Fixing Rising Price Paths for Fossil Energy: Basis of a "Green Growth" without Rebound Effects

Stephan Schulmeister

Introduction

At present, the key policy challenges are twofold, first, preventing a climate catastrophe and, second, overcoming the social and economic crisis. The first challenge calls for a reduction of (net) carbon emissions to zero as fast as possible. Reaching this target necessitates a comprehensive renovation of the capital stock[1]:

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[1] Many studies deal with pathways towards a zero-carbon economy. See the publications of the Commission on the European Green Deal and on the intermediate target of reducing CO_2 emissions until 2030 by 55% ("Fit for 55"), in particular on the investments necessary to achieve this target (European Commission, 2022). Wildauer, Leitch, and Kapeller (2020) consider a higher volume of investments necessary to reach climate neutrality than the European Commission. A much more optimistic scenario is sketched in McKinsey & Company, 2020. For a comprehensive treatment of the climate crisis in the context of environmental sustainability in general, see European Environment Agency, 2019. A roadmap for the global energy sector is provided by the International Energy Agency (IEA, 2021). For Germany, pathways towards a climate-neutral economy are investigated in Prognos et al. (2020) and in the Ariadne Report (2021). All these studies do not quantify the impact of the different "transition investments" on economic growth and, hence, do not deal explicitly with the related rebound effects.

S. Schulmeister (✉)
Independent reseacher, Vienna, Austria
e-mail: stephan.schulmeister@wifo-pens.at

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- Transformation of residential and commercial buildings into little power stations through the combination of better isolation, photovoltaics, heating pumps, and batteries.
- Construction of a trans-European high-speed railway net as alternative to air travel.
- Expansion of local public transport, especially in large cities, as an alternative to private car transport.
- Replacing cars and trucks with combustion engines with emission-free vehicles.
- Moving in industrial production from using fossil energy to “green” hydrogen.
- Massive expansion of power generation from renewable sources as well as of power grids and storing capacities to meet the massively rising electricity demand.

The realization of these investment programmes would raise economic growth over the transition period of roughly 30 years. In the case of Germany, GDP would grow by roughly 3 percentage points per year higher than without such a Green Deal (as sketched in the annex). Such “green growth” would enable the renewal of the capital stock as the basis of a future circular economy. Once this is achieved, economic growth could be reduced to close to zero. Over the transition period, the “green growth” would also mitigate the social and economic crisis through providing more good jobs and financial means for modernizing the welfare state.

But what about the rebound effects of “green growth”? This issue is particularly important as using exclusively renewable electric power necessitates, e.g. the production of many times more wind power stations as already exist (as sketched in the annex). Since they consist mainly of steel and cement, their production is extremely CO_2-intensive.

This example points to the following paradox: on the way to an emission-free economy, additional CO_2 emissions must be accepted, stemming from the production of those capital goods that enable an emission-free economy in the future.

Adherents of a degrowth strategy might argue that this dilemma should be solved by shrinking production and consumption in other sectors. This conclusion is drawn from the empirical evidence: “absolute decoupling” of greenhouse gas (GHG) emissions from GDP growth (i.e. declining emissions in absolute terms) has rarely been realized in the past, certainly not as large, and fast as necessary to prevent a climate catastrophe (Haberl et al., 2020).

In the case of CO_2 emissions, however, it is particularly problematic to extrapolate from past trends to the future. First, the awareness of the danger of a climate catastrophe is much more pronounced today than it was in the past. Second, fossil energy prices and, hence, emission costs have fluctuated enormously in the past and have fallen in real terms over the long run. Hence, the profitably of emission-reducing investments has remained uncertain.

In more technical terms: for any path of economic growth, there exists a path of rising fossil energy prices so that the (demand raising) income effects of overall production are overcompensated by the (demand dampening) substitution effects of rising (relative) prices of fossil commodities. In this way, one can control and restrict the rebound effects of economic growth on CO_2 emissions and, hence, can reconcile economic growth with ecological targets.

To put it concretely: if the prices of crude oil, coal, and natural gas had risen steadily faster than the general price level over recent decades, CO_2 emissions would have become progressively more expensive. This would have incentivized business and households to save fossil energy and to invest in energy efficiency as well as in renewable energy production. In this way, carbon emissions would have been steadily decoupled from economic growth.

Unfortunately, carbon pricing through taxes or emissions trading cannot incentivize carbon-reducing investments to a sufficient extent as they cannot anchor the expectation that the *effective* costs of emissions will increase *steadily*. These effective costs consist of two components, the respective world market price of oil, coal, and natural gas and the CO_2 tax or the cost of emission certificates, respectively. If people repeatedly experience that the effective emission costs decline because world market prices of fossils and/or emission prices decline, then these expectations cannot be established.[2]

In other words, in a world of widely fluctuating prices of fossil commodities as well as of emission certificates, conventional carbon pricing cannot provide *planning security* necessary for a strong and steady expansion of carbon-reducing investments. This uncertainty problem is massively exacerbated by the extremely long payback periods of those investments.

As neither carbon taxes nor emission trading schemes can sufficiently incentivize the necessary investments in a permanent reduction of carbon emissions, this paper presents an alternative approach taking the EU and its European Green Deal as an example: the EU sets a path of steadily rising prices (e.g. by 7% per year) of crude oil, coal, and natural gas by skimming off the difference between the EU target price and the respective world market price through a monthly adjusted quantity tax. In this way, the uncertainty about future costs of carbon emissions and, hence, about the profitability of avoiding, then would be eliminated.

This chapter is structured as follows: the next section deals with the contradiction between the need for planning security of "green investments" and the price instability of fossil energy and carbon emission permits, respectively. Then, the reasons are discussed why the conventional ways of CO_2 pricing cannot incentivize green investments to an extent required for a sustained carbon reduction. The next section explains the alternative approach of fixing long-term price paths for crude oil, coal, and natural gas. Then, the political feasibility of the price path model in a (partly) de-globalizing world is examined. The final section evaluates the model as a contribution to the challenge of organizing a global "collective action" for avoiding a climate catastrophe.

[2] This is in no way to suggest that the current forms of CO_2 pricing do not have a dampening effect on emissions. That this is indeed the case is shown by developments in countries such as Great Britain, Sweden, Denmark, and Germany, where absolute decoupling has succeeded to a noticeable extent (for the effects of CO_2 pricing to date, see Andersson, 2019, Best et al., 2020, World Bank Group, 2020). However, much greater efforts are needed to achieve a climate-neutral economy by 2050.

Oil Price Instability and Planning (In)Security of Green Investments

Investments in energy efficiency and/or in renewable energy only pay for themselves after many years (e.g. energetic refurbishment of buildings, diffusion of electric cars, etc.) or even decades (e.g. hydrogen technology in industry, a trans-European net of high-speed trains, etc.). A successful ecological transition therefore requires *maximum planning security*.

At the same time, prices of fossil commodities, in particular crude oil, fluctuate in a sequence of bull and bear markets (typical for asset prices in general). Between 1973 and 1982, e.g. crude oil prices increased tenfold, mainly due to the two "oil price shocks" in 1973 and 1979, respectively (Fig. 1). In both cases, OPEC took advantage of political turbulences in the Middle East to "retaliate" for the preceding dollar depreciations 1971/1973 and 1976/1979, respectively (Schulmeister, 2000).

Triggered by the global recession 1980/1982, oil prices fell by more than 50% between 1980 and 1985. However, oil producers were compensated by the rising value of the dollar. When the dollar started to fall again, Saudi Arabia flooded the oil market with additional supply to restore production discipline within OPEC. This strategy failed and oil prices stagnated for roughly 15 years (Fig. 1).

After the recession of 2001, oil prices started to boom again, declined between 2011 and 2016 by roughly 70% (mainly due to additional supply stemming from fracking technologies), recovered between 2016 and 2018, and then fell again and almost collapsed in early 2020 when Saudi Arabia returned to her strategy of 1986,

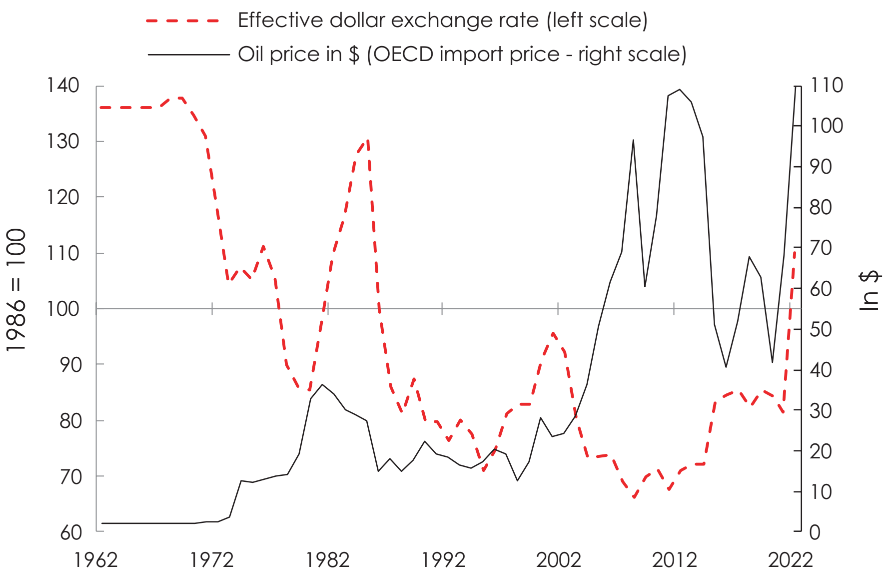


Fig. 1 Dollar exchange rate and oil price fluctuations. (Source: OECD, IMF)

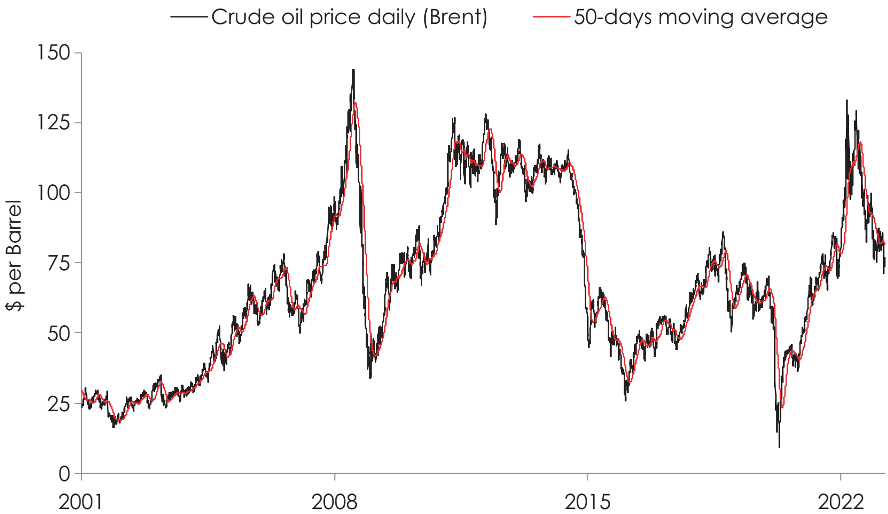


Fig. 2 Trending and speculation in the crude oil futures market. (Source: US Energy Information Administration (EIA))

i.e. flooding the market with additional oil supply (this time to "punish" Russia for not cooperating in reducing oil production). At the same time, also stock prices collapsed in reaction to the outbreak of the COVID-19 pandemic.

The unprecedented intervention by central banks in March 2020 "aborted" the bear markets and fostered a bullish sentiment in all asset markets (stocks, bonds, commodities, real estate, crypto currencies). The quadrupling of crude oil *prices* (from \$20 to \$80 between April 2020 and November 2021 (Fig. 2)) was additionally fostered by supply restrictions of oil-producing countries (see also section "Political Feasibility of the Price Path Model in Times of Multiple Crises"). In contrast to what was "rationally" to be expected, also EU emission prices quadrupled (Fig. 3). Fossil energy prices continued to rise after the invasion of Russia into Ukraine (in contrast to stocks, bonds, and cryptocurrencies).

As sketched above, important turning points in oil price trends were triggered by economic and political events ("fundamentals"). But why did the subsequent upward or downward trends last so long? Such an "overshooting" of asset prices can be explained as follows.

Speculative prices like those of stocks, foreign exchange, oil futures, or CO_2 emission permits fluctuate almost always around "underlying" trends (Figs. 2 and 3).[3] The phenomenon of "trending" repeats itself across different time scales ("self-similarity"). For example, there occur trends based on tick or minute data as well as trends based on daily data.

[3] Empirical research on the role of technical trading in asset price dynamics in general is documented in Schulmeister, 2009, as regards commodities prices, in particular oil prices, in Schulmeister, 2012.

"Technical" or "algo(rithmic)" trading aims at exploiting the trending of asset prices. In the case of *trend-following* moving average models, a trader would open a long position (buy) when the current price crosses the MA (moving average) line from below and sells when the opposite occurs (Figs. 2 and 3). By contrast, *contrarian* models try to profit from trend reversals and, hence, change open positions when a trend "loses momentum".

Technical models are applied to price data of almost any frequency. Due to the increasing use of intraday data, algo trading has become the most important driver of the rising "speed" of trading and the related boom in the volume of financial transactions.

Long-term price trends result from the following process: "mini-trends" (e.g. based on minute data) add up to one trend based on 10-minute data. Several of these trends accumulate to one trend based on hourly data and so on. Over an extended period, upward (downward) trends last longer than countermovements (mainly due to a "bullish" or "bearish" sentiment), causing the price to rise (fall) in a stepwise process. Figure 2 shows how oil price trends based on daily data accumulate to bull markets and bear markets.

The concurrence of two types of market failure in fossil energy pricing, i.e. neglect of environmental costs and "overshooting", represents fundamental causes of global warming. As a consequence, a consensus has emerged since the 1990s that CO_2 emissions should be priced, either through emission trading or through carbon taxes.[4] Unfortunately, neither instrument can ensure that the effective emission costs will steadily and permanently rise.

Carbon Pricing Through Emission Trading Systems

The EU Emission Trading System (ETS) was introduced in 2005 and covers the main CO_2 emitters from industry such as steel, paper, chemical or cement producers, as well as power generators which together account for about 45% of all CO_2 emissions in the EU.

In theory, emission trading is an optimal control instrument (see the literature mentioned in footnote 5): CO_2 emissions are limited by the volume of emissions allowances (EUA), and this cap is gradually reduced. A uniform price is formed on the permit exchanges, which ensures that the emissions take place where their benefit is greatest: A company that needs certificates buys them via the exchange from another company that has a surplus. These transactions constitute *compliance transactions*.[5]

[4] The general issue of carbon pricing is analysed in Edenhofer et al. (2019); Guttman (2018); Köppl, Schleicher, and Schratzenstaller (2019); OECD (2018); Sachverständigenrat (2019); and the report of the Stiglitz-Stern-Commission (2017).

[5] For an overview of the EU Emissions Trading System, see Marcu et al., 2022, European Environment Agency, 2020, and Ellerman et al., 2016. A summary of emissions trading worldwide

Fig. 3 Fluctuations of the futures price of EU CO_2 emission allowances. (Source: Intercontinental Exchange (ICE))

In order to incentivize sufficiently investments in carbon reduction, permit prices would have to rise steadily – at least they should not widely fluctuate. But precisely this has been the case: Since the introduction of the ETS, the price for the emission of 1 ton of CO_2 has been fluctuating between (roughly) €3 and €30. Such a low level could not provide a significant incentive to invest in reducing emissions. However, between April 2020 and December 2021, the CO_2 price rose from € 30 to roughly € 90 (Fig. 3), astonishingly in tandem with the boom of fossil energy prices (Fig. 2 – higher energy prices should have dampened the demand for emission permits). Since then, carbon prices have been fluctuating between € 70 and € 100.

This failure of emission trading to incentivize (investments in) carbon reduction to a sufficient extent has two main causes. First, the number of certificates must be fixed in advance for a longer period. This organizational necessity leads to misallocations and thus "wrong" CO_2 prices due to the fundamental uncertainty about the medium-term economic developments like a financial crisis and its effects.[6] This

is ICAP, 2021, and OECD, 2022. The microstructure of carbon emission markets is discussed in Kachi and Frerk, 2013, and Mizrach and Otsubo, 2014. The importance of (destabilizing) speculation in the spot and derivative markets of EU emission allowances is examined by Berta et al., 2017. Schultze (2021) provides anecdotical evidence about the rising importance of hedge funds and other financial speculators in EU emissions trading.

[6] The problem of uncertainty about the effective carbon emission costs is even bigger in the case of emission trading schemes as compared to carbon taxes as actors can know the carbon tax rate but not the future emission permit prices (Aldy and Armitage, 2020). Bayer and Aklin (2020) argue that even if carbon prices are low, an emission trading system can reduce emissions if it is a credible institution which is believed to become a more stringent in the future. They show that the EU ETS saved 3.8% of overall emissions relative to a world without carbon markets. The extent of this reduction is, however, much too low compared to what is required.

shortcoming could only be mitigated through ETS reforms (implementation of the Market Stability Reserve, reduction of the emission caps and of free permit allocation, raising the reduction targets as part of "Fit for 55", etc.).

Second, financial actors on the CO_2 permit exchanges "interpose" themselves between companies with a surplus or deficit of permits and use permit futures as vehicles for speculation. Thus, since 2010, 99% of all permit transactions have been carried out in derivatives and only 1% in genuine certificates. Already in 2012, the total CO_2 transaction volume (including derivatives) of all actors was more than 33 times higher than the companies' "compliance needs" (Berta et al., 2017) Moreover, the CO_2 price dynamics show the pattern typical for speculative prices in general: short-term trends, which are exploited by algorithmic trading, accumulate into longer-term bull or bear markets (Figs. 2 and 3).

However, most studies on the role of financial institutions in carbon trading conclude that the activities of these agents focus on hedging transactions for (polluting) nonfinancial corporations as well as on market making, i.e. providing liquidity. Speculation would play only a minor role (Ampudia et al., 2022). If this were true, then the share of outstanding open positions *between financial institutions* in the EUA futures markets should not be as big as it is, i.e. almost 50% of overall positions (see Chart B in Ampudia et al., 2022). This observation is in line with the fact that in asset markets the greatest part of liquidity is generated by "algo trading" of all kinds (between 60% and 70% of total volume). In addition, one should keep in mind that there is no precise distinction between market making (arbitrage) and speculation because the difference between the sell and the buy price reflects not only the bid/ask spread but also the speculative component due to extremely short-term price movements.

Carbon Pricing Through Emission Taxes

In all EU countries, there has long been a tax on fuels. It is equivalent to a tax on CO_2 emissions caused by fuel consumption since there prevails a fixed relationship between the quantity of fuel consumed and the related carbon emissions.[7]

In Germany, e.g. the tax on diesel is 47 cents per litre. Since the burning of one litre diesel produces 2.65 kg CO_2, the diesel tax burdens the emission of one ton of CO_2 by roughly 180 € (= 0.47/2.65 per kg). This is much more than in most planned or – like in Sweden or Switzerland – already implemented (general) carbon taxes (see Kettner and Kletzan-Slamanig 2018).[8]

[7] An overview of carbon taxes on CO_2 emissions from energy use in 42 countries can be found in OECD (2018). Kirchner et al. (2018) analyse the macroeconomic and distributional effects of CO_2 taxes for Austria.

[8] In fact, fuel taxes compensate also for other externalities like air pollution and noise as well as for the wear and tear of infrastructure. However, in this paper I focus on the effective costs of CO_2 emissions for households and enterprises.

Due to the volatility of crude oil prices, there occur frequently phases of markedly declining end-user prices for fuels despite (very) high-quantity taxes on fuels and – implicitly – on carbon emissions (even as high as 180 € per ton).

A concrete example illustrates the issue: between 2004 and 2008 and between 2009 and 2012, the price of crude oil rose dramatically and with it the price of fuels, heating oil, and natural gas. In Germany, e.g. the diesel price rose to € 1.50 (Figs. 2 and 4). However, the oil bull market was followed by a bear market, and the diesel price fell again to only about € 1 in 2009 as well as in 2016. Consequently, the demand for (diesel-consuming) SUVs picked up again and investments in CO_2 reductions, which were profitable at an oil price of € 70 (and more), turned into "sunk investments". In early 2020, oil and diesel prices fell once again strongly, followed by a reverse movement afterwards.

The combination of small price elasticities of both, demand and supply in oil markets, with frequent demand and supply shocks causes sharp oil price changes which are then reinforced by algo trading. Under these conditions even rising carbon tax rates cannot anchor the *expectation* of *steadily* rising paths of the *effective* costs of CO_2 emissions.

Rather the opposite could take place: the more the EU (and other countries) succeed in reducing demand for fossil energy, the more likely it is that world oil prices will fall (again, in particular as the proven reserves of oil, coal, and natural gas amount to roughly 54, 139, and 49 times global annual demand and, hence, are much larger than the global carbon budget – if a climate catastrophe is to be avoided, the reserves must not be exhausted.[9]

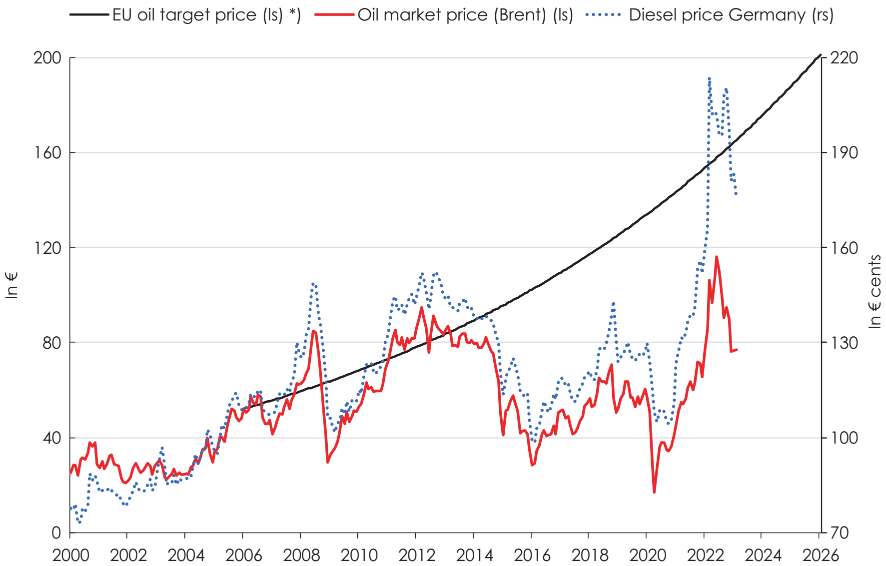
Fixing Long-Term Rising Paths of Fossil Energy Prices

If neither emission trading schemes nor carbon taxes can *ensure* that emitting CO_2 becomes *permanently* more expensive, how then could a rising path of effective emission costs be achieved?

The EU should set a path with steadily rising prices for oil, coal, and natural gas and skim off the difference between the EU target price and the respective world market price by means of a monthly adjusted quantity tax – instead of the end-user prices (including taxes and/or emission permit costs), the quantity tax should fluctuate. Hence, this tax can be conceived as a (implicit) carbon tax just constructed differently.

Here is a thought experiment using the example of crude oil to illustrate the working of such a price and tax regime. On January 1, 2006, the following regulation came into force in the EU: starting from the (then) current oil price (Brent) of

[9] For data on global oil, coal, and natural gas reserves, see https://ourworldindata.org/grapher/years-of-fossil-fuel-reserves-left. For a documentation of the discrepancy between countries' planned fossil fuel production and global production levels consistent with limiting warming to 1.5 °C or 2 °C, see http://productiongap.org



** Target price path: Crude oil prices in the EU rise by 5 percentage points faster than target inflation, i.e., by 7% per year (fictitiously from January 1, 2006).*

Fig. 4 Price incentives for CO_2-reduction – market prices versus target prices. (Source: US Energy Information Administration (EIA), German Automobile Club (ADAC))

52.0 €, the price valid within the EU would rise along a predetermined path by 7% per year (5 percentage points higher than target inflation).

As a result of a second bear market, the oil price fell from €95.0 to €28.3 between March 2012 and January 2016, while the diesel price in Germany fell from €1.52 to €0.99 (Fig. 4). However, the EU guideline price for oil would be € 102.4 in January 2016. For February 2016, the EU oil tax would thus amount to 74.1 € – 102.4 minus 28.3 – per barrel, about three times the oil bill (the figures are for illustrative purposes only; if an EU price path had been introduced, the world market price would have been dampened further). The (final) diesel price in Germany would have risen continuously (as Fig. 4 shows, both prices – expressed in the same currency – move very much in tandem).

If one considers that the EU had to pay a total of € 414.5 billion in 2016 for energy imports – almost exclusively fossil – it becomes clear that such a fossil energy tax could yield more than € 1.000 billion in the medium and long run (depending on the "start price"), and its returns would increase at an above-average rate. On the one hand, the EU target price is rising, while on the other hand, the EU's climate policy is curbing its energy imports and thus world market prices. As a result, part of "fossil rents" would be diverted to the EU.

Technically, the implementation of such a flexible quantity tax would be simple in the "digital age": based on the difference between the EU target price and the world market price, the tax per unit of quantity of oil, coal, and natural gas valid in the following month is determined at the end of each month by the EU Commission and paid in the member states by producers and importers of fossil energy in the EU.

The levels from which the crude oil, coal, and natural gas price paths start as well as their annual growth rate are to be determined in a political process: the higher the priority given to incentivizing investments and consumption behaviour consistent with limiting climate change, the higher should be the initial price levels as well as their growth rate.

Since reliable expectations about the future profitability of ecological investments are the most important determinant of sustained willingness to invest, a comparatively small but permanent relative increase in the price of fossil energy could be sufficient to generate a sufficiently large volume of investment. If this turns out to be insufficient, price paths can be adjusted upwards. Since a reduction in the price of fossil energy is ruled out, the following holds: the earlier an investment is made, the greater is its profit. Such a system of pricing fossil energy would therefore initiate a long-lasting investment boom in avoiding CO_2 emissions.

Goods imported into the EU would be subject to an equivalent border carbon adjustment tax. As long as no comparable carbon taxes exist in the EU's trading partners, EU exports could be relieved from the EU fossil energy tax paid (analogous to VAT).

Technically, it would be far easier to implement just three flexible quantity taxes on oil, coal, and natural gas than managing the complex EU emissions trading scheme.

What would be the most important price and investment effects of EU target prices for fossil energies? All goods and services would become more expensive within the EU to the extent that fossil energy is used in their production – from fuels including kerosene to plastic products. Products produced with renewable energy or less energy would become relatively cheaper.

The predetermined rise of the prices of oil, coal, and natural gas will be processed in an almost Hayekian manner on the various submarkets, i.e. completely decentralized. This will eliminate the need for much regulation. If coal becomes steadily and predictably more expensive, then coal-fired power plants will be closed for cost reasons. Conversely, the increasing profitability of energy production from renewable sources will make the current system of surcharges on electricity consumers and their diversion to "green" producers obsolete.

The main impact of steadily rising fossil energy prices on CO_2 emissions will not be direct but rather indirect via the thereby induced investments. For any given capital equipment, the reaction of demand to rising prices is rather low, i.e. its short-term price elasticity. In the case of fuels, e.g. even the wide price fluctuations by 30 percentage points and more (Fig. 4) had very little impact on driving behaviour and, hence, on fuel demand. Exceptional price increases of fossil energy like in 2022 do, of course, force people to reduce their energy consumption; this effect will, however, be only temporary. By contrast, if people *know for sure* that the price of fuels will rise permanently and reliably, then a growing number will choose an electric vehicle when replacing their old car. The same reasoning holds for the investments of industry, electricity producers, or the energetic refurbishment of buildings.

Even though steadily rising fossil energy prices are not a sufficient condition to successfully fight global warming, they are a necessary condition for incentivizing all projects which will enable the transition towards a new energy system as part of a circular economy. Using part of the (enormous) returns from the fossil energy tax for long-term infrastructure projects would foster the ecological transformation (another part of tax revenues should offset the burden of energy price increases on low-income groups). These projects include the creation of a trans-European network for high-speed trains and investments in power grids as well as in hydrogen pipeline networks and in local public transportation systems.

Political Feasibility of the Price Path Model in Times of Multiple Crises

Under present conditions (high energy prices, Putin's war against Ukraine, etc.), it seems illusory to call for a steady increase in the price of oil, coal, and natural gas. The relevance of this model of carbon pricing can better be understood if one takes into consideration the systemic components of the present multidimensional crisis, in particular the relationship between global heating, the ownership of fossil energy as main polluter, and the related struggle over global income distribution between the "fossil rentiers" and the industrialized countries as the largest energy consumers. This struggle has drastically intensified in recent years:

- Either the strategy of the "fossil rentiers" to tighten their supply and keep fossil energy prices high fails (as it did in the past), then it will take the price paths to prevent the amplification of global warming through again (too) low fossil energy prices.
- Or OPEC and non-OPEC together with the transnational energy corporations succeed in forming a "quasi-cartel", then the industrialized countries need to fix rising price paths for oil, gas, and coal as a counterattack in the distribution struggle.

Looking back at the developments in recent years clarifies the issue. The Paris Agreement of 2015 took an important step to combat global warming. Slowly the "fossil rentiers" realized their business is going out of business. If the price of CO_2 were to rise steadily through taxes or emissions trading, the industrialized countries would reap the profits from the rising (gross) prices of fossil energy. It would then be difficult for the "fossil rentiers" to raise prices themselves, also because of their enormous oil, gas, and coal reserves, e.g. the global oversupply. Under these conditions, the main strategic target of "fossil rentiers" became as follows: if fossil energy must become more expensive for containing global warming, then it is up to us to raise oil, gas, and coal prices – and not industrial countries through raising carbon taxes and/or emission permit prices.

This strategy calls for a close cooperation between OPEC, non-OPEC, and energy corporations to control supply and prices of fossil energy over a transition period of several decades. As the demand for fossil energy is price-inelastic over the short and medium run, "fossil rentiers" as a "quasi-cartel" could raise prices and keep them high.

No country had and still has a greater interest in such strategy than Putin's Russia. For this is the only way she can reduce her technological backlog and pursue her world power ambitions. Therefore, the escalation of the Ukraine conflict is not only part of Putin's neo-imperial ambitions but also of his economic strategy. And this coincides with the interests of the other "fossil rentiers" and the energy corporations. The subsequent invasion of Ukraine by Russian forces increased fossil energy prices and profits of producer countries as well as of energy corporations even further. This success in turn strengthened their collusive behaviour even more. Saudi Arabia, e.g. the most important ally of the USA in the Middle East, could halve the price of oil simply by announcing an expansion of its production, but it is not interested in doing so. Reducing production volumes and profiting from price increases is much more attractive.[10]

Whether OPEC and non-OPEC countries, together with the major energy companies, can succeed in keeping fossil energy prices high through controlling supply, cannot be assessed at present. Several arguments speak against this: the level of economic development and (thus) the interests of the various producer countries vary greatly; in view of the high prices of oil, natural gas, and coal, the poorer countries will increase their production and thus exert pressure on prices. One of the most important "players", namely, Russia, could lose power in the wake of the Ukraine war and thus also in the commodities business. Moreover, Western countries could ease sanctions against Iran and Venezuela, thus increasing the global supply of fossil energy, at least in the medium term (after possible changes in the respective political regimes).

But even if the "fossil rentiers" succeed in controlling the world's supply of fossil energy, this would mean a permanent struggle over the distribution of income and power on two levels: first, on the international level between a relatively small, economically less developed group of net fossil energy exporters and the major economic blocs the USA, EU China, and Japan, and, second, within the industrial countries between the energy sector (increasingly "financialized") and the industrial and service sectors.

The most effective "counterattack" of industrial countries is to dampen demand for fossil energy, to make investments in renewable energy sources more profitable and to disincentivize investing in fossil energy. All three objectives can be achieved

[10] Also oil refiners and fuel distributors used Putin's war to significantly raise their profit margins: whereas the price of crude oil and diesel at the pumping station has been moving in tandem in normal times, diesel became much more expensive as compared to crude oil in the months after February 24, 2022 (Fig. 4).

by implementing the price path model as it drives a "tax wedge" between (high and rising) prices for fossil energy users and (depressed) prices for producers. If, e.g. "fossil rentiers" succeed in pushing fossil energy prices above the EU target price and keep them there, then the EU would need to shift the price path up. Otherwise, only the "fossil rentiers" would profit from rising oil, gas, and coal prices which in turn would incentivize investments into more extraction of the "toxic treasures".[11]

Fighting Global Warming, "Climate Clubs", and the Price Path Model

The most important "promotors" of the price path model would be a growing number of environmental disasters demonstrating the variety of future catastrophes due to global heating. If, e.g. during the 2020s catastrophes of various kinds become increasingly shocking and if at the same time it becomes obvious that the climate targets set for 2030 cannot be achieved, then pressures will increase to find a simple and flexible instrument for CO_2 pricing.

The price path model meets these requirements because it represents a uniform method, even though its implementation can be differentiated according to countries and economic areas (developing countries, e.g. could introduce a fossil energy price path with a lower level and/or smaller rate of growth of target prices as compared to industrial countries). If the price path model became the basic instrument of carbon pricing for a growing number of countries, it would help to overcome the biggest obstacle to limiting global warming. This obstacle is not technical but political: all important countries and regions must pull together – never before has the problem of "collective action" arisen with such force at the level of the entire planet.

In his seminal work *The Logic of Collective Action: Public Goods and the Theory of Groups*, Mancur Olson examined already in 1965 the essential problems that arise when a group wants to maintain and preserve a common good, i.e. a good from whose consumption no one can be excluded (Olson, 1965). His thoughts can be applied to the way the "world group" deals with its most important common good, the natural environment.

The focus is on the conflicts between individual and collective rationality. Thus, the larger the group and therefore the smaller the consequences of his selfish behaviour and the less conspicuous it is, the more likely an individual will not contribute anything to the preservation of the common good, i.e. act as a "free rider". In a small group, such as a farming community, "free riding" can therefore be contained in terms of a common at the local level (Ostrom, 1990; for an application to climate

[11] Even considering the efforts to fight global warming, OPEC expects in its forecast (OPEC, 2022, Table 2.1) that global oil demand and production will rise by 12.3% between 2022 and 2045. The share of fossil energy in world primary energy demand would only decline from 80.2 (2021) to 69.6% (2045) – a catastrophic development for the climate. However, if the problem of a global collective action is not successfully tackled, this forecast is plausible.

change see Harris, 2007). This, however, is not true as regards preserving biodiversity at a regional level or the climate at the global level. Hence, the climate crisis can be conceived as a "tragedy of the commons" on a planetary scale.

Incentives for preserving and cultivating common goods are usually provided by the state, for example, through taxes or subsidies; however, there is no "world state" that could protect the climate. Hence, at the global level, the greatest progress has been made only in diagnosing the problem, e.g. by the International Panel on Climate Change (IPCC). Policy has yet only set targets without binding and verifiable agreements on how these targets will be achieved (as in the Paris Agreement of 2015).

This problem is deepened by the fact that the conflict between individual and collective rationality also arises at the international level in the form of national self-interest on the one hand and the global commons on the other hand: if there is no consensus on the method of combating carbon emissions, each country will choose those ways which also serve its national interests. The idea that nation-states compete against each other on a global level like companies rather than cooperating with each other as partners reinforces this danger.

Felbermayr (2021) gives a realistic example. If one country (e.g. the EU) increases the relative price of fossil energy compared to renewable energy through taxes and another country (e.g. the USA) increases it to the same extent by subsidizing renewable energy, this has very different consequences for the economies of the two countries, in terms of both their international competitiveness and their internal distribution of income.

It would therefore be ideal if, as a first (major) step towards harmonizing methods to combat CO_2 emissions, the three largest emitters, China, the USA, and the EU, were to agree on common price paths for oil, coal, and natural gas and on corresponding carbon border adjustment taxes to prevent "carbon leakage" to countries with no or low CO_2 taxation (the idea of "climate clubs" stems from William Nordhaus and has been adapted to fit the WTO rules; see Tagliapietra and Wolff, 2021; Felbermayr, 2021).[12] Exports of non-member countries to the "club" would be burdened by a border adjustment tax.

The efforts of these countries to reduce carbon emissions would be strengthened significantly if they could be convinced to also introduce price paths for fossil energy – otherwise they would have to pay the carbon adjustment tax for their exports to the "club", the most important markets for exports of developing countries. In addition, also a group of emerging market economies, e.g. the Mercosur countries, could form a "climate club" to complement economic cooperation with a common form of carbon pricing which would not affect the intraregional price competitiveness (as in the case of different national carbon taxes). At the same time, the "Mercosur climate club" could deal with the "China-US-EU climate club" about a

[12] Harmonizing the effective carbon prices between the member countries would provide a level playing field also within the club. This would not be the case if, e.g. China burdens CO_2 to a lesser extent than the EU. In this case, China would enjoy a comparative price advantage (only imports from non-members would be treated equally).

differentiation of fossil energy price paths. Generally, the shape of the price paths should account for the different level of carbon emissions as well as of economic development: the higher the level of emissions and of GDP per capita, the higher should be the starting level and the rate of increase of the price paths. In contrast to other forms of carbon pricing, fossil energy price paths can easily be implemented, adjusted (if necessary), and controlled.

Under these conditions, global demand for fossil energy could be steadily dampened and, hence, also carbon emissions. At the same time, also supply would be dampened as the price path model drives a wedge between steadily rising fossil energy prices for consumers/users (to dampen demand) and low prices for producers (to dampen supply).

Achieving a circular economy necessitates not only a permanent carbon emission reduction but also a steadily rising share of recycling of raw materials of all kinds. This is more important as the "material consumption" in the EU amounted to 13.4 tons per person in 2020.[13] Only 30% of the waste left at the end of the production process is recycled ("output recycling rate") or 10% of the overall material consumption ("input recycling rate").

Even though the most important instruments for raising the recycling rates consist of regulations with respect to the product design (durability, reusability, reparability), economic incentives also play a role, in particular the development of the prices of raw materials as production input. If, e.g. plastic producers *know* that crude oil prices will permanently rise faster than the general price level, then investing in more recycling capacity becomes reliably profitable. This argument holds for recycling in general as the profits of the respective investments consist primarily of the saved raw material costs. As in the case of fossil energy, setting rising price paths of (recyclable) raw materials would anchor the respective expectations.[14]

Finally, a remark to those who are convinced that degrowth is "the" necessary condition for a transition towards a circular economy. For me, economic growth is by no means an intrinsic value. Economic activities should aim at providing the basis for a good life of the greatest possible number of people. At present, the biggest challenge is organizing a collective action at the global level to fight the climate crisis. The necessary renovation of the capital stock as one fundament of a future circular economy implies huge investment programmes which would contribute to economic growth and cause additional carbon emissions. This effect could and should be (over)compensated by steadily rising prices of fossil energy.

This combination of a *transitory* "green growth" and rising fossil energy price paths seems much more in line with the goal of providing the basis for a good life of the many than shrinking economic activities in other sectors of the economy (not to speak about other parts of the world like the global South). Such a degrowth strategy would call for a radical change of the economic system as regards the

[13] See https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210713-2.

[14] A plan for the transition towards a circular economy in the EU (though without considering the role of raw material prices) is sketched in European Commission (2020).

distribution of working time, income, wealth, and political power.[15] Given the extremely unequal distribution of economic and political power at present, striving for a radical change of both, the ecological and the social-economic system, seems to me a mission impossible. Hence, at present one should focus on fighting global warming through the combination of "green growth" and rising price paths of fossil energy. The related creation of "good" jobs might then – gradually – also mitigate the social crisis.

Concluding Remarks

This chapter proposes a new approach to pricing CO_2 emissions: setting a path of steadily rising prices of crude oil, coal, and natural gas by skimming off the difference between the target price and the respective world market price through a monthly adjusted quantity tax. In this way, the uncertainty about future price developments of crude oil, coal, and natural gas and, hence, of the effective emission costs would be eliminated. Firms and households could calculate the profitability of investments in avoiding carbon emissions. By contrast, neither carbon taxes nor emission trading schemes can provide such a planning security, indispensable for successfully combatting global warming. The price path model of efficient carbon pricing could be implemented, e.g. by the EU but could also serve as a common basis for "climate clubs", initially comprising the greatest carbon emitters, i.e. China, the USA, and the EU, potentially followed by groups of emerging market economies like the Mercosur countries.

At first glance, fixing a path of steadily rising fossil energy prices by means of economic policy might appear as falling back to a "centrally planned economy". However, if one takes into consideration the causes of global warming, the specific conditions in (derivatives) markets for fossil energy and carbon emission permits as well as the theory of externalities and public goods, then the proposal should appear worth being discussed. The global natural environment is the most valuable common good of mankind. Confronted with the threat of its destruction, the courage to escape from conventional modes of thinking should not be lacking.

To put it in the words of Albert Einstein: "You can never solve a problem on the level on which it was created".

[15] For a primer in degrowth economics, see Kallis et al. (2018), Schmelzer et al. (2022), and Priewe (2022).

Annex: A Back-of-the-Envelope Estimation of the Growth Effects of a Decarbonization of the German Economy

The purpose of this exercise is to gauge in an extremely rough manner how the investments necessary to achieve a carbon-free economy might impact upon economic growth. The more the ecological renovation of the capital stock would induce a significant "green growth", the more important an effective carbon pricing becomes.

As a first step, I take estimates of the additional electricity production needed for a decarbonization of the German economy in general and its industry in particular. I estimate the number of additional wind turbines which could produce the required power as well as the costs of their installation (as regards the rated power, effective electricity production, and investment costs, I use data for the already existing wind power stations in Germany). As power production costs (per KWh) are roughly the same for wind, solar, and biogas installations (Fraunhofer, 2018), this assumption simplifies the estimation of overall power plant investment costs. Based on the results of another study, I present estimates of renewable power demand and investment costs of a decarbonization of German industry.

As a second step, I estimate the volume of investments needed to replace combustion engine cars and trucks with electric vehicles, to energetically refurbish residential buildings, and to contribute to the enlargement of the European high-speed railways net.

Power Production and Installation Costs of Wind Turbines in Germany

Power production:

(https://www.wind-energie.de/themen/zahlen-und-fakten/ – retrieved September 25, 2021 – numbers are rounded)

Number: 31.100.

Total rating power: 63 GW.

Total production: 132 TWh.

Ø Rating power: 2,03 MW (=63.000/31.000) = 2.026 KW.

Ø Production: 4,24 GWh (=132.000/31.100).

Investment costs:

(Fraunhofer ISI, 2018)

Costs per KW rating power: 2.030 € (weighted average of the average costs of onshore and offshore turbines).

Ø Costs per installation: 4112 Mill. € (= 2.030 € * 2.026 KW)

Renewable Power and Investments Needed for a Climate-Neutral German Economy

In a comprehensive study, a consort of many research institutions investigates decarbonization pathways of the German economy (Ariadne-Report, 2021). As regards the power production necessary to achieve this target, different models arrive at estimates between 639 and 1.480 TWh (Ariadne-Studie, 2021, p. 19). Taking the mean value of 1.055 TWh and subtracting the actual production volume in 2020 of 251 TWh, I arrive at an estimate of roughly 800 TWh as additionally needed renewable power. The estimate of another study (632 TWh) is smaller but not completely at odds with the Ariadne study (Prognos et al., 2020, Fig. 8).

Additional power from renewable resources: 800 TWh.

Number of additional wind turbines: 188.679 (= 800.000 GWh/4,24 GWh).

Investment costs: 774 bn. € (= 188.679* 4,1 Mill. €) = 22,1% des BIP (2021: 3.500 Mrd. €)

Investments Needed for Carbon-Free Buildings

Single-family homes (40% of population).

Number: 16 Mill.

Estimated average costs of a complete energetic renovation, i.e. combining better isolation, photovoltaics, heat pumps, and batteries: 60.000 €.

Total investment costs: 960 bn. € (= 60.000 * 16.000.000).

Apartment buildings (including houses with only few flats – 60% of population).

Here, I operate with an extremely rough estimate since apartment buildings differ very much from one another as regards size, quality of isolation, heating system, etc. Considering that a complete energetic refurbishment of apartment buildings is more expensive as compared to single-family homes (per m^2 living space) and that roughly 60% of the population live in apartment houses, I use as estimate of overall investment cost 1.500 bn. €.

Investment cost of renovating all residential buildings: ~2.460 bn. €.

Commercial buildings.

As their floor space in Germany amounts to 10% of the overall floor space of residential buildings, I take 10% of the renovation costs of residential buildings as estimate for commercial buildings, i.e. 246 bn. €.

Estimate of renovation costs of all buildings: 2.706 bn. € or 77,3% of GDP

Investments Needed for Carbon-Free Road Transport

If one assumes that an electric car costs on average 20.000 € more than a combustion engine car and that the stock of passenger cars falls from 48 mill. to 25 mill. Between 2020 and 2050, then additional investment costs can be estimated at 500 bn. € or 14.3% of GDP.

For electric and hydrogen trucks, additional costs can be estimated at 50.000 € per truck. If the number of trucks declines until 2050 from 3.5 mill. to 2 mill. Due to shifting goods transport to railways, then overall additional investment costs can be estimated at 100 bn. € or 2,9% of GDP.

Investments Needed for the Enlargement of a Trans-European High-Speed Railway Network

As part of the construction of a European Green Deal, the high-speed railway network should be accelerated. If additional 30.000 km would be constructed (at present: 10.000 km), then investment costs would amount to 600 bn. € in the EU or 4.3% of GDP of the EU (according to the International Union of Railways, construction cost per km vary in Europe between 12 and 30 mill. €; assuming 20 mill. €, one arrives at overall cost of 30.000 * 20 = 600 bn. €).

If Germany contributes an equivalent share to the European railways network, then the respective investments would amount to 4.3% of its GDP.

Overall Costs of Investments in the Transition Towards a Climate-Neutral Economy in Germany

The above back-of-the-envelope estimates sum up to 120.9% of German present GDP (2021). If all these investments were continuously carried out until 2050, they would "ceteris paribus" raise economic growth by 2.7 percentage points per year. The actual growth effect of complete decarbonization of the German economy would be higher since the above estimation exercise did not account for investments in energy storage (beyond batteries in buildings); in energy distribution through additional power grids and hydrogen pipelines; in the production of biofuels, in particular for aircrafts (and the related retrofits); in improvement of local public transportation (in particular in metropolitan areas); in reducing emissions in agriculture (biogas plants); and in carbon capture and storage. A complete decarbonization of the German economy would therefore raise economic growth over roughly three decades by 3.0 to 3.5 percentage points per year.

There are two reasons why the potential growth effects of a transition towards a climate-neutral economy were estimated in this annex. First, studies which sketch or even elaborate in detail the respective pathways assume a certain GDP growth over the transition period without analysing the feedback of the emission-reducing investments on overall growth. Prognos et al. (2020), for example, assume a growth rate of 1.3% per year until 2050 which seems inconsistent with the size of the necessary investment programmes as elaborated in their study.

Second, the results of the estimation of the growth effects of decarbonizing the economy suggest that the income effects on additional carbon emissions would be massive. Hence, emissions can only be steadily reduced through a simultaneous substitution effect of permanently and sufficiently rising prices of fossil energy (overcompensating the income effects).

References

Aldy, J. E., & Armitage, S. (2020). "The cost-effectiveness implications of carbon Price certainty", AEA papers and proceedings. *American Economic Review*, 113–118.

Ampudia, M., Bua, G., Kapp, D., & Salakhova, D. (2022). The role of speculation during the recent increase in EU emission allowances prices. *ECB Economic Bulletin, 3*.

Andersson, J. J. (2019). Carbon taxes and CO_2 emissions: Sweden as a case study. *American Economic Journal: Economic Policy, 11*(4).

Ariadne Report. (2021). *Deutschland auf dem Weg zur Klimaneutralität 2045 – Szenarien und Pfade im Modellvergleich*.

Bayer, P., & Aklin, M. (2020). The European Union emissions trading system reduced CO2 emissions despite low prices. *Proceedings of the National Academy of Sciences of the United States (PNAS), 117*(16), 8804–8812.

Berta, N., Gautherat, E., & Gun, O. (2017). Transactions in the European carbon market: A bubble of compliance in a whirlpool of speculation. *Cambridge Journal of Economics, 41*, 575–593.

Best, R., Burke, P. J., & Jotzo, F. (2020). Carbon pricing efficacy: Cross-country evidence. *Environmental and Resource Economics, 77*, 69–94.

Edenhofer, O., Flachsland, C., Kalkuhl, M., Knopf, B., & Pahle, M. (2019). Optionen für eine CO_2-Preisreform, MCC-PIK-Expertise für den Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung. In *Mercator research institute on global commons and climate Change (MCC)*. Potsdam-Institut für Klimaforschung (PIK).

Ellermann, A. D., Marcantonini, C., & Zaklan, A. (2016). The European Union emissions trading system: Ten years and counting. *Review of Environmental Economics and Policy, 10*(1), 89–107.

European Commission (EC). (2020). *Circular economy action plan*.

European Commission (EC). (2022). Towards a green, digital and resilient economy: Our European growth model, Brussels, 2.3.2022 COM. 83 final.

European Environment Agency (EEA). (2019). *The European environment – State and outlook 2020.*

European Environment Agency (EEA). (2020). The EU emissions trading system in 2019: Trends and projections, Copenhagen.

Felbermayr, G. (2021). Steuerliche Aspekte der Klimapolitik. *Wirtschaftsdienst, 6*, 428–431.

Fraunhofer ISE. (2018). Stromgestehungskosten erneuerbare Energien.

Guttmann, R. (2018). *Eco-capitalism – Carbon money, climate finance and sustainable development*. Palgrave Macmillan.

Haberl, H., Wiedenhofer, D., Virag, D., Kalt, G., Plank, B., Brockway, P., Fishman, T., Hausknost, D., Krausmann, F., Leon-Gruchalski, B., Mayer, A., Pichler, M., Schaffartzik, A., Sousa, T., Streeck, J., & Creutzig, F. (2020). A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: Synthesizing the insights. *Environmental Research Letters, 15*, 065003.

Harris, P. (2007). Collective action on climate change: The logic of regime failure. *Natural Resources Journal, 47*, 195–224.

ICAP (international carbon action partnership). (2021). Emissions trading worldwide: Status Report 2021.

International Energy Agenc (IEA). (2021). Net Zero by 2050.

Kachi, A., & Frerk, M. (2013). *Carbon market oversight primer*. International Carbon Action Partnership (ICAP).

Kallis, G., Kostakis, V., Lange, S., Muraca, B., Paulson, S., & Schmelzer, M. (2018). Research on degrowth. *Annual Review of Environment and Resources*, 291–316.

Kettner, C., & Kletzan-Slamanig, D. (2018). Carbon taxation in EU Member States: Evidence from the transport sector. In S. E. Weishaar, L. Kreiser, J. E. Milne, H. Ashiabor, & M. Mehling (Eds.), *The green market transition, chapter 2* (pp. 17–29). Edward Elgar Publishing.

Kirchner, Mathias, Sommer, Mark, Kettner-Marx, Claudia, Kletzan-Slamanig, Daniela, Köberl, Katharina, Kratena, Kurt CO_2 tax scenarios for Austria – impacts on household income groups, CO_2 emissions, and the economy, WIFO Working Paper 558, 2018.

Köppl, A., Schleicher, S., & Schratzenstaller, M. (2019). *Policy Brief: Fragen und Fakten zur Bepreisung von Treibhausgasemissionen*. WIFO.

Marcu, A., Hernandez, J. F. L., Alberola, E., Faure, A., Qin, B., O'Neill, M., Schleicher, S., Caneill, J.-Y., Bonfiglio, E., & Vollmer, A. (2022). *State of the EU ETS Report, European Roundtable on Climate Change and Sustainable Transition (ERCTS), BloombergNEF*. Wegener Center, ecoact (eds.).

McKinsey&Company. (2020). Net-Zero Europe, December.

Mizrach, B., & Otsubo, Y. (2014). The market microstructure of the European climate exchange. *Journal of Banking & Finance, 39*, 107–116.

OECD. (2018). *Effective carbon rates 2018 – pricing carbon emissions through taxes and emissions trading*.

OECD. (2022). *Pricing greenhouse gas emissions: Turning climate targets into Climat actions*.

Olson, M. (1965). *The logic of collective action: Public goods and the theory of groups*. Harvard University Press.

OPEC. (2022). World Oil Outlook 2045.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.

Priewe. (2022). Growth in the ecological transition: Green, zero or de-growth? *European Journal of Economics and Economic Policies: Intervention, 19*(1), 19–40.

Prognos, Öko-Institut, Wuppertal-Institut. (2020). Towards a Climate-Neutral Germany. Executive Summary conducted for Agora Energiewende, Agora Verkehrswende and Stiftung Klimaneutralität.

Prognos, Öko-Institut, Wuppertal-Institut, Klimaneutrales Deutschland. (2020). Studie im Auftrag von Agora Energiewende, Agora Verkehrswende und Stiftung Klimaneutralität

Schmelzer, M., Vetter, A., & Vansintjan, A. (2022). *The future is degrowth*. Verso.

Schulmeister, S. (2000). Globalization without global money: The double role of the dollar as national currency and as world currency. *Journal of Post Keynesian Economics, 22*(3), 365–395.

Schulmeister, S. (2009). Profitability of technical stock trading: Has it moved from daily to intraday data? *Review of Financial Economics, 18*(4), 190–201.

Schulmeister, S. (2012). *Technical trading and commodity Price fluctuations*. WIFO Study.

Schultz, Stefan. (2021). Wie Hedgefonds den Kohleausstieg befeuern, DER SPIEGEL, 29. https://www.spiegel.de/wirtschaft/service/emissionshandel-wie-hedgefonds-den-kohleausstieg-beschleunigen-a-44bf3116-4557-4f05-b1c3-f7a4944f7be3

Stiglitz-Stern-Commission. (2017). Report of the high-level commission on carbon prices, international bank for reconstruction and development and international development association/ The World Bank, May 29.

Tagliapietra, S., & Wolff, G. B. (2021). Form a climate club: United States, European Union and China. *Nature, 59*(1), 526–528.

Wildauer, R., Leitch, S., & Kapeller, J. (2020). *How to boost the European Green Deal's scale and ambition, Foundation for European progressive studies*. Arbeiterkammer, Renner-Institut.

World Bank Group. (2020). *State and trends of carbon pricing 2020*.