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The European Green Deal – More Than Climate Neutrality

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		Emission reduction trend preceding the EGD	39	
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8%	20	European Silk Road	20	growth, convergence
27%	70	Energetic building renovation	24	employment
12%	30	R&D for energy-saving digitalization	30	
12%	30	Advanced green vocational education	catalyst	employment, cohesion
12%	30	A European breakthrough innovation system	catalyst	employment
4%	10	Subcontracting management tasks for EGD	catalyst	employment
8%	20	European Planetary Health policy	catalyst	health, employment
100%	255	Total public investment per year		
		Total emissions reductions per year	161	

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Abstract The European Green Deal aims at climate neutrality of Europe by 2050, implying a significant acceleration of emission reductions. To gain the necessary support, at the same time it needs to reduce regional and social inequalities in Europe. We propose objectives in terms of jobs, growth, and price stability to complement the emission reduction targets and present a proof-of-concept investment profile for reaching these. Substantial additional public investments, of about 1.8% of last year's GDP annually, are proposed for the next decade. Their allocation includes retrofitting the European building stock, consciously fostering a renewal of the European innovation system, and complementary measures such as education and health. The scenario thus outlined is meant as an input to the urgently needed discussion about how the European Green Deal can shift the EU economy to a new development path that realizes a carbon neutral Europe by 2050 while strengthening European cohesion much earlier.

1 Introduction

The European Green Deal (EGD) has been proposed as a mission for Europe to become the world's first carbon neutral continent by 2050, and to strengthen European cohesion through this mission (von der Leyen 2019). Both goals present massive challenges; we will argue that there are ways to turn them into not only an environmental, but also a social and economic opportunity.

The target of -55% greenhouse gas (GHG) emissions by 2030 (compared to 1990), proposed by the European Commission, has gained geopolitical weight with Chinese plans to peak carbon emissions in 2030 and reach carbon neutrality no later than 2060 (UN News 2020). A whole range of nations and regions has declared similar goals.

Over the last two decades, processes of divergence and polarisation have been unfolding in the EU and the Eurozone (Gräbner et al 2020; Algan et al 2017). With the Coronavirus pandemic and the measures taken to control its spreading, these processes have intensified. Expected growth rates for Spain, Italy, and Portugal in 2020 are -12.4%, -9.9%, and -9.3%; the figures for Germany and Denmark are less severe, at -5.6% and -3.9% (European Commission 2020a). At the same time, the fiscal impulses as a response to the Coronavirus crisis amount to 8.3% and 5.5% of GDP for Germany and Denmark, whereas for Spain, Italy, and Portugal they are 4.3%, 3.4%, and 2.4% (Anderson et al 2020). The EU recovery plan holds promise to mitigate these processes – as should the EGD.

A European climate strategy aiming at carbon neutrality by 2050 can only be successful if it shifts the economy to a new development path that generates broad social and political support early on. This means it needs to come with tangible improvements of living

This paper, to appear in Intereconomics, can be viewed as a new and substantially updated version of the previous GCF working paper no 1 / 2020 "About the European Green Deal" (Wolf et al 2020). It is meant as an input to discussions on implementing the European Green Deal, wherefore comments are very welcome.

conditions for European citizens at large, across all regions and social groups. Grounded in a line of research on how climate policy can trigger a transition to a new growth path (Jaeger et al 2011, 2015; Jaeger 2012; Schütze et al 2017), we present a feasibility check of such a shift.

A historical transition like the EGD can and should not be planned in detail all the way to 2050, nor is it sufficient to declare an ambitious 2050 goal – first steps need to be specified. In this sense, we sketch a proof-of-concept EGD investment profile for 2021-2030 and explore its potential consequences in terms of emissions, unemployment, growth and inflation. Analysing what it takes to achieve the strictest emissions target of -60% (as proposed by the European Parliament), technically, economically, and socially, the main findings hold for -55% as well, with slightly different numbers. The quantitative scenario outlined is meant as a contribution to further discussions on designing and implementing the EGD in its first decade. By 2030, key developments will need to be carefully documented and evaluated in order to learn from experience for the following two decades.

Relevant emissions dynamics and the basic idea

Among the multitude of dynamics relevant for the EGD, GHG emissions of the EU can be rather reliably specified; as illustrated in Figure 1, the pattern shows variation around a linear trend. In the baseline year of current climate policy, 1990, GHG emissions[1] of today's EU27 countries stood at 4857 Mt CO_2e. This includes CO_2 emissions and others, like methane, accounted via CO_2 equivalents. By 2018, they had fallen to 3764 Mt (out of which 3055 Mt were CO_2 emissions), that is, on average the decline was about 39 Mt per year (Eurostat 2020b).[2] A 60% reduction goal by 2030 implies a target of 1943 Mt. This requires an annual decline in the order of 162 Mt, a massive break with the past decades.[3] After 2030, two decades remain for reducing the remaining 1943 Mt to zero, implying an average annual decline of 97 Mt. It is reasonable to expect that if the challenging 2030 target is reached, the EU will then be able to move on towards climate neutrality in 2050.

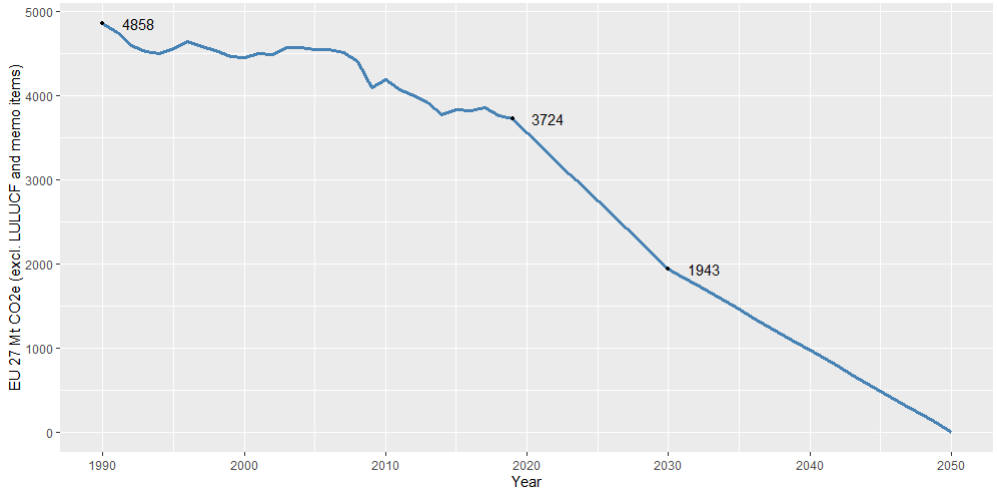

Fig. 1: Achieving a climate neutral EU27 by 2050 via -60% in 2030. GHG Emissions 1990-2018 from Eurostat (2020b), 2019 own estimation following trend 1990-2018.

[1] We use emissions data excluding international aviation.

[2] At the time of writing, the most recent data available are those for 2018. We estimate the 2019 value by subtracting the average annual decline of 39 Mt from the 2018 figure and compute required reductions for 2020-2030 from this.

[3] The 55% target implies an annual decline of 140 Mt – hardly reducing the necessary break with the past.

With the pattern thus illustrated, emission dynamics fluctuate around three different speeds of linear decline: a phase of sluggish reduction for three decades in the recent past, a breakthrough decade starting at the time of writing, and two decades for bringing the effort to completion. Once available, the EU27 numbers for 2020 may seem on track with emissions reductions required for the coming decade, but the economic recovery expected for 2021 can also be expected to increase emissions again,[4] leaving little time for achieving the 2030 goal.

This is relevant for the role of carbon prices: they can quickly influence the way existing stocks of capital and other durable goods are used but fail to replace existing stocks by those needed for carbon neutrality quickly enough (Patt and Lilliestam 2018). Therefore, direct regulations are as important as carbon prices, as shown by the rapid impact of recent EU emission rules for cars (Financial Times 2020).

Neither carbon prices nor direct regulations, however, will automatically trigger the investments needed for building the infrastructure to support a carbon neutral Europe. Public investments are therefore indispensable. At the same time, public investment is needed to overcome the widely underestimated slack in the EU economy (Brooks and Fortun 2020). Because of this slack, well targeted public investments can reduce GHG emissions without increasing costs for industries, but rather creating additional output, employment, and welfare – i.e., a new development path. The basic idea underlying this text hence is that the key to earning the buy-in of European citizens for the EGD lies in unleashing the full potential of the European economy by combining carbon taxes and direct regulation with EGD-oriented public investment.

Further criteria for a new development path

Change required for carbon neutrality can be perceived as change for the better if the European Green Deal generates tangible and widely shared economic and social benefits. Along with the breakthrough in emissions reductions just discussed, we therefore consider the following further criteria important.

1. *Unemployment rates below 7%, and rates of youth unemployment below 15% across EU member states by 2030.* Overall unemployment in the EU (6.3% in the last quarter of 2019)[5] is not a sufficient criterion since unemployment figures for individual countries differ widely. Pre-Covid levels ranged from 2.0% in Czechia, 3.1% in Germany, and 3.3% in Poland to 10% in Italy, 14.1% in Spain, and 17.3% in Greece (Eurostat 2020f). Similarly, youth unemployment levels spread up to 29.2% in Italy, 32.5% in Spain, and 35.2% in Greece before the current crisis (Eurostat 2020g) and are expected to rise significantly (Bacher and Tamesberger 2020). The EGD can be experienced as an attractive perspective if it improves the current situation quickly, reaching and stabilizing the stated goals by 2030.
   Strengthening convergence and cohesion. A related issue is reducing inequality of wealth and income, both between and within European countries. Especially the latter has been increasing recently (Blanchet et al 2019). Agreeing with European Parliament President David Sassoli that the "Green Deal must be an opportunity to fight inequality" (European Parliament 2020), we leave the specification of measurable goals on this issue to further, urgent and promising, research.[6]
2. *Average annual growth rates of EU GDP clearly above 2% for the period until 2030.* The EGD should support a fast and strong recovery from the current crisis and help avoid another period of sluggish growth at a lower level than before the pandemic, as

[4] In autumn 2020, the EU Commission expected a GDP decline of 7.4% for the year as a whole, and a rebound of 4.1% for 2021 (European Commission 2020a).

[5] Current estimates see the Covid pandemic leading to a rise of EU unemployment to around 7.7% in 2020 and 8.6% in 2021 (European Commission 2020a).

[6] European Commission (2015) may be a good starting point.

happened after the financial crisis. Between crises, growth rates hovered around 2% (European Commission 2012; Trading Economics 2019) and pre-Covid growth estimates relevant for the decade 2020-2030 pointed to a range between 1.5% and 2% (Grosand and Alcidi 2013; European Commission 2012; PwC 2017; Knoema 2019; Trading Economics 2019). For the beginning decade, a tangible improvement of the new development path over the previous one is needed. To the extent that improvements in other indicators of well-being – e.g. of public health, harmony with nature, fairness, fulfilling jobs – should materialize, such indicators may later become more salient than GDP growth (Stiglitz et al 2018; Jakob et al 2020).

3. *Inflation rates in line with price stability as defined by the ECB*, that is, currently "below, but close to, 2% over the medium term"(European Central Bank 2019).[7] Runaway inflation experiences are well documented at levels higher than 10%, but there is no evidence suggesting that a monetary policy focusing on a stabilization goal of, say, 4% would be problematic, quite the opposite (Ball 2014). However, an EGD driving inflation higher than the defined upper bound would be obstructed by the ECB raising interest rates. Most observers consider inflation rates since the financial crisis in the EU27 – averaging 1.55% between 2008 and 2019 (Eurostat 2020c) – too low. Forecasts for after the Covid crisis are lower still: 0.7% for 2020 and 1.3% for 2021 (European Commission 2020a). Inflation rates substantially below 2% are an indicator of slack and signal a danger of economic depression. The EGD should help to overcome this condition in the short run and avoid it in the long run.

A proof-of-concept investment profile up to 2030

In view of the above criteria, for the first decade of the EGD, we consider the following annual expenditure profile, building on two previous proposals (Wolf et al 2020; Creel et al 2020). The first items are geared directly towards emissions reductions.

– **A European electricity grid for 100% renewables**. Electricity industry accounts for around 1015 Mt of CO_2e or 27 % of EU emissions (European Environment Agency 2020b). Creel et al (2020) describe the necessity and feasibility of frontloading investments into the European electricity grid for a 100% renewables by 2050 (no fossil nor nuclear fuels) described by the European Network of Transmission System Operators for Electricity (ENTSO-E 2015). Their proposal amounts to an average of about EUR 25 billion annually until 2030.

– **Transforming the car-based mobility system**. There were around 233 million passenger cars in the EU27 in 2018 (computed from European Automobile Manufacturers Association 2019), responsible for about 15% (European Environment Agency 2020b) of the EU27 CO_2 emissions[8] i.e., 469 Mt or about 2 t per car. Currently, passenger transport uses almost 83% passenger cars, 9% motor coaches, and under 8% rail (Eurostat 2020e). Emissions can be reduced via more efficient cars and via shifting the modal split, e.g., to increase the share of public transportation, four times more efficient in terms of CO_2 than cars (UITP 2014). The latter option can provide additional benefits in terms of e.g., noise, air quality, road safety, and health. For cities, large variations in modal split (e.g., under 10% cars in London, or 65% walking in Bilbao (EPOMM 2020)) suggest possibilities for a sustainable mobility system. For a breakthrough towards it (not only for cities), we consider an annual public investment of EUR 20 billion reasonable, rounding up the infrastructure investments proposed by Wolf et al (2020) for charging (5 billion), cycling (5 billion), and local public transport (10 billion).

[7] For a discussion on inflation targets, as part of the ongoing strategy revision of the ECB, see Bremus et al (2020).

[8] European Commission (2020d) states 12%, but an average of about 160 g CO_2/km tailpipe emissions (ICCT 2018) and an average of 12,000 km/year for the EU as a whole (Odyssee Mure 2020) is consistent with the former source.

– **A European Silk Road**. Heavy duty trucks and buses were responsible for about 5.5%, or 208 Mt, of EU GHG emissions in 2018 (European Environment Agency 2020b). As Creel et al (2020) argue, it is time to balance the Chinese Belt and Road initiative with a European Silk Road initiative (see also Holzner et al 2018; Mangalagiu et al 2016). In terms of emissions, this offers a unique opportunity for a shift from yesterday's heavy vehicles to tomorrow's trains.
  If the financing is organized through a special purpose vehicle (SPV) established by EU countries so as to be able to issue long-term bonds at near zero (positive or negative) real interest rates, public investment can be rather small compared to the overall volume. To set up the SPV and to ensure positive spillovers to the European transport network, an annual flow of EUR 20 billion will suffice. The experience with the European Fund for Strategic Investments (EFSI), supporting investments of around EUR 500 billion, using EUR 33.5 billion of public investment and guarantees in 5 years, can serve as an example (European Investment Bank 2020).[9]

– **Accelerating the energetic renovation of the building stock**. Buildings are accountable for 36% of the CO_2 emissions in the EU (European Commission 2016a), presently about 1100 Mt. The largest part of these emissions, about 750 Mt, is due to residential buildings[10]. With about 16 billion m^2 of residential floor space[11], the average is about[12] 47 kg/m^2. Up to now, only about 0.4 to 1.2% (European Commission 2016b) of the building stock has been renovated each year, that is, at most about 150 million m^2. At this pace, renovating the inefficient European building stock – estimated at about 75% of the total (European Commission 2016a) – would take more than sixty years.
  To accelerate energetic renovation of residential buildings, we consider an annual investment in the order of EUR 70 billion. Present estimates of energy renovation costs range from EUR 200 to 450 per m^2, depending on the depth of renovation (European Parliament 2016b). Providing 100 EUR of grants per m^2 out of EUR 70 billion, under condition that house owners invest at least 200 EUR, would allow for energetic renovation of about 700 million m^2 per year.[13]

– **R&D in digitalisation for energy saving**. While the ICT industry produces GHG emission through its own energy use, digitalisation can lead to much larger emission reductions through energy savings – in buildings, transport, industry, households, agriculture and more. With the exception of some specialized niches, the EU ICT sector lags its main global competitors. In the EU, R&D investment by ICT businesses was about 0.2% of GDP, the amount publicly funded less than 0.05% of GDP in recent years (European Commission 2019). We suggest an additional public investment stream of EUR 30 billion, that is, another 0.2% of GDP, to change this situation in the direction of the EGD. These should be disbursed in such a way that they increase incentives for ICT companies to invest in applications promising large-scale energy savings and carry out the respective R&D in cooperation with building companies as well as regulating authorities.

[9] For an analysis of EFSI funded projects see Schütze et al (2020); unlike for EFSI, here the allocation of funds needs to be shifted away from funding airports and highways, e.g., to railways.

[10] Calculation based on relative energy intensity of residential and non-residential buildings as stated by Buildings Performance Institute Europe (2011).

[11] Calculated by subtracting Great Britian's 4 billion from a total EU28 floor space of 25 billion m^2, and taking into account that about 25% of the total floor space are non-residential (European Parliament 2016a).

[12] This is a very crude estimate obtained by dividing total emissions by total square meters. However, as Coma et al (2019) find, data on the European building stock are scarce and for their analysis of six European countries spread over a factor of ten. Hence, we use this estimate.

[13] Grants should be disbursed on a first come, first serve basis, with additional measures such as a CO_2 price and suitable regulations giving a strong signal to house owners that sooner or later their buildings will have to satisfy stringent energy standards in any case.

While the following investment streams cannot be as directly associated with emissions reductions, they are nevertheless essential for such reductions to happen under the given circumstances, e.g., to bring down emissions from industry.

– **Advanced green vocational education** The EGD will disrupt occupational biographies in a number of sectors and requires innovative forms of advanced vocational training nurturing new skills on a broad scale (Jaeger 2014). An annual investment stream of EUR 30 billion can provide education opportunities, including e.g. one year of training for about 10% of the workforce in the construction sector (Wolf et al 2020).

– **A European breakthrough innovation system.** Since World War II, Europe has excelled in continuously improving existing technologies and practices, but not in generating breakthrough innovations. Sometimes, catching up on such innovations developed elsewhere has worked, as in the case of planes and high-speed trains. However, for carbon neutrality, breakthrough innovations will be crucial in fields like green hydrogen, agriculture, ICT, or to bring down costs of transforming existing urban structures. In view of the European Green Deal, industry needs a combination of challenges from regulation and an overhaul of the European innovation system, e.g., along the lines suggested by Mazzucato (2016, 2018).
The US innovation system, which clearly has breakthrough capacity, differs in institutional arrangements[14] and in funding magnitude: US public R&D expenditures at the federal level alone (i.e. without states like Massachusetts or California) are in the order of 0.8% of GDP (Hourihan and Parkes 2019). R&D expenditures of the EU are less than one tenth of that – in 2019, e.g., the EU umbrella program for R&D, Horizon2020, amounted to around EUR 12 billion, i.e. 0.075% of (then EU28) GDP. We hence suggest an additional investment stream of at least EUR 30 billion, or about 0.2% of (now EU27) GDP, as a step into the direction of an innovation system capable of breakthroughs centered on the EGD.

– **Subcontracting management tasks.** Realizing the EGD will require greatly amplifying the managerial capabilities of the EU and its member states. As in many other domains, here public-private partnerships are important. Carefully organized, an annual investment of EUR 10 billion in human capital can become a unique experience of mutual learning by public administration and private enterprise for management at the local, national, and European scale.

– **A European Planetary Health policy.** Finally, it was the Covid-19 crisis that triggered fundamental change in financial resources becoming available to tackle common challenges in the EU. To consolidate this process, it is vital to embed the goal of climate neutrality in the broader ambition of tackling the risks and seizing the opportunities of the Anthropocene. As a response to the Covid-19 pandemic, the EU should develop a European Planetary Health policy (Whitmee et al 2015). Initial tasks are building the capability and infrastructure for real-time monitoring of European health dynamics, rapid large-scale contact tracking and testing, cross-border transfer of medical equipment, vaccines and pharmaceuticals, step-wise development of health-conscious socio-ecological systems, and expansion of global professional information exchange beyond intergovernmental channels. Estimates for appropriate annual investments vary between EUR 20 and 70 billion (European Commission 2020c). As the long-term establishment of a European Planetary Health policy will be a step-wise process, we consider an initial budget of EUR 20 billion per year, to be complemented with investments by the member states.

[14] A discussion of an equivalent of the US DARPA whose backbone will not be the military but the European Green Deal is beyond the scope of the present paper (but see also Marin 2020).

The proposed investment profile sums to an annual public investment of EUR 255 billion which is about 1.8% of the EU27's 2019 GDP and is in the range of volumes previously discussed in view of the EGD (European Commission 2020b).

Feasibility check

To show that the investment profile outlined can shift the EU economy to a new development path compatible with the proposed criteria for emissions, unemployment, growth and inflation, we roughly estimate plausible effects of the investments based on literature and basic calculations. The obvious first step concerns emissions reductions.

- **The emission reduction trend before the EGD**. As the investments proposed here are additional to existing measures, the average annual reductions of the past three decades (about 40 Mt of CO_2e per year) form the basis on which to build. GHG emissions per capita differ widely between European countries, as does, e.g., carbon intensity in electricity generation (from Sweden's 13 g CO_2/kWh to 773 g CO_2/kWh in Poland (European Enviroment Agency 2018)). This leaves room for a continuation of the previous trend if countries can catch up to the least carbon intensive ones.

- **Frontloading of a 100% renewables European electric grid**. Presently, renewables in the EU make up 15% of total energy use, and the state of the grid is a key hindrance to rapidly expanding that share. 30 Mt CO_2e (less than 3% of current emissions from electricity industry) are a conservative estimate for the annual emissions reductions that can be achieved by using the frontloaded ENTSO-E 100% scenario to overcome this hindrance.

- **Transforming the car-based mobility system** With tailpipe emissions of an average car of about 160 g CO_2/km (ICCT 2018) and around 122 g CO_2/km for a new car in 2019 (European Environment Agency 2020a), an old car replaced provides an efficiency gain of about 24%. Investments in charging infrastructure will be critical to achieving the 2020/2021 average fleet emission target of 95 g CO_2/km (European Commission 2020d), corresponding to about 40% gained. About 9 million old cars were replaced in 2018[15]; similar numbers lead to emission reductions of about 7 Mt if the greater efficiency gain is implemented. Further, we consider realistic that the investments outlined lead to a modal shift of 20% from passenger cars to an improved public transport system and 5% to biking and walking by 2030. Roughly, that corresponds to shifting 0.5% to active mobility and 2% to public transport per year. As a percent of the modal shift using cars corresponds to 5.65 Mt of emissions[16], this could save another 11.3 Mt, so that we estimate reductions in the order of 18 Mt annually.

- **The European Silk Road**. Today's railways are up to 9 times less CO_2 intensive than road (Finger et al 2019), and a European Silk Road can constitute a "big push" for a European train-centered freight system of the future (Creel et al 2020). According to CER (2015), a doubling of rail freight transport, with the freight shifted from roads, could result in a reduction of GHG emissions of around 45-55 Mt CO_2e per year. As such an initiative takes time to realize its full potential, we estimate emissions reduction in the order of 20 Mt CO_2e per year.

- **Accelerating the energetic renovation of the building stock**. Renovating "an average inefficient building" into an efficient building means reducing its emissions by

[15] In the EU27, 14.1 million cars were new (Eurostat 2020d) in 2018, but the total number of cars increased by 5 million compared to 2017.
[16] 83% produce 469 Mt.

around 75%[17], or by an average of about 35kg CO_2 per m^2. Renovation of about 0.7 billion m^2 per year, as sketched above, then decreases emissions by about 24.5 Mt.

– **R&D in digitalization for energy saving** Estimates for CO_2 emission reduction potential through ICT range from 0.1-1.0% per year for households alone (Bastida et al 2019) or across the whole society to up to 3.7 % (British Telecommunications 2019). GeSI (2015) estimates net GHG emission reductions in the order of 1.3% per year, corresponding to just under 50 Mt CO_2e in the EU27's early 2020s. To exclude energy savings already accounted for above, we consider 30 Mt CO_2e per year as a conservative estimate.

share (≈)	billion EUR	area of investment/emission reduction	Mt CO_2e	societal benefits
		Emission reduction trend preceding the EGD	39	
10%	25	Frontloading a 100% renewables grid	30	
8%	20	Transforming the car-based mobility system	18	health
8%	20	European Silk Road	20	growth, convergence
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12%	30	Advanced green vocational education	catalyst	cohesion, employment
12%	30	A European breakthrough innovation system	catalyst	employment
4%	10	Subcontracting management tasks for EGD	catalyst	employment
8%	20	European Planetary Health policy	catalyst	health, employment
100%	255	Total public investment per year		
		Total emissions reductions per year	161	

Table 1: Annual EGD investment streams proposed for 2021-2030, emission reductions estimated and main further effects expected.

Thus, the total annual emissions reductions achievable with the investment profile defined in the preceding section fit the requirements for the breakthrough decade 2020-2030, keeping in mind that investment streams into education, a breakthrough innovation system, management, and a planetary health policy support these emissions reductions in general.

Concerning the criterion of growth, EUR 255 billion, being more than 1% of GDP, will lead to additional growth of at least 1.5% of GDP, due to a fiscal multiplier of at least 1.5 (Boitani and Perdichizzi 2018). Together with the pre-crisis trend of around 1.5%, the annual growth rate will thus sum up to at least 3%. According to the International Monetary Fund (2020), in conditions of high uncertainty, like those created by the Covid crisis, the fiscal multiplier might even be larger than 2, as the EUR 255 billion would trigger further private investments. This does not consider important indirect effects, such as the role of technical change, nor the fact that training accelerates the rate of productivity growth (Sala and Silva 2011), so that growth effects can be expected to be larger still in the longer run.

The criterion of unemployment was defined at country level in view of the danger of divergence and the possibility of convergence in the EU. We consider the case of Greece, the EU country worst hit by unemployment, especially for youth. It has 2% of the EU population, about 800.000 unemployed in 2019 (Eurostat 2020a), and a GDP of about EUR 200 billion. Therefore, directing 5% of the EUR 255 billion, i.e. about EUR 13 billion, towards public investments in Greece, would be a shock of about 6% of Greek GDP.

[17] Energy Class A compared to E, or D compared to A+ (Enev Online 2014).

Under present conditions, employment increases by about 1.2% over two years in response to a positive shock of 1% of GDP due to public investment (International Monetary Fund 2020). Considering the resident working age population of about 3.8 million (Eurostat 2020a), with the employment multiplier of 1.2, this shock translates into about 270 000 additional jobs over two years, constituting concrete steps towards the proposed targets, especially if hiring young people is incentivised.

Significant amounts of EGD public investments will need to be directed towards countries with excessive unemployment rates, but of course in such a way that countries near to or at full employment still experience a substantial stimulus. If the EU as a whole can accelerate growth up to the order of 3%, in Greece, employment can further increase to meet the goals. By similar considerations, this holds also for other countries with unemployment rates currently above the stated goals.

Finally, considering the inflation rate, in the present situation, the main challenge for the ECB is to bring average inflation close to 2%. The investment push considered here would make this goal easier to reach, especially if wages catch up with productivity where they are lagging. The required increase of inflation would then facilitate an innovative dynamic of the overall economy, keep the danger of deflation at bay, and create leeway for policy responses in future crises.

Conversely, to avoid a rise of inflation above the target set by the ECB, the quality of the European innovation system and the development of new forms of vocational education become crucial. Improvements in these areas create the capacity and flexibility needed to overcome bottlenecks that might lead to problematically high rates of inflation.

A broader perspective

The present analysis is meant as an initial step in a broader research program for understanding how Europe, and ultimately also other parts of the world, can shift to a new development path characterised by reducing emissions and increasing well-being.

Once reached, public investments needed to maintain such a development path, while still essential, are likely to be lower than the levels needed for the transition itself. Given a decade of large-scale directed technical change, shifting back to a "brown" trajectory once a "green" one has been implemented is unlikely (Acemoğlu et al 2012) and similarly, for change in behaviour and social norms that leads to improved living conditions, such as cities with less pollution, noise, etc (Gehl and Rogers 2013).

It is setting in motion the virtuous circle of investment, well-being, and innovation towards such a new development path that requires further research on potential options and development of the relevant technologies. Dialogue processes with decision makers and citizens, for deliberating what is desirable in a given context and for negotiating who contributes how to the necessary changes, are just as important. Against this background, a co-evolutionary development of policies, technologies, cultural values, and economic institutions seems to offer the best chance of successfully designing and implementing the European Green Deal.

The structure of a Green Deal outlined here is intended as a proof of concept, putting up for discussion elements and orders of magnitude that are feasible, relevant for, and consistent with a shift to the new development path indicated. It also points to questions that will need answering, such as the creation of a European innovation system capable of the breakthrough innovations needed to decarbonize not only Europe but the world economy as a whole.

A related and even more daunting challenge lies in establishing a common will to realize the European Green Deal across EU member states. The nationally fragmented initial response to Covid-19 has confirmed the need for reversing the trend of decreasing European cohesion, observable in rising support for anti-European parties in many countries, with

Brexit as its most obvious example. It remains to be seen whether and how the ambitious mission of becoming the first climate-neutral continent may be turned into an opportunity for uniting the European people.

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References

Acemoğlu D, Aghion P, Bursztyn L, Hemous D (2012) The Environment and Directed Technical Change. American Economic Review 102(1):131–166

Algan Y, Guriev S, Papaioannou E, Passari E (2017) The European Trust Crisis and the Rise of Populism. Brookings Papers on Economic Activity Fall edition:309–382

Anderson J, Bergamini E, Brekelmans S, Cameron A, Darvas Z, Domínguez Jiménez M, Lenaerts K, Midões C (2020) The fiscal response to the economic fallout from the coronavirus. Bruegel datasets

Bacher J, Tamesberger D (2020) COVID-19 Crisis: How to Avoid a 'Lost Generation'. Intereconomics 55:232–238, DOI 10.1007/s10272-020-0908-y

Ball L (2014) The Case for a Long-Run Inflation Target of Four Percent. IMF Working Paper WP/14/92, URL https://www.imf.org/external/pubs/ft/wp/2014/wp1492.pdf, (12 December 2019)

Bastida L, Cohen JJ, Kollmann A, Moya A, Reichl J (2019) Exploring the role of ICT on household behavioural energy efficiency to mitigate global warming. Renewable and Sustainable Energy Reviews 103:455–462, DOI https://doi.org/10.1016/j.rser.2019.01.004

Blanchet T, Chancel L, Gethin A (2019) How Unequal Is Europe? Evidence from Distributional National Accounts, 1980-2017. URL https://wid.world/document/bcg2019-full-paper/, (12 December 2019)

Boitani A, Perdichizzi S (2018) Public Expenditure Multipliers in recessions. Evidence from the Eurozone. Università Cattolica del Sacro Cuore - Dipartimento di Economia e Finanza, March 2018, URL https://dipartimenti.unicatt.it/economia-finanza-def068.pdf, (23 February 2020)

Bremus F, Dany-Knedlik G, Schlaak T (2020) Price Stability and Climate Risks: Sensible Measures for the European Central Bank. DOI https://doi.org/10.18723/diw_dwr:2020-14-1, URL https://www.diw.de/de/diw_01.c.745707.de/publikationen/weekly_reports/2020_14_1/price_stability_and_climate_risks__sensible_measures_for_the_european_central_bank.html

British Telecommunications (2019) The role of ICT in reducing carbon emissions in the EU. URL https://www.btplc.com/Purposefulbusiness/Ourapproach/Ourpolicies/ICT_Carbon_Reduction_EU.pdf, (28 January 2020)

Brooks R, Fortun J (2020) Eurozone Output Gaps and the COVID-19 Shock. Intereconomics 55:291–296, URL https://www.intereconomics.eu/contents/year/2020/number/5/article/eurozone-output-gaps-and-the-covid-19-shock.html

Buildings Performance Institute Europe (2011) Europe's buildings under the microscope. URL http://bpie.eu/wp-content/uploads/2015/10/HR_EU_B_under_microscope_study.pdf, (18 October 2020)

CER - The Community of European Railway and Infrastructure Companies (2015) Railroad and Enviroment Facts and Figures. URL https://www.cer.be/sites/default/files/publication/Facts%20and%20figures%202014.pdf, (10 October 2020)

Coma J, Maldonado JM, de Gracia A, Gimbernat T, Botargues T, Cabeza LF (2019) Comparative Analysis of Energy Demand and CO2 Emissions on Different Typologies of Residential Buildings in Europe. Energies 12(12), DOI 10.3390/en12122436, URL https://www.mdpi.com/1996-1073/12/12/2436

Creel J, Holzner M, Saraceno F, Watt A, Wittwer J (2020) How to Spend it: A Proposal for a European Covid-19 Recovery Programme. The Vienna Institute for International Economic Studies Policy Notes and Reports 30, URL https://wiiw.ac.at/how-to-spend-it-a-proposal-for-a-european-covid-19-recovery-programme-dlp-5352.pdf

Enev Online (2014) Einteilung in Energieeffizienzklassen. URL https://enev-online.com/enev_2014_volltext/anlage_10_einteilung_in_energieeffizienzklassen.htm, (1 September 2020)

ENTSO-E (2015) Europe's future secure and sustainable electricity infrastructure – e-Highway2050 project results. URL https://docs.entsoe.eu/baltic-conf/bites/www.e-highway2050.eu/fileadmin/documents/e_highway2050_booklet.pdf, (11 October 2020)

EPOMM (2020) TEMS - The EPOMM Modal Split Tool. URL http://epomm.eu/tems/index.phtml, (17 February 2020)

European Automobile Manufacturers Association (2019) ACEA Report Vehicles in use Europe 2019. URL https://www.acea.be/uploads/publications/ACEA_Report_Vehicles_in_use-Europe_2019.pdf, (30 November 2020)

European Central Bank (2019) Inflation the in Euro Area, European Central Bank. URL https://www.ecb.europa.eu/mopo/html/index.en.html, (06 January 2020)
European Commission (2012) Global Europa 2050, European Union. URL https://ec.europa.eu/research/social-sciences/pdf/policy_reviews/global-europe-2050-report_en.pdf, (06 January 2020)
European Commission (2015) An even closer Union amongst the people of Europe? – Rising inequalities in the EU and their social, economic and political impacts. Outcomes of EU-funded research. URL https://op.europa.eu/de/publication-detail/-/publication/13d51aaa-e287-4b1f-a082-eb560d50817e, (15 November 2020)
European Commission (2016a) Energy performance of buildings directive: Factsheet. URL https://ec.europa.eu/energy/content/factsheet-energy-performance-buildings-directive_en, (17 January 2020)
European Commission (2016b) EU Building Stock Observatory. URL https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/eu-bso_en?redir=1, (8 February 2020)
European Commission (2019) The EU ICT Sector and its R and D Performance. URL https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=59978, (15 October 2020)
European Commission (2020a) Autum 2020 Economic Forecast. URL https://ec.europa.eu/info/sites/info/files/economy-finance/ecfin_forecast_autumn_2020_overview_en.pdf, (1 December 2020)
European Commission (2020b) Financing the green transition: The European Green Deal Investment Plan and Just Transition Mechanism. URL https://ec.europa.eu/commission/presscorner/detail/en/ip_20_17, (20 November 2020)
European Commission (2020c) Identifying Europe's recovery needs. URL https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020SC0098&from=EN, (25 November 2020)
European Commission (2020d) Reducing CO2 emissions from passenger cars. URL https://ec.europa.eu/clima/policies/transport/vehicles/cars_en, (2020)
European Enviroment Agency (2018) Overview of electricity production and use in Europe. URL https://www.eea.europa.eu/data-and-maps/indicators/overview-of-the-electricity-production-2/assessment-4, (18 February 2020)
European Environment Agency (2020a) Average CO2 emissions from newly registered motor vehicles in Europe. URL https://www.eea.europa.eu/data-and-maps/indicators/average-co2-emissions-from-motor-vehicles/assessment-2, (18 November 2020)
European Environment Agency (2020b) EEA greenhouse gas - data viewer. URL https://www.eea.europa.eu/ds_resolveuid/f4269fac-662f-4ba0-a416-c25373823292, (19 November 2020)
European Investment Bank (2020) The European Fund for Strategic Investments: The Legacy. DOI DOI:10.2867/279140, URL https://www.eib.org/en/publications/efsi-the-legacy
European Parliament (2016a) Boosting Building Renovation: What potential and value for Europe? URL https://www.europarl.europa.eu/RegData/etudes/STUD/2016/587326/IPOL_STU(2016)587326_EN.pdf, (8 October 2020)
European Parliament (2016b) Global Europa 2050, European Union. URL https://www.europarl.europa.eu/RegData/etudes/STUD/2016/587326/IPOL_STU(2016)587326_EN.pdf, (17 January 2020)
European Parliament (2020) Statement by European Parliament President David Sassoli to the World Economic Forum in Davos. URL https://www.europarl.europa.eu/the-president/en/newsroom/sassoli-enough-of-the-obsession-with-profit-green-deal-must-be-an-opportunity-to-fight-inequality, (2 February 2020)
Eurostat (2020a) Employment and activity by sex and age - annual data. URL https://ec.europa.eu/eurostat/databrowser/view/lfsi_emp_a/default/table, (2 December 2020)
Eurostat (2020b) Greenhouse gas emissions by source sector. URL https://ec.europa.eu/eurostat/databrowser/view/ENV_AIR_GGE/default/table, (15 Ocotber 2020)
Eurostat (2020c) HICP - inflation rate. URL https://ec.europa.eu/eurostat/databrowser/view/tec00118/default/table?lang=en, (2 January 2020)
Eurostat (2020d) New registrations of passenger cars by type of motor energy and engine size. URL http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_eqr_carmot&lang=en, (12 March 2020)
Eurostat (2020e) Passenger transport statistics. URL https://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_transport_statistics, (17 July 2020)
Eurostat (2020f) Unemployment rate - annual data. URL https://ec.europa.eu/eurostat/databrowser/view/tipsun20/default/table?lang=en, (1 December 2020)
Eurostat (2020g) Unemployment rates, seasonally adjusted. URL https://ec.europa.eu/eurostat/statistics-explained/index.php/Unemployment_statistics, (20 January 2020)
Financial Times (2020) Ford to pair with rivals to avoid EU fines over emissions. URL https://www.ft.com/content/d8a17d40-e242-4fc6-aa8e-e5c4a121ba0e, (15 October 2020)
Finger M, Teodora S, Lapenkova I (2019) Green Finance and Sustainability – Which Role for Railways? Robert Schuhman Centre for Advanced Studies, February 19, URL https://cadmus.eui.eu/bitstream/handle/1814/61345/PB_2019_05_FSR_Transport.pdf?sequence=1&isAllowed=y, (21 February 2020)
Gehl J, Rogers R (2013) Cities for People. Island Press

GeSi – Global e-sustainability initiative (2015) SMARTer2030 ICT Solutions for 21st Century Challenges. URL https://unfccc.int/sites/default/files/smarter2030_executive_summary.pdf, (13 October 2020)

Gräbner C, Heimberger P, Kapeller J, Schütz B (2020) Is the Eurozone disintegrating? Macroeconomic divergence, structural polarisation, trade and fragility. Cambridge Journal of Economics 44:647–669

Grosand D, Alcidi C (2013) The Global Economy in 2030: Trends and Strategies for Europe, Centre for European Policy Studies. URL https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/The%20Global%20Economy%20in%202030.pdf, accessed 14 December 2019

Holzner M, Heimberger P, Kochnev A (2018) A European Silk Road. The Vienna Institute for International Economic Studies, URL https://wiiw.ac.at/a-european-silk-road-dlp-4608.pdf, (19 October 2020)

Hourihan M, Parkes D (2019) Federal R&D Budget Trends: A Short Summary. URL https://www.aaas.org/news/federal-rd-budget-trends-short-summary, (25 November 2020)

ICCT (2018) Effects of battery manufacturing on electric vehicle life-cycle greenhouse gas emissions. URL https://theicct.org/publications/EV-battery-manufacturing-emissions, (22 April 2020)

International Monetary Fund (2020) Fiscal Monitor Reports Fiscal Monitor: Policies for the Recovery. URL https://www.imf.org/en/Publications/FM/Issues/2020/09/30/october-2020-fiscal-monitor, (19 October 2020)

Jaeger C (2014) A Choice for China: What Role for Vocational Education in Green Growth? China & World Economy 22:55–75, URL https://www.researchgate.net/publication/265646568_Choice_for_China_What_Role_for_Vocational_Education_in_Green_Growth

Jaeger CC (2012) Scarcity and coordination in the global commons. In: Jaeger CC, Hasselmann K, Leipold G, Mangalagiu D, Tábara JD (eds) Reframing the Problem of Climate Change: From Zero Sum Game to Win-Win Solutions, Routledge, pp 85–101

Jaeger CC, Paroussos L, Mangalagiu D, Kupers R, Mandel A, Tábara JD (2011) A New Growth Path for Europe – Generating Prosperity and Jobs in the Low-Carbon Economy. Synthesis Report, A study commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Berlin, URL https://globalclimateforum.org/fileadmin/ecf-documents/Press/A_New_Growth_Path_for_Europe__Synthesis_Report.pdf

Jaeger CC, Schütze F, Fürst S, Mangalagiu D, Meißner F, Mielke J, Steudle G, Wolf S (2015) Investment-Oriented Climate Policy: An opportunity for Europe. A study commissioned by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Berlin

Jakob M, Lamb W, Steckel J, Flachsland C, Edenhofer O (2020) Understanding different perspectives on economic growth and climate policy. WIREs Climate Change DOI https://doi.org/10.1002/wcc.677

Knoema (2019) European Union GDP Growth Forecast 2019-2024. Data and Charts URL https://knoema.com/mewdmh/european-union-gdp-growth-forecast-2019-2024-data-and-charts, knoema, accessed 01 December 2019

von der Leyen U (2019) A Union that strives for more – My agenda for Europe, European Commission. URL https://ec.europa.eu/commission/sites/beta-political/files/political-guidelines-next-commission_en.pdf, (01 December 2019)

Mangalagiu D, Meissner F, Mielke J, Jaeger C (2016) A Green Corridor for Europe Connecting the EU and the Balkans – Background Paper No 1: the Western Balkans. Global Climate Forum, URL https://globalclimateforum.org/fileadmin/ecf-documents/pdf/Microsoft_Word_-_Green_Corridor_Study_GCF.docx.pdf, (19 October 2020)

Marin D (2020) Europe Needs a DARPA. URL https://www.project-syndicate.org/commentary/germany-europe-need-government-technology-research-agency-by-dalia-marin-2020-02?barrier=accesspaylog, (20 August 2020)

Mazzucato M (2016) From market fixing to market-creating: a new framework for innovation policy. Industry and Innovation 23(2):140–156, DOI 10.1080/13662716.2016.1146124

Mazzucato M (2018) Mission-oriented innovation policies: challenges and opportunities. Industrial and Corporate Change 27(5):803–815, DOI 10.1093/icc/dty034, URL https://doi.org/10.1093/icc/dty034

Odyssee Mure (2020) Change in distance traveled by car. URL https://www.odyssee-mure.eu/publications/efficiency-by-sector/transport/distance-travelled-by-car.html, (22 November 2020)

Patt A, Lilliestam J (2018) The case against carbon prices. Joule 2(12):2494 – 2498, DOI https://doi.org/10.1016/j.joule.2018.11.018, URL http://www.sciencedirect.com/science/article/pii/S2542435118305671

PwC (2017) The Long View – How will the global economic order change by 2050? URL https://www.pwc.com/gx/en/world-2050/assets/pwc-the-world-in-2050-full-report-feb-2017.pdf, PricewaterhouseCoopers International, accessed 12 December 2019

Sala H, Silva J (2011) Labor Productivity and Vocational Training: Evidence from Europe. Journal of Productivity Analysis 40, DOI 10.1007/s11123-012-0304-0

Schütze F, Fürst S, Mielke J, Steudle GA, Wolf S, Jaeger CC (2017) The role of sustainable investment in climate policy. Sustainability 9(12):2221, URL http://dx.doi.org/10.1007/s00191-006-0026-4

Schütze F, Stede J, Blauert M, Erdmann K (2020) EU taxonomy increasing transparency of sustainable investments. DOI https://doi.org/10.18723/diw_dwr:2020-51-1, URL https://www.diw.de/documents/publikationen/73/diw_01.c.807288.de/dwr-20-51-1.pdf

Stiglitz J, Fitoussi JP, Durand M (2018) Beyond GDP: Measuring What Counts for Economic and Social Performance. OECD Library, DOI https://doi.org/10.1787/9789264307292-en, URL https://www.oecd-ilibrary.org/economics/beyond-gdp_9789264307292-en

Trading Economics (2019) European Union GDP Annual Growth Rate, Trading Economics. URL https://tradingeconomics.com/european-union/gdp-annual-growth-rate, accessed 11 December 2019

UITP (2014) Climate action and public transport. URL https://cms.uitp.org/wp/wp-content/uploads/2020/10/Climate-action-and-PT.pdf, (20 November 2020)

UN News (2020) 'Enhance solidarity' to fight COVID-19, Chinese President urges, also pledges carbon neutrality by 2060. URL https://news.un.org/en/story/2020/09/1073052, (1 October 2020)

Whitmee S, Haines A, Beyrer C, Boltz F, Capon AG, de Souza Dias BF, Ezeh A, Frumkin H, Gong P, Head P, Horton R, Mace GM, Marten R, Myers SS, Nishtar S, Osofsky SA, Pattanayak SK, Pongsiri MJ, Romanelli C, Soucat A, Vega J, Yach D (2015) Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation – Lancet Commission on planetary health. The Lancet 386:1973–2928

Wolf S, Mielke J, Schütze F, Teitge J, Jaeger CC (2020) About the European Green Deal. GCF Working Paper 1/2020. https://globalclimateforum.org/2020/03/11/new-gcf-working-paper-01-20-about-the-european-green-deal/