FORUM FOR A NEW ECONOMY

NO. 01 2025

Basic Papers

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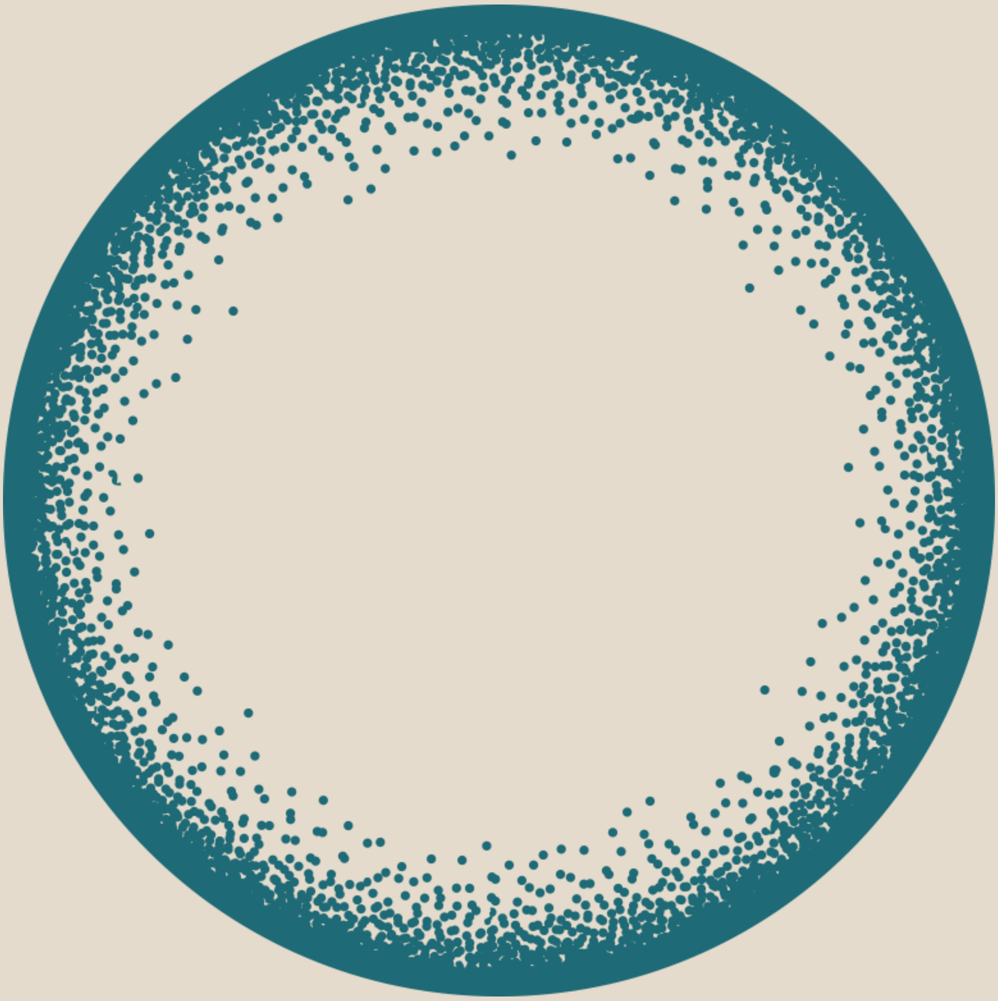

Impressum:
Forum New Economy Basic Papers
ISSN 2702-3222(electronic version)
Publisher and distributor: Forum for a New Economy
Neue Promenade 6, 10178 Berlin, Germany
Telephone +49 (0) 30 767596913, email press@newforum.org
Lead Editor: Thomas Fricke

An electronic version of the paper may be downloaded:
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A positive approach to climate policy: what are preliminary lessons learnt from the US Inflation Reduction Act?

Isabella Wedl*, Thomas Fricke, Forum New Economy

Abstract

For decades, climate economists and policymakers have favored market-driven solutions with minimal government intervention, advocating carbon pricing as the primary climate policy instrument. The Inflation Reduction Act (IRA), enacted in 2022, represents a fundamental departure from this approach, emphasizing positive incentives through subsidies and substantial public investment in infrastructure. This paper examines the limitations of carbon pricing in advancing the transition to a low-carbon economy and contrasts these with the investment-driven approach embodied by the IRA. In particular, it seeks to stimulate discussion on the extent to which this model could inform European climate policy.

To this end, we provide an overview of the IRA's key provisions and assess its early impact on private cleantech investment, drawing on data from the Clean Investment Monitor. This is followed by a summary of projected effects on emission reductions and macroeconomic developments in the United States. To contextualize these findings, we outline the EU's current strategies for supporting cleantech industries and its policy response to the IRA. Against this backdrop, and informed by expert discussions, we highlight key lessons from the IRA and identify open questions relevant to European policymakers. We conclude that the IRA has significantly boosted cleantech investments in its initial years, and projections on both its potential for emissions reduction and its macroeconomic impacts are promising. It will, however, be important to monitor its long-term effectiveness and cost-efficiency to confirm the sustainability of these positive impacts.

JEL codes: Q54, Q48, L5, L6

Keywords: climate policy, Inflation Reduction Act, green industrial policy, clean energy

We thank participants of the Berlin Summit 2024 for their valuable input, in particular, the contributors in the session 'Modern Climate Policy': Frauke Thies, Jonas Meckling, Philipp Steinberg, Michael Grubb, and Jean Pisani-Ferry. Many thanks also to the participants of the follow-up workshop on climate policy in October 2024 for their valuable feedback. This study has been commissioned by Forum New Economy. The opinions expressed in this paper are those of the authors and do not necessarily reflect the views of Forum New Economy.

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1. INTRODUCTION

When President Biden passed the Inflation Reduction Act (IRA) in August 2022, it was hailed as the most significant US climate policy to date. Over a decade, the bill aimed to direct approximately 400 billion USD in public funds toward incentivizing the deployment of climate-friendly technologies – primarily through tax credits. The previously enacted Bipartisan Infrastructure Law had already laid the groundwork for a cleaner energy economy by providing significant public investment in infrastructure, including grid modernization, EV charging networks, and public transit upgrades.
The IRA has since spurred a clean energy investment boom: private investment in these technologies reached nearly 500 billion US in the two years since its passage - an increase of over 70 per cent compared to the two years before (Bermel et al, 2024). Due to the higher-than-expected uptake of IRA tax credits, total public funding has recently been re-estimated to be even larger - around 730 billion USD over ten years.
The new Trump administration, which took office in January 2025, has cast uncertainty over the IRA's future. The government has halted IRA fund disbursement for review and has openly sought to dismantle the law, aligning with its broader rollback of climate commitments. A full repeal of all the IRA incentives, however, remains unlikely, as many Republican-led districts have benefited from the IRA, and Congress members from both parties support the existing policy. While the current regulatory uncertainty poses challenges for businesses, many private sector commitments made in response to the IRA may prove resilient, given the momentum in the clean energy economy that has been unlocked, and the sunk costs of infrastructure investments.
The focus on positive incentives via subsidies and on public investment in infrastructure that we have seen in the US contrasts sharply with the longstanding European emphasis on carbon pricing. For decades, the immense policy influence of economists advocating for a price-centred approach to climate policy has led to the perception of carbon pricing as the 'first best' priority for climate policy. Biden's climate course marked a paradigmatic shift away from this traditional economic belief, prioritizing state-led investment in a low-carbon economy over market-based mechanisms. The momentum generated by the IRA – alongside new empirical evidence on the role of subsidies in driving successful clean technology diffusion (Grubb et al, 2024) – seems to challenge this long-held paradigm.

While the IRA's adoption was largely driven by geopolitical considerations and domestic opposition to carbon pricing rather than policy effectiveness concerns, it provides a great empirical case for analysis. With the COP28 global stocktake underscoring the urgency of accelerating decarbonization, the question arises: Can Biden's investment-driven climate policy serve as a model for other economies facing similar socioeconomic, financial, and political challenges in the green transition?
This paper focuses, in particular, on the lessons that can be drawn from the IRA for the EU and European countries. The EU has established itself as a global climate leader over the past decades: It was the first region to launch a comprehensive Green Deal, aiming to achieve an ambitious 55 per cent reduction in emissions by 2030. Its comprehensive climate policy mix features a range of instruments, including carbon pricing, subsidies, regulations, and procedural tools. While the EU has implemented green stimulus packages akin to the IRA in the past, they have been smaller in scale, and the emissions trading remains the centrepiece of the European approach to reducing GHG emissions.

However, significant challenges persist in financing, social acceptance, and cleantech competitiveness. In particular, the EU is struggling to close its green investment gap. It currently meets less than half of the additional 350 billion EUR in annual investment needs (Mack/Findeisen, 2023) and remains far from mobilizing the 1 trillion EUR in private sustainability investments it targets by 2030 (European Commission, 2020). Investment trends show that while Europe still leads in total clean energy investments, growth has stagnated, whereas investment in the US is gaining momentum (International Energy Agency, 2024).

When it comes to social fairness, the European Green Deal pledges to 'leave no one behind'. However, the planned introduction of the EU's Emissions Trading System 2 (ETS-2) in January 2027, which will introduce carbon pricing for consumer-facing sectors like transport and buildings, could drive up costs and require high individual investments, which might disproportionately affect low- and middle-income households (Pisani-Ferry et al, 2023). Meanwhile, Europe's green technology sectors are losing competitiveness against the US and China. The recent 'Future of EU competitiveness' report by Mario Draghi highlights that "to achieve both industrial decarbonisation and EU leadership in manufacturing, businesses need additional support" (Tordoir et al, 2024).

By contrasting the limitations of carbon pricing with the advantages of an investment-centred approach to climate policy, and presenting some of the IRA's preliminary effects, this paper aims to spark a discussion about the role of positive incentives and public infrastructure investments in addressing the abovementioned challenges.

The structure of this paper is as follows: Chapter 2 examines the limitations of the traditional, price-centred approach to climate policy, and Chapter 3 introduces key elements of an investment-centred climate policy approach. Against this background, Chapters 4 and 5 provide an overview of the IRA's climate-related incentives and their effects on private investment so far, as well as estimated future emissions reductions and macroeconomic impacts, followed by a short intermediate conclusion. To offer comparative context, Chapter 6 outlines EU public spending on climate efforts and responses to the IRA. Chapter 7 presents lessons learned from the IRA as key takeaways for Europe, informed by expert discussions. The final chapter offers conclusions and emerging questions for further research.

2. TRADITIONAL CLIMATE POLICY AND ITS SHORTCOMINGS

Climate policy employs diverse economic, regulatory, procedural, and informational instruments. For the purpose of this paper, we mainly differentiate between negative incentives and regulation on the one hand, and positive incentives (i.e., subsidies and financial support instruments) and public investment in infrastructure on the other hand - a distinction often referred to as 'sticks' versus 'carrots'. While we acknowledge the important role of regulatory instruments, we focus on carbon pricing as primary instrument for creating negative incentives, which embodies the traditional neo-liberal paradigm of the past decades. We contrast this approach in a stylized way with the use of positive incentives, such as targeted subsidies, and public investment instruments at scale, which we suggest represents a new paradigm in climate policy.

While climate policy mixes have evolved to incorporate diverse instruments over the past decades, policy debates are still dominated by an emphasis on carbon pricing. In fact, some economists have gone so far as to argue that addressing climate change essentially requires no other type of policy instrument. In his Nobel prize lecture, William Nordhaus claimed that "for any policy to be effective, it must raise the market price of CO2" (Nordhaus, 2018, p.453). The immense policy influence of these economists has resulted in the widely accepted perspective that carbon pricing is the 'first best' priority for climate policy due to its cost-efficiency (Mason, 2022; Oberthür/Homeyer, 2023).

The rationale behind carbon pricing

The price-centred approach to climate policy sees the fundamental problem as a market externality that needs to be internalized: As long as the harmful consequences of CO2-intensive goods and services are not reflected in market prices, these societal costs remain 'externalized', and the interests of individual market participants will diverge from societal interests. Such market failure calls for government interventions to correct for the under-pricing - either through a carbon tax, which sets the carbon price directly, or a cap-and-trade program which sets the volume of emissions. The assumption is that once this is done, private businesses and consumers will find the lowest-cost path

to decarbonizing the economy in a decentralized way. Carbon pricing mechanisms follow a market-liberal logic rooted in neoclassical economics, operating under the premise that the market will find the most efficient path to reduce emissions, with minimal government intervention.
A fundamental choice, from this point of view, is how high the carbon price should be. In fact, determining the economically optimal price for carbon - which will equal the social cost of carbon[1] - was framed as the key challenge of climate policy by climate economist William Nordhaus. In general, the market-liberal approach favours the trading of emission certificates over taxes as it allows market participants the flexibility to make emission reductions where they are most cost-efficient. Economists use cost-benefit analysis to weigh the benefits of avoiding climate change damages against abatement costs - assuming that reduction measures will by default lower current consumption and living standards. This perception may lead to pathways that are incompatible with international climate goals: for instance, Nordhaus' DICE model projects an optimum of over 3°C warming by 2100 – far exceeding international policy targets that aim to protect ecosystems, human health and livelihoods (Nordhaus, 2018).

Limitations of carbon pricing in effectively transforming the economy

Cost-efficiency (at least in the short term) is probably the most often cited reason why economists have advocated for carbon pricing. Further advantages that are often mentioned are its alignment with the 'polluter-pays' principle**,** and its ability to generate revenue streams for further climate action. However, overfocusing on a price-centred approach has several major shortcomings, which are increasingly recognized. In particular, carbon pricing as a standalone policy has been criticized for:

a. its **limited ability to induce behavioural change,** depending on elasticity of demand, as well as cultural and psychological factors
b. its **lack of leverage on disruptive innovation and infrastructure investments**,
c. a history of **ineffective or volatile prices**,
d. its potential **adverse distributional impacts**, and
e. its **limited political feasibility** due to vested interests and weak social acceptance.

Limited ability to induce behavioural change

The assumption of traditional economics is that carbon pricing results in broad changes in consumption by signalling to consumers which goods and services should be used more sparingly. Such behaviour change is, however, highly dependent on the price elasticity of demand[2], i.e., how sensitive consumer demand is to a change in prices. This elasticity is, in turn, determined by certain conditions, mainly the existence of attractive alternatives at scale. Consumers can be expected to change their preferences if there are close, climate-friendly substitutes that are available at lower prices relative to the high-carbon good. If consumers depend on something – e.g., heating, or daily transport –this price differential needs to be very wide to incentivize rapid behavioural change (Lonergan/Sawers, 2022). This is particularly true if adopting climate-neutral behaviours requires substantial individual investment, such as purchasing a new heating system or a new car. Thus, scaling low-carbon substitutes and making sure they are available at competitive prices are major preconditions for the effectiveness of pricing CO2-intensive goods in changing consumer behaviour (Lonergan/Sawers, 2022). In line with this argument, a new empirical study on climate policy effectiveness (Stechemesser et al 2024) finds that complementary policy instruments to carbon pricing, e.g., subsidies and/or standards, are crucial to incentivise a switch to low-carbon alternatives in consumer-facing sectors like building and transport.
Traditional economics also tends to ignore the psychological and cultural factors that can prevent a change in consumption despite price signals – such as short-term thinking, inadequate information, principal-agent problems, and loss-aversion in decision-making, as well as the influence of habits,

[1] i.e., the societal damage caused by an additional ton of CO2.
[2] Defined as the change in the demand for a product as a result of a change in its price

social norms, and cultural practices on consumption choices. As a result, policies focused on altering relative prices, in isolation, typically do not change behaviour to the extent hoped (Grubb et al, 2023; IMF, 2021).

Lack of leverage on disruptive innovation and infrastructure investments

Another assumption of neoclassical theories is that carbon pricing would provide enough "market incentives for inventors, innovators, and investment bankers to invent, fund, develop, and commercialize new low-carbon products and processes" (Nordhaus, 2018). While public funding of early research & development (R&D) as an additional policy is usually supported from this standpoint, positive incentives for the scaling and deployment of clean technologies are considered excessively costly and inefficient.

Relying on price signals to incentivize low-carbon innovation tends to ignore the dynamics and barriers in innovation processes, though. First, private sector innovation in industries central to tackling climate change, especially the energy sector, has typically been weak due to a disconnect between technology push and market pull. Second, the type of new low-carbon technologies that can actually drive large-scale emissions reductions is usually disruptive, and thus expensive at first. This means that high initial investment is needed to bring costs down and make them competitive. The targeted policies that created favourable market conditions for renewable technologies and were successful in driving the revolution in the cost of renewables were, in fact, deployed against mainstream economic advice. By contrast, carbon pricing incentives tend to bring forth mostly incremental innovation instead of more radical innovation (Grubb et al 2023).

Often, using these new, low-carbon technologies at scale also requires major infrastructure changes to break existing path dependencies. The most prominent example might be the switch from petrol cars to electric mobility, which is not happening at scale as long as the network of charging points is only insufficiently developed. The size of initial investments required for such large infrastructure changes presents a major barrier for private investment that is hard to overcome through rising carbon prices. It can also be argued that crucial infrastructure should be publicly owned to avoid adverse structural impacts of significant market power concentration (Krebs, 2023).

High risk of ineffective or volatile carbon prices

Recent estimates of the 'social cost of carbon' amount to over 100 USD per ton of CO2 (Grubb et al 2023), and price levels required for carbon pricing to be a major driver of global decarbonization are calculated to range between 100 and 160 USD/t CO_2 (ICC, 2022). Most realized prices in emissions trading systems and carbon taxing schemes remain far below this.

While the price for emitting carbon dioxide under the EU ETS has risen sharply in the past few years, it did not develop as hoped for decades: it fell far below the expected level when the market was introduced and remained way too low to be effective until 2021. This development can be explained by two potential distortions in ETS markets that have long been overlooked by classic economists: first, a tendency towards short-term thinking among market participants leads them to ignore expected future costs of compliance if allowances are abundant in the presence, inducing prices that are too low to be effective. Second, regulatory uncertainty leads to speculation about future political decisions regarding the volume of certificates, which can influence price developments significantly. If market participants expect a relaxation of the cap in the future, this will likely prevent prices from increasing. Some emissions trading systems have addressed these challenges by setting a carbon price floor in response to low prices, and/or introducing an upper ETS price limit to reduce regular uncertainty (Knopf et al, 2018).

The main factor behind the sudden price increase since 2021/2022 were higher gas prices, accelerated by extreme weather conditions in Europe, and further aggravated in 2022 by the Russian war in Ukraine. This encouraged electricity producers to switch to more CO2-intensive coal-fired power generation. Policy played a role as well, though - in particular, the announcement of the “Fit for 55” legislative package, and ETS reforms limiting more strongly the future supply of allowances (ECB, 2022).

Carbon prices under the EU ETS have risen to around 80 € per ton of CO_2 as of January 2025. However, the EU ETS market has shown high price volatility in recent years: in 2024 alone, prices fluctuated between highs of around 80 € and lows of around 50 € (Statista, 2025). A highly volatile market, where periods of strong price growth are followed by periods of sharp price declines, poses as much risk to successful decarbonization as a long-term low price, because this unpredictability creates significant uncertainty for market participants who lack a reliable basis for planning and calculating investment strategies necessary for the long-term transition to a low-carbon system (EY, 2023).

Potential adverse distributional impacts of effective carbon prices

Carbon prices that are high enough to be effective in reducing emissions come with the challenge of adverse distributional impacts on vulnerable households and small businesses as they tend to put a disproportionately high burden on them. Acemoglu et al. (2016) find that relying only on carbon pricing in the absence of subsidies leads to significant welfare costs.

Studies show that costs imposed by the EU ETS are almost fully passed through to consumers in the form of higher electricity prices (Mayer et al, 2021). Poor households spend a larger share of their budget on carbon-intensive necessities, such as food or fuels for heating and cooking, and are consequently more heavily affected by high carbon prices (Linden et al, 2024). In addition, structural challenges put low-income households at a disadvantage: for instance, they are more likely to live in badly insulated buildings which require several times the amount of heat per square metre compared to the best-performing buildings. To avoid adverse socioeconomic consequences, it is usually advised to recycle revenues from carbon taxes or emissions trading for compensating households, e.g., in the form of cash transfers. In practice, the difficulty of designing compensation schemes is to tackle distributional issues effectively without undermining the desired incentives and thus reduce the climate effectiveness (Grubb et al 2023).

On the supranational level, an EU-wide carbon price can be problematic due to the existing wealth disparity between the different EU states and regions. Inter-country differences lead to an overall regressive effect at the EU level (Feindt et al, 2021). This is currently addressed by transferring a certain percentage of the auction revenues to less wealthy member states, and the EU Just Transition Mechanism provides additional funds for the regions and sectors most seriously affected.

It is sometimes argued that carbon pricing tends to be regressive only in developed economies, as opposed to low-income countries because access to energy and car ownership are limited in the latter. However, universal access to energy is a major policy goal of developing economies and the international community, and moving towards this desirable development is bound to worsen the distributional impacts of carbon pricing (IMF, 2021).

Limited political feasibility due to vested interests and weak social acceptance

Policy initiatives that aim to implement or strengthen carbon pricing instruments often face major political economy constraints due to public opposition from industry associations, labor unions, and voters. This can hinder the policy making process by preventing or delaying the implementation of effective prices, or of any pricing schemes in the first place.

As a result, the use of carbon pricing has remained very constrained on a global basis, even after three decades of economic advocacy (Grubb et al 2023). This opposition to climate-effective carbon prices is driven, on the one hand, by the fear of negative distributional impacts mentioned above - a prominent example of which was the Yellow Vest protest movement of 2018 against a proposed fuel tax increase by the French government. On the other hand, businesses and workers in carbon-intensive sectors have vested interests in maintaining the status quo.

The role of carbon pricing in current European climate policy

As mentioned in the introduction, the EU has a diverse climate policy mix, but with a strong focus on carbon pricing. The European Emissions Trading System (EU ETS) was introduced in 2005 and has remained a core element of the EU's climate policy mix since - reflecting the predominance of the price-centred approach in the European policy debate.

The system was further strengthened under the European Green Deal in 2020 and the 'Fit for 55' legislative package designed to achieve the EU's 2030 climate targets. Reforms include both an expansion in scope as well as measures to achieve a more significant reduction of emission allowances in the future. The existing emissions trading system (EU-ETS 1) – which initially only covered energy production and some energy-intensive industries – is expanded to include maritime shipping, and a new, additional trading system (ETS-2) that will cover buildings, road transport, and small industry. At the same time, the cap is being adjusted by increasing the annual rate at which allowances are reduced, while also phasing out the free allocation of allowances in certain sectors. In addition, a Carbon Border Adjustment Mechanism (CBAM) will tax the carbon-content of emission-intensive imports.

3. A POSITIVE APPROACH TO CLIMATE POLICY

More recently, a different approach to climate policy has been gaining ground, which assigns the state a leading role in actively building up a low-carbon economy. This approach addresses a variety of market failures beyond externalities that come with the complex challenge of decarbonising the economy, e.g., capital market imperfections, path dependency, and monopoly power. In terms of policy instruments, it emphasizes the use of positive instead of negative market incentives, as well as public funding of necessary infrastructure changes. It further rejects the idea that climate action implies a sacrifice of current living standards, but instead focuses on creating synergies between tackling GHG emissions and addressing issues of economic competitiveness and social justice (Meckling et al, 2022; Mason, 2022; Krebs, 2023; Grubb et al, 2024).

The concept of Modern Climate Policy
Krebs (2023) frames this new approach to climate policy as **'Modern climate policy'** which he conceptualizes as "a set of policies and institutions that support the transformation process to a green and just economy […] while maintaining prosperity", thus generating green and inclusive economic growth. This includes:

1) **An expansion of public investment in:**
    - **Innovative companies:** subsidies for private investments in green technologies, providing incentives to transform the privately held physical capital stock of the economy (a prominent example being the Inflation Reduction Act policies)
    - **People:** Subsidies and other support for re-training workers to help them acquire the skills needed in newly emerging green jobs.
    - **Green infrastructure:** public investment in green infrastructure, transforming the public capital stock of the economy
2) **The creation of pro-worker green institutions** that ensure a level playing field against the background of concentrated market power:
    - **Pro-worker institutions and instruments** such as union coverage, workers' councils, co-determination, a minimum wage and making labour standards a condition in public procurement
    - **Public companies driving green infrastructure investment** to make sure that investment decisions are aligned with public interests (Krebs, 2023).

Underlying vision: decarbonization as an economic opportunity
One of the main differences between this approach and the traditional price-centred strategy is their different underlying basic assumptions: based on an understanding of the economy as the allocation of scarce means between alternative ends, market-liberal climate economists assume that there must be a trade-off between reducing climate emissions and maintaining levels of consumption. Consequently, they emphasize the opportunity costs of decarbonizing the economy – with the conclusion that emission reduction measures are bound to reduce current living standards.
By contrast, the new approach stresses that decarbonization is likely to be experienced as an economic boom and has the potential to raise the wealth of our society (Lonergan/Sawers, 2022; Mason, 2022). Given the complexity of economic processes, potential economic output is not restricted to fixed levels at any given time but remains open-ended and is likely to increase through a big influx of new spending (Mason, 2022). While owners of carbon-intensive assets will experience losses due to the transformation to a low-carbon economy, this only affects a very small group of people given the concentrated ownership of these assets. By contrast, returns on most of the massive investments involved in the transformation are bound to exceed funding costs, which in turn creates new assets and jobs (Lonergan/Sawers, 2022).

Using positive incentives to mobilize capital towards low-carbon alternatives
Positive incentives function as a lever to mobilize capital towards the low-carbon energy transition. The scope of public support is broadened beyond the conventional focus on R&D towards the targeted support of clean technology deployment, including manufacturing and adoption of technologies, and even the reskilling of workers in newly emerging green sectors. New empirical evidence on what has driven progress to date in the low-carbon transition shows, in fact, that a common denominator of outstanding successes in clean technology diffusion has been policies targeting investment towards new technologies, e.g., through subsidies, cheap finance, or bulk public procurement. A prominent example is the success story of solar PV, which developed from being uneconomically costly and

sparsely deployed in 2005 to emerging as the cheapest source of electricity and largest global renewable energy resource by 2020 - with deployment being ten times the volume projected 15 years earlier. This was made possible through a combination of support policies around the globe, spanning early R&D support in the US and Australia, targeted investment in Japan which supported the early development of supply chains, German feed-in tariffs facilitating large-scale developments, and government deployment policies in China which allowed for massive costs reductions through scaling of production, international trade and investment (Grubb et al 2024).

Providing public infrastructure investment for a low-carbon economy

A second major pillar in terms of policy instruments is public financing of the expansion and transformation of necessary infrastructure for the switch to low-carbon technologies. This might include, for example, an expansion of the electricity grid, energy storage systems, and EV charging grids, or setting up a pipeline system for green hydrogen. Building these new infrastructure systems requires massive investments. The state can either strengthen infrastructure companies' financial capacity through direct participation or government ownership in companies, or finance infrastructure changes with public funds. Krebs (2023) emphasizes the importance of public companies driving green infrastructure investment to make sure that investment decisions are aligned with public interests. Since transport infrastructure often constitutes a natural monopoly, public ownership can help address the market failures associated with private monopolies (Krebs, 2023).

Leveraging the dynamics of technology diffusion to reduce high initial costs and uncertainty

Deep decarbonisation involves competition between investment in low-carbon versus carbon-intensive ways of production. At first, however, new technologies are expensive, and thus less competitive. Traditional cost-benefit analysis tends to favour ‘current least-cost’ options. But new technologies that require high capital investments today may have much greater potential to reduce emissions in the future. This time lag between investment and benefits further down the line makes it less attractive for the private sector to invest, as can be observed, for instance, in hard-to-abate sectors such as aluminium, cement, and steel. In addition, carbon-intensive technologies have accumulated a larger knowledge stock over time, which makes investments in them more profitable and reinforces path dependencies. While conventional economists are sceptical about governments ‘picking winners’ through targeted public investment, this is key to driving down the costs of clean technologies and overcoming path dependencies (Meckling et al, 2022).

The success of targeted investment and support policies can be explained by their ability to directly stimulate ‘feedbacks’, i.e., dynamic developments that are mutually reinforcing and create a self-amplifying effect in the diffusion of new technologies. Stimulating such dynamics is especially important in the early phases of the green transition (Grubb et al, 2024). These ‘feedbacks’ include:

- **learning-by-doing** (experience leads to better technologies);
- **economies-of-scale** (expanded production and delivery systems make it cheaper);
- the emergence of **complementary technologies** (growing use stimulates development of other technologies that make it more useful, more widely);
- and the **reinforcing dynamic between rising investment, falling cost, growing confidence**, **and growing demand**.

Overcoming political economy constraints, and facilitating policy sequencing

Investment-based climate policies have so far been much more successful in mobilizing political support than price-based policies. Consequently, they are already the most widely adopted form of low-carbon policy (together with standards), despite still being considered a costly second-best policy by many economists (Meckling et al, 2017).

These policies have the potential to avoid or overcome political economy constraints by linking climate policy to other, socioeconomic, policy goals, such as energy security. What is more, ‘picking winners' through targeted investment also shifts the balance of power from polluters to the beneficiaries in decarbonization, which helps to build political support for the further strengthening of climate policy in the future (Meckling et al, 2022).

4. IRA CLIMATE SPENDING: AN OVERVIEW

Context and policy goals

After the failed attempt to introduce an economy-wide emissions trading system in 2009, and climate policy coming to a near standstill during Trump's last presidential term, Biden's Inflation Reduction Act (IRA) of 2022 represents the most ambitious climate legislation passed in the United States to date. The bill combined the policy objectives of building a clean energy economy, ensuring energy security and affordability, and creating good jobs. It was designed to make a major contribution to achieving the US emissions reduction goal of 50 per cent below 2005 levels by 2030 (equalling a 40 per cent reduction below 1990 levels, to make it comparable to the EU's climate goal).

There are synergies between the IRA and other major US public investment policies passed in 2021 and 2022, namely the Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law, and the CHIPS Act. The former included significant investment in clean energy technologies and electric grid renewal, EV charging infrastructure, and modernization of public transit. The latter authorized over 100 billion USD in public spending to boost domestic research and manufacturing of semiconductors in the United States, which renewable energy systems heavily rely on to convert and manage power.

Climate-related IRA spending by sector

When the IRA was introduced, its lion's share - 394 billion USD[3] in public spending over ten years - was earmarked for energy- and climate-related purposes. These incentives span the entire value chain of the energy sector, from producers of raw materials to end-use consumers. They also include different stages of technology readiness, from advancing climate tech innovations, and scaling mature technologies to incentivizing deployment of clean energy supply and reducing cost of green financing. Funding instruments include production and investment tax credits, grants, loans, and blended finance elements. Given that uncapped tax credits make up the largest share of earmarked spending by far, the level of public spending for these climate-related provisions is not limited, and has since been recalculated to reach about 730 billion USD.

Figure 1 categorizes allocated IRA spending by sector, highlighting the extent to which different sectors benefit. The biggest portion of the initially designated amount, over 160 billion USD, was allocated to clean electricity production and storage. This included over 50 billion USD of tax credits for the production of electricity from renewable resources (awarded per MWh) and the same amount for investment tax credits in clean electricity generation or storage facilities (awarded as a percentage of investment costs). 30 billion USD were designated for nuclear energy production.

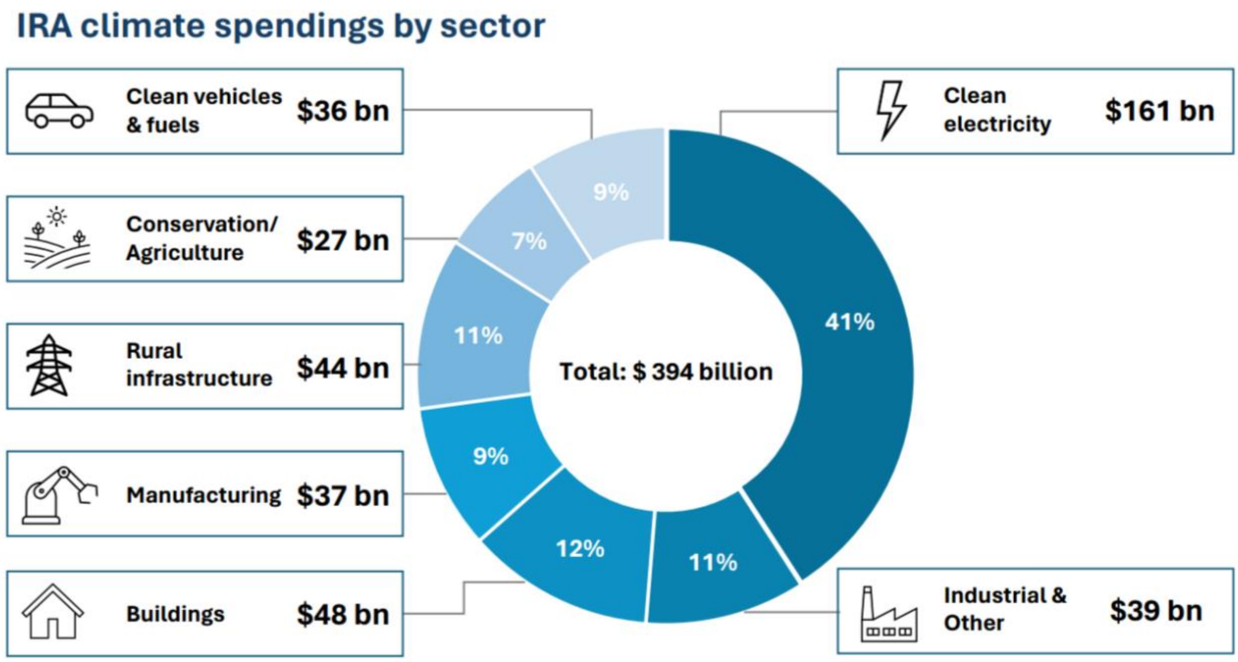
37 billion USD in tax credits were allocated to manufacturing, supporting both investments in clean energy manufacturing facilities, and the production of components for wind, solar, and batteries (awarded per unit of production). A similar amount, 36 billion USD, was designated for the transport sector, including consumer and commercial tax credits for the purchase of clean energy vehicles, and production tax credits for clean hydrogen and other alternative fuels. The transport sector also benefits from the manufacturing subsidies listed above, with a significant share dedicated to battery cell production.

With regard to buildings, the bulk of spending targeted homeowners with approximately 37 billion USD in tax credits for residential energy efficiency, electrification, and decentralized clean energy

[3] Due to higher-than-expected uptake of IRA tax credits, the Joint Committee on Taxation (JCT) and Congressional Budget Office (CBO) have since updated their estimate on the IRA's climate-related spending to about 730 billion USD.

solutions. This category also included 10 billion USD in direct expenditures on energy efficiency programs, such as retrofit programs. The rural infrastructure category was allocated around 17 billion USD in energy loans for rural electric cooperatives and the replacement of emissions-intensive energy infrastructure, along with a 27 billion USD Greenhouse Gas Reduction Fund to provide low-cost financing for clean energy infrastructure projects, especially in low-income and disadvantaged communities.
Funding dedicated to agricultural and forestry conservation programs amounted to 27 billion USD, primarily channelled through existing conservation programs; emissions-intensive industries were supported through a 5 billion USD program for industrial emissions reduction projects and 3 billion USD in production tax credits for carbon capture and sequestration. The industrial sector may also benefit from the clean hydrogen tax credits mentioned above (NPUC, 2023; Credit Suisse, 2022; Bistline et al, 2023 a; Maye/Mazewski, 2023).

Figure 1



Source: own illustration based on NPUC, 2023; Credit Suisse, 2022; Bistline et al, 2023 a; Maye/Mazewski, 2023

Key features of IRA tax credits

More than two thirds of the climate-related provisions were designed as production and investment tax credits. What is remarkable about the design of these tax incentives is that they a) use conditional bonuses to leverage the investments for complementary policy objectives, b) have features that make them extraordinarily easy to access, even for small companies and nonprofits, and c) are mostly uncapped, providing maximum flexibility.

First, almost all the credits include conditional bonuses for projects that meet certain labour requirements, use domestic content, and/or are located in communities that are most affected by the energy transition. In fact, IRA tax credits can be up to 50 per cent higher for projects that meet these conditions.
The largest bonus benefits projects that support the creation of decent jobs and the training of workers: tax credits for renewable energy projects, for example, increase fivefold, if requirements on prevailing wages and apprenticeships are met, raising them from a base of 5 USD/ MWh to a level of 27.5 USD/ MWh (Bistline et al, 2023 a).

The energy communities bonus has supported areas where income has been dependent on fossil fuels in the past, to avoid or mitigate any negative socioeconomic impacts of the clean energy transition. If the project is located on a brownfield site, in an area with a certain share of employment and tax revenue from fossil fuels, or in a community with closed coal mines or power plants, investment and production tax credits increase by an additional 10 percentage points.
Similarly, the procurement of domestically produced materials, such as steel, is rewarded with a 10 percentage point raise of the tax credit. This bonus also applies to tax credits for individuals who purchase a new electric vehicle if the final assembly of the vehicle takes place in North America, and a share of the critical minerals and battery components come from North America (ibid.).

Second, the IRA has made the tax credits extremely accessible through two features: some of them are direct pay and some of them are transferable.
Direct pay essentially transforms the tax credit into a grant. It enables nonprofits, municipalities, and other tax-exempt organizations, which have historically been unable to claim such credits to directly access them and offset project costs. Eligible organizations can receive a payment that is equal to the tax credit amount for qualifying clean energy technologies or projects.
Transferability mainly benefits smaller businesses: developers with tax bills too small to absorb the credits can transfer them in exchange for cash to an unrelated party who can use them, i.e., whose tax bill is larger than the value of the credits (Bistline et al, 2023 a). This feature has effectively created a new marketplace supporting transactions that help smaller companies working on emissions-reducing technologies gain access to funding. Corporate buyers, such as big corporations with significant tax liability, benefit from these transactions because they can buy these credits at a discounted price: currently major players are paying between 75 and 95 cents on the dollar (The New York Times, 2023).

Third, most IRA tax credits were designed without cap, which provides users with high planning certainty and flexibility. However, the absence of a fixed overall budget for tax credits also means that fiscal expenditure could far exceed initial estimates. What is more, clean energy tax credits expire only after reaching an emissions reduction threshold, potentially extending beyond the 2031 budget window.

IRA measures to achieve cost neutrality
To offset this spending, the IRA introduced several measures aiming to increase government revenues, including a 15 per cent minimum tax on large corporations, increased enforcement of tax compliance, and a prescription drug pricing reform designed to lower healthcare costs. At the time of the introduction of the IRA, the Congressional Budget Office (CBO) estimated that the newly generated revenues would not just offset the bill's costs but reduce budget deficits over its 10-year period.

5. IRA EFFECTS ON PRIVATE CLEANTECH INVESTMENT AND PROJECTED EMISSIONS REDUCTION – A PRELIMINARY EVALUATION

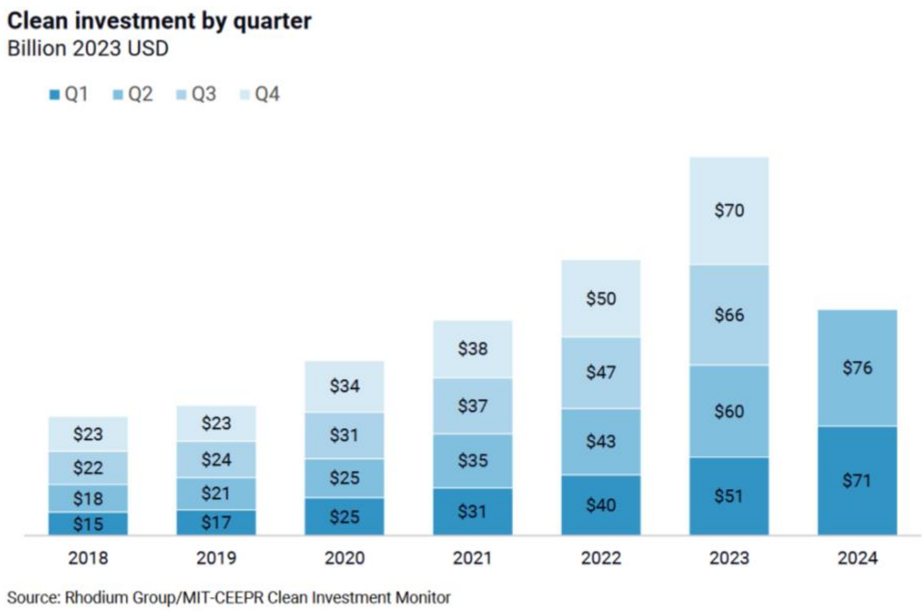
It is too early to examine the full impact of the IRA, especially on GHG emission reductions, but a look at cleantech investment trends during the two years since the bill's enactment allows for an assessment of its preliminary effects. A number of investment trackers were specifically developed to monitor the IRA's impact on private investment. The findings presented below draw on analyses by the Clean Investment Monitor (CIM), a joint project of Rhodium Group and MIT's Center for Energy and Environmental Policy Research, which developed a comprehensive database of private and public investments in clean technologies eligible for tax incentives under the IRA.

Overall investment effects after two years of the IRA

The analysis of investment developments over time reveals a significant effect thus far: by mid-2024, actual private investment in cleantech increased by 71 per cent since mid-2022, compared to investment during the two years preceding the law, reaching a total of 493 billion USD.[4] CIM provides a breakdown of investments by quarter that shows this development on a more granular level (see Figure 2).

The catalytic impact of public funding on private capital flows has been significant as well: For every dollar of the Federal Government's 78 billion USD spending, private investment was five to six times higher. A comparison with overall domestic investment trends further illustrates the momentum created: clean investment has accounted for more than half of the total growth of US private investment in structures, equipment, and durable consumer goods during that period (Bermel et al, 2024).

Figure 2



Investments by segments and subsectors

A more detailed breakdown reveals which subsectors have benefitted the most so far from the boom. CIM categorizes investments into three segments:

(1) Manufacturing, i.e., investment in the facilities and equipment used to manufacture emission-reducing technology;
(2) Energy & Industry, i.e., investment in the deployment of that technology, both to produce clean energy or decarbonize industrial production; and
(3) Retail, i.e., the purchase and installation of that technology by individual households and businesses.

Manufacturing: Actual investment in the manufacturing segment experienced the fastest growth: from 22 billion USD in the two years prior to the IRA's enactment, it more than quadrupled to 89 billion USD in the two following years. Battery manufacturing received the largest share of this

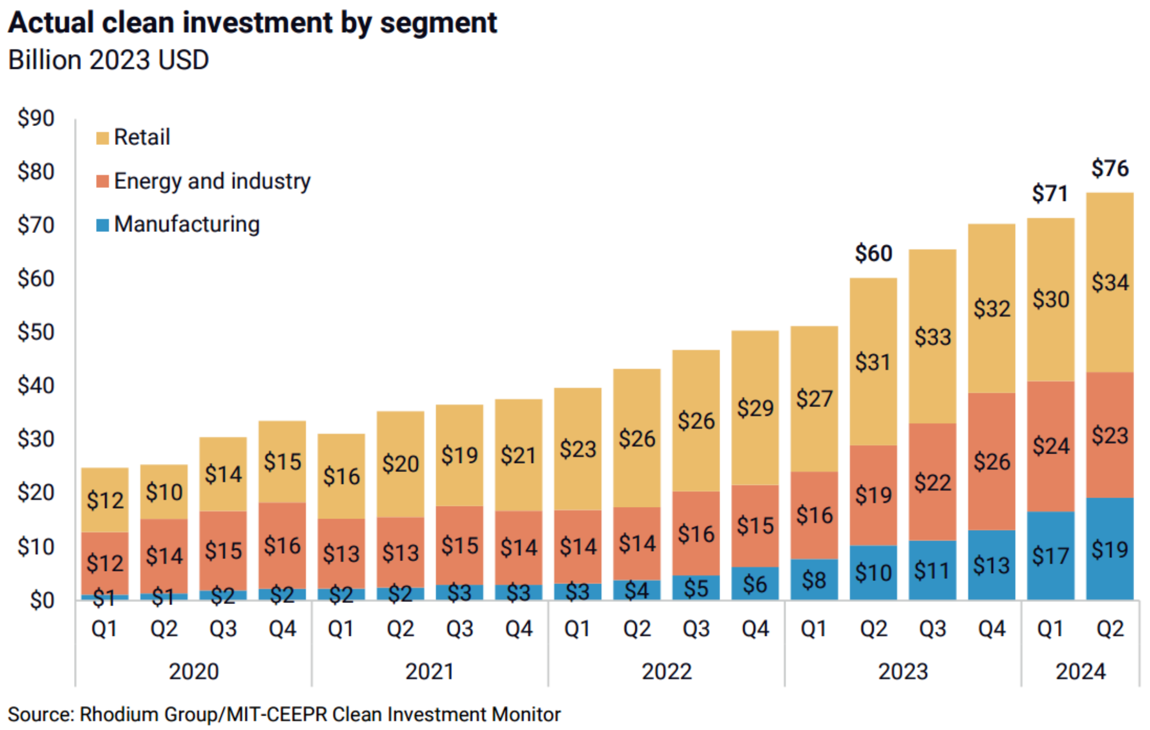
[4] CIM synthesizes the data on a quarterly basis, and compared the period between July 1 - June 30, 2024, to the prior 24-month period.

investment, about 65 per cent. Investment announcements in manufacturing increased to more than 133 billion USD – with massive increases of up to 700 per cent for manufacturing of components for solar energy, electrolysers, and wind energy (Bermel et al, 2024).

Energy & Industry: Investments in clean energy production and industrial decarbonization reached 161 billion USD - 43 per cent more than in the preceding two years. Investments in solar energy (at 71 billion USD) and energy storage (at 37 billion USD) account for the largest shares. While investment in emerging climate technologies, such as carbon management, clean hydrogen, and sustainable aviation fuels, is still relatively small in comparison - 28 billion USD -, it increased 12-fold compared to the pre-IRA period. Investment announcements in the energy and industry segment amounted to 276 billion USD.

Retail: American households and businesses invested over 242 billion USD in total over the two years in purchases of zero-emission vehicles, heat pumps, residential or commercial solar systems, fuel cells, and storage systems. This is a 58 per cent increase relative to the previous two-year period. 65 per cent of all investment in this segment is attributed to the purchase of zero-emission vehicles, which nearly doubled from pre-IRA investment.

Figure 3
US cleantech investments by quarter and segments 2020 - 2024

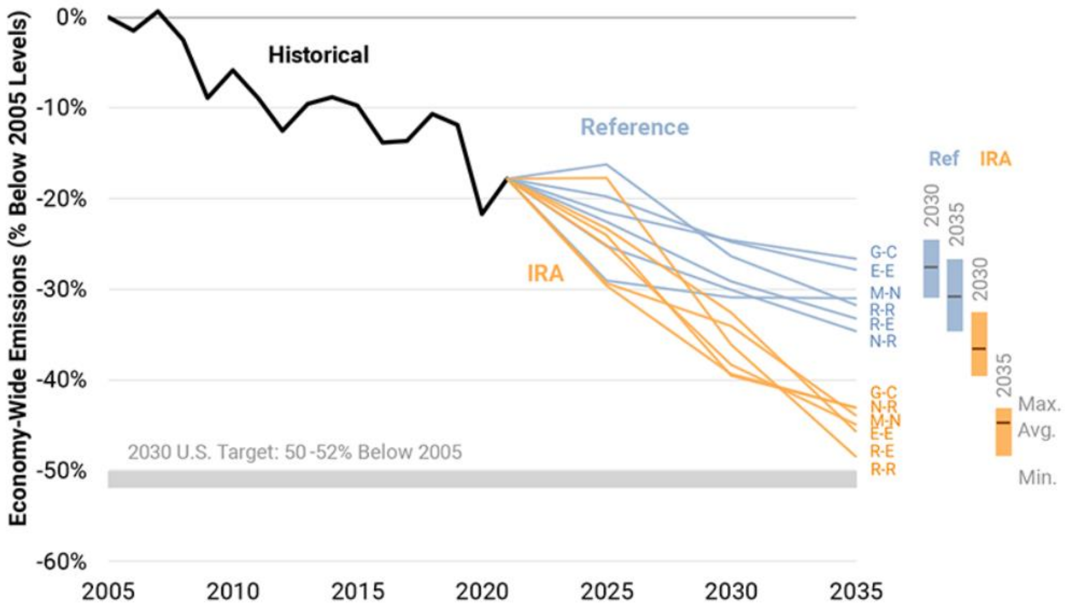


Projected impact on GHG emission reduction
After the IRA was released, different research teams modelled its potential impact on future GHG reductions and came to a wide range of estimates, due to differences in model structure, data input, and assumptions. To increase the robustness of these results, Bistline et al (2023 b) compared the commonalities among a broad set of different studies.

Leveraging results from nine independent models, they find that the IRA has put the U.S. on track to reduce emissions by 33–40 per cent below 2005 levels by 2030[5] - driven by dramatic decreases in emissions in the power sector, which range between 47 and 83 per cent in the same period. While this would still fall short of the US climate goal of 50 per cent reduction by 2030, it significantly narrows the gap. According to Bistline et al (2023 b), the IRA makes a difference of 8.5 percentage points compared to a reference scenario without the IRA, where reduction is only 25-31 per cent by 2030. Projected emission reduction effects from the IRA also grow significantly over time and increase to 43-48 per cent below 2005 levels by 2035.

Figure 4

Historical and projected U.S. GHG emissions under IRA and reference scenarios from 2005 levels



Source: Bistline et al, 2023b

Projected macroeconomic implications

Evaluating the effectiveness of a climate policy that mainly relies on positive incentives also depends on the macroeconomic impact of such a policy, as well as on the overall fiscal costs. Similar to emission reduction impacts, it is too early for a final empirical assessment of the macroeconomic effects of the IRA. However, various studies have modelled the bill's potential effects on GDP, inflation, employment, and the federal budget.

With respect to GDP development and inflation, by and large, the literature expects the IRA to have only a marginal impact: a literature review shows that across studies, real GDP is expected to increase by around 0.1 percent over ten years due to the IRA, and the national Consumer Price Index is expected to decrease by 0.33 percent by then (Voigts and Paret, 2024).

Bistline et al (2023a) suggest that IRA subsidies might initially raise interest rates and thus slightly increase debt-servicing costs. While this would affect the debt-to-GDP ratio, the effect would be mitigated by higher output over time. IMF modelling on debt effects of green subsidies shows that in

[5] This roughly converts to 21 -29 percent below 1990 levels, based on historic US emissions (White House, 2021).

advanced economies, subsidies that are in the range of the IRA's energy-related provisions would, on balance, increase the debt-to-GDP ratio by 10–15 percentage points by 2050, with the primary deficit rising moderately, by 0.4 per cent of GDP a year (Garcia-Macia et al, 2024). At the same time, the IRA subsidies are raising the capital stock through massively increased asset creation in the clean energy sector.

Regarding employment effects, modelling by Maye and Mazewski (2023) predicts that the climate and energy provisions could be responsible for an average of around 1 million jobs created or preserved from 2023 to 2032.

With regard to the fiscal side, it is crucial to estimate both the costs for the government linked to tax credits and public investment on the one hand, and the fiscal revenue stemming from the IRA's cost neutrality provisions on the other hand. When balancing costs and revenues against each other, the IRA was designed to have a positive net impact on the federal budget.

Revenue-generating measures included minimum taxes on large corporations, a 1% excise tax on stock buybacks, improved tax law enforcement, and a prescription drug pricing reform. At the time of the introduction of the IRA, the CBO estimated that, over ten years, these measures would bring in about 737 billion USD and would thus not just offset the bill's costs but, on net, reduce budget deficits by 237 billion USD in total.

In the meantime, both cost estimates and revenue estimates have been updated. Official cost estimates for the IRA's climate-related provisions were revised from 390 billion USD to about 730 billion USD in 2024 to take into account the greater-than-expected uptake of tax credits (as of October 2024; Centre for American Progress, 2024).[6] While new revenues from improved tax compliance under IRA regulations were assumed to be significantly higher than expected as well, estimates of the IRA's net impact on the federal budget now vary widely depending on the source - from it still reducing the federal deficit by about 175 billion USD (Centre for American Progress, 2024) to it being roughly deficit neutral over the decade, or increasing the deficit in the longer term (Committee for a Responsible Federal Budget, 2024).

It is yet unclear how the new Trump administration's efforts to roll back IRA regulations will affect the fiscal impact of the bill. Some of the executive orders signed by President Trump in January 2025 affect the IRA's revenue-generating regulations - e.g., the decision to cut funding for the Internal Revenue Service, the U.S. government agency responsible for tax collection, is likely to reverse improvements in tax law enforcement.

Estimates on cost-effectiveness based on abatement cost projections

A useful comparison to gain an understanding of a policy's cost-effectiveness is between its emissions abatement costs and the social cost of carbon. Abatement costs are the costs of an intervention that will reduce emissions by one tonne; when applied to a policy, they refer to the costs of measures incentivized, not to the policy's fiscal costs. The social cost of carbon is the discounted value of economic damages from emitting one ton of CO2 today, and therefore a key factor in climate cost-benefit analyses. Bistline et al (2023a) found that measures incentivized by the IRA reduce carbon emissions at an average abatement cost of 45-61 USD/ ton CO2 in the power sector – which is considerably less than recent estimates of the social cost of carbon of around 200 USD/ ton CO2 (EPA, 2022).

Marginal abatement cost estimates are often also used to identify the lowest-cost opportunities to reduce emissions. However, this approach was designed for marginal emission reductions (e.g., a 15 percent reduction) with a focus on short-term cost savings. In contrast, the international climate

[6] Some studies even expect the spendings on climate-related provisions to reach 900 billion USD in total, including 780 billion USD in tax credits and 121 billion USD fixed costs for direct expenditures (Credit Suisse, 2022; Bistline et al, 2023 a).

objective is to reduce emissions to net zero within a few decades. The challenge is thus not to concentrate on the lowest-cost opportunities first, but to avoid all emissions at the lowest *total* cost possible until carbon neutrality is reached.

Some mitigation measures that appear expensive in the short term may turn out to be low-cost approaches in the long term because they induce innovation and accelerate radical changes in modes of production, while some measures that appear economical in the short term, especially incremental improvements, can unintentionally cause inefficiencies by locking in carbon-intensive technologies. In fact, modelling by the World Bank found that an emissions abatement strategy designed for optimal total costs until 2050 starts by implementing the most expensive option before the cheapest (Vogt-Schilb and Hallegatte, 2013).

Modelling by Bistline et al (2023a) applies the marginal abatement cost comparison to the IRA and simulates a comparison between IRA incentives and a hypothetical scenario with carbon pricing in the US power sector as an alternative climate policy until 2035. The latter scenario assumes that one of the main changes induced by carbon pricing would be switching from coal to gas in electricity generation (natural gas, while still a fossil fuel, produces about 50-60 percent less CO2 than coal). As the costs for this switch are low and incremental - the necessary infrastructure is already in place or can be adapted easily - the average abatement costs in this scenario are estimated to be only around a fifth of those linked to the IRA (around 10 USD /ton of CO2 versus 45-61 USD/ ton CO2 for IRA incentives) (Bistline et al 2023a). This would, however, mean that a large share of power generation would still rely on fossil sources by 2035 and further, expensive measures would still be required to decarbonize the economy.

As shown above, prioritizing measures and policies based solely on their marginal abatement costs is inappropriate for finding the most cost-efficient way to achieve carbon neutrality (World Bank, 2023). Instead, long-term decarbonization strategies are needed, which seek to minimise the total cost of the transition.

Overall, these estimates and projections show that the costs for taxpayers linked to the IRA policy package are most likely close to neutral thanks to its revenue measures counterbalancing costs, and the policy might even add to the federal budget. On a societal level, the benefits outweigh the costs by far as the comparison of IRA abatement costs with the social costs of carbon indicates. Other macroeconomic impacts, such as GDP and inflation development are predicted to be close to neutral, and employment effects are estimated to be positive.

Challenging positive incentive policies by comparing them to the short-term marginal abatement costs of carbon pricing policies overlooks the bigger picture of achieving cost-efficient decarbonization in the long run.

Discussing its early effects in view of the IRA's potential for becoming a role model

The cleantech investment boom of the past two years and projected US emission reductions described above seem to suggest a high effectiveness of the IRA.

However, they do not yet prove that this approach is superior or ready to serve as a role model compared to the more conventional European strategy centred on carbon pricing. First, more official data is needed to either confirm or challenge the impact estimates made so far. Second, trends must be monitored closely in the near future to verify their sustainability and ensure the effects are not merely transitory. If the effects are short-lived, the initial efforts (and associated costs) might not be justified by the results. In the same vein, the potential of the new US climate policy to serve as a role model will hinge on its actual cost-effectiveness.

A comparison of the IRA's effects with more conventional European climate policies might also be distorted by baseline differences between the U.S. and the EU. Given that the US has lagged in GHG emission reduction and the development of various clean energy sectors over the past years – in comparison with the EU and China - the strong current momentum may be attributed to the fact that the U.S. is playing catch-up. The current lack of such momentum in the EU might, in turn, be due to the fact that markets are already in a more developed stage. In the electric vehicles sector, for instance, new electric car registrations in the EU reached 22 per cent of total car sales in 2023, while this share was still at 10 per cent in the United States in the same year. Similarly, when looking at total private investments in clean energy, the EU has a higher annual level of total investments than the US – although it is currently plateauing.

Nevertheless, these different starting positions can only partially explain the strong dynamic that we have seen in the US, which would indicate that even in a more advanced stage of the transition towards clean energy, these instruments might be more impactful than carbon pricing, given that they have the potential to foster innovation and avoid socio-economic backlashes. A critical contribution of the IRA seems to be the swift pace with which it is allowing the US to catch up in these sectors. For instance, while still lower than in the EU, EV car sales increased by more than 40 per cent compared to 2022 in the US.

*

As an interim conclusion, the evidence so far clearly indicates that IRA incentives have greatly accelerated private investment in clean energy, accompanied by a boom in EV sales and increased employment in the US. It will be important to monitor current trends and take into account new data to confirm the sustainability of the IRA's positive impact.

Whether positive incentives can be a more effective climate policy strategy than carbon pricing also depends on their ability to overcome the limitations of carbon pricing – such as its limited influence on behavioral change, weak leverage on disruptive innovation and infrastructure investment, price volatility, potential adverse distributional effects, and political feasibility challenges (see page 4). Preliminary impacts of the IRA suggest that it has been effective in addressing some of these challenges:

The rapid increase in EV sales, for instance, highlights the IRA's success in driving behavioral change by making low-carbon alternatives more attractive. The incentives have mobilized substantial private capital for innovation and clean energy infrastructure. Moreover, since IRA tax credits lower electricity prices and are accessible to small businesses and nonprofits, they have not created any negative distributional effects. While IRA incentives avoid the short-term uncertainty associated with volatile carbon prices, they face a different challenge: political uncertainty due to the new Trump administration's efforts to reverse the policy. Lastly, social acceptance of IRA measures has been high, as they have benefited a broad range of regions and stakeholders.

Ultimately, a comparison of both policy approaches must also consider their respective cost-effectiveness. The estimates cited show that both the IRA and a hypothetical carbon pricing policy would incentivize emission reduction at a lower cost than the social cost of carbon. As argued above, economists often compare short-term marginal abatement costs to assess the cost-effectiveness of policies. However, this approach is misleading since it cannot determine whether a policy enables long-term, cost-effective decarbonization. Identifying policy packages and sequences that allow for the lowest total cost in the long run requires a more holistic and context-specific analysis of decarbonization pathways.

6. IN COMPARISON: PUBLIC SPENDING ON CLEAN ENERGY IN EUROPE AND THE EU'S RESPONSE TO THE IRA

Despite the emphasis on emissions trading as a key mechanism, climate policy in the EU and European countries has been more nuanced. In the past, there have been various examples of clean energy subsidies and green stimulus packages. Feed-in tariffs, for example, have historically been a critical policy instrument across Europe for promoting renewable energy, especially from the late 1990s through the early 2010s. They offered guaranteed payment rates to producers of renewable energy, which significantly lowered the financial risk for investors and spurred rapid growth in renewable installations across Europe. Germany was an early adopter of this policy approach: it introduced the 'Electricity Feed-in Act' in 1991, which mandated utilities to purchase renewable energy at fixed rates, and further expanded this system through the 'Renewable Energy Sources Act' (EEG) in 2000, which led to massive growth in the solar and wind sectors. Similar policies were launched in Spain, Italy, France, and the UK during the 2000s decade.

Similarly, the EU's 2009 green stimulus, as part of the economic recovery package after the global financial crisis, allocated around 22 billion € towards renewable energy, energy efficiency, and clean technology, and the EU's 2020 COVID-19 recovery package allocated a substantial portion of its budget to green investments.

Current EU clean energy funding scattered across various programmes

While the EU currently offers substantial public spending on clean technologies and infrastructure as well, the funding framework is much less targeted. Funding is scattered across different programmes because it was built up by mainstreaming climate investment into financial instruments created for other purposes.

A major, albeit temporary, funding source over the last years has been the Recovery and Resilience Facility (RRF), which was originally established in 2021 to provide a total of 750 billion € in loans for economic recovery purposes during and after Covid. 225-300 billion € of unused EU loans from this fund are currently used as EU grants to support the decarbonisation of energy systems under the REPowerEU Plan which sets the EU's renewable energy target to 45 per cent by 2030. However, the RRF as a funding source will expire at the end of 2026.

Another big portion, around 67 billion €, comes from the climate mainstreaming into the 2021–27 budget for the Regional Development Fund and the Cohesion Fund. Both aim at reducing economic and social disparity between the EU's regions and different Member States. At least 30 per cent of the 200 billion € Regional Development Fund and 37 per cent of the 43 billion € Cohesion Fund are earmarked to support the clean energy transition in these regions and countries.

EU ETS revenues are financing a number of different funds, namely the Innovation Fund, the Modernisation Fund, and the Social Climate Fund: The Innovation Fund provides 38 billion € in subsidies over ten years (2020-2030) for cutting-edge climate technologies. The Modernisation Fund, which amounts to €14 billion in 2021-2030, depending on the carbon price, will support the investment in renewable energy production and storage, energy efficiency, modernisation of energy networks, and the just transition of 13 lower-income EU countries. Finally, the Social Climate Fund will provide 65 billion € over the period 2026-2032 to buffer the potential social impacts of the introduction of ETS2 in 2027.

Finally, the EU has established the Just Transition Fund, with a budget of 17.5 billion € for the 2021-2027 period, which aims at supporting regions and sectors particularly dependent on fossil fuels or carbon-intensive processes, to transition to a more sustainable economy. Another instrument is the 26 billion € InvestEU Fund (including €11 billion in guarantees from the EU budget) which aims to mobilize additional private investments in sustainable infrastructure and R&D (Norton Rose Fulbright, 2024; Oberthür and Homeyer, 2023).

EU responses to the IRA

In response to the IRA, and as part of its Green Deal Industrial Plan, the EU adopted the Net-zero Industry Act (NZIA) in early 2024, which mirrors the IRA's focus on domestic manufacturing in the clean tech sector and aims to reclaim or maintain EU competitive advantages in clean tech manufacturing. The Act defines 19 strategic net-zero technologies whose manufacturing should be supported by the EU. Similarly to the focus of the IRA, these are more mature, tried-and-tested technologies, e.g., solar PV, electrolyzers and clean hydrogen, batteries, heat pumps, etc. It also includes a preference for EU-manufactured technology in national tenders and support schemes. However, since the next EU budget cycle starts only in 2028 and current funds are already allocated, there is very little additional funding on the EU level for the support of these strategic sectors. Instead, the NZIA established the Strategic Technologies for Europe Platform (STEP) that channels funds from existing EU programmes towards the manufacture of strategic clean technologies (Jones, 2024). Given that the EU is currently not able to establish a fund like the IRA, Member States will have to step in to provide support for these sectors. Such funding from any Member States must adhere to the EU State aid rules, and be notified to, and approved by, the European Commission. The NZIA thus needs to be understood side-by-side with a reform of the State aid rules which gives more flexibility to member states in creating investment incentives for key green industries. The new guidelines represent a significant relaxation of the previous approach, allowing aid in the form of sector-specific tax credits, and increasing the thresholds for relatively small amounts of aid that do not need to be notified. They also add a new 'matching aid' category that allows EU Member States to match subsidies offered by non-EU countries (like the U.S.) for companies that invest in critical clean energy sectors. The idea is to keep these investments within the EU and prevent companies from relocating to regions with more attractive subsidies.

Nevertheless, the investment framework for companies investing in Green Deal technologies remains more complex and scattered in the EU than in the US under the IRA. Also, if cleantech subsidies and infrastructure investments rely almost entirely on the availability of national funding, it might further widen the gap between the transition in wealthy versus less wealthy Member States (Agora Energiewende, 2024).

7. DISCUSSION: LESSONS LEARNED SO FAR

What insights can be drawn from the design and early outcomes of the IRA for addressing the big challenges of the green transition? And is this approach transferable to the European context? The lessons learned discussed in this section are largely based on the input of international experts at the Berlin Summit 2024, who debated this topic during the session 'Modern Climate Policy - lessons from the US for Europe'. These lessons do not provide definite conclusions but rather serve as a framework for the exploration of emerging questions.

Lesson 1: Effective climate policy requires a smart combination of different instruments

There is growing consensus that carbon pricing will not generate the necessary momentum for a green transition. The cleantech investment boom triggered by the IRA underscores the role of industrial policy in creating such dynamism. Nevertheless, despite its limitations, carbon pricing might still have a role to play in achieving a low-carbon transition.

Despite the acceleration of the development and deployment of green technologies that the US is currently experiencing, its 2030 emission reduction goal will likely not be met. This raises the question of how the US might create synergies and enhance effectiveness by combining its approach with other policy instruments. As Meckling and Strecker (2023) argue, the 'carrots' of investment need to go hand in hand with regulatory 'sticks'. The public investment approach that we currently see in the US offers an opportunity to advance this through 'green bargains' where governments tie climate requirements to public support policies.

For Europe, a key question is whether adopting the U.S. approach of providing positive incentives is feasible, given that the EU's regulatory and fiscal landscape differs significantly. Offering easily accessible tax credits - a key feature of the IRA's policy design - is limited by the EU's tax framework. This constraint does not negate the limitations of carbon pricing, but it underscores the need for a more tailored European approach when it comes to positive incentives in climate policy.
On the national level, easily accessible tax credits in the style of IRA credits could be more feasible though. For instance, this could be an interesting role model for Germany, where the complexity and bureaucratic hurdles linked to green subsidies have been criticized by companies. It would thus be valuable to assess the practical applicability at multiple levels.
A frequently discussed option for combining different policy instruments is to use them in a sequence where positive incentives are used to create momentum for the development and deployment of clean technologies on a large scale, paving the path for the implementation of carbon pricing at a later stage. This has the advantage that affordable low-carbon alternatives are available at scale when prices for carbon-intensive goods increase, which reduces the pressure of having high carbon prices and thus the risk of adverse social impacts. By building the necessary political support, it also lays the foundation for the introduction of strengthened climate regulations and carbon pricing.
On the other hand, the parallel use of different instruments may provide important synergies. Carbon pricing can play a motivational role in making investments in low-carbon options. An example of using carbon prices in that way would be, for instance, the idea of introducing a contingent carbon tax on profits targeted at companies whose performance consistently falls below industry best practice on emissions (Lonergan and Sawers, 2022).
Empirical analysis shows that, in most cases, effect sizes are larger if a policy instrument is part of a mix rather than implemented alone However, effective policy mixes vary across sectors and between developed and developing countries, considering the distinct challenges, decision-making processes, and relevant stakeholders involved (Stechemesser et al, 2024).

Lesson 2: Positive incentives create a compelling narrative around climate action

One of the most distinct lessons from the current US approach is the importance of a compelling narrative to increase public acceptance of climate policy. In the context of the IRA, climate protection has been framed as an opportunity, which conveys a progressive vision, and increases public acceptance. For instance, despite the deep political divides in the US, the IRA gained the support of unlikely proponents, such as several Republican members of Congress, the U.S. Chamber of Commerce, and thousands of companies, as it successfully tied climate action to economic development and industrial policy (Reuters, 2024).
By contrast, in Europe, the predominant narrative has been that achieving net-zero requires making sacrifices - in line with the traditional climate economics paradigm. As a consequence, climate policy tends to be perceived as a burden. A prominent example of this narrative was evident in the public debate about the German 'Heating Act' of 2023, formally part of the Buildings Energy Act, which aims to encourage the transition to more climate-friendly heating systems. An early draft of the law, which did not yet include any financial support mechanisms, was leaked by Germany's largest tabloid newspaper. This led to significant public concern over potential costs for homeowners, and major public opposition. The final version of the bill introduced a range of subsidies and incentives but was significantly less ambitious than the initial proposal because of the political backlash that the debate had triggered.
A recently emerging narrative, which might be more likely to increase public acceptance, is the framing of climate policy as security policy, i.e., obtaining energy independence from other countries.

Lesson 3: Thriving domestic markets have boosted public acceptance, but international strategies are needed to reconcile domestic priorities with global governance

The IRA contains ample requirements for the use of domestic content in cleantech manufacturing. Apart from geopolitical considerations, this might be a necessary element of a domestic just transition

as it mitigates negative impacts on workers and vulnerable regions. It also helps to create flourishing domestic markets, which boost public acceptance of climate action (Project Syndicate, 2023).
For Europe, the creation of investment opportunities and thriving markets in the context of the clean energy transition is similarly important.
However, the US did not complement its domestic investment incentives with international strategies to allow for positive spillover effects. This might create supply risks and can have significant international repercussions. Prioritizing the use of domestic content can also drive up the cost of production. The question arises of how to avoid non-cooperative protectionism and reconcile domestic goals with global trade governance.

Lesson 4: Public funding should strategically target key sectors for the transformation
On a more granular level, what stands out when looking at the US approach is that public spending via the IRA is very targeted. Despite the new definition of strategic net-zero technologies, the EU's financial strategy for supporting its clean energy sectors lacks clarity in comparison. Given the EU's significant budget constraints, there is a need for climate funding to be much more coordinated and to target sectors that can drive the transformation of hard-to-abate industries, including electrification, energy efficiency, green hydrogen, and Carbon Capture & Storage.

Lesson 5: Buffering the anticipated social impacts of ETS2 will require creative solutions
As mentioned throughout this paper, the EU has decided on the introduction of ETS2 in 2027, which expands the emissions trading system to consumer-facing sectors. The challenge of mitigating the negative social impacts expected to accompany this expansion presents us with the opportunity to explore innovative complementary measures. This links to the question above about smart policy mixes. The EU's announced Social Climate Fund of around 65 billion € is considered by many insufficient to buffer the shock on vulnerable households. What could be promising complementary policies? For instance, apart from climate dividends that would return revenues from emissions trading to poorer households, creating investment windows that specifically benefit low-income and vulnerable households could be an approach to ensuring social cohesion.

8. CONCLUSION

The outline of new economic thinking on climate policy and the summary of the preliminary effects of the IRA provided in this paper aimed to spark a discussion on the extent to which the IRA's focus on positive incentives can serve as a role model for Europe.

Given the limitations of carbon pricing in driving the economic transformation needed for reaching net-zero, its reputation as the 'first best' priority for climate policy needs to be reconsidered. As discussed in Chapter 2, the price-based approach is constrained in its ability to induce behavioural change, foster disruptive innovation, and drive infrastructure investments, due to its history of low or volatile carbon prices, potential negative distributional effects, and political economy challenges. The alternative approach to climate policy that the IRA illustrates, is based on an economic vision that emphasizes the potential synergies between climate action, economic competitiveness and social justice. By leveraging the dynamics of technology diffusion, positive incentive policies and public investment in infrastructure reduce high initial costs and uncertainty – which are key success factors in driving clean technology diffusion. This helps to overcome political economy constraints and facilitates policy sequencing in climate policy.
The climate-related provisions of the IRA have harnessed these dynamics for the deployment of clean energy technologies at scale. The tax credits were designed in a way that makes them extraordinarily easy to access, and their catalytic impact on private capital flows has been significant over the last two years. So far, the biggest sectoral impacts can be seen in zero-emission vehicles, battery

manufacturing, and solar energy production. Based on the projection of dramatic emission reductions in the power sector, modelling suggests that the IRA could cut emissions by up to 40 per cent below 2005 levels by 2030 – 8.5 percentage points more than without it.

The IRA was initially designed so that its revenue provisions would offset its costs, resulting in a net positive impact on the federal budget. However, revised cost estimates and regulatory uncertainty under the new Trump administration, which aims to roll back parts of the bill, have made its fiscal effects uncertain. The IRA's emissions abatement costs in the power sector are estimated at 45-61 USD per ton of CO_2 – well below the social cost of carbon. Regarding the comparative cost-effectiveness of the policy, it is key to understand the role of marginal abatement costs: While a hypothetical carbon pricing policy may have lower marginal abatement costs, this does not mean it would achieve long-term decarbonization at the lowest total cost. On the contrary, incentivizing more radical but slightly costlier abatement measures now, rather than incremental and cheaper ones, is likely the more cost-effective strategy, as it prevents technological lock-ins that would be more expensive to overcome in the long run. Other often-overlooked economic factors include the asset accumulation driven by cleantech subsidies and the positive spillover effects, as other countries can build on advancements in low-carbon technologies.

In comparison, the EU also provides large sums of public funding for clean energy sectors, which are, however, scattered across various programmes. In response to the IRA, it defined strategic net-zero technologies as priorities for cleantech manufacturing in Europe, but this prioritization is not backed by additional funding at the moment. The accompanying reform of the EU state aid rules gives member states more leeway in supporting their cleantech sectors, though.

The insights gained from the IRA as an investment-based approach to climate policy raise several important questions. If the initial trends are confirmed, the U.S. experience presents a strong case for reconsidering carbon pricing as a primary tool, at least in the early stages. Nevertheless, this does not necessarily mean that carbon pricing has no role to play. A key question becomes what the optimal policy mix and sequence might be. Others pertain to crafting public narratives that foster social acceptance of climate action, striking a balance between supporting domestic markets and advancing international strategies, directing funding toward critical subsectors, and developing innovative solutions to mitigate the expected social impacts of carbon pricing in consumer-facing sectors.

In summary, while the significant effects of the IRA on cleantech investments in its first two years are compelling, a definite conclusion on its long-term effectiveness will depend on more rigorous policy evaluations. Further research is also needed to determine how this approach could be best applied to the EU and European countries while taking into account institutional barriers, current policy frameworks, and political challenges.

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