A New Growth Path for Europe

Generating Prosperity and Jobs in the Low-Carbon Economy

Synthesis Report

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A study commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

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1 Executive Summary

Josef Ackermann: "Make no mistake: a new world order is emerging. The race for leadership has already begun. For the winners, the rewards are clear: Innovation and investment in clean energy technology will stimulate green growth; it will create jobs; it will bring greater energy independence and national security." [1]

Jean-Claude Trichet: "When the crisis came, the serious limitations of existing economic and financial models immediately became apparent. In the face of the crisis, we felt abandoned by conventional tools. [...] we need to develop complementary tools to improve the robustness of our overall framework [...] we may need to consider a richer characterization of expectation formation." [2]

Post-crisis Europe can revitalize its economy by tackling the climate challenge. Raising the European climate target from 20% to 30% emissions reductions can open the way towards higher growth and increased employment. The financial crisis has reduced European GDP by several percentage points; if business as usual prevails, the EU growth path will proceed at a lower level than before the crisis. What is more, under business as usual it will be hard to even maintain the growth rate of the pre-crisis times. As a result, unemployment across Europe is likely to stay high, with major disparities between different regions. Sticking to the 20% target in a situation where this target has become too weak to mobilize innovations and to stabilize political will is the equivalent of digging deeper while being stuck in a hole.

It is time for boldness. Clear policies associated with a decisive move to a 30% target, can be doubly beneficial for the climate and the EU economy. The climate target must not be pursued in isolation, but be embedded in a comprehensive range of measures, setting expectations for growth of the European economy at a more ambitious level. What matters is to explicitly declare an ambitious growth target in the aftermath of the financial crisis and to pursue this target on a variety of fronts – including incentives for additional investment, growth-oriented fiscal policy, public procurement, and, of course, climate policy. With this strategy, Europe can define its role in the global economy by focussing on high-quality products where stable unit costs do not depend on low wages but on continuous learning-by-doing. European industry can then maintain and enhance its competitiveness by developing the low-carbon materials and technologies that will shape the future.

In the coming decade, Europe will need to accept the challenge of increasing economic growth while reducing both unemployment and greenhouse gas emissions. New model results show that these three goals can actually reinforce one another. Over the coming decade raising the EU's climate target from 20% to 30% can foster the following outcomes by 2020:

[1] CEO of Deutsche Bank, December 2010 (Ackerman 2010).
[2] President of the European Central Bank, November 2010 (Trichet 2010).

- increase the growth rate of the European economy by up to 0.6% per year
- create up to 6 million additional jobs Europe-wide
- boost European investments from 18% to up to 22% of GDP
- increase European GDP by up to $\$_{2004}$842 bn
- increase GDP by up to 6% both in the old (EU15) and new (EU12) member states.

The economic opportunities of a European 30% reduction scenario are available independently of an international post-2012 climate agreement. The simulations performed for the present study assume domestic reductions of 30% and no international climate agreement that would go beyond the modest pledges made in the Copenhagen Agreement of 2009. If more ambitious goals should be pursued in the future by major economies, the positive impacts for Europe would be even larger.

Along the new growth path, all broad economic sectors – agriculture, energy, industry, construction, and services – increase production, with the largest increase in construction. The new growth path implies a major effort to retrofit buildings and enhance the built environment. This is advantageous in view of employment because people with very different vocational skills can operate in these sectors after a few months of on-the-job training (in construction, as in the industry, nowadays the majority of jobs are not centered around manual work - and there too, on-the-job training can be very effective).

Emissions are reduced by increasing energy efficiency and shifting from coal to renewables and gas. Energy efficiency is mainly, but not only, a matter of buildings. Over the next decade, renewables will be mainly wind, both on- and offshore. Carbon capture, photovoltaics, and nuclear cannot make much of a difference over this time span. Nevertheless, it will be important to prepare for the longer term too. The shift towards gas can raise concerns about energy security. European imports of natural gas, however, are reasonably diversified. The largest supplier, i.e. Russia, delivers just one third of total imports. Due to the expansion of shale gas in the USA and the Chinese determination to limit dependency on energy imports, Europe is a vital customer for Russia. However, Eastern European countries need improved transport and infrastructure for gas imported into Western Europe, and storage facilities need to be improved across Europe.

The key for this revitalization is a substantial increase of investment in Europe. Building wind turbines, implementing cogeneration of heat and electricity, insulating houses, modernizing the power grid, etc., all require substantial investment. If this green investment simply displaced investment in other sectors – tool-making, health, education, etc. – growth would not speed up and employment would only be re-allocated between sectors, without reducing the number of unemployed. However, in the coming years green investment can be part of a broader surge of investment. After the global crisis of 1929, such a surge of investment in Europe as elsewhere was initiated by the perspective of military armament. Nowadays, this is obviously not an option. However, after the financial crisis of 2007–08, the perspective of sustainable development can mobilize investment in a similar way for a worthier purpose. The new model results show that it is possible to increase the EU climate target to 30% while

achieving investments 25% higher than in business as usual. The share of investment in GDP, which under business as usual would be 18%, will then be up to 4 percentage points higher.

The basic mechanism creating this opportunity for a new growth path is the mobilization of a virtuous circle of additional investment, learning-by-doing and expectation formation. It works as follows:

- If the EU announces and implements a new growth strategy including an ambitious target for emissions reduction, it can trigger additional investments that increase the share of gross investment in GDP by up to 4%.
- This substantial additional investment induces learning-by-doing across the economy as a whole, and at an even higher rate when it comes to new technologies like advanced construction materials, renewable energy and more.
- Learning-by-doing in turn increases competitiveness and thus spurs economic growth, thereby improving the expectations of investors.
- If the EU stabilizes the enhanced expectations of investors by policies consistently oriented to increasing sustainability, it can stabilize the new investment behavior and lead the European economy to a superior growth path.

The experience of the global financial crisis shows that the existing economic models were seriously limited. Against this background, a fundamental overhaul of European climate policy models is required. To identify and assess options for climate policy we need models that meet the challenges exposed by the financial crisis. For example, the models that were state-of-the-art before the crisis assumed that economic systems have a single stable equilibrium. Studies based on this kind of models imply that reducing greenhouse gas emissions creates extra costs in the coming years in order to avoid damages in the distant future – thereby win-win strategies are excluded by construction. A key problem of climate policy is, however, to balance the short-term view of businesses with the much longer-term view required from policy-makers aware of climate change. The financial crisis has exposed the fact that different expectations can lead to different investment behaviors, turning those expectations into self-fulfilling prophecies. Research has now started to take this into account in models used for policy advice.

For the first time in the academic climate modeling field, the present study has taken a state-of-the-art model of climate economics and enhanced it along those lines. The enhanced model includes:

- the fact that investments depend on subjective expectations, not on correct previsions of whatever future possibilities may arise
- the fact that higher investments trigger higher learning-by-doing, thereby reducing unit costs
- the resulting existence of different possible equilibria with different growth paths.

The new simulations show that 30% is achievable and can be economically beneficial by shifting the European Economy into a new, more advantageous equilibrium – a path of low-carbon growth. This result is consistent with upper bound green growth scenarios of previous studies. However, Europe is in danger of falling prey to a self-fulfilling prophecy of low growth. The 30% reduction target offers the opportunity to break out of this predicament. This phenomenon is well known: a new challenge can mobilise capabilities that could not be tapped without it. Similarly, economic systems have different possible regimes that can be activated in the face of different challenges.

To realise the win-win opportunity that comes with the 30% reduction target requires consistent policies and measures that reframe expectations in a broader framework of low-carbon growth. In addition to existing or proposed EU policies and measures, the present study considers that the move to 30% requires the following macro- and micro-economic measures:

- Macro-economic measures, e.g.:
  - Using part of the ETS auctioning revenue and resources from the structural funds to support mitigation efforts in Eastern European countries.
  - Incentivising entrepreneurial investment by tax relief balanced with marginal tax increases on capital incomes used for other purposes.
  - Building in low-carbon growth expectations in public procurement.
  - Managing growth expectations along the lines central banks manage inflation expectations.
- Micro-economic measures e.g.:
  - Enhancing building codes to foster investment in energy efficiency; enhancing standards for energy efficiency in transport.
  - Using part of the ETS auctioning revenue to foster energy efficiency and renewable energies.
  - Standardising smart grid infrastructures and smart household appliances.
  - Creating learning networks of businesses developing innovative solutions across Europe.

2

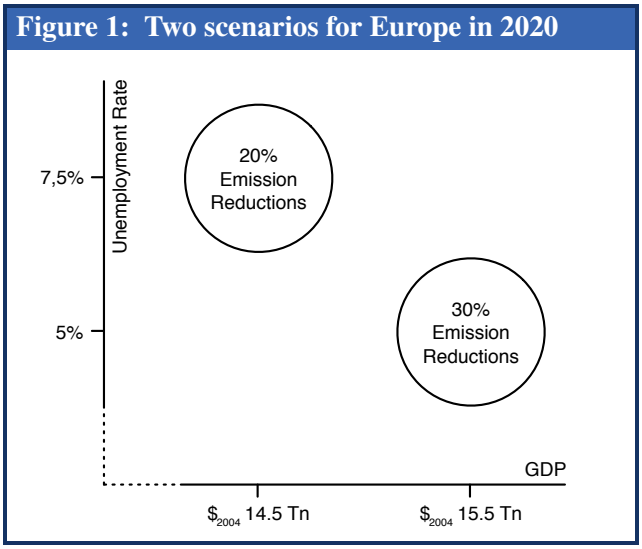
Growth, Jobs, and Emissions

2.1 Boosting the European Economy

Before the financial crisis of 2007–08, GDP per capita was growing in Europe at a rate of slightly more than 2% per year. The crisis has reduced European GDP by about 4%, and there is no sign that this loss will be fully compensated anytime soon. It is likely that if Europe follows business as usual regional disparities in Europe will increase and average unemployment will stay high. In fact, decision-makers, investors, and the general public begin to expect such a future. This is a dangerous development: such expectations can turn into self-fulfilling prophecies.

However, post-crisis Europe can revitalize its economy by developing a credible vision of additional investment leading to higher growth and more jobs. The challenge of building a low-carbon economy can provide that vision. In line with OECD terminology (see www.oecd.org/greengrowth) we label the result as *green growth.* What will make the difference against business as usual is not simply investment in windfarms and the like. It is the shared understanding that developing the quality of life that comes with a sustainable future provides plenty of avenues for mutually reinforcing investments – in education, health, entertainment, housing, transport, and much more. In this perspective, raising the European climate target from 20% to 30% emission reduction can open the way towards higher growth and increased employment (Figure 1).

Figure 1: Two scenarios for Europe in 2020



Source: own analysis based on GEM-E3 simulations.

The financial crisis has reduced emissions, but in the wrong way. Now the target of reducing greenhouse gas emissions by 20% in 2020 as compared to 1990 is not a challenge any more.

It has become too weak to mobilize innovations and to stabilize political will. Sticking to that target is the equivalent of digging deeper while being stuck in a hole.

It is time for boldness. Clear policies, associated with a decisive move to a 30% target, can lead Europe towards a new growth path, one that is doubly beneficial for the climate and the EU economy. For this purpose, the climate target must not be pursued in isolation, but be embedded in a comprehensive range of measures, setting expectations for growth of the European economy at a more ambitious level. What matters is to explicitly declare an ambitious growth target in the aftermath of the financial crisis and to pursue this target on a variety of fronts – including incentives for additional investment, growth-oriented fiscal policy, public procurement, and of course climate policy.

The question is whether in the coming decade Europe will accept the challenge of increasing economic growth while reducing both unemployment and greenhouse gas emissions. New model results show that these three goals can actually reinforce one another. The simulations performed for the present study assume domestic reductions of 30% and no international climate agreement that would go beyond the modest pledges made in the Copenhagen Agreement of 2009. If more ambitious goals should be pursued in the future by major economies, the positive impacts for Europe would be larger. Under the given assumptions, over the coming decade raising the EU's climate target from 20% to 30% can foster the following outcomes (Table 1):

- increase the growth rate of the European economy by up 0.6% per year
- create up to 6 million additional jobs Europe-wide
- boost European investments from 18% to up to 22% of GDP in 2020
- increase European GDP in 2020 by $\$_{2004}$842 bn

Table 1: Macroeconomic features, EU27

	Green Growth	Business as Usual	Δ
GDP in 2020 (billion $\$_{2004}$)	15421	14579	5.77%
GDP growth-rate 2010–2020	2.8%	2.2%	0.6*pp*
Unemployment rate in 2020	5.3%	7.6%	−2.3*pp*
Number of unemployed (millions)	13.4	19.4	−30.9%
Investment in 2020 (share of GDP)	22.4%	18.4%	4.0*pp*
Investment in 2020 (billion $\$_{2004}$)	3457	2685	28.8%
Emissions (Mt of CO_2e)	3927	4414	−11.0%
Carbon Price (€/t CO_2)	32.19	19.47	65.3%

Δ: Difference 20% vs. 30% either as percentage of 20% value or as difference in percentage points (pp).
Source: own analysis based on GEM-E3 simulations.

There are two reasons why this may seem too good to be true. First, it is often taken for granted that GDP can only be increased with increased emissions. There are, no doubt, situa-

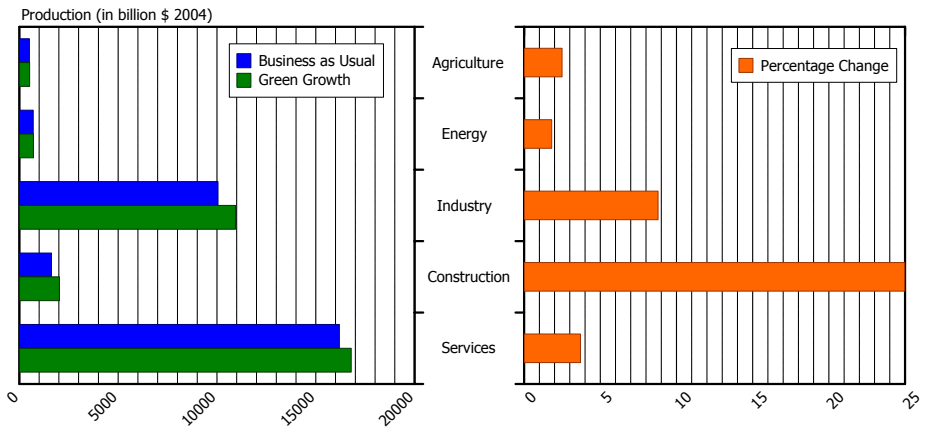
tions where this is true, but in Europe in the years to come, serious emission reductions imply higher growth than business as usual. The reason is straightforward: such reductions require a renewal of the built environment, and the built environment is by far the largest component of the overall capital stock. Therefore, its renewal implies larger investment and therefore larger growth. To a lesser, but still significant extent, the same is true for investments in the energy efficiency of machinery and in renewable energy.

The second issue of relevance here is whether larger investment can indeed generate higher growth beyond the 2.2% that business as usual promises. The fact that before the financial crisis many European countries did indeed experience much higher growth suggests that this may well be possible. And there is ample evidence to the effect that investment induces productivity gains via learning-by-doing, especially in the case of new technologies like renewables or new building materials.

2.2 Sectoral Dynamics

Along the new growth path, all broad economic sectors – agriculture, energy, industry, construction, and services – increase production (Figure 2). Even the energy sector gains, mainly because of the expansion of renewables. The largest procentual – although not absolute – increase happens in construction. The new growth path implies a major effort to retrofit buildings and enhance the built environment. This is advantageous in view of employment because people with very different vocational skills can operate in this sectors after a few months of on-the-job training (in construction, as in the industry, nowadays the majority of jobs is not centered around manual work - and there too, on-the-job training can be very effective).

Figure 2: Production by Sector, EU27



Source: own analysis based on GEM-E3 simulations.

Emissions are reduced in all sectors except construction. The emissions reductions achieved by increased energy efficiency of buildings is much larger than the additional emissions from construction, however. Across the European economy, emissions are reduced by increasing

energy efficiency and shifting from coal to renewables and gas. Energy efficiency is mainly, but not only, a matter of buildings. Over the next decade, renewables will be mainly wind, both on- and offshore. Carbon capture, photovoltaics and nuclear cannot make much of a difference over this time span. Nevertheless, they will be important to prepare for the longer term. The evolution of production costs and public acceptability will determine their future prospects.

The shift towards gas sometimes can raise concerns about energy security. European imports of natural gas, however, are reasonably diversified. The largest supplier, i.e. Russia, delivers just one third of total imports. Other major suppliers are Norway, Algeria, and Qatar. Due to the expansion of shale gas in the USA and the Chinese determination to limit dependency on energy imports, Europe is a vital customer for Russia. However, Eastern European countries need improved transport opportunities for gas imported into Western Europe, and in order to deal with the vagaries of fossil fuel markets storage facilities need to be improved across Europe.

2.3 Regional Dynamics

Not only is the new growth path quite balanced with regard to sectors, it is also remarkably balanced between old and new member states, i.e. EU15 and EU12 countries (Tables 2 and 3).

Table 2: Macroeconomic features, EU15

	Green Growth	Business as Usual	Δ
GDP in 2020 (billion $\$_{2004}$)	14373	13594	5.7%
GDP growth-rate 2010–2020	2.7%	2.1%	0.6*pp*
Unemployment rate in 2020	5.1%	7.4%	−2.3*pp*
Investment in 2020 (share of GDP)	22.1%	18.1%	4.0*pp*
Investment in 2020 (billion $\$_{2004}$)	3178	2459	29.2%
Emissions (Mt of CO_2e)	3164	3581	−11.6%

Δ: Difference 20% vs. 30% either as percentage of 20% value or as difference in percentage points (pp).
Source: own analysis based on GEM-E3 simulations.

In both groups of countries, average growth rates are about 0.5% larger on the new growth path than for business as usual. This also means that the catch-up process of EU12 is maintained. The unemployment rate, which is somewhat higher in the EU12, decreases slightly more in this group of countries. Emissions, which are much larger in EU15, decrease more there. Overall, it is clear that none of the two groups of countries is at a disadvantage with the new growth path.

Table 3: Macroeconomic features, EU12

	Green Growth	Business as Usual	Δ
GDP in 2020 (billion $\$_{2004}$)	1048	986	6.3%
GDP growth-rate 2010–2020	3.8%	3.2%	0.6*pp*
Unemployment rate in 2020	6.1%	8.7%	−2.6*pp*
Investment in 2020 (share of GDP)	26.7%	22.9%	3.8*pp*
Investment in 2020 (billion $\$_{2004}$)	279	226	23.5%
Emissions (Mt of CO_2e)	763	833	−8.4%

Δ: Difference 20% vs. 30% either as percentage of 20% value or as difference in percentage points (pp).
Source: own analysis based on GEM-E3 simulations.

Even within the two groups, the new growth path is remarkably balanced. Table 4 gives a breakdown by countries: the new growth path corresponds pretty much to a tide that lifts all boats.

This holds for the EU12 as well (Table 5). The figures for emissions must not be misunderstood as normative assignments of emissions quota. They are important, though, because they show that economically reasonable emission reductions can be distributed among countries in ways that seem quite fair from a common sense point of view.

Table 4: Macroeconomic features by country, EU15

		GDP in 2020 (billion $\$_{2004}$)	GDP growth rate	Unemployment rate	Investment in 2020 (share of gdp)	Investment in 2020 (billion $\$_{2004}$)	Emission (Mt)
Austria	-20%	310	2.0%	4.7%	20.8%	64.7	86.3
	-30%	320	2.3%	3.6%	25.9%	82.7	78.5
	Δ	3.2%	0.3pp	-1.1pp	5.1pp	27.9%	-9.1%
Belgium	-20%	449	2.2%	7.8%	22.5%	101.1	111.0
	-30%	476	2.8%	5.3%	26.9%	127.7	105.0
	Δ	6.0%	0.6pp	-2.5pp	4.4pp	26.3%	-5.4%
Germany	-20%	2914	1.8%	8.5%	14.9%	433.2	880.1
	-30%	3103	2.4%	5.6%	18.6%	576.5	742.8
	Δ	6.5%	0.6pp	-2.9pp	3.7pp	33.1%	-15.6%
Denmark	-20%	239	1.6%	5.0%	18.2%	43.5	61.9
	-30%	245	1.9%	3.8%	21.7%	53.2	57.4
	Δ	2.5%	0.3pp	-1.2pp	3.5pp	22.1%	-7.4%
Spain	-20%	1314	3.0%	10.6%	24.1%	317.2	440.6
	-30%	1385	3.6%	7.0%	27.3%	378.4	387.6
	Δ	5.4%	0.6pp	-3.6pp	3.2pp	19.3%	-12.0%
Finland	-20%	215	2.0%	7.7%	19.2%	41.1	60.7
	-30%	219	2.2%	5.1%	24.0%	52.7	55.3
	Δ	1.9%	0.2pp	-2.6pp	4.8pp	28.2%	-9.0%
France	-20%	2206	2.0%	8.1%	18.9%	416.5	424.3
	-30%	2351	2.7%	5.4%	22.9%	537.4	383.5
	Δ	6.6%	0.7pp	-2.7pp	4.0pp	29.0%	-9.6%
United Kingdom	-20%	2377	2.3%	4.4%	15.3%	362.4	393.0
	-30%	2550	3.1%	3.5%	19.4%	495.1	347.0
	Δ	7.3%	0.8pp	-0.9pp	4.1pp	36.6%	-11.7%
Greece	-20%	270	2.8%	8.7%	25.1%	67.8	122.1
	-30%	283	3.3%	6.0%	27.0%	76.4	104.4
	Δ	4.8%	0.5pp	-2.7pp	1.9pp	12.8%	-14.5%
Ireland	-20%	218	3.2%	9.0%	8.8%	19.1	62.4
	-30%	224	3.5%	5.7%	12.1%	27.2	54.6
	Δ	2.8%	0.3pp	-3.3pp	3.3pp	42.6%	-12.6%
Italy	-20%	1820	1.8%	7.6%	20.4%	370.9	571.1
	-30%	1908	2.3%	5.0%	26.4%	504.2	512.5
	Δ	4.8%	0.5pp	-2.6pp	6.0pp	35.9%	-10.3%
Luxembourg	-20%	56	3.3%	3.4%	21.5%	12.0	16.5
	-30%	59	3.8%	3.1%	24.7%	14.5	15.6
	Δ	5.4%	0.5pp	-0.3pp	3.2pp	20.5%	-5.6%
Netherlands	-20%	603	1.7%	3.9%	17.8%	107.0	193.0
	-30%	627	2.1%	3.3%	19.5%	122.0	189.0
	Δ	4.0%	0.4pp	-0.6pp	1.7pp	13.8%	-2.1%
Portugal	-20%	178	2.0%	6.3%	24.5%	44.0	81.0
	-30%	184	2.3%	4.5%	30.1%	55.0	69.0
	Δ	3.4%	0.3pp	-1.8pp	5.6pp	27.2%	-14.5%
Sweden	-20%	425	2.3%	5.8%	13.8%	59.0	78.0
	-30%	439	2.6%	4.1%	17.0%	75.0	62.0
	Δ	3.3%	0.3pp	-1.7pp	3.2pp	27.4%	-20.1%

Δ: Difference 20% vs. 30% either as percentage of 20% value or as difference in percentage points (pp).
Source: own analysis based on GEM-E3 simulations.

Table 5: Macroeconomic features by country, EU12

		GDP in 2020 (billion $\$_{2004}$)	GDP growth rate	Unemployment rate	Investment in 2020 (share of gdp)	Investment in 2020 (billion $\$_{2004}$)	Emission (Mt)
Bulgaria	-20%	41	3.1%	7.7%	20.8%	8.5	50.7
	-30%	41	3.2%	5.3%	24.4%	10.1	48.9
	Δ	0.0%	0.1pp	-2.4pp	3.6pp	18.8%	-3.5%
Cyprus	-20%	25	3.8%	5.1%	21.6%	5.3	7.8
	-30%	26	4.3%	4.0%	25.1%	6.5	7.1
	Δ	4.0%	0.5pp	-1.1pp	3.5pp	21.2%	-9.8%
Czech Republic	-20%	144	3.0%	6.0%	22.0%	31.6	113.3
	-30%	151	3.6%	4.3%	26.2%	39.6	106.3
	Δ	4.9%	0.6pp	-1.7pp	4.2pp	25.2%	-6.1%
Estonia	-20%	12	3.2%	7.5%	19.7%	2.4	18.0
	-30%	13	3.5%	5.1%	25.1%	3.2	15.9
	Δ	8.3%	0.3pp	-2.4pp	5.4pp	31.3%	-11.6%
Lithuania	-20%	32	3.6%	8.0%	19.9%	6.4	12.8
	-30%	34	4.2%	5.7%	21.5%	7.4	12.1
	Δ	6.3%	0.6pp	-2.3pp	1.6pp	14.4%	-5.0%
Latvia	-20%	19	3.0%	7.7%	21.6%	4.2	9.4
	-30%	20	3.5%	5.4%	26.5%	5.4	7.6
	Δ	5.3%	0.5pp	-2.3pp	4.9pp	28.6%	-18.8%
Malta	-20%	8	2.6%	6.0%	20.2%	1.6	2.4
	-30%	8	3.1%	4.3%	24.5%	2.0	2.4
	Δ	0.0%	0.5pp	-1.7pp	4.3pp	26.9%	0.4%
Slovakia	-20%	81	4.3%	12.5%	21.4%	17.3	46.2
	-30%	85	4.8%	8.6%	25.1%	21.5	42.7
	Δ	4.9%	0.5pp	-3.9pp	3.7pp	23.9%	-7.6%
Slovenia	-20%	51	3.0%	4.7%	24.9%	12.7	21.9
	-30%	54	3.7%	3.7%	27.5%	15.0	19.4
	Δ	5.9%	0.7pp	-1pp	2.6pp	18.0%	-11.4%
Romania	-20%	123	3.7%	5.1%	36.4%	44.8	117.8
	-30%	137	4.8%	3.9%	40.3%	55.2	112.1
	Δ	11.4%	1.1pp	-1.2pp	3.9pp	23.1%	-4.8%
Poland	-20%	328	3.0%	12.5%	20.3%	66.4	364.2
	-30%	351	3.7%	8.5%	23.9%	83.8	328.7
	Δ	7.0%	0.7pp	-4pp	3.6pp	26.2%	-9.7%
Hungary	-20%	122	2.7%	4.9%	20.2%	24.6	68.7
	-30%	126	3.0%	3.7%	23.7%	29.9	59.8
	Δ	3.3%	0.3pp	-1.2pp	3.5pp	21.3%	-12.8%

Δ: Difference 20% vs. 30% either as percentage of 20% value or as difference in percentage points (pp).
Source: own analysis based on GEM-E3 simulations.

3 A Virtuous Circle

The basic mechanism creating the opportunity for a new growth path in Europe is the mobilization of a virtuous circle of additional investment, learning-by-doing and expectation formation. We discuss these three topics in turn.

3.1 Triggering Investment

The starting point for a revitalization of the European economy is a substantial increase of investment. This is why an ambitious climate policy is actually a major opportunity for economic policy, too. Building wind turbines, implementing cogeneration of heat and electricity, insulating houses, modernizing the power grid, etc., all require substantial investment. If this green investment simply displaced investment in other sectors – health, education toolmaking, etc. – growth would not speed up and employment would only be re-allocated between sectors, without reducing the number of unemployed. However, in the coming years green investment can be part of a broader surge of investment.

Model results show that it is possible to increase the EU climate target to 30% while increasing the share of investment in GDP, which under business as usual would be 18%, by up to 4 percentage points. This is mainly, but not only, due to investment in the built environment, which makes up the largest part of the European capital stock.

Table 6: Main focus of climate policy making

Type of measure	Number of citations
Economic	371
Regulatory	342
Information	182
Fiscal	119
Voluntary	80
Planning	76
Education	49
Research	39

Source: European Environmental Agency (2010).

To realise the win-win opportunity that comes with the 30% reduction target requires consistent policies and measures that reframe expectations in a broader framework of low-carbon growth. Mainstreaming climate concerns into the next decade of institutional reforms can decisively help the EU to enter a path of low-carbon growth in line with its broader aspirations of sustainable development (EU Sustainable Development Strategy: Commission of European Communities (CEC) 2005; European Commission (EC) 2010).

No single measure can deliver the type of reductions that are needed to meet the 30% target by 2020, but a combined approach is required. At present, however, there is a bewildering multitude of climate policies and measures in place. In order to get on new growth path, it will be essential to greatly increase the coherence of, and synergies between those measures. There may well be quite a bit of red tape to be eliminated as well.

The European Environmental Agency (2010) currently cites a total of 860 policies and measures that EU countries (EU15) have officially reported to the UNFCCC as part of their effort

to reduce GHG emissions. A simple analysis of this data base yields the picture shown in Table 6.

The problem, then, is not a lack of measures, but rather the lack of an overarching thrust of those measures. This needs to be provided at the European level. However, here again the variety of policies and measures leaves room for improvement.

In order to turn this profusion of policies and measures into an effective thrust towards a new growth path, two steps will be essential. First, to declare explicitly that entering this growth path is indeed the goal of the EU. Moving from the meanwhile redundant target of 20% greenhouse gas emissions reduction towards a schedule aiming first at 30% and ultimately at a near-zero emissions economy, should be an integral component of this goal setting. Simultaneously, a target of increasing European economic growth by about 0.5% and decreasing the unemployment rate in Europe by at least 2% should be stated as forcefully as the ECB target of an inflation rate slightly below 2%.

Second, the EU needs to walk the talk, i.e. to implement measures that do establish the thrust towards the new growth path. They include both macro- and micro-economic measures:

- Macro-economic measures, e.g.:
  - Using part of the ETS auctioning revenue and resources from the structural funds to support mitigation efforts in Eastern European countries.
  - Incentivising entrepreneurial investment by tax relief balanced with marginal tax increases on capital incomes used for other purposes.
  - Building in low-carbon growth expectations in public procurement.
  - Managing growth expectations along the lines central banks manage inflation expectations.
- Micro-economic measures e.g.:
  - Enhancing building codes to foster investment in energy efficiency; enhancing standards for energy efficiency in transport.
  - Using part of the ETS auctioning revenue to foster energy efficiency and renewable energies.
  - Standardising smart grid infrastructures and smart household appliances.
  - Creating learning networks of businesses developing innovative solutions across Europe.

3.2 Learning-by-Doing

If the EU announces and implements a new growth strategy including an ambitious target for emissions reduction, it can trigger additional investments that significantly increase the share of gross investment in GDP. This additional investment induces learning-by-doing across the

economy as a whole, and at an even higher rate where it comes to new technologies like advanced construction materials, renewable energy and more.

From Wright's classical study of factors affecting the costs of airplanes (Wright 1936) to current work on technological progress in information technology (Koh and Magee 2006), a huge literature documents the importance of learning-by-doing. Three elements are essential here. First, even for familiar products with a long technological history like shoes, chairs, or windows, learning-by-doing is an on-going process leading to increased labor productivity in their production. Second, for new technologies that succeed in entering a competitive market, learning rates are much higher than for well-established technologies. And third, there is no way of telling in advance whether a new technology that looks plausible at first sight will actually succed in the market place, nor is there a way of telling how long it will take for a "new" technology to become a "familiar" one.

What can be confidently expected, then, is that an increase in European investment will accelerate learning-by-doing and therefore increase labor productivity and decrease unit production costs. This will happen across the whole economy, but at higher speed in sectors using new technologies that have begun to show their competitiveness. Such technologies include the use of wind energy, as well as advanced medical technology, new construction materials, and information technology.

With new technologies, however, there is a danger of overconfidence: it is easy to claim that amazing cost reductions will make expensive new production processes competitive in a few decades, but it is nearly impossible to find empirical evidence for such a claim as soon as one talks about a particular technology. In the present study, therefore, we have only assumed learning rates that hold even for well-established technologies. This means that our results may well be too conservative, which we consider a virtue in the present context.

An even greater virtue, however, is to break out of the straightjacket of mind that takes the modest rate of productivity increase displayed by the European economy in the recent past as the upper limit of what that economy is capable of. If such were the case, increased investments would only lead to higher production costs and therefore to lower returns or higher inflation or both. In reality, a new growth path is possible because of a virtuous cycle that moves from higher investment to higher learning-by-doing, from there to improved expectations, and from there again to higher investment.

Clearly, there are limits to the extent to which additional investment can trigger learning-by-doing, and this in turn limits the amount of emission reductions that can be achieved in a given time span by a win-win strategy. A reduction of 30% in 2020 compared to 1990 levels is certainly feasible along a higher growth path than business as usual.

3.3 Expectation Management

Additional investment induces learning-by-doing, which enables the economy to grow faster than it could have done otherwise. The faster growth in turn leads to more positive expecta-

tions for the future, which leads to further investment. This is the virtuous cycle leading to the new growth path.

However, investors are no fools: they try to correct their expectation whenever there may be a reason to do so – after all, their fortunes are at stake. This leads to the danger of volatile expectations, a major challenge for monetary policy. Indeed, monetary policy has important lessons to offer for a policy aiming at a new growth path. The first lesson is that the expectations of investors must indeed be consciously managed. If this had not been done in 2007-2008, the world would have experienced a global economic breakdown that would have dwarfed even the global crisis of 1929.

A next lesson is that expectation management starts with explicitly stating goals, loud and clear. In the case of the ECB, the main goal is an inflation rate slightly below 2%. To be effective, the goal declaration must be credible. An inflation rate of 0% would not be credible, because experience has shown that seriously pursuing such a goal would throw the economy in a serious depression. Nor would a rate of 6% or more be credible, because again experience has shown that an inflation at that rate would pose a continuous danger of turning into a runaway inflation and into major social unrest. If the EU would announce a growth target of 5% for the coming years, this would not be credible, despite the fact that many countries, including European ones, rather easily achieve growth rates of 5% and more. But for Europe as a whole, such a growth target would simply be too far away from the experience of the past decades. At the same time, if the EU should stick to the 20% emissions reduction target as an expressions of its will to assume global responsibility, perhaps even to claim leadership, it would loose credibility, too: after the financial crisis, this target simply does not express a will to tackle global environmental problems.

The problem of credibility is also essential to asses the possible effects of conceivable intermediate targets. The key problem is not to find some magic number, but to show that the EU is determined to get beyond business as usual. Otherwise the expectations of investors will stay focused on this perspective and neglect the possibility of a new growth path. As a result, no additional investment would occur, and the investment needed to achieve a given target would crowd out other, economically more promising investments. There would then indeed be an additional cost to the economy as a whole rather than a win-win strategy. The growth rate would not be slightly higher than in business as usual, but indeed slightly lower. Of course there is no sharp threshold at which the expectations of investors would mechanically switch towards the new growth path. Much depends on how the EU will communicate its target for 2020, especially how that target will be embedded in a broader view of the growth path and the emissions trajectory the EU wants to realize.

Credibility, however, is not only a matter of announcing targets, but also of implementing them. Central banks have learned over decades that only by consistently pursuing their announced targets through a long series of decisions, can they establish a solid credibility. The same is true with a new growth path. Sticking to the target of increasing growth and investment while reducing unemployment and emissions will be essential. Public procurement, reviewing the common agricultural policy, building complex European infrastructures, re-

search and development, etc., these are all areas where the credibility of the new growth path can be established.

The last lesson from monetary policy to be considered here concerns the global context in which European targets must be met. A credible inflation target is one that does not depend on what the U.S., China or global markets do. They appropriate way to pursue the target will vary greatly depending on global circumstances, but not the target itself. The same holds for the new growth path. The economic opportunities of a European 30% scenario are available independently of an international post-2012 climate agreement. The simulations performed for the present study assume no international climate agreement. As a reference frame, we have taken the modest pledges made in the Copenhagen Agreement of 2009. If more ambitious goals should be pursued in the future by major economies, the positive impacts for Europe would be even larger.

By declaring its will to achieve a new growth path and then by increasing growth while reducing emissions and unemployment, Europe can find a new and influential role in the global arena of the 21th century. It should not be forgotten that after the global crisis of 1929, a surge of investment in Europe as elsewhere was initiated by the perspective of military armament. By showing that in the decade up to 2020 the vision of sustainable development can be turned into high economic growth with decreasing greenhouse gas emissions, Europe can offer a perspective for organizing the expectations of investors worldwide. This may end up being the most significant contribution of Europe to global emissions reductions.

4 Enriching Existing Models

4.1 Previous Assessments

A series of climate policy assessments have been produced during the process leading to the EU20/20/20 package. These studies consider mainly two effects: the substitution of fossil fuels by renewables and the reduction of energy use by energy efficiency measures. Both effects are assumed to involve social costs in the short run. Their only possible justification is seen in the avoidance of long-term costs from climate change. A simple linear dynamics is assumed, by which social costs increase for every additional unit of greenhouse gas avoided. As a result, the reduction of 30% is seen as more costly than a reduction of 20% of the GHG emissions.

The reference study on the 20% target before the financial crisis (Capros et al. 2008) was commissioned by the European Commission and performed using the PRIMES[3] equilibrium model of the European energy system. It analyzes the implementation of the EU20/20/20 package under various scenarios of the flexibility mechanisms associated to the emission reductions and renewable energy sources (RES) constraints, as well as the price of fossil fuels.

With this kind of models, the effects on GDP are necessarily negative. In the assessment of Capros et al. (2008), they lie below one percent of GDP.

An independent assessment (Boehringer, Rutherford and Tol 2009) of the EU20/20/20 package has been performed in the framework of the Stanford energy modeling forum[4], using a series of computable general equilibrium models (whose taxonomy is presented in Table 7).

Table 7: CGE models used in the EMF study for -20% assesment

Model	M20 impact study references	Link to model description
Pace	Boehringer et al. 2009a	http://www.transust.org/models/pace/
DART	Kretschmer et al. 2009	http://www.narola.ifw-kiel.de/narola-models/dart/
Gemini E3	Bernard and Vielle 2009	http://gemini-e3.epfl.ch/
WorldScan	Boeters and Koornneef 2010	http://www.cpb.nl/eng/model/worldscan.html

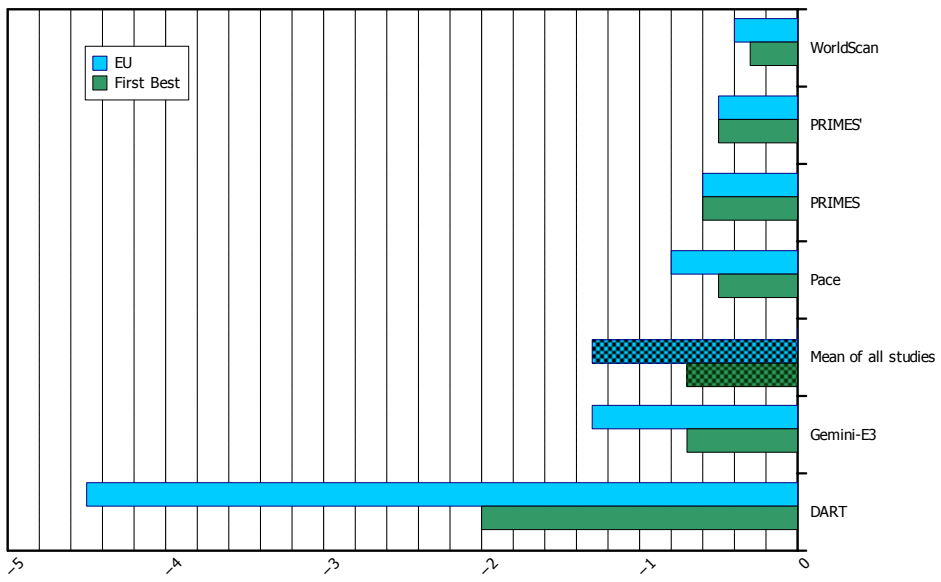
Source: Boehringer, Rutherford and Tol (2009).

A comparative analysis of these studies is presented in (Tol 2010); key results are reported in Figure 3. The implementation of the package comes at a mean cost of 1.3% welfare loss in 2020 through a mean carbon price of 75€ per ton. If the package is implemented optimally according to the criteria of these models, the welfare loss goes down to 0.7% and the carbon price to €44.

[3] see http://www.e3mlab.ntua.gr/manuals/PRIMsd.pdf

[4] see http://emf.stanford.edu/

Figure 3: The impact of the EU 20/20/2020 package on welfare in 2020 for the EU27, in %



Source: Tol (2010).

The economic crisis led to a decrease of 5% of GDP in 2009 compared to 2007 in the EU27 (Eurostat 2010). As far as GHG emissions are concerned, the fall has been even sharper, with a 9% decrease of emissions, the effect of the economic recession superimposing itself on the sustained trend of decrease in emissions since 2003 (European Environment Agency (EEA) 2010). As a result, total GHG emission in 2009 were 17% below the 1990 level, almost reaching the 20% target.

Table 8: Comparison of macro assumptions of 2007 and 2009 baselines

	2005	2020 Baseline 2009	2020 Baseline 2007
Population (millions)	489	513	496
GDP (billion $€_{2008}$)	11687	14963	16572
GHG emissions reduction (% from 1990)	-7.5	-13.8	-1.5
Coal import price $\$_{2008}$/boe	14	25.8	16
Gas import price $\$_{2008}$/boe	39.7	62.1	50

Source: European Commission Staff (2010a) [Table 4].

These major developments led to a new assessment of the EU20/20/20 package, in the process of elaborating the EU commission communication on options to move beyond 20% greenhouse gas emission reductions (European Commission Staff 2010a). This new assessment is also based on the PRIMES model (Capros et al. 2008) but uses a new baseline with macro-economic features consistent with the "sluggish recovery" scenario of the Europe 2020 strategy (Communication from the Commission 2010). It also takes into account up-to-date

population projections (EUROPOP2008 convergence scenario from (Eurostat 2010)). As Table 8 underlines, this new baseline assumes a GDP reduction of 10% in 2020 compared to the pre-financial crisis one.

Table 9: Comparison of energy prices projections of 2007 and 2009 baselines

	2005	2020 Baseline 2009	2020 Baseline 2007
Crude oil import price	489	513	496
GDP (billion $€_{2008}$)	11687	14963	16572

Source: European Commission Staff (2010a) [Table 4].

These macro-economic developments, as well as the increase in fossil fuel prices, lower considerably the estimates of the costs of the 20/20/20 package. According to simulations performed using the new baseline, the costs of the package come at €48 bn in 2020, or 0.3% of GDP.

Table 10: Range of energy scenario results EU27-2020

Internal GHG reduction vs. 1990	−20
RES share in Gross final energy	20
Carbon-price EU-ETS €/t CO_2	16.5
Carbon value non-ETS €/t CO_2	4
RES values energy supply €/MWh	50

Source: Capros et al. (2008) [Table 7].

This decrease in costs is also reflected in the evolution of the carbon price (Table 10) which falls to €16.5 in the ETS sector and €4 in the non-ETS sectors. The interpretation of these results is clear-cut:

"The lower economic growth forecast has made achievement of the GHG reduction targets easier" (European Commission Staff 2010b p. 33).

The roughest estimates of the 30% target can be obtained through a linear extrapolation of the results surveyed in (Tol 2010). This leads to an estimate of 2% GDP loss in 2020. However, such an approximation is based only on studies performed before the financial crisis.

Much more detailed results are provided in (European Commission Staff 2010b) using the new 2009 baseline. The estimates of macroeconomic outcomes are summarized in Table 11. These estimates vary according to the assumptions made about the level at which Copenhagen pledges are implemented in the rest of the world, the access to international carbon credit markets, the modes of allocation of permits in the ETS sectors and the modes of recycling of revenues from the ETS. The overall picture suggests a relatively mild effect on employment and GDP with a carbon price between €30 and €55. If the revenues from ETS are recycled by reducing labour costs, 30% could create up to one million additional jobs (+0.7%). Other potential benefits are the decrease of the energy consumption and of the imports of fossil fuels.

Table 11: Effects of -30% in EU27		
Variable	Lower Bound	Upper Bound
GDP (% change from M20)	−1.5	0.6
Employment (% change from M20)	−0.6	+0.7
Carbon price ETS (€/t CO_2)	30	55
Energy consumption (% change from M20)	−3.5	−6.5
Renewables share in energy consumption (%)	20	22
Reduced oil and gas imports (billion €)	−9	−14

Source: European Commission Staff (2010a).

4.2 The Need for Enhanced Models

The differences between the studies considered so far are relatively small (Kretschmer, Narita and Peterson 2009). If the assumptions made in these studies are incorporated in the enhanced GEM-E3 model used for the present study, very similar results are obtained.

However, these assumptions neglect two major economic effects and their interaction: the effect of investment on learning-by-doing, and the effect of expectations on investment. These effects are well-established on both empirical and theoretical grounds. Yet, they are hard to implement in existing models and have been neglected so far.

The financial crisis has shown that such neglect can no longer be justified in view of the actual dynamics of the global economy. More precisely, in the global financial crisis of 2007-2008, it became apparent that the economic models currently used to assess the course of economic systems are not good enough for situations where basic patterns of how an economy functions are modified. Such situations arise in financial crises, but also in accelerations of economic growth in emerging economies, or in the transformation of the energy system that climate policy aims to achieve.

This insight has led to an intense debate about how to further improve the modeling tools presently available for describing and understanding economic developments and policy measures. A key reference point for this debate are the various single equilibrium models that have become the standard in macro-economic modeling. They share the assumption that the economy is characterized by a single stable equilibrium – an assumption that is critical for climate policy.

The resulting models perform quite well as long as only small changes over limited time spans are analysed. What the financial crisis has shown is that these models become misleading when major changes in the functioning of the economy arise.

The fundamental structure of single equilibrium models in economics is well understood. This is how it works: imagine a large number of households with identical preferences between different goods and between obtaining these goods at different moments in time. Households don't like to work but like to consume more rather than less. They can buy goods or some kind of financial asset that yields an interest revenue. Households then decide how much to work, what goods to consume now, and how much of their income to save for fu-

ture consumption. This decision is made for every point in the time span considered. At no moment in time do households regret a previous decision. They may, however, react to new events like a change in prices induced by a carbon tax. Their preferences are such that there is only one optimal decision for any given actual and expected prices.

The savings decisions of households depend on their expectations of the future. In a single equilibrium model, these expectations must identify the relevant equilibrium. Otherwise, the modeler would assume that he is smarter than the people investing at Wall Street and might have a hard time answering the well-known question: "If you're so smart, why are you not rich?", and indeed richer than any of the investors that in the model are represented as being less smart than the modeler.

Next, there is a large number of firms grouped in one or several industries. In each industry and at each moment in time, firms have some given production technology and are faced with a price for their product that they cannot change without loosing their market. Under these conditions, they hire people and lease capital goods from the households so as to produce the quantity of output at which they maximize profits. The technologies are such that there is only one such quantity for any given set of prices.

The decisions of each agent can only be optimal if they are consistent with the decisions of all other agents. Otherwise a mismatch of supply and demand would arise somewhere, and at least one agent would be unable to realize his supposedly optimal decision.

This basic framework has been implemented in computer models for climate policy assessment as well as for all sorts of policy assessments, and economic analyses. The assumptions listed above have been modified in many ways, but always so as to maintain the single equilibrium property. As much data as could be obtained and used in the overall framework has been incorporated in those models, and the parameters have been chosen so as to fit that data as well as possible.

What is needed now is to stepwise improve existing models so that they represent the fact that the actual economy can and does from time to time switch from the environment of a given equilibrium to another one.

In the present study, we have undertaken three steps in this direction, starting precisely with the GEM-E3 model used by the EU for its climate policy assessments. The steps are:

- Take into account learning-by-doing. For this purpose, technical progress, which is exogenous in the original model, has been made dependent on the speed at which the capital stock is expanded. Because of lack of sufficiently robust data, we have not yet taken into account the additional learning effect of new technology, the actual effect should therefore be larger than estimated in the model.
- Take into account the effect of expectations on investment. In the original model, the expectations of investors are calibrated on the past dynamics of the European economy. This is certainly appropriate for the business as usual case, and in a single equilibrium

world there would be no other equilibrium to be considered. For the new growth path, we have let investors expect a higher growth than the one of business as usual.

- Take into account the interaction of the previous effects across the economy as a whole. With learning-by-doing and the effect of expectations on investment, the behavior of the economy as a whole is modified. In particular, the split between insiders and outsiders on the labor market is much less serious along the new growth path than in business as usual. Therefore, as a final enhancement, for the new growth path we have modified the parameter representing that split in the original model.

Developing enriched models along these lines is a major research program that will keep many researchers busy for many years. Much more work will be needed to provide the modeling tools required to handle both the risks involved in global financial markets and the risks of climate change. The present study shows that this is a promising route. It is possible to take the mentioned critical effects into account in order to reach a more realistic assessment for Europe after the financial crisis.

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