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TNO report

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Future of Industry: Competitive sustainability in the Dutch construction sector

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1 Introduction

The construction industry is not known for its sustainable nor for its innovative nature. Yet, innovations, and especially sustainable innovations are of crucial importance for the industry to reduce its footprint and maintain its competitive position. In the built environment such a transition is desirable for two reasons. First because the construction is a big user of energy and materials, and creates much waste. According to Spence & Mulligan (1995) it consumes annually 25% of the virgin wood and 40% of the raw stone, gravel and sand are consumed for building construction. Globally buildings consume 16% of the water and indirectly produce nearly 70% of all sulphur oxides (Dimson in Ngowi 2001). Additionally buildings account for up to 50% of carbon dioxide emissions, 40 % of energy requirements, and 71 % of electricity consumption 50 % of raw materials and 40% of solid landfill waste (PRQ, 2008). Though sustainable competitiveness refers to activities which restore and enhance natural as well as social systems this research focuses on the natural aspect as construction is acknowledged to cause environmental stress. Second, because construction industries are not 'footloose', hence, all progress that is made in improving the sustainability performance of the construction industry benefits the regions and countries they operate in, while at the same time knowledge and experience can be built up that can be sold internationally.

In this report we therefore investigate:

1. The extent to which the construction industry is innovative, and how they compare to other (resource intensive) industries;
2. The extent to which the construction industry is sustainable, and how we can measure this;
3. The factors that underlie the performance of this industry on sustainable innovation, i.e. the barriers and drivers for sustainable innovation, in the perspective of the incumbent firms, and entrepreneurs.

To investigate these questions, we made use of quantitative data of the CBS (CIS data), data from organisations annual reports and social responsibility reports and of semi-structured interviews. 34 interviews were conducted with different actor groups in the sector. This was done to get a good insight into the drivers and bottlenecks for sustainable innovation that actors experience in this sector. We chose this approach because the 'view' on the system's functioning can differ greatly depending on the angle one takes on the subject. Approximately half of the interviews 18 were conducted with actors that work with the established players (incumbents) in the field, such as BAM Vastgoed, Bouwfonds, Ballast Nedam, Dura Vermeer and Blauwhoed, and 16 interviews were with entrepreneurs that were introducing new sustainable products and technologies into the industry.

In both cases we spoke to company representatives that were involved in the management and execution of projects. This means that if the companies do innovate by using or developing new sustainable products, technologies or processes, these representatives know and are familiar with the opportunities and the difficulties that come up in such a process. All interviews have been dealt with in a confidential way, and the results represent the different opinions and experiences of the respondents without specifying who these respondents were. It must also be noted that the respondents do speak on behalf of their organisation, but that individual perceptions and opinions may differ considerably within these organisations.

1.1 Theoretical model for analysis

For the analysis of the construction industry we made use of the Market and System Failure Framework that distinguishes between:

1. Infrastructure: The enabling structures that make economic activities possible. Examples are roads, railways, IT infrastructure etc. Innovations that involve a paradigm shift, such as electrical cars or internet, generally involve a requirement for new infrastructure as well (electrical grid for cars, IT infrastructure for fast internet). The presence of such supporting infrastructures are essential for the success of innovation and can even be a strong driver for innovation by creating first movers advantages for the first countries/ regions investing in them.
2. Institutions: Coercive pressures refereeing to hard institutions such as rules and regulations set by regulators. They are hard in the sense that they are explicit, specific and enforceable. Absence of well functioning formal institutions (i.e. absence of contract law or IP protection) hinders innovation, but too rigid formal institutions may have the same effect (i.e. bureaucracy). Normative pressures are the 'intangible rules of the game' or softer institutions such as norms, values, cultures that implicitly shape actors preferences, interpretations and consequent behaviours. Informal 'rules' can stimulate innovation if they value creativity and change, whereas the opposite is true if the consensus tends towards keeping things as they are. Mimetic pressures, lastly refer to the copy-cat behaviour and competitive pressures: if the leading actors in a field adopt certain practices, others are likely to follow to reduce risk and increase legitimacy (if you act/perform relatively similar to the leader you will be reasonably competitive).
3. Interaction: Hard network failure referring to too much interaction between parties that know each other well and for a long time (strong ties) leading to 'lock in' and blind spots. Weak network failure referring to too little interaction between parties, or absence of linkages all together which hinders innovation as parties do not know each other (well enough) and will hence not engage in knowledge exchange, learning and/or collaboration.
4. Capabilities: Referring to the knowledge and know-how that actors have in house to engage in innovation. This includes the technological and/or technical knowledge and know-how to for instance develop a new product successfully, but also to the organizational and marketing skills that are required to manage the innovation process and the successful introduction of a product or process into the market.

For the analysis in this paper we add the following market characteristics that may hinder innovation:

5. Market demand: Characteristic of the introduction of new products and processes is that the rate of adoption can be very slow in the beginning. As a result economics of scale cannot be achieved and costs remain high. The innovator will need the market to become sufficiently large to overcome this problem (*demand quantity*). To get to the stage where products or processes can be 'produced' in larger quantities, the 'child diseases' have to be discovered and restored to make a large 'role out' possible. For this, lead users or lead markets are needed that demand a high quality (*demand quality*) which stimulates parties to innovate and seek the cutting edge in new technologies. The government can play an important role here in public procurement or setting standards to increase the requirements for products and processes.
6. Market structure: *Market power* and *entry barriers*: The market structure mainly determines the openness of the market to new players, new products and processes,

or in other words, the degree to which the market is dominated by a limited amount of actors that can effectively determine (or influence) the quantity and prices of the goods available in that market (market dominance, varying from monopoly (single actor) to oligopoly (small group of suppliers), monopsomy (small group of buyers) and cartels (collaborative agreements on prices and competition). This is referred to as *market power*. *Entry barriers* can have a similar effect on innovation and entrepreneurship when high initial costs, e.g. for knowledge development or setting up capital intensive production or research facilities (sunk costs) hinder entry into a field or market.

7. Externalities: *Positive or negative externalities* may corrupt the incentives for innovation when the market price does not account for the external effects of an economic activity on other individuals and/or the environment. Pollution is the classical example of negative externalities. Positive externalities might also hinder innovation though, if actor A invests in e.g. more energy efficient buildings and actor B benefits from this investment without A having the possibility to earn back its investment. This problem is often referred to as the issue of split incentives, which can occur in
   - *the value chain*: investments and benefits lie with different actors in the value chain, e.g. energy efficient building where the end-user benefits from low energy bills without sharing the investment,
   - *time*: benefits and/or costs resulting from an investment are delayed in time, e.g. the costs of the demolition of a building is not carried by the builder,
   - *place*: the costs and benefits are split geographically, e.g. environmentally hazardous ships are sailed to third world countries to be demolished there where there are less stringent environmental and labour laws.

In all these cases, the direct relation between cause and consequence is lost and hence market incentives for innovation or sustainability are dampened. To deal with such issues, market regulation is of great importance, as it increases *transparency* for buyers to be able to decide not only on price, but also on the process that led to the price (fairness). These aspects are at the core of sustainability issues as the reason behind unsustainable practices is often the lack of ‘total cost’ approaches, the lack of transparency, and the ‘footloose’ nature of international business which factors open up the possibility for actors to use the principle of externalities to their advantage, i.e. reaping benefits without carrying the full costs of their actions.

Table 1.1.1: Market- and system failure framawork

Actors: ***Categories of system interactions:***		**Users** (consumers, companies, lead clients i.e. government)	**Producers** (MNEs, SMEs, entrepreneurs)	**Knowledge providers** (universities, research institutes)	Third parties, **Capital providers** (banks, private	**Government** (national, local)
Infrastructure						
Institu-tional	Regulative Coercive					
	Social Normative					
	Competitive Mimetic					
Inter-action	Too much					
	Too little					
Capa-bilities	Technological					
	Organizational/ Marketing					
Market demand	Quantity					
	Quality					
Market structure	Externalities / Split incentives					
	Entry barriers/ Market power					
	Transparency/ Perfect info.					

1.2 Structure of the report

This report is structured as follows

In Chapter 2: 'Innovation in the construction industry' we give a description of the construction industry on the basis of CBS data. We describe the industry on its innovativeness and benchmark the industry against two other industries (services and manufacturing) to get an idea of its relative functioning vis-à-vis these industries. After the description and conclusion that the construction industries generally lags behind a bit on innovation, we try to determine the factors that hinder innovation by performing a correlation analysis on the market and system characteristics of the industry and the degree of innovation and successfulness of the companies within the industry. The

analysis is only a first attempt to make such an analysis as the data are seriously flawed which makes it difficult to draw clear conclusions.
In Chapter 3 'Sustainability in the construction industry' we give an overview of how a leading group of companies in the construction industry is performing on sustainability measures as people, planet and profit. We benchmark the firms against a list of measures as composed of various social responsibility reports. From the benchmark we conclude that the level of reporting is still in its infancy in the sector, whereas the intentions to work towards more sustainable practices is certainly present.

In Chapter 4 'System analysis in the construction industry' we try to unveil the underlying mechanism that explain A) the level of innovation as presented in Chapter 1, and B) the level of performance on sustainability as presented in Chapter 2. In this chapter we present the results of 18 interviews with incumbent firms and 16 interviews with entrepreneurs. The interviews were aimed to get an in-depth insight as to why companies innovate or not, and why these companies invest in sustainable innovation (or not). The results have been summarised in the Market and System Failure Framework to give a compact overview of the system.

In Chapter 5 'Overall conclusion' we present the conclusions of this research, combining the quantitative results from the CBS data with the qualitative data from our 34 interviews in the sector. Together these data give us a relatively complete insight into how the construction industry works, both seen from a bird's eye through the data, and seen from the perspective of the companies.

2 Innovation in the construction industry

2.1 Level of innovation in the construction industry: descriptive statistics

To get a good insight into the level of innovation in the construction industry, we first turned to macro CIS data of the Dutch Statistics Bureau (CBS) (see Table 2.1.1). Here we conducted a comparative analysis of the construction industry vis-à-vis manufacturing and services. When we look at the innovativeness of the construction industry, we see a sector that lags behind the other industries.

Table 2.1.1: Innovators in the construction industry

Overview of research population					**Relative position to total**		
	Total	**Services**	**Manufacturing**	**Construction**	**Services**	**Manufacturing**	**Construction**
Population	62790	41232	10855	8244			
Innovators	15462	9257	4564	1041			
Innovators as share of population	25	22	42	13	-3	**17**	**-12**
Firms with new product or service	10206	5910	3438	525			
Share of innovators with new methods of production	10	11	9	7	1	-1	-3
Share of innovators with new or improved logistics, distribution system	14	15	12	9	1	-2	-5
Share of innovators with large organisational change	46	47	45	48	1	-1	2

From the data presented in Table 2.1.1, we can conclude that the construction mainly lags behind on the number of innovative firms that are active in the industry. Where in the total economy, 25% of the companies have introduced new products, services, or processes in the last 3 years, in the construction industry the percentage is only 13%, or 12% less than the mean. This can perhaps be explained by the nature of the industry: whereas there are less then 25 companies with over 500 employees, there are over 20.000 small firms, of which around 15.000 with less then 10 employees (EIB, 2002). It is mainly these very small firms that are often not in the position to do much in the way of innovation. They are often independent or small installers that work with low profit margins at small projects. These projects hardly ever give room for creative solutions. It contrasts sharply with the manufacturing industry where they have 17% point more innovative firms than in the economy in total (42% vs. 25%).

Table 1.1.2: Effect of innovation on competitiveness

Competitiveness (effect of innovation): share of innovators					**Relative position to total**		
	Total	**Services**	**Manufacturing**	**Construction**	**Services**	**Manufacturing**	**Construction**
% turnover products new to market	10	11	9	7	1	-1	-3
% turnover new to firm	14	15	12	9	1	-2	-5
% turnover unchanged	76	74	79	84	-2	3	**8**

Competitiveness (effect of innovation): share of innovators					Relative position to total		
	Total	**Services**	**Manufacturing**	**Construction**	**Services**	**Manufacturing**	**Construction**
Increased market share	64	63	73	43	-1	**9**	**-21**
Improved quality	74	75	79	60	1	5	**-14**
Reduced labour costs per unit	41	36	49	37	-5	**8**	-4
Organisational innovation							
Reduced time to market	68	68	67	58	0	-1	**-10**
Improved quality	73	75	69	63	2	-4	**-10**
Reduced costs per unit	51	50	55	48	-1	4	-3

When we look deeper into the effects of innovation within the population of innovators in the construction industry (see Table 2.1.2), and look whether the introduction of new products and processes has led to higher turn-over, higher market share, reduced time to market, or improved quality, we get a relatively negative picture. Whereas for the whole economy, 64% of the companies state that the introduction of new products or services has led to increased market share, this is only the case in 43% of the companies in the construction industry, ***thus 21% points or 33% less than the average*** The picture for the construction industry is negative along all indicators: Whereas innovation leads to improved quality in 74% of the companies in total, only 60% of the construction companies experiences such positive effect. Also the effect on cost reductions from innovation is lower in the construction industry, although the difference is smaller than with the other factors.
For organisational innovation, we see a similar trend: whereas organisational innovation leads to reduced time to market in 68% - and improved quality in 73% of the cases in the total economy, in the construction industry this is 58 and 63% respectively, both 10% points lower than the average.

In short, we see that whereas one would expect the introduction of innovations to contribute to competitiveness indicators such as turn-over and market share, we see that the figures indicate that these positive effects occur less so in the construction industry then in other industries. A clear difference again exists with respect to the manufacturing industry where companies, more than the economies average, report that innovation contributes to increased market-share and labour cost reductions. In the construction sector not only half of the respondents experience such positive effects! To the contrary, 84% report that their turn-over is unaffected by innovation.

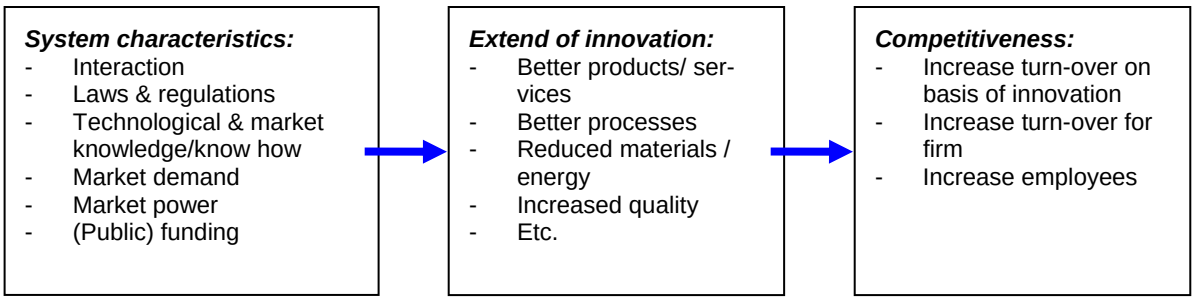
2.2 Barriers and drivers for innovation: correlation analysis

When we explore the CIS data in more detail, we can try to establish the underlying factors of why innovation in the construction industry does not lead to increased market share, quality, lower costs etc. to the same extent as in other industries. To answer this question we make use of the Market and System Failure Framework as introduced in the introduction. In the CIS data there were variables included that give a reasonable coverage of this model. We hence decided to make a system analysis on the basis of this data to test whether the CIS data can be used to make a system scan, i.e. whether such analysis can bring to the surface the factors that hinder or stimulate innovation in an industry.

For the operationalisation we made use of the existing data in the CIS data which means that we adopt also the flaws in data gathering of this database. For instance, not all categories as discussed in our theoretical model were included in the CIS data-base, so we cannot come to a complete test of our model. We further discuss these flaws in the limitations of our research section. Seen the considerable limitations, this research should be considered as a first step towards making a quantitative system analysis, like a quick scan of an industry. In such a scan we can potentially discover system failures, but also those system characteristics that act as strong drivers for innovation. Such analysis can help policy makers to address the bottlenecks for innovation in the system, and potentially strengthen the drivers.

The model for testing includes

1. system characteristics that are assumed to either hinder or stimulate innovation
2. realized innovation, conceptualized as dependent on the system's characteristics
3. performance of companies in term of turn-over growth and company growth, conceptualized as dependent on the innovation performance of the firm



2.2.1 Correlation between system characteristics and innovation performance

Correlating system characteristics with innovation performance in the construction sector shows that many variables are significantly correlated, however, many of these show comparatively low correlation coefficients.

Table 2.2.1: Correlation between market and system characteristics and innovation performance

System characteristics		Innovation performance				
		Effects of product/service innovation		Sustainability		
		ERANGE	EQUA	EMAT	EENV	EFORSA
INSTITUTIONS: institutional pressures	SCOM	,216(**)	,171(*)		,185(*)	
	ESTD	**,283(**)**	**,398(**)**	**,447(**)**	**,680(**)**	**,262(**)**
CAPABILITIES	HPER			,211(**)		**,300(**)**
	HTEC	,191(**)	,242(**)	**,300(**)**	,144(*)	,212(**)
	HINF	,229(**)	,192(**)	**,270(**)**	**,251(**)**	**,260(**)**
MARKET DEMAND	HDEM	,215(**)		**,259(**)**	,192(**)	**,286(**)**
	HMAR			,213(**)		,195(**)
Public funding R&D	FUNLOC			,174(*)		
	FUNGMT	**,311(**)**	**,330(**)**	,226(**)	,216(**)	

NOTE: From this table the categories that had lower correlations than 0.250 have been excluded! (interactions, market structure, access to funding)

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Missing values = no significant correlation

Most important variables explained (for complete list see Appendix):

Vertical:

ESTD : the degree to which firm conform to laws and regulations
HTEC/HINF : Technological and Market knowledge and know-how
HDEM : uncertainty of market demand
FUNGMT : funding received of national government

Horizontal:

ERANGE/EQUA : range and quality of new products / services
EMAT : degree to which less material use is achieved
EENV : degree to which less environmental damage is achieved
EFORSA : degree to which more employee satisfaction is achieved

From the correlation matrix we excluded all coefficients smaller than 0,250 to include only the strong results. The most important system characteristic, measured by the highest significant correlation coefficients are:

- compliance with regulation;
- public funding for R&D from national agencies.

These are particularly highly correlated with reduced material and energy use and improved environmental performance. Secondly, these show a positive correlation with improved product and service quality and a broader product. These results confirm the important role of government regulations and funding to support innovation and sustainable innovation in the sense that it reduces environmental impact and material use.

2.2.2 Correlation between innovation performance and competitiveness

If we next look at how innovation performance, in turn, relates to the economic performance of firms, we see the following picture.

Table 2.2.2: Correlation between innovation and economic performance

Innovation performance		**Economic performance** Percentage of new products TURNMKT	TURNIN
Product innovation: product/service	INPDGD	**,320(**)**	**,335(**)**
	INPDSV	**,453(**)**	**,296(**)**
Process innovation	INPSPD	**,251(**)**	**,228(**)**
	INPSLG	,188(**)	**,228(**)**
Effects of product/service innovation	ERANGE		
	EQUA		,168(*)
Effects of process innovation	EFLEX		
	ECAP		
Sustainability	EMAT		
	EENV		
	EFORSA	,182(**)	,136(**)

Missing values = no significant correlation

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

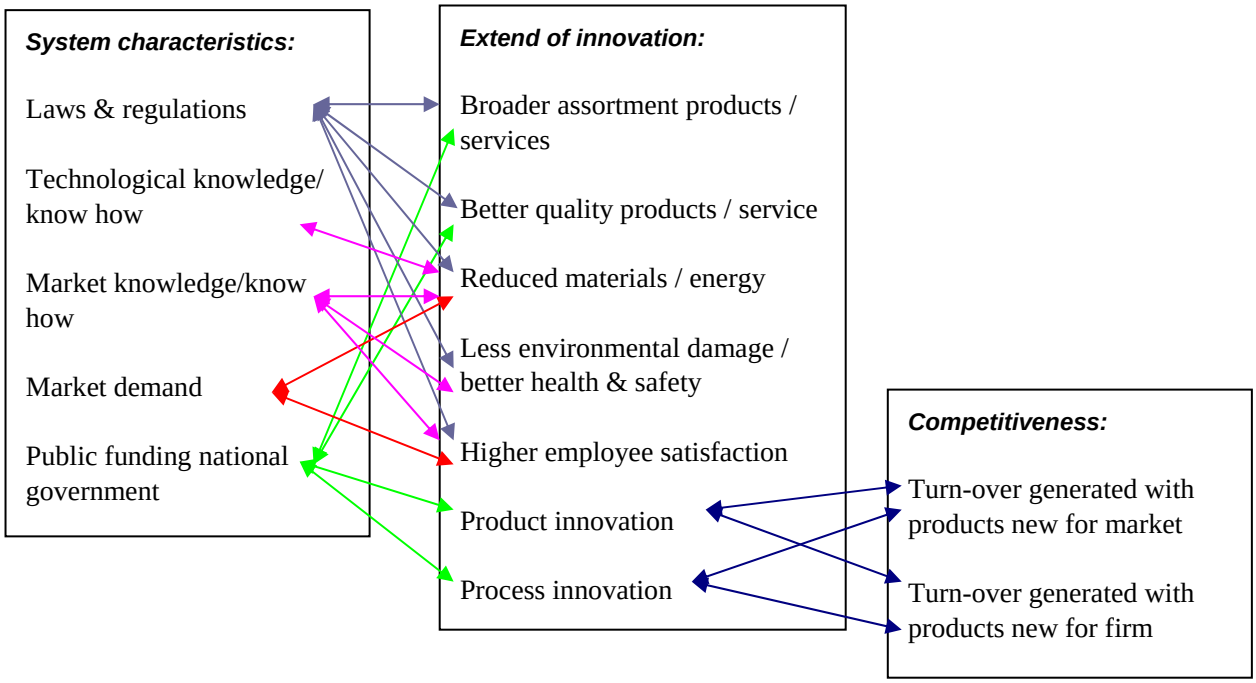
TURNMKT/TURNIN: Turnover generated from innovation that is new to the market/firm

When we look at these data, we see that whereas we did not see strong relationships between market and system characteristics on product and service innovations, these innovations (when they take place) do have a strong correlation with the turn over that is generated from these products. This poses questions on how strong the influences are from the environment in stimulating or hindering innovation. Whereas there are many significant correlations, these are generally low. In a way this is also to be expected as no single environmental factor will be key in explaining innovation. They rather form a mix of factors that together form a context that is either conducive or hampering for innovation.

In the original research we also correlated this innovation performance to growth in turn-over and employees. Due to measurement problems we did not get meaningful answers for this. In a next research we will have to address this issue.

We have summarized the results in figure 2.2.1 below.

Figure 2.2.1: The relationships between context, innovation and competitiveness



In the figure above we sketch the strongest correlations we have found. Unfortunately we have to be very careful with the conclusions we can draw from this. A quick glance could suggest that the only strong factor to increase innovation and competitiveness is public funding, as this is the only factor that increases product and process innovation, which in relates to higher turn over rates from innovation. However, we ought to be careful for several reasons.

First, the data as collected in the CIS database is collected on the basis of a questionnaire with serious flaws concerning the measurement of the system and market characteristics. The questions are all phrased in a way that the answer is actually implied in the question. An example:

To what extend did lack of market knowledge hinder innovation?
In this question respondents can not answer that market knowledge was actually a stimulus for innovation, they can only indicate the extent to which a lack of it, hindered innovation. As a result the outcomes of this research can actually not lead to proper conclusions, nor can the correlations lead to meaningful interpretations. We therefore see these research as a first attempt to make a system scan of an industry. We conclude that such a system scan can be made when we only use the prescriptive data as presented in the first part of this chapter, but that we run into serious problems when looking for the underlying factors for innovation and sustainability performance.

Second, the correlations only indicate that 2 variables are related but do not give insight into causality and the direction of this causality. In other words: when we see that there is a positive correlation between innovation and rules and regulation, this could mean that stricter rules and regulations stimulate innovation, but the other way around, it could also mean that innovating firm are better able to meet current rules and

regulations. In other words, here again, we run into problems of interpretation as soon as we look deeper into the factors that explain innovation and performance.
A third limitation of the research is that the CIS data are not designed according to the system and market failure framework. We are thus not able to report macro data on all categories as distinguished in the framework.

Fourth, the CIS data distinguishes respondents on the criteria of having innovated or not (innovators vs. non innovators) whereas we distinguished between incumbent firms and entrepreneurs. However, as the entrepreneurs that we interviewed have all introduced new products, processes or services, we can state that their responses are very likely to correspond with those of the innovators in the CIS data.

All in all we suggest that the results of the CIS data analysis are interpreted with care and are seen as a first step towards a quantitative measurement of the relationships between an industry's characteristics and innovation and economic performance. Furthermore, we plea for further questionnaire development to come to a more accurate system analysis to solve these issues.

2.3 Conclusion

In this chapter we described the level of innovation in the construction industry. With the CIS data we sketched a picture of a sector that generally lags behind other sectors, both with the number of innovating firms as with the number of innovations. We see the start of an explanation for this when we see that the introduction of innovations into the market, to a much lesser extent than in other sectors, contributes to increased turn-over, decreased costs, or other performance measures in the construction industry. In other words, innovation does not seem to pay off as much as it does in other sectors.

In the second part of this chapter we tried to unveil the underlying factors that could explain this picture. We found that our analysis of this was seriously hampered by the way the CIS data were collected and hence only see suggestions for further research in the correlation analyses. From the correlations we see that mainly rules and regulations and government funding are strongly related to product and process innovation and that these, in turn, are related to the percentage of turn-over achieved with new products and services.
For other system and market characteristics, the questions were sometimes phrased in such a way that meaningful conclusions could not be drawn. We hence suggest further research to get to a proper 'quantitative system scan' on the basis of a newly developed questionnaire.

3 Sustainability in the construction industry

Whereas in Chapter 1 we looked at the level of innovation in the construction industry, the topic of this research is not only to look at innovation, but at innovation that contributes to sustainability. In this Chapter we therefore focus on the level of sustainability, also vis-à-vis other sectors, and the degree to which companies have measures in place for sustainability reporting. If uniform sustainability reporting schemes would be present, this could greatly enhance transparency and set a bench mark for the sector to work towards.
We complement this picture with the answers from the 18 incumbent respondents on questions on their attitudes and intentions towards sustainability. So whereas the first part of this chapter gives an insight into the current state of affairs on sustainability, the results from the interviews give insight into the future directions and actions in this field in the construction industry.

3.1 The level of sustainability

To get a good insight into the level of sustainability in the construction industry, we first turned to macro data from the CBS (see Table 2.1.1). Here we conducted a comparative analysis of the construction industry vis-à-vis manufacturing and services.

Table 2.1.1: Effect of product, process and organizational innovation

Effect of product, process and organizational innovation					**Relative position to total**		
Share of innovators	**Total**	**Services**	**Manufacturing**	**Construction**	**Services**	**Manufacturing**	**Construction**
Reduced material and energy use per unit	30	24	44	26	**-6**	**14**	-4
Reduced environmental impact or health and safety issues	32	24	44	41	**-8**	**12**	**9**
Met regulation	38	34	43	47	-4	5	**9**
Improved employee satisfaction	61	63	59	59	2	-2	-2

When we analyze the data, we can see that the construction industry is performing well: the effects of their product, process and/or organizational innovations on the environment and health and safety issues is neutral to positive compared to the other sectors. Although they slightly lag behind the average of these sectors on reducing material and energy use, they do well in introducing new products and processes that help to reduce environmental impact, meet stricter regulations, and deal with health and safety issues. So, whereas the innovations do not seem to contribute to the profit aspect of sustainable competitiveness of the companies, it does seem to contribute to the people and planet aspects.

3.2 Sustainability reporting

To establish the level of competitive sustainability of the incumbent companies in this study, we tried to acquire all the information that these companies have available on

their performance on people, planet and profit. We looked for this information on their websites and downloaded their annual reports, and sustainability reports, and where necessary contacted the companies to provide additional information. We managed to find information on 9 out of the 16 incumbent construction companies. The main role of these organizations is the development of construction projects.

- ASR vastgoed
- Ballast Nedam
- BAM
- Blauwhoed
- Bouwfonds
- DHV
- DuraVermeer
- Heijmans
- OVG

In our sample two organizations (ASR and OVG) are relatively small (<100 employees). Four companies are medium sized (1.000 – 5.000 employees) and 2 organisations are large (Heijmans 11.000 employees and BAM 30.000 employees).
A number of construction companies in the Netherlands are part of a housing corporation (Dutch: woningcorporatie). The results from renting activities and construction activities are mostly not reported separately. Therefore, these organisations are excluded form our sample.

In order to make a balanced assessment of the environmental impact of construction companies, the indicators are split in three categories: profit, people and planet.

3.2.1 Profit

The overview of the financial results for the organizations investigated within this research can be found in Table 3.2.1. The methods of financial reporting for construction companies in the Netherlands are similar. Nevertheless, the heterogeneous nature of construction companies makes a clear comparison difficult:

- Most construction companies offer consultancy activities in addition to construction work. For some organizations this amount to a considerable share of total activities, nevertheless these are mostly not reported separately.
- A number of large construction companies (amongst others: BAM, Ballast Nedam) include international dredging activities.
- Some construction companies own production facilities for asphalt and cement (amongst others DuraVermeer).

These differences are not specified in the financial report. Furthermore, one construction company (Blauwhoed) does not publicize her financial results.

Table 3.2.1: Profit figures - construction industry

Category	Variable	Unit	ASR	Ballast Nedam	BAM	Blauw-hoed	Bouw-fonds	DHV	Dura Vermeer	Heijmans	OVG
Profit											
Financial	Turnover	€ (x 1.000.000)	112	1.426	8.835		2.423	468	1.132	3.631	269
	Cost of sales	€ (x 1.000.000)	114	1.344	0		2.139	362	1.128	3.458	258
	Labour costs	€ (x 1.000.000)	10	267	1.591		217	210	190	647.214	6
	Profitability	€ (x 1.000.000)	0	42	233		96	19	4	-14	2
	Profitability	%	0,4%	2,9%	2,6%		4,0%	4,1%	0,3%	-0,4%	0,8%
	Turnover growth y/y	%	-8,9%	12,3%	3,5%		-9,9%	18,4%	5,2%	-2,7%	-17,6%
	Share price end of year	€		13,83	4,65					3,4	
	Share price increase y/y	%		-51,1%	-74,4%					-86,8%	
Distribution of work	Infrastructure	%		50%	3,7%				40%	40%	
	Utilities	%		18%					23%		99%
	Residential	%		32%					34%		
	Other	%	-						2%	32%	1%
Distribution of work	Renovation	%	-						34%		
	Development	%	-						66%		

For all organizations profits have gone down between 2007 and 2008. Only Ballast Nedam and DHV have seen profits that have respectively been stable or increased. For those organizations for which share price are available, share price has collapsed from 2007 to 2008. These developments are related to the demand fallout caused by the mortgage crisis (credit crunch).

Most organizations do not provide a distribution of their work between infrastructure, utilities, residential and other activities. Furthermore, no distinction is made between renovation and development activities. The figures which are available indicate that large organizations have a similar distribution of work, whereas small organizations seem to specialize in one area.

3.2.2 People

The overview of the results in the category people for the organizations investigated within this research can be found in Table 3.2.2.

Work in the construction industry is physically demanding and often hazardous. There are a high number of serious incidents and the fatality rate in the construction industry is second only to mining. Furthermore, heavy lifting and difficult working conditions lead to many physical problems (Schartinger 2009).

Four out of nine companies reported absenteeism (%), number of fatalities, accident frequency (IF) and staff training expenditure (hours or value) for their own employees. Only one company (BAM) also included information on accident frequency and fatalities for their subcontractors.

Table 3.2.2: People figures - construction industry

Category	Variable	Unit	ASR	Ballast Nedam	BAM	Blauw-hoed	Bouw-fonds	DHV	Dura Vermeer	Heijmans	OVG
People											
	Mean number of employees	Aantal		3.941	28.544		1.199	5.320	3.182	10.987	57
	Mean number of employees	FTE						4.714			
Health and safety	Fatalities employees	Total number			1						
	Total reportable injury rate employees	IF		11,4	6,8			2,0		11,0	
	Lost time injury rate employees	ID						48		129	
	Occupational illness rate employees	IP (%)								0,14%	
	Total illness absence rate employees	%		5,0%	5,2%				5,3%	4,2%	
Health and safety contractors	Fatalities contractors	Total number			8						
	Total reportable injury rate contractors	IF									
	Occupational illness rate contractors	IP (%)									
Employability	Training expenditure	€ (x 1.000.000)								7	
	Training time	h / employee			25			34	17		

Because of the high fatality rate in the construction sector we would expect a larger number of fatalities then reported (one). Most construction companies do not report fatalities with subcontractors. In one case this number is reported and is found to be relatively high (eight). This discrepancy can be explained by the fact that most construction workers are hired through subcontractors. The total reportable injury rate of DHV is considerably lower than that of other organizations that report this figure. Most probably this is caused by the fact that DHV does a lot of consultancy work which is less hazardous than construction work.

3.2.3 Planet

The overview of the results in the category planet for the organizations investigated within this research can be found in Table 3.2.3.

Three out of nine construction companies make use of the standardized reporting method supplied by the Global Reporting Initiative (GRI). Two of these also provided information to the Carbon Disclosure Project. Nevertheless the information supplied through these standardized reporting methods can not readily be compared as organizations may choose which information they provide.

Four out of nine organizations publish a corporate responsibility report separate to their annual report. One organization included the corporate responsibility report in their annual report. Mostly information in corporate responsibility reports is very qualitative in nature. Therefore, it is difficult to make a comparison between different organizations.

Corporate responsibility reports of Dutch construction companies are focused on the business process of the organization. The main environmental impact of construction companies is thus located in energy consumption for heating and lighting of their offices and fuel consumption for mobility of their employees. Although these two sources do represent construction companies' direct impact, the indirect environmental impact of construction companies is much larger. This indirect impact is located in the material use, waste and energy use during the life-cycle of buildings.

Box 1 Indirect environmental impact of the construction industry

Material use

40 - 50% (depending on sources) of all materials extracted from earth are transformed into construction materials and products (OECD 2002; OECD 2003; Calleja, Delgado et al. 2004; ETCP 2005; Graedel and Howard-Greenville 2005; Bilsen, Rademaekers et al. 2009).

Waste

The construction industry is accountable for 10-30% of all solid waste globally (Graedel and Howard-Greenville 2005). In Europe construction and demolition even accounts for 40-50% of total waste (Calleja, Delgado et al. 2004).

Energy use during the life cycle of buildings

Residential and commercial buildings are responsible for approximately 30% of the primary energy use in OECD countries (OECD 2002; OECD 2003). And the built environment accounts for 40% of CO_2 emissions in the EU (Emtairah, Tojo et al. 2008; Uihlein and Eder 2009). The built environment is responsible for 42% of total EU final energy consumption (Bilsen, Rademaekers et al. 2009). In 2030 the emissions for buildings worldwide are predicted to amount to 14,3 $GtCO_2$ (Blok, Geng et al. 2007).

Therefore, indicators such as the CO_2 footprint of construction companies have only limited explanatory power.

In order to compare the efforts of construction companies in reducing material use, improving waste recycling and reducing the energy use during the lifetime the following values are requested to the construction companies within this investigation:

1) The environmental impact in material use is located in the amount of materials used and the environmental impact of these materials. For the amount of material used we asked if the construction company have formulated an aim for the reduction of material usage (%) and to what extend they achieve this aim. As material usage in construction is divers and mostly materials are incorporated within prefabricated building segments therefore, construction companies will not have absolute values available. The environmental impact of materials used can be decreased by substituting hazardous materials with more environmental friendly materials. Nevertheless, it is difficult to find a measure which can indicate these efforts. Therefore, it was decided only to ask how much of the wood they use is FSC certified. This is a measure that should be available to construction companies.

2) For waste the total amount of waste during the building phase and the destruction phase was investigated. Although it should be remarked that construction companies can do little to reduce waste during demolition. Furthermore, the way the waste is processed is considered. Waste that is recycled on high grade is re-used as product. Low grade recycling is re-using waste as a low grade function. In construction this is mostly the use of building material as aggregate. Furthermore, waste can be used to produce energy (burned). Or it can be land-filled.

3) The energy performance of the production of construction companies is mostly relevant for office buildings and houses. Roughly three measures for energy performance of buildings are used in the Netherlands; EPC, GPR and Greencalc+ The Energy Performance Coefficient (EPC, Dutch: Energie Prestatie Coëfficiënt) is a Dutch measure for energy performance. As companies are obliged to provide this measure for newly build offices and homes this is a good measure for the energy efficiency of the production. The Municipal Performance Statute (GPR, Dutch: Gemeentelijke Prestatie Richtlijn) includes besides energy performance also measures of comfort and therefore, is a nice addition to the EPC. On the other hand, construction companies are not obliged to provide this figure. Therefore, this information is more difficult to obtain. Greencalc+ is a measure which eventually leads to a label similar to the energy labels on household appliances. Separate Greencalc+ measures exist for the performance for investors and end-users[1]. Lastly, we ask for the aim for CO_2 reduction in buildings set by building companies as some companies has implemented them.

[1] We did not include GreenCalc+ in our list of measures which were requested from the participating construction companies.

Table 3.2.3: Planet figures - construction industry

Category	Variable	Unit	ASR	Ballast Nedam	BAM	Blauw-hoed	Bouw-fonds	DHV	Dura Vermeer	Heijmans	OVG
Planet											
Input	Materials										
	Material reduction (aim)	%									
	Material reduction (realisation)	%									
	FSC gecertified wood	%									
Throughput	Energy use										
	Gas	m3			2.889.287						
	Oil	l / m3									
	Other	GJ									
	Total	GJ									
	Electricity	Kwh						10.640.000			
	Green electricity	%						38%	100%	100%	
	Mobility										
	Car	km (x 1.000)						41.087		113.142	
	Airplane	km (x 1.000)						42.315			
	Carbon footprint										
	CO2 emission	CO2 (tons)			106			16.033	22.097		
Output	Waste										
	Total waste	m3			1.166.189						
	Waste during construction	m3									
	Waste during demolition	m3									
	Waste disposal										
	High grade recycling	m3 / %									
	Low grade recycling	m3 / %									
	Energy production	m3 / %									
	Landfill	m3 / %									
	Energy performance of production										
	Mean EPC production	EPC value								0,8	
	Mean GPR production	GPR value								7,3	
	Buildings for which GPR is calculated	%									
	Buildings for which GPR is calculated	Aantal								757,0	
	CO2 reduction buildings (aim)	%								24,0%	

Box 2 Interesting initiatives in Sustainability

As mentioned in the introduction to this chapter, information provided in corporate responsibility reports is mainly qualitative. To give an impression of the actions undertaken by construction companies some interesting initiatives are described below.

ASR:	In the concept 'land for land' ASR develops $1m^2$ of nature for every $1m^2$ of houses, offices or stores it develops.
Ballast Nedam:	Ballast Nedam established the energy exploitation organization 'Climate Green' in order to realize sustainable energy concepts in building developments commercial property.
BAM:	BAM developed a new form of asphalt: 'Low Energy Asphalt'. This asphalt is processed at a temperature of 95°C compared to the normal temperature of 165°C. The reduction of CO2 emissions achieved ranges from 25 to 40%. At the same time the asphalt hardens faster, which reduces the time it takes to put a new road in operation.
DuraVermeer:	Dura Vermeer Infra has set a target to reduce its energy use with 10% before 2012 in respect to 2008. Furthermore, DuraVermeer wants to reduce waste. Therefore they implement ways to consider future waste in the design and development phase.
Heijmans:	Heijmans developed a new form of asphalt in collaboration with Shell. This asphalt is based upon a natural binding agent. Because of the lower production temperature energy reduction is realized.
OVG:	OVG made a commitment to invest 1 billion dollar in the upcoming 5 years in the development of sustainable buildings. During the total lifecycle of the buildings OVG will reduce 1 megaton CO2 opposite to traditional developments.

3.2.4 Conclusion and recommendations for sustainability reporting

The conclusion we draw from this part of our study is that it is very hard, if not impossible, to get a meaningful comparison between companies on PPP measures of sustainable competitiveness. Companies are held to different standards nationally as well as internationally (e.g. GRI) and use different parameters to report on.
When we contacted the companies for clarification on certain measurements, and complementary information, they indicated that they do not have measurement instruments in place to provide the information we required. In some cases, the respondent did say that they were working on the development of measurement- and reporting instruments. In other cases there was limited commitment to improving their reporting practices as they were considered time-consuming and not of key importance to the company.

Some construction companies were of the opinion that a focus on organizational processes only was too limited. In more recent corporate responsibility reports also aims are set to reduce energy usage of buildings during their lifetime. Yet, mean EPC / GPR values were only supplied by one organization.
The fact that we cannot find a unified reporting practice of PPP, even not when adjusted to the specific industry, is a very interesting and important finding. It means that we cannot establish the level of performance on people, profit and planet of companies in the construction industry and can hence not give meaningful feedback or advice on which aspects go well, which need improvement, or make plans to improve these aspects. If the industry wants to make serious steps forwards in the field of sustainability, unified reporting instruments could be a great aid in achieving this. Also, when instruments are unified, this saves the companies much time as they otherwise have to comply with the various standards that exist and are still developing (e.g. Standard & Poors, GRI, and national standards). The question is who should take up this task: the companies, the government? And whether this is a task that should unify reporting practice within an industry, nationally or internationally? From our comparative case in the chemical sector we found that different industries again report on different aspects (different content for e.g. people and planet as they use different processes). This makes clear how difficult it is to tackle the problem of measuring sustainable competitiveness.

3.3 Attitudes towards sustainability and innovation

Whereas the previous paragraphs dealt with the macro data of the sector, and the ‘tangible outcomes’ of companies’ investments in innovation and sustainability, the remainder of this report deals with the willingness of actors to invest in sustainable innovation, the opportunities they see, the attempts they make, and their experiences with trying to introduce new product and processes in the market, and new organisational processes within their own companies. Whereas the previous results indicate the situation as it is, the willingness of actors will give an indication of what might become, and how these actors should develop, and be helped, to realize the envisaged potential for sustainable innovations.
First we asked the respondents to what extent they knew sustainability concepts (such as total cost of ownership) and technologies, and to what extent they had integrated sustainable products and technologies in their companies and the construction processes. Second, we asked them what were the drivers and the barriers they faced when trying to introduce sustainable innovations in the market.

On the questions to what extent the respondents are familiar with sustainability and concepts that relate to sustainable innovations and to what extent sustainability has become part of their operating procedures and strategies the answers were that:

1. All respondents are well aware of the importance of sustainability for their competitive position in the future.
2. 9 out of 18 incumbent firms say they have 'embraced' sustainability and have integrated it in their strategies, external and internal operations. 6 out of 18 see no problems with the 'mindset' and routines in the industry. The existing mindset is positive towards sustainability.
3. All respondents know the cradle to cradle concept. Nearly all respondents are aware of pricing methods for total costs of ownership (13/18) and are looking for ways to implement these methods.
4. 11 out of 18 firms explicitly state that they are not pro-active in adopting new sustainable technologies. They do not want to be "the guinea pig" and do not want to experiment: they wait for others to implement new technologies and adopt this technology once it has proven to be reliable. This to reduce risks and circumvent the problems associated with new developments such as the teething problems and legislation issues. Only 2 out of 18 firms indicate that they take a lead in the developments around sustainable innovations.
5. Several respondents leave it to external consultants to scan which technologies have proven themselves and have a good return on investment and can be adopted.
6. None of the respondents say to face problems implementing new technologies or finding the right knowledge and expertise (they have good connections to knowledge institutes and experts)

For the existing large players in the construction industry we can hence conclude that their behaviour with regards to sustainable innovations is:

- *Positive* in the sense that they embrace the concept and are keeping up-to-date with sustainability knowledge and practices, and that they are trying to implement these new concepts in their businesses, however, we can also conclude that in doing so they are:
  a. re-active,
  b. risk averse,
  c. reliant on external advice, and
  d. that they are technology followers.
- The outcome is also positive in the sense that knowledge and know-how do not seem to be the bottleneck.

In other words, the respondents that we have spoken with in the construction industry have a positive and open (although not pro-active) attitude towards sustainable innovation and have the capabilities to introduce new products and processes. We hence conclude that there are other factors that hold the industry back from investing more in sustainable innovation. Part of the answer we found in the previous sketch of the industry that showed that these investments do not *yet* contribute to market share or turn-over (the Profit part of sustainable competitiveness).

This image above partially confirms earlier research in the construction industry and the easy conclusion would be that the industry is just conservative by nature and that innovation will be hard to achieve. We will – however – focus on the willingness of the industry to innovate and on the factors that stop these actors from doing so and keeping 'stuck' in the old, conservative paradigm. By looking at the mechanisms behind (the lack of) change, we can also arrive at recommendations to stimulate change in the sector.

Box 3 Case : One actor can make a difference

During our research, we found that recent events have made an impact on the environmental reporting of construction companies in the rail sector. ProRail is the network infrastructure manager of the Dutch railways. In its role it is the sole provider of rail-infrastructure projects in the Netherlands. As of 1 December 2009, ProRail will reward companies that produce in a climate conscious manner by awarding points in tendering procedures. The level that a company has reached in the reduction of its CO_2 emissions translates into an 'award advantage'. The higher the level on the certificate, the greater is the advantage that the company gains in the award weighting.

Because of this procedure a number of Dutch construction companies have applied for the certificate, and set explicit goals for CO_2 reduction

- Strukton Rail BV
- BAM rail BV
- Structon groep NV
- DuraVermeer divisie infra BV
- Ballast Nedam Infra BV
- VolkerRail Nederland BV

This example clearly shows how a single company can make an impact on the environmental impact of its suppliers.

3.4 Conclusion

The picture that emerges from this chapter is that the construction industry is doing well in the field of sustainability. The innovations that they introduce often contribute to people and planet measures (decreased environmental damage, use of materials, increased employee satisfaction) thereby increasing the industry sustainability performance. We unfortunately do not have reliable measures that connect sustainability performance to the economic performance of the companies. We will address this in further research.

Despite the fact that the industry seems to be doing well in improving their practices in the field of sustainability, we found that it was near to impossible to get a meaningful comparison between companies on the PPP measures of sustainable competitiveness. Companies are held to different standards nationally as well as internationally (e.g. GRI) and use different parameters to report on. As a result there is no industry consensus on sustainability reporting and there is hence to benchmark to 'steer' the industry on. Here clearly lies a chance for the sector to strive for more unification of

measures to increase the industry's transparency and create clear objectives for the industry to work towards.

From our interviews we conclude that there is a great willingness to think about, and invest in sustainable innovation. Nearly all respondents we have spoken with in the industry have a positive and open (although not pro-active) attitude towards sustainable innovation and have the capabilities to introduce new products and processes. We hence conclude that there are other factors that hold the industry back from investing more in sustainable innovation. Part of the answer we found in the previous sketch of the industry that showed that these investments do not *yet* contribute to market share or turn-over (the Profit part of sustainable competitiveness). In Chapter 4 we will look further into the underlying mechanisms that hinder of stimulate this development.

4 System analysis of the construction industry

In Chapter 1 we looked at the level of innovation in the construction industry and we tried to get a first insight into the underlying factors of this innovating performance by looking at the correlations between market and system characteristics and innovation and the consequent relation with competitiveness.
In Chapter 2 we did the same for sustainability, and sustainable innovation. We found that whereas the construction lags behind on innovation, they perform relatively well on sustainability measures when we take the CIS data as our point of departure. This is not reflected though in a proper reporting culture in the industry.
From the previous chapters we learn that the main question is why the construction industry is not seeing more innovation, and especially why innovation cannot be transformed into sustainable competitiveness. Whereas innovation does seem to contribute to people and planet measures, we see that the industry stumbles into problems transforming investments in sustainable innovations into increased market share and eventually increased profits and viability of their businesses. In this chapter we will try to unveil the system and market characteristics that can explain this phenomenon.

We will first make use of the quantitative data where available on market and system characteristics to sketch the general picture, and then use our interviews to get a more in-depth insight into market and system functioning and the way actors interpret and act upon this.

4.1 Quantitative system description: CIS data

In out theoretical model in Chapter 1, we saw that an important factor for innovation is collaboration. This collaboration should be both horizontal and vertical (i.e. between companies and also with customers and research institutes) and should be a good mix between close collaboration and competition.

Table 4.1.1: CIS data : Collaboration

Collaboration (most important partner): share of innovators					**Relative position to total**		
	Total	**Services**	**Manufacturing**	**Construction**	**Services**	**Manufacturing**	**Construction**
Share of collaborating innovators	36	32	44	35	-4	**8**	-1
Difficulty finding collaborators	14	12	15	20	-2	1	**6**
Within own firm	18	18	19	13	0	1	-5
Suppliers	43	44	38	62	1	-5	**19**
Customers	20	18	24	7	-2	4	**-13**
Competitors	5	6	3	9	1	-2	4
Consultants	8	9	9	1	1	1	**-7**
Universities	5	4	5	7	-1	0	2
Public (research) institutes	1	1	1	2	0	0	1

In the data we find that there are, on average, as many collaborative relationships as in the other industries (see Table 4.1.1). Four aspects call our special attention though:

1. There is relatively much collaboration with suppliers (more than 60%!)
2. There is relatively little collaboration with customers (only 7%)
3. Almost no use is made of consultants (1%)
4. One has much difficulty in finding good partners to collaborate with.

The first 2 aspects are very crucial: links are strongest upstream of the value chain, and links to the real market – the customer – seem to be poorly developed. We will see other aspects of the poorly developed links to the end-users in further parts of this research.
The finding that relatively little use is made of external consultants contradicts the findings from our interviews in which we found that the interviewed firms do make use of consultants for sustainability issues. This can be typical of the larger companies though, or typical of the topic. On average the industry does not make much use of external advice when compared to the other industries. This is an important finding as consultants function as bridges between knowledge and organisations. They form an important vehicle for the transfer of knowledge and business practices. Hypes, such as TQC or 'cradle to cradle' are very much products that consultants 'carry around' in their suitcases and sell to their customers. In that way, they play an important role in diffusing innovation. Here we see an important point for recommendation in the construction industry.
Also remarkable is that parties say that they find it relatively difficult to find suitable partners.

If we look as to which are the most important sources for innovations for the most innovative firms in the construction industry, we see the above repeated in the sense that customers again play a much smaller role than in the economy as a whole as a source of innovation (see Table 4.1.2). If one compares the construction industry with manufacturing, one sees that there the own firm, suppliers and customers all form an important source for innovation. In the construction industry it is not clear from these data where their innovations come from as no single factor sticks out.

Table 4.1.2: CIS data : Sources of innovation

Sources (important or very important): share of innovators					**Relative position to total**		
	Total	**Services**	**Manufacturing**	**Construction**	**Services**	**Manufacturing**	**Construction**
Within own firm	76	75	83	65	-1	**7**	**-11**
Suppliers	65	60	72	67	-5	**7**	2
Customers	56	54	66	44	-2	**10**	**-12**
Competitors	41	40	42	35	-1	1	**-6**
Consultants	19	19	21	18	0	2	-1
Universities	12	11	15	7	-1	3	-5
Public (research) institutes	9	8	11	11	-1	2	2
Conferences etc	29	27	34	24	-2	5	-5
Literature	28	28	29	25	0	1	-3
Branch organisations	27	28	24	30	1	-3	3

Another aspect that is considered important for the innovative capacity of an industry is that companies should have enough knowledge and know-how on both the technolo-

gical and market- and organizational aspects of innovation to be able to successfully develop and introduce new products and processes into a market. Conform our earlier reported findings, there seems to be no problem with regards to the capabilities (see Table 4.1.3). In the construction industry the level of knowledge of the employees, and on technologies ad markets seem to be around the same as in the other industries. Only the knowledge on markets lags behind slightly, which should come as no surprise when considering the earlier findings on the links with customers and the market.

Table 4.1.3: CIS data : Capabilities

Capabilities					**Relative position to total**		
Share of innovators	**Total**	**Services**	**Manufacturing**	**Construction**	**Services**	**Manufacturing**	**Construction**
Lack of qualified personnel	41	40	42	42	-1	1	1
Lack of information on technology	21	20	24	19	-1	3	-2
Lack of information on markets	19	18	21	14	-1	2	-5
Share of non-innovators							
Lack of qualified personnel	28	28	30	27	0	2	-1
Lack of information on technology	9	9	10	11	0	1	2
Lack of information on markets	6	5	6	3	-1	0	-3

Also the access to both internal and external funding is important for innovation. Costs of innovation are often high, and high risks make returns uncertain. Hence, actors need access to either internal funding, or willing external funds that are willing to invest in risky projects.

From the data in Table 4.1.4, we conclude that financing is not a greater or smaller problem than on average in the Dutch economy. Access to both internal and external funds is a problem in about 20-30% of the cases, which is a better situation than in the manufacturing industry.

Table 4.1.4: CIS data : Financing

Financing					**Relative position to total**		
Share of innovators	**Total**	**Services**	**Manufacturing**	**Construction**	**Services**	**Manufacturing**	**Construction**
Lack of external funds	22	21	22	25	-1	0	3
Lack of internal funds	34	32	38	33	-2	4	-1
Innovation costs too high	33	29	39	40	-4	**6**	**7**
Share of non-innovators							
Lack of external funds	30	28	34	27	-2	4	-3
Lack of internal funds	43	42	50	38	-1	**7**	-5
Innovation costs too high	24	21	34	19	-3	**10**	-5

Lastly, we looked at are the market characteristics. For innovations to be successful there should be demand, both in quantity and quality, and the market should be open so

that existing parties cannot block new products, processes or players from 'their' market.
When we look at the data in Table 4.1.5, we see that lack of market demand for innovation is more of a problem in the construction industry than in other sectors. We see that there is both a lack of demand (more than twice as often as in the economy on average), and that demand is uncertain (in over 30% of the cases). On top of that existing innovations block the way for new ones, and existing players block the market from new entry and innovations (according to the less innovative actors). This forms a clear difference with the other industries which leads us to conclude that not only the connection of actors to the market is a problem (as found with aspects of collaboration and sources for innovation) but also the demand from these markets is poorly developed.

Table 4.1.5: CIS data : Market structure

Demand and lock-in					**Relative position to total**		
Share of innovators	**Total**	**Services**	**Manufacturing**	**Construction**	**Services**	**Manufacturing**	**Construction**
Market dominated by established players	22	21	24	22	-1	2	0
No demand due to prior innovations	9	7	9	17	-2	0	**8**
Uncertain demand	24	22	27	31	-2	3	**7**
No demand	9	8	7	22	-1	-2	**13**
Share of non-innovators							
Market dominated by established players	14	14	10	23	0	-4	**9**
No demand due to prior innovations	10	10	12	12	0	2	2
Uncertain demand	13	11	17	15	-2	4	2
No demand	19	18	19	24	-1	0	5

It is interesting to see that whereas in our interviews the entrepreneurs indicated that the construction industry was dominated by the incumbent firms that had the market firmly in their hands, whereas the incumbents did not experience it this way. They indicated that relationships were open and collaborative.
The data show a different picture: 22% of the 'innovator' respondents indicate that the market is dominated by incumbents, and 23% of the non-innovators do so. In other words, there is consensus among the innovators and non-innovators that there is some market power by established firms. This is not much higher though than in other industries.

4.2 Qualitative system analysis: incumbent firms

In this part we report on the the interviews that have been conducted with the incumbent firms. The interviews were done on the basis of our theoretical model as presented in Chapter 1. On the basis of the responses we have drawn a picture of the industry in Table 4.2.1. In the table, red ellipses indicate a bottleneck for sustainable innovation, whereas green ellipses indicate that the market or system characteristic stimulates innovation. The ellipses are place along a market or system characteristic and under a

system actor. In this way we cannot only indentify which market or system characteristic is important, but also which actor can also for whom this characteristic forms a problem or stimulus, and which actor can solve the problem or strengthen the stimulus. As such the framework provides clear guidelines for policy design and can form a basis for formulating industry actions.

Table 4.2.1: Drivers (green) and barriers (red) for sustainable innovation of incumbent firms

Actors: ***Categories of system interactions:***		**Users** (consumers, companies, lead clients i.e. government)	**Producers** (MNEs, SMEs, entrepreneurs)	**Knowledge providers** (universities, research institutes)	Third parties, **Capital providers** (banks, private	**Government** (national, local)
Infrastructure						
Institu-tional	Regulative		Regulation slowly pushing			Conflicting rules & regs
	Social		“We have embraced sustainability”			Lack vision / guidance
	Competitive		Price competition			
Inter-action	Too much		Fruitful collaboration projects, changing coalitions, enough quality and flexibility			
	Too little					Lack inter-govern.collab.
Capa-bilities	Technological					
	Organizational/ Marketing					
Market demand	Quantity			Lack demand		
	Quality		Price buying			
Market structure	Externalities / Split incent.					
	Entry barriers/ Market power					
	Transparency/ Perfect info.					

4.2.1 Enabling infrastructures

Infrastructure plays a role in the implementation of various new products as current infrastructures in houses and offices are based on the ‘old’ paradigm of one central grid for electricity and water, and individual end-users that use and do not produce. In the ‘new’ paradigm the users can also become producers and the water- and electricity grid can become more de-central. In practice, the entrepreneurs were stumbling into

problems with the implementation of their products that enable this switch. For example, one entrepreneur that sells an electricity switch board that allows households to share electricity amongst them, stumbled into the problem that houses are and have to remain separate units in the current system. Related to this electricity problem is the uncertainty in The Netherlands about the 'feed-in' tariffs as there are no clear cut plans of regulations in this field.
Other such problems are the use of rain water for domestic usage. In the past mistakes were made by installers which caused 'grey' water to mix with drinking water. As a result, regulations were made more stringent on using grey water for e.g. toilets and washing machines, making the introduction on greener technologies in this field more difficult.

4.2.2 Institutions

First we will sum up the results from the interviews with the incumbent firms. Coercive institutions refer to the rules and regulations that form the legal or formal rules of the game, normative institutions refer to the informal rules of the game such as culture and habits, and mimetic institutions refer to competition and the me-too effects: if a leading firm adopts certain practices, the weaker ones are likely to follow.

4.2.2.1 Coercive institutions: Rules and regulation

First the response with regards to rules and regulations:

- 3 out of 18 incumbent companies find the current regulation good and helpful
- 9 out of 18 find the regulation contra-productive for achieving sustainability in the construction industry

Problems that incumbent firms experience with the current regulation:

Problems with clarity and vision and subsequent rewards

- Policies are not clear, what is sustainability? (4/18)
- Sustainability is not being rewarded no financial incentives (2/18)
- Subsidy schemes are difficult to find and to access (4/18)
- Too strong focus on EPC, sustainability is more than energy (3/18)

Problems with consistency and coherence of policy:

- No integration of sustainability requirements with planning permissions ('bestemmingsplan') (3/18)
- All municipalities have other policies, rules, regulations (7/18)
- The housing scorecard ('Woningwaarderingsstelsel') does not enhance sustainability. The rental system should change to housing cost (3/18)
- Sustainable solutions are not possible because of rules and regulations on aesthetics (2/18 'welstand commissies')
- Building act ('Bouwbesluit') lacks behind sustainability aims

Problems with ambition level

- Regulation is too ambitious (2/18)
- Regulation is not ambitious enough (2/18)

Problems with reliability and capabilities of government

- Subsidy schemes are random and are unreliable
- Civil servant lack flexibility and pro-activeness, government bureaucratic (2/18)

- Insufficient communication between governmental bodies (one does not know what the other is doing)

When looking at these results we have to take into account that these are 'only the opinions' of 18 respondents within large and heterogeneous companies. However, these are the large and dominant players within the industry and these respondents are the ones that have a good overview on the efforts that these companies undertake to invest in sustainability. These respondents are also the employees that will contact the government to plea for support for their innovative new projects, and that will be involved in the breakthrough experiments in sustainable building, and hence they will have a good 'feel' for how the government is as a partner for sustainable innovation. This also explains the 'quality' of the criticism; the remarks on the role of the government do not stay on the level of just bad-mouthing the government, the remarks are very explicit and precise on where inconsistencies and short comings are noted. The overall outcome on rules and regulations, and the role of the government in this, is a grim picture of an unreliable and incapable government, with inconsistent policies and poor policy implementation.

4.2.2.2 Normative institutions: culture, norms, values and education

When we turn to the culture of the firms itself, its surroundings (the markets and societies in which the firms operate) and to those of the (future) employees, we arrive at the following picture:

Norms/ routines in own organization

- 9 out of 18 incumbent firms say they have existing routines, norms and values that are aimed at sustainability: they have 'embraced' the concept and have integrated it in their strategies, external and internal operations by e.g. driving 'green' cars (Prius or LPG).
- 6 out of 18 indicate that they have adopted sustainability but that it sometimes still leading to minor discussions (e.g. when decisions on individual projects have to be made). Resistance is mostly because of the higher costs, sometimes because of the mindset of the older generation.
- 3 out of 18 say that there is still resistance to sustainability within their organization, but also these actors do adopt the concept.

Norms /routines in industry (with partners):

- 6 out of 18 see no problems with 'mindset' and routines in industry. The existing mindset is positive towards sustainability.
- 5 out of 18 see clear problems and say sustainable building clashes with industry culture of low price, conservatism and lack of interest for sustainability on the demand side.
- 8 out of 18 sketch a mixed picture: the industry is moving towards sustainability but 1) there is often a lack of clarity what sustainability is and how it can be implemented (4/8), 2) or partners lack behind on the adoption of sustainability (3/8).

Knowledge on - and attitude towards sustainability in education and new employees:

- Most respondents notice that the next generation, by training and culture, are more focused on sustainability. 10 out of 18 note that new employees are better trained in sustainable technologies and applications
- The role of education in forming a 'mindset' is emphasized over the concrete knowledge (5/18).

- 6 out of 18 respondents see a role for the universities, often in collaboration with the construction sector (e.g. NEPROM) and the government to further develop sustainability knowledge.
- Not one of the respondents sees a problem with education: the level is good, and training on the job can fill any gap.

All in all we see a positive picture emerging when we look at the adoption of sustainability on the level of mindsets: the ideas have been widely adopted, the problem lies more in the realization of ideas there where outcomes cannot be controlled. For instance, companies do implement sustainable technologies within their own firm, but find it hard to sell a sustainable solution to a client that purchases on price.
Looking into the future the picture is also positive as the new generation has more knowledge on sustainable solutions and a different mindset that will make implementtation of such solutions more plausible.

4.2.2.3 Mimetic institutions: Copying the leaders and their actions in the field of sustainability

It is common for people and companies alike to copy the behaviour of the most successful people/companies in a population. Whereas copying this behaviour will perhaps not make you equally popular or successful, you will at least not stand out in a negative way. This mimicking behaviour can be a strong incentive for innovations to spread through a population of firms, e.g. an industry. Therefore we asked what the 'lighthouse example' companies are in the industry, what they do in the field of sustainability and whether our respondents take their actions as a guideline for their strategies.
From the interviews we found that AM and OVG are seen as leaders in the field, together with Synchroon 2009, Dura Vermeer, MAB, RaboBouwfonds, BAM, and ProperStok. These companies are considered examples because these companies do well on sustainability or are very advanced on other aspects such as process control, different financing models (5/18). Most companies keep an eye on their strategies and/or their projects, and try to copy the successful elements out of them. A slight majority of the respondents is of the opinion though that these 'lighthouse examples' will not be essential in setting new standards in the industry. They are convinced that real progress will only be possible if pushed by the government through more stringent, or new, rules and regulations (9/18).

4.2.3 Interaction

As mentioned before, innovation requires fruitful collaboration between companies and complementary partners in the fields of knowledge, marketing etc. Important is also that these relationship are not so close that they block out new information, but close enough to enable open knowledge exchange which is necessary for innovation.
The respondents in the incumbent firms in the construction industry draw a very positive picture of their collaborative relationships:

- 15/18 state to have very successful collaborations on sustainability issues:
  - Their partners have positive attitudes towards sustainability
  - These are no 'steady collaborative agreements', partners vary per project.
- 5/18 do have ongoing relationships with advisors/specialists on sustainability issues.
- Some do have an ongoing relationship with suppliers, a preferential list of advisors and builders, steady collaboration with another firm or with maintenance partners.

A similar positive perception exists on the learning effects from these collaborations:

- 10/18 state that they actively learn from each other, e.g. in experiments, research which contributes to innovation
- 5/18 state that what they learn in such collaborative projects is not an aim, but an accidental circumstance

The access to knowledge is at no point a problem for the parties in this industry. They have all sorts of industry linkages (through weak ties) with e.g. universities, (semi) governmental organizations (SenterNovem), industry platforms (NEPROM), suppliers, TNO, internet, industry journals and the like.

- *Consultants and specialists play a very important role in this knowledge transfer: 11 out of 18 companies mention them as important vehicles for knowledge transfer*.
- 4 out of 18 incumbent firms emphasize the importance of disseminating this knowledge internally and remark that this can be a difficult process.
- 4 out of 18 incumbent firms remark that they would like a more guiding role of the industry association and/or the government in creating and providing the body of knowledge needed for change.

4.2.4 Capabilities

As was mentioned in the earlier part of this research, knowledge and capabilities are not considered a problem for innovation in the construction industry. Although technology is considered very important, it is not a problem to access. All but two of the incumbent firms have knowledge and know-how in house, and if not, know where to find it. Prices of the new technologies are still high though, and newness sometimes means that there are problems with the implementation of new technologies.

8 out of 18 of the incumbent respondents indicate however that technology is only one aspect: the whole process of innovation should be considered. Technology fits into the bigger picture of developing a city, region or estate, and is only a part of the sustainability puzzle.

They do see a role for themselves to bring sustainable solutions more to the market by better marketing strategies, e.g. providing better information to end-users as to create more demand.

4.2.5 Market demand

Lack of demand (quantity, access to the masses)

All incumbent firms see that in one form or the other, the lack of demand is the key problem for sustainable innovations to ‘take off’. The great turnaround that respondents envisage should come from awareness and adoption of sustainability by the masses. 14 out of 18 respondents say that there is currently no demand for sustainable housing/ buildings. Clients choose for price, location and functionality rather than sustainability. One respondent puts it:

“1-2% wants to pay more for a sustainable house, 20-25% wants a sustainable house when this is cheaper than a conventional house, and the rest does not care”.

However:

There is a slow development towards sustainability in the rental offices (5/18). The (semi)-government plays a role here as a lead user asking for new concepts and solutions and putting the money where the mouth is.

4.2.6 Market structure

4.2.6.1 Externalities and split incentives

For investments in innovation to take place, an essential ingredient is the possibility to earn back those investments. Intellectual property rights are the classical example as an

instrument to protect new knowledge for a period of time to enable actors to have a temporary monopoly position in the market and earn back investments. If such mechanisms would not be in place, everyone could copy these innovations and free-ride on the investments of others. Mechanisms to reward innovators are thus essential for innovation to take place.

When we look at the situation for investments in sustainable innovation in the construction industry and the possibility to earn back investments in sustainable solutions, the following picture emerges:

- All respondents indicate that sustainable innovation comes at a cost and that the extra costs of sustainable building are substantial.
- 12 out of 18 incumbent firms indicate that customers are not willing to pay for these higher costs. The use of sustainable materials or energy sources does not give the end-product additional market value. Builders are therefore hesitant to apply new technologies as they cannot earn back their investment.
- 3 noticeable exceptions are large builders that mainly have (semi) government as their clients, such as government buildings, hospitals and universities: these clients go for quality and serve as 'lead users' for the implementation of new sustainable technologies.
- 4/18 incumbent respondents see a development towards new 'pricing techniques' that are designed such that extra costs can be earned back through energy labels (social urban rental) or higher rental prices (offices).
- 13 out of 18 incumbent firms know and use 'total costs of ownership'.
- 10 out of 18 feel responsible for what happens to the building after its physical life cycle has ended: they use re-usable concrete, FSC wood, materials with longer life spans etc. Sustainable here mainly means 'with a long life span' and not that the materials have a low carbon footprint (energy to grow, make, transport, demolish the materials used).
- The incumbents do not yet make use of deconstructable buildings, only 6 out of 18 actors indicate to take future uses into account by designing flexible spaces (interiors and exteriors can be changed without having to rebuild the structure).

Here again, we see a predominantly positive picture of the large construction companies. They are aware of the problems, acknowledge that most markets are not yet developed far enough to make it possible to earn back investments, but they do feel responsible for contributing to a development in this direction. They look into pricing mechanisms, new materials and new building concepts to move towards more sustainable practices.

4.2.6.2 Transparency /perfect information

17 out of 18 say there is insufficient awareness of the benefits of sustainability is cost advantages and comfort

12 out of 18 emphasis that there should be financial incentives to go green, in other words, the cost and benefit structures have to be made such that real costs are carried by the one who causes these costs (including externalities) and the ones that invest should reap the benefits of these investments. Mechanisms to achieve these aims which the respondents see are:

- total costs of ownership/ lower exploitation costs for the business market, offices (6/18),
- different mortgages for the consumer market (3/18),
- transparency on exploitation costs and comfort for consumer market (5/18),
- estate agents should value sustainable houses higher (2/18).

Mechanisms for increasing transparency and thereby stimulating market creation that respondents envisage are:

- 8/18 find that the government should take the lead in creating more awareness through means as media, television showing that sustainability works for ordinary people (benefits) and showing what are the negative externalities of unsustainable building (costs)
- 7/18 think that large coalitions should be created between industry and the government (2/7), or between industry, government, industry association, banks/ financers, developers, builders, media, consumer organizations etc. to jointly increase the support for sustainable building (5/7)

4.3 Conclusion on the incumbent firms in the construction industry

All in all we can conclude that although the 'hard figures' confirm existing beliefs about the construction industry as a conservative industry that does not innovate, we see a much more positive picture emerge from our interviews with some of the largest players in the construction industry. We conclude that they have a positive and willing attitude towards sustainable innovation, and that they have good collaborations with the knowledge infrastructure as well as other companies. Access to knowledge and know-how and technological and organisational capabilities are not the problems that keep these firms from being successful in sustainable innovations.
The main bottlenecks as distinguished in our interview are (see Table 4.2.1):

- Unreliable and inconsistent government: conflicting policies and rules and regulations.
- Lack of demand for sustainability (location, cost, comfort are main arguments).
- Lack of transparency and absence new cost structures that enable firms to earn back investments.

The main (potential) drivers for innovation are considered:

- Growing awareness and the fact that parties have embraced the concept.
- Fruitful collaboration with good partners with positive mindsets; in these relations mutual learning plays an important role.
- Rules and regulation, slowly pushing the industry forwards, or just forcing change through.
- Newcomers in the sector: young employees with different mindset and new set of skills.
- Consultants play an important role in knowledge transfer and in providing knowledge on successful new sustainable technologies.

4.4 Qualitative system analysis: sustainable entrepreneurs

Next we will discuss the barriers and drivers for sustainable innovation as perceived by the entrepreneurs in the construction industry. As these actors play a different role in the field, one would also expect that they experience different bottlenecks and drivers for innovation. The entrepreneurs are often of special interest to policy makers as they are seen as the actors that bring innovation and change to a sector.

The companies that we interviewed share as characteristic that they aim to introduce new sustainable products and technologies into the construction industry's markets.

They are in different phases of their business development and are all successful in the sense that they survive and are profitable (see Table 4.4.1).

Table 4.4.1: Characteristics of interviewed entrepreneurs

Reference number:	**Phase in life-cycle:**	**Technology used for sustainable innovation:**
1	Start-up	Photo-voltaics with solar thermal
2	Growth	Photo-voltaics, solar thermal, urban wind, biomass
3	Start-up	Photo-voltaics
4	Maturity	Heat collection & storage
5	Start-up	Solar thermal, water power
6	Growth	Solar thermal, wind, heat pump & storage
7	Start-up	Urban biowaste
8	Growth	Photo-voltaics
9	Start-up	Electricity, electronics
10	Start-up	Urban wind power
11	Growth	Climate systems, electronics
12	Growth	Electricity, wireless electronics
13	Growth	Wind, solar thermal, photo-voltaics, heat storage
14	Growth	Heat exchange
15	Start-up	Solar thermal
16	Start-up	Mechanics and photo-voltaics

Of the 16 respondents, 7 were smaller then 10 employees, 4 had between 10 and 49 employees, 2 were between 50 and 99, and 3 companies had more then 100 employees.

The interviews have led to a list of influences that have been mentioned by entrepreneurs, with underlying explanations for these influences. In the table a red circle indicates that the system interaction is considered an impediment for sustainable innovation in the construction industry, whereas a green ‘block’ indicates a stimulus for innovation.

On the next page we will first present the results in Table 4.4.1 and after we will discuss the drivers and barriers in more detail.

Table 4.2.1: Drivers (green) and barriers (red) for sustainable innovation of incumbent firms

Actors: ***Categories of system interactions:***		**Users** (consumers, companies, lead clients i.e. government)	**Producers** (MNEs, SMEs, entrepreneurs)	**Knowledge providers** (universities, research institutes)	Third parties, **Capital providers** (banks, private	**Government** (national, local)
Infrastructure						'Old' paradigm
Institu-tional	Regulative		Regulation pushing			Conflicting rules & regulations
	Social		Old routines and beliefs keep actors 'imprisoned'			Lack vision / guidance
	Competitive		Vision, media attention → beliefs start to change!			
Inter-action	Too much		Price competition			
	Too little		Lock-in			Lack inter-govern.collab.
Capa-bilities	Technological			Knowledge exchange		
	Organizational/ Marketing					
Market demand	Quantity			Lack demand		
	Quality		Price buying			Procurement on price
Market structure	Externalities / Split incent.					
	Entry barriers/ Market power		Large players block entry			
	Transparency/ Perfect info.		Cost-benefits not well known			

4.4.1 *Infrastructure*

Infrastructure plays a role in the implementation of various new products as current infrastructures in houses and offices are based on the 'old' paradigm of one central grid for electricity and water, and individual end-users that use and do not produce. In the 'new' paradigm the users can also become producers and the water- and electricity grid can become more de-central. In practice, the entrepreneurs were stumbling into problems with the implementation of their products that enable this switch, i.e. one entrepreneur that sells an electricity switch board that allows households to share electricity amongst them, stumbled into the problem that houses are and have to remain separate units in the current system. Related to this electricity problem is the uncertainty in The Netherlands about the 'feed-in' tariffs as there are no clear cut plans of regulations in this field.

Other such problems are the use of rain water for domestic usage. In the past mistakes were made by installers which caused 'grey' water to mix with drinking water. As a result, regulations were made more stringent on using grey water for e.g. toilets and washing machines, making the introduction on greener technologies in this field more difficult.

4.4.2 Institutions

4.4.2.1 Regulative institutions

Positive: Rules and regulations pushing the 'laggards' forwards
Specifically in the field of regulative institutions, the interviewed entrepreneurs mention strong coercive pressures mainly due to the rules and regulations from the government. Some entrepreneurs [1,4,5] find regulation a 'pushing mechanism' for large incumbent firms to push them towards sustainability (such as energy labels and energy performance standards). Indirectly this creates a demand for entrepreneurs that supply innovative sustainable solutions to these large players.
Regulations are experienced by reactive entrepreneurs as a driver for sustainable innovations, and by pro-active entrepreneurs as a barrier. Subsidy schemes contain barriers for both types, but pro-active entrepreneurs do not depend on them.

Negative: Lack of speed and uniformity leaves entrepreneurs looking for direction
Five pro-active entrepreneurs [2,8,9,10,15] experience regulation as a barrier to innovation as they try to introduce solutions that are "ahead of current standards and requirements" [2] and hence find the current regulation restrictive for their actions. One states that they "even introduce illegal innovations, because the government is too slow with adapting the regulations" [9].
Eight entrepreneurs, in various manners, point to the problem that the rules and regulations are conflicting and that as a result they do not know what to do, or which regulations to keep an eye on for the product development or business activities. First, there is a lack of standardization of policies and regulations in innovation and sustainability [1,2,9,10, 15,16] and too little coordination between the national, regional and local governmental levels [2,10]. For instance, national and local rules on planning regulation differ, and regulations conflict each other in their implementation. An example is that the requirements for sustainable technologies conflict with the requirements concerning 'visual aspects' of houses and streets (the Dutch 'welstandscommissie'). This is the case for solar heat boilers and urban windmills [1,2,3,5,10,15].

Negative: Subsidies hinder the innovators
Whether entrepreneurs are so called 'front runners' or more followers, they both predominantly see subsidies more as an obstacle than as a stimulus for innovation. One entrepreneur describes the problem as follows: "The whimsical and unreliable nature of the subsidy policies makes long-term positive influences impossible" [5]. He refers to the effect, experienced by 13 out of all entrepreneurs, that the short term nature of subsidy programs creates shocks in the market [1-3,5-10,13-16]. Additional complaints concern the vast amounts of complex paperwork involved [1,6,9,13,14,16] and the long waiting times for approval [3,7,9,10,14,15]. One entrepreneur states that the unreliability of the government is "killing for investors" [9]. Most companies therefore choose not to get involved in subsidy schemes and rather 'go their own way'.

Positive: Subsidies for demonstration projects
An exception to this rule is the subsidies given for demonstration projects [6,7,11,14] and long-term tax deduction schemes [11,12]. These measures are considered clear and reliable.

4.4.2.2 Social institutions

Negative: Mindsets of companies and consumers need to change but it is hard to do so
An important barrier mentioned by entrepreneurs resides in the minds of people (normative pressures). Many entrepreneurs are of the opinion that it is not yet 'normal' to use sustainable innovations in constructions and houses [1,3-0,11,13,15,16]. One phrases it as "people first need to grasp the concept of sustainability in their mind" [9]. The required change not only includes the products and processes, but the whole value chain. However, this change is difficult. Some entrepreneurs state that actors around them fear innovation, they rather stay within the old, safe routine: Many actors…:

- "have prejudices against sustainable innovations" [6]
- "are reluctant to try something new" [4]
- "are unwilling to implement sustainable innovations" [7]

The common belief is that sustainability costs money, that sustainable innovations don't work (well) and that they increase risk and complexity.

Two actor groups are considered to be especially conservative when it comes to sustainable innovation are the installers and investors. Seven out of 16 entrepreneurs [3,5,6,8,11,13,15] typify the installers as a very difficult hurdle to take in transforming the construction industry as they are have the most direct link to the end-users (both offices and houses) but refuse to change their working routines. This is seen as a result of their low level of education and their general resistance to change as they often do not believe the claims of novel products and they avoid the risk of trying them. The result is that sustainable solutions are not even being offered to the end user and hence the market stays very small.

The second group of actors that have not got a mindset in which sustainability plays a role, are the investors. Entrepreneurs describe how they are always searching for investors but that these:

- "look at profitability on the short term" [9] (whereas sustainable investments often pay back in the long run)
- "are more reluctant when investing in sustainability" [1]

Finding funding sometimes costs time, but eventually all 16 entrepreneurs succeeded with private investors, with government funding or by using own capital.

Negative: Lack of long term vision of the government hinders investments and innovation.
Eleven entrepreneurs stress that the national government does not adequately built a culture, norms, values, a vision (*normative pressures*) that supports sustainability in general, and in the construction industry in specific: "*it does not clearly indicate a direction for progress of society*" [13]. "*The government does not stick to the choices they make. This short-term behavior coupled with major political changes every 4 years is hurting the national reliability and stability*" [8]. The consistency of public policies is

crucial for the entrepreneurs as they can develop their business strategies accordingly: *"the government should worry about vision and the long-term, then I can start worrying about my short-term survival"* [3].

Positive: Awareness in general, and Al Gore in specific, stimulates green construction
Five of the entrepreneurs emphasize the great importance of media attention and a clear vision of (representatives of) the government as it creates legitimacy for the entrepreneurs [4,5,7,9,10,12,15]. These policy messages give a clear signal to the society as a whole, and to the business community is specific, that this is the way developments will go. All 16 entrepreneurs indicate that these are important influences to them as it:

- creates legitimacy and awareness with customers (e.g. after Al Gore's plea for sustainability, people do not have to explain the reasons for investing in sustainable solutions anymore), and hence also creates more demand [1-3, 5,8-13,15,16]
- creates a guideline for investments, e.g. the feed-in measure in Germany makes that people can invest in that technology knowing that they have a set period of time, and a set price, which makes it possible to make a calculation on whether investments can be earned back, stimulating companies to invest in new products and application [4,6,14]
- increases the awareness at local and municipal *governments* with as an effect that they initiate building projects [6] and support actors involved in such projects [6,7,9,13].

4.4.2.3 Competitive institutions

Positive: Competition proves new developments to be challenging!
Entrepreneurs perceive no negative influences from competing entrepreneurs, since all of them are fighting the same enemy [3,7,9,12]. In fact, actions by competitors even result in a positive influence for entrepreneurs, since it leads to "increased attention for the emerging entrepreneurial industry" [3].

Negative: Competition on price rather than quality and innovation
Half of the entrepreneurs argue that mainly in the construction industry (more so than with energy providers) there are still opposing institutional forces as competition is still based primarily on price and not so much on other aspects such as quality, innovativeness or sustainability. Entrepreneurs note that "the building market still believes sustainable investments are costing money" [11], and that there is a lot of "ignorance and lack of knowledge" [6] and partly due to the fact that most investors, contractors and consumers "look on short-term pay-back times and not on the longer term" [9]. So, although increased awareness has provided a strong boost for sustainable entrepreneurial undertakings, barriers still exist in other categories of system interactions.

4.4.3 Interaction: Collaboration and knowledge exchange in networks

Too much interaction: lock-in due to closed collaborative ties between vested interests
Another strong barrier to sustainable entrepreneurship mentioned by entrepreneurs is that of too strong collaboration between actors with vested interests. Projects in the built environment require inputs and effort from many stakeholders, from governments, businesses, owners, developers, suppliers etc., which makes cooperation and coordination crucial. All the interviewed entrepreneurs indicate that the large players occupy the strong and powerful positions within the construction networks [1,2,4,6,11-13,15] who "seek to maintain power and control in the sector" [1] as this increases their profits. The whole supply chain, up to the contacts with the customers, is dominated by these large

players. The interactions between them are based on historic relations, are rigid and fixed. Entrepreneurs mention that they cannot interact with them, because "these stakeholders have been operating and cooperating in the same manner for decades" [11] and "the whole system with all activities is based on rusted routines" [6] which are hard to change. This creates strong network failures and 'lock-in' in the sense that new knowledge, know-how and working routines will be hard to establish with these players and hence, the industry will tend to stay conservative

From the energy sector there is a less negative influence coming from vested interests than from the building sector, since most of the large players are forced to become more sustainable. However, these large energy companies have power and a strong energy lobby: "they can afford to hire their own lobbyists" [3]. Although the government aims to force these big companies to move towards sustainability through regulation and negotiation, the energy lobby can influence, stall or even prevent this. The entrepreneurs lack this power [3,6,9,10,13-16], and argue that "they are too small to have an influence" [16]. System following entrepreneurs connect with the vested interests and as a result mainly experience positive effects from the initiatives of energy companies – including increased media attention for sustainability, the ability to participate with large players in large projects, gaining access to existing markets and gaining access to higher governments. System building entrepreneurs cooperate outside of the vested interests and experience more opposing effects from them, such as the delaying of sustainable investments and lobbying to halt new sustainability regulations. Therefore, system building entrepreneurs argue that energy companies have no real incentive for reducing energy consumption or for promoting sustainable energy, they have "no clean motives" [6], but rather a "conflict of interests" [1,8] since their primary aim is to make as much profit as possible from selling energy. According to the system building entrepreneurs, energy companies are sometimes an initiator for sustainability, but mostly they follow other actors and "do not run forward in the field of sustainability" [13] as they do themselves.

Too little collaboration between governmental bodies

Moreover, the government suffers from weak interaction failure, which also primarily hurts system building entrepreneurs. The national government tends to listen mainly to the large industrial players and does not support innovative SME's. Innovative entrepreneurs that do not have relationships with these large players are overlooked by the government [8-10,15,16]. The government is open to sustainability initiatives from established players, but "does not listen to ideas from newcomers" [10]. The national government follows the hype of the technology of the day which is led by large industrial companies, while sustainable innovations by entrepreneurs "need long-term encouragements" [8] that are independent of individual powerful actors. Governments are in the unique position to ignore the powerful position of individual stakeholders to stimulate an entire industry and therefore they should initiate overarching cooperative projects for sustainability.

4.4.4 Capabilities

Technological knowledge and know-how

Technology, in the form of technological knowledge and development, was mentioned by 75% of the entrepreneurs as being an important enabling factor, but all of them emphasized that "there are other factors that eventually make the difference" [11] for successfully developing sustainable innovations [1,3-7,11-16]. However, some differences are noticeable between reactive and pro-active entrepreneurs: whereas the reactive ones

feel they are waiting for the technology to 'prove itself' ("the technology is not yet ready and needs further development before we can proceed" [5]), the proactive entrepreneurs emphasize that the technological developments underlying their innovations are "essential for staying competitive" [8] and "make our existence today possible" [9]. Also, these entrepreneurs emphasize the role of knowledge providers in this process: "the availability of technological knowledge providers forms the foundation of our existence" [8-10].

4.4.5 Market structure

4.4.5.1 Market demand

Quantity of demand
All entrepreneurs mention that there is a small, but growing demand for sustainable technical solutions in the construction industry. In the offices market this demand is more developed as the future user is more involved in the design and development of the buildings, and sees clear advantages in a sustainable office because of the positive effects of a reduced energy bill and a better image for the company.
In domestic housing the link to the final user is more distant and users are more interested in common characteristics as comfort and price. Still, there is a clearly a growing demand for sustainable solutions as end-users want to contribute to a more sustainable world and want to increase their independency of central providers as a reaction on fluctuating (and feared increasing) energy and water prices. The entrepreneurs all are convinced of the market potential.

Quality of demand
In the current state of the art in the construction industry, demand is still very much on price. In many sectors of the construction industry, tendering procedures decide who will get the job. The result of these purchasing processes is that temporary coalitions between price fighters prevail over longer term strategic partnerships that strive for quality and innovation. Common sense is that (semi) government bodies should play the role of 'lead customer' in creating quality demand. However, these bodies are also subject to national and European legislation on procurement procedures.

4.4.5.2 Market power / Barriers to entry

Investment costs
Although almost all sustainable innovations require initial investments, all sustainable innovations eventually pay-back economically within 1 to sometimes 15 years. This is because some innovations directly and immediately lead to cost-savings, whereas others require large upfront investments and have long pay-back times. All the entrepreneurial companies in this research were actively focused on contributing to sustainability and have experienced growth in recent years in terms of turnover and employees. This confirms the proposition of the literature on sustainable entrepreneurship: entrepreneurs are indeed able to reconcile economic growth with a contribution to sustainability.

Market power by incumbent firms
The strong and closed networks in the construction industry are considered limiting for the possibilities for entrance of innovative entrepreneurs, since they feel that there is "little room for outsiders to enter the competition of the industry" [2]. 14 (out of 16) entrepreneurs mention strong negative influences from these vested interests and say

they have to fight them in order to gain a position and power and to successfully introduce their sustainable innovations. The fact that projects concerning energy in the built environment typically involve many stakeholders from both the energy and the building industries increases the complexity of changing this process towards sustainability. It is much harder to get all these stakeholders facing in the same direction to try something new – there can easily be "just one stakeholder that veto's the implementtation" (7) of sustainable innovations (4,6,7,11,15). And if the entrepreneurs do find a way in to establish a position in the industry, often they remain dominated by a large partner or a more powerful supplier who can effectively control the small entrepreneur due to it's power over resources or market access (3,8).

Transparency
Entrepreneurs indicate that although there is a general awareness on sustainability, (end)users have insufficient knowledge on the potential of new technologies and products: the costs and benefits are not clear, and externalities are not counted into the price.

4.5 Conclusion system analysis entrepreneurs

All in all we conclude that the entrepreneurs – on the whole – sketch a picture that much resembles the analysis on the basis of the interviews with incumbent firms: both recognize the lack of connection with the market (lack of demand, quality of demand) and both see large problems in the regulatory sphere. Also, both feel limited responsebility for changing the situation: they feel that raising awareness and creating a market is a task that is too big to handle for individual firms.

The most important pressures that the entrepreneurs experience from the system and market lie within the category institutions: the regulative, social and competitive pressures that shape the field. Laws and regulations are considered confusing and inconsistent and often conflicting between different government actors. Policies at the national level can for instance not be executed because they are blocked by conflicting policy interpretations at the local level.

Interaction also forms a bottleneck for innovation in the perception of the entrepreneurs. They find that existing parties have too close links, leading to lock-in to existing technologies and solutions, thereby blocking the introduction of new products and technologies as introduced by the entrepreneurs. Some entrepreneurs therefore decide to collaborate with these existing powerful players to sell their products through their distributions channels on the basis of generally accepted selling points as price and comfort. Other entrepreneurs decide to 'fight' the status quo and establish new networks of innovative actors and try to convince the clients of new selling points as energy efficiency and environmental friendliness. The latter actively try to weaken the existing structures to create more room for new business.

Technological and organizational capabilities play only a minor role. Actors either have knowledge and know-how in-house, or know where to get it (e.g. universities, consultants).

With regard to the actors behind the influences, the Market and System Failure framework showed that there are three actor groups that are considered a barrier for innovation:

- The government with their lack of vision and consequent inconsistent policies
- The large incumbent players in the construction industry that throw up barriers of entry for new actors with their closed network structures
- The installers that 'block' access to markets as they do not want to try out new technologies and do not sell these to their customers (whereas they are the ones with most customer contact).

With respect to the government we find no evidence that actors actually try to change the government's perceived failure in guiding the economic system to a more sustainable new equilibrium. Actors do complain, but at the same time feel they have no 'voice' to protest against it, and hence decide to leave it as it is and try to work with the regulative system, or work around it.

The entrepreneurs do take action to address the other actor groups: they try to build up competing coalitions to break open the collusive industry structures, and try to convince installers and re-sellers with cost as well as ideological arguments to join them on their path to sustainability.

All together we conclude that the entrepreneurs only use strategies there where they feel that change is possible. The strongest example of this is the fact that most entrepreneurs experience the limiting nature of old beliefs, routines etc. (social institutions), rules and regulations (regulative institutions), and competitive structures (competition on price) but that entrepreneurs do not challenge these rules of the game directly. They generally feel they cannot change these institutions: they are too small, the government does not listen, the habits, norms and values will not change fast enough etc.. The Dutch government, that wants to be a protagonist of innovation and the transition towards a more sustainable society, comes out especially negative: they are seen as barrier rather than a stimulus for innovation and sustainability.

As a response entrepreneurs to their inability to change these factors directly they decide 'to make some noise' in the hope that the attention to new development slowly warms people to adopt new ideas, or leave the changing of institutions just to whoever feels responsible to do so. Generally entrepreneurs choose to work on their individual goals rather than some collective aim to overthrow a regime. We conclude that entrepreneurs are 'street wise' in their decision on what to spend their resources. They are business managers, and not ideologists. They are also wise in the way they aim their strategies so that they address only those pressures from their environment that they experience as hindering the success of their businesses in the long run.

The question whether the entrepreneurial actions as we describe add up to regime change cannot be answered as the reactive strategies (which on face value seem to lead to more business success than the actions of the pro-active entrepreneurs) might lead to unintended field change and the actions of pro-active entrepreneurs might not. To draw conclusions on this question we would have to perform a study in retrospect. In this study we are interested in the dynamic relationship between the pressures of the system and the responses of the entrepreneurs without judging the effectiveness of those strategies. By studying these processes we can confirm or falsify some of the theories in

institutional entrepreneurship and theories on the role of entrepreneurs in innovation systems.

5 Overall conclusion

In this report we have taken an in-depth look into the construction industry from different angles. We have looked at the:

- Industry on a macro level, comparing the construction industry with service and manufacturing to establish to what extent the industry is innovative.
- Companies in the industry from a reporting point of view, trying to get an idea of how sustainable competitiveness is, or can be measured.
- Underlying mechanisms in the industry by looking at the system and market characteristics that stimulate or hinder (sustainable) innovation in the industry, seen from the perspective of the incumbent firms and entrepreneurs

From the combination of these different angles we can conclude that if we look at the construction industry in the traditional way, we see a confirmation of an old belief being that the construction industry has relatively few innovators and lags behind on introducing innovations onto the market when compared to other industries. If we take a deeper look though, the underlying reasons for this also become evident, mainly by looking into the mechanisms that explain why actors do, or do not innovate.

First we find an answer within the CIS data being that a relatively low percentage of firms in the construction industry actually benefit from the introduction of new products and processes compared to other industries: 84% of the companies indicate that there was no improvement of their turn-over. This is confirmed by the fact that – more than in the services or manufacturing industry - there is no demand for (sustainable) innovations. In other words, even if companies innovate, they will find it hard to sell these new products or processes and to improve their performance by doing so.

Second, when we looked into the way the construction industries acts and performs on sustainability, we saw that they were doing well compared to other industries. Their innovations contribute to lessening environmental damage and material use. We did not see an indication though that these innovations also contributed to the Profit aspect of sustainable competitiveness: they did not seem to be able to transform successful innovation into better performance.

Third, we took a deeper look into the industry by looking at incumbent firms (established companies) and entrepreneurs that want to introduce sustainable innovations into the industry as their core business. Incumbent forms are often thought to block industry transformation and innovations as this can damage their position, whereas the entrepreneurs are fighting to take over these positions. From the interviews we hence expected different views on the functioning of the system: on where the bottlenecks are and the opportunities lie for sustainable innovation.

From the interviews we learn that although entrepreneurs and incumbent companies have different views on some aspects, they agree on most.

- They all believe in the value and potential of sustainable competitiveness: they believe they can marry sustainability with profit and believe they should to stay competitive in the future
- They all notice that there is not yet a strong demand for sustainable innovation (but the demand is enough for small entrepreneurs to run their businesses)

- They all find that the government (local, provincial, national) plays a very ambivalent and unreliable role in the process to get to more sustainable innovation in the industry

They differ slightly in the way they want to approach the issues. The incumbent firms feel they have fruitful collaborations with willing partners in the field of sustainable innovation, and they work with these partners towards innovation and sustainability. They do experience that the costs of innovation are high and cannot be earned back due to underdeveloped market demand. They call upon the government to subsidize or otherwise support pilots to prove the viability of sustainable solutions.

The most pro-active entrepreneurs feel that incumbent firms form collusive structures that block innovations and newcomers from the market. They therefore try to establish networks of new players next to the established structures, and create an alternative sustainable industry next to the existing one. The goal is that the new system will overthrow the old one over time. These entrepreneurs call upon the government to create more awareness and stricter and more consistent regulations so that their businesses have more legitimacy and have long term horizon on which to base their investments.

The more re-active entrepreneurs form a middle ground: They use existing structures to bring their products to the market, i.e. they collaborate with the incumbent companies to grow their own company. Also, instead of convincing customers of ‘a new truth’ they stick to old accepted selling points to market their products such as price and comfort.

5.1 Stimulating factors for sustainable innovation

The most important market and system characteristics that we have indentified to be a bottleneck or stimulus for sustainable innovation in the construction industry are the following:

5.1.1.1 Positive beliefs of entrepreneurs as well as incumbent firms

We see great support of – and belief in – the potential in sustainable competitiveness with both entrepreneurs and incumbent firms in the construction industry. There is a generally shared belief that sustainability, in the sense of people, planet and profit, has the future and companies are willing to invest in this development. From the data we see prove of this as their innovations do contribute to people and planet measures.

This very positive picture can however be coloured by the design of our research. We might have spoken with a small group of enthusiasts within a larger company, and with entrepreneurs that have sustainability as the core of their business. However, we believe that we have strong indications that sustainability is slowly getting into the core of the businesses. Especially within the utilities market sustainability is an important issue in project development, e.g. sustainable offices are very popular as they reduce maintenance and energy bills, while benefitting the tenant’s image of being a responsible firm. In housing development this is more difficult as pricing mechanisms lack that make it possible to earn back investments in sustainability (e.g. lodgers benefit from lower energy bills without paying more rent to compensate for the investment).

5.1.1.2 International awareness to be picked up by national government

Al Gore is the protagonist of sustainability. All respondents mention the strong positive effect of people like Al Gore have on their business as their stories provide legitimacy and a unique selling point for their business. They call upon the Dutch government to take over this role and strengthen the transparency of markets, the knowledge on sustainable products and the awareness of general sustainability issues to provide drive and legitimacy to sustainable business propositions. They suggest national campaigns with e.g. television programmes and /or advertisements.

5.1.1.3 Rules and regulations

The respondents give a mixed picture on the role of rules and regulations in their innovation efforts. Most firms though indicate that they see rules and regulation as an important driver for innovation as they slowly push the industry forwards. The rules also give a clear window of opportunity: actors know that business activities can be developed within, or ahead of this window which provides a good guideline for investments. This picture is confirmed by the data that show that rules and regulations, together with national government funding, play an important role in stimulating product and process innovation. With the bottlenecks we will however see that the picture is not that straight forward, as in the execution of innovative projects, also many problems are encountered with rules and regulations.

Funding also plays a positive role. Despite the fact that respondents complain about funding possibilities, the data show that funding is relatively speaking not a problem compared to other industries, and that the companies that do receive funding from the national government, innovate more and transform these innovations into business success.

5.2 Bottlenecks for sustainable innovation

5.2.1.1 Lack of demand and weak customer linkages

There are various aspects that are problematic when we look at the connection to the market. First there is a limited demand for sustainability: people buy on location, price and comfort. Second, clients do not have enough information: they do not know enough about different solutions, there is a lack of transparency, prices do not always include costs, and hence customers choose the best known, existing solution instead of choosing for innovative products or concepts. The respondent companies see a task for both themselves and the government to provide better information through public campaigns and marketing.

From both the interviews and the data we learn that the construction industry has very underdeveloped linkages with the market or end-customers. Where – overall – there is a strong development within modern economies to involve end-users in innovation processes, the construction industry is not yet able to organize this link. Customers are not involved in setting goals or giving ideas for innovation, they are not involved in the networks of the construction industry, they just are not represented in the whole value chain of the sector. Here lies a big change for improvement!

5.2.1.2 Dysfunctional government

The report sketches a grim picture about the role of the government in stimulating sustainable innovation in the construction sector: rules and regulations that contradict

each other, bureaucratic structures that block change, conflicting policies at local and national level, lack of vision. It is clear that both incumbent and entrepreneurial firms see much room for improvement for the role of the government in this process. They wish for a government that has a clear vision and a long term plan for policy implementation which remains stable over a long period of time. Such a policy horizon could enable firms to invest in certain project knowing that rules and regulations, subsidy schemes or other government measures will not 'destroy' their investment. Furthermore, they wish for a government that is coherent: different ministries that know of each other what they are doing, and coordination of tasks on a local, provincial and national level so that policies from one level, are not annulled at another level.

5.2.1.3 Scaling up of innovations: funding and transfer mechanisms

It is interesting to see that there is clearly not a lack of good products and technologies in the construction industries. Solutions and knowledge and know-how exist, and if more is needed, the industry has good connections to e.g. the knowledge infrastructure to tab into new knowledge. Also, there are enough pilots in the industry to test these products and technologies. The problem hence mainly lies in the diffusion of innovation. Companies often mention the lack of market demand (due to high prices) as a cause for this, or a lack of government subsidies for their pilots. We note though that the industry makes very little use of consultants, whereas consultants (or specialist third parties / knowledge experts) can play an important bridging role. They are vehicles for knowledge transfer on new techniques, practices, standards etc.. It is interesting to mention in this respect that the respondents that were investing in sustainable solutions were very much relying on external advisors to bring them to 'proven' technologies so that they did not have to be 'guinea pig' in new developments. Clearly the group that uses external advisors is very small, but they do use these advisors for exactly that: the consultants do function as a vehicle for innovation diffusion. We hence conclude that there also lies a great opportunity here.

We find less prove for the general held belief that innovation is too expensive. When looking at the data we see that the costs of innovation are not considered more problematic in the construction industry than in other sectors.

5.2.1.4 Lack of uniformity in reporting practices

Construction companies struggle with the ways they can make their sustainable efforts more visible, both in their reporting practices as in their communications to customers. In the reporting of sustainability figures problems arise as reporting requirements differ nationally and internationally and per organisation (e.g. Standard and Poor). Smaller construction companies lack the capacity to gather the required information. A common reporting system for sustainability figures, tailored for the construction industry, would benefit the industry to a great extent as this would increase the transparency and legitimacy of the industry, and provide clearer guidelines for 'steering' the industry towards a more sustainable future.

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