Determining the ideal mix –
(finding out) what range of measures is best for one‘s business?

Stefan M. Buettner, Institute for Energy Efficiency in Production, University of Stuttgart
Werner Koenig, Reutlingen Research Institute, Reutlingen University

ABSTRACT

Many companies of various sizes have pledged to decarbonise. As many different routes could be taken, how do they identify their ideal mix of measures? What baseline information is needed and what strategic priorities do they need to get clarity on by the management board to be able to determine the mix? Motivation and scope aside, how do companies prioritise diverse options that come with direct costs, these being clustered as measures reducing their energy demand, on-site generation of clean energy, purchase of green energy, and compensation measures? Is it the level of investment, the cost per tonne of carbon saved, technical aspects, experience in the type of intervention or access to skilled personnel, or is it other factors such as environmental considerations and image aka visible interventions – or is it a mix of them? How do companies identify a mix of measures that is ideal for them, such as saving most emissions and preparing for a potential and increasing price on carbon? This paper builds on survey data gathered from 861 manufacturing companies operating in Germany and confirms a significant divergence between company sizes as well as energy intensities. Whilst cost-factors unsurprisingly have the highest relevance in determining the choice of measures, other factors appear quite close; irrespective of company size about 60% of intended measures are of an on-site nature.

Introduction

At the New York Climate Summit in September 2019, it not only was the governments raising their ambition on their climate plans and targets but also many ‘non-state actors’ pledged and made their statements. Among these were many actors from financial markets along with numerous global enterprises (FT 2019). Their pledges, as well as the raised ambitions in combination with the growing pressure of civil society in several regions, have since led to a continuous surge of companies developing targets for themselves. Some of them by determination, some due to investor, customer, or supply chain pressure. The recently escalating price on CO_2, predominantly in Europe, also increases the financial pressure on companies, as acting becomes increasingly economic in comparison with non-acting and the arising monetary climate risks and emission costs (Buettner, Wang, and Schneider 2021).

Making the decision to decarbonise goes along with the motivation to identify a mix of measures that is ideal for a company. Such a mix cannot be taken off the shelf, as each company’s situation varies, even if the difference appears marginal. Marginal or not, it may severely impact the ‘decarbonisation efficiency’ which will be defined later.

Assessing the status, the marginal differences, the underlying motivation as well as the strategic considerations is something that needs to be decided upon as a pre-requisite which will be discussed at length in a forthcoming publication (Buettner and Koenig 2021a) and hence only be briefly touched upon in this paper.

The focus of this paper is to study how companies determine their ideal mix of decarbonisation measures based on strategic priorities, current situations, and motivations, as

well as their target level and deadline. At the core of identifying a mix stands the question of what determinant(s) the measures at hand are ranked against and which of the determinants are most decisive in weighting the different decarbonisation options.

The *Energy Efficiency Index of German Industry EEI* of the Institute for Energy Efficiency in Production (EEP) gathered information from 861 manufacturing companies in May 2020, supporting this paper by providing an empirical answer to the question (EEP 2020).

Understanding which determinant(s) matter(s) the most in entrepreneurial decision-making concerning decarbonisation allows tailoring fitting policies appealing to these priorities, and also aide equipment- and service providers to shape their portfolio and to uncover differences between sectors, sizes, or energy intensities. It will also be explored whether the level of ambition or supplier status has an influence.

Lastly, although an identical survey in ten languages is currently handed out to manufacturing companies in numerous countries[1], the data collected from manufacturers in Germany shall be the basis of this analysis.

Methodology

Ideas, analyses, and conclusions presented in this paper are based on empirical data as well as the experiences gained working with manufacturing companies in Germany and with dedicated international working groups on energy efficiency and decarbonisation issues, such as the Energy Efficiency Financial Institutions Group (EEFIG) of European Commission and the UNEP Finance Initiative. These experiences are further complemented by observations stemming from newspaper articles along with press releases on the topic matter.

The hypotheses arising from professional work and general observations as well as the question of what aspects are most decisive in determining a company's decarbonisation mix are then quantitatively assessed within the framework of the Energy Efficiency Index of German Industry (EEI).

First implemented in 2013, EEI's objective is to study the intentions, expectations, experiences, and opinions of entrepreneurs from companies of all sizes, -energy intensities, and across 27 manufacturing sectors on matters of relevance to energy efficiency. Furthermore, it aims to inform businesses, science, policy- and lawmakers, as well as the public on basis of the arising findings. The focus has since widened to include aspects of relevance for a gradual decarbonisation of the industrial sectors. EEI has been made available in multiple languages and has dedicated versions for eleven additional countries referred to as the 'Energy Efficiency Barometer of Industry' (#EEBarometer). EEI is modelled after the general methodology of Germany's monthly economic indicator, the ifo-Index (Mandel and Sauer 2014).

This paper builds on data EEI gathered in May 2020, in-midst of the initial wave of the COVID-19-pandemic, and only a few months after a series of events that gave energy, climate, and decarbonisation considerations additional momentum: the wave of support for Green parties at the European Parliament elections and movements such as Fridays for Future, Scientists for Future and Entrepreneurs for Future, the tightened German climate package and the September

[1] Emerging from *Energy Efficiency Financial Institutions Group*'s (www.eefig.eu) data working group in 2015, the *Energy Efficiency Barometer of Industry* (www.eep.uni-stuttgart.de/eeei) is gathering evidence from manufacturing industries in 12 dedicated country versions in addition to five international versions and thus reaches native speakers in 88 countries. EEBarometer is reporting to the Industrial Energy Efficiency Task Force of the United Nations Economic Comission for Europe (UNECE) as part of its action plan and to other national and international bodies.

2019 United Nations Climate Action summit, and lastly the announcement of a European Green Deal to reach climate neutrality by the European Commission on 11 December 2019. The data set comprises 864 observations (European Commission 2019, EEP 2020, Brunsden 2019).

The semi-annual data collections of EEI always comprise a section, in which a specific focus on selected current issues is highlighted. For the first data collection in 2020, the focal point was aimed at motivation, prioritisation, and intended actions of the German manufacturing industry in respect to decarbonisation.

Companies were asked to answer 18 questions. Apart from the selected thematic- and index-associated questions, companies were asked to indicate their sector (with the largest share of their revenue), revenue, energy consumption, and number of employees. These are the foundation to cross-reference and analyse outcomes of current issue questions across these categories. As revenue and energy consumption are often considered confidential a significant number of respondents chose not to provide these figures or not to respond to some of the other questions asked. The number of observations, therefore, varies in the analysis to come.

Table 1: sample composition by company size (n=845)

Company size	Number of employees	Revenue	Observations	Percentage
micro	0-9	< 2 mio. EUR	186	22.0 %
small	10-49	2 to < 10 mio. EUR	228	27.0 %
medium	50-249	10 to < 50 mio. EUR	248	29.3 %
large	>249	≥ 50 mio. EUR	183	21.7 %

The data collection was carried out in a mixed-methods design, combining online (7 %) and telephone surveys (93 %). Table 1 provides an overview of the sample by company size (as defined by European Commission 2003). We purposely aim for an approximately even distribution across company sizes in EEI's samples rather than mirroring the actual size distribution of manufacturing companies in Germany (Destatis 2019, 526). This is to allow us to compare across and make statements for all company sizes.

Even though desired, it is difficult to achieve an even distribution of responses from across the 27 manufacturing sectors which represent 178,000 companies. 'Core industries' that are of high relevance to German industry were therefore defined for the telephone survey aiming for at least 24 responding companies. Among these were for instance automotive industries and mechanical engineering. Wherever a sectoral view is taken, only those sectors with at least 20 responding companies for the respective question are considered.

Even though the sectors are defined according to the '*Klassifikation der Wirtschaftszweige 2008*', they are compatible to the United Nations' *International standard industrial classification of all economic activities*, ISIC. (Destatis 2008, Eurostat 2020).

Assuming that position, priorities, and envisaged action in respect to decarbonisation activities differ depending on the energy intensity of production, energy intensity was computed for each company where sufficient data was provided. The variable 'energy intensity' is calculated as the ratio between the energy used and the revenue of a company. The variable 'energy use' contains information on the overall energy demand of a company (converted) in megawatt-hours (MWh). The variable 'revenue' provides information on companies' revenue for the previous financial year in million euros (1.2 million USD) (Buettner et al. 2020).

The 656 results of this operation span across a wide range, from 0.0111 to over 10,000 watthours (Wh) consumed per euro of revenue (Wh/EUR) for this sample.

To classify energy intensity, values have been grouped into five classes as illustrated in Table 2. The lower the class of the variable energy intensity, the higher the energy productivity level of a company – and vice versa. Energy efficiency is an essential measure to increase energy productivity. As only 20 of the energy intensity observations fall into the fifth class, there are just enough cases ($n \geq 20$) to include this class in the analysis conducted. In whatever analysis the figure drops beneath 20 observations, only the lower four energy intensity classes remain. Each of the energy intensity classes cut across a broad spectrum of sectors making it difficult to tag a sector with a specific energy intensity level. The share of energy intensive companies however is high in i.e. the building material, chemical, glass, paper, non-iron metal and steel industries.

Table 3: sample composition by energy intensity (n=656)

Energy intensity class	Energy intensity interval	Observations	Percentage
not energy intensive	0 to <10 Wh/EUR	151	23.0 %
less energy intensive	10 to <100 Wh/EUR	243	37.0 %
moderately energy intensive	100 to <1,000 Wh/EUR	198	30.2 %
energy intensive	1,000 to <10,000 Wh/EUR	44	6.7 %
very energy intensive	≥10,000 Wh/EUR	20	3.1 %

Results

At the beginning of determining an ideal mix is the question: an ideal mix for what? Therefore, it is essential for a company's executive management to take a clear position (i.e. defining goal and due date) and assess the status quo. This is, for instance, to establish a common understanding of the target dimension (i.e. climate neutrality) as well as how it is defined. How ambitious the goal shall be within this target dimension and by when it shall be reached is as important as defining system barriers for this goal, i.e. limited to ones' manufacturing sites and the sources of energy acquired (Scope 1+2, WRI 2021). Understanding the current situation in terms of energy and emission footprints, actions feasible or already undertaken is as essential as having a clear definition of the target dimension, -level, and -date: only when starting point and finish line are known, a 'decarb efficient' strategy can be derived.

Being trigger to the decision to act in the first place, the underlying motivation and needs play a major role as they largely influence the choice of options. If public image is the major driver, measures that particularly contribute to a positive image or are easily noticed would have to be prioritised over measures that do not, given similar outcomes.

Only once all other environmental factors, starting points, finish lines and system barriers are identified, and all technically feasible intervention options are on the table, an ideal mix can be derived. 'Decarb efficiency' can only be reached, if such a (decarbonisation) mix is comprised in a way that allows reaching (the) decarbonisation (goal) in the most effective manner. Similar to energy efficiency, which is defined as achieving the same output with less energy put in – a more efficient use of energy - , 'decarb efficiency' considers the efficiency and effectiveness (of the set of measures applied) in reaching a set outcome, i.e. net decarbonisation. It is benchmarked against the starting point of the decarbonisation process; this is the emissions footprint and energy consumption within the chosen system barriers. Ingredients of such packages can positively or negatively influence the effect of each other and thus the overall effect of the package. Whilst it is tempting to define decarbonisation efficiency only against the

speed or against the budget required to reach decarbonisation, it is sensible to define it as the aggregate economic performance forecasted against one or two pre-determined milestone dates.

The automotive supplier Bosch (2019) for example set a short 'net zero' target of fewer than two years (2020) but calculated spendings also against total costs and savings achieved by 2030. This means that their expenditures to achieve net-zero which initially cost them EUR 2bn (USD 2.44bn), will have cost them 'only' EUR 1bn (USD 1.22bn) in 2030. Considering emission prices (on electricity) climbed much faster than was foreseeable at the time and with additional emission charges (on other sources of energy) introduced by the German Government in early 2021 and considerations by the European Commission to do so across the union the net costs are likely to be much below EUR 1bn or even lead to a surplus compared to a scenario of inaction. The price of the European emission trading scheme ETS rose from EUR 5 per tonne of CO_2-equivalent in 2017, to EUR 25 in late 2020. The tightened climate goals since caused it to rise to EUR 53 within 6 months; the German system on emissions not covered by EU ETS starts at EUR 25 and increases annually, first by EUR 5, then by EUR 10 until 2026. (DEHSt 2020).

Net zero can be achieved straightforwardly by purchasing green energy and paying for compensation for all remaining emissions. Since both (as of now) require continuous additional spending, they are not the most economical way to decarbonise an industry in the medium- to long term. Therefore, the decarbonisation mix composition is in flux and likely to evolve: Bosch (2019) reached a speedy net zero state with the easy measures described, however simultaneously launched a longer-term process to optimise energy use and increase on-site generation of energy. This component of intertemporal optimisation is further explored by Buettner, Wang, and Schneider (2021) and hence not the focus of this paper.

1. Which determinants play the largest role in composing a decarbonisation mix?

Key to a company's 'decarb efficiency', thus their ideal mix, is choosing wisely what measures must be prioritised or ranked by and which of these determinants considered for the ranking are most decisive. Is it the level of investment or the investment costs per tonne of CO_2-equivalent avoided? Or is it the achievable savings on emissions charges, respectively reduction of (external) cost risks as a whole, the return on investment, or image effects due to visible measures or motives in relation to the business valuation, expected productivity gains, or technical aspects/risks, such as the complexity of a measure or its severity? Or is it the potential risk of how interventions may interfere or disrupt core or peripheral processes, the availability of or access to personnel that can implement possible measures?

This question is the focus of this analysis and will be assessed from different points of view. For ease of the analysis, these determinants have been grouped into six categories, as illustrated in Figure 1. Companies have been asked to rank up to three priorities (Prio 1, 2 and 3).

As can be seen, there is no dominating determinant. This means that companies are heterogeneous regarding their primary determinant for the decision of their decarbonisation mix. What is however visible is an almost linear decrease between the different shown determinants: The cost per avoided tonne of CO_2-equivalent is the most decisive factor for 21 % of companies. Not much less, 19 % of companies mention the level of investment required to reduce emissions as their most decisive determinant. Technical aspects (e.g. complexity/difficulty/technical compatibility of the measure) are marginally more often chosen as the main priority (17 %) than expected increases in (general) productivity. Measures related to soft factors, such as image effect (14 %) or one's competence (12 %) are down at the bottom of the primary priority list.

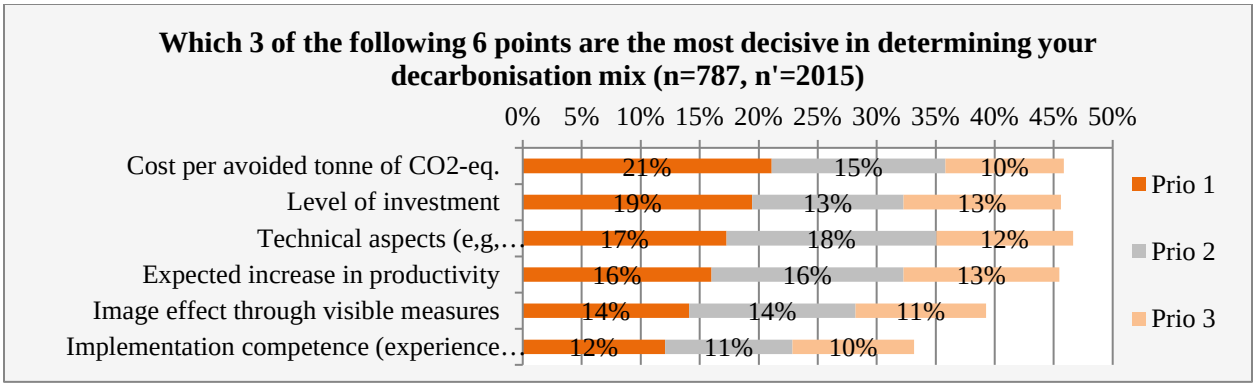

Figure 1. Measures most decisive in determining the decarbonisation mix composition. *Source:* EEP 2020.

Looking at the secondary priority, the picture changes and technical aspects (18 %) are chosen most frequently. This is not surprising as whatever is implemented needs to fit in the existing setup and must not cause production risks during the implementation or operation phase. Productivity increases (16 %) are coming second with investment and image aspects following.

As for the tertiary priority, the preferences are almost evenly distributed. Not all of the 787 companies provided secondary or tertiary priorities.

However, looking at the aggregate of all three priorities, technical aspects are a decisive determinant for most companies (47 %), closely followed by investment aspects (46/45 %) and productivity expectations (45 %) that are all chosen nearly equally often. Even though falling behind them, nearly 40 % of companies stating image considerations within their top three determinants for their decarbonisation mix composition underlines the increasing relevance for companies to pay attention to their outside perception. Considering that there is a shortage of skilled personnel on the job market and both young graduates and the existing workforce pay increasing attention to the (future) employers' stance towards climate-related issues, it is not surprising that hoped for image effects of decarbonisation activities are a priority when four out of ten companies determine the composition of their decarbonisation mix (Scheppe, Sommer, and Specht 2021; Scheppe and Steinharter 2019).

These findings, which are based on the overall sample, may look very different when the data is dissected by either company sizes, energy intensities, or manufacturing sectors. The underlying motivation to decarbonise may as much have an influence as whether a company is supplier to other companies or not, as the decarbonisation pressure imposed on supply chains significantly increased over the past months.

2. Does company size have an influence on the prioritisation according to which the decarbonisation mix is determined?

Surprisingly, the emission avoidance costs per tonne are most often cited as the first priority by micro companies (24 %, cf Figure 2.1). Considering decarbonisation activities often go along with significant investments, one would have thought that the absolute level of investment required (16 %) would rank higher than the relative avoidance costs. Instead, it is ranked third, just slightly above the image effects (15 %) and productivity increase (14 %); technical aspects, however, are the most important determinant for 22 % of companies. Technical aspects are not only the most frequently chosen secondary priority (20 %) but also the most important determinant overall, named as a priority by one out of two micro companies. In

contrast, implementation competence is a priority for less than a quarter of companies in determining their decarbonisation mix. This may be a consequence of companies thoroughly assessing technical aspects, where too complex solutions that would require specific competencies are ruled out already. Another reason might be that micro companies often do not have in-house personnel specialised in energy and footprint matters and are therefore used to hire-in external expertise leading three-quarters of them not to consider this as a priority in determining the composition of their decarbonisation mix.

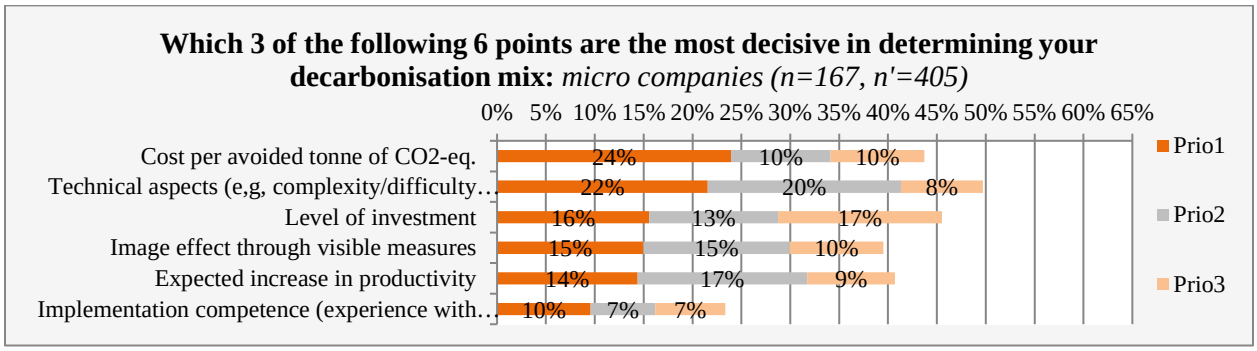

Figure 2.1. Measures most decisive in determining the decarbonisation mix composition. By size: micro companies
Source: EEP 2020.

The situation differs quite a lot looking at small companies (cf Figure 2.2). In contrast to the sample average, level of investment is considered the first priority by most small companies (19 %). Relative avoidance costs (18 %), technical aspects (18 %) and expected productivity increases (17 %) are nearly as frequently named first priority. As for micro companies, technical aspects are the leading secondary priority (18 %). Expected productivity increases are not only an important secondary priority but also the determinant that was named a priority most often by small companies (49 %).

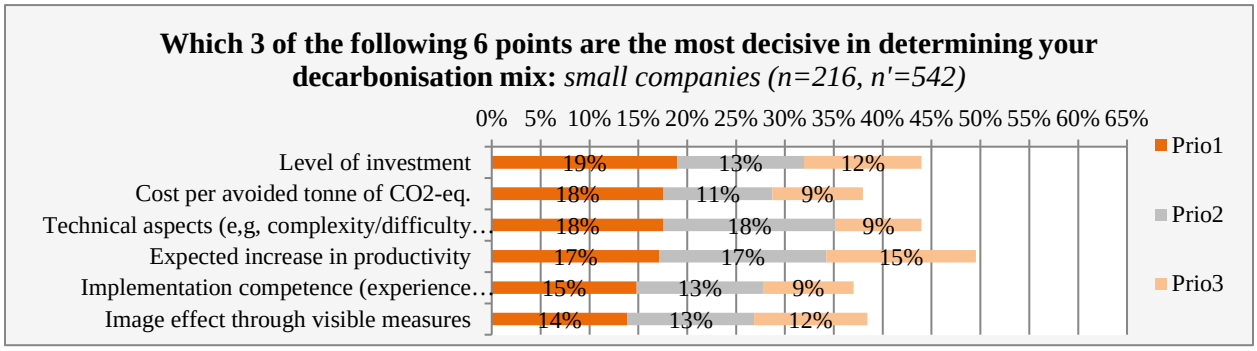

Figure 2.2. Measures most decisive in determining the decarbonisation mix composition. By size: small companies
Source: EEP 2020.

Relative avoidance costs are not only first priority (22 %), but also second (20 %) and third (20 %) for medium-sized companies (cf Figure 2.3) and thus a priority to many more companies than the other determinants. A possible explanation could be that such companies are large enough to manage bigger investments and have the necessary expertise, and at the same time not yet a too large degree of complexity of their operations allowing them to attach such priority to the relative costs. On the other hand, it may also be that medium-sized companies,

many of which are among the so-called ‘hidden champions’ in Germany with a high share of exports and international competition, are consequentually vulnerable to market- and hence price pressure, as much as to pressure to decarbonise from their downstream supply chain. Whilst the level of investment is the first priority (19 %) for nearly every third medium-sized company, in aggregate technical aspects, productivity expectations and image are considered a priority more often (48/47 %). Implementation competence is least often a priority for medium-sized companies, possibly as the relevant expertise can be hired-in if need-be.

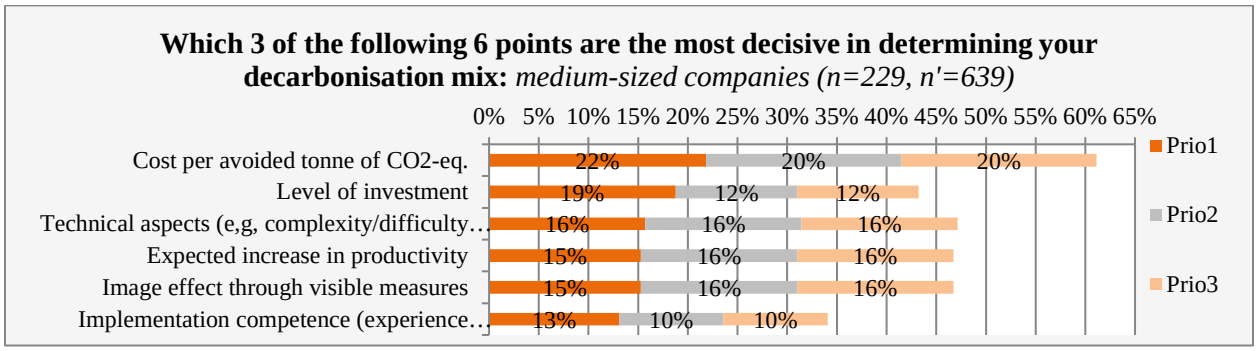

Figure 2.3. Measures most decisive in determining the decarbonisation mix composition. By size: medium-sized companies *Source:* EEP 2020.

For large companies (cf Figure 2.4), level of investment (24 %) and relative avoidance costs (23 %) are almost equally often the first priority. Other determinants are named the first priority much less often. Here, too, technical aspects are the most frequent secondary priority (18 %) and almost as often of overall priority (48 %) as absolute (49 %) and relative (50 %) costs.

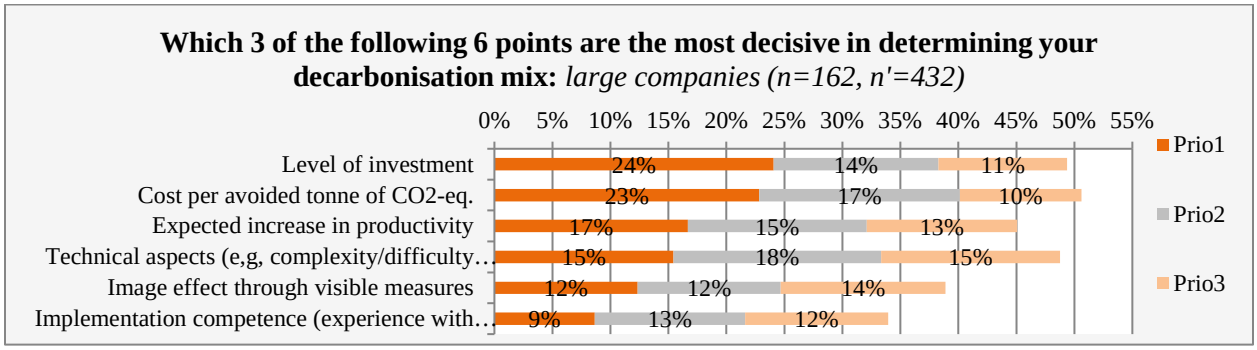

Figure 2.4. Measures most decisive in determining the decarbonisation mix composition. By size: large companies *Source:* EEP 2020.

Looking across company sizes, the priority companies attach to the six determinants assessed differ quite significantly: Taking a closer comparative look per determinant, the cost per avoided tonne of CO_2-equivalent is much beyond average (46 %) a priority for medium-sized companies (62 %), and much below average for small companies (38 %), likely for one of the reasons described. Whilst most important to large companies (49 %), the spread is much smaller for the level of investment (45 % +/-4 % points). This may be the case as absolute costs often can be attached to the question of whether one can afford the expenditure, whereas relative costs can be attached to the question of which measure is the most economic one to decarbonise with.

Technical aspects, most important to micro companies (50 %), have a similar spread (47 % +/- 3 % points). Expected productivity increases (45 %) are least often a priority to micro companies (40 %) and most often to small companies (49 %). Whilst image considerations are in general a priority to 39 % of companies of most sizes, this is a priority to 47 % of medium-sized companies, perhaps due to the mentioned exposition both regionally and on the world market. While larger companies attach an average priority to the implementation competency (33 %), this is more important to smaller companies (37 %) and is, likely due to one of the reasons discussed before, only a priority to a quarter of micro companies (24 %).

3. **Does energy intensity have an influence on the prioritisation according to which the decarbonisation mix is determined?**

Energy intensity often comes along with a higher amount of energy-related emissions. Energy-intensive processes are also often among those with an above-average share of process emissions. Therefore, it is worth exploring whether energy intensity influences the determination of the decarbonisation mix composition.

For non-energy-intensive companies (cf Figure 3.1), the level of investment is a key priority, not only as the first one (22 %) but also overall (57 %). Productivity increase expectations are of priority to every second company (50 %). As energy-related emissions often are the main cause of emissions under direct control (scope 1+2) of not energy-intensive companies, tackling these is at the centre. At the same time, the proportional share of the energy cost of their total costs is low. Saving a proportionally high share of energy therefore does not have an as big effect on total cost as it would for more energy-intensive companies. This may explain why the absolute level of investment has been chosen as a priority that often. This is a bit counter-intuitive as one could also have assumed, that relative avoidance costs would have played a more dominant role in not energy-intensive companies. That said, there may not be many different approaches to structurally reduce the energy-related footprint, most of which are capital intensive, hence the focus on the level of investment.

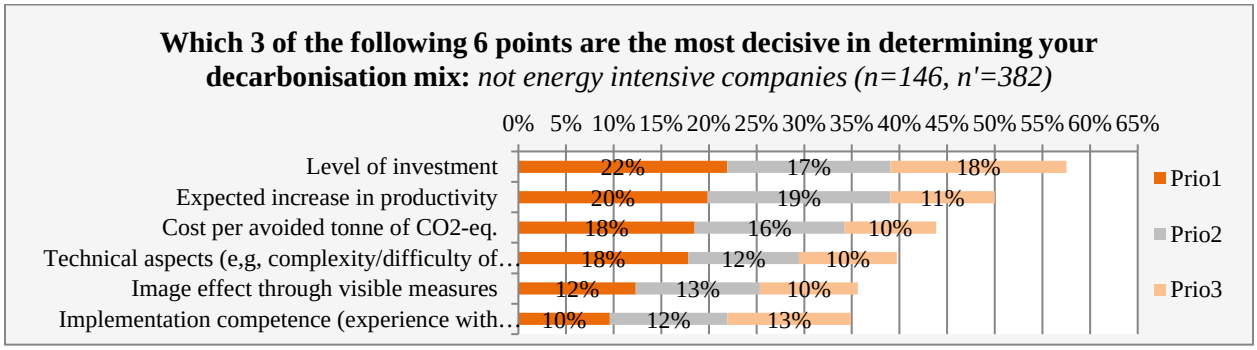

Figure 3.1. Measures most decisive in determining the decarbonisation mix composition. By energy intensity: not energy intensive companies. *Source:* EEP 2020.

It is the less energy-intensive companies (cf Figure 3.2) for which the relative avoidance costs are of the highest importance, both as a first priority (22 %) and overall (48 %). Technical aspects are however most often named second priority (20 %) coming in a close second in overall priority (47 %). This underlines that as soon as energy plays a larger role, technical aspects do so, too, when determining the composition of a company's decarbonisation mix.

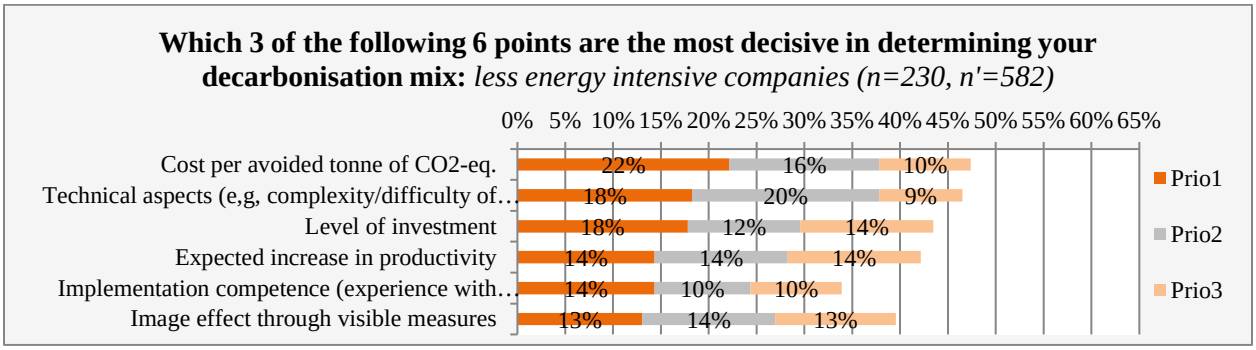

Figure 3.2. Measures most decisive in determining the decarbonisation mix composition. By energy intensity: less energy intensive companies. *Source:* EEP 2020.

Looking at moderately energy-intensive companies (cf Figure 3.3), the situation is very different: Whilst relative avoidance costs are, with a margin, most frequently mentioned as the first priority (20 %), followed by other economic aspects, technical aspects are not only the second priority chosen by most companies (19 %) but also a decisive aspect for more than half of all moderately energy-intensive companies (52 %). This may be the case as from experience energy- and process emissions are increasingly difficult to address the more energy-intensive a company is. From experience, the more energy intensive a company is the more important is addressing the process technology when decarbonising, the less energy intensive a company is the more cross cutting technologies, often 'low hanging fruit' are in focus. The process technology chosen has a large influence on process emissions arising from the process. Overall, expected productivity increases are a priority for more companies (49 %) than relative costs (46 %).

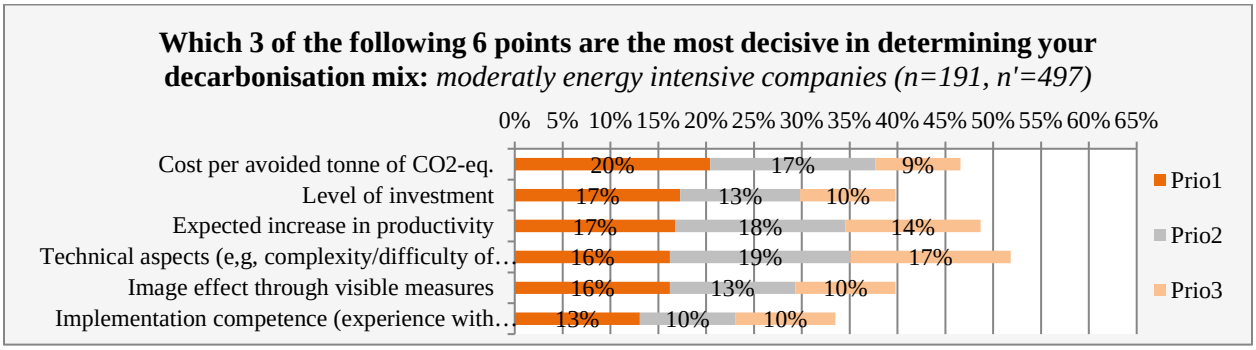

Figure 3.3. Measures most decisive in determining the decarbonisation mix composition. By energy intensity: moderately energy intensive companies. *Source:* EEP 2020.

Even though the sample group of the energy-intensive companies (cf Figure 3.4) is much smaller, these companies are deemed to represent the general group. Technical aspects are by far the most decisive aspect (24 %), followed by productivity gains (20 %). Energy and emission costs are significant cost factors because many energy-intensive companies are obliged to participate in the European emissions trading scheme (ETS). Therefore, a reduction of these costs has a large impact on the energy productivity of companies and their margins; being an important part of the core process, improvements can, but must not, lead to an overall productivity increase. As heavy emitters publicly 'stand out of the crowd', it is not surprising

that image considerations are by far the most often chosen secondary priority (27 %). These are indicated as a priority by every secondenergy-intensive company responding to this question (49 %). As many on-site decarbonisation options, such as energy efficiency measures or reducing process emissions cut deep into the core operations, required investments are likely to be high. Therefore, it is not surprising that being a first priority (17 %), the level of investment is much less often defined as a priority in general (27 %) than the relative avoidance costs (39 %) or put differently which of the expensive interventions provide the lowest costs per avoided tonne of CO_2-equivalent.

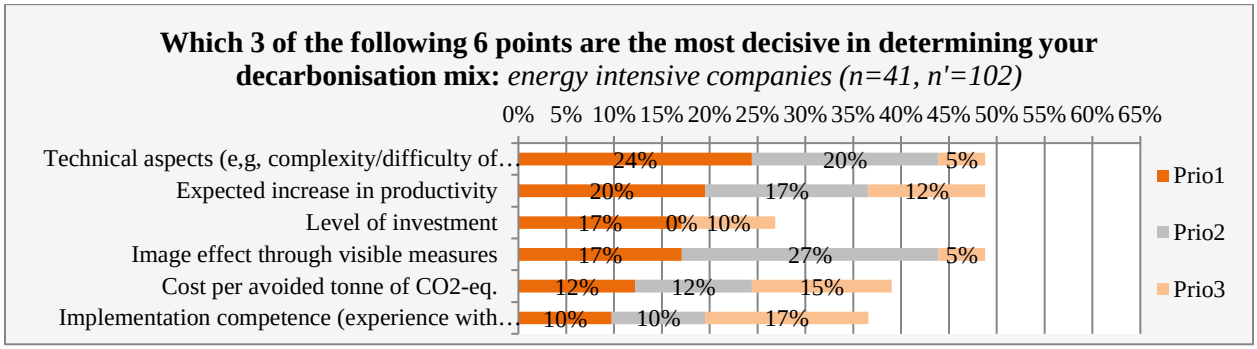

Figure 3.4. Measures most decisive in determining the decarbonisation mix composition. By energy intensity: energy intensive companies. *Source:* EEP 2020.

Across all energy intensity classes, relative costs are, however, categorised as priority least frequently by energy-intensive companies (39 %) while around 45 % of companies belonging to the other intensity classes set this aspect as a priority (average: 46 %). Confirming the assumptions made, the level of investment is mentioned as a priority most often by not energy-intensive companies (57 %). That share gradually declines across company sizes and is lowest for energy-intensive ones (27 %, average: 45 %). Technical aspects are a priority most often to moderately energy-intensive companies (52 %) and least to non-energy-intensive companies (40 %, average: 47 %). Expected productivity increases are, overall, of equally high importance (49/50 %) to companies of almost all energy intensity classes, except for less energy-intensive companies (42 %, average: 45 %). The statement that energy intensity has an impact on the weight of image considerations in determining the decarbonisation mix is enhanced by the observation that the number of companies considering this aspect as a priority is increasing with increasing energy intensity: this comprises 35 % of non-energy-intensive companies, 40 % of less- and medium energy-intensive companies, and 49 % of energy-intensive companies. The implementation competence is a fairly relevant determinant across the energy intensity levels (around 33 %). Only non-energy-intensive companies (35 %) and energy-intensive ones (37 %) suggest it as a priority more often.

4. Is being a supplier influencing how companies prioritise the composition of their decarbonisation mix?

Whilst the role of relative avoidance costs is chosen equally often as the first priority (21 %, cf Figure 4A-B), this differs for the role of the level of investment and technical aspects. For the non-suppliers, they are fairly equal (19 %), whereas, for suppliers, the level of investment (20 %) is more often a priority than technical aspects (17 %). This may be due to the

weight of supply chain pressure on margins and the emission footprint. Where productivity increases are of similar relevance (16/17 %), image is less important to suppliers (13 % vs. 15 %), whereas implementation competence is more (13 % vs. 10 %). Only looking at the overall priorities the differences are more significant: Where productivity increases and costs per avoided tonne of CO_2-equivalent are the determinants most often named priority by suppliers (47 %) and investment levels, as well as technical aspects not far behind (45/46 %), for companies that are not predominantly suppliers, technical aspects are the determinant named a priority most often by a margin (50 %). This may be as the share of micro and large companies being a supplier is considerably larger and for those technical aspects have a higher relevance than for the other company sizes. Also the second most frequently named determinant, level of investment (47 %), is chosen considerably more often than relative costs (43 %), productivity expectations, as well as image considerations (both 41 %). Implementation competency appears to be more (often) important to suppliers (35 vs. 30 %). While supplier state appears to have a clear influence on the composition of the decarbonisation mix, it is diffuse why. This is, however, understandable as the heterogeneity of companies in this dimension is far bigger than from a company size or energy intensity viewpoint.

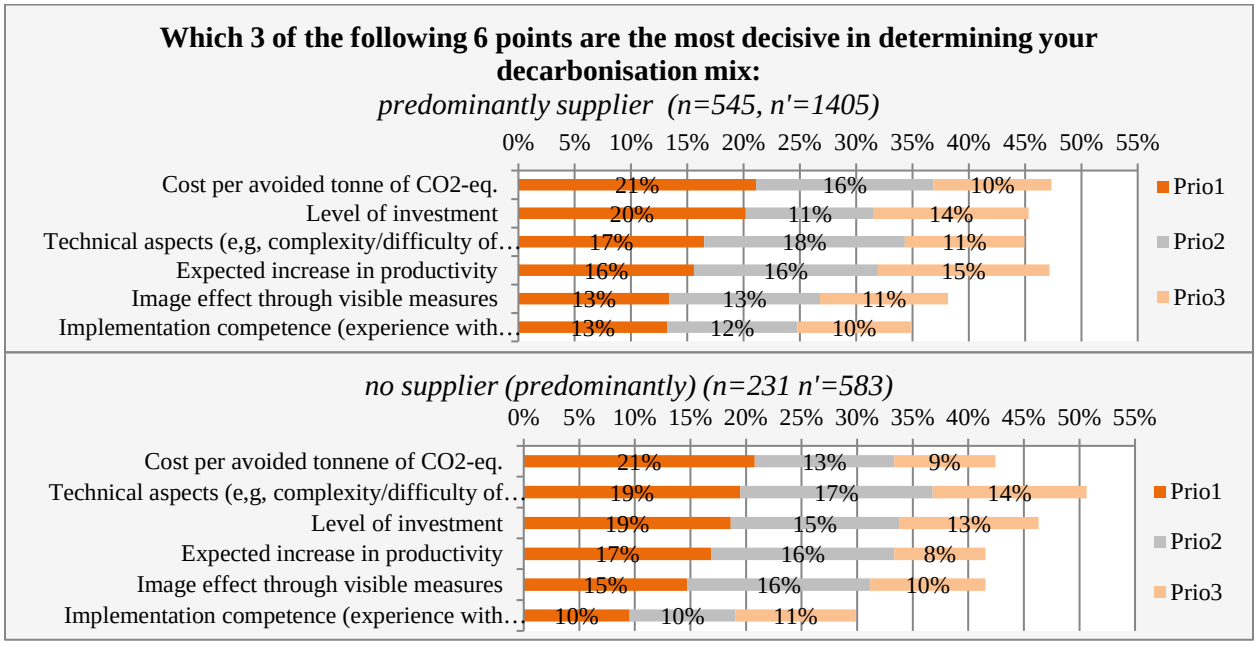

Figure 4A-B. Measures most decisive in determining the decarbonisation mix composition. By supplier state. *Source:* EEP 2020.

5. What influence has the motivation to decarbonise on the priorities in relation to the composition of the decarbonisation mix?

The motivation to decarbonise is thoroughly analysed by Buettner and Koenig (2021b). In brief, for those companies that decarbonise predominantly because of government requirements, technical aspects are the priority (48 %), followed by relative avoidance costs (47 %) and productivity expectations (46 %).

Not surprisingly, for companies whose primary motivation is long-term economic advantages, productivity expectations are named by far most often a decisive determinant

(55 %), followed by technical aspects and level of investment (both 46 %). Relative avoidance cost plays a role for much fewer of these than of all companies (37 vs. 46 %).

For those companies where customer requirements are the driving motivation to decarbonise, the level of investment (51 %) is most frequently mentioned as a determinant, with productivity increases close behind (48 %). This could be as these companies aim to fulfil what their clients expect with least capital expenditure weighing on their margins, and the highest productivity increases gained in doing so.

Looking at companies whose primary motivation to decarbonise is image improvement (cf Figure 5), image surprisingly is neither more nor less often named a priority than in the overall sample (39 %). On the contrary, relative avoidance costs and technical aspects (both 48 %) are most often declared as a decisive determinant. This leads to the reading that it matters most which technically feasible measures allow to reach the decarbonisation goal cheapest; their individually visible actions appear to be less weighty less than the image gain from achieving the goal itself.

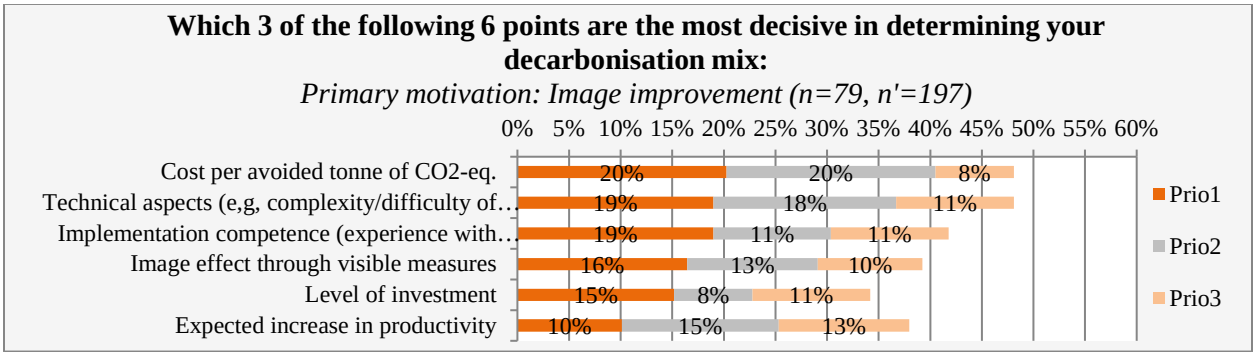

Figure 5. Measures most decisive in determining the decarbonisation mix composition. By primary motivation: image improvement. *Source:* EEP 2020.

More intuitive is that companies aiming at a reduction of cost risks much more often name the relative avoidance costs (56 %) and level of investment (49 %) than the other determinants. With 32 %, image consequently plays a role less often for these companies.

Where investor requirements are driving motivator to act, all economic and technical determinants are considered decisive by roughly every second company of that group, with productivity increases being chosen most often (55 %) and relative avoidance cost second most often (51 %). This follows intuition as investors care for achieving targets in the most economic manner (therefore the relative costs) but also look for a continuous improvement of productivity.

For companies being motivated to decarbonise following their corporate social responsibility (CSR), image considerations are a decisive determinant as often as relative avoidance costs (both 49 %). This follows the notion of the saying ‘do good and talk about it’, particularly as the emission reduction ambition and goals aimed at by these companies are not higher than average. Instead, they are lower than the ones of the average company and considerably lower than the ones of those being motivated to decarbonise by their investors, to reduce cost risks or to improve their image (EEP 2020). Whether CSR is lip service in terms of its environmental component cannot be judged adequately in the context of this paper.

Overall, relative avoidance costs are most often called decisive by companies whose decarbonisation motivation is the reduction of cost risks (56 %) and least by those looking for long-term benefits (37 %), the level of investment most by those companies being motivated by

customer requirements (51 %) and least by those striving for image improvement (34 %). Expected productivity increases are most often a determinant for those with either a long-term expectation or following investor requirements (both 55 %). As described, image effects are most often the decisive factor in the CSR context (49 %), however least for those motivated by investor requirements (29 %). The competence to implement stands out as a decisive factor for companies motivated by image improvement considerations (41 %).

6. Is there a link between the sector and the determinants according to which the decarbonisation mix is composed?

As it would go too far to look at each of the 27 manufacturing sectors within the context of this paper, we will briefly highlight some sectors where the results appear to be most striking: except for implementation competence, each of the determinants is the most often chosen decisive determinant in at least one of the sectors with a sufficient participation rate for this analysis.

Image effects through visible measures are most often a primary determinant for companies in the pharmaceutical (29 %) and not surprisingly in overall priority for those in the 'manufacture of coke and refined petroleum products' industry (59 %). Image consideration is, by a margin, least often labelled as a critical determinant in the chemical industry (23 %).

Whereas implementation competency is most often the primary determinant in the 'printing and reproduction of recorded media' sector (23 %), it is the 'manufacture of food products' sector in overall priority (50 %). With 16 %, least companies attach importance to this in the 'manufacture of coke and refined petroleum products' sector.

The expected increase in productivity is the dominating determinant in a number of sectors, but from a cross-sectoral viewpoint, it is most often primary determinant for the food industry (33 %), however closely followed by the chemical industry (30 %), where it is also of highest overall priority (57 %). Productivity increases are least often a critical determinant for the composition of the decarbonisation mix in the 'printing and reproduction of recorded media' sector (23 %).

Technical aspects are by far the most often primary determinant in the 'other manufacturing' sector (32 %) that also leads from an overall viewpoint (64 %), closely followed by the leather industry (62 %). Technical aspects appear to be of least concern in prioritising decarbonisation options to the (extraction of) oil and gas industry (23 %) where there is not much flexibility on the technically feasible options at hand.

The level of investment is awarded by far with the highest primary priority in the 'printing and recorded media' sector (45 %), more than fifty percent higher than the next one. However, overall the 'manufacture of coke and refined petroleum' sector attaches the highest overall priority to the level of investment (59 %), with the fabricated metals sector close behind (57 %). For the 'other manufacturing' sector it is of least relevance with a distance (24 %).

The cost per avoided tonne of CO_2-equivalent is primary determinant by far most often for companies in the 'manufacture of computer, electronic and optical products', 'coke and refined petroleum' and 'extraction of crude petroleum and natural gas sectors (45 %, 42 %, and 38 %). However overall priority of relative avoidance costs is highest in the 'manufacture of motor vehicles, trailers and semi-trailers' sector (64 %), closely followed by the computer and electronics industry (60 %). Least often but still on a high level, this determinant is considered a key priority in the 'printing and reproduction of recorded media', followed by the 'manufacture of food' sector (32/33 %).

Discussion and Conclusion

While the average viewpoint indicated that relative avoidance costs, level of investment, technical aspects, and expected productivity increases are a decisive determinant for nearly the same and high share of companies (around 45 %), the multidimensional analysis has shown that this homogeneity vanishes when looking closer and that every view point we looked from has its justification. Even though taken in consideration indirectly, the state of the economy, stimulus or support programmes (that i.e. serve to reduce absolute or relative costs of a measure) are external factors that can also have a significant impact on the composition of the mix.

This means that there cannot be a standard package of measures to suit all needs and perspectives. Instead, the focus ought to be devising a procedure according to which an 'ideal' mix of measures can be devised. The determinants to which decarbonisation options are prioritised and weighted are an important part of this decision process, however only a part.

What these decarbonisation options are, which ones are applicable in which context, serving which goal and in which timeframe, however, are issues that call for closer separate analysis and build on strategic considerations and a thorough status quo assessment (cf. Buettner and Koenig 2021a).

Doubtlessly, many decarbonisation mix ingredients, and hence the 'ideal mix' by itself are also affected by variable energy and emission prices, respectively acquisition risks, so any strategy ought to consider temporal effects (Buettner, Schneider, and Wang 2021).

What is clear though, is that the challenge ahead is large, as are the opportunities within. On average the 861 companies participating in this sample aim to reduce their greenhousegas emissions by 22 % by 2025 (base: 2019), which is equivalent to a 49 % reduction compared to 1990, the international base year in climate issues. Even though the specific decarbonisation mix remains to be determined, companies have stated that they envisage tackling, irrespective of company size, 60 % of these emissions through measures on-site (6 % through energy efficiency, 3 % via a reduction of process related emissions, 5 % through on-site generation and storage) and the remaining 40 % through purchase of green energy (5 %) and compensatory measures (3 %) (EEP 2020).

Whether and in what way the findings presented apply in other geographies and cultures remains to be seen. Potentially the data currently gathered by the 'EEBarometer' can shed light upon this question.

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