity consumption into more sustainable energy sources is not a direct threat to EU businesses, and can even lead to more revenue for EU companies, e.g., producing wind turbines in the US.

We expect limited direct impact on EU competitiveness in this part of the value chain and the IRA may increase some EU companies' revenue in the US. However, indirect impacts from green hydrogen and refined electrofuels are expected with potential increased demand for renewable energy needed to produce these fuels.

Trade in *components* for renewable energy power plants may be affected by the IRA requirements for US manufacturing.

The biggest risk for EU competitiveness lies in the IRA subsidies for green hydrogen and refined electrofuels as these products are tradable across the Atlantic Ocean. With the IRA subsidies, we expect more investments flowing to the US, and we expect increased EU imports of these fuels from the US due to the IRA.

US green hydrogen may become competitive in some European markets with high production costs. Refined electrofuels have relatively lower transportation costs than green hydrogen, and therefore, refined electrofuels are expected to have a larger impact on EU competitiveness on the EU market, especially in areas where production costs are high.

With the IRA subsidies for green hydrogen, production costs of green steel also lowers in the US. As steel is commoditised and currently traded globally, this makes another business case for US producers to compete on the EU market.

AUTOMOTIVES

Electric vehicles

Chapter introduction

In this chapter, we deep dive into the value chain for electric vehicles to examine impacts of the IRA.

First, we outline the electric vehicle value chain from inputs of raw materials for batteries, iron and steel to final assembly, see figure. Both raw materials (lithium, nickel, manganese, cobalt, and graphite) and iron, steel and aluminium go into battery production, but the latter is a small part. Steel and aluminium is also used for final assembly.

We show that commercial and private cars both are traded between the US and the EU, and that automotive companies also produce locally as they invest in local production facilities (FDI).

Second, we investigate the EV subsidies in place *pre-IRA* in the US and EU Member States, and show that these are not that different in the US and the EU Member States.

Third, we examine the marginal impact of the new IRA subsidies on the value chain EV in the US. We find that while the IRA does increase the level of EV subsidies in the US, it is not the *size of the subsidies* that may harm EU competitiveness as EU effective subsidies for EVs are already relatively large , and most of the IRA subsidies are targeted EVs *purchases* in the US.

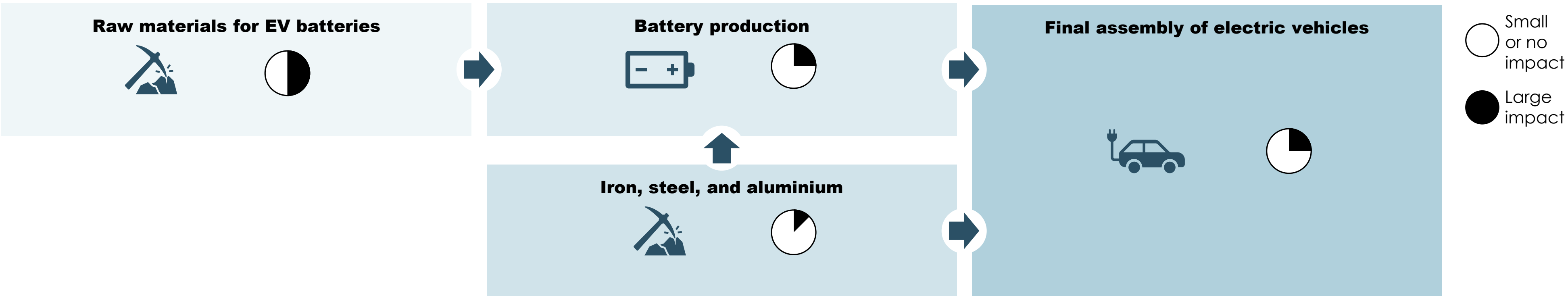
Instead, we find that the IRA *requirements* are expected to impact EU competitiveness throughout the value chain, as certain content requirement thresholds have to be met to be eligible for the IRA subsidy. This may lower future investments in the EU, and lower EU exports of private EVs to the US as these are not eligible for the IRA subsidy.

Private and commercial vehicles are treated differently in the IRA. Private EVs have to be assembled in North America to be eligible for the IRA subsidy, whereas this is not necessary for commercial EVs. This means that imported private EVs cannot obtain a subsidy, whereas commercial EVs can.

Recent changes to the IRA guidelines have opened up for imported private EVs to be eligible for the IRA subsidies if they are leased, but there is still not a level playing field on the US market for private EVs produced in North America or elsewhere. In our assessment, we therefore focus on private EVs.

In this chapter, we also discuss the implications of EU policies on the impact of the IRA, and we conclude that both the ETS and the CBAM have no or limited impact. The upcoming Green Deal Industrial Plan (covering the Net-Zero Industry Act and the Critical Raw Materials Act)[36] may have an impact on EU competitiveness, vis-à-vis the IRA, due to potential increased EU subsidies, but the plan is in too early a stage to know how much this impact would be.

Expected impact of the IRA on EU competitiveness in the electric vehicle value chain and potential direct impact of the IRA



36) European Commission (2023, c).

Production of electric vehicles relies on access to critical raw materials for battery production

The global automotive industry

Car companies rely on global trade for both own in-house supply chains and to source raw materials, iron, steel, and components from suppliers across the world. Global value chains are even more important with the transformation of the car fleet towards EVs.

Raw materials for batteries (lithium, nickel, manganese, cobalt, graphite) are essential for future EV production, see figure. The majority of known reserves of these materials are only available in few countries; including Australia, Brazil, Canada, Chile, China, DR Congo, Indonesia, and South Africa.[37] These materials constitute 50-60 per cent of the cost of battery production, and batteries make up 35-50 per cent of the production cost of an EVs, see figure. Therefore in total, the raw materials currently constitute 20-30 per cent of the production of an EV.

Transportation costs of batteries are relatively high, as batteries are considered a dangerous good. Due to transportation costs and security issues, batteries are often produced close to the final EV assembly. As transportation costs of vehicles are also relatively high, and subject to price risks in fluctuating freight rates, the final assembly of cars is often also close to the target markets. Therefore FDI is a common option in the automotive industry, but some vehicles are still traded between countries.

Conceptual illustration of the electric vehicles value chain from raw materials to final products

Raw materials for EV batteries (lithium, nickel, manganese, cobalt, graphite)

Key inputs: Availability of reserves

Demand drivers: Battery industry for EVs, smartphones, laptops etc., industrial materials and chemicals.

Tradability: Traded commodities.

Battery production

Key inputs: Raw materials (50-60 per cent of costs)

Demand drivers: EVs, consumer electronics, power market stabilisers.

Tradability: To some extent traded products, but batteries are classified a dangerous transportation good.

Iron, steel, and aluminium

Key inputs: Availability of reserves

Demand drivers: Automotive industry, other manufacturing and construction.

Tradability: Traded commodities, standardised products, and specialised products.

Final assembly of electric vehicles

Key inputs:
Batteries (35-50 per cent of production costs)
Aluminium (10-15 per cent of production costs)

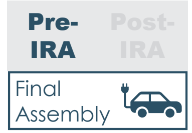
Demand drivers: Regulation (e.g., ban on fossil fuel cars), price reductions, changes in consumer preferences, roll-out of charging infrastructure.

Tradability: Both trade and FDI are common. FDI is used to produce locally and avoid shipping cost.

37) Visual Capitalist (2021). Sweden is ranked 22.

Note: Cathode is 51 per cent of the battery costs with contains lithium, nickel, cobalt and manganese. Anode is 12 per cent of the cost, which consists of graphite.
Source: Visual Capitalist (2022), König et al (2021), U.S. Department of Transportation (2023).

The US and the EU are large markets for private and commercial vehicles, and automotive trade and investments help supply vehicles in local markets



Private and commercial vehicles

While automotives are often produced in local production facilities close to the target markets, some car models are traded between countries.

The EU is an exporter of private cars and commercial vehicles with net exports ranging USD 58-91 billion from 2017-2021, see figure. The US is on the other hand a net importer ranging USD 110-144 billion annually. Almost USD 33 billion US of imports come from EU countries in 2021 (net USD 22 billion), equivalent to 4.3 per cent of EU exports. The US also has imports from Japan, Canada, and Mexico.

The large EU export of automotives may reflect that domestic EU car production is partly protected on the EU market, as the EU has ad valorem import tariffs are 10-16 per cent for automotives. Similarly, the US import tariffs are around 2 per cent.[38]

In 2021, the US imported 6.1 million private cars and commercial vehicles, down from 7.9 million in 2017, out of 15.5 million new car registrations and a total fleet of 290 million vehicles.[39]

In 2021, there was 246 million vehicles on the road in the EU and 9.7 million new cars were registered.[40]

Even though there is large global trade in automotives, it is common for car companies to use FDI to enter markets. Car companies invest in manufacturing of inputs for car production, final assembly plants and automotive sales offices. From 2013 to 2019, the US received FDI worth USD 33 billion in automotives, whereas the EU received USD 15 billion, see figure.

Electric vehicles

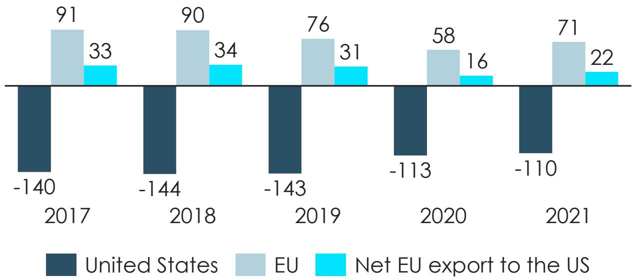
While EVs are currently a small part of the global car fleet, EV car production has soared in recent years from less than 100,000 new registrations in 2010 (0.1 per cent of new registrations) to around 6.5 million new EVs in 2021 (8.6 per cent of new registrations).[41] This trend is expected to continue going forward.

In the EU, 18 per cent of new car registrations in 2022 were electric and plug-in hybrid vehicles, but EVs only account for 1.1 per cent of cars on the road.[42]

As EV production is increasing, so are investments in battery production as this is the key component that differs from traditional vehicles with combustion engines.

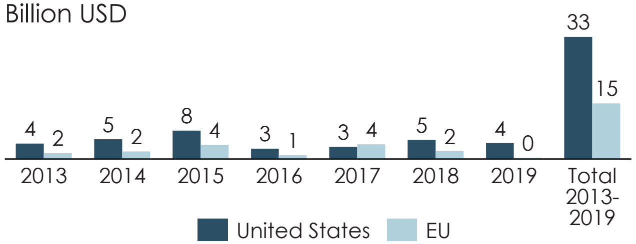
In the period 2013-2019, few FDI projects were made in the US and EU in battery production, but investments are expected to increase going forward.

Net export of automotives (private cars and commercial vehicles), 2017-2022
Billion USD



Note: Intra-EU trade is not covered.
Source: UN Comtrade data covering automotive products outlined in the methodology section.

Inflow of FDI in automotives
Billion USD



Note: Covers greenfield investments. Intra-EU FDI is not covered. 2019 covers the first 6 months.
Source: Orbis Crossborder.

38) Most favoured nation tariffs from the WTO tariff database in 2021. /// 39) Numbers from UN Comtrade. /// 40) Hedges Company (2022) /// 41) IEA (2022, a) /// 42) ACEA (2022).

Consumer subsidies for EVs are both present in the US and EU Member States to incentivise EV purchases

EV consumer subsidies

EV subsidies and related taxes can be categorised in two groups, as purchase and tax reduction incentives *when consumers buy an EV* and as subsidies and taxes in *the value chain of EVs*.

Consumer subsidies make the majority of the effective subsidies for EVs, see figure, but lower electricity costs from renewable energy subsidies and taxes affect the total cost of production of cars through the value chain in for example battery production.

Pre-IRA, both US states and EU Member States had subsidies for purchasing EVs, see figure. We evaluate the effective subsidy of an EV from the subsidy or tax benefit relative to a car with a combustion engine. For example in Denmark, you are exempt from part of the car registration tax when buying an electric vehicle.

The effective subsidies depend on the type of car. Plug-in hybrid cars typically have lower effective subsidy than a fully electric car. In addition, the price of the car may affect the effective subsidy either negatively or positively.

Pre-IRA, the effective US and the EU Member State subsidies for a B-segment private EV ranged between USD 5,900 and 11,600, except for Denmark, which has higher effective subsidies of USD 15,500 due to relatively high car registration tax on cars in general. However, some EU countries have recently *lowered the subsidies*. For example, Sweden has removed the purchase incentive for cars purchased after November 2022 (the incentive is shown in figure for 2022 to the right).[43]

The pre-IRA federal US subsidy was *maximum* USD 7,500 for an EV, with additional USD 2,000 purchase incentive in California. In the EU Member States, a mix of purchase incentives and tax savings are in place.

Value chain taxes and subsidies

Pre-IRA, the sizes of taxes and subsidies in the EV value chain were relatively small compared to the consumer subsidies.

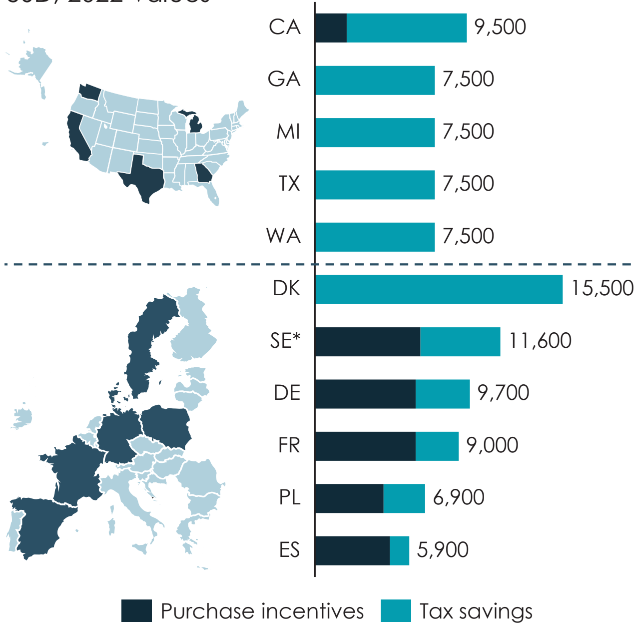
In 2021, the total *direct* ETS taxes for related emissions in EU steel and aluminium inputs for automotives ranged from USD 160-180 for an average car.[44]

Indirect subsidies for renewable electricity used in battery production for EVs were USD 20-40 in the US and between USD 0 and 160 in the EU Member States.[45]

In addition, renewable energy subsidies also lower the electricity price and thus the cost of charging and hence driving an EV.

Maximum effective consumer subsidy for a B-segment private car over ten years of ownership (EV vs petrol), 2022

USD, 2022-values



**Sweden has removed the purchase incentive for cars purchased after November 2022.*
Note: An example of an B-segment car (small car) is Peugeot 208. Purchase incentives or grants are direct subsidies when purchasing the car. Tax subsidies include acquisition tax, car ownership tax, and fuel tax and electricity tax. US tax savings only include the federal tax credit.
Source: Transport and Environment (2022), Tesla (2023), Wallbox (2023), IRS (2022), Drive Clean (2021).

Note: 43) Regeringen.se (2022) /// 44) Numbers not shown in figure. Include direct quota costs. Based on 150 kg. aluminium in a car (Ash & Lacy (2021)), and 900 kg steel (World Steel Association (2019)) /// 45) Numbers not shown in figure. For a 50 kWh battery. In reality, the effective indirect subsidy is lower when the battery production is connected to the grid.

The IRA increases effective subsidies for electric vehicles and plug-in hybrids in the US through direct subsidies and indirect battery subsidies

IRA subsidies for EVs

The IRA increases the federal subsidy for some (not all) EVs, but the marginal increase depends on the type of car, the battery, and the price if the EV.

The main IRA subsidy is the consumer tax credit on the EV purchases. US-based producers do not get this subsidy *when exporting* cars outside the US, only for domestic US sales. For cars with a retail price above USD 55,000, no IRA subsidies are provided.[46]

As an example to the right, a Volvo S60 plug-in hybrid model from 2019 with a current retail price of USD 52,000 were eligible for USD 5,000 (9.6 per cent of retail price) in consumer tax credit *pre-IRA*, i.e., not the maximum pre-IRA subsidy amount of USD 7,500 shown on the previous page.

The *marginal subsidy impact* from the IRA for the Volvo is an increase of USD 5,050 to USD 10,050 (19 per cent of retail price), see figure.

These marginal IRA subsidies include an increase of USD 2,500 in consumer tax credits (to USD 7,500), and a subsidy for the production of batteries with up to USD 2,250 for a standard 50 kWh battery, if produced on US territory.[47]

In addition, the IRA offers a credit of 10 per cent for the production cost subsidy for critical materials if these are sourced and refined in the US or a specified US trading partner.[48] For a 50 kWh battery, the critical material subsidy amounts to approximately USD 300.[49]

While subsidies can attract FDI in EV production in the US, it is not necessarily lowering incentives to invest in EV production elsewhere as the subsidy is on the EV *purchase* in the US, not EV *production*.

In addition, high vehicle transportation costs and volatile freight rates mean that it may still be preferable for car companies to have local final assembly of some car models.

IRA requirements for US production

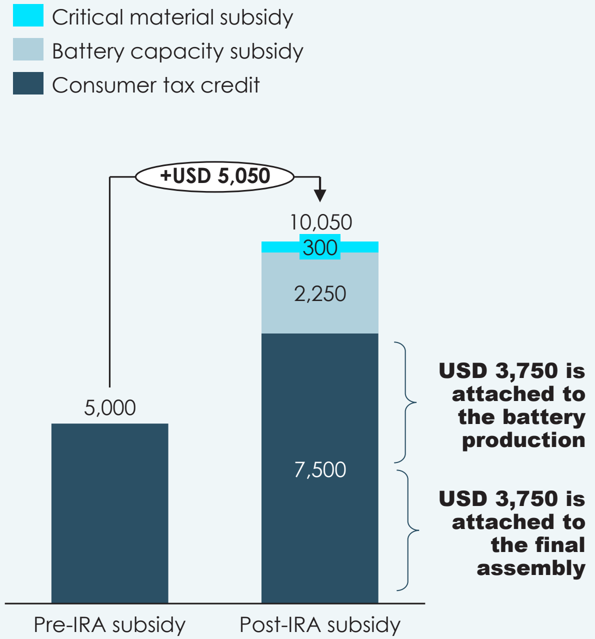
While EV *subsidies* may not affect EU competitiveness that much, the IRA *requirements* for production of EVs and battery subsidies may have distorting impacts on trade and FDI.

As of February 2023, only US-produced cars and batteries are covered in the guidelines for private EVs in the IRA as long as they fulfil the requirements. The IRA does not distinguish on company ownership, so for example EU companies with production in the US can be eligible for the subsidies, if they fulfil the requirements for sourcing and production. Private EVs are currently not eligible for the IRA subsidies if imported from outside North America.

USD 3,750 of the total USD 7,500 IRA consumer tax credit for a private EV is attached to the battery where at least 50 per cent of the components are required to be manufactured or assembled in North America, increasing to 100 per cent in 2029.[50] The other USD 3,750 is attached to the final assembly.

Producers of *components* for critical materials and batteries based outside the US may be hit by the domestic content requirements, including iron, steel and aluminium inputs, see appendix. We do not find that producers of *other car components* are directly affected by the IRA requirements.

Example: Subsidies for a plug-in hybrid Volvo S60 model from 2019
USD, 2022-values



Notes: Maximum subsidies if all requirements are fulfilled. Numbers are rounded to nearest 50. Example is for a Californian retail price, including VAT.
Sources: California Department of Tax and Fee Administration (2023), IRS (2022), Drive Clean (2021), IRS (2023), Congress (2022), CNBC(2023).

Sources: 46) Electrek (2023) /// 47) The subsidy is up to USD 45 per kWh capacity, where USD 35 per kWh is a subsidy specific to the battery cell and USD 10 is a subsidy for the battery module, see Congress (2022), page 136. /// 48) The subsidy is applied to all critical components and does not expire after 10 years, see Congress (2022), page 136. /// 49) In 2021, the cost of a lithium-ion battery was estimated to be USD 125 per kWh. Bloomberg (2021). /// 50) Politico (2023).

Raw materials are essential for car battery production – the majority of known reserves are centred around few countries, not including the US, nor the EU

Raw materials

Critical raw materials for batteries

Raw materials for EV batteries include lithium, nickel, manganese, cobalt, and graphite. Some of these are not abundantly available across the globe, but the majority of known reserves are located in just few locations, see the map. For example, half of the world's known cobalt reserves are in the DRC, and Chile and Australia hold two-thirds of the world's known lithium reserves.

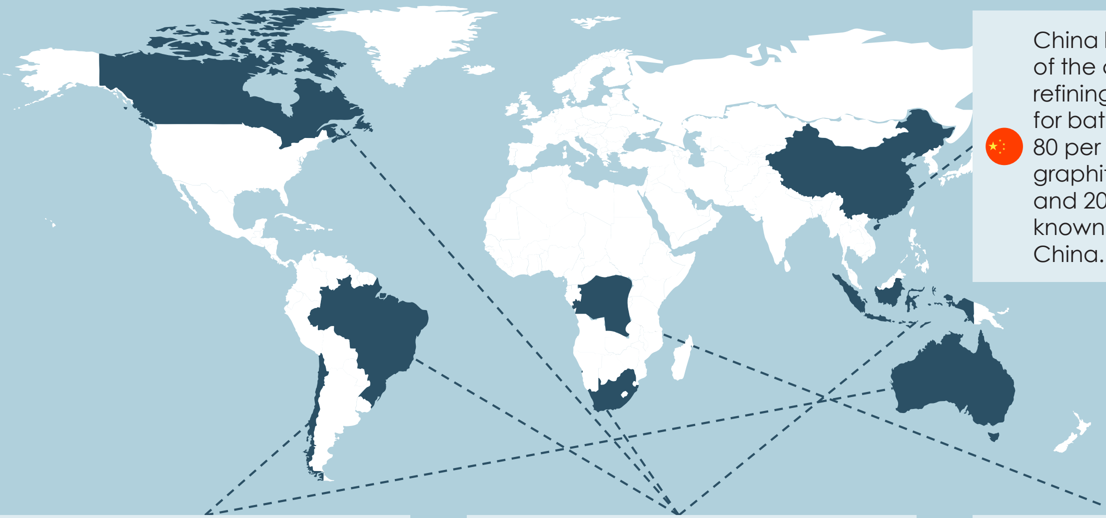
The IRA requirements specify that raw materials for EV batteries should come from the US or a specified trading partner, which currently include Chile, Australia, and Canada.[51] With the likely fast ramp up of EV battery production in the US, there will be a pull of raw materials for EV batteries towards the US, particularly from US trading partners.

In recent years, China has invested in mines abroad, in particular mines in the DRC which are 70 per cent under Chinese control.[52] China currently holds 80 per cent of the world's capacity for refining raw materials for batteries, and China produces 80 per cent of graphite globally.

With China sitting on a large part of the market for raw materials and refinement, and the likely pull of raw materials to the US from the IRA, the EU risk getting squeezed between the two when it comes to sourcing raw materials for EV batteries.

The EU acknowledge the need for access to raw materials in the Critical Raw Materials Act under the Green Deal Industrial Plan, where the EU calls it "a race" for these materials, and without access to these materials, the ambition to become the first climate neutral continent is "at risk".[53]

Key countries with production and known reserves of raw materials for lithium, nickel, manganese, cobalt, and graphite for battery production



China has 80 per cent of the capacity for refining raw materials for batteries.
80 per cent of global graphite production and 20 per cent of known reserves are in China.

Chile and Australia have combined two-thirds of the world's lithium reserves.

Canada, Brazil, South Africa, and Indonesia have production and reserves of graphite, manganese, cobalt, nickel, and/or lithium

Almost 70 per cent of produced cobalt and 50 per cent of known reserves are in the DRC.

Note: Assessment made based on a ranking of countries in the sources. Graphite reserves are scattered globally with known reserves also in Europe, including Sweden, Norway and Ukraine. In addition, graphite powder can be produced synthetically.
Sources: Numbers from 2020 and 2021 based on U.S. Department of the Interior U.S. Geological Survey (2022) and Visual Capitalist (2021).

51) US Treasury (2022) /// 52) SP Global (2020) /// 53) European Commission (2022, a).

Conclusion: The IRA *subsidies* are not expected to have a large impact on EU electric car production, but the IRA *requirements* may have an impact

Chapter conclusion

We find that the IRA subsidies for EVs are expected to increase production of components, batteries, and EVs in the US, and speed up decarbonisation of US road transportation.

The IRA requirements may lower EU's access to raw materials for batteries, lower EU battery component production, and future EU exports of private EVs to the US.

Our analysis shows that some investments in battery production and final EVs assembly may be made in the US earlier than expected due to the IRA but investments in batteries and final assembly are still likely to be made on the EU market. However, the US will attract more investments due to the IRA subsidies, and thus fewer investments are made in the EU in the short run.

There are still many unknowns such as US consumer preferences and whether the necessary grid and charging infrastructure can support the US uptake of EVs if this happens relatively fast.

Impact on EU trade, FDI and competitiveness

Small or no impact / Large impact

Raw materials for EV batteries

China's investments in mines abroad and the likely pull of raw materials to the US from the IRA incentives, may put the EU at risk of not having access to these materials in the short-term, or the EU may need to pay higher prices for these materials, which has happened recently due to a Chinese quasi-monopoly for magnets.[54]

Battery production

The IRA will likely ramp up US battery production quickly and increase investments in US battery production. The specific IRA subsidies and requirements for US produced batteries could distort trade in batteries, but high trade costs and security issues in transportation are likely to lower this effect. Therefore, final battery assembly is often close to final demand. It is more likely that battery components will be affected before final assembly as many of these are safer and more cost-efficient to transport.

Final assembly of private EVs

The majority of IRA *subsidies* are for the purchase of EVs in the US, which should not affect EU production negatively. However, the IRA *requirement* that private EVs should be produced in the US could lower EU's future export potential of private EV to the US, and over time move investments from the EU to the US.

For EU car manufacturers already producing in the US, the subsidy will likely increase their sales (and potentially investments) of EVs in the US. Production close to final demand follows the trend of automotive companies moving final assembly closer to the consumer because of disrupted supply chains due to pandemic, high freight rates, etc.[57]

No private EVs produced outside the US are currently equally eligible for the subsidy as US produced EVs. However in December 2022, the new guidelines opened up for IRA subsidies for imported private EVs, if these are used for leasing.

EU production of commercial EVs is not expected to be hit directly as they are not covered by the same requirements as private EVs.

Iron, steel, and aluminium

The IRA requirements for battery production components may lower US imports of iron, steel, and aluminium from the EU, as a certain share of components for battery production needs to be sourced from North America, see appendix. We do not expect an impact on iron, steel, and aluminium imports for final assembly.

Effectively, the IRA requirements could increase input cost of iron, steel and aluminium in the US EV industry as they would have to source more from domestic, more expensive sources. However, the automotive industry does not make the majority of the markets of US steel consumption[55] and of aluminium.[56]

Other US industries will not pay increased domestic prices and will therefore source more iron and steel from imports. The total impact from the IRA requirements on EU exports of iron and steel to the US is therefore likely to be small.

54) For example, a 50-90 per cent increase in price magnets were seen in the EU due to China's quasi-monopole, see European Commission (2022). /// 55) Statista (2022) /// 56) Aluminum Association (2020) /// 57) Automotive World (2022)

The EU's plans for a CBAM and the expansion of ETS probably will not affect the impacts from the IRA but the Green Deal Industrial Plan may

The US's and the EU's subsidy systems

The *level of subsidies* you receive as an investor is easier to understand in the US than in the EU. In the US, subsidies are mainly on a federal level and it is clearly stated what support you receive if you fulfil the criteria set out. The current EU support system is scattered with individual Member State subsidy systems and EU-programs administered by the EU Member States, but they all adhere to the same EU state aid regulation. For renewable energy and green hydrogen, the level of support that companies receives is currently not straightforward in EU Member States, as it typically depends on individual tenders, and the subsidy thus differs from project-to-project.

While EU and US subsidies may improve competitiveness in the domestic industries supported, the financing will have to come from taxation, or in the short-term from increased debt, meaning that other parts of the economy could be worse off.

EU regulation and response to the IRA

Current and forthcoming EU regulation may affect the competitive situation within clean energy products and automotives. Below, we discuss the implications of these in relation to the IRA subsidies and requirements, see also fact box to the right.

In isolation, the EU ETS effectively increases the price of non-green steel produced in the EU as the production emits greenhouse gasses. Potential increases (or decreases) in the ETS price will directly affect the production price of EU-produced steel. Currently, there is no similar taxation of *imported* steel. The aim with the proposed CBAM is to tax imported products' production emissions to lower current distortions on the EU market, while also avoiding carbon leakage, and encouraging decarbonisation in other parts of the world.

CBAM is not likely to lower any IRA impacts as the potential trade distortions from the IRA for the products in question (in particular EU imports of green hydrogen and EU exports of EVs) are not affected by CBAM. Instead, the combination of ETS and CBAM may increase price of steel in the EU as imported steel becomes more expensive. In isolation, this will lower EU competitiveness for EU-based industries using steel, for example renewable energy power plants and automotives. This impact is expected to decrease when green steel is supplied on the EU market.

In the expanded ETS system, it may be possible for green hydrogen producers to receive free ETS allowances for their production. This could lower the impact of the IRA for green hydrogen, as these allowances are indirectly subsidising green hydrogen in the EU.

As a potential response to the IRA, The EU is opening up for increased subsidies for clean energy in the EU Net-Zero Industry Act as stated by Ursula von der Leyen at the World Economic Forum.[58] This includes a reform of the state aid rules and the establishment of a European Sovereignty Fund to finance and accelerate medium-term and emerging technologies. If the Act comes to life, subsidies in the EU and EU Member States are likely to increase which would accelerate EU's decarbonisation and potentially lower the impacts of the IRA subsidies on EU competitiveness in industries covered. However, the impacts of the Act are not possible to assess in its current form, as subsidy levels and timelines are not yet clear.

The EU ETS and CBAM

The EU emission trading system (ETS) is a quota system for allowing a fixed amount of CO_2 emissions in selected industries in the EU and few other countries. The quotas are traded on a market at an 'ETS price'. While the EU ETS is in a process of expanding, the current ETS covers EU manufacturing, power production, and domestic aviation. Emissions in iron, steel, and aluminium production are all covered in the ETS.

In addition to the ETS, the EU is currently in the process of establishing a carbon border adjustment mechanism (CBAM) which aims to create a level playing field on the EU market for products that are currently taxed under the ETS in the EU. Effectively, importers will have to buy enough CBAM certificates to cover the emissions embedded in the imported good. The price of the CBAM certificates will be the same price of the ETS quota price, adjusted for any emission taxes already paid in the country of production.[59]

Iron, steel, and aluminium are covered in the current CBAM proposal, which are all relevant inputs for both clean energy and automotives. With CBAM, trade distortions from EU taxation of emissions will be lowered in the EU but import prices may also increase.

58) European Commission (2023, b). /// 59) KPMG

Conclusion: The largest risks from the IRA on EU competitiveness are in future production of green hydrogen and refined electrofuels

Our analysis shows that the **largest risks from the IRA on EU competitiveness are in future production of green hydrogen and refined electrofuels**. The IRA subsidies are so large that US producers could become competitive on the EU market, thus lowering future investments and production in the EU. This would make it more difficult to achieve the goals of the EU Hydrogen Strategy to produce 10 million tonnes of green hydrogen in the EU by 2030.[60]

Potential impact on EU exporters

We find that some EU companies in the value chain of clean energy products and EVs could expect lower exports to the US due to the IRA production requirements. However, we should expect a shift in the trade pattern such that the EU companies instead may be able to export to other US industries not covered by the IRA requirements. These products include – but are not limited to – iron, steel and aluminium products, which constitute 2 per cent of total EU exports to the US including both goods and services.

On one hand, EU specialised metal products produced for a particular industry (e.g. renewable energy or EVs) are expected to be more hit than commodities and standardised products, as other US industries not part of the IRA more easily can take over import of commodities and standardised products, than they can for specialised products designed for a specific purpose. On the other hand, if the US not currently produces similar specialised products as currently imported from the EU, EU exports of these products may be less hurt as they have no direct US competitors.

Current EU exporters of private automotives are, as it stands now, affected by the IRA production requirements and could therefore expect lower future exports of EVs to the US. However, the IRA guidelines already have been changed to allow for import of private EVs for leasing to be covered by IRA subsidies, so further changes could happen going forward. EU automotive exports constitute less than 5 per cent of total EU exports to the US including both goods and services.

EU exporters of components for critical materials and batteries to the US may also be hit by the IRA requirements.

Potential impact on inward and outward FDI in the EU

Over the coming years, companies operating in renewable energy, battery production, and final EV assembly may move their investments towards the US and invest less in other areas such as the EU simply because of the size of IRA subsidies they will receive towards 2031.

The EU and other areas have set decarbonisation targets, so long-term *direct* impacts on FDI are expected to be limited.

However, as the IRA subsidies for green hydrogen are large, and because hydrogen can be transported, the EU may miss out on future FDI and domestic investments in green hydrogen, refined electrofuels, and *indirectly* in new renewable energy to supply electricity to this production. Should the US become cost competitive on the EU market, they will likely export green hydrogen and/or refined electrofuels to the EU, thus lowering future investments and production in the EU.

EU companies and investors will likely increase investments in the US (outward FDI) within renewable energy, green hydrogen, refined electrofuels, battery production, and final EV assembly.

Potential impact on EU competitiveness

With the increased subsidies and requirements in the IRA, the EU will lose competitiveness in clean energy products and EVs relative to the US. The size of these impacts are difficult to assess, as there are many factors and uncertainties that come into play:

- Production costs and transportation costs are uncertain and are key for the business case of US exports to the EU market.
- Potential temporary EU relaxation of state aid rules could increase EU competitiveness within these industries.
- IRA requirement guidelines may be relaxed to include more imported content.

There are also potential benefits to other EU industries from the IRA subsidies:

- EU companies producing clean energy products and automotives that are present in the US could expect increased demand on the US market.
- EU companies within engineering, digitalisation, data analytics, consulting, etc. may also see additional opportunities to export their services to the US within clean energy products and automotives.
- EU decarbonisation may speed up from the IRA subsidies, as US subsidised green hydrogen and/or refined electrofuels could provide low-cost clean energy products on the EU market and thus lower the costs of decarbonisation in industries in the EU where emissions are hard-to-abate.

For further research

This report focuses on IRA impacts on ***clean energy products***, including green steel and green aluminium.

The IRA may lower energy prices for US-based **energy-intensive industries *in general***; most likely for industries using electricity that – in some locations – would receive a lower electricity bill due to the IRA subsidies for renewable energy. For US companies that uses fuels and gas in their production, a potential IRA impact is a more complex question which could be researched further.

60) European Commission (2022, b).

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Copenhagen Economics

APPENDIX

Scoping of geography, industries, and products

Geography

While the IRA only have implications for subsidies in the US, we have a broader scope when it comes to the effective subsidies already in place in the US and the EU.

Our scope covers the US federal level and the 'federal' EU, as well as five US States and six EU Member States, see table to the right. These countries and states are chosen based on the presence of the industries in scope, the availability (or lack of) of relevant subsidies, and to have a geographical scope covering different areas of the US and the EU, see preface.

Industries

We use industry data for the delimitation of the focus industries and to assess foreign direct investment and other industry statistics.

Industries are classified using NACE Rev. 2 codes in the EU, and with NAICS codes in the US. As the classification is not exactly the same, we use corresponding tables to compare US and EU numbers.

In the table below, we outline the industries covered in the analysis, both the direct industry focus, and indirectly affected industries, including battery manufacturing, critical materials, aluminium, steel, iron and green hydrogen.

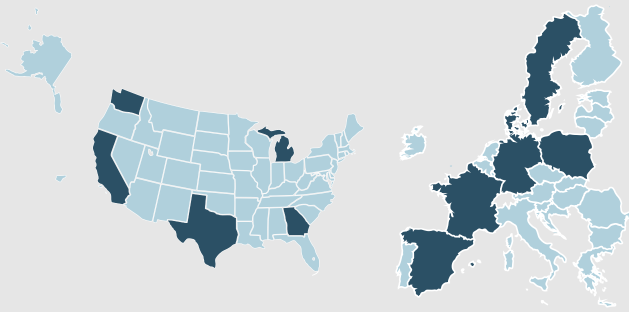
Products

For trade in products, we use product (HS) codes to address international trade and import tariffs.

Fuels (hydrogen, ammonia, methanol and LNG) are categorised under HS codes 271111, 280410, 281410, 281420, and 290511. Other clean energy products include wind turbines (850231) and solar panels (854140). While there is also trade in furnaces for power generation, geothermal energy equipment etc., this trade is found to be low.

For trade in automotives, vehicles (87) is the overarching category. We focus on motor cars (8703) and transport vehicles (8704), as these constitute private and commercial vehicles.

Similarly, we examine trade in products that are indirectly affected; batteries, raw materials, aluminium, steel, and iron.



The US	The EU
• Federal level • California • Georgia • Michigan • Texas • Washington	• The EU • Denmark • France • Germany • Poland • Spain • Sweden

Industries to address	Direct industry focus	Related value chain industries
Automotives	Car and commercial vehicle manufacturing (EVs)	• Raw materials for batteries • Aluminium • Steel and iron • Battery manufacturing
Clean energy products	Renewable electricity and green hydrogen	

Sources of TCO, transport costs, and subsidies

Total cost of production

Our assessment of total cost of production is used for comparing price levels in the US and the EU. Concretely, we find literature and report estimates of the production costs of the products in scope. With this we can assess different locations' cost competitiveness in producing each product. We present the numbers in ranges as there are multiple estimates for the production costs.

Transportation costs

Production costs have to be accompanied by transportation costs to assess the competitiveness of a product on export markets. Similarly to production costs, we find literature and report estimates for these costs.

EU subsidies

Over the last decade, many EU Member States have started using project specific auction system for renewable energy production where producers bid for an award price. The difference between the award price and the realised electricity market spot price is then the effective subsidy.

We use the AURES database to access most recent award prices from projects from 2018 and forward. We compared these prices to the spot prices in 2018-2020 to get an estimate of the effective subsidy. We use prices from 2018-2020 to avoid the high electricity prices in 2021 and 2022, which do not reflect realistic prices in the long-term. For each technology in each country of interest, we use the highest and lowest award price to create a subsidy range.

For the electric vehicle subsidies in the EU we examine at the difference in tax payments for a similar class of electric and petrol car, including VAT, acquisition taxes, ownership taxes, and energy taxes, as well as purchase incentives.

US subsidies

Both EVs and renewable electricity production in the US received subsidies already before the IRA. For EVs, those subsidies were dependent on the capacity of the battery installed. They were paid to consumers in form of tax credits and could reach a maximum of USD 7,500, see table. They were, however, limited to a pre-specified number of cars of a certain type. In addition, California has additional subsidies for consumers.

Renewable energies subsidies were paid to producers and in two different forms: as producer tax credits (PTC) or as investment tax credits (ITC). PTCs are subsidies paid for each produced kWh of electricity. ITCs are subsidies paid for installed capacity. The amount and form of subsidies offered depended on the technology, see table.

With the IRA, consumer subsidies for EVs were extended but included some new local content requirements. In addition, producers also received subsidies dependent on the capacity of the installed battery and on the origin of the raw materials.

For renewable energy production, subsidies increased but were still paid in form of PTC or ITC. In addition, the IRA also subsidises *manufacturing of renewable technologies* by providing tax credits for individual components.

Industries	Pre-IRA subsidies	Post-IRA subsidies	
		Subsidy	**Requirements**
Automotives (commercial and private EVs)	• Tax credit based on battery capacity: USD 0 – 7,500 (based on capacity of EV battery).	Consumer tax credit: USD 0 – 7,500.	1. Car must not exceed retail price of USD 55,000; 2. Buyers only qualify if their annual gross income does not exceed USD 150,000 (USD 300,000 for married couples). 3. Final assembly of car must have been in North America. 4. Battery minerals must be extracted or processed in US or specified free trade partners; 5. 50 per cent of battery components must be manufactured or assembled in North America, increasing to 100 per cent in 2029.
		Credit for battery cells and modules: up to USD 45 per kWh	Components must be produced in US
		Producer tax credit for battery critical minerals: 10 per cent	Components must be produced in US
Clean energy and manufacturing	• Solar: 26 per cent on investment costs (ITC). • Onshore + Offshore: 0.015 USD/kWh on production costs (PTC) or 26 per cent on investment costs (ITC).	Solar: 0.026 USD/kWh on production cost or 30 per cent on investment costs.	Wage and apprenticeship requirements
		Onshore and offshore: USD 0.026 per kWh on production costs or 30 per cent on investment costs.	Wage and apprenticeship requirements
		Manufacturing production tax credits for different components and technologies.	Components must be produced in US
		Producer tax credit for incorporation of domestic steel and iron: 10 per cent (each).	40% (20% for Offshore) of steel or iron content must come from North America. Share will increase to 55% in 2028.
		Green H_2: Production credit: USD 3 per kg.	Hydrogen must be produced from RE or nuclear power. To achieve the 5x multiplier (from USD 0.6 per kg to USD 3 per kg), the investment must fulfil certain labour requirements.

Sources: IRS (2022), IRS (2023), Congress (2022), Solar Energy Industry Association (2023), Department of Energy (2021), Solar Topps (2022), Sidley (2022), ICCT (2023), White & Case (2022), Wind Exchange (2022), Foley (2022), and CNBC (2023).

Calculation of effective net post-IRA subsidy rate for renewable energy and green hydrogen

USA

In this report, we calculate the IRA subsidies in the USA. However, investors may not access the extended subsidy for two reasons: i) The IRA's financial support expires in 2031 but the average lifetime of renewable energy plants is longer, and ii) Many individual subsidies are tied to requirements such as local content requirements. For some investors, it may not be possible to comply with all those requirements.

Below, we explain how we calculate the extended IRA subsidy, the current IRA subsidy considering a limited period and a lower bound IRA subsidy.

Extended subsidy

To calculate the extended IRA subsidy, we assume no depreciations and that all requirements to qualify for the respective subsidy are fulfilled. Then, we simply stack the available subsidies. For solar PV, those are production tax credits a and manufacturing tax credits. For hydrogen those are direct production tax credit and the indirect subsidies for renewable electricity used in green hydrogen production.

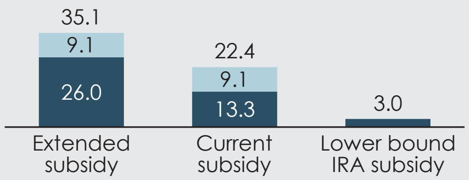
Current subsidy

To account for the limited time period of the IRA (i), we assume that the respective technology can be used for 25 years but subsidies are only paid until 2031. We also assume an (low) annual depreciation rate of 5 per cent. With shorter asset lifetime and/or higher depreciation, the current subsidy would increase. The manufacturing tax credits are paid up front and thus no depreciation is used for these.

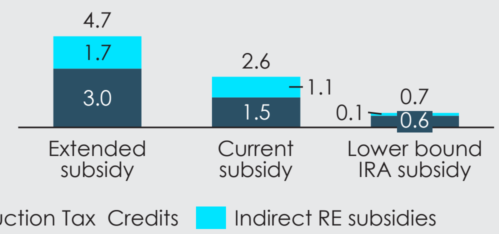
Lower bound IRA subsidy

To account for (ii), we calculate the lower bound of the IRA subsidy by assuming that the investor cannot comply with any of the requirements (which include local content requirements for technology components and wage requirements). For both wind and solar technologies, manufacturing tax credits cease entirely and only a minimum production tax credit persists.

Solar PV, USD per MWh



Hydrogen, USD per kg H_2



EU

The total green hydrogen subsidy comprise of a direct subsidy for green hydrogen and an indirect subsidy for renewable energy subsidies.

Direct pledged green hydrogen subsidy

The direct subsidy is calculated based on the pledged public budget and electrolyser capacity in national hydrogen strategies. For example:

In their hydrogen strategy, Germany pledged to support green hydrogen with EUR 7 billion (USD 7.4 billion), and aims to have 5 GW (5 million kW) electrolyser capacity by 2030. With 5,000 full load hour production annually, an hydrogen plant lifetime of 25 years, hydrogen energy content of 33 kWh per kg and an electrolyser efficiency of 70 per cent, this amounts to:

5m kW x 5,000h x 25y / (33 kWh / 70%)

= 13.3 billion kg. hydrogen over the plant's lifetime

And to convert this into an average subsidy we use, as shown in figure below:

USD 7.4b / 13.3 billion kg = USD 0.6 per kg

As the public budget is expected to be provided in the investment phase, we have not discounted the subsidy.

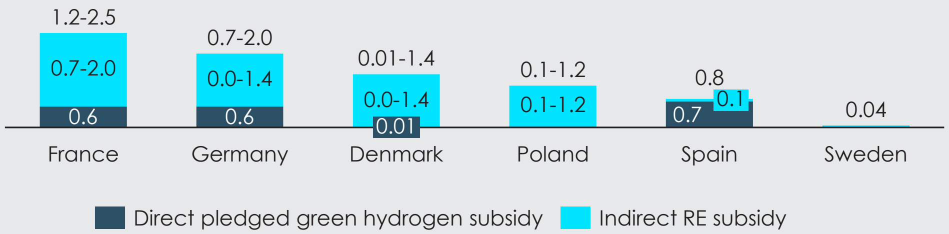
Indirect renewable energy subsidies

The renewable energy subsidy is transformed into an indirect subsidy for green hydrogen simply by the electricity content needed to produce one kg of hydrogen, i.e., for Germany the renewable energy subsidy ranges USD 0-30 per MWh (i.e., USD 0.00-0.03 per kWh):

USD 0.00 per kWh x (33kWh /70%) = USD 0.0

USD 0.03 per kWh x (33kWh / 70%) = USD 1.4

Hydrogen subsidies, USD per kg H_2



Note: Spain's direct pledge includes subsidies for renewable energy
Sources: Copenhagen Economics based on IRA budget, ENS (2021), Netherlands Enterprise Agency (2021), IEA (2022, c), GH2 (2023), Clifford Chance (2021), Energimyndigheten (2021), and calculations based on AURES database

Our estimates compared to other estimates found in literature

Estimate comparisons

As another sensitivity check, we compared our numbers and calculations of the LCOE and IRA subsidies with what is found in other studies.

For LCOE for solar, our estimates are in the lower range relative to other sources, whereas we are more on par with onshore wind LCOE.

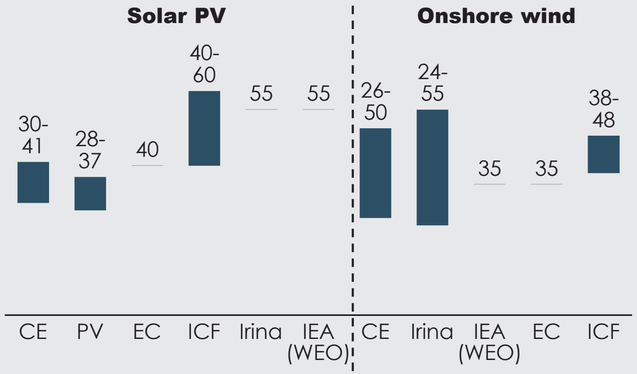
IRA subsidy comparisons only make sense if we compare "extended subsidy" scenarios with other "extended subsidy" scenarios, and so on.

Our numbers align well with other estimates for the IRA for both renewable electricity and hydrogen, see figure. There are some differences, which can be due to subsidies included, assumptions of lifetime/full load hours, additional cost of inputs, etc.

Differences for current subsidies may lie in the assumptions behind the calculation. For example, the lower range ICCT estimate for green hydrogen only assumes subsidies for a 2-3 years towards the end of the IRA-period.

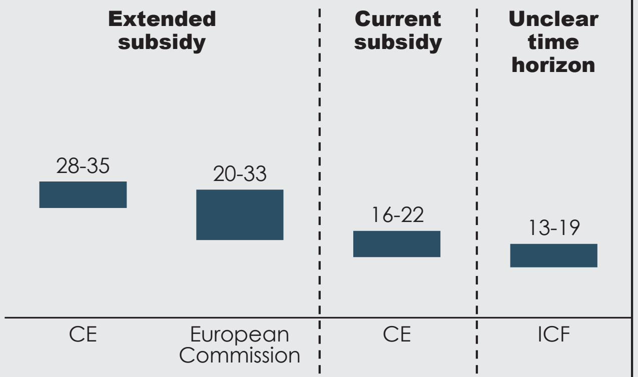
For some estimates, it is not clear whether they use the extended subsidy, a current subsidy or a third method.

LCOE excluding subsidies for solar PV and onshore wind in the US
USD per MWh



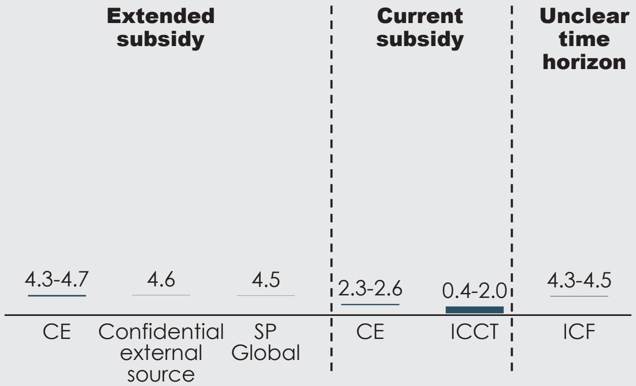
Note: Estimates are for 2020-2022. Irina solar PV number is an average for North America and therefore higher than the expected low-cost areas. Some numbers are read off graphs. CE numbers are from Lazard (2021).
Source: European Commission (2022), Irina (2021), ICF (2022), PV Magazine, (2022), IEA (2021), and Lazard (2021).

IRA subsidies for renewable electricity from different sources
USD per MWh



Note European commission may not include all subsidies that we include. Some numbers are read off graphs.
Source: Own calculations, European Commission (2022), ICF (2022).

IRA subsidies for hydrogen sensitivity check from different sources
USD per kg hydrogen



Note ICF have been converted from MWh to energy content of one kg hydrogen. Some numbers are read off graphs.
Source: Own calculations, ICCT (2022), ICF (2022), SP Global (2022).

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