Relative Importance of different Climate Policy Elements for Corporate Climate Innovation Activities: Findings for the Power Sector

Carbon Pricing for Low-Carbon Investment Project

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Executive Summary

Background

This study investigates the relative importance of different climate policy elements for power sector companies' investment decisions regarding "building of new plants" (adoption) and "research, development and demonstration" (RD&D). The climate policy elements examined are the EU Emission Trading System (EU ETS), as Europe's core climate policy instrument, on the one hand, and long-term climate policy targets for 2020, on the other hand. These elements are compared to the relevance of other factors in the business environment, including other policies relevant for such investment decisions. Throughout the study the firms are differentiated along their value chain position, i.e. power generators (with at least one of their plants subject to the EU ETS) and technology providers (equipment manufacturers). The study pays particular attention to differences in firms' technology portfolios and CO2 price expectations. The analysis is based on data from a survey conducted among European firms in November and December 2009.

Results

In the following, the main findings of this study are summarized, based on which policy recommendations are derived thereafter.

1. Interrelatedness of relevance of long-term climate policy targets with current policies

   - We find that for power generators the relevance of long-term climate policy targets is highly correlated with the relevance of the EU ETS (for both innovation dimensions, RD&D and adoption). However, long-term targets do not correlate with technology specific support policies (such as feed-in tariffs), neither for RD&D nor for adoption decisions.
   - For technology providers this turns out to be different. For them, the relevance of long-term targets is highly correlated with both the EU ETS and technology specific support policies with respect to their sales as well their RD&D.
   - Implications: Our results show that for power generators the climate policy elements EU ETS and long-term targets are strongly interrelated, whereas for technology providers the EU ETS and technology specific support policies are mutually reinforcing with long-term targets. Thus, policy-makers should always strive for a congruent mix of long-term targets and the EU ETS (and technology policy in the case of technology providers) in order to increase the impact of policies. This implies that future changes in the policy mix need to be coordinated, i.e. the stringency of all elements needs to be raised in a synchronized manner.

2. Relevance of EU ETS and long-term climate policy targets in relation to other business environment factors

   - Power generators report only small differences between the relevance of the EU ETS and long-term climate policy targets, with the EU ETS being slightly more relevant than long-term targets for adoption decisions, and the opposite being true for RD&D. All climate policy elements are typically rated with a lower relevance than other factors in the business environment. More specifically, market prices for fuels and electricity, and technology-specific regulations (such as feed-in tariffs for renewable energies) were mentioned as the most relevant decision factors for investments in RD&D and adoption.
   - Technology providers perceive long-term climate policy targets as significantly more relevant than the EU ETS for both their investment decisions in RD&D and the demand for their

products. Also, the relevance assigned to long-term targets is comparable to that assigned to market prices, while the EU ETS has a very low relevance for both investment dimensions. Finally, technology-specific regulation is the decision factor with the highest relevance for sales and RD&D of technology providers.
- Implications: The findings show that so far climate policy tends to be only one of the less relevant factors in corporate decision-making and underline the importance of technology-specific policies. This implies that policy makers should, first, strive for an increase in the stringency of the EU ETS (and other climate policy elements) and, second, ensure that the broader policy mix is aligned with the objectives of climate policy.

3. Role of technology portfolio (i.e. a firm's activity in one or several different power generation technologies) for relevance of climate policy in relation to other business environment factors

- No significant correlations between the technology portfolio and the relevance of the climate policy elements for investment decisions could be found.
- The relevance ratings of power generators (with at least one of their units covered by the EU ETS) does not differ with respect to their different technology portfolios, neither for RD&D nor for adoption of new plants.
- In contrast, the product portfolio of technology providers impacts the relevance ratings for technology-specific policies both in terms of sales and RD&D: the higher the share of sales of components and installations for fossil-fuel based power generation, the lower the relevance assigned to technology-specific policies.
- Implications: First, our results imply a lower path dependency of power generators than what is typically assumed. Second, the results show that technology providers are indeed bound to their technological capabilities. Policies specifically tailored to technology providers could target the decarbonisation of their technology portfolios or should support new firms in clean energy technology niches in their process of innovation and growth.

4. Current and future price expectations and the importance of investment decision factors

- The expected CO2 prices by power generators are much higher for 2020 than for 2012. However, firms assign much uncertainty to the 2020 price expectations. The differences in their CO2 price expectations, in combination with the associated certainty about these, correlate with the relevance level assigned to the EU ETS for investment decisions regarding the adoption of new plants and RD&D. That is, power generators with higher long-term CO2 price expectations and a higher certainty about these expectations rate the relevance of the EU ETS for new plants more highly for their investment decisions.
- Implications: The wide spread of future price expectations implies a certain inefficiency of the carbon market. In order to reduce this inefficiency, a more predictable price is needed. Stringent, predictable long-term targets and price floors are two potential measures for this purpose.

The results provide important insights into the relevance of different elements in the policy mix targeting clean power generation technologies. First, regarding the climate policy mix the findings highlight the fundamental importance of credible, ambitious long-term climate policy, particularly for RD&D activities of technology providers. Such targets provide the basis for corporate visions of the future and can thus serve as a benchmark for corporate targets. Therefore, a climate policy mix targeting technological change needs to include long-term targets, but it also needs to consist of stringent and predictable climate policy instruments which operationalize them. Second, the study underlines that technology-specific regulations, such as feed-in tariffs, play an important role in companies' decision making. More specifically, they currently appear to be typically more influential in driving the low-carbon transition of the power sector than climate policy instruments such as the EU ETS.

1 Introduction

Climate change is one of the most prominent challenges of our time, requiring substantial mitigation and adaptation efforts to counteract its tremendous environmental, economic and social effects (Stern, 2006, IPCC, 2007b). In the Copenhagen Accord, major political leaders acknowledged that the global temperature increase should remain below 2℃ (UNFCCC, 2009), which requires deep cuts in global greenhouse gas (GHG) emissions over the coming decades (IPCC, 2007a). This calls for a radical redirection and acceleration of technological change towards low- and zero-carbon solutions.

The challenge requires ambitious national, European and international climate targets as part of a stringent and predictable policy mix targeting technological change. In Europe, the cornerstone of such a climate policy mix is the EU Emission Trading System (EU ETS). With five years of experience of the EU ETS, the Climate Strategies “Carbon Pricing for Low Carbon Investment” project aims to assess how it influences investment and strategic choices, how it feeds through to finance decisions, and how hedging and banking of carbon allowances influence the price over time. Towards this end, the project also explores how firms respond to carbon prices.[1]

In this paper we explore the relative importance of different climate policy elements for two investment dimensions: adoption of new plant[2] and research, development and demonstration (RD&D) activities. Empirically, we do so by analyzing the power sector because this sector is key for achieving the substantial emission reductions due to its high share of global GHG emissions and large mitigation potential (IEA, 2009). Here, company case study findings have pointed to the important role of long-term targets for corporate innovation decisions and also to the targets’ greater credibility due to the operationalization of these long-term targets short- and medium term climate policy instruments (Rogge et al., forthcoming). In this paper, we investigate the relative importance of long-term targets in the year 2020 versus. the EU ETS for companies’ investment decisions – that is regarding the adoption of new plant and RD&D activities – as two factors in the overall decision-making process. Due to this study’s focus on the EU ETS and long-term climate targets, we assume a narrow definition of climate policies and thus do not consider technology-specific policies, such as renewables regulations, as element of the climate policy mix but as separate factor in the business environment.

We want to answer the following four research questions:

1. What is the perceived relevance of the EU ETS (as today’s core climate policy instrument in the EU) and long-term climate policy targets, in relation to other business environment factors, and how does this differ between the two investment dimensions of adoption and RD&D?
2. What role does a company’s technology portfolio play in the company’s perception of the relevance of climate policy - in relation to other business environment factors - for investment decisions regarding the adoption of new plant and RD&D decisions?
3. Is there interrelation of the perceived relevance to investment decisions of the EU ETS and long-term climate policy targets? If so, how?

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1 http://www.climatestrategies.org/component/reports/category/63.html

2 New plant is typically best available technology and thus highly efficient.

4. How do differences in companies' price expectations – including perceived certainty – correlate with the perceived relevance of the two climate policy elements - EU ETS and long-term climate policy targets to investment decisions?

We find that the different climate policy elements typically receive a lower relevance than other factors in the business environment, such as market prices and also technology-specific regulations such as feed-in-tariffs for renewable power generation. The study also clearly shows that technology providers perceive long-term climate policy targets as significantly more relevant than the EU ETS for both RD&D and sales. Firms do not strongly differ in their relevance ratings for decision factors despite varieties in their technology portfolio. Finally, we find that power generators with higher CO_2 price expectations and a higher certainty about these expectations rate the relevance of the EU ETS for new plant more highly for their investment decisions than other firms, thereby showing the mutual/interrelated importance of stringent and predictable climate policies.

The structure of the paper is as follows. First, we will describe the data collection method and then present our findings. We start with an analysis of the relevance of investment decision-factors for adoption and RD&D. We will then discuss the role of firm characteristics in explaining the relevance figures assigned by companies. Fourth, we will extend the analysis of the different climate policy elements EU ETS and long-term climate policy targets by conducting a factor analysis. Finally, we will analyze the role of price expectations and perceived certainty for the importance assigned to the investment decision factors. In the concluding section we will summarize our findings, derive policy recommendations and present a brief outlook.

2 Data

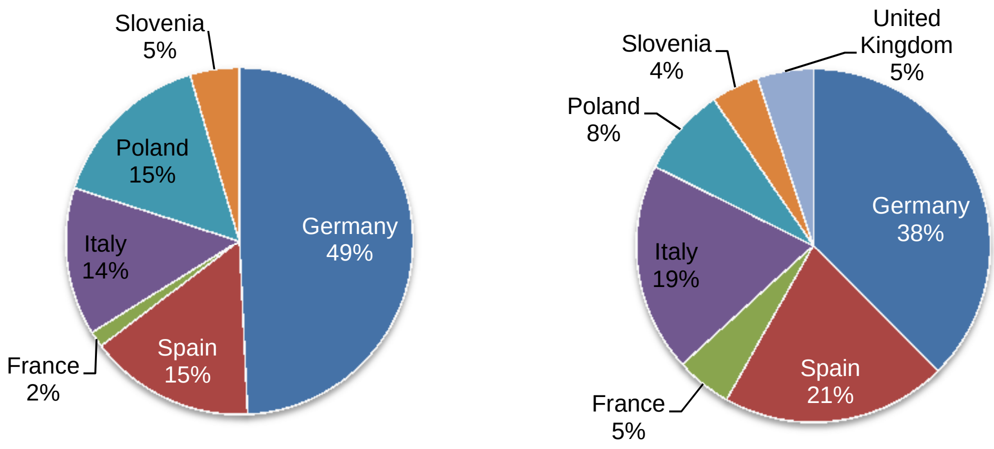
The analysis is based on a pan-European survey amongst power generators (we only considered firms with at least one plant covered by the EU ETS) and power generation technology providers conducted in November and December 2009[3]. It was sent to the management of firms in Germany, France, Italy, Poland, Slovakia and Spain, and power generation technology providers in the UK. We chose these countries based on an analysis of the characteristics of their electricity sector regarding size, CO_2 intensity, allocation rules and national innovation dynamics (number of patents and change in technology use since 1990). The aim of this selection was, to obtain a mix of countries with very different characteristics.

The results presented in this paper are based on the answers of 65 utilities and 136 technology providers, which represent response rates of 14.6% and 13.1%, respectively. As shown in Figure 1, half of the power generators in our sample are based in Germany, 15% in both Spain and Poland, 14% in Italy, 5% in Slovenia and 2% in France. The strong bias towards Germany is to a great extent based on the very high number of (small) utilities subject to the EU ETS in that country compared to in other countries. A similar trend can be observed in the technology provider sample. German firms are

[3] The survey and the preceding case studies were funded by the Volkswagen Foundation.

again the largest group at 38% of the total, followed by firms from Spain (21%) and Italy (19%). Firms from Poland (8%), France, the UK (both at 5%) and Slovakia (4%) complete the sample. With the exception of France and the UK, which are clearly underrepresented, these numbers are a fair representation of the entire population of power generation technology providers.

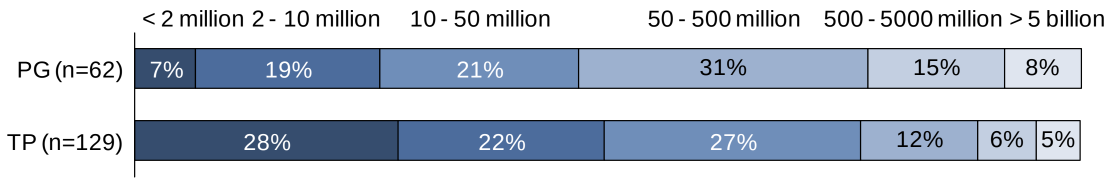
Figure 1: Firm characteristics 1: provenience of the firms



Power generators (n=65) Technology providers (n=136)

The composition of the sample with regard to company size shows that for power generators medium-sized and large firms dominate the sample, while the technology provider sample is mainly comprised of small and medium sized firms (see Figure 2). Both distributions nicely reproduce the structure of each population.

Figure 2: Firm characteristics 2: size according to turnover in 2008[4]



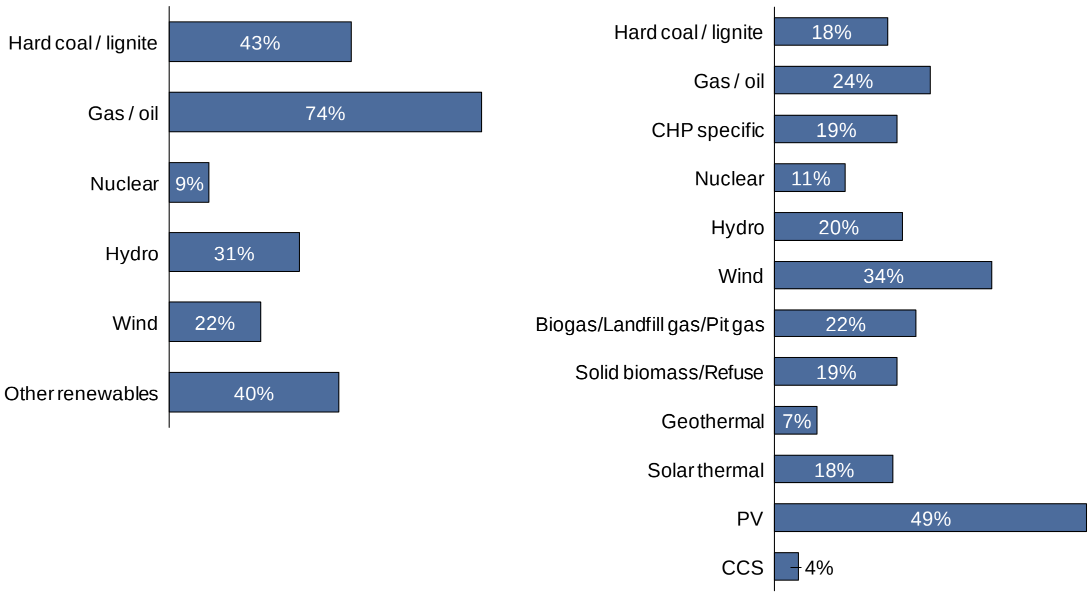
The second important firm characteristic is the technology portfolio which is presented in Figure 3. Power generators were asked to specify how their electricity generation was split across energy sources or technologies in 2008 (hard coal/lignite, gas/oil, nuclear, hydro, wind, other renewables). For technology providers, we asked for the share of turnover from electricity sector products for an extended list of energy carriers/technologies in 2008.[5] For reasons of simplicity, these energy

4 Not all firms answered the question on turnover, thus the small difference in the number of answers and the total sample size.

5 For technology providers we further differentiated other renewables into biogas/landfill gas/pit gas, solid biomass/refuse, geothermal, solarthermal, PV, CCS; the other categories are the same as for power generators.

sources/technologies can be either classified as technologies threatened by climate policies (hard coal/lignite, gas) or as technologies aligned with climate policies (renewables and nuclear)[6].

Figure 3: Firm characteristics 3: technology portfolio in 2008



a) power generators (n=65) b) technology providers (n=136)

Regarding activities in the two investment dimensions, 77% of power generators have undertaken adoption measures, i.e. invested in new plant, and 37% have conducted RD&D activities within the last ten years (2000-2009). As expected, the number of technology providers with RD&D activities is higher, namely 76%. The remaining 24% are technology assemblers without own product development.

6 In the following pages, technologies will be referred to as "threatened" and "aligned" technologies with the criteria for this classification being their carbon-intensity (and no other environmental indicators, i.e. an aligned technology, may still be not sustainable on all merit dimensions).

3 Results

The following four sub-sections provide answers to each of the four research questions postulated in section 1.

3.1 Relevance of factors for companies' investment decisions

The first research question treats the importance of the EU ETS and long-term climate policy targets in relation to other important business environment factors for investment decisions. For policy makers, it is of interest whether climate policy is one – or even the – decisive element of the business environment. Respondents of the survey were asked to assess the relevance they assigned to each of eight factors for investment decisions and demand development, respectively, in the last five-year period (2005-9). This time period coincides with the first five years of the EU ETS being operational. We were interested in the importance of the factors in general irrespective of whether they had a supportive or inhibitive effect. For power generators, we differentiated between the two investment dimensions new plant (NEW) and research, development and demonstration activities (RD&D). For technology providers, we inquired about demand development (sales) and RD&D. For each of these, companies were presented with a list of eight factors which cover market factors, public acceptance, other policies and three different climate policy elements:

1. Prices and availability of fuels (p&a of fuels)
2. Prices and availability of installations or components (p&a of installation)
3. Prices and demand for electricity (p&d for electricity)
4. Public opinion or acceptance of certain technologies (public opinion)
5. Technology-specific regulations and policy support in the investment location (e.g. for renewable energies or CHP[7]) (tech.-spec. policy support)[8]
6. EU Emission Trading (EU ETS)
7. Clean Development Mechanism and potential follow-on mechanisms (CDM)
8. Long-term European/global targets of policies to reduce greenhouse gases (long-term climate policy)

Companies were asked to rate the relevance of these decision factors on a scale from 0 (=no relevance) to 4 (= very high relevance). In the following, we will look at the results of the relevance ratings of power generators and technology providers.

[7] Combined Heat and Power

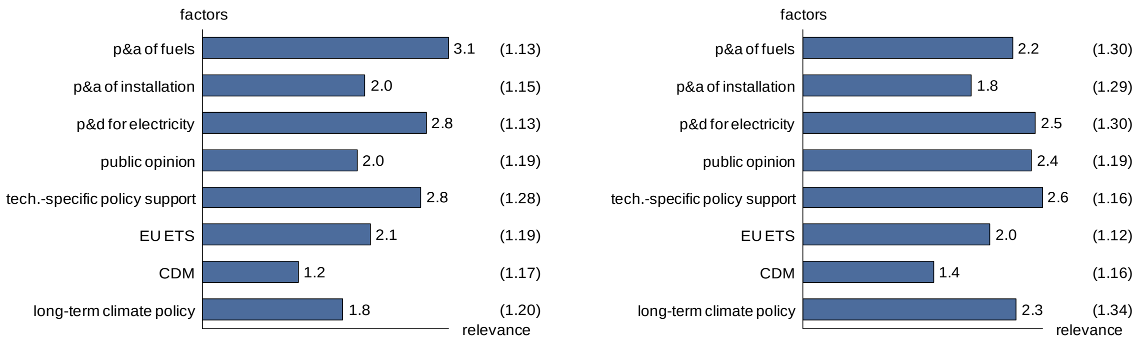
[8] While technology-specific regulations targeting renewable energies or CHP can be seen as part of a broad climate policy mix, in this study we assume a narrow definition of climate policies to consists of the EU ETS, CDM and long-term targets only.

3.2 Power generators

Figure 4 shows the results of the ratings assigned by power generators to the relevance of our set of eight decision factors to investments in (a) new plants and (b) and RD&D. The figure provides means for each factor, as well as the standard deviation. For investment in new plant, climate policy is relatively less important than market factors (particularly prices and availability of fuels, prices and demand for electricity) and other technology-specific policies, such as the feed-in tariffs. Of the three climate policy dimensions, the EU ETS seems to matter most.

In contrast, for R&D the most relevant climate policy dimension is long-term targets, which are almost as relevant as market factors and other technology-specific policies. The outstanding relevance of the public opinion for RD&D investments, particularly if compared to its relatively low importance for investments in new plant (2.4 vs. 2.0), is also striking. Overall, among the most relevant decision factors for power generators are technology-specific policies, such as feed-in tariffs. The crucial role of technology-specific policies is particularly true for RD&D.

Figure 4: Relevance of factors for power generators (mean, standard deviation)

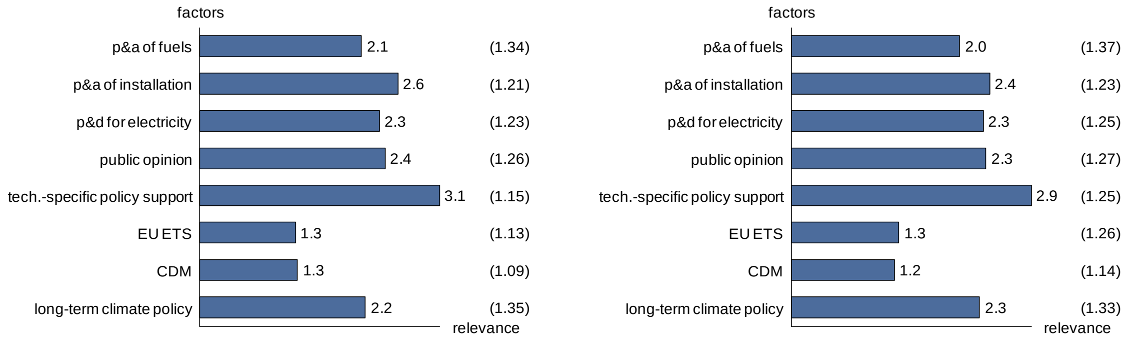


a) New plants (n=65) b) RD&D (n=25)

3.3 Technology providers

Figure 5 shows how technology providers assigned relevance to our set of eight decision factors for (a) sales and (b) RD&D. As before, the figure provides means for each factor, as well as the standard deviation. Clearly, the two climate policy instruments in the focus of this study are of the least and only very limited relevance for sales and RD&D decisions. However, long-term climate policy targets were rated much more highly than the EU ETS and CDM, and their relevance had the same order of magnitude as most of the other factors. Yet, what stands out as the most relevant factor for both investment dimensions are technology-specific policies, such as feed-in tariffs for renewables, which indicates their strong demand-pull as well as technology-push effect.

Figure 5: Relevance of factors for technology providers (mean, standard deviation)



a) Sales (n=136) b) RD&D (n=98)

3.4 Differences in decision factors

We now want to investigate whether the relevance ratings differ significantly across factors. More specifically, from the descriptive statistics we expect to find that climate policy is one of the less important variables and that long-term climate targets outrank the EU ETS and CDM in terms of relevance for most circumstances. In order to test this, we use one-way repeated measures ANOVA. We find – both for power generators and technology providers – a significant main effect for the variation of the relevance assigned to the eight factors for investment decisions in both investment dimensions (each $p<0.001$).

More specifically, the pairwise comparisons in Table 1 reveal the differences for individual factors and the significance level for these. Each factor is compared with each of all other factors in terms of the mean difference (in table: I-J). For these differences the standard deviation and the significance level are provided. All significant differences ($p<0.05$) are highlighted with gray shading. The table includes values for power generators (new plant, RD&D, on the left) and technology providers (sales, RD&D, on the right).

As can be seen, a variety of factors significantly differ from each other at $p<0.05$. However, the observed difference between the relevance of the EU ETS, compared to that of long-term climate policy targets, is only significant for technology providers, for whom we find that long-term climate targets are rated as more important than the EU ETS ($p<0.001$) – with a difference of 0.904 for sales and 0.959 for RD&D.[9]

[9] For power generators, the EU ETS is rated more important than LtCP in the case of investments in new plant (0.351). Regarding RD&D, the opposite is true: LtCP is rated more relevant than the EU ETS (0.280), but both effects are not significant.

Table 1: Pairwise comparison of factors

		1. Power generators						2. Technology providers					
		a) New plants (n=65)			b) RD&D (n=25)			a) Sales (n=136)			b) RD&D (n=98)		
factors (I)	factors (J)	Mean Difference (I-J)	Std. Error	Sig.[a]	Mean Difference (I-J)	Std. Error	Sig.[a]	Mean Difference (I-J)	Std. Error	Sig.[a]	Mean Difference (I-J)	Std. Error	Sig.[a]
1 - fuel	2	1.062*	.156	.000	.440	.259	1.000	-.478*	.123	.004	-.459*	.126	.012
	3	.277	.153	1.000	-.240	.233	1.000	-.235	.128	1.000	-.296	.116	.335
	4	1.154*	.199	.000	-.200	.277	1.000	-.309	.146	1.000	-.337	.153	.852
	5	.354	.185	1.000	-.320	.269	1.000	-1.022*	.146	.000	-1.010*	.159	.000
	6	.985*	.163	.000	.240	.185	1.000	.853*	.133	.000	.745*	.137	.000
	7	1.892*	.174	.000	.840*	.206	.012	.838*	.136	.000	.760*	.141	.000
	8	1.338*	.179	.000	-.040	.196	1.000	-.051	.150	1.000	-.214	.154	1.000
2 - install	1	-1.062*	.156	.000	-.440	.259	1.000	.478*	.123	.004	.459*	.126	.012
	3	-.785*	.141	.000	-.680	.263	.452	.243	.128	1.000	.163	.117	1.000
	4	.092	.180	1.000	-.640	.257	.567	.169	.118	1.000	.122	.132	1.000
	5	-.708*	.197	.018	-.760	.273	.285	-.544*	.114	.000	-.551*	.134	.002
	6	-.077	.177	1.000	-.200	.252	1.000	1.331*	.138	.000	1.204*	.141	.000
	7	.831*	.162	.000	.400	.238	1.000	1.316*	.134	.000	1.219*	.135	.000
	8	.277	.148	1.000	-.480	.284	1.000	.426*	.130	.038	.245	.133	1.000
3 - elect	1	-.277	.153	1.000	.240	.233	1.000	.235	.128	1.000	.296	.116	.335
	2	.785*	.141	.000	.680	.263	.452	-.243	.128	1.000	-.163	.117	1.000
	4	.877*	.172	.000	.040	.227	1.000	-.074	.140	1.000	-.041	.137	1.000
	5	.077	.160	1.000	-.080	.152	1.000	-.787*	.127	.000	-.714*	.137	.000
	6	.708*	.168	.002	.480	.217	1.000	1.088*	.119	.000	1.041*	.123	.000
	7	1.615*	.169	.000	1.080*	.258	.009	1.074*	.125	.000	1.056*	.121	.000
	8	1.062*	.164	.000	.200	.277	1.000	.184	.134	1.000	.082	.141	1.000
4 - public	1	-1.154*	.199	.000	.200	.277	1.000	.309	.146	1.000	.337	.153	.852
	2	-.092	.180	1.000	.640	.257	.567	-.169	.118	1.000	-.122	.132	1.000
	3	-.877*	.172	.000	-.040	.227	1.000	.074	.140	1.000	.041	.137	1.000
	5	-.800*	.169	.000	-.120	.176	1.000	-.713*	.101	.000	-.673*	.100	.000
	6	-.169	.198	1.000	.440	.259	1.000	1.162*	.126	.000	1.082*	.139	.000
	7	.738*	.186	.005	1.040*	.274	.024	1.147*	.130	.000	1.097*	.132	.000
	8	.185	.175	1.000	.160	.269	1.000	.257	.127	1.000	.122	.123	1.000
5 - techpol	1	-.354	.185	1.000	.320	.269	1.000	1.022*	.146	.000	1.010*	.159	.000
	2	.708*	.197	.018	.760	.273	.285	.544*	.114	.000	.551*	.134	.002
	3	-.077	.160	1.000	.080	.152	1.000	.787*	.127	.000	.714*	.137	.000
	4	.800*	.169	.000	.120	.176	1.000	.713*	.101	.000	.673*	.100	.000
	6	.631*	.180	.024	.560	.224	.553	1.875*	.132	.000	1.755*	.143	.000
	7	1.538*	.187	.000	1.160*	.281	.011	1.860*	.135	.000	1.770*	.128	.000
	8	.985*	.183	.000	.280	.268	1.000	.971*	.112	.000	.796*	.117	.000
6 - ETS	1	-.985*	.163	.000	-.240	.185	1.000	-.853*	.133	.000	-.745*	.137	.000
	2	.077	.177	1.000	.200	.252	1.000	-1.331*	.138	.000	-1.204*	.141	.000
	3	-.708*	.168	.002	-.480	.217	1.000	-1.088*	.119	.000	-1.041*	.123	.000
	4	.169	.198	1.000	-.440	.259	1.000	-1.162*	.126	.000	-1.082*	.139	.000
	5	-.631*	.180	.024	-.560	.224	.553	-1.875*	.132	.000	-1.755*	.143	.000
	7	.908*	.150	.000	.600	.183	.087	-.015	.079	1.000	.015	.084	1.000
	8	.354	.146	.513	-.280	.187	1.000	-.904*	.113	.000	-.959*	.116	.000
7 - CDM	1	-1.892*	.174	.000	-.840*	.206	.012	-.838*	.136	.000	-.760*	.141	.000
	2	-.831*	.162	.000	-.400	.238	1.000	-1.316*	.134	.000	-1.219*	.135	.000
	3	-1.615*	.169	.000	-1.080*	.258	.009	-1.074*	.125	.000	-1.056*	.121	.000
	4	-.738*	.186	.005	-1.040*	.274	.024	-1.147*	.130	.000	-1.097*	.132	.000
	5	-1.538*	.187	.000	-1.160*	.281	.011	-1.860*	.135	.000	-1.770*	.128	.000
	6	-.908*	.150	.000	-.600	.183	.087	.015	.079	1.000	-.015	.084	1.000
	8	-.554*	.130	.002	-.880*	.194	.004	-.890*	.120	.000	-.974*	.125	.000
8 - LtCP	1	-1.338*	.179	.000	.040	.196	1.000	.051	.150	1.000	.214	.154	1.000
	2	-.277	.148	1.000	.480	.284	1.000	-.426*	.130	.038	-.245	.133	1.000
	3	-1.062*	.164	.000	-.200	.277	1.000	-.184	.134	1.000	-.082	.141	1.000
	4	-.185	.175	1.000	-.160	.269	1.000	-.257	.127	1.000	-.122	.123	1.000
	5	-.985*	.183	.000	-.280	.268	1.000	-.971*	.112	.000	-.796*	.117	.000
	6	-.354	.146	.513	.280	.187	1.000	.904*	.113	.000	.959*	.116	.000
	7	.554*	.130	.002	.880*	.194	.004	.890*	.120	.000	.974*	.125	.000

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

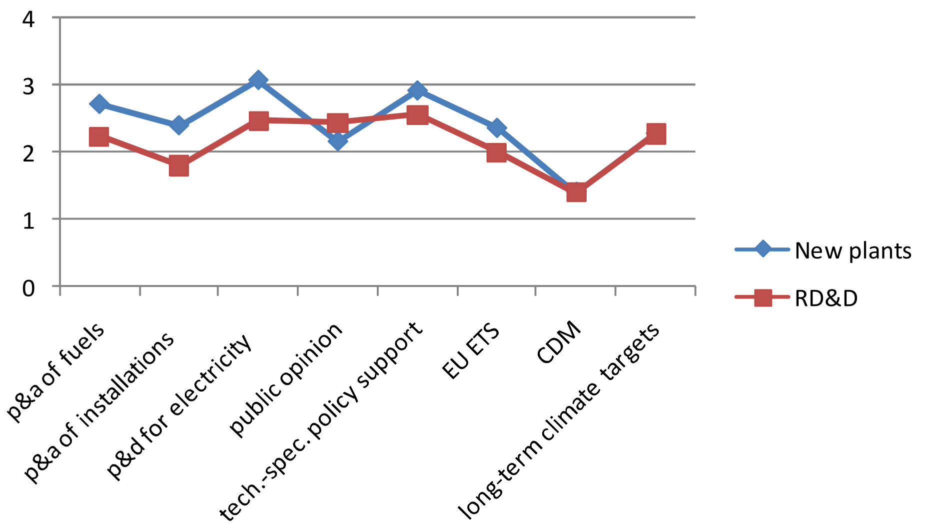
a. Adjustment for multiple comparisons: Bonferroni.

3.5 Differences across investment dimensions

In order to control for differences across new plant and RD&D for power generators, and sales and RD&D for technology providers, we conducted a factorial repeated measures ANOVA with two independent variables: investment dimensions (new plant/sales, RD&D) and decision factors (eight factors).

For power generators, we do not find a significant main effect between the two investment dimensions, i.e. the ratings assigned by participants are not significantly higher or lower between the two investment dimensions - new plant and RD&D (n=25). However, the ratings for factors remain significantly different even without distinguishing between the two investment dimensions ($F(7,161)=8.830$, $p<0.001$). However, the pairwise comparison of factors reveals that this is purely driven by the exceptionally low relevance assigned to the CDM, which is in all instances ranked as significantly less important than all other factors ($p<0.05$). In contrast, the mean difference between the lower relevance assigned to the EU ETS - when compared to long-term targets (-0.104) - remains insignificant. This means that neither EU ETS nor long-term targets significantly vary in comparison to the other factors, except for the CDM.

Figure 6: Power generators' estimated marginal means of decision factors for new plant (1) and RD&D (2) (PG, n=25)[10]

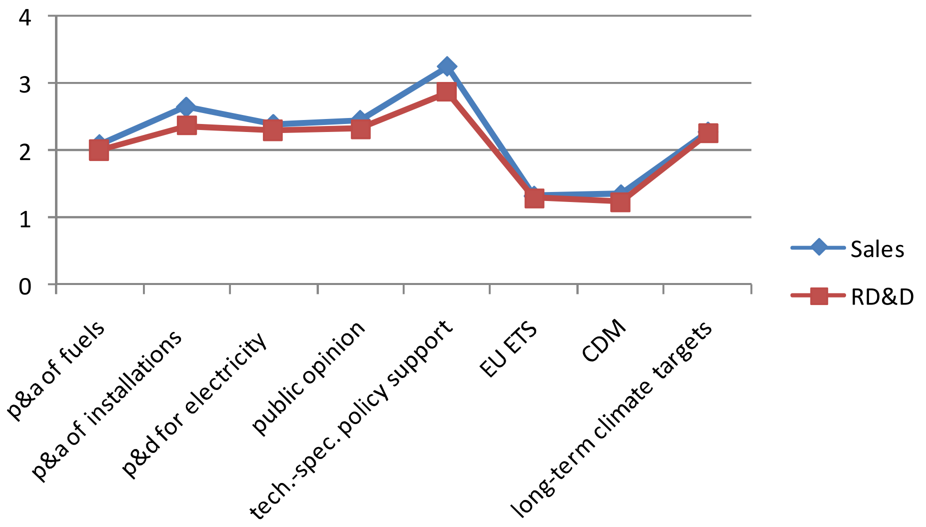


The picture changes when we look at technology providers (n=98). For them, we find a significant main effect for the differences both in investment dimensions ($F(1,95)=4.129$, $p<0.05$) and factors ($F(5.272, 500.829)=42.059$, $p<0.001$). That is, the investment dimension RD&D receives slightly lower ratings for all decision factors than the investment dimension sales (mean difference of 0.139). A pairwise comparison of the factor differences reveals a significantly higher rating of long-term climate targets than the EU ETS (mean differences of 0.979, $p<0.001$) as well as the CDM (mean difference of 0.99, $p<0.001$), independent of the investment dimensions. Also, the ratings assigned for the relevance of long-term climate targets only vary significantly for the two other climate policy elements (EU ETS and CDM are significantly less relevant) and technology-specific policy support which is significantly more relevant than long-term climate targets (mean difference of 0.807, p<001). In

10 For the comparison of the relevance ratings of power generators we could only use those companies which were active in both investment dimensions, i.e. only companies performing RD&D could be included in the repeated measures design. This is why the reference values for new plant differ from those provided in Figure 4 (n=65 vs n=25).

contrast, the ratings for the relevance of the EU ETS significantly differ for all other investment decision factors, except for the CDM, i.e. the factors are significantly rated as more relevant than the EU ETS. Here, the greatest effect occurs for technology-specific policy support (mean difference of 1.786, p<0.001) which technology providers rated as most relevant factor for both investment dimensions.

Figure 7: Technology providers' estimated marginal means of decision factors for sales (1) and RD&D (2) (TP, n=98)[11]



3.6 Role of firm characteristics for the importance of decision factors

In this section, we address our second research question, about the role of a company's technology portfolio in the company's perception of climate policy relevance in relation to other business environment factors. Again, we differentiate our analysis between RD&D and the two interrelated investment dimensions of new plant and sales. We run this analysis for both power generators and technology providers.

We separated the samples into two groups, one with 50% or more fossil technologies in the portfolio and one with less than 50%. A dummy variable was introduced which obtained the value one in the former and zero in the latter case. We correlate this variable with the relevance ratings. In addition, we control the relevance ratings for differences due to recent (2005-9) investment decisions in new plant, for which we distinguish between between (1) no investments, investments in either (2) aligned or (3) threatened technologies only, and (4) investments in new plant using both aligned and threatened technologies. The results are summarized in Table 2 and Figure 8.

[11] For the comparison of the relevance ratings of technology providers across sales and RD&D the repeated measures procedure could be applied to n=98. Thus, for RD&D the values depicted here are equivalent with those in Figure 5 but the values for sales differ because only those companies can be included in the analysis which provided values for sales and RD&D. Note that RD&D is not conducted by all technology providers.

Table 2: Correlations for power generators' ratings of decision factors with their technology portfolio

Firms with portfolios long on fossil technologies attribute higher value (if neg. sign, lower value) to the following factors:		Relevance for New plants	Relevance for RD&D
p&a of fuels	Correlation Coefficient	0.173†	-.125
	Sig. (1-tailed)	.073	.254
	N	62	24
p&a of installations	Correlation Coefficient	.031	.049
	Sig. (1-tailed)	.395	.398
	N	62	24
p&d for electricity	Correlation Coefficient	.085	.148
	Sig. (1-tailed)	.235	.219
	N	62	24
Public opinion	Correlation Coefficient	-0.159†	.048
	Sig. (1-tailed)	.085	.399
	N	62	24
Technology-spec. policy support	Correlation Coefficient	.062	.197
	Sig. (1-tailed)	.300	.150
	N	62	24
EU ETS	Correlation Coefficient	.012	-.084
	Sig. (1-tailed)	.459	.329
	N	62	24
CDM	Correlation Coefficient	-.033	-.133
	Sig. (1-tailed)	.390	.242
	N	62	24
LtCP	Correlation Coefficient	-.146	-0.274†
	Sig. (1-tailed)	.104	.074
	N	62	24

Kendall's tau_b, † significant at p<0.1, * significant at p<0.05, ** significant at p<0.01

Not all firms stated their technology portfolio, leading to a small drop in the number of observations

As perceptions are strongly impacted by the technology portfolio but the portfolio is rather inert and is not impacted by the perception immediately, we assume uni-directional coherence. Hence, we used a 1-tailed test, only

The correlation shows that the technology portfolio of power generators does not seem to play an important role for the relevance assigned to the decision factors for new plant and RD&D. We only find significance at the p<0.1 level, which should be interpreted with caution as the number of observations is very low. However, the negative sign indicates that long-term climate policy is more important for firms with mainly non-fossil portfolios than for firms with mainly fossil portfolios.

Figure 8: Comparison of power generators' factor ratings according to their investments in new plants in 2005-9

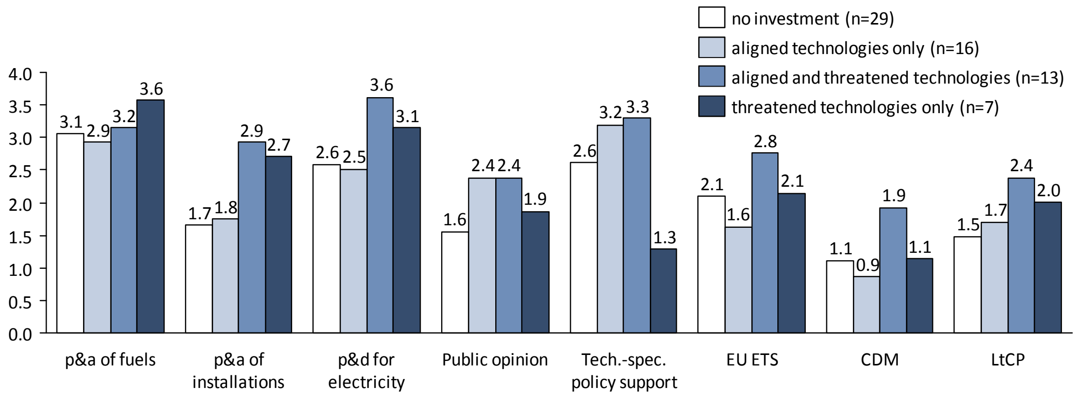


Figure 8 shows the descriptive statistics of a mixed design in which we control the ratings of the relevance of the decision factors by grouping power generators into four groups: those that have not invested in new plant in 2005-9 (i.e. since the introduction of the EU ETS), those that have invested in aligned technologies only, those that invested in threatened technologies only (i.e. fossil-fuel based power generation technologies) and those with an investment mix consisting of aligned and threatened technologies. Overall, we find significant main effects both for the factors as well as for the factors*investment group (p=0.001). This means that the differences in investments (2005-9) in terms of the climate-friendliness of technologies do have an impact on the magnitude of the relevance ratings for decision factors. However, when looking at these differences in more detail, it becomes clear that only power generators that have invested in a mix of clean and fossil fuel technologies rate the relevance of climate policies significantly higher than those having not invested in new plant at all. Taking a broad look at all eight factors, these findings imply that that power generators aiming at a portfolio mix perceive all factors in their business environment as more relevant than companies specializing in aligned or threatened technologies only. The latter companies' investment decisions might be more driven by internal aspects.

Table 3: Correlations for technology providers' ratings of decision factors with their technology portfolio

Firms with portfolios long on fossil technologies attribute higher value (if neg. sign, lower value) to the following factors:		Relevance for Sales	Relevance for RD&D
p&a of fuels	Correlation Coefficient	.013	.049
	Sig. (1-tailed)	.435	.296
	N	136	98
p&a of installations	Correlation Coefficient	-.028	-.015
	Sig. (1-tailed)	.363	.435
	N	136	98
p&d for electricity	Correlation Coefficient	.032	.025
	Sig. (1-tailed)	.339	.391
	N	136	98
Public opinion	Correlation Coefficient	-.045	-.092
	Sig. (1-tailed)	.281	.157
	N	136	98
Technology-spec. policy support	Correlation Coefficient	-.234**	-.195*
	Sig. (1-tailed)	.002	.018
	N	136	98
EU ETS	Correlation Coefficient	.023	.070
	Sig. (1-tailed)	.384	.224
	N	136	98
CDM	Correlation Coefficient	.009	.084
	Sig. (1-tailed)	.452	.183
	N	136	98
LtCP	Correlation Coefficient	-0.121†	.019
	Sig. (1-tailed)	.059	.416
	N	136	98

Kendall's tau_b, † significant at $p<0.1$, * significant at $p<0.05$, ** significant at $p<0.01$

As perceptions are strongly impacted by the technology portfolio but the portfolio is rather inert and is not impacted by the perception immediately, we assume uni-directional coherence. Hence, we used a 1-tailed test, only

For technology providers, we also control for technology portfolio effects. In a similar manner as for power generators, we divided technology providers into two groups based on their turnover's fossil share (a share greater than 50% qualifies for the fossil dummy group). The results are depicted in Table 3. The most outstanding finding is the significant correlation between the investment factor technology-specific policies and the technology portfolio in terms of sales and investment decisions in RD&D. The higher the share of sales of components and installations for fossil-fuel-based power generation, the lower the relevance assigned to technology-specific policies. In contrast, the higher the share of sales of components and installations for power generation free of direct CO_2 emissions, the higher the relevance assigned to technology-specific policies which underlines the importance of policies such as the feed-in tariffs for renewable energies.

For long-term climate targets we only find a weakly significant correlation for the investment dimension of sales. Here, long-term targets are apparently increasingly important for technology providers with a higher share of aligned power generation technologies, i.e. for sales of low-carbon technologies. The opposite applies for technology providers with a higher share of turnover in low-carbon technologies: they assign a higher relevance to long-term climate targets. One explanation could be the importance of such targets for a positive market outlook for these clean energy technologies.

3.7 Correlation of the relevance of climate policy elements

In order to address our third research question about the interrelatedness of the perceived relevance of the EU ETS and long-term climate policy targets for companies' investment decisions, we conducted a two-tailed correlation (Kendall's tau). As long-term targets might be reinforced not only by the EU ETS but also by technology specific support policies, we performed the same analysis for the latter two policy elements.

Again we differentiate our findings between the two actor groups power generators and technology providers and the two investment dimensions adoption of new plant (and sales of technology providers, respectively) and RD&D activities. Table 4 shows that for *power generators*, EU ETS and long-term targets positively correlate in a highly significant (p<0.01) manner. This is however not the case for technology specific support policies and long-term targets, where no significance occurs. In contrast, the *technology provider* sample shows a high correlation between the relevance of long-term climate policy targets and EU ETS as well as technology-specific support policies, for both their sales and RD&D.

Table 4: Two-tailed correlation of the relevance of long-term climate policy targets with…

	Power generators		Technology Providers	
	new plants	RD&D	sales	RD&D
EU ETS	.427**	.599**	.371**	.364**
Tech-spec support policies	.184	.312	.404**	.313**

Kendall's tau_b, 2-tailed, † significant at p<0.1, * significant at p<0.05, ** significant at p<0.01

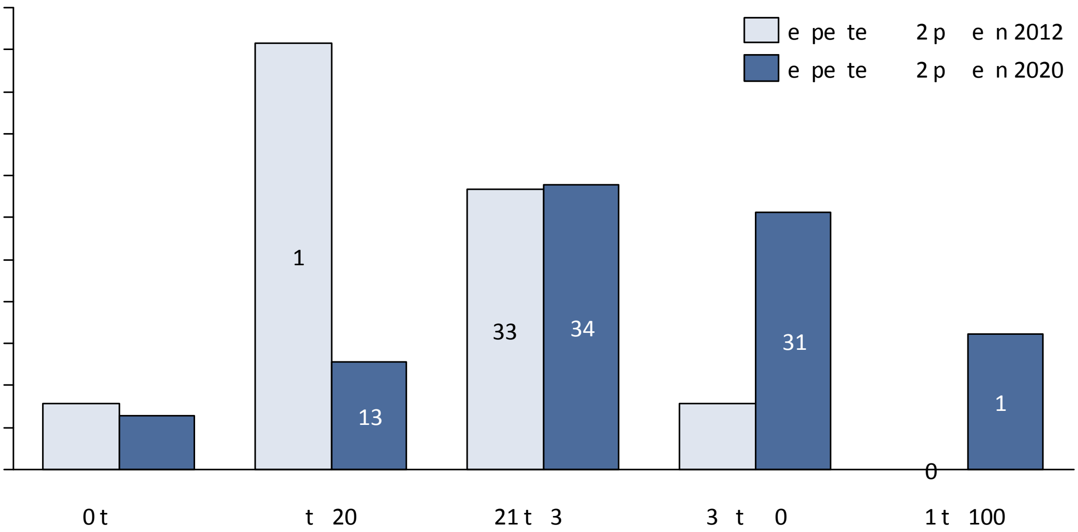
This indicates that current and future climate policies mutually reinforce each other. In other words, the probability that firms that rate the EU ETS as important also perceive a high relevance of long-term climate policy and vice-versa. This implies that short- and long-term policies are congruent to a certain extent. Another finding is that for power generators, the climate policy credibility is explained by the congruence of EU ETS and long-term targets, solely, whereas for technology providers also technology specific support policies and long-term targets are reinforcing each other.

3.8 Current and future price expectations and the importance of investment decision factors

Finally, the fourth research question is concerned with how differences in companies' price expectations – including the perceived certainty – correlate with the perceived relevance of the two climate policy elements EU ETS and long-term climate policy targets. In order to answer this question, we analyze how power generators' expected short-term (2012) and long-term (2020) CO_2-price and its associated certainty impact their ratings of the relevance of the eight investment decision factors by looking at correlation figures. However, in a preliminary step we present the descriptive statistics for the short- and long-term CO_2-price and their associated certainty.

As can be seen in Figure 9, for the short-term the majority of power generators expected a price in the range of 6 to 35€ (84%). In the long-run, the majority of power generators expected a higher CO_2 price in the range of 21 to 50 € (65%).[12]

Figure 9: CO_2 price expectations of power generators (share in %)

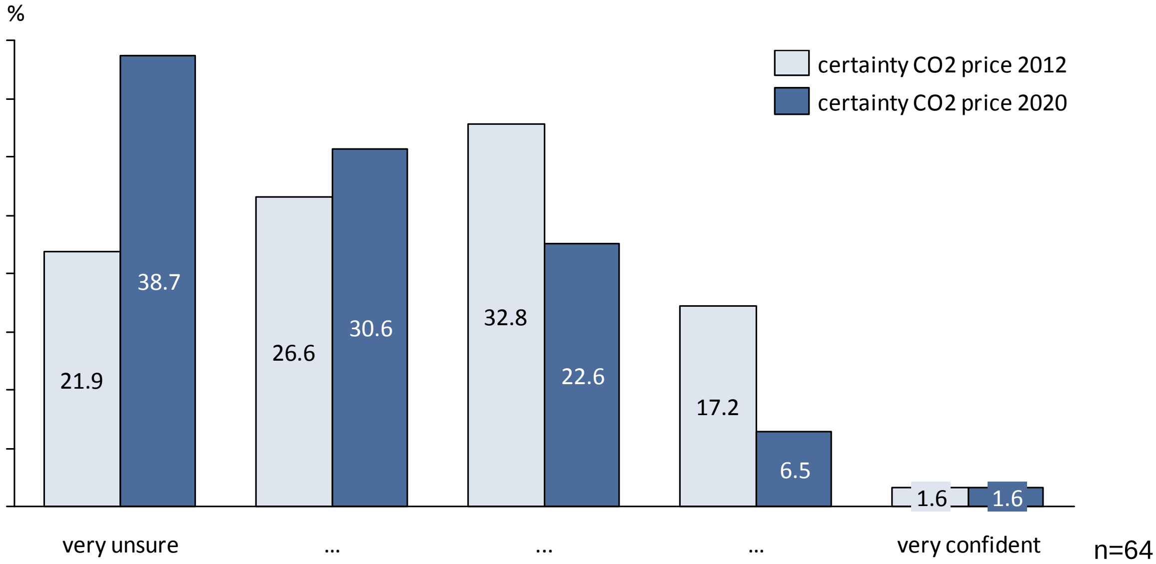


n=63 (2012), n=62 (2020)

Respondents were also asked about how confident they felt with their price expectations (see **Figure** 10). The data supports the expectation that the certainty decreases over time, which is particularly exemplified by the greater percentage of power generator's who said to be very unsure about their 2020 CO_2 price expectation (39% for 2020 compared to 22% for 2012).

12 Note that the survey took place shortly before the signing of the non-binding Copenhagen Accord (November and December 2009), so that the reported long-term price expectations might have been higher than could have been the case after the conclusion of COP 15 in Copenhagen.

Figure 10: Perceived certainty associated with CO_2 price expectations (share in %)



(2012), n=62 (2020)

In order to investigate the correlation of the price expectations with companies‘ ratings for the relevance of investment decision factors, we run two correlation analyses the results of which are presented in Table 5 in the Annex.

The first analysis correlates the decision factors with the short- and long-term CO_2 price expectations while the second analysis uses uncertainty-weighted price expectations. In both instances we differentiate between the two investment dimensions new plants and RD&D. The results show one single significant correlation, i.e. between the uncertainty weighted long-term price expectations and the importance of the EU ETS. This means there is a slight tendency for firms with higher CO_2 price expectations and more certainty about these expectations, to rate more highly the relevance to their investment decisions of the EU ETS for new plant. Providing long-term stringency and certainty at the same time thus increases the effects of current policy. Furthermore, our results let us conclude that the expected CO_2 price in the year 2012 as well as the associated uncertainty do not significantly correlate with the relevance of investment decision factors as assigned by power generators and that there is no significant correlation between price expectations and the relevance of climate policy .

4 Conclusion

In this paper we analyzed the relative importance of the two different climate policy elements - EU ETS and long-term climate targets - for companies’ investment decisions in the case of the power sector, and compared these ratings to the relevance assigned to a set of other context factors in the business environment. In conclusion, we summarize our findings and derive policy recommendations, which are backed by citations from case study interviews.

4.1 Summary

Our findings show that climate policy tends to be only one of several factors in corporate decision-making and that for many firms the other factors are (still) more important for their investment decisions. We also find differences in the relevance of the two climate policy elements - EU ETS and long-term climate targets- for both investment dimensions and actor groups. While for technology providers, long-term targets were rated as significantly more relevant than the EU ETS for RD&D decisions and demand development, for power generators we observe a slightly greater – but not significant – relevance of the EU ETS compared to long-term targets – with regard to the adoption of new plant. For both actor groups we also find a very low relevance of the CDM.

Carbon intensity differences – in terms of companies' technology portfolios – are only responsible for limited differences in how the companies rate the relevance of investment decision factors. For new plant investments, our analysis suggests that the higher the CO_2-intensity of the technology portfolio of power generators, the higher the relevance assigned to both EU ETS and long-term targets. In contrast, technology providers with carbon-intensive technologies in their portfolio attach a relatively lower relevance to long-term climate targets. Also, technology providers' rating of the relevance of the EU ETS, which is always low, is not significantly impacted by their technology portfolio, rather the ratings for technology-specific policies clearly vary for threatened and aligned technologies in both investment dimensions.

Finally, price expectations follow the expected trend of an increase over time in terms of both price and the associated certainty, but these expectations have no impact on the relevance attributed to investment decision factors. Evidently, the relevance ratings are driven by more fundamental assumptions on the part of decision-makers.

4.2 Policy recommendations

The combination of our findings on the relative importance of different climate policy elements and those of Rogge et al. (forthcoming) and Schmidt et al. (2010) highlight the fundamental importance of credible, ambitious long-term climate policy, particularly for RD&D of technology providers. These targets, which would ideally be set at a global level, fulfil two major functions.

First, they provide the basis for corporate visions of the future and can thus serve as a benchmark for corporate targets. As such, they are particularly relevant for RD&D investment, and also portfolio decisions. This was illustrated by a quote from one power generator: *"Climate policy played a massive role in getting [us] into renewables because [..] looking at the portfolio structure and then the climate targets formulated around us, in the order of 50% by 2030 or 80% by 2050, as a company you have to find a role there somewhere. [..] Emission trading doesn't go that far. But we can assume that policy-makers will come up with some kind of instrument to implement these targets."* (Rogge et al., forthcoming)

Second, in combination with policy instruments such as the EU ETS targets provide credibility and predictability. That is, a climate policy mix targeting technological change needs to include long-term targets and climate policy instruments which operationalize them (see also Del Rio Gonzales, 2008). These could be, for example, the EU ETS or feed-in-tariffs for renewables. The importance of this policy mix is underlined by the statement of a technology provider: “There is considerable dynamism in renewables, which is simply driven – very indirectly – by the fact that states confronted with internationally legally-binding CO_2 reductions are able politically to enforce production quotas. [...] my hypothesis is that the promotion of renewables is politically very stable, despite scarce funds. And that has consequences for us implicitly, that we say we have to consider where there are possibilities for us, and how does that fit in with our business, and our competences and strengths – a typical portfolio question. [...] the question of innovation can then follow [...]. [Within this] really big movement, the EU ETS is only a small impulse. Although I would claim it is no coincidence that we [perceive] a change in awareness in the discussion, also in the public one, I believe that the fact that we have a system that gives CO_2 a monetary value has a strong influence.” (Rogge and Hoffmann, 2010, Table 3). This policy mix, however, needs to be tailored to address the specific requirements of the different investment dimensions, adoption of new plant and RD&D. Also, policies may have to be differentiated according to the value chain position of a company, since we have found that power generators and technology providers demonstrate different patterns of the relevance they attribute to investment decision factors.

Further, from our analysis we derive two ways to raise the currently relatively low relevance of climate policy for corporate investment decisions in the power sector. The first one is straightforward, i.e. the introduction of ambitious long-term targets up to 2050 and the tightening of the emissions cap in the EU ETS. Together, these would increase the stringency and predictability of the policy mix and thus also the relevance assigned to climate policy. The second way concerns the other investment decision factors. Here, policies targeted at bringing these factors of the business environment into alignment with climate policy objectives would also increase the relative importance of climate policy. A classic example in this regard is to abolish subsidies for fossil fuels.

4.3 Outlook

While we have focused on the two investment dimensions of adoption and RD&D, our survey also sheds important insights on underlying organizational changes. In the context of investment decisions, these may be particularly relevant regarding a company’s shared long-term vision (Hart, 1995). Vision also alludes to the recognition that collective frames may have to be broken in order to do things fundamentally differently (Kaplan and Tripsas, 2008). We find that climate policy, and here particularly the EU ETS, brought climate change onto the agenda of top management. More specifically, 82% of power generators and 56% of technology providers stated that their company became more engaged with the topics of CO_2/climate policy at management level in the course of the last five years (2005-2009). Similarly, 74% of power generators and 38% of technology providers have introduced or extended climate-relevant targets in their company. Finally, 83% of power generators and 46% of technology providers have integrated CO_2/climate policy when constructing future scenarios. These figures show that, with the introduction of the EU ETS in particular, and the intensification of the debates about long-term targets in general, profound changes have been observable on an organizational level in the last five years (2005-2009). However, for fundamental changes in corporate behaviour it may be necessary to change the mental frames of incumbents, particularly of power generators. To instigate such a shift in mental frames, the current climate policy mix appears to be a first step, but still only a first step. In order to further investigate this aspect, the cognitive features of company behaviour (Nooteboom, 2009) in the context of climate change need to be the focus of analysis.

A second point is that the current low importance of climate policy for investment decisions so far can be expected to increase by 2020. Overall, the companies in our sample of the European power sector indicated that adoption and RD&D climate policy in general will become more important in 2020 ($p<0.01$). Also, while the majority of technology providers typically assume being more positively affected by climate policy, the trend for power generators is tending toward a more negative impact. These figures indicate that companies are expecting a tightening of climate policy in the future and may be preparing for this.

The findings of this study are restricted to the power sector, and caution should be applied when attempting to generalize them across industries. Thus, future research will be needed, to investigate sector differences. However, the findings provide a good starting point for such an analysis and provide important recommendations for policy-makers.

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Annex

Table 5: Correlation matrix of decision factors and CO_2 price expectations

			New plants		RD&D		New plants		RD&D	
			CO_2 price expectation				CO_2 price expectation x certainty			
			Short term (2012)	Long term (2020)	Short term (2012)	Long term (2020)	Short term (2012)	Long term (2020)	Short term (2012)	Long term (2020)
investment decision factors	p&a of fuels	Correlation Coefficient	.144	.083	.056	.013	-.022	.209*	-.103	.152
		Sig. (2-tailed)	.188	.428	.748	.938	.829	.050	.543	.380
		N	65	65	25	25	64	62	24	24
	p&a of installations	Correlation Coefficient	-.028	-.031	-.047	.074	.009	.055	.113	.277
		Sig. (2-tailed)	.792	.762	.790	.660	.932	.600	.508	.112
		N	65	65	25	25	64	62	24	24
	p&d for electricity	Correlation Coefficient	.012	-.018	.152	.196	-.077	-.084	-.032	-.091
		Sig. (2-tailed)	.911	.863	.389	.251	.452	.426	.852	.601
		N	65	65	25	25	64	62	24	24
	Public opinion	Correlation Coefficient	.085	.113	.112	.105	.140	.141	.134	-.052
		Sig. (2-tailed)	.424	.266	.521	.534	.162	.174	.429	.764
		N	65	65	25	25	64	62	24	24
	Technology-spec. policy support	Correlation Coefficient	.093	.126	.076	.130	.090	.103	-.091	-.086
		Sig. (2-tailed)	.392	.224	.665	.447	.376	.329	.595	.620
		N	65	65	25	25	64	62	24	24
	EU ETS	Correlation Coefficient	.180	.110	.337	.196	.125	.238*	.063	.162
		Sig. (2-tailed)	.092	.281	.055	.250	.213	.022	.710	.350
		N	65	65	25	25	64	62	24	24
	CDM	Correlation Coefficient	.094	-.004	.123	-.089	.070	.153	.104	.163
		Sig. (2-tailed)	.382	.966	.487	.604	.490	.146	.543	.352
		N	65	65	25	25	64	62	24	24
	LtCP	Correlation Coefficient	.013	.006	.141	.018	.100	.133	-.014	.144
		Sig. (2-tailed)	.903	.957	.419	.917	.319	.202	.936	.407
		N	65	65	25	25	64	62	24	24