MASTER

Improving successful collaboration

a private-party collaboration to optimize the municipalities' corporate real estate performance by performance contracting

Blokland, B.

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Colophon

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A private-party collaboration to optimize the municipalities' corporate real estate performance by performance contracting

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Preface

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This report is the final result of my graduation research, as final project within the master program *Construction Management and Engineering* at the Eindhoven University of Technology. I conducted this research as graduate intern at the company Royal HaskoningDHV, within the business line *Buildings, New Strategic Initiatives*.

Within this research a proper balance between theory and practice is realized, which was for me an important starting point and challenging objective. It was my aim to provide a social contribution, scientific contribution, and also a practical contribution with my research findings. In addition to this, the research topic is in accordance with my fields of interests, which combined with my curiosity and ambitions has led to a higher quality level of my final research.

Achieving my set objectives and completing my graduation research to the current quality level, was only possible with the support of some people. I want to express my gratitude to my supervisors Bart Hueben and Bart Brink of the company Royal HaskoningDHV, who were closely involved during my graduation period. I would like to thank them for the practical and analytical insights I received, in combination with the support to reach an optimal final product. Besides, the opportunity to involve in the projects within the company Royal HaskoningDHV made my graduation period as very useful. I want to express my gratitude also to my supervisors of the Eindhoven University of Technology Han Qi and Elke den Ouden, who guided me through the research process. I would like to thank them for the given constructive feedback during this period. Lastly, I would like to thank my family and friends who supported me during my whole study period and also during my graduation period of course.

Bas Blokland

Management Summary

The main objective of this research is providing insights in possible improvements to the successful collaboration within a researched partnership (contractor, engineer/consultant, energy supplier); this in combination with the possible implementation of performance contracting. The achievement of this objective will lead to insights in the opportunity to answer the request of municipalities to optimize their real estate property performance in a sustainable way. The main objective of this research will be achieved by answering the main research question:

"In which way could the successful collaboration be optimized, for a partnership-solution which optimizes the municipalities' property performance in a sustainable way?"

Following the objectives of the national government of the Netherlands, the provinces and municipalities are emphasizing the necessity of sustainable developments. The considerations of municipalities to optimize the performance of their real estate properties in a more sustainable way is based on three motives: pressure to contribute to the governmental set objectives, the municipalities' own ambition and objectives, and possible (energy) cost savings. In order to achieve the set targets and meet the ambition of municipalities regarding their sustainable and innovative improvements, the search for collaboration opportunities with private parties is present. Public parties like municipalities are looking for long-term partnership solutions with private parties, where performance agreements could provide an extra value for both, municipalities and contracting parties. The risk reduction for the municipality and the stimulation of innovative and sustainable improvements could be realized by performance contracting.

Several research has been conducted to general aspects that influence a (successful) partnership within the construction industry (e.g. (Chen & Chen, 2007; Hwang, Zhao, & Gay, 2013). However, specific research directed to the collaboration of private parties in the given situation of municipalities, will contribute to the improvement of the future successful collaboration. Researching the influences to the collaboration aspect in relation with performance contracting (recent market developments) will provide new insights to the current state of research.

This research focuses to influences to the collaboration aspect within a set partnership. This partnership will be a consortium between a contractor, engineer/consultant, and an energy supplier, following a current partnership situation of the company Royal HaskoningDHV. This research provides insights to the possibilities to collaborate within the consortium, to subsequently answering the request of municipalities to optimize their real estate property performance in a sustainable way. This research emphasizes the collaboration aspect between the consortium partners, when performance contracts (long term, ca. 10 years) are implemented. In this research are included *energy performance, maintenance performance,* and *comfort performance,* as given market opportunities (e.g. experts RHDHV, 2015; (World Green Building Council, 2014; Institute for Energy and Transport, 2015)).

The literature review functioned as method to collect the possible influencing attributes to the collaboration between (private) parties in the construction industry. Based on a research comparison and a content analysis, a selection of ten influencing attributes is conducted. By analyzing the companies' request (Royal HaskoningDHV), the observation of a similar ongoing project case, the conduction of different case analyses (RHDHV), and the literature review, the input is gathered for the creation of potential performance contract scenarios. By interviewing different experts of Royal HaskoningDHV (experts RHDHV, 2015), three performance contract scenarios are validated as suitable to implement in this research:

- Scenario 1 **EPC** *Energy Performance contract*
- Scenario 2 **EOPC** *Energy Performance and Maintenance Performance contract*
- Scenario 3 **EOPC + CP** *Energy Performance, Maintenance Performance and Comfort Performance contract*

These performance contract scenarios are further researched in combination with two risk and benefit division methods (validated by experts RHDHV, 2015), following the mutual responsibility for the performance output:

- ***Method A*** | Equal division of risks and benefits (1/3)
- ***Method B*** | Division of risks and benefits based on the share (%) in total project turnover

The Fuzzy Delphi Methodology (FDM) is applied in this research to determine the influences of selected attributes to the successful collaboration between the involved parties. The implementation of the Fuzzy Delphi Methodology is determined as highly suitable in this research, mainly because of the *fuzziness* of the experts answering is taken into account (Glumac,

Han, Smeets, & Schaefer, 2011). Within the explorative section of this research, a Game Theoretical approach is used in order to give insights to the interdependencies of the different involved parties (Barough, Shoubi, & Skardi, 2012). Because of the complexity and challenges within the partnership and associating decision-making, Game Theory will provide useful insights in this process (Javed, Lam, & Chan, 2014; Kargol & Sokol, 2008). Hence, by making use of Game Theory in this study, insights to improving the (successful) collaboration within the set partnership will be given, by the modeling of an associating 'success value' for the collaboration.

A questionnaire is used to determine, as first the preferences in performance contracting scenarios in combination with the mutual risk and benefit division methods, and as second the influences of attributes to the collaboration aspect. This questionnaire is distributed to experts in three categorized expert groups in accordance to the set consortium partners: Contractor (8 experts), Engineer/consultant (6 experts), and Energy supplier (2 experts). The overall response rate is 36% (16 out of 45).

The analyzed results and findings of this research lead to the final conclusion of this study by answering the main research question:

In which way could the successful collaboration be optimized for a partnership-solution, which optimizes the municipalities' property performance in a sustainable way?

Regarding the implementation of performance contracting and the associating risk and benefit division (performance output), the following conclusions are set:

- The inclusion of *Maintenance Performance* is essential when implementing an *Energy Performance*, or a *Comfort Performance contract*.
- The *Energy Performance, Maintenance Performance, and Comfort Performance contract* is determined in this study as most appropriate, of the researched performance contract scenarios.
- A risk and benefit division (performance output) based on the share (%) in project turnover is determined in this study as most appropriate for the given performance contract scenario.

In order to improve the (successful) collaboration in performance contracting, the following attributes ask for the highest priority by improving the handling and management of these attributes:

1. Good and existing relationship between the partners within the partnership
2. Trust between the partners within the partnership
3. Clear understanding of personal objectives within the partnership of all parties
4. A detailed description of tasks and responsibilities in contractual agreements

The influencing attributes to improve the collaboration aspect are essential for the involved consortium parties (expert groups): Contractor, Engineer/consultant, and Energy supplier. The findings apply for the shown preferred implementation of an *Energy Performance, Maintenance Performance, and Comfort Performance contract,* which is combined by a risk and benefit division method based on the share (%) in the total project turnover. This in combination with the findings of the influencing attributes to the (successful) collaboration, could contribute substantially to the optimization of the municipalities' property performances in a sustainable way, by the given consortium partners.

Some remarks should be given with respect to the interpretation of the given findings and conclusions, as recommendations for future research. An increased number of consulted experts will contribute to the reliability of the results, mainly concerning the expert group 'energy supplier'. The provided findings in this study will positively influence the proper implementation of performance contracting, although a decent business case should be present. Further research directed to the combination of the business case and the findings in this study, will contribute to the successful practical implementation of performance contracting. Further research to the specific concluded influencing attributes will be recommended; this in order to make the attributes more specific and determine specific actions to improve the successful collaboration. In order to further develop and optimize the 'success value' modeling provided in this study, the inclusion of existing project cases would be recommended in future research.

Management Samenvatting

De hoofddoelstelling van dit onderzoek is inzicht verkrijgen in de mogelijke verbeteringen die leiden tot een succesvolle samenwerking in een vastgesteld partnership (aannemer, engineer/consultant, energie leverancier); dit in combinatie met de mogelijke implementatie van prestatie contracten. Het bereiken van deze doelstelling zal tot inzichten leiden om het vraagstuk van gemeenten te kunnen beantwoorden, waarbij de prestaties van het (kantoor) vastgoed van gemeenten geoptimaliseerd dienen te worden op een duurzame manier. De hoofddoelstelling van dit onderzoek wordt bereikt middels beantwoording van de volgende hoofdonderzoeksvraag:

"Op welke manier kan de succesvolle samenwerking geoptimaliseerd worden voor een partnership oplossing, welke de prestaties van het (kantoor) vastgoed van gemeenten op een duurzame manier optimaliseert?

In navolging van de gestelde doelstellingen door de Nederlandse regering, de provincies en de gemeenten, wordt de nadruk steeds meer gelegd op de noodzakelijke duurzame ontwikkelingen. De overwegingen van gemeenten om de prestaties van het eigen (kantoor) vastgoed te optimaliseren op een duurzame manier, is gebaseerd op drie motieven: de druk om bij te moeten dragen aan de doelstelling van de regering, de eigen ambitie en doelstellingen van gemeenten, en een mogelijke (energie) kosten besparing. Om de gestelde targets en gevormde ambitie te behalen met betrekking tot het doorvoeren van duurzame en innovatieve verbeteringen, wordt er gezocht naar (nieuwe) kansen om samen te werken met private partijen. Publieke partijen zoals gemeenten zijn zoekende naar mogelijke lange termijn partnerships met private partijen, waar de implementatie van prestatie contracten een extra waarde zou kunnen bieden voor beide, gemeenten en aannemende partijen. De risicoverlaging voor gemeenten en de stimulans tot duurzame en innovatieve ontwikkelingen, kan gerealiseerd worden (mede) door middel van prestatie contracten.

Diverse onderzoeken zijn uitgevoerd naar de verschillende elementen die van invloed zijn op de (succesvolle) samenwerking in de constructie industrie (e.g. (Chen & Chen, 2007; Hwang, Zhao, & Gay, 2013). Echter, onderzoek specifiek gericht op de samenwerking tussen private partijen in de gegeven context van het vraagstuk van gemeenten, zal een bijdrage leveren aan de mogelijke verbeteringen voor een geschikte en succesvolle samenwerking. Het onderzoeken van verschillende beïnvloedende samenwerkingselementen, ten opzichte van de samenwerking op basis van prestatie contracten (recente markt ontwikkelingen), zal nieuwe inzichten bieden ten opzichte van huidig uitgevoerd onderzoek.

Dit onderzoek richt zich dus voornamelijk op de invloeden van de samenwerkingselementen, binnen het gestelde partnership. Dit partnership zal gelden voor een consortium bestaande uit een aannemer, engineer/consultant en een energie leverancier, afgeleid uit een huidig partnership situatie van het bedrijf Royal HaskoningDHV. Dit onderzoek biedt inzichten in de samenwerkingsmogelijkheden binnen het consortium om daarmee het vraagstuk van gemeenten te beantwoorden, waarbij de prestaties van hun (kantoor) vastgoed geoptimaliseerd dienen te worden op een duurzame manier. De nadruk in dit onderzoek ligt op de samenwerkingsaspecten tussen de consortium partners, wanneer prestatie contracten (lange termijn, ca. 10 jaar) geïmplementeerd worden. In dit onderzoek betreffen dit *Energie Prestatie*, *Onderhoud Prestatie* en *Comfort Prestatie*, als gegeven kansen in de huidige markt (e.g. experts RHDHV, 2015; (World Green Building Council, 2014; Institute for Energy and Transport, 2015)).

De literatuur studie heeft gediend als methode om elementen te verzamelen die mogelijk invloed hebben op de samenwerking tussen (private) partijen in de bouwindustrie. Gebaseerd op de uitgevoerde vergelijking tussen voorgaande onderzoeken en de bijbehorende inhoudsanalyse, zijn tien elementen geselecteerd die mogelijk van invloed zijn op de samenwerking. Op basis van het vraagstuk van het bedrijf Royal HaskoningDHV, de observatie van een vergelijkbaar lopend project (RHDHV), het uitvoeren van een aantal case analyses (RHDHV), en de literatuur studie, is de input verzameld waarmee potentiele prestatie contract scenario's zijn opgesteld. Door middel van het interviewen van verschillende experts van Royal HaskoningDHV (experts RHDHV, 2015), zijn drie prestatie contract scenario's gevalideerd als geschikte scenario's om in dit onderzoek toe te passen:

- Scenario 1 **EPC** *Energie Prestatie contract*
- Scenario 2 **EOPC** *Energie Prestatie en Onderhoud Prestatie contract*
- Scenario 3 **EOPC + CP** *Energie Prestatie, Onderhoud Prestatie en Comfort Prestatie contract*

Deze prestatie contract scenario's zijn verder onderzocht in combinatie met twee methoden om risico's en opbrengsten te verdelen (gevalideerd door experts RHDHV, 2015), gebaseerd op de gedeelde verantwoordelijkheid voor de prestatie output:

- ***Methode A*** | Gelijke verdeling van risico's en opbrengsten (1/3)
- ***Methode B*** | Verdeling van risico's en opbrengsten op basis van het aandeel (%) in de totale project omzet

De Fuzzy Delphi Methodology (FDM) is toegepast in dit onderzoek om vast te stellen wat de invloed is van de geselecteerde elementen op de succesvolle samenwerking tussen de betrokken partijen. Het implementeren van de Fuzzy Delphi Methodology (FDM) kan als zeer geschikt beschouwd worden voor dit onderzoek, voornamelijk omdat de '*vage beantwoording (fuzziness)*' van de geraadpleegde experts wordt meegenomen in de analyse (Glumac, Han, Smeets, & Schaefer, 2011). Dit onderzoek bevat een innovatief gedeelte waarin Game Theory wordt toegepast, om vervolgens inzicht te krijgen in de onderlinge afhankelijkheden van de betrokken partijen (Barough, Shoubi, & Skardi, 2012). Vanwege de complexiteit en de uitdagingen binnen het vastgestelde partnership en de bijbehorende beslissingen, zal Game Theory nuttige inzichten geven in dit proces (Javed, Lam, & Chan, 2014; Kargol & Sokol, 2008). Door de implementatie van Game Theory in dit onderzoek, zijn inzichten gegeven ten behoeve van de verbetering van de (succesvolle) samenwerking binnen het vastgestelde partnership, door middel van het modeleren van de daaraan gekoppelde 'Success Value' voor de samenwerking.
Een vragenlijst is gebruikt om allereerst vast te stellen wat de voorkeuren zijn in prestatie contract scenario's in combinatie met de methoden om de gedeelde risico en opbrengsten (prestatie output) te verdelen. Vervolgens om de invloed van de geselecteerde elementen te bepalen ten opzichte van de (succesvolle) samenwerking. Deze vragenlijst is verspreid onder experts in drie gecategoriseerde expert groepen. In overeenstemming met de vastgestelde consortium partners: de Aannemer (8 experts), de Engineer/consultant (6 experts), en de Energie leverancier (2 experts). Het totale responspercentage is 36% (16 uit 45).

De geanalyseerde resultaten en bevindingen in dit onderzoek leiden tot de eindconclusie van deze studie door het beantwoorden van de hoofdonderzoeksvraag:

Op welke manier kan de succesvolle samenwerking geoptimaliseerd worden voor een partnership oplossing, welke de prestaties van het (kantoor) vastgoed van gemeenten op een duurzame manier optimaliseert?

Met betrekking tot de implementatie van prestatiecontracten en de bijbehorende risico en opbrengsten verdeling (prestatie output), zijn de volgende conclusies vastgesteld:

- De implementatie van *Onderhoud Prestatie* is essentieel wanneer een *Energie Prestatie*, of een *Comfort Prestatie* contract wordt geïmplementeerd.
- De combinatie van een *Energie Prestatie*, *Onderhoud Prestatie* en *Comfort Prestatie* is vastgesteld in dit onderzoek als meest geschikte prestatie contract scenario van de scenario's die onderzocht zijn.
- De methode om risico's en opbrengsten (prestatie output) te verdelen op basis van het aandeel (%) in de totale project omzet, is vastgesteld in dit onderzoek als meest geschikte verdelingsmethode voor de prestatie output.

Om uiteindelijk de (succesvolle) samenwerking in prestatie contracten te verbeteren, zijn de volgende elementen van belang om goed mee om te gaan en te managen:

1. Een goede en bestaande relatie (samenwerking) tussen de partners in het partnership
2. Vertrouwen tussen de partners binnen het partnership
3. Duidelijk en helder inzicht in de individuele doelstellingen van alle partners binnen het partnership
4. Een gedetailleerde beschrijving van taken en verantwoordelijkheden in contracten.

De gegeven elementen welke een sterke invloed hebben op de verbetering van de samenwerking, zijn essentieel voor de betrokken consortium partijen (expert groepen): Aannemer, Engineer/consultant, en Energie leverancier. De bevindingen in dit onderzoek zijn toepasbaar op een combinatie van een *Energie Prestatie*, *Onderhoud Prestatie* en *Comfort Prestatie contract*, in combinatie met een verdeling van de risico's en opbrengsten (prestatie output) gebaseerd op het aandeel (%) in de totale project omzet. Dit in combinatie met de bevindingen betreffende de vastgestelde elementen met een relatief hoge invloed op de (succesvolle) samenwerking, kan een hoge bijdrage leveren aan de optimalisatie van de prestaties van het gemeentelijk (kantoor) vastgoed op een duurzame manier, door de gegeven consortium partners.
Een aantal opmerkingen zullen geplaatst moeten worden betreffende de interpretatie van de bevindingen en conclusies, om te dienen als aanbevelingen voor toekomstig onderzoek. Indien een hoger aantal experts de vragenlijst in zal vullen, zal de nauwkeurigheid van de resultaten stijgen. Dit geldt voornamelijk voor de expert groep 'Energie leverancier'. De bevindingen in dit onderzoek zullen positief bij kunnen dragen aan de implementatie van prestatie contracten, al moet een goed onderliggende business case aanwezig zijn. Toekomstig onderzoek zou zich dan ook moeten richten op de combinatie tussen de business case van prestatiecontracten en de bevindingen in dit onderzoek. Ook toekomstig onderzoek specifiek gericht op de beïnvloedende elementen wordt aanbevolen; dit zodat deze elementen beter gespecificeerd kunnen worden en bijbehorende acties kunnen worden vastgesteld. Om het geïntroduceerde 'Success Value' model verder te optimaliseren en te valideren, wordt de implementatie van eventuele bestaande (en toekomstige) projecten aanbevolen voor toekomstig onderzoek.

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List of abbreviations

CP	Comfort Prestatie – Comfort Performance
DM	Delphi Methodology
EPC	Energie Prestatie Contract – Energy Performance Contract
EOPC	Energie Prestatie en Onderhoud Prestatie Contract – Energy Performance and Maintenance Performance Contract
FDM	Fuzzy Delphi Methodology
FT	Fuzzy Theory
GT	Game Theory
P1, P2, P3	Player 1 (Contractor), Player 2 (Engineer/Consultant), Player 3 (Energy supplier)
PPP	Public Private Partnership
R&B	Risk and Benefit (division method A and B)
RHDHV	Royal HaskoningDHV
SER	Sociaal Economische Raad – Social and Economic Council
TU/e	Technische Universiteit Eindhoven – Eindhoven University of Technology
TCO	Total Cost of Ownership

1 Research Introduction

1.1 Company introduction

This research is conducted within the master program Construction Management and Engineering of the Technical University in collaboration with the company Royal HaskoningDHV. In order to provide a better understanding of the background of this study and due to the companies' involvement, the company Royal HaskoningDHV will be briefly discussed.

Given the explanation of the company, Royal HaskoningDHV is given as:
"Royal HaskoningDHV is an independent, international engineering and project management consultancy with over 130 years of experience. Our professionals deliver services in the fields of aviation, buildings, energy, industry, infrastructure, maritime, mining, transport, urban and rural planning and water. Backed by expertise and experience of nearly 7,000 colleagues across the world, we work for public and private clients in more than 130 countries" (Royal HaskoningDHV, 2015).

The company DHV, as international engineering consultant, was founded by Dwars, Heederik and Verhey in 1917. Royal Haskoning was founded by Hasselt and de Koning in 1881. In 2012, the two companies merged into the international engineering and project management consultancy company Royal HaskoningDHV.

Royal HaskoningDHV consists of eight different 'Business Lines' given as:

- Aviation
- Maritime and Waterways
- Infrastructure
- Planning and Strategy
- Water Technology
- Rivers, Deltas and Coasts
- **Buildings**
- Industry, Energy, and Mining

This research is conducted within the Business Line '*Buildings*'. Within this Business Line, different Business Units and Advisory Groups are active focusing to their specific expertise and market segments. As given in Figure 1.1, the Business Line '*Buildings*' consists of five different Business Units.

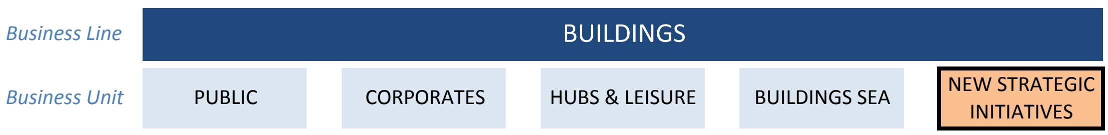


Figure 1.1 Business line 'Buildings' Royal HaskoningDHV

Within the Business Line '*Buildings'*, the Business Unit '*New Strategic Initiatives'* is the department wherein this study is conducted. This Business Unit is started since January 2015. Within the Business Unit 'New Strategic Initiatives', new products and services will be explored and developed. The other departments of the company are focusing more to Royal HaskoningsDHV' core business: engineering, project management, and consultancy. Within the Business Unit 'New Strategic Initiatives', the development of new products and services will possibly lead to the implementation of new revenue models. By these new developments and the possible implementation of new revenue models, opportunities will be discovered to result in a different and probably higher profitability. Despite the Business Unit is focusing to new developments of products and services, close cooperation with the other departments of the company is present in order to explore and execute new market opportunities.

1.2 Research Context

1.2.1 Background

For several years, the environment in the construction and real estate environment is changing rapidly. During the current aftermath of the financial crisis, started in 2008, the search for new forms of cooperation is becoming fiercer. Forms of cooperation are more focusing on the different phases of the building related processes, where coherence between the design, realization and exploitation phases will be explored (Tenkink, 2013).

Different new initiatives are introduced regarding the integration of the exploitation phase to the, among others, design phase. The total life span and exploitation are taken into account in earlier stages of the (re)development processes. Mostly, those forms of cooperation are regulated by integrated contracts, which arise in different formats. Within the integrated contracts, the Design & Construct form is frequently occurring (Pianoo, 2015). Recent cooperative initiatives like Design-Build-Maintenance-Operate (DBMO), or including the financial part (DBFMO), are examples of new contract forms, which are arising more frequently in the current market. The shift in responsibility, an appeal to the knowledge of the market, and the possible implementation of performance contracting are key elements in DB(F)MO as public-private partnership, (Algemene Rekenkamer, 2013). Different researches show the downsides of those types of contract forms, like in the research from S. Verweij et al. (2014), who shows that the high expectations of DBFMO contracts are not always been honored. Doubts concerning the transparency, quality, and flexibility in DB(F)MO-forms are arising, mainly regarding involved private parties (Verweij & Reynaers, 2014). Nevertheless, the position of the different stakeholders in this process is shifting, and thus asking for a different way of acting in these new forms of cooperation, also for the client itself. What does the result of these evaluations mean for the future? Are the new forms of (performance) contracts useful in the current market situation, or should we review the current (private) market opportunities in order to better anticipate to this?

Sustainability

Nowadays, awareness is increasing regarding real estate developments in a more sustainable manner. During the financial crisis, mainly a shift in focus concerning the governmental policies is emerging; a shift from a major focus on sustainability, to other considerations regarding the stability and improvement of the European and Dutch economy (Norbruis & Schaik, 2014). This does not mean that there is no focus anymore to sustainability objectives, but rather a change in origin of these objectives (Norbruis & Schaik, 2014). The Kyoto-protocol (1997) was a base for the targets set for 37 industrial oriented countries. The purpose of this protocol is at one hand the decrease in CO_2-emission and on the other hand the improvement of efficiency regarding the energy consumption (UNFCCC, 2014; Blasic, 2014). This CO_2-emission and energy consumption targets for the Netherlands are difficult to manage and achieve. In a recent published report (June 2014) of the European Environment Agency, the latest progress of the first commitment period (2008-2012) is evaluated. An important point of discussion is the achievement of the set targets for the western European countries. Twelve mainly West European countries did officially not achieve their targets, which resulted in surrender payments for their non-achievements. The Netherlands is one of those countries, which will probably be obliged to pay the second highest financial compensation of 446 million Euro. Despite of the relatively large number of countries that paid a financial compensation, the countries agreed on an extension of this protocol agreement wherein another 40% reduction of the CO_2-emission should be realized in 2030 (European Environment Agency, 2014; Blasic, 2014). This shows that there is awareness of sustainability and reduction of energy consumption, but there are still major steps to put into practice. The government of the Netherlands is implementing their objectives into national policies and more local oriented policies, conducted by provinces and municipalities.

When shifting the focus to the construction field, the awareness of sustainability is improving as well. Besides construction of new buildings, where sustainability is of great importance, the sustainable redevelopment or improvements of buildings is arising and highly supported as well (e.g. (Rijksdienst voor Ondernemend Nederland, 2014). Within these more complex developments, the cooperation between partners will be key to create and implement new sustainable products or services (Bouwend Nederland, 2015). In the Netherlands, initiatives regarding the sustainable development of our environment are present, in which different policy documents are designed to support this vision (Rijksdienst voor Ondernemend Nederland, 2014; Draijer, 2013). Within the growth to a more

sustainable society and fully sustainable energy supply in 2050, the handles will be provided by the SER (Sociaal Economische Raad), in order to support a more sustainable growth (Draijer, 2013).
This necessity of sustainable developments is under increasing pressure for public parties as well. Following the national government of the Netherlands, the provinces and municipalities are emphasizing the necessity of sustainable developments. The considerations of municipalities to (re)develop in a more sustainable way, is based on three motives. The governmental and politic pressure will set targets for sustainability and reduction of CO_2-emission elaborating on the Kyoto-protocol towards 2030. Second municipalities set their own objectives in order to translate their ambition into future reality. Besides the environmental and sociological responsibilities, as third also the reduction in cost is a key motive for municipalities. The sustainable purchases by municipalities is since 1st of January 2014 around 90% but their procurement could be much more innovative and more sustainable (Buitelaar, 2014). Following the municipalities' ambition for sustainable improvements, the municipalities' real estate properties could possibly be an opportunity. The mindset of municipalities is present, but why are those developments still absent or slowly developing? Are those sustainable investments postponed or are they (yet) unfeasible, and what could be the role of the private market parties herewith?

1.2.2 Context

Besides the awareness of sustainable necessities, the process of development and the associating roles are changing. Nowadays, examples of changes in the development process are the *Total Life Cycle* and *Circular Economy* of buildings (Alduurzaam, 2014). These developments are given as possible opportunities for both, the client and the (contracting) market parties in the construction field (Alduurzaam, 2014). Where formerly a clear distribution was present between the operational, tactical and strategic roles; nowadays, the tactical oriented roles are shifting. This role is also changing for municipalities. Formerly they were acting in a strategic and a tactical level, regarding possible (re)developments. In that situation, the execution role was (partially) contracted. Currently, municipalities are focusing more on their core activities, where they focus more to their strategic and tactical role, instead of operational activities (e.g. (Gelderen & Koopmans, 2015); experts RHDHV, 2015). Internal processes, maintenance and redevelopment for instance, become outside these core activities. As stated by van Gelderen and Koopmans (2015), municipalities are changing their role from 'care for' to 'make sure that' which emphasizes the tactical and strategic way of acting (Gelderen & Koopmans, 2015). This asks for possible anticipation of the market. The field between the execution and the strategic level is more open to anticipate to; these changes bring new opportunities for private market parties.

Because of the complexity of this changing situation for municipalities, the role and position of different stakeholders like private market parties, is changing as well. New initiatives are more frequently necessary to respond to more complex and integrated demands/problems that are brought to the market by public parties. Examples of those new initiatives are *energy performance contracting (e.g.* (Institute for Energy and Transport, 2015) and *managing agent contracting (e.g.* (Royal HaskoningDHV, 2015). The implementation of these initiatives is regarding the increase of sustainability and in the end in order to realize cost savings, possibly for new sustainable investments (e.g. (Siemens, 2013)). These energy saving concepts are more obvious, but as the World Green Council (2014) states recently, the improvement of the comfort level could yield more cost savings. These cost savings are not specifically based on energy savings, but on lowering production costs through improving employer healthiness, wellbeing and an improved productivity (World Green Building Council, 2014). These improvements could be realized by the implementation of comfort performance (contracting) (e.g. (Castilla, Alvarez, Rodriguez, & Berenguel, 2014)). Both types of *performance contracting* (energy and comfort) are opportunities, to which the market possibly should anticipate in the form of a long-term partnership. The inclusion of performance based contracting will lead, amongst others, to an approach where the *Total Cost of Ownership* is more implemented. *Total Cost of Ownership* will include the financial consequences of the decisions made to the design and building phases on the short-term but also on the long-term period (Duurzaam Vastgoed, 2015). By including this TCO principle, decisions regarding the design could be more adjusted to the expected performance and associating cost reduction, instead of a more initial cost based approach (e.g. (Manesco, 2014)).

Different initiatives like performance contracting are implemented in the market, but new types of projects ask frequently for customized solutions. Finding a more generic way of cooperation between public and private parties is important. This should ideally lead to an increase of both, the quality of the workplace and an improved sustainability level. Public parties are looking for long-term partnerships with private parties, where performance agreements could provide an extra value. The public parties like municipalities should take a leading role in the involvement of private parties, but the responsibility of the market is to anticipate and contribute to this and to develop and deliver sustainable solutions (Graaf, 2015).

1.2.3 Motives

The sustainable awareness is an important point of attention, which has lead to several changes in the construction process. For instance, several public parties like municipalities want to transform their real estate into more sustainable properties. As mentioned in Chapter 1.1, a three-way motive underlies this by: the governmental pressure, their ambition, and cost reduction. This will expose the necessity of their sustainable improvements. Besides, this could be an established example, which could function as stimulus for the market and further sustainable developments. The improvements of their own buildings (municipalities) can be an important first move in order to create a raise in awareness of the total municipality. By searching for opportunities in the collaboration of private market parties, the municipalities' sustainable property optimization could be possibly served. Ideally, this is leading to opportunity transitions in the construction industry, where more sustainable initiatives would be established in the future. This could be an opportunity as well for public parties like municipalities for instance. The contradiction between pressurized budgets and the will to invest in sustainable developments of municipalities, demands for new forms of cooperation (Hermans, 2012). It will be extremely difficult for a single party to realize this new long-term developments (experts RHDHV, 2015). Complexity and the shift in roles within this life cycle process leads to a search for solid cooperative partnerships. In order to make this development as a solid successful implemented partnership, insights in the way of acting and preferences of involved stakeholders should contribute to this. Several research has been conducted to general aspects that influence a (successful) partnership (e.g. (Chen & Chen, 2007; Hwang, Zhao, & Gay, 2013). However, specific research directed to the collaboration of private parties in the given situation of municipalities, will possibly improve the chance of a successful collaboration. More specific, the relation with new developments like performance contracting is not frequently researched.

1.3 Research problem definition

1.3.1 Problem analysis and scope

The changes regarding new initiatives (e.g. performance contracting) directed to sustainability as described in Chapter 1.2.2, become more common in the current construction environment. However, these are arising in a specific way for public parties like municipalities. Municipalities are under (high) pressure, influenced by policies, budgets and social responsibilities. Sustainability and risk reduction are important points of consideration. The internal processes of municipalities have to change in order to meet requirements of sustainability, risk reduction, implementation of new (sustainable) developments, and make the public party more future-proof, guided by the stricter policies and pressurized budgets. The role of the municipality within this process is changing. Their core activities will get a stronger governmental focus. This makes them adopting a more strategic and directing role in for example sustainable improvements for their real estate. In order to achieve the set targets and meet the ambitions of municipalities regarding their sustainable improvements, a municipality will be more dependent on private party involvement. This requires the market to anticipate and to be able to fulfill this request. Among others, the desired reduction of the municipalities' risks forms the basis of this request. This request is also based on the stimulation of the sustainable improvements. The risk reduction for the municipality and their willingness for sustainable improvements could be realized by performance contracting. This performance based contracting could be for instance *energy performance* and *comfort performance* contracting, as examples of costs and risk reduction developments in the current market (e.g. (World Green Building Council, 2014; Institute for Energy and Transport, 2015)).

To meet this request of municipalities, probably a partnership solution should be introduced. This partnership will not only realize the sustainable improvements. It also could anticipate to the gab between the current execution role by a market party and the single strategic view of the municipality. A municipality wants to meet their objectives, where the involvement and responsibility for the process and solutions will possibly shift to the anticipating market. An important issue for this is the trust of public parties like municipalities, in the (private) market (experts RHDHV, 2015). Because of the complexity, magnitude and shift in roles within a long-term partnership solution, a single party will probably not be able to provide a solution for this. The anticipation by market parties to cooperate and together provide this possible solution for municipalities, can result in a market opportunity (experts RHDHV, 2015).

By involving a cooperation of market parties, two parallel partnership processes will be initiated. First, the procurement process between the client (municipality) and the tenderer is ongoing. Second, a process within a team of stakeholders as tenderer is ongoing. Within a team (possible consortium) the interest, capabilities, and responsibilities for instance, will determine a possible role allocation. Besides, the way of acting by each involved party could influence the whole process and success of a possible introduced partnership. Distinguishing and understanding the involved stakeholders and their way of acting will be necessary to form a successful cooperative partnership. As given by experts (experts RHDHV, 2015), the collaboration of parties is influencing the success of a partnership. However, influences to the collaboration are not given as most essential for the partnership. The (financial) business case is highly prioritized and given as essential for the success of a partnership for most private parties (experts RHDHV, 2015). Of course, this business case aspect will be essential in order to realize 'business', but will already have the priority to consider in each project. This will be part of the estimation whether or not a project will be 'successful'.

As given by the experts (experts RHDHV, 2015), the influences to the collaboration could definitely influence the success of the project and partnership, although there is a proper business case. The scope of this research will concern the influences to the collaboration within a set partnership. This partnership will be a consortium between a contractor, engineer/consultant, and an energy supplier, following a recent partnership situation. This partnership composition will be explained later in more detail. The partnership between this consortium and the municipality will be excluded in this research, except the outlines and problem statement given before. This will concern, amongst others, the long-term partnership (ca. 10 years) and the inclusion of performance contracting elements.

1.3.2 Research Questions

This study is conducting a research to the aspects influencing the successful partnership, which is anticipating to the previously described situation of public parties like municipalities. This partnership will be directed to the request of municipalities to develop a solution for a more future proof sustainable property performance optimization and exploitation. For this business opportunity, a cooperative partnership will be initiated, where the involved (private) parties are intended to cooperate together over a longer time period (>10 years). In order to realize this, the influences to the success of this type of partnership will be a key element in this research. This research determines the key factors for the collaboration in a successful partnership and insights to stakeholders' preferences, regarding performance-based output. Hence, the encompassing research question will be directed towards two important elements; this will provide insights to the optimization opportunities for the success of a drafted partnership, by determining influencing aspects to the collaboration and the preferences in performance-based contracting where mutual responsibility is initiated.

Main Research Question

In which way could the successful collaboration be optimized for a partnership-solution, which optimizes the municipalities' property performance in a sustainable way?

In order to contribute to the answer of the main research question, four sub questions are composed which are the base of the analysis process. All sub questions are concerning the given context, where insights to the optimization of the collaboration within a partnership will be researched. This to anticipate to the municipalities' request of optimizing their real estate properties performance, and by including performance based components.

Research sub questions

Q1 *Which possible scenarios could be established, where performance contracting will be implemented and leading to a mutual responsibility within the partnership?*

Q2 *Which insights could be given about the preferences to the created scenarios, consisting of performance-based components and the associating mutual responsibilities?*

Q3 *Which attributes will be considered as influencing attributes to a successful collaboration within a set partnership composition, concerning the performance-based scenarios, by a Fuzzy Delphi Methodological approach?*

Q4 *To what extent will the influence of attributes to performance-based scenarios, give insights in the successful collaboration within the set partnership composition, by a Game Theoretical approach?*

1.3.3 Research Objectives

The main objective of this research is providing insights to the successful collaboration within a partnership of market parties, to possibly answer the request of municipalities to optimize their real estate property performance in a sustainable way. The optimization of the municipalities' real estate property performance could be realized in several ways. The focus for this optimization will be to the implementation of performance-based components, as *energy performance, maintenance performance,* and *comfort performance*, previously described as market opportunities (e.g. (World Green Building Council, 2014; Institute for Energy and Transport, 2015)). In order to guide the process to the main objective in this research, several sub objectives are given:

- Insights in scenarios composed of different performance contracts, where a mutual responsibility is initiated.
- Insights in the preferences of different market parties (construction industry) to the created performance-based scenarios.
- Insights in the influence of specific attributes to the collaboration within performance-based scenarios.
- Insights in the influences to the success of the partnership collaboration, when performance based contracts are implemented. This in order to contribute to the collaboration aspect in future project cases.

The implemented research focus for the optimization of the municipalities' real estate properties performance will be the implementation of performance-based components, where mutual responsibility will be initiated. First, by this research better insights into the partnership collaboration and vision of possible involved parties will be given. Second, this research will provide some concluding recommendations about the influencing attributes which should be properly managed; this in order to improve the collaboration aspect for future project cases where performance contracting is implemented.

1.4 Research Design

1.4.1 Methodological justification

In order to achieve the research objective and answer the associating research questions, different scientific research methodologies will be used during the research process. Three methodologies are the main components of this research: Literature Review, Fuzzy Delphi Method and the Game Theoretical approach.

Literature Review | The literature review in this research will make a comprehensive overview of the previous research conducted, related to the field of study in the current research. By reviewing the previous literature, a base will be created for the current research wherein the background information, input information, and the substantiated use of the methodologies are obtained. This will form the guidelines for the creation of the research model and methodology, where after the contribution of this study to previous research, will be explained.
The literature review will specifically function as method to collect the possible influencing attributes to the collaboration between (private) parties in the construction industry. Based on a research comparison and a content analysis, a selection of these attributes in previous studies will be conducted. The content analysis will be suitable as attribute selection methods, based on previously conducted researches (e.g. (Hwang, Zhao, & Gay, 2013; Kyei & Chan, 2015); this analysis method will make a selection of attributes, by analyzing the number of times a specific attribute is given in previous studies, which are relevant and comparable.

Fuzzy Delphi Method | For the determination of the influence of attributes to the collaboration, an appeal to the knowledge of experts will be necessary in this study. The Fuzzy Delphi Methodology (FDM) will be applied in this research to determine the influences of selected attributes to the success of a partnership. The Fuzzy Delphi Methodology is an analyzing technique which is based on two different methodologies. These two methods are the Delphi methodology and the Fuzzy Theory (Glumac, Han, Smeets, & Schaefer, 2011; Damigos & Anyfantis, 2011). This combined methodology will be suitable for this research because of the diversity in answering by the different questioned experts, based on the possible deviations in interpretation and available knowledge (Jafari, Jafarian, Zareei, & Zaerpour, 2008). The Fuzzy Delphi Methodology will capture these uncertainties, where this *fuzziness* is taken into account (Glumac, Han, Smeets, & Schaefer, 2011). By taking this fuzziness into account, the quality of the questionnaire and questioning will improve, and will lead to a more reliable study and efficiency (Ishikawa, Amagasa, Shiga, Tomizawa, Tatsuta, & Mieno, 1993; Glumac, Han, Smeets, & Schaefer, 2011). The final result of applying the Fuzzy Delphi Method in this research will be the determination of 'highly influencing' attributes to the collaboration aspect in the created performance contract scenarios. The application of the Fuzzy Delphi Methodology will be extensively discussed in Chapter 4.2.4.

Game Theory | Over the years many previous researchers studied different approaches to improve the decision making process, by for example the methodology of Game Theory. The methodology of Game Theory will be included in this study. The suitability of the Game Theoretical approach in this research is based on the main aspects of the interdependencies and interactions between the different parties which will be researched (e.g. (Chapman & Corso, 2005; Arsenyan, Buyukozkan, & Feyzioglu, 2015). This interaction between the involved parties and deviations in their vision makes this decision making more complex. A Game Theoretical approach will be used, in order to give insights to the interdependencies of the different involved parties (Barough, Shoubi, & Skardi, 2012). The suitability of Game Theory in this decision making process is also named by other researchers (e.g. (Javed, Lam, & Chan, 2014; Kargol & Sokol, 2008)). Because of the complexity and challenges within the partnership and associating decision-making, Game Theory will provide useful insights in this process (Javed, Lam, & Chan, 2014; Kargol & Sokol, 2008). The use of Game Theory could improve the cooperation and leverage the overall results (McCain, 2008; Brady & Trif, 2013). Hence, by making use of Game Theory in this study, insights to improve the successfulness of partnerships can be given. A more detailed explanation of the Game Theoretical approach is discussed in Chapter 4.2.5.

1.4.2 Research Model

Figure 1.2 shows the research model in this study. This is provided in a flowchart where a distinction is made in four different phases: Input, Analysis, Results, and Explorative (innovative) research. The arrows indicate the sequence of steps and interrelationships of the research elements in the research model. The research questions described in Chapter 1.3.2 are in accordance with this research process. The relation between the research model and the four research sub questions (Q1 to Q4) is visualized in Figure 1.2 by the given colored boxes. In the different research model, some research elements are expressed in a dark blue box. This indicates a 'Result' which will be further explained in Chapter 4.4 *Results*. The research model and the associating (methodological) elements will be explained further in Chapter 4 *Research Model.*

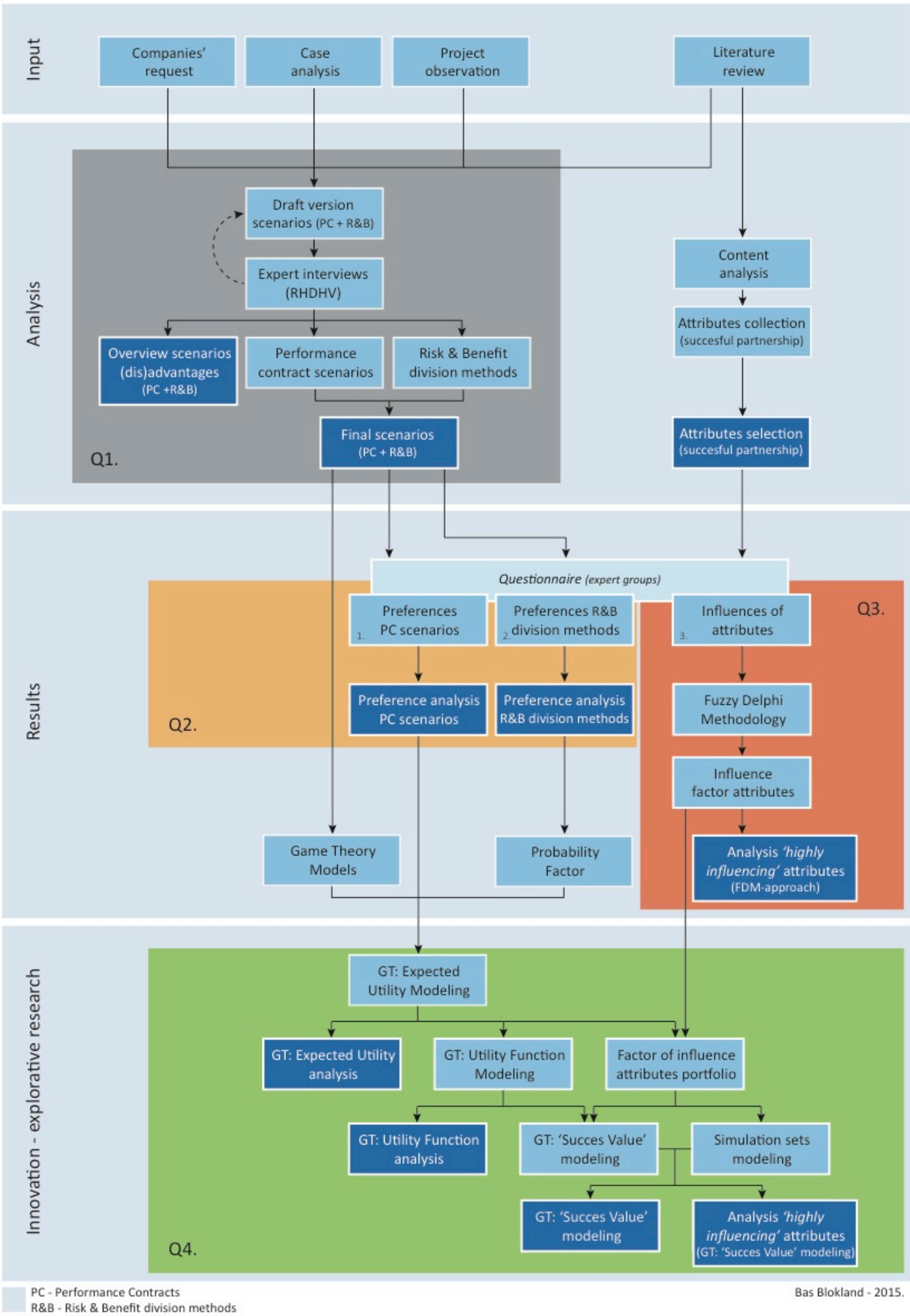


Figure 1.2 Research Model

1.5 Expected research results

The expected results of the research will be related to the answers of the four research sub questions and the research main question.

Q1 Which possible scenarios could be established, where performance contracting will be implemented and leading to a mutual responsibility within the partnership?

The expected results of research sub question ***Q1***, expert interviews and case analyses, will lead to the development of three possible performance contract scenarios. These scenarios will consist of performance-based components, as *energy performance, maintenance performance,* and *comfort performance.* By focusing in this study to the mutual responsibility regarding the performance output, possible mutual risk and benefit division methods will be introduced to these performance-based scenarios. The expected result will be an overview of three performance-based scenarios linked to risk and benefit division methods where a mutual responsibility is included.

Q2 Which insights could be given about the preferences to the created scenarios, consisting of performance-based components and the associating mutual responsibilities?

Research sub question ***Q2***, is sequential to the developed performance-based scenarios. These scenarios will be presented to several experts of different companies in the construction industry. This will lead to an expected result about the preferences of these experts regarding: the developed performance-based scenarios and specific the associating performance components, and the mutual responsibility division methods for the performance output.

Q3 Which attributes will be considered as influencing attributes to a successful collaboration within a set partnership composition, concerning the performance-based scenarios, by a Fuzzy Delphi Methodological approach?

In research sub question ***Q3***, the influences of the selected attributes will be researched. The expected result will be a clear overview of the 'highly influencing' attributes to the different developed performance-based scenarios, based on the Fuzzy Delphi Methodology. This will determine the link between the 'highly influencing' attributes and both, the performance components and the researched mutual risk and benefit division methods.

Q4. To what extent will the influence of attributes to performance-based scenarios, give insights in the successful collaboration within the set partnership composition, by a Game Theoretical approach?

Research sub question **Q4**, will make a combination between the preferences given by the experts and the influences of the attributes to the collaboration aspect. Both are linked to the developed performance-based scenarios. By making use of a Game Theoretical approach, an overview of the success value of collaboration will be modeled. By taking the preferences, expected decisions, and the influence of attributes into account, new insights will be provided to the successful collaboration by the 'success value' modeling. The different performance-based scenarios will be modeled for the different involved parties (expert groups), where a portfolio of influencing elements provides insight in the opportunities to improve the successful collaboration in future project cases.

The results of the four research sub questions are leading to answering the main research question in this study:

"In which way could the successful collaboration be optimized for a partnership-solution, which optimizes the municipalities' property performance in a sustainable way? "

The expected result for the research main question is in accordance with the final objective of this research. Insights will be provided about possible (recommended) solutions for the different possibly involved parties, regarding performance contracting scenarios and the associating mutual risk and benefit division. The findings in this study will provide (recommended) handles to improve the success of the collaboration aspect, by determining the (positive) highly influencing attributes. These attributes ask for the highest priority by improving the handling and management of these attributes, in order to improve the successful collaboration. These findings could finally contribute to the optimization of the municipalities' property performance in a sustainable way, by the involved collaborating parties.

2 Glossary

Comfort Performance Contract | A Comfort Performance Contract is a contract form where a performance agreement will be made for the level of comfort performance of a building. The main components concerning the comfort level are set as: the climate control (heating and cooling), the lightning, and the air control (e.g. air composition and ventilation). The level of comfort is relatively hard to measure and will be mainly based on the users' perception and satisfaction.

Delphi Method | The Delphi Method is a research methodology that collects data by the opinion of different experts, by a structured approach. Important in the application of the Delphi methodology is the judgment of attributes or variables, where experts give their opinion independently of each other. The Delphi methodology could be applied in various fields of research and is given as a useful methodology regarding the estimations (opinion) of involved expert groups.

Energy Performance Contract | An Energy Performance Contract is a contract form where a performance agreement will be made for the energy performance of a building. This set performance could be price-based (energy costs) or volume-based (energy consumption). The contracting party will guarantee to deliver the set performance in exchange for (a part of) the (cost) savings it will realize. The improvements of the energy performance of a building could be realized by for example: upgrades in building installations; improved energy regulation systems; improvement of users' behavior regarding energy consumption; etc.

Fuzzy Delphi Methodology | The Fuzzy Delphi Methodology is a research methodology which is based on the 'Delphi Method' and the 'Fuzzy Theory'. This analyzing technique will combine the main components of these two methodologies in one research methodology. The Delphi Method will collect data by the opinion of experts, by a structured approach. The Fuzzy Theory includes the uncertainties attributed to the human element, like for example the inconsistent answering of experts within a similar expert group, given as fuzziness.

Fuzzy Theory | The Fuzzy Theory is a research methodology that includes (partially) the uncertainties attributed to the human element. These uncertainties could be given as 'fuzziness', resulting from inconsistency in answering of experts in the similar expert group for example. This could lead to a lack of proper consensus within an expert group in answering and will be better obviated by taken this 'fuzziness' into account in this methodology.

Game Theory | Game Theory is a modeling technique which could provide insights to the (optimal) decision-making by game modeling; this in order to achieve the 'best' outcome. Besides the 'strategic' decisions and associating game-outcome, also the interaction between the involved 'Players' will be taken into account by this modeling technique.

Maintenance Performance Contract | A Maintenance Performance Contract is a contract form where a performance agreement will be made for the quality level of the building components (including installations). This will be mainly regulated by the implementation of maintenance activities, in order to realize the set level of quality for the building components.

Municipalities' corporate real estate properties | The municipalities' corporate real estate properties are the real estate properties that will be used for the own (operational) purposes and activities of the municipality.

Nash-equilibrium | The Nash-equilibrium is a Game Theoretical solution discovered by John Forbes Nash, which solves the 'equilibrium problem'. The Nash-equilibrium describes the moment in which players have chosen their strategy, such that a one-sided adaptation will not yield an improvement of the situation provided that all players act rationally.

Total Cost of Ownership (TCO) | The Total Cost of Ownership (TCO) is a principle that is based on the complete insight to the total costs (direct and indirect) a certain building-component will have during its lifecycle. Total Cost of Ownership will focus not only to the short-term costs, but includes all associating (financial) consequences on a long-term period during the ownership.

3 Literature Review

This literature review will make a comprehensive overview of the previous research, which is in accordance with the given research context in Chapter 1.2 *Research Context*. As given in this chapter, the scope of this research is focusing to optimization municipalities' real estate properties. Following the vision of the company RHDHV (experts RHDHV), the collaboration aspect of a set (private party) partnership will be researched. The aim of this study is given as providing insights to possible improvements of this collaboration for future project cases. For this literature review, the given scope and aim of this research is leading for exploring previous research.
By reviewing previous studies, the starting points for this study will be given: this literature review will describe necessary background information regarding, among others, (sustainable) developments of municipalities' real estate; this literature review also provides input information for, among others, the possible influencing attributes to the collaboration in partnerships; and this literature review will review previous research regarding research methodologies to include in this study, like for example the application of Fuzzy Delphi Methodology and Game Theory. These elements of the literature review will form the starting points for the research outline en conduction of this study, as given in Chapter 1.4.1 *Research Design*. As last part of this literature review, the link between previous research and this study will be shown by explaining the expected contribution of this research.

Chapter 3.1 will focus to the municipalities as possible client, and their recent developments regarding property management and sustainable property optimization. The problem statement given in Chapter 1.3 is arising from the recent request of municipalities. Internal processes of the property management of municipalities for instance, will possibly reorganized. Besides, the request of optimizing public parties' real estate in a sustainable way will be discussed. This in combination with the municipalities' ambition and sustainable objectives, will provide insights to the sustainable improvements of municipalities' real estate. In Chapter 3.2, previous literature shows a shift in the construction industry to more collaboration by market parties. Besides, opportunities are discussed by previous studies regarding the involvement of private parties to the projects with a public party as client. These two components could possibly anticipate to the request of municipalities, as formalized in Chapter 3.1. Chapter 3.3 is reviewing previous literature in order to determine which factors are influencing the success of a partnership, focusing to the collaboration. As introduced in Chapter 1.3.1, the scope of this research is concerning the cooperation between three private parties in order to anticipate to the set municipalities' request. Because of this given focus, the included previous research and possible influencing attributes, will be related to the partnership between private parties. In Chapter 3.4, starting points for the decision making process within a partnership is analyzed by previous conducted studies. In order to stay in line of the scope (Chapter 1.3.1) of the current research, literature related to the partnerships within the construction industry is reviewed. Different studies will be compared based on their concept and implemented methodologies. This will form the starting point for the research model in this study. Besides, by comparing previous studies the current state of research is determined. Chapter 3.5 will subsequently clarify the contribution of this study to the previous conducted research.

3.1 Municipalities

3.1.1 Focus of municipalities to their core activities

As in several researches coming forward (e.g. (Tang, Shen, & Cheng, 2010)), the European Union is positioning their focus on the involvement of private parties in public party projects. This will support the public authorities to meet their priorities, and will provide solutions for the limitation of public funds (Tang, Shen, & Cheng, 2010). The research of Cumming (2007) notes the advantage of the involvement of private parties into the projects of public parties. This is because of the possibility to realize savings of their resources for instance. These savings for the governmental authorities will be realized mainly because of their improved focus to their core activities as local government (Cumming, 2007). Utilizing the expertise and resources of private parties for those projects outside the core activities of the public party, will not only lead to avoiding the waste of resources by public authorities. Edkins and Smyth (2006) determine in their research also an improvement of the services and the facilities of the public parties, because of the focus to their core activities (Edkins & Smyth, 2006).

The pressure to change the focus to their core activities (local governance) of the municipalities is given by the national government and political parties. This higher focus to their governmental activities will possibly modify some internal processes of the municipality; this could be for instance the property management of the real estate properties of the municipality (Valen & Olsson, 2012). As given by Tang et al (2010), an often-occurring issue when conducting a project of a public authorization by the private sector, is the political barriers as given by Tang et al (2010). These barriers are often formed by legislation problems where more flexibility and other cooperation forms are necessary, regarding the partnerships between public and private parties (Tang, Shen, & Cheng, 2010). Besides the legalization issue, the change of this approach by public parties could create a lot of resistance by political parties as representatives of the community (Tang, Shen, & Cheng, 2010; Vermiglio, 2011). As given by Tang et al (2010), this should be taken into account in case a municipality outsources a larger part of their processes.

3.1.2 Property management of municipalities

Nowadays, municipalities are facing some issues regarding the management of their own real estate properties. As given by previous research (e.g. (Vermiglio, 2011; Stattev, Daskalova, Constantin, Raleva, & Goschin, 2012)), the approach to manage this is difficult to determine. Given as important is that these public authorities should be able to realize a proper insight in their real estate portfolio. The research of Vermiglio (2011) set a theoretical framework to determine the key variables for the management of the strategy regarding the public asset portfolio of the real estate (Vermiglio, 2011). A stated problem by Vermiglio (2011) is the flexibility of municipalities to make adjustments in their processes because of the time span that it takes. The political system in the Netherlands regarding the elections of the municipal council consists of an election once every four-year (Kiesraad, 2015). Due to this political system, a short-term mind set by municipalities will occur relatively often following the study of Vermiglio (2011). The real estate assets of municipalities are an example where a long-term vision should be adopted to make this more future proof. The lifespan of real estate should be taken into account, what thus possibly conflicts with the current political and bureaucratic system of the Netherlands. This system consists of short periods of time, wherein they will conduct their (new) policy as soon as possible. In order to initiate long-term investments, which are necessary to realize sustainable improvements, some reticence will occur (Vermiglio, 2011; Lyons, 2004).

The focus to the governmental role of the municipalities is possibly influencing the internal property related processes. Because of the focus to the core activities of the municipalities, processes like the maintenance of buildings could be neglected. As stated by Valen et al (2012), the building condition of municipalities' property is positively correlating with proper governance where prioritization of facilities and maintenance is realized (Valen & Olsson, 2012). New possibilities should be researched to avoid the lack of focus by municipalities for maintenance processes for instance. For these processes, the long-term objective and strategy should be present where the political and public support is a key element. Stated in this research of Valen et al (2012) is the necessity of the strategy and goals regarding the maintenance and other internal property related processes. These processes should be considered over a long-term period. Given by Valen et al (2012), this could and should be guided by adopting and implementing this by a long-term political vision and policy (Valen & Olsson, 2012).

In the research of Stattev et al (2012), the 'new role' of municipalities is described and researched. Several previous researches are related to new concepts for the municipalities' organization. Following Stattev et al (2012), this will be called the 'modern concept of public management'. In case of the management of municipal real estate properties, Stattev et al (2012) gives three characteristics in relation to the new concepts of public management: First, the change in the origin of the management of the real estate of municipalities; Second, the improvement in monitoring the real estate of municipalities as an asset which provides cash revenues and will function more efficient; As last, the involvement of private parties into the management of the real estate of municipalities (Stattev, Daskalova, Constantin, Raleva, & Goschin, 2012). These three characteristics (mainly the third characteristic) are related to the request of the municipality as given in the problem statement of this study (Chapter 1.3). Derived form these previous studies, the management of municipalities' property by private parties could be linked to the shift of focus of municipalities to their governmental activities (Stattev, Daskalova, Constantin, Raleva, & Goschin, 2012). This given linkage could be interpreted as the possibility to let private parties involve into the management of the municipalities' real estate properties.

3.1.3 Sustainability of municipalities' corporate real estate

Regarding the asset management of the property of municipalities, a more long-term approach will be initiated more frequently, as given by Vermiglio et al (2011). Within this long-term oriented strategy, the determination of the future state of the assets will be taken into account in the management of the assets. Retaining or efficiently exploiting of assets should be determined over a longer period (Vermiglio, 2011; Lyons, 2004). As shown in previous research, a new development is given by which assets should be possibly disposed of, to generate the resources for new investments. This specifically counts for sustainable investments (Vermiglio, 2011; Lyons, 2004).

In the research of Grasman (2009), possibilities by implementing Public-Private partnerships (PPP) are researched which provides opportunities for improvements in this type of projects. In order to improve the corporate real estate of municipalities in a sustainable manner, a partnership between the public part (municipality) and private parties could be introduced. The research of Grasman (2009) gives results in a more efficient project management, proficient risk mitigation, and enhanced technological innovation, as advantages when a Public-Private partnership will be introduced. As addition to these advantages, the research of Grasman (2009) and Hwang et al (2013) state that the involvement of the private parties are bringing added benefits for public parties like municipalities; By expanding the role of the private sector, the expertise of these parties could be better utilized in different sections: financial, management and technical (Grasman, 2009; Hwang, Zhao, & Gay, 2013). As given in both researches, the involvement of the private parties will create possibilities in order to improve the program performance and the innovative technological application. The utilization of the expertise and capital of private parties could function as contribution to these improvements of program performance and innovative technological application (Grasman, 2009; Hwang, Zhao, & Gay, 2013). As described previously, the involvement of private parties could bring up opportunities for public parties like municipalities, to conduct their projects in a more innovative and sustainable way. In the research of Grasman (2009), two factors are important for public parties in the situation of private party involvement. First, the public party should provide sufficient financial support to the private firms to make it possible to use the innovative solutions. Second, the public party should possibly adjust the procurement process. This procurement process should reward the innovation and technological application instead of creating a barrier for private parties (Grasman, 2009). The given problem statement in this study is concerning the optimization of municipalities' (corporate) real estate in a sustainable way, by a possible involvement of private parties. Both derived factors of the research of Grasman (2009) are thus possibly important when involving cooperating private parties to answer the request of the municipality.

3.2 Construction Industry

As given in Chapter 1.3, the collaboration within a set partnership will be introduced and researched in this study. At one hand, this will be the collaboration between a municipality as public party and one or more private parties. At the other hand, the formation of a partnership between different private parties in the construction industry will be established, and researched in this study. The objective of reviewing previous research regarding this collaboration of private parties, is to provide insights in improving the collaboration of this partnership. First a reference to changes in the construction industry is made, which are relevant for the current research. Second the involvement of private parties to the projects of public parties like municipalities is described. This will provide a further substantiation for the set problem statement in this study (Chapter 1.3), to involve cooperating private parties in order to answer the set request of municipalities.

3.2.1 Shift in construction industry

An occurring change in the construction industry is to search for collaboration within the market, and by that responding to new developments and opportunities in the market (Rahman, Endut, Faisol, & Paydar, 2014). The presence of collaboration within the construction industry is occurring more nowadays as described by Rahman et al (2014). The former construction industry is described as a less cooperative environment, where typical features as divergent relations, separated management forms, little cooperation and complex content of projects are regularly named (Rahman, Endut, Faisol, & Paydar, 2014). The possibility to cooperate into this industry is now seen as an opportunity within the market (Rahman, Endut, Faisol, & Paydar, 2014). As Rahman et al (2014) describes, the collaboration could be seen as answering to the opportunities within the market. In the research of Suen et al (2003), the lack of cooperation is considered in the construction industry. In this research, the lack of cooperation within the construction industry is given as an important cause for the inefficacy within the construction industry (Suen, Wong, Ng, & Cheung, 2003). Suen et al (2003) arguing this even further, where collaboration and partnering within the construction industry only could be realized when a change in culture and attitude of the industry and associating parties would be established (Suen, Wong, Ng, & Cheung, 2003).

In comparing the research of Chen et al (2007), the essence in this study is more in line with the research of Rahman et al (2014) where collaboration is a response to opportunities into the market. The opportunity of forming partnerships within the construction industry will provide possibly extra benefits when the parties aim a long-term partnership, as given by Chen et al (2007). By establishing a long-term commitment, the objectives of both (or more) parties could be achieved or even increased. Following the study of Chen et al (2007); when partnering on a long-term base, different and possibly more opportunities in the market could be seized. The boundaries of traditional models are shifting in order to create the opportunity to cooperate (Chen & Chen, 2007). Eriksson provides in his research (2007) that a proper way to establish a long-term cooperation between partners and facilitate the collaboration, is defining it in a long-term contractual agreement (Eriksson, 2007). By combining this, the creation of a long-term contract for the cooperation (Eriksson, 2007), could contribute to the collaboration as response to the opportunity in the market (Chen & Chen, 2007; Rahman, Endut, Faisol, & Paydar, 2014).

3.2.2 Involvement of private parties into public projects

The focus to the involvement of private parties in public party projects increases, as given by previous research (Vermiglio, 2011; Stattev, Daskalova, Constantin, Raleva, & Goschin, 2012; Hwang, Zhao, & Gay, 2013). This increased involvement of private parties is also emphasized by the European Union who directs attention to this involvement (Tang, Shen, & Cheng, 2010). The implementation of the private parties into partnerships with pubic parties is increasing since the financial crisis started in approximately 2007-2008 (Kyei & Chan, 2015). An example of the involvement of private parties into projects of public parties, could be in the form of 'partnering' (Suen, Wong, Ng, & Cheung, 2003). As given by the research of Suen et al (2003), several previous researches are conducted to 'partnering in the construction industry'. Partnering will be often considered as a management approach for construction projects, by public authorities like municipalities (Suen, Wong, Ng, & Cheung, 2003). By making use of 'partnering', this will influence positively the quality and process in order to avoid or decrease the conflicts within the partnership, and improve the collaboration (Suen, Wong, Ng, & Cheung, 2003).

As described previously, the research of Grasman (2009) identifies the opportunities for a successful involvement of private parties in the partnership; Mainly concerning the implementation of innovative applications, the expertise (and capital) of private parties should be used (Grasman, 2009). A common occurring problem is the underdevelopment of the value for the involved private parties regarding partnerships with public authorities. The concept is clear for the involvement of private parties and a framework for this is given in the research of Grasman (2009). Previous studies to the partnership between public and private parties, address the balance (or ratio) between the private party involvement and their assigned responsibility (e.g. (Grasman, 2009)). Grasman (2009) states that the involvement of these private parties, and so giving them responsibility, will be desirable in the public sector. This is researched and stated too, in previous mentioned research of Vermiglio (2011), Stattev et al (2012), and Hwang et al (2013) (Vermiglio, 2011; Stattev, Daskalova, Constantin, Raleva, & Goschin, 2012; Hwang, Zhao, & Gay, 2013). Private parties have experience, expertise, and wants to implement innovative applications in order to improve their incentives and opportunities in the market, with or without new established cooperative partnerships (Grasman, 2009; Chen & Chen, 2007; Consoli, 2006; Rahman, Endut, Faisol, & Paydar, 2014). As given by Trim et al (2008), this implementation of innovation is partially directed by the pressure for sustainable development, in which parties are seeking for a competitive advantage. The formation of partnerships and collaboration will contribute to achieve this (Trim & Lee, 2008). A frequently arising issue is concerning financing innovative and technological developments. Grasman (2009) address this issue by indicating that the role of public parties for financial support is described as important. The public parties, like municipalities, could and possibly should provide financial support by direct funding, loan guarantees, supplements, and other mechanisms. Mainly loan guarantees, besides the direct funding, could provide a financial solution for long-term investments of innovation (Grasman, 2009), in the new to develop service solution. Another given financial option for public parties is the extension of the time span of the agreement. This results in a lower uncertainty for the project and increases the project revenues (Grasman, 2009). Besides, public parties should share more additional risks to balance the additional effort of the involved parties in a partnership (Grasman, 2009; Tang, Shen, & Cheng, 2010). The essence of the research of Grasman (2009) is the emphasis to the lack of present frameworks to guide the different concepts of involvement of collaborating private parties. The concepts are researched several times (given by (Grasman, 2009)) but the lack in guiding these involvement processes is the base of the practical application of the involvement of collaborating private parties. By paying attention to the involvement of (collaborating) private parties in projects with public authorities, a contribution to this practical application could possibly given. As given in the problem statement (Chapter 1.3), the focus of the involvement will be directed to the collaboration aspect within the partnership. As given scope (Chapter 1.3.1), the collaboration aspect between the involved private parties will be researched. By studying influences to this collaboration of the private parties, insights could be given to the anticipation to recent market developments. An addressed market development in this literature review is for instance, the involvement of (collaborating) private parties to the property management or optimization of municipalities (e.g. (Vermiglio, 2011; Stattev, Daskalova, Constantin, Raleva, & Goschin, 2012).

3.3 Attributes to successful partnerships

In order to determine the possible influencing factors to the successful collaboration of a partnership in the construction industry, previous conducted studies are reviewed. The included studies address the success factors for a partnership, where after a proper list of attributes is retrieved. In Chapter 3.3.1 a comparison is given of sixteen selected studies. The selection of these studies is based on four set elements, related to the problem statement (Chapter 1.3) given in this study. The four elements are set in order to structure the selection of previous research, which are relatively in line (following these combined four elements) with the problem statement of this study. By setting these four elements for the selection, relevant studies could be selected in order to retrieve the possible influencing attributes. The four elements are: Construction industry, (collaborative) Partnerships, Determining success factors, and Private party collaboration. The sixteen previous studies will be thereafter used in order to select the possible influencing attributes, which are given in Chapter 3.3.2. Based on a content analysis, a matrix is created in Chapter 3.3.3 of these possible influencing attributes.

3.3.1 Comparison of previous research

In this paragraph an overview is given of the researches which are used to obtain possible influencing attributes to the collaboration within a partnership. The attributes are retrieved from previous studies to the collaboration aspects in partnerships in the construction industry. The selection of the previous studies is based on the similarities with the relevant elements included in this study. As given previously, the four elements are: Construction industry, (collaborative) Partnerships, Determining success factors, and Private party collaboration.

By reviewing the selected previous studies, an overview of the concepts and possible applicable methodologies in these studies will be given. Besides providing possible influencing attributes, a possible trend could be noticed in the used concepts and conducted methodologies in previous research.

In order to improve the suitability of the adoption of the selected attributes into this study, all of the obtained attributes will be appointed as '*possible influencing attributes*'. The obtained *possible influencing attributes* will only function as input, and will be reevaluated and revalidated by experts, later in the current research. The reasoning for reevaluating these attributes will be comprehensively explained in Chapter 3.3.2 of this literature review. An overview of the retrieved attributes from the compared literature in this paragraph will be given in and Chapter 3.3.3.

The comparison of previous studies is including sixteen previous conducted studies. Table 3.1 gives the overview of these included studies. Based on the content of the different included studies, information about these previous studies is given by distinguishing: author and year of publication; field of study; research topic; research methodology; region; focus group; respondents and associating response rate. A comparison of the researches is made based on the distinguished components, which leads to some noticed patterns in both, the field of study and the used methodologies. Table 3.1 shows the overview of the sixteen studies included in the research comparison, where after the comparison of these studies will be discussed in more detail.

Table 3.1 Research comparison (16 studies)

Author	Year	*Field of study* Construction industry	(Collaborative) Partnerships	Determining success factors	Private party collaboration	Research topic	*Research Methodology* Literature Review	Questionnaire	Interviews	Case Study	Statistical analysis	Country	Focus group	Respondents	Response rate
Suen, Wong, Ng & Cheung	2003	X	X	X	X	Researching the behavioural aspects in partnering within the construction industry, which are influencing the collaboration.	X	X		X	X	Hong Kong	Involved parties in the case	Q: 20	-
Consoli	2006	X	X	X	X	Researching the relationship (management) between the parties in consortia for the construction of prison projects.	X		X			Australia	Private prison operators, who interfaced with consortia parties	I: 9	-
Cheung, Yiu &Chim	2006	X	X	X	X	Researching the application of relational contracts in the construction industry, by assessing the relational degree.	X					-	-	-	-
Stanley, Fawcett, Ogden, Magnan & Cooper	2006		X	X	X	Researching the extent and nature of commitment to supply chain collaboration	X	X	X	X	X	USA	Members of 3 logistic institutions	Q: 588 I: 50	-
Akintoye & Main	2007	X	X	X	X	Researching the perceptions of contractors concerning collaborative partnerships; reasons for collaborative relationships and the success factors for collaborative partnerships	X	X			X	United Kingdom	Contracting parties	Q: 63	Q: 25,2%
Chauri & Crespin-Mazet	2007	X	X	X	X	Researching the project co-development in the construction industry by analysing the factors to a successful co-development strategy.	X			X		France	Contractors	C: 2	
Chen & Chen	2007	X	X	X	X	Researching the different critical factors which are influencing the success for construction partnering.	X	X			X	Taiwan	Construction professionals and experts	Q: 221	Q: 67%
Smyth & Pryke	2008	X	X	X	X	Reviewing researches concerning the contractual and conceptual collaborative practices in construction	X					-	-	-	-
Grasman	2009	X	X			Researching a framework to understand the processes and relationships with regard to PPP's	X					-	-	-	-
Tang, Shen & Cheng	2010	X	X	X		Researching the previous conducted research in the field of PPP's in order to create a comprehensive overview	X					-	-	L: 85	-
Rowlinson & Cheung	2011	X	X	X	X	Researching the way of managing the relationship and improving the communication and cooperation to a more sustainable supply chain management within the construction industry.	X	X	X	X	X	Australia	Contracting parties	Q1: 100 Q2: 116	Q2: 24%
Shen & Tang	2013	X	X	X		Researching the importance of factors by stakeholders that should be known by the involved project parties, in the briefing stage of PPP's.	X	X			X	Hong Kong	Government departments with work experience in PPP	Q: 122	Q: 24,4%
Rahman, Endut, Faisol & Paydar	2013	X	X	X	X	Researching the view of contractors to the importance of collaboration in the construction industry (supply chain), and determining the challenges in the collaboration.	X	X	X		X	Malaysia	Q: Delegates at a national forum of the Malaysian Malay Contractors I: Contractors	Q: 87 I: 25	Q: 54,38%
Hwang, Zhao & Gay	2013	X	X	X		Researching which critical factors and risks are present and the influence of these factors for contractors, in the field of PPP's.	X	X			X	Singapore	Q: Registered contractors at the BCA (Building Construction Authority)	Q: 48	Q: 40%
Zou, Kumaraswamy, Chung & Wong	2014	X	X	X		Researching the perceptions and critical success factors of Relationship Management in PPP's.	X	X	X			Hong Kong	I: Senior managers and academics with experience in PPP Q: Senior positioned international experts, with experience in PPP	I: 11 Q: 16	Q: 31,4%
Kyei & Chan	2015	X	X	X		Researching the previous conducted research to the critical success factors in partnership, for implementing PPP.	X					-	L: Publications in the construction field (1990-2013)	L: 27	-

Field of Study

The addressed 'field of study' of the previous studies, is given expressed in four elements as previously explained: Construction industry, (collaborative) Partnerships, Determining success factors, and Private party collaboration. The four elements are set in order to structure the selection of previous research, which are relatively in line (following these combined four elements) with the problem statement of this study. By setting these four elements for the selection, relevant studies could be selected in order to retrieve the possible influencing attributes.

Most of the selected studies are at least in accordance with both, the element of 'construction industry' and '(collaborative) partnerships'. Studies that include the 'determination of success factors' to partnerships in their aim of the research, are also selected in case they are considered as relevant to the problem statement (Chapter 1.3) of this study. Some studies have not specifically described this into their aim of the research, but are obviously determining success factors to partnerships. When these studies are considered as relevant and could be considered as suitable to include. This selection is based on the estimation and opinion of the researcher. The fourth criterion included is the focus to partnerships between private partnerships in the construction industry. Ten out of sixteen studies are focusing at the partnership between only private parties. The focus to the partnership between private parties is in accordance with the set scope (Chapter 1.3.1) in this research.

Research Methodology

The studies included in the research comparison are differing in the applied research methodologies. Based on the comparison given in Table 3.1, all studies incorporate a literature review. Two researches (Tang, Shen, & Cheng, 2010) (Hwang, Zhao, & Gay, 2013) consist of a comprehensive literature review of previous studies in a specific research field. As addition to this literature review, two researches (Hwang, Zhao, & Gay, 2013; Kyei & Chan, 2015) include a method of selecting attributes from previous research. A content analysis is used, in order to determine the number of times that a certain attribute is mentioned as influencing attribute in previous researches. For example, the number of times an attribute is given as influencing in previous studies determines or a certain attribute could be considered as ‘possibly influencing’. By calculating the number of researches that contain a certain attribute, it determines whether or not to select this attribute. This method is included in the research of Hwang et al (2013) and Kyei et al (2015) and will be adopted in the current research (Hwang, Zhao, & Gay, 2013; Kyei & Chan, 2015).

Half of the researches (8 out of 16) are including a questionnaire in order to research aspects regarding the collaboration in partnerships within the construction industry. The majority of included researches use the questionnaire to validate or evaluate the attributes which are possibly influencing he partnership. Based on this methodology, the questionnaire and revalidating these possible influencing attributes will be included in the research model of this study, as explained in Chapter 4.3.1 *Questionnaire*.
A pattern is shown to the application of a questionnaire in combination with a statistical analysis. The way of statistical analyzing the data differs in the different researches. In most of these researches, at least the *analysis of variance* (ANOVA) is used and significance level is indicating whether or not the different aspects are significantly influencing the partnership.

Region
By evaluating the focus region in the adopted previous studies, a large variation of different countries is shown. Previous relatively similar (recent) researches, in accordance with the given problem statement (Chapter 1.3), is not present with regard to the location of the current research (Netherlands, North-West Europe). There are two researches focusing to a region of Europe, to France (Ghauri & Crespin-Mazet, 2007) and the United Kingdom (Akintoye & Main, 2007). As given by Tang et al (2010), the deviation in focus region in combination with the cultural differences (Tang, Shen, & Cheng, 2010) should and is taken into account in the current research. This is one of the reasons for the reevaluation and revalidation of the selected attributes, by the incorporated respondents in this study.

Focus group
The respondents involved in the previous researches are different types of focus groups. Derived form the research comparison, these focus groups differ from only focusing to a single party or for instance to the parties (expert groups) involved in a certain partnership. The previous researches focusing to a single party is mainly typified as ‘experts’ from contracting parties (Akintoye & Main, 2007; Ghauri & Crespin-Mazet, 2007; Rowlinson & Cheung, 2011; Rahman, Endut, Faisol, & Paydar, 2014). As given in these researches, the perspective of the respondents is essential. This makes a proper analysis of the necessary respondents also essential for this study. The perspective of the respondents and the group of experts they are belonging to, will determine the focus group for this study. Following the given essence of the perspective of the respondents, this will be another reason for reanalyzing the influences of the attributes in this study.

Respondents & Response Rate
In order to give a better understanding of the questioned respondents, an overview of the number of respondents is given in Table 3.1. Depending on the type of research and associating methodology, the number of respondents is differing for the compared studies. The researches including a questionnaire are having a range between 16 and 588 respondents. The response rate given by previous research is a range between 24% and 54%. As given by the research of Hwang et al (2013), reflecting Akintoye (2000), the response rate between 20% and 30% is assumed as a minimal norm (Hwang, Zhao, & Gay, 2013; Akintoye, 2000). Of course, this response rate is highly dependent on external factors like for example the type of questionnaire (and questions), amount of respondents, selection criteria of respondents, distribution of questionnaire, etcetera. Nevertheless, the assumed norm (Hwang, Zhao, & Gay, 2013; Akintoye, 2000) could consider the response rate of some researches as relatively low (< 30%) (Akintoye & Main, 2007; Rowlinson & Cheung, 2011; Shen & Tang, 2013).

The sixteen studies included in the research comparison are the base for the next phase in the literature review. By reviewing these studies, the attributes which ‘possibly influencing the successful collaboration of a partnership’ in the construction industry, could be derived. The obtained attributes from the compared previous studies are further described in Chapter 3.3.2.

3.3.2 Attributes for successful partnerships

This paragraph will give an overview of the attributes selected from the previous described researches in the research comparison. The attributes that are selected will be considered as '*possible influencing attributes*' and will be reevaluated and revalidated by experts, later in this research (Chapter 4.3 *Data collection*). This means that the attributes are function as input for the analysis but will not be interpreted as proven influencing attributes to the success of a partnership in the construction field. The reasons for the necessity of re-analyzing the influence are given as:

- Focus region and cultural differences could have influenced the results in previous research (Tang, Shen, & Cheng, 2010).
- The type of partnership could have influenced the results from previous research.
- The type of involved parties could have influenced the results from previous research. The point of view of a certain party could lead to a possibly biased result.
- The period of time and possibly outdated research, could give a wrong impression of the results the results in previous research.
- The response rate in several researches is relatively low and thus possibly giving a wrong representation of the specific focus group.
- In order to make a more comprehensive view of the possible influences to the success of the partnerships, attributes from previous research are added which are not jet significantly proven as influencing to the success. Based on the scope of the current research, in comparison to the previous compared researches, different attributes are added or erased. This in order to create a comprehensive list of possible influencing attributes, which are estimated as relevant for the scope of the current research.

Based on the previous researches, a list of possibly influencing attributes to the partnership is created. These attributes will be researched about their influence to the researched partnership (Chapter 4.2.4 *Fuzzy Delphi Methodology*), by the influence determination as given by respondents (Chapter 4.3 *Data Collection*). The list of attributes will be set up based on the number of researches which contains a certain attribute, based on the previous mentioned content analysis (Hwang, Zhao, & Gay, 2013; Kyei & Chan, 2015). As given in the research of Hwang et al (2013) based on the research of Wang et al (2004), an unavoidable situation is the linguistic terms of the attributes, which are qualitatively 'vague' (Hwang, Zhao, & Gay, 2013; Wang, Dulaimi, & Aguria, 2004). In order to obviate the possible deviating interpretations, a suitable research methodology will be introduced in Chapter 4.2.4 *Fuzzy Delphi Methodology*.

In previous research, different possible influencing attributes related to the formation process of the partnership are arising. As coming forward from the compared researches of Rowlinson et al (2011) and Tang et al (2010), the organizational vision and culture could influence the stability of the partnership. A similar organizational culture and vision is not specifically necessary, but similarities herein will contribute to the partnership (Rowlinson & Cheung, 2011; Tang, Shen, & Cheng, 2010; Chen & Chen, 2007; Ghauri & Crespin-Mazet, 2007). As given in the research of Akintoye et al (2007), the deviation in the culture of the organizations is one of the elements which is responsible for an unsuccessful collaboration in a partnership (Akintoye & Main, 2007). Another appearing element that is possibly influencing the partnership, is the strong position of a party within the market. Parties prefer to cooperate with relatively strong market parties when they are looking for a stable partnership (Hwang, Zhao, & Gay, 2013; Tang, Shen, & Cheng, 2010; Shen & Tang, 2013; Kyei & Chan, 2015). As mentioned by Shen et al (2013) the level of experience is inherent to this (Shen & Tang, 2013).

In the literature review of Tang et al (2010), the factor of relationship is evaluated concerning the partnerships of public and private parties. Conducted from several researches in the literature review of Tang et al (2010), the relationship is crucial for a successful partnership, mainly in the field of public-private partnerships. This will also count for a stable partnership with private parties, who are cooperating with public parties. The stable relationship is given as influencing attribute to the success of a partnership in several researches (Zou, Kumaraswamy, Chung, & Wong, 2014; Rowlinson & Cheung, 2011; Tang, Shen, & Cheng, 2010; Smyth & Pryke, 2008; Cheung, Yiu, & Chim, 2006; Akintoye & Main, 2007). As addition to this, the relationship within the partnership and the associating communication are given as highly important of partnering, where a proper communication model should probably be implemented (Rowlinson & Cheung, 2011; Tang, Shen, & Cheng, 2010; Chan, Chan, & Ho, 2003; Consoli, 2006; Shen & Tang, 2013; Chen & Chen, 2007; Rahman, Endut, Faisol, & Paydar, 2014; Kyei & Chan, 2015; Ghauri & Crespin-Mazet, 2007; Suen, Wong, Ng, & Cheung, 2003). As given by Consoli (2006), a negative influence whether or not a partnership will be successful is the friction between the different partners of the partnerships. An existing partnership where a stable relationship is already present is given as influencing attribute to the success of the partnership (Consoli, 2006).

Smyth and Pryke (2008) conducted a new management approach, concerning the relational aspects in partnerships within the construction field. Relationship management has more awareness in this field, which will contribute to the effectiveness of the partnership (Smyth & Pryke, 2008; Zou, Kumaraswamy, Chung, & Wong, 2014). The relationship management is based on the good relations within a partnership. In case of close collaboration within a partnership, the existing relationship is more important than when lower collaborative intentions are present. The management of the relationship will finally lead to a more successful application of the created partnership (Rowlinson & Cheung, 2011). The study of Rowlinson et al (2011) applied this to the sustainability of supply chains within the construction industry. By using different case studies, the management relationships are studied. Within this relationship management, the collaborative problem solving approach and an open communication, leads to a more sustainable collaboration form (Cheung, Yiu, & Chim, 2006; Rowlinson & Cheung, 2011).
As stated elements regarding the successfulness of partnerships within the construction (supply chain) industry, the leading role in relation management is given (Rowlinson & Cheung, 2011). This because of the necessary facilitation of relation management. As addition to this leading role, a proactive role of all partners in relationship management will form a more stable foundation for a successful partnership (Rowlinson & Cheung, 2011). The commitment of all partners is essential as well, where the support of top management will improve this need for commitment (Rowlinson & Cheung, 2011; Stanley, Fawcett, Ogden, Magnan, & Cooper, 2006; Zou, Kumaraswamy, Chung, & Wong, 2014; Hwang, Zhao, & Gay, 2013; Shen & Tang, 2013; Chen & Chen, 2007; Kyei & Chan, 2015; Ghauri & Crespin-Mazet, 2007; Suen, Wong, Ng, & Cheung, 2003; Akintoye & Main, 2007). The support of top management is given as key element in the research of Stanley et al (2006) and in the research of Akintoye et al (2007). A lack of commitment and support from top management level will lower the effectiveness of the partnership and reduce the given effort to the partnership. This because of the strategy and direction of the organization, which is guided by the top (or senior) management level (Stanley, Fawcett, Ogden, Magnan, & Cooper, 2006; Zou, Kumaraswamy, Chung, & Wong, 2014; Chen & Chen, 2007).

Trust will be mentioned as an other obvious element which highly influences the relationship between the partners (Rowlinson & Cheung, 2011; Zou, Kumaraswamy, Chung, & Wong, 2014; Cheung, Yiu, & Chim, 2006; Shen & Tang, 2013; Consoli, 2006; Chen & Chen, 2007; Rahman, Endut, Faisol, & Paydar, 2014; Kyei & Chan, 2015; Suen, Wong, Ng, & Cheung, 2003; Akintoye & Main, 2007). As given in the research of Ghauri et al (2007), several researchers are presenting trust as key element within the partnership. By improving the trust component, the uncertainty decreases in the emergence of issues within the partnerships (Ghauri & Crespin-Mazet, 2007). An study of Kadefors (2004) is emphasizing this as well, where three different requirements are given, in order to create trust between partners in construction projects: ability, benevolence, and integrity (Kadefors, 2004; Ghauri & Crespin-Mazet, 2007). Trust could be considered as 'inter-personal' or 'inter-organizational' regarding the relationship, and will function as a high influencing element to the stability of a partnership over a long-term period (Suen, Wong, Ng, & Cheung, 2003).
Subsequently to this, the transparency and associating insights in knowledge and information will play a possible big role in the relationship. Transparency and information sharing are coming forward from previous research, regarding the successful cooperation within the construction industry (Grasman, 2009; Chen & Chen, 2007; Rahman, Endut, Faisol, & Paydar, 2014; Ghauri & Crespin-Mazet, 2007).
As important note to above stated influencing elements to the partnership 'success', the development of the elements in the relationship between the partners takes some time. This time period should be provided before a proper evaluation could be conducted (Rowlinson & Cheung, 2011).

As determined in the research of Grasman (2009), the value proposition should be clear in a collaborative partnership between private parties and possibly a public authority. With regard to the collaboration between the public and private party, the most common incentives are the decrease of responsibility and associating risk for public parties, and the financial incentive for private parties (Grasman, 2009). This is also mentioned as point of consideration for the partnership between private parties. This is in accordance to the given research context (Chapter 1.2 *Research Context*), where a partnership will be established to answer the request of a municipality. Risk allocation is an important element within the partnership formation, collaboration, and during the project execution. Based on previous literature this could be influenced at one hand by financial incentives. At the other hand, these studies show that the risk should be allocated to a party who is able to absorb the risk the best (Grasman, 2009; Li, Akintoye, Edwards, & Hardcastle, 2005; Kyei & Chan, 2015). Mainly during the stage of cooperation, the flexibility is given as influencing element to a partnership. By being flexible, the risk mitigation could be improved during the project and partnership. Taking this flexible position by the different partners is not a matter of course within the partnership, but will possibly influencing the success (Tang, Shen, & Cheng, 2010; Grasman, 2009; Cheung, Yiu, & Chim, 2006; Suen, Wong, Ng, & Cheung, 2003).

As given previously, the aspect of a *flexible* risk allocation is mentioned as important regarding the collaboration within a partnership. An *appropriate* risk allocation is also a critical factor to the successful conduction of partnerships within the field of cooperation between public and private parties (Shen & Tang, 2013; Hwang, Zhao, & Gay, 2013; Kyei & Chan, 2015). This will be relevant for this research in accordance to the given problem statement (Chapter 1.3 *Research problem definition*), because of the conduction of a project for a public authority. This risk allocation should be conducted in the early stage of a certain project. A very often-used principle is the risk allocation to the party who is able to manage the risk best (Hwang, Zhao, & Gay, 2013; Grasman, 2009; Kyei & Chan, 2015). As mentioned before, several risks could possibly influence the successful collaboration of the partnership.

Regarding the risk allocation between partnerships where both, public parties and private parties are involved, the risk allocation could be categorized. Three categories are occurring in an ideal distributed situation: Risks allocated to the public party, risks allocated to the private party and optional some shared risks (Hwang, Zhao, & Gay, 2013). Following the problem statement in this research (Chapter 1.3), a big part of the responsibilities and risks will be probably taken over from the public party by the involved private parties. Following the results of previous research (e.g. (Hwang, Zhao, & Gay, 2013)), this will possibly influence the collaboration aspect within the partnership of private parties. As given results regarding the risk allocation, the level of risk division in an early stage and the level of flexibility during the process will possibly influencing the successful collaboration within the partnership (Hwang, Zhao, & Gay, 2013; Rowlinson & Cheung, 2011; Tang, Shen, & Cheng, 2010; Grasman, 2009).

As given by Zou et al (2014), the purpose of a project and the associating objectives of all involved parties (the client and contractor) should be clear. The objectives of public and private parties are generally not similar. The determination of these objectives is important in order to get more insights in the vision and way of acting of the different parties (Zou, Kumaraswamy, Chung, & Wong, 2014). In the research of Zou et al (2014), which is focusing on Public-Private partnerships, these objectives are more generalized. Public parties are mostly searching for savings in their costs and/or improvements of their services. An important characteristic is the awareness of value for money and the involvement of the social interest (Zou, Kumaraswamy, Chung, & Wong, 2014; Kyei & Chan, 2015). The objectives of private parties are generally more commercial directed. Nevertheless, also within the partnerships between private parties the objectives could be differing (Zou, Kumaraswamy, Chung, & Wong, 2014). Expectations of private parties are concerning the increase in revenues, profitability and the future opportunities within the partnership (Zou, Kumaraswamy, Chung, & Wong, 2014). Objectives of the cooperating parties should not definitely be similar, and could be on both, project level and organizational level (Chen & Chen, 2007). In contrast to this, the research of Akintoye et al (2007) determines that the benefits and associating objectives of the different parties, from the perspective of contractors, should be similar to realize a successful collaborative relationship (Akintoye & Main, 2007). Nevertheless, within a partnership the possibility for having objectives for both should be present and several researches (e.g. (Chen & Chen, 2007)) indicate the influence of the clear objectives of the different involved partners. Also for the collaboration of private parties, an identified mutual interest and associating objectives should be present, in order to contribute to the stability of the partnership (Hwang, Zhao, & Gay, 2013; Grasman, 2009; Zou, Kumaraswamy, Chung, & Wong, 2014; Consoli, 2006; Rahman, Endut, Faisol, & Paydar, 2014; Chen & Chen, 2007; Shen & Tang, 2013; Ghauri & Crespin-Mazet, 2007; Suen, Wong, Ng, & Cheung, 2003).

Following the study of Cheung et al (2006) and Zou et al (2014), the *time aspect* (cooperation or contract for example) is given as important element regarding partnerships. This is mainly considered for the collaboration between private parties and public parties (Cheung, Yiu, & Chim, 2006; Zou, Kumaraswamy, Chung, & Wong, 2014). Contract time spans are increasing in order to realize long-term relationships. Not only the contracting parties prefer this long-term relationships (contacts). The long-term based relationships (and contracts) are more frequently a request by the client as well, within the construction industry (Chen & Chen, 2007). A consequence to this long-term relationships and contract forms is the change in circumstances over time. The prediction of the future and the associating changing circumstances are difficult to determine. At the same time, the guidance of these changes is sometimes not properly secured in an agreement. One of the elements which could improve this, is the flexibility of risk sharing (e.g. (Tang, Shen, & Cheng, 2010)). Also the element of trust in the relationship will make it more stable (e.g. (Ghauri & Crespin-Mazet, 2007)). The elements of flexibility in risk sharing and trust are mentioned before, and are both concerning the long-term partnership. This could lead to another more flexible risk sharing approach in case of a longer type of partnership is established (Zou, Kumaraswamy, Chung, & Wong, 2014; Tang, Shen, & Cheng, 2010; Cheung, Yiu, & Chim, 2006).

3.3.3 Attribute overview and selection

An overview of the attribute selection is given in this paragraph, where the list of attributes will be set up based on the different previous studies. By comparing the different researches, several attributes are given as *possible influencing attributes* to the successful collaboration within a partnership. In general the number of times that a certain attribute is mentioned as influencing attribute in previous research, makes an attribute considered as a possibly high important and *possibly influencing attribute*. This selection to arrange the attributes (content analysis) is based on the previous research of Hwang et al (2013) and the research of Kyei et al (2015) (Hwang, Zhao, & Gay, 2013; Kyei & Chan, 2015).

In case of adopting the influencing attributes to the success of a partnership in the current research, this needs some points of consideration as explained before in Chapter 3.3.2. As example, the cultural and regional differences (e.g. (Tang, Shen, & Cheng, 2010)) of the focus group in previous research, could influence (decrease) the suitability of the attributes for this study. In order to obviate this, the attributes will be appointed as '*possible influencing attributes*'. The obtained *possible influencing attributes* will only function as input, and will be reevaluated and revalidated by experts, later in this research (Chapter 4.3 *Data collection*). Reevaluating and revalidating the influence of these attributes will contribute to the reliability of the current research. The overview of the *'possible influencing attributes'* is given in Table 3.2.

Table 3.2 Selection of possible influencing attributes to the partnership (content analysis)

Obtained attributes from previous research (20) :	Kyei & Chan; 2015	Zou, Kumaraswamy, Chung & Wong; 2014	Hwang, Zhao & Gay; 2013	Rahman, Endut, Faisol & Paydar; 2013	Shen & Tang; 2013	Rowlinson & Cheung; 2011	Tang, Shen & Cheng; 2010	Grasman; 2009	Smyth & Pryke; 2008	Chen & Chen; 2007	Ghauri & Crespin-Mazet; 2007	Akintoye & Main; 2007	Stanley, Fawcett, Ogden, Magnan & Cooper; 2006	Cheung, Yiu & Chim; 2006	Consoli; 2006	Suen, Wong, Ng & Cheung; 2003	Total
Trust between the partners	x	x		x	x	x				x	x	x		x	x	x	11
Commitment of all partners	x	x	x		x	x				x	x	x	x			x	10
A proper communication (model) between the partners	x			x	x	x	x			x	x	x			x	x	10
Confusion of objectives (clear and consistent objectives)		x	x	x	x			x		x	x	x			x	x	10
Good and improved (existing) relationship within the partnership		x				x	x		x			x		x	x		7
Support and commitment of top management level		x				x				x		x	x			x	6
Similarities in organizational vision and culture						x	x			x	x	x					5
Appropriate risk allocation and sharing (determined in scenarios)	x		x		x		x	x									5
Flexibility in risk sharing, to improve the risk mitigation							x	x						x		x	4
Transparency and sharing of information during the project				x				x		x	x						4
Strong market parties within partnership	x		x		x		x										4
Every element should be described in detail in a contractual agreement				x			x									x	3
Time span of project; possible generating revenues in a late stage		x					x							x			3
Selection based on their innovative ambition, besides their competences					x		x										2
High (inititial) participation costs			x				x										2
Lengthy negotiation process	x		x														2
Transparency in partner cooperations and selection								x									1
Leading role within the partnership (control)						x											1
Pro-active role of all partners						x											1
Little to no financial risks							x										1

3.4 Decision making in private-party partnerships: a Game Theoretical approach

In Chapter 3.2.3 a justification is given of the involvement of private parties in projects of public authorities. As explained before, the cooperation of private parties will be researched in the current study following the problem statement (Chapter 1.3). In this chapter, the formation and collaboration within a partnership (private parties) will be further explored. More insights will be provided to the decision making process, by reviewing previous conducted studies. In Chapter 3.4.1, some starting points will be given for the decision making process regarding the partnership collaboration. This will be an addition to the introduced attributes in Chapter 3.3. The focus to the partnerships between private parties will be leading, in accordance with the given problem statement in Chapter 1.3 *Research problem definition*. A Game Theoretical approach will be introduced as possible suitable methodology to guide the decision making process (Chapter 3.4.2). A research comparison based on the game theoretical concepts and used methodologies by previous researchers, will be given in Chapter 3.4.3. By comparing the different elements of the previous researches in Chapter 3.4.4, some starting points could be set. These starting points will function as input for (a part of) the research model in this study (Chapter 4.2.5 Game Theoretical approach).

3.4.1 Starting points for decision making

This paragraph will briefly describe three elements which will be considered as the starting points for strategy decision-making in the construction field. As given in Chapter 3.3, different attributes are selected which are *possibly* influencing the collaboration within a partnership (private parties). As addition to these attributes, this chapter will further explain three elements to the collaboration aspect of a private party partnership. The three elements are given as trust within the partnership, the duration of the partnership, and the added value and mutual benefits for the involved parties. Deepening into these elements will contribute to the relevant knowledge about the collaboration within a private party partnership. These elements are comprehensively discussed in previous researches (e.g. (Suen, Wong, Ng, & Cheung, 2003; Bygballe, Jahre, & Sward, 2010; Chen & Chen, 2007)), regarding the private party partnerships in the construction industry.

As described in Chapter 3.3.2, the trust into a partnership is influencing possibly high to the success of the partnership. This element of trust is in most of the included researches of the research comparison given as influencing (Chapter 3.3.3). This is derived from the results of the content analysis (Table 3.2). Although the influence of this attribute will be researched later (Chapter 4.2.4 Fuzzy Delphi Methodology), this attribute is discussed in an interesting way by Suen et al (2003) for instance. This research argues that trust in between private party partnerships in the construction industry should be treated differently than a regular interpreted form of trust. Within the construction industry, the aspect of trust will be determined within the contractual agreement (Suen, Wong, Ng, & Cheung, 2003). This aspect could lead to different decisions in the partnership formation processes. For example, the personal influences could be from lower interest than the official contractual agreements, stated by Suen et al (2003). Analyzing the results of the research by Couchman et al (2009), the trust element is positively effecting on the sharing of information and will definitely influence the effectiveness of the partnership. As addition to this, the performance of the collaboration between the partners will be highly influenced with a higher payoff, by cooperating with a relatively high trust element involved (Couchman & Fulop, 2009; Arsenyan, Buyukozkan, & Feyzioglu, 2015). The previous mentioned research of Arsenyan et al (2015) proves a significant positive influence of trust to the achieved payoff and profit (Arsenyan, Buyukozkan, & Feyzioglu, 2015). The research of Eriksson (2007) will take this one step further where trust will lead to an enhancement of cooperation, where players will choose more frequently to collaborate (Eriksson, 2007).

Previous researches focus mainly to the partnering within a specific project type. As example, within the scope of a project partnership, the relationship between the contractor and the client will be mainly reviewed (e.g. (Akintoye & Main, 2007)). As stated in the research of Bygballe et al (2010), Eriksson et al (2007) and Atkin et al (2008), the partnership should be focusing on a more long-term relationship. By introducing a long-term partnership arrangement, the relationship could function as network strategy. A remark to the before mentioned conclusions is the difficult implementation of the theoretical directives in a practical manner (Bygballe, Jahre, & Sward, 2010). This long-term view is researched in more detail by Eriksson et al (2007) and Atkin et al (2008). Obtained from these studies, the chosen strategy should be based on the long-term value. By shifting the objective from the project level to an objective for the network relationship, the added value by cooperation could be determined (Bygballe, Jahre, & Sward, 2010). For both, client-contractor and other forms of cooperation, the long-term incentive should be considered by choosing a proper strategy (Eriksson, 2007; Atkin, Nilsson, & Eriksson, 2008).

By reflecting different industries, the vision by construction parties should be widened to a long-term approach, as mentioned above (e.g. (Chen & Chen, 2007)). As key element to convince the construction industry, the value by adopting this long-term vision should be shown (Bygballe, Jahre, & Sward, 2010). After exposing this added value, the strategy focus could be changed in this direction. Not only the single objective of the different parties should be reached, but also a mutual objective by getting an arrangement will be found in a future cooperation (Bygballe, Jahre, & Sward, 2010).

Based on the review of the given researches, a further elaboration in this research should take these elements in account and as possible starting points for the partnership establishment. The selection of the parties in a private party partnership will be important, where trust between the parties should be established (e.g. (Suen, Wong, Ng, & Cheung, 2003; Couchman & Fulop, 2009). Besides, a long-term partnership will bring up new opportunities in the currently developing market, and bring up possibly a more decent collaboration between the involved parties (e.g. (Bygballe, Jahre, & Sward, 2010; Eriksson, 2007). Further more, the added value and the mutual benefits for a long-term partnership between private parties should be clarified (e.g. (Bygballe, Jahre, & Sward, 2010)).

3.4.2 Cooperative strategies in the construction industry

As explained in the context and problem statement of this research (Chapter 1.2 and 1.3), this research is focusing to the collaboration of private parties regarding the request of municipalities. Essential for this partnership could possibly be the willingness of parties to cooperate. The cooperation within the construction field, in the form of partnering, is researched by Brygballe et al (2010). Brygballe et al (2010) made a literature review based on the conducted researches into partnering relationships within the construction field. The problem statement in this research (Chapter 1.3) follows up the exploration of the collaboration aspects in partnerships. As given by Brygballe et al (2010), a better understanding to relationships as 'partnering' will contribute to the proper implementation in the construction industry (Bygballe, Jahre, & Sward, 2010). The most important element of building up a relationship in the form of a partnership, is to achieve the objectives of both; this could also be given as an increase in objective for each of the parties (Bygballe, Jahre, & Sward, 2010).
Regarding a Game Theoretical approach (e.g. (McCain, 2008; Javed, Lam, & Chan, 2014)), the objective could be translated into a (financial) payoff of the involved stakeholders. By reaching this certain payoff for the single involved parties, and the payoff for the formed partnership, the different parties should agree on terms to reach their desired (mutual) payoff. The decision making process they will face, is mainly focusing on the process to come to an agreement. Different modeled scenarios lead to different decision-making processes. A scenario could be given for instance as the type of partnership, amount of players, (non)cooperative mind set, etc. (Schramm, Silva, & Morais, 2012). Within the different scenarios, each party is creating a set of decisions, given as *strategy*. The reason for choosing a strategy is to reach a preferred outcome (Schramm, Silva, & Morais, 2012). The complexity of this form of decision-making, leads to challenges in the formation of this partnership. In order to give proper insights in this partnership formation and associating decision-making, Game Theory could provide proper insights (Javed, Lam, & Chan, 2014; Kargol & Sokol, 2008). The collaboration within the private party partnership, assumed here as *cooperative*, should lead to a better overall outcome for the different players (McCain, 2008; Brady & Trif, 2013). Outcomes could be win-lose, lose-lose, or win-win (Schramm, Silva, & Morais, 2012), where Game Theory gives proper insights for the associating decision making process.

Introduction to Game Theory

Over the years many attempts have been made to approach human decision-making processes in a scientific way. In 1928 John van Neuman developed the formal conception of Game Theory when he published the Minimax Theorem, which is a decision rule for minimizing the possible loss of a worst-case scenario (Schwalbe & Walker, 2001). Together with Oscar Morgenstern (Neumann & Morgenstern, Theory of Games and Economic behavior, 1953) he published the book „Theory of Games and Economic Behaviour" in which they further elaborate on Game Theoretical principles (Schwalbe & Walker, 2001). Another important discovery was realized by John Forbes Nash, who wrote his dissertation 'Non-cooperative game' in which he elaborates on the 'equilibrium problem', which will later be known as the 'Nash-equilibrium'. The Nash-equilibrium describes the moment in which players have chosen their strategy, such that a one-sided adaptation will not yield an improvement of the situation provided that all players act rationally (Slikker, 2014; Osborne, An introduction to Game Theory, 2000). The foundation laid by Neuman, Morgenstern and Nash resulted in the development of Game Theory, which can presently be described as a theorem which deals with decision making processes by different involved players.

Cooperative games vs. non-cooperative games

To reach a certain outcome, the (mutual) strategy chosen by the different involved parties is key. A division of strategy could be based on two different branches: a non-cooperative and cooperative situation, where the cooperative situation is based on a more mutual strategy (McCain, 2008). This could come forward from the interest and involvement of the parties, and the formation of a possible coalition. Chatain (2014) describes the differences in cooperative and non-cooperative games. A non-cooperative strategy in the negotiation within a partnership, will model the strategies of the players in order to reach a maximal utilization with an as high as possible payoff. These strategies are based on the description of actions and information (Chatain, 2014). A cooperative form could be given as, modeling how the different players could cooperate (and possibly compete) as a coalition, based on unstructured interaction where a value will be created (Chatain, 2014). Chatain (2014) defines the cooperative Game Theory as a more 'coalitional approach' and the non-cooperative Game Theory as a more 'procedural approach'. Derived from these definitions, cooperative games are not specifically based on the level of cooperation between the agents, where negotiation between the players still could occur within the coalition (Chatain, 2014).

The way of looking to the cooperative or non-cooperative forms of partnerships is researched several times before, mainly by a game theoretical approach (e.g. (Bossert, Brams, & Kilgour, 2002)). As given by Bossert et al (2002) cooperative and non-cooperative approaches could lead to different outcomes. By viewing this from both perspectives, the differences in these forms (cooperative and non-cooperative) the possible outcomes could be analyzed (Bossert, Brams, & Kilgour, 2002). As given in this study of Bossert et al (2002), in general the analysis of non-cooperative analysis will give less positive outcomes for the different players, than in a cooperative form (Bossert, Brams, & Kilgour, 2002). Some researchers underpin this beneficial outcome of cooperative game (e.g. (Gou, Zhang, Liang, Huang, & Ashley, 2014)). As given in different previous researches (e.g. (Gou, Zhang, Liang, Huang, & Ashley, 2014)), the result of a cooperative form of partnership will be improved in comparison to non-cooperative partnerships. This is stated in for instance the research of Gou et al (2013) where strategies are analyzed based on (horizontal) cooperative programs. Herein, a focus is given to joint ventures and alliances (Gou, Zhang, Liang, Huang, & Ashley, 2014). The research of Perng et al (2005), is investigating whether or not forming a coalition by a cooperative partnership, the profitability will be improved (Perng, Chen, & Lu, 2005). This research makes use of a case study, where the developed models give an improved profitability when forming a cooperative partnership, as stated by Perng et al (2005). There are some remarks to this, where possible extra influences (e.g. management effort, negotiation costs, etc.) should be taken into account and needs further study (Perng, Chen, & Lu, 2005). The above-mentioned research outcomes are in line with the definition and the condition stated by Chatain (2014). This condition of a cooperative game is based on both, the self-interest and the coalitional interest in the game. The coalition will have an equal or higher payoff than for a single player (Chatain, 2014). This condition of receiving a higher payoff by cooperating is specifically stated by Perng et al (2005) (Perng, Chen, & Lu, 2005).

Game Theory as decision-making model

As previously mentioned (Chapter 3.4.2), the complexity in the decision-making within a partnership leads to challenges in the formation and agreement process. These challenges are mainly corresponding the decision making by more than a single player. The interaction between the involved parties and the influence of the chosen strategies by the different parties makes this decision making more complex as given by Barough et al (2012). Game Theory could possibly provide a solution for this (Barough, Shoubi, & Skardi, 2012). The suitability of Game Theory in this decision making process is also considered by other researchers (Javed, Lam, & Chan, 2014; Kargol & Sokol, 2008). The proper application of Game Theory in the field of construction engineering and management as a decision making approach, is determined by Kaplinski et al (2010). This is based on a review of 42 years of scientific research of F. Pelschus, as professor in the research area of the construction engineering and management field by different game theoretical approaches (Kaplinski & Tamosaitiene, 2010). Based on the research of Blokhuis et al (2010), Game Theory is assumed as possibly suitable for applying to the research model in this study. This is because of the interdependency of the involved parties and the decisions of the different player, which rely on the expected payoff (Blokhuis, Snijders, Han, & Schaefer, 2012).
By adopting principles of Game Theory in the current research, new insights could be given for forming a partnership of private parties (in this study) within the construction industry. Game Theory will be suitable for analyzing the, among others, cooperative 'games' (Bossert, Brams, & Kilgour, 2002). This is underpinned by Eriksson (2007), based on the research of Lazar (2000), where Game Theory are modeling tools which gives proper insights in the relationship between the different involved partners and the interactions they will have. Construction projects could be frequently considered as relatively similar to the prisoner's dilemma games in Game Theory (Eriksson, 2007; Lazar, 2000).

3.4.3 Research comparison: Strategy modeling by Game Theory

Several researches are conducted regarding the cooperation aspects of partnerships within the construction field. By implementing Game Theory, the decision making process could be guided and provide new insights to the cooperating aspects. This paragraph will give a comparison of previous conducted researches, which is analyzing by a game theoretical approach and in line with the scope (Chapter 1.3.1) in the current research. The scope as given in Chapter 1.3.1, focuses in short to the collaboration aspects of private parties within the construction industry. This will be given as partnership in order to anticipate to the municipalities' request to improve their real estate properties in a sustainable way. Besides the attributes selected in Chapter 3.3.3, the given elements (trust between parties, long-term partnerships and the mutual benefits) discussed in Chapter 3.4.1 should be taken into account regarding the partnership formation research (Suen, Wong, Ng, & Cheung, 2003; Couchman & Fulop, 2009; Arsenyan, Buyukozkan, & Feyzioglu, 2015; Eriksson, 2007; Bygballe, Jahre, & Sward, 2010; Atkin, Nilsson, & Eriksson, 2008). In this research comparison, five previous studies are selected which are relevant to the above given research context.

Table 3.3 Research comparison: Strategy modeling by Game Theory

				Research Methodology						*Game Theoretical Concepts*					
Author	**Year**	**Research topic**	**Branche**	**Literature Review**	**Questionnaire**	**Interviews**	**Case Study**	**Statistical analysis**	**Game Theory**	**Prisoner dilemma**	**2-Player games**	**3-Player games**	**N-Player games**	**Non-cooperative**	**Cooperative**
Bossert, Brams & Kilgour	2002	Researching the differences between the cooperative and non-cooperative approaches in three person games, by making use of analyzing *Truels* by Game Theory.	Theoretical	X					X			X		X	X
Perng, Chen & Lu	2005	Researching by a Game Theoretical approach, or forming a cooperative partnership (coalition) will improve the profitability; this in case of cooperationof formwork subcontractors.	Construction industry; formwork subcontractors			X	X		X			X	X	X	X
Eriksson	2007	Researching the possible application of Game Theory to examine the cooperation in relationships between buyer and supplier, within the construction and facility management.	Construction industry; buyer - supplier	X		X			X	X	X				X
Wang, Fang & Hipel	2007	Researching a support methodology by a Game Theoretical approach in the negotiation of brownfield redevelopment projects, including the cost and benefit allocation.	Construction industry; redevelopment of brownfield	X			X		X			X	X		X
Blokhuis, Snijders, Han & Schaefer	2010	Researching the explanation for the occurence of cooperation or conflict by creating a generalized model, for the redevelopment projects of brownfield.	Construction industry; redevelopment of brownfield	X	X			X	X	X	X				

First, a comparison of the five previous studies will be given in Table 3.3. Thereafter, the comparison of these researches will be explained by the concepts of the game theoretical approach, the number of players in the game theoretical approach, and the data collection. By comparing the different researches, the guidelines will be drawn for the possible implementation and application of Game Theory into and important part of the research model created in Chapter 4.2.5 *Game Theoretical approach*.

Concepts of Game Theory in the construction industry

Previous research is conducted, wherein the comparison of cooperative games and non-cooperative games leads to different outcomes (Bossert, Brams, & Kilgour, 2002; Perng, Chen, & Lu, 2005). Within the cooperative game, different forms of Game Theory are analyzed within the construction industry in a cooperative game. As given in the research of Eriksson (2007), the application of the Prisoner Dilemma in the cooperation forms within the construction industry is proven as well applicable in case this occurs (Eriksson, 2007). By focusing on long-term contracts, the behavior regarding cooperation in the partnerships could be changed, which could be analyzed by a game theoretical approach (Eriksson, 2007). The adoption of the Prisoners Dilemma is also forthcoming from the research of Blokhuis et al (2012). Blokhuis et al (2012) indicates the Prisoners Dilemma as a suitable game based on the benefits of mutual cooperation and disadvantages by having no cooperation. The players are (partially) interdependent and have (partially) shared interest, which could lead to an outcome by cooperating, which is not the single players preferable outcome (Blokhuis, Snijders, Han, & Schaefer, 2012). This is corresponding the current situation in this research by private party cooperation, where no cooperation and no conduction of the project, leads to a lower (or no) payoff. The payoff utilized by cooperation, will not specifically be higher than the preferred strategy, without concerning others strategy (e.g. (Suen, Wong, Ng, & Cheung, 2003)). As given by the research of Wang et al (2007), cooperative Game Theory is frequently applicable in the negotiation situation, regarding cost allocation as an example (Wang, Fang, & Hipel, 2007).

N-person games

The compared researches use different forms of involved players. Blokhuis et al (2012) for example, uses a 2X2 game, which means a 2-person game where both have 2 different strategies (decisions) (Blokhuis, Snijders, Han, &

Schaefer, 2012). By reflecting to the current research, the guiding case (private parties) is identifying probably three involved players (e.g. (Grasman, 2009)). The researches to a N-person game, mainly focusing to 3-person player games, will possibly applicable in this study because of the multiple involvements of private parties. As given in the research of Perng et al (2005), the integration of 3-persons is optional in the form of a cooperative game set up (Perng, Chen, & Lu, 2005). By adopting 3 persons, cooperation forms could be researched wherein more than two players are involved, as given in the current situation of this research. Based on the Chapter 3.2.1, the shift in the construction industry leads to (new) cooperation initiatives, where more frequently 3 or more parties are involved. The involvement of three players is also considered in the research of Wang et al (2007), called the 'decision makers' (Wang, Fang, & Hipel, 2007). The research of Wang et al (2007) is also taken into account the possibility of 4 players in a cooperative game, which will be excluded from this comparison.

Data-collection

Derived from previous research (e.g. (Eriksson, 2007)), it is hard to make the game theoretical analysis in the construction industry quantitative applicable. Frequently, an empirical data collection is conducted, where after making this data quantitative will contribute to future researches within the construction industry (Eriksson, 2007).
Based on the research of Blokhuis et al (2012), the payoffs for the game theoretical approach could be determined by examining the respondents about their expected outcomes. Respondents could be selected as 'experts' in order to provide their expected preferences, which could be given as payoff. In the research of Wang et al (2007), a quantitative analysis is conducted to the three involved parties, as decision makers, where the 4-player game is left out of consideration. The obtained data is based on the cost figures and value, instead of an assigned preferences number (Wang, Fang, & Hipel, 2007).
For the research of Blokhuis et al (2012), the respondents are selected based on their expertise. All respondents are consultants and representing other companies and municipalities (Blokhuis, Snijders, Han, & Schaefer, 2012). This would be optional when the number of respondents is lower than desired. Nevertheless, selecting respondents who are representing themselves (or own company e.g.) would be preferred, and adopted in this study.

3.4.4 Components of Game Theoretical modeling

The research comparison in Chapter 3.4.3 provides insights in the previously conducted research within the construction industry, by making use of a game theoretical approach. By comparing the different elements of the previous researches, some starting points could be set, in order to create a proper model for this research. As described above, the frequently applied analysis methodology will be Game Theory in a cooperative format, where some associating starting points will guide this analyzing process. Here a brief overview will be given of these game theoretical elements. This chapter of the literature review will provide starting points for the model creation where Game Theory will be included. The creation of the research model, including the game theoretical approach, will be comprehensively explained in Chapter 4. Research Model.

Win-win situation and size of Payoffs

First of all, the win-win situation should be realized, in order to make the collaboration beneficial for every involved party (Arsenyan, Buyukozkan, & Feyzioglu, 2015). The size of the win-outcome is then leading, including the mutual outcome. When the difference between the win-win and the win-lose payoff will be lower than the difference between the win-lose and the lose-lose, the probability of cooperating will increase (Eriksson, 2007).

Interaction

In previous research the aspect of the interactions within a possible collaboration formation is researched (Arsenyan, Buyukozkan, & Feyzioglu, 2015). For the implementation of Game Theory to this study, the vision and possible actions of the involved parties will be important as well. As described in Chapter 3.4.3, the interaction between the partners is important for this study, as emphasized in previous research (e.g. (Chapman & Corso, 2005; Arsenyan, Buyukozkan, & Feyzioglu, 2015)).

Scenario selection

The creation of scenarios will provide different game models. Differences in the scenarios could be elements like for example a certain role division, value estimation (Wang, Fang, & Hipel, 2007), cost determination (Wang, Fang, & Hipel, 2007), risk division and benefit division (Arsenyan, Buyukozkan, & Feyzioglu, 2015). In previous research, some of these elements are analyzed. As given in the research of Arsenyan et al (2015), the division of revenues is adopted in the game theoretical analysis. As result, the equal distribution of revenues between the involved players is significantly proven (Arsenyan, Buyukozkan, & Feyzioglu, 2015). Also in the research of Wang et al (2007), the cost determination and value estimation (based on revenues) is given by the respondents (Wang, Fang, & Hipel, 2007).

Length of the game

The length of the game could influence the outcome of a game, for example in the prisoner's dilemma (Eriksson, 2007). The length of the game determines whether or not there is a single game (single decision per player) or there are subsequently more rounds of playing. Based on a single game, the chosen strategy by the players will possibly not leading to the mutual most rewarded payoff (Eriksson, 2007). The combination of different game models is also suitable which depends, among others, on the created scenarios and associating game models.

N-person games and the Nash-equilibrium

As described by Lewis et al, predictions of the cooperation outcome of games, depends on the model that is used. Specifically in N-person games, the equilibria could differ based on the type of model, certain conditions (group size e.g.) and the ratio between costs and revenues (Lewis & Dumbrell, 2013). Finding the equilibrium gives a solution (decision strategy) for a certain scenario and associating game. An equilibrium has as characteristic that it has no tendency to change, what means that it is less favorable to change the strategy for a player (Neumann & Morgenstern, Theory of games and economic behavior, 1953). Given by Osborne (2000), the most frequently used concept for a solution in Game Theory is the Nash equilibrium. This idea includes a stable play of a strategic game where each player assumes the expectation about the other players' behavior and is acting rational (Osborne, An introduction to Game Theory, 2000). The equilibrium could be given as Nash Equilibrium, which is given as strategy profile wherein each player's strategy is optimal, given the other players' strategy (Osborne, An introduction to Game Theory, 2000). Despite the Nash-equilibrium is a frequently used solution to solve game theoretical models, other researches (e.g. (Chiu, 2009; Sönmez, 2014)) named the three most applied strategic game solutions to find the equilibrium.

- Dominant strategies

  A dominant strategy will be present when a player yields the best payoff (for itself), independently the strategy another player will choose. This means that when all players will have a *dominant strategy*, from a rational perspective it will be naturally for each player to choose that strategy. This will lead to the equilibrium of the dominant strategies. (Chiu, 2009; Sönmez, 2014)
- Dominated strategies (iterative elimination)

  A dominated strategy will be present when a player has another strategy which yields an payoff at least as good (for itself), independently the strategy another player will choose. When a player has a dominant strategy, the other players' strategies will be dominated. In case a player has no dominant strategy, a dominated strategy could be (iteratively) eliminated in order to exclude this strategy in the game model. By iterative elimination of the dominated strategies, a possible dominant strategy could be found which leads to an equilibrium and game model solution. (Chiu, 2009; Sönmez, 2014)
- Nash equilibrium

  Game Theoretical models will not always lead to a strategy solution based on dominant strategies and the elimination of dominated strategies. Finding the Nash equilibrium could provide a solution for the strategic game. As given before, the Nash equilibrium will occur when none of the involved players will unilaterally change to another strategy, given that the other players will act rationally. (Chiu, 2009; Sönmez, 2014; Slikker, 2014)

Derived from previous research (e.g. (Wang, Fang, & Hipel, 2007), the game models focusing to 3 (or more) players give possible new insights for this research. By finding game theoretical solutions for different modeled scenarios, insights could be possibly given to the expected collaboration within a set partnership.

3.5 Contribution to the current state of research

As addition to the previous discussed researches, this paragraph provides a brief overview about the contributions of this study to the current state of research. The evaluation of previous conducted research shows that there is not much (recent) research conducted jet in the field of private-private (cooperative) partnerships; Mainly regarding the more long-term partnership development within the construction field. As mentioned in the study of Bygballe et al (2010), a missing field of study is noticed in the 'partnering' between the private parties. The collaboration of private parties should be focusing more to the long-term relationship as given in previous research (e.g. (Atkin, Nilsson, & Eriksson, 2008; Eriksson, 2007; Bygballe, Jahre, & Sward, 2010). An other element which should be adopted into further research, is the perspective of the different involved actors (Bygballe, Jahre, & Sward, 2010). By providing better insights to the perspective of different involved parties, the collaboration aspect within partnerships could be better researched.

Several previous researches are focusing on the influence of attributes to the success of a partnership (e.g. (Chen & Chen, 2007)). By indicating to what extent attributes are influencing the successful collaboration within a partnership, insights to the improvement of the collaboration could be possibly provided. This will be adopted in this research by exploring the influences of attributes to the collaboration aspect within a private party partnership. Previous research (e.g. (Mazzocchi, Ragona, & Zanoli, 2013)) shows that implementing impact or influence levels to the final expected outcome, could provide insights to possible implementable improvements. A combination will be made between the expected preference (determined by experts) and the influences of attributes to the collaboration aspect. This could provide new insights regarding the 'successful collaboration' by private parties in the construction industry. Nevertheless, previous research to influences of attributes into game theoretical modeling is limited conducted and will probably result in an explorative type of study.

Previous research is often sticking to the benefits of partnership strategies for example (e.g. (Suen, Wong, Ng, & Cheung, 2003). By providing insights to the scenario modeling concerning the (private party) partnership, the added value of collaborating will be possibly given by a different scientific substantiation. The new insights it will give, is mainly concerning the influences of attributes to the collaboration, and possible success of the established partnership scenarios. Game theoretical analysis is giving insight in the expectancies, strategies, and interdependencies of the different players, which could differ for each player (e.g. (Javed, Lam, & Chan, 2014)). By analyzing this in combination with the analyzed influences to the successful collaboration within a partnership, this study could bring up new insights and predictions for future project cases.

As given in the limitations of the research of Eriksson (2007), the game theoretical approach of cooperative games will not specifically contribute to solving the lack of cooperation in a partnership (Eriksson, 2007). By combining Game Theory in cooperative games with the influences to successful partnerships, this lack of cooperation issues could be researched further. As addition to this, previous research to cooperation is often assumed as theoretical and mathematical, in case of using a game theoretical approach (Eriksson, 2007). Based on this information, a combination will be made between theoretical and scientific methodologies and the practical implementation. This will be realized by implementing practical case scenarios to the, among others, game theoretical research approaches. Besides, by making use of the Fuzzy Delphi Methodology, the influences of attributes to the collaboration aspect will be determined by different experts who are representing the possible involved parties. This involvement of representing experts will improve the reliability, following the vision of Eriksson (2007) about the proper representation of respondents (Eriksson, 2007).

Nowadays, partnerships of more than two parties are occurring more frequently in the construction industry (e.g. (Grasman, 2009)). Previous research to 2-player or 3-player partnerships in the construction industry is frequently consisting of an involved public party (e.g. (Blokhuis, Snijders, Han, & Schaefer, 2012; Wang, Fang, & Hipel, 2007). This research will focus to the collaboration of private parties within a partnership. Following the context of this research (Chapter 1.2 *Research Context*), the involvement of three parties will be further researched. This will contribute to the current state of research, by implementing 3-player game theoretical modeling. The 3-player game modeling will implement the perspective of (selected) private parties within the construction industry. By combining these perspectives (preferences) with the influences of attributes to the collaboration, the possible improvement of the successful collaboration will be researched.

4 Research Model

4.1 Research Model introduction

Figure 4.1 shows the research model in this study. This is provided in a flowchart where a distinction is made in four different phases: Input, Analysis, Results, and Explorative (innovative) research. The arrows indicate the sequence of steps and interrelationships of the research elements in the research model. The relation between the research model and the four research sub questions (Q1 to Q4) is visualized in Figure 4.1 by the given colored boxes. In the different research model, some research elements are expressed in a dark blue box. This indicates a ‘Result’ which will be further explained in Chapter 4.4 *Results*. The (methodological) elements in the research model will be further explained in the following paragraphs.

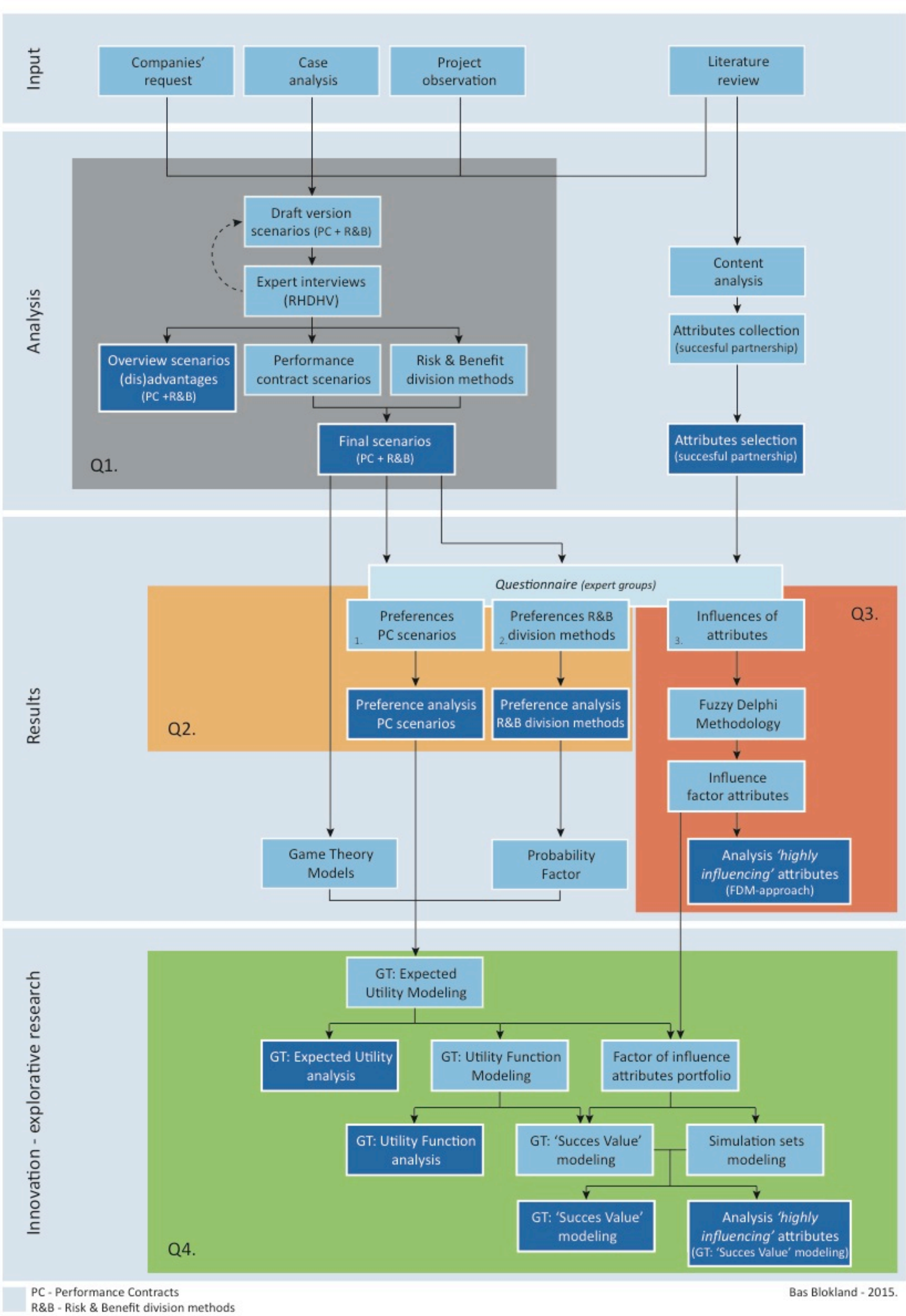


Figure 4.1 Research Model

4.2 Research Methodology

4.2.1 Attributes selection

Attributes influencing the collaboration

The attributes that are possibly influencing the successful collaboration of a partnership, have been analyzed in previous research. In this research the methodology of a content analysis in the Literature Review is used, in order to obtain the possible influencing attributes. This methodology is based on the conducted research of Hwang et al (2013) and Kyei et al (2015). In this analysis, the number of times that a certain attribute is mentioned as influencing attribute in previous research, will be marked as a possibly high important and possibly influencing attribute (Hwang, Zhao, & Gay, 2013; Kyei & Chan, 2015). The number of researches (included in the research comparison) that contains a certain attribute is calculated. Based on this number, the attribute is selected as input attribute for this research. The attributes obtained from previous studies are given in Table 3.2 in Chapter 3.3.3 *Attribute overview and selection*.

Selection of possible influencing attributes

A total of twenty attributes are obtained by a content analysis of previous research (Table 3.1 in Chapter 3.3.3 *Attribute overview and selection*. The twenty attributes are given as *possibly influencing attributes* to the partnership of private parties within the construction industry. As given by the research of Kyei et al (2015), some attributes could be excluded for further processing in this study. By excluding some attributes, the total amount of attributes will be limited which leads to a more clear and concrete list of attributes, which are repeatedly proven as influencing to the partnership. Based on these previous studies (e.g. (Hwang, Zhao, & Gay, 2013; Kyei & Chan, 2015), the total list of obtained attributes from previous researches (twenty attributes), is reduced.

This reduction is conducted, based on a twofold reasoning. First, attributes which are mentioned relatively often in previous research are considered as 'more likely influencing to the partnership'. Second, by compressing the magnitude of the attributes list, a more clear and concrete list of repeatedly proven influencing attributes is created. An extra advantage is the magnitude of the questionnaire, wherein the attributes are examined. By reducing the number of attributes, the length of the questionnaire will decrease and finally lead to relatively more convenient filling in of the questionnaire. The reduction of the list of possible influencing attributes is realized by the following steps:

- Out of twenty attributes, thirteen attributes are selected as influencing attributes in at least three previous conducted studies of the conducted research comparison. [13 attributes]
- Three other attributes of these thirteen are also excluded. The attribute *'Appropriate risk allocation and sharing'* and the attribute *'Flexibility in risk sharing'* are overlapping to be researched risk and benefit division, which will be included in the risk and benefit division methods which will be later explained. The attribute *'The long time span of the project'* is obviated by the set case description in this study and thus also excluded. As starting point, a long-term partnership (ca. 10 year) is set where this attribute will be irrelevant to research as such in this study.

In Table 4.1, an overview is provided of the ten selected attributes which will be further researched as *possibly influencing attributes* to the collaboration aspect.

Table 4.1 Final selection of 'possible influencing' attributes to the partnership (Content analysis)

Obtained attributes from previous research (10) :	Kyei & Chan; 2015	Zou, Kumaraswamy, Chung & Wong; 2014	Hwang, Zhao & Gay; 2013	Rahman, Endut, Faisol & Paydar; 2013	Shen & Tang; 2013	Rowlinson & Cheung; 2011	Tang, Shen & Cheng; 2010	Grasman; 2009	Smyth & Pryke; 2008	Chen & Chen; 2007	Ghauri & Crespin-Mazet; 2007	Akintoye & Main; 2007	Stanley, Fawcett, Ogden, Magnan & Cooper; 2006	Cheung, Yiu & Chim; 2006	Consoli; 2006	Suen, Wong, Ng & Cheung; 2003	Total
Trust between the partners	x	x		x	x	x				x	x	x		x	x	x	11
Commitment of all partners	x	x	x		x	x				x	x	x	x			x	10
A proper communication (model) between the partners	x			x	x	x	x			x	x	x			x	x	10
Confusion of objectives (clear and consistent objectives)		x	x	x	x			x		x	x	x			x	x	10
Good and improved (existing) relationship within the partnership		x				x	x		x			x		x	x		7
Support and commitment of top management level		x				x				x		x	x			x	6
Similarities in organizational vision and culture						x	x			x	x	x					5
Transparency and sharing of information during the project				x				x		x	x						4
Strong market parties within partnership	x		x		x		x										4
Every element should be described in detail in a contractual agreement				x			x									x	3

Translation of attributes

Based on the selection of the attributes, all attributes will be compared in a later stage by their influence to the partnership, based on the opinion of the selected respondents. In order to compare the influences of the attributes, it is important whether or not they are positive or negative influencing. By translating the attributes as all either positively influencing or all negatively influencing to the partnership, the influence is appointed in the same direction. Most of the attributes are described as positively influencing; the given negatively influencing attributes are translated into a positive influence. By directing the influence all positively, the influence can be more easily quantitatively determined by the respondents. The questioned rate of influence (all positive) by the consulted respondents, will so be comparable.

4.2.2 *Performance-based scenarios determination*

The aim of this research is to give insights into the optimization of the collaboration within a set partnership composition. This partnership will exist of private market parties, in order to answer the request of municipalities to make their property more sustainable. Answering this request by market parties could be conducted in plenty of manners. In this research, the decision is made to create different scenarios, to analyze and give insights in the improvement of the successful collaboration of these partnerships. The Input process of determining the different scenarios, which will be relevant to analyze, is given in steps in Figure 4.2 and will be explained further.

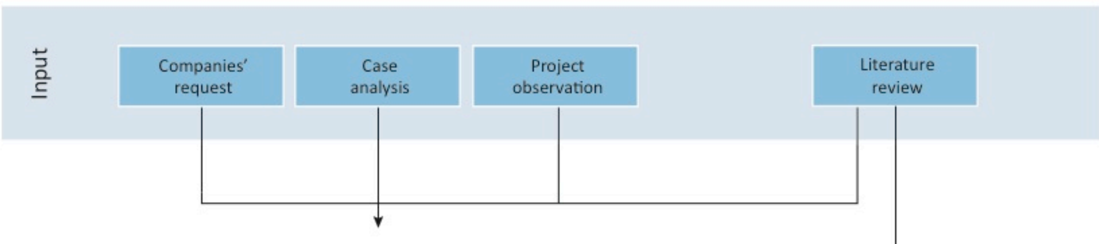


Figure 4.2 Research Model phase 1 | Input

In order to determine which particular scenarios will be researched, three steps are underlying to the scenario determination (draft version). These steps are subdivided in the '*Request of the company Royal HaskoningDHV*', '*Case analyses*', and the '*Process observation of a similar project case*'.

Companies' request

The companies' request is the underlying reasoning for the problem statement of this research (Chapter 1.3 *Research problem definition*). Subsequent to the problem statement, the vision of the company is important to create the scenarios for this research. The companies' vision of the market developments and new opportunities will function as input for the scenarios. Relevant implemented aspects for the creation of the scenarios are:

- The company Royal HaskoningDHV is looking for opportunities where new earning models could be introduced. Their role in projects is mostly derived from their engineering and/or consulting role they normally have.
- In the current market, the performance delivered will be more relevant than 'just finalizing a project'. Performance contracting could lead to a different role and acting within the project, and probably also to a different elaboration of the risk and benefits models. This makes performance contracting relevant to research further. Both following the problem statement in this research and the vision of the company.
- Within the field of performance contracting, new developments are arising in the current market. For example, *Energy Performance contracts* are already occurring more often. The demand for performance based contracting in the market is growing in both, number and scope. Building performance, energy performance, and comfort performance are examples of partially actual and possible new performance demands in the market.
- The company is currently involved in a project to improve the corporate real estate of a municipality in a sustainable way. This request of the municipality is taken into account by creating the problem statement of this research. This is given as starting point, where possibly future similar projects (for municipalities) will be conducted. Including a similar type of partnership in this research will provide possible insights in order to anticipate to in future similar projects.

Case analyses

The company Royal HaskoningDHV also provided insights into the analysis of previous projects. Three cases have been analyzed. By analyzing the cases on the decision making process within the partnership and the associating points of consideration, insights are obtained for the creation of the scenarios.

The analyzed results of these cases function as input for the design of the different scenarios. These scenarios will be given and comprehensively explained in the following paragraph.
The selected cases consist of relatively similar components as in the scope and problem statement of the current research. In order to provide insights in the suitability of the case analyses in this research, a brief overview of the similarities of the used cases in comparison to the current research are summarized as follows:

- An important objective in each case is to improve the real estate property of, for example a municipality. Sustainability is a key element by upgrading the properties in the different cases.
- In these cases, a long-term partnership is given as starting point between the municipality and a market party. This could be the single company of Royal HaskoningDHV, or a combination of market parties (consortium).
- Within the long-term contracts, the inclusion of performance-based agreements is considered. This performance-based partnerships are initiated for a longer period of time between the involved parties, where they agreed upon to deliver a set (energy) performance. This is different when compared to a more traditional model of client-contractor. Traditional models are more effort-based where performance contracting is more related to the value it will provide for the customer (certainty). In these cases, aspects like the *Total Cost of Ownership* (TCO) for example are more considered, where performance based contracting will possibly introduced.
- Within these cases, the consideration is made between different models of '*Risk & Benefit division', which* will be used in the current research. Specifically this risk and benefit division is an important discussion aspect when including performance-based contracts.
- The mutual responsibility for performance-based output is in these cases an arising point of consideration and discussion. This is given as related to the responsibility division and the (common) associating risk and benefit division.

Further more, based on these cases, several input elements are retrieved to implement into the created scenarios. The most important results retrieved of these case analyses are given as follows:

- Performance-based components (e.g. *energy performance)* could provide possibly proper solutions regarding the requested cost savings in the current market. An additional effect of performance based contracting, will be the risk decrease for the client by agreeing on a performance, which should be delivered by the market parties.
- Based on the performance elements, the role of an engineer/consultant could be important regarding the *Design* of the Real Estate improvements. However, in order to provide a solution for the requests in the provided cases, collaboration with other market parties is essential. The involvement of a contractor, and possibly a company which deals with (sustainable) energy solutions for instance, are possibilities to consider in forming a certain partnership.
- A long-term partnership is probably necessary in order to realize the above mentioned performance elements by the collaboration of the different types of market parties. Besides, it will stimulate to consider whether to make extra improvements (e.g. new sustainable or innovative solutions) during the time span of the long-term partnership.
- Risk and benefit division is an essential element within the collaboration agreement terms in the previous cases. There are different possibilities to divide the risks, where two risk and benefit division methods are highlighted in order to possibly improve the collaboration aspect during a long-term partnership. First, a division of the risks and benefits is based on the share each involved party has within the total project. Second, an (more) equal risk and benefit division will make the involved parties more interdependent of each other's decisions and actions. This could possibly lead to a higher level of involvement and improvement of the coherent decisions and actions. Third, a more 'traditional' way of dividing risks and benefits could be considered, where all risks are divided (as much as possible) between the involved parties, by detailed contractual agreements. Following the considered risk and benefit division methods, a mutual responsibility is given as possibly (positively) influencing to the performance of the partnership.

Project observation

The company Royal HaskoningDHV is involved in a project, which will function as important input for this research. This project is in accordance with the problem statement where the request of a municipality in the Netherlands is asking for, among others, the sustainable improvement of their (corporate) real estate. This project will be conducted by a cooperation of three parties in the form of a consortium: a contractor, Royal HaskoningDHV (as engineer/consultant), and an energy supplier. As researcher, observations are made in the weekly meeting sessions, during a 3-month period. This to get insights in the decision making process, the points of consideration of the consortium, and the points of consideration from the single perspective of each party. By analyzing the decision making process in this project, input is gathered for the scenario outline in this research.

Components of scenarios

For this research, the scenarios are based on the three previous explained methods to obtain the relevant input: the companies' vision, process observation of a similar project, and case analyses. This results in a draft version of the components combined in different scenarios, following the process in Figure 4.3.

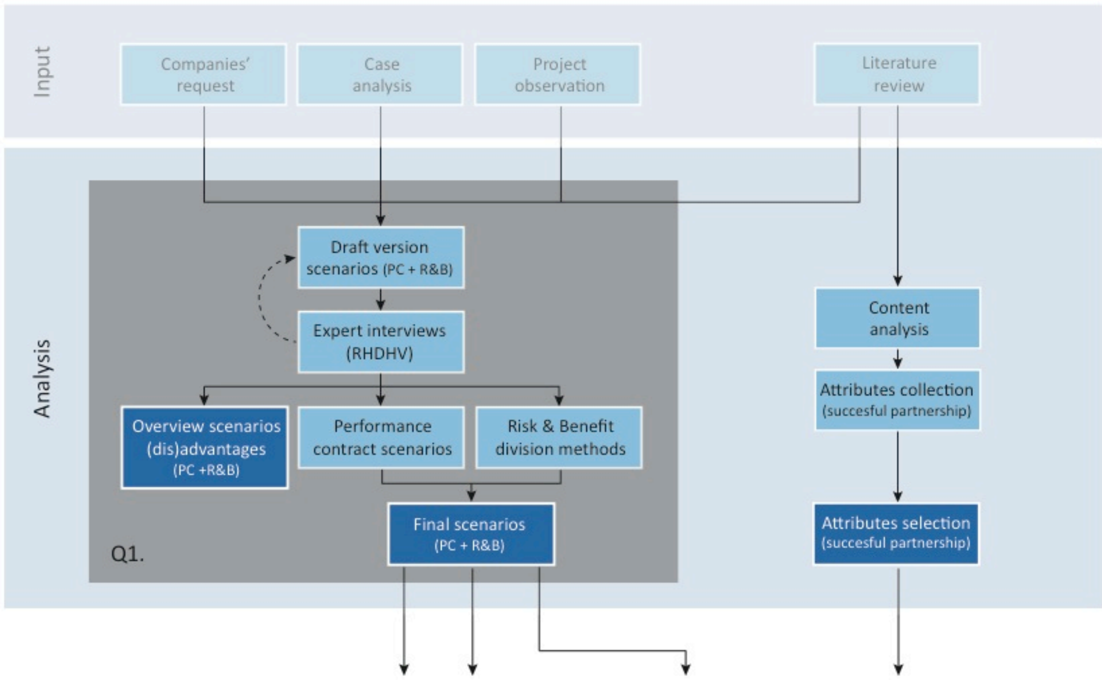


Figure 4.3 Research Model phase 2 | Analysis

Important for the creation of the scenarios is that they are distinguishing obviously. This is necessary to obviate the interpretation deviations. Besides, the final conclusion of this research could be more reliable linked to the elements of the scenarios. The scenarios will distinguish in two main components: performance-based elements (contracts) and the associating mutual risk and benefit division. Before explaining the components of the scenarios, some starting points for the scenarios will be given. These starting points will count for every provided scenario situation in this study.

As given in Figure 4.4, a division of the roles and associating responsibilities in the project partnership is made. This figure (4.4) provides the starting point for each scenario, which consists of four triangles. The three triangles at the outside refer to the main responsibility for a single party. This means that *Build* will be assigned to the contractor, the *Design* to the engineer/consultant, and the (sustainable) *Energy supply* components to the energy supplier. This division of responsibilities will count for each created scenario. Based on the case three previous described analyses methods (companies' vision, case analyses, process observation of a similar project), the division of these three responsibilities (*Build, Design, (sustainable) energy supply)* properly applicable in the given research case. This is arising from the 'responsibility elements' as part of the municipalities' request. By assigning these three components to the three different types of companies, the three parties are all responsible for a main component of the given municipalities' request.

The triangle in the center of Figure 4.4 represents the performance-based outputs, for which a mutual responsibility will apply. Based on the vision of consulted the experts

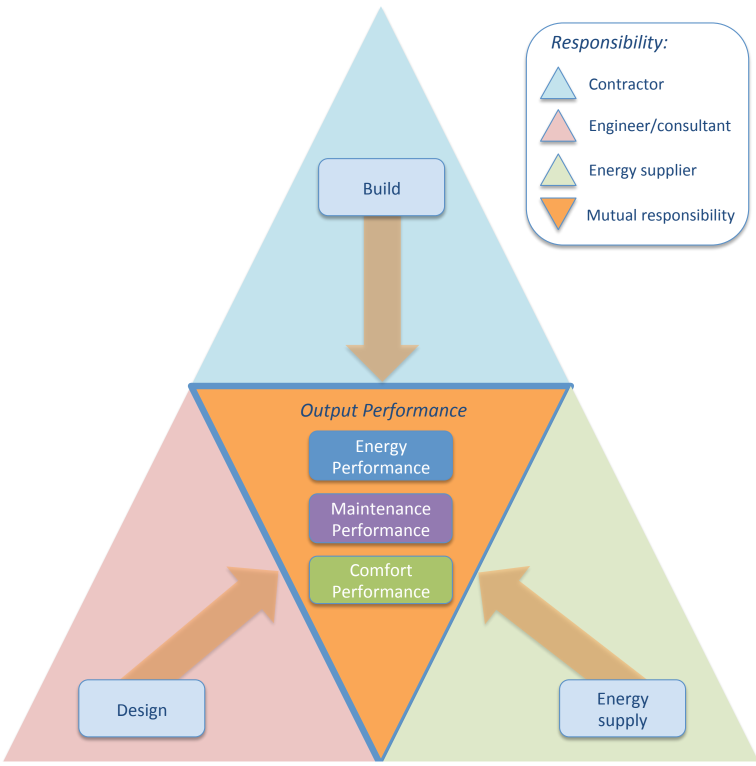


Figure 4.4 Responsibility division consortium

(experts RHDHV, 2015), the scenarios will contain three different combinations of the given performance contracts. This results finally in three different created scenarios, based on the performance-based components.

Arising from the problem statement, the implementation of performance contracting in the scenarios leads to more insights in the possible way of acting for the different involved parties when performance contracts are implemented. By including *Energy Performance*, *Maintenance Performance*, and *Comfort Performance*, three important recent performance contract developments are included which will be further discussed in next paragraph. These three performance components (contracts) are forced to a proper collaboration between the involved parties. For these performance contracts, the *Design, Build*, and *(sustainable) Energy* components are integrated and essential in order to realize a certain (set) performance output. This will make the collaboration of these three types of parties highly suitable in order to answer the municipalities' request. The coherence between these components *(Design, Build, (sustainable) energy supply)* to realize the set performance output *(Energy, Maintenance, and Comfort)*, asks also for coherence in the collaboration between the involved parties.

Performance contracting

As given in Chapter 1.3 *Research problem definition*, researching performance based contracting by including this in the scenarios could provide insights to this market opportunity. The selection of performance-based components is based on previous research, vision of experts (experts RHDHV, 2015), and the possibilities to anticipate to the given request of municipalities (Chapter 1.3.1). A division is made between three different performance output deliverables which will be further explained: *Energy Performance, Maintenance Performance* and *Comfort performance.*

Energy Performance is concerning the performance agreements of the energy related aspects, during the time span (long-term) of the contract. The energy performance is highly related to the aspects of Design and Operate, which are highly influencing the feasibility of the agreed performance. As given by the experts, influence to the *Design* and *Operate* element is essential to deliver and control a set energy performance. *Energy Performance Contracting* could be explained in a more extended form, focusing to the funding of upgrades to improve the energy level. This funding is based on the cost reductions realized by energy savings in an early stage, where after more investments could be realized regarding new energy savings (Institute for Energy and Transport, 2015). As given by the experts, this will possibly lead to reinvestments during the long-term partnership in order to improve the energy performance. The implementation of new innovations in order to improve the energy performance, will be more essential and feasible. This because of the inclusion of the TCO principle where reinvestments in innovative solutions could lead to a cost reduction over the total life span of the project partnership.

A *Maintenance Performance* contract is an agreement about the quality level of the building components (including installations). This will be mainly regulated by the implementation of maintenance activities, in order to realize the set level of quality for the building components. These set performance to deliver could be expressed in for instance, the level of quality by maintenance activities for installations for instance (condition of installations), and costs regarding the maintenance activities (e.g. (Thijssen, 2013). Maintenance performance is a performance-based contract which is frequently linked to the *Energy Performance Contract*; this because of the influence maintenance activities have to the energy consumption (Roskam, 2013). The installations which are installed and the measurements in order to deliver a certain building performance, are important for the associating maintenance activities.
By including *Maintenance Performance* into the performance-based scenarios for this research, the level of control to the installations will increase. The decisions making process within the previously given main responsibilities (*Design, Build*, *(sustainable) energy supply)* is important regarding the level of control to the performance output. Following the experts of RHDHV (experts RHDHV, 2015), an energy performance contract will be highly recommended to expand with maintenance activities by set performances to deliver. Mainly regarding other building performance components, by for instance implementing *Comfort Performance*, the control and maintenance performance becomes more essential. By having a set maintenance level, the balance between the other performance-based outputs in combination with the set maintenance level, will be secured. By having only a high priority to the energy performance for example, this could lead to insufficient priority to the quality level of the building components (installation e.g.) or could possibly lead to relatively high maintenance costs for the client.

By including *Maintenance Performance*, an improvement of the manageability of installations could be realized, mainly in a long-term partnership. Besides, the implementation of for example a 'Total Cost of Ownership' approach, could lead to a better decisions regarding, among others, the *Design* and *Build* decisions. For instance, the selection of installations could take costs for maintenance activities into account. These decisions are forthcoming from the interdependent decision-results for the three given main components *Design, Build, and (sustainable) Energy supply*.

Comfort Performance is a more recent development regarding the performance-based agreements in the construction sector. Comfort is a factor which is important for both, the building owner but mainly the user of the building. The difference is that comfort mainly will be noticed by the user instead of the building owner. Of course is this only the case when the building owner and consumer are two different parties. Comfort performance in buildings will be mainly based on the suitability of the comfort level to the expectations and behavior of the user, where these expectations are increasing nowadays (O'Brien & Gunay, 2014). This is substantiated by the experts (experts RHDHV, 2015) who are adding that implementation of a comfort level will achieve the objective of an increased productivity of the employees (users). Thus this comfort for employers is given as important aspect, regarding the work environment in buildings. The improvement of effectiveness and productivity (experts RHDHV, 2015; (DGMR, n.d.)) by increasing the comfort level, is determined in previous research in distinctive comfort-elements. As given by Ioannou et al (2015), the comfort aspect is mainly influenced by the behavior of the consumer and concerns the climate and ventilation inside the building (Ioannou & Itard, 2015; O'Brien & Gunay, 2014). Castilla et al (2014) defines the comfort performance into buildings, as *Thermical comfort*, *Visual comfort*, and *Indoor air quality* (Castilla, Alvarez, Rodriguez, & Berenguel, 2014) which are also considered as main components by the experts (experts RHDHV). The definition of comfort is derived from the given thermal comfort definition by Fanger (1973), and is described as: "*That condition of mind which express satisfaction with the (thermal) environment"* (Fanger, 1973; Castilla, Alvarez, Rodriguez, & Berenguel, 2014). As Castilla et al (2014) argued, the condition of mind and satisfaction will influence the comfort experience (Castilla, Alvarez, Rodriguez, & Berenguel, 2014).

As given by the experts (experts RHDHV) and derived from previous research (e.g. (Ioannou & Itard, 2015; O'Brien & Gunay, 2014; Castilla, Alvarez, Rodriguez, & Berenguel, 2014), the components concerning the comfort level are here given as: the climate control (heating and cooling), the lightning, and the air control (e.g. air composition and ventilation). By including the comfort element by a performance based contract, the influence to the different project phases (*Design, Build, etc.)* will be relatively high, as given by the experts.
As result of the expert interviews, the comfort performance is a next step ahead in the performance based contracting within the construction industry (experts RHDHV). By increasing the comfort level, the satisfaction and finally the productivity of the employees will increase. Based on the experts opinion and previous research (e.g. (World Green Building Council, 2014), the comfort performance will lead to possible high cost reductions, also based on the satisfied and productive employees. Around 90% of the companies' expenses are concerning the employee costs, which makes a small productivity improvement already a relatively large cost reduction (World Green Building Council, 2014).

Providing the comfort performance component in a project could lead to an added value to the client. This added value is mainly referring to the certainty it provides (experts RHDHV). When you are able to properly anticipate to this as market party, this (future) market opportunities could be answered (experts RHDHV). By including performance-based components into the scenario research, the exploration to this (relatively new) market opportunities could lead to additional added value for the client, as municipality for example.

Combinations of the three set performance components will lead to different scenarios and probably a different way of acting of the involved parties. As important element of the performance based components, the performance-based output asks for a mutual responsibility of involved parties.

Risk & Benefit division

The last component for the scenario creation is the mutual risk and benefit division between the involved parties. Based on the case analyses and the expert interviews (experts RHDHV, 2015), the risk and benefit division is expected to be an important element in the collaboration within the partnership. The performance-based components could bring up higher and different risks (e.g. delivering performance output) for the responsible parties, in comparison to non-performance based components. By linking the risk and benefit division to the different performance based contracts, the relation of these division methods to the scenario components will be established. As explained by Figure 4.4 *Responsibility division consortium*, only the risks and benefits of the performance-based output will be divided. In general, the risk and benefit division could be given as (experts RHDHV):

- All responsibilities and associating risks and benefits will be traced back and assigned as much as possible to each party, who is (made) responsible for this. This is given (experts RHDHV), as a common occurring situation and considered as more 'traditional'.
- The performance-based output (performance contracts) could be assigned as a mutual responsibility. This mutual responsibility of the performance-based output leads to an associating mutual responsibility of the risks and benefits. Following the experts (experts RHDHV), this will possibly lead to changes in the way of acting of the involved parties within the project and their cooperation.

As result of the case analyses and the expert interviews (experts RHDHV, 2015), the risk and benefit division methods will be relevant to research, when focusing to the mutual responsibility. This will exclude the more 'traditional' risk and benefit division for this research, as explained before. Included in this research, the focus to the relational and collaborative aspect will possibly be influenced by the mutual risk and benefit division. By the inclusion of mutual R&B division methods, experts (experts RHDHV, 2015) consider this as relevant for further research.

Two methods are set (case analyses and expert interviews) to divide the associating risks and benefits of the performance based output. An important remark to the risk and benefit division methods is, that this will only concern the performance-based output. The risks of the other components (e.g. design and build) are assigned to the associating responsible party, based on the responsibility for execution. The two R&B division methods (A and B) are given (experts RHDHV, 2015) as suitable, regarding only the performance-based output. As obtained from the case studies and the analysis of the expert interviews (experts RHDHV, 2015), advantages and disadvantages of this division methods regarding the performance contracts, will be given in Chapter 4.4 *Results*.

Risk and benefit division Method A

The first risk and benefit division method included in this research is an *equal risk and benefit division*. This means that every party gets *'an equal part of the pie'*, as illustrated in Figure 4.5.

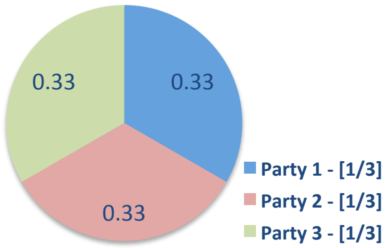


Figure 4.5 R&B division Method A: *equal division of risks and benefits (1/3)*

Risk and benefit division Method B

The second method included in this research, is a *risk and benefit division based on the share (%)* in the project. The most occurring division is the percentage (%) share of each involved party, in the *total turnover* of the consortium. An illustration of a risk and benefit division example based on the share in turnover, is given in Figure 4.6.

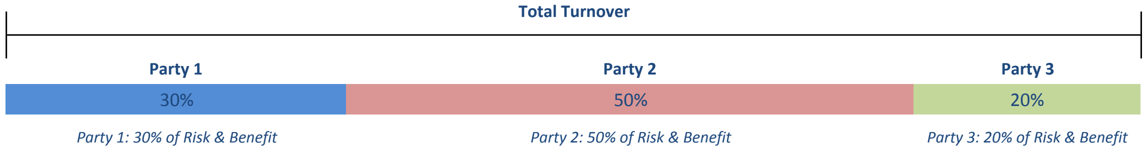


Figure 4.6 R&B division Method B: division of risks and benefits based on share (%) in total project turnover

Within this example (*fictive figures*), each party has a different share in the total turnover for the consortium which leads to a specific ratio in share. This ratio will indicate the division of the risks and benefits, of the components with a mutual responsibility between the involved parties.

Validation of scenario components

Different experts of the company Royal HaskoningDHV are consulted to provide their vision to the described components. This will contribute to the validation of the created performance-based scenarios. As remark, it will be clear that the given scenarios will not be the only possible possibility for implementing performance contracting and certain risk and benefit division methods. As result of the analyzed opinion of the experts (experts RHDHV, 2015) and the case analyses, the three performance-based scenarios will be considered as suitable for this research and relevant to study further. The expert interviews are not only conducted for the validation after creating the scenarios, but functioned also as input during the scenario creation. The scenario creation could be considered as an iterative process of delivering input and validation. This is the reason that the results of the expert interviews are taken into account in the previously described process to create the scenarios.

4.2.3 Scenario description

Based on the previous explained analyses, three performance-based scenarios are created for this study. As addition to the three performance-based scenarios, two different methods are initiated to divide the risks and benefits. These risk and benefit division methods are only regarding the performance output. The combination between the three performance-based scenarios and the two different R&B division methods leads to six possible scenario outcomes.

Based on the previous analyses, the scenarios are concerning the inclusion of performance contracting opportunities. Three types of performance contracting are included regarding energy, maintenance, and comfort. Based on the vision of the experts (experts RHDHV, 2015), the three performance-based scenarios could be seen as a flow model from a basic *energy performance* contract to a total and more complex model with *maintenance performance* and *comfort performance* included. The three performance contract scenarios are given in Figure 4.7.

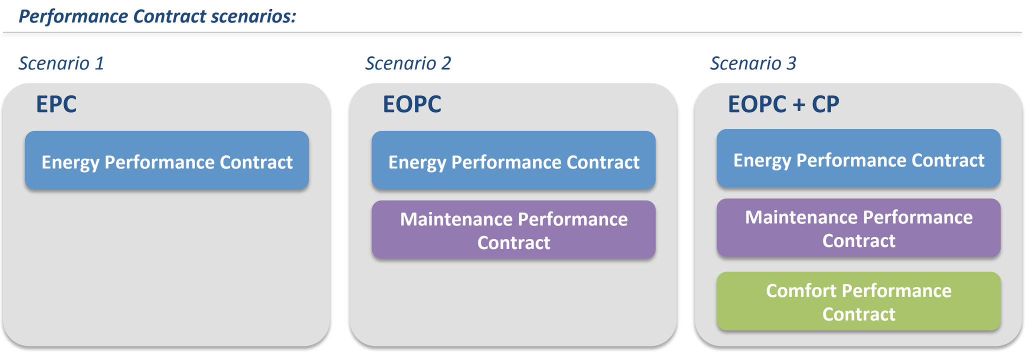


Figure 4.7 Performance contract scenarios

Scenario 1 includes the *Energy Performance contract*, and is set as 'minimal' scenario for this study. This could be expanded by the maintenance component which will provide, among others, more (maintenance) control to the performance of building installations (Scenario 2). Scenario 3 includes the *Comfort performance* element combined to the other two performance components (*Energy* and *Maintenance*).

Each scenario is indicated by the abbreviated associating contract term, given as EPC, EOPC, and EOPC + CP:

- Scenario 1 **EPC** *Energy Performance contract*
- Scenario 2 **EOPC** *Energy Performance and Maintenance Performance contract*
- Scenario 3 **EOPC + CP** *Energy Performance, Maintenance Performance and Comfort Performance contract*

The abbreviated contract term is commonly used in practice, which will lead to a better understanding by describing the different performance-based scenarios. Performance constructions like EPC and EOPC are commonly occurring concepts, where *Comfort performance* agreements are relatively new in the construction industry.

Figure 4.8 gives a brief overview of the different performance contract scenarios in combination with *Method A* (equal risk and benefit division) and *Method B* (risk and benefit division based on the share (%) in project turnover). Following these two methods, a decision could be made about the risk and benefit division (of the performance output), which will be implemented in the three different performance-based scenarios. From now on the risk and benefit division (R&B) methods will be named as:

- *Method A* | Equal division of risks and benefits (1/3)
- *Method B* | Division of risks and benefits based on share (%) in total project turnover

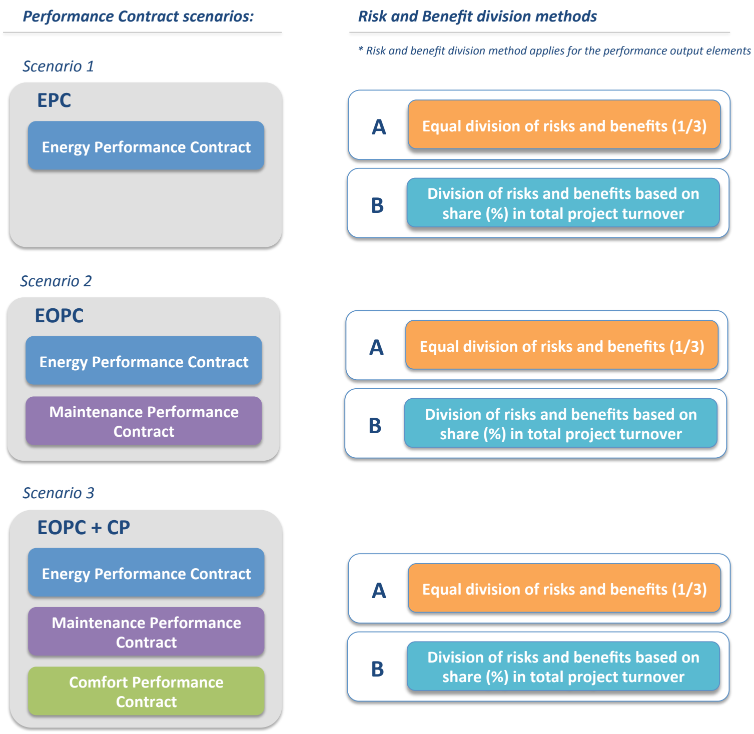


Figure 4.8 Performance contract scenarios and R&B division methods

Following the previous analysis, a few starting points (input related) are set which are fixed in each given scenario:

- In each scenario, the consortium consists of three parties: a contractor, engineer/consultant, and an energy supplier
- The responsibility for the *Build* component will be assigned to the contractor, the *Design* component to the engineer/consultant, and the (sustainable) *energy supply* component to the energy supplier. This will count for all elements included in a possible project case, including the performance-based elements.
- The given risk and benefit division methods are only regarding the performance-based output. This means that the risks of the regular *Design* and *Build* elements in the project case for example, are assigned to the associating responsible party.
- The risk and benefit division methods for the performance-based output are limited to the two given risk and benefit division methods (A and B).
- An important element in performance contracting is the level of control to this performance. As starting point, operating and monitoring will be present and will be the consortiums' responsibility.
- Following the given scope (Chapter 1.3.1), this research focuses to the different performance-based scenarios (including R&B division methods) in relation to attributes which are possibly influencing the collaboration aspect. The exact (financial) business case and possible consequences to this will be out of scope and thus excluded in this research, apart of the set assumption that this business case will be feasible. Inclusion of the financial business case regarding this study is further explained in Chapter 4.5.2 *Further Research.*
- The scenarios are based on a long-term agreement (ca. 10 years), where an agreed performance output should be delivered. Apart of this, the partnership between the consortium and the municipality and possible consequences to this will be out of scope and thus excluded in this research.

4.2.4 Fuzzy Delphi Methodology

The Fuzzy Delphi Methodology is applied in this research to research the influences of the attributes to the different set scenarios consisting of performance contracts and an associating mutual R&B division. First a better understanding of the Delphi methodology and the Fuzzy Theory, combined as Fuzzy Delphi Methodology (FDM), will be given. Second, the application and suitability of this methodology will be discussed. Thereafter the analysis model by FDM, as included in this research, will be described. In order to provide a better understanding of the application of the Fuzzy Delphi Methodology in this research, the research model is (partially) shown in Figure 4.9.

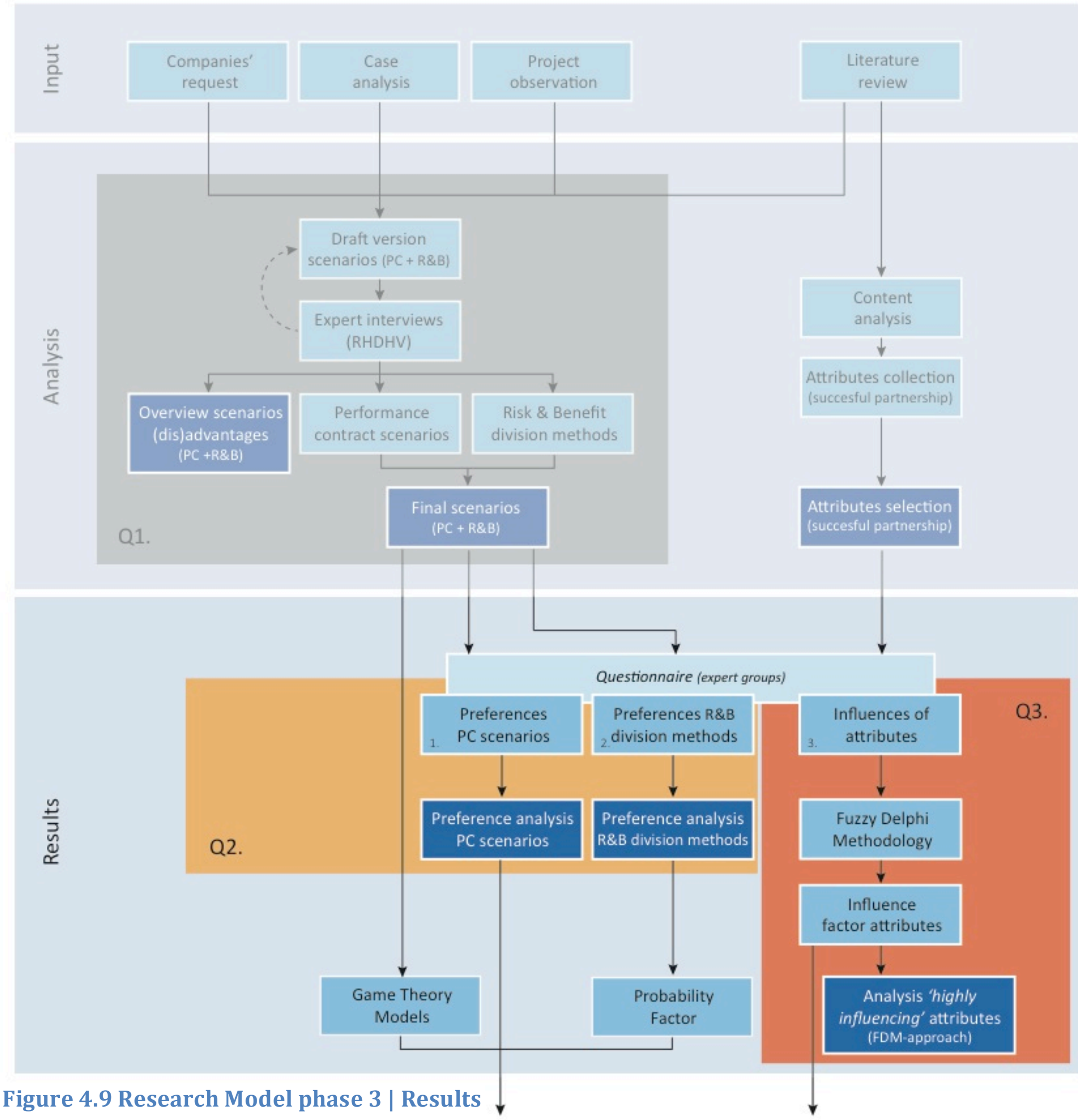


Figure 4.9 Research Model phase 3 | Results

Background of the Fuzzy Delphi Methodology

The Fuzzy Delphi Methodology is an analyzing technique which is based on two different methodologies. These two methods are the Delphi methodology and the Fuzzy Theory (Glumac, Han, Smeets, & Schaefer, 2011; Damigos & Anyfantis, 2011).

The first methodology is the Delphi method, which is a structured approach of collecting data by the opinion of experts, in the form of a questionnaire (Damigos & Anyfantis, 2011). Important in this Delphi methodology is the judgment of attributes or variables, where experts give their opinion independently of each other. As given by Damigos et al (2011), the Delphi method is applied in several fields of studies like health research, world events, and real estate e.g. (Damigos & Anyfantis, 2011). Delphi methods are applicable in various situations and are given as a useful methodology regarding the estimations of involved experts. This method will contribute to the decision making process. Nevertheless, some downsides are given in previous research and should be taken into account. The opinion of the experts is the base of this methodology; hence, the results are relatively dependent on the specific judgment of the experts. Another point of consideration that should be taken into account is the degree of expertise the respondents have (Damigos & Anyfantis, 2011). These two drawbacks will be obviated in this research by selecting experts who are representing their own type of company. This ensures that the opinion of the 'experts' is relatively in line with the involved companies and makes the results less dependent on the personal perspective of a single expert.

As second, the Fuzzy theory will be applied in the Fuzzy Delphi Methodology. The Fuzzy theory is applicable to the uncertainties in the problems to research (Damigos & Anyfantis, 2011). The uncertainties attributed to the human element, will be obviated in a better way by adopting this fuzziness (Glumac, Han, Smeets, & Schaefer, 2011). Fuzziness of results is also a derivative of the inconsistency of answering of experts within the similar group. This could lead to a lack of proper consensus in answering and will be better obviated by taken this *fuzziness* into account in this methodology (Glumac, Han, Smeets, & Schaefer, 2011). The main difference in applying *fuzziness* into the Delphi Method, is the use of fuzzy numbers. These fuzzy numbers take the *fuzziness* of the answers of experts into account.
By taking this fuzziness into account in this method, the quality of the questionnaire and questioning will improve, and will lead to a more reliable study and efficiency (Ishikawa, Amagasa, Shiga, Tomizawa, Tatsuta, & Mieno, 1993; Glumac, Han, Smeets, & Schaefer, 2011).

The Fuzzy Delphi Methodology as combined method will be applicable when diversity in answering by the different questioned experts could arise (Jafari, Jafarian, Zareei, & Zaerpour, 2008). This could always occur based on interpretation deviations of descriptions and questioning in de questionnaire. This possible deviation in answering is also underpinned by Glumac et al (2011), where uncertainties are leading to fuzziness in answers (Glumac, Han, Smeets, & Schaefer, 2011).

Application of Fuzzy Delphi Methodology

The Fuzzy Delphi Methodology (FDM) will be applied in this research to determine the influences of the attributes to the different set scenarios consisting of performance contracts and an associating mutual R&B division. The influences of these selected attributes are proven in previous research, but reanalyzing will be necessary to improve the reliability by determining the suitability of the implementation of these attributes in this research. As given in the Literature Review (Chapter 3.3.2), the reasons for reanalyzing the influences is based on the deviations between this research and the studies included in the research comparison. These studies are used in order to derive the possible influencing attributes, but could deviate in focus region, cultural aspects, and deviations in type of partnership (e.g. (Tang, Shen, & Cheng, 2010).

The Fuzzy Delphi Methodology will be suitable for this research because of the expected diversity in answering by the different questioned experts (three groups). This diversity of expert answers could arise from possible deviations in interpretation of the provided research problem knowledge and provided information (Jafari, Jafarian, Zareei, & Zaerpour, 2008). The *fuzziness* of the answers within the group of experts (respondents), could be processed by this methodology. By making use of the Fuzzy Delphi Method, the most important advantage is that it takes this 'fuzziness' into account of the different expert groups, which are involved in this research. Taking the 'fuzziness' into account will be important in this study, because of the description and room for interpretation of the influencing elements. By making use of this methodology a more reliable and improved quality of the questionnaire and questioning will arise, in a more efficient way (Glumac, Han, Smeets, & Schaefer, 2011; Ishikawa, Amagasa, Shiga, Tomizawa, Tatsuta, & Mieno, 1993). The final result of applying the Fuzzy Delphi Method in this research will be the final processed single values for each attribute influence, determined by each involved group (three groups).

Calculation model of Fuzzy Delphi Methodology

The application of the Fuzzy Delphi Methodology in this research will be discussed in more detail. This will be realized by a comprehensive description of the calculation model which will be conducted after the attribute selection. The calculation model included in this research will be given by four main steps:

1. *Triangular Fuzzy number*
2. *Defuzzification*
3. *Influence factor of attributes*
4. *Assigning attributes as 'highly influencing'*

1. *Triangular Fuzzy number*

Different formulas are in previous research used in the calculation model, in order to take the fuzzy numbers into account (e.g. triangular, trapezoidal, quadratic, etc.). Most commonly, the triangular calculation method is applied

(Glumac, Han, Smeets, & Schaefer, 2011). For this research, the triangular calculation method will also be used. The reason for this is the balance between the collection of as much relevant information as possible, and to keep the questioning easy to understand.

In this research, the maximum-minimum method as described by Ishikawa et al (1993) is implemented in the calculation model of the triangular fuzzy number. This will be established by validating each attribute by experts, by giving three values. The values indicate the possible influence of an attribute in a certain scenario, based on a range (Low and High) and a value which indicates the optimum (Ishikawa, Amagasa, Shiga, Tomizawa, Tatsuta, & Mieno, 1993; Glumac, Han, Smeets, & Schaefer, 2011). Each value should be given between 1 (very low influence) and 10 (very high influence), where Low < Optimum < High:

- *Low value* | This is the lowest value of the range, of which the respondent thinks the attribute could minimal influence the certain scenario.
- *Optimum value* | This is the value, which the respondent considers as optimal influence of this attribute in the certain scenario (between low and high value).
- *High value* | This is the highest value of the range, of which the respondent thinks the attribute could maximal influence the certain scenario.

When a range is determined, based on the minimum influence and the maximum influence of an attribute, an interval of the possible influence is given. This interval consists more information than a single expected value; this will handle the uncertainty in a better way and will improve the reliability of the data processing (Ishikawa, Amagasa, Shiga, Tomizawa, Tatsuta, & Mieno, 1993; Glumac, Han, Smeets, & Schaefer, 2011).

Experts from three different groups (contractor, engineer/consultant, energy supplier) will validate the single attributes, related to their influence in the before mentioned scenarios consisting of performance contracts and an associating mutual R&B division. For each expert group, by making use of the given (3-weighted) values of each respondent, the triangular fuzzy number of each attribute in a certain scenario will be calculated. The overall triangular fuzzy number of an expert group, in a certain scenario and for each specific attribute, will be calculated by a general mean model (Klir & Yuan, 1995; Glumac, Han, Smeets, & Schaefer, 2011). The three values (Low, Optimum, High) determined by the expert groups are functioning as input in the triangular fuzzy number:

- These values indicate the influence of a certain attribute (*j*) in a certain scenario (*s*): X_{jsi}, Y_{jsi}, and Z_{jsi} ; where X is the Low value, Y is the Optimum value, and Z is the High value.
- The triangular fuzzy number T_{jsi} will be given as: $\mathbf{T_{jsi} = X_{jsi} + Y_{jsi} + Z_{jsi}}$;
  with j as the attribute number (1,2,3,...,10); s as the combination of a performance-based scenario (1,2,3) and R&B division method A and B (1A, 1B, 2A, 2B, 3A, 3B); i represents the expert group (P1, P2, P3); and n is the number of respondents in each group (1,2,…, m).
- The overall value of an attribute, which is influencing a performance-based scenario (s) determined by an expert group (i), will be given in Formula 4.1 *Triangular Fuzzy Number*.

Formula 4.1 *Triangular Fuzzy Number*

$$T_{jsi} = X_{jsi} + Y_{jsi} + Z_{jsi}$$

Where,

$$X_{jsi} = \mathrm{Min}_j \{X_{njsi}\}$$

$$Y_{jsi} = \frac{1}{m} \sum_{n=1}^{m} Y_{njsi}$$

$$Z_{jsi} = \mathrm{Min}_j \{Z_{njsi}\}$$

T_{jsi} = Overall (triangular) influence of attribute *j* in scenario *s* determined by respondent group *i*
X_{jsi} = 'Low value' as influence of attribute *j* in scenario *s* determined by respondent group *i*
Y_{jsi} = 'Optimum value' as influence of attribute *j* in scenario *s* determined by respondent group *i*
Z_{jsi} = 'High value' as influence of attribute *j* in scenario *s* determined by respondent group *i*
j = attribute number where *j* = 1,2,3….,10
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
n = Respondents in an expert group where *n* = 1,2,3,…,m
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

2. Defuzzification

By translating the given triangular fuzzy numbers into a *single real number*, the final influence of an attribute (*j*) will be determined. For each scenario (s), for every expert group (i), the influence of each attribute (j) will be determined by defuzzification. The defuzzification will be calculated by a *simple centre of gravity* method (Klir & Yuan, 1995; Glumac, Han, Smeets, & Schaefer, 2011). This formula will be given as follows:

Formula 4.2 *Defuzzification*

$$\alpha jsi = \frac{Tjsi}{3}$$

α_{jsi} = Influence of Attribute *j* in scenario *s*, for expert group *i*

T_{jsi} = Overall (triangular) influence of attribute *j* in scenario *s* determined by respondent group *i*

j = attribute number where *j* = 1,2,3….,10

s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)

i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

3. Influence factor of attributes

The calculation of the single real number by the Fuzzy Delphi Methodology results in an overview of the influences of the different attributes. Each calculated influence factor (α_{jsi}) will be based on:

- Performance contract scenario (s) and R&B division methods | 1, 2, 3, and A, B | 5
- A single attribute influence (j) | 1, 2, 3, … ,10 | 10
- Each different expert group (i) | 1, 2, 3 | 3 x

  (where j: Contractor, engineer/consultant, energy supplier) 150

Each performance based scenario will be linked to both risk and benefit division methods A and B. The influence factor should count for the combination between a certain scenario and the division method A and B. This makes a combination of the influence factor of the three performance-based scenarios and the R&B division *Method A* and *Method B*. The given factor of the performance-based scenario will be multiplied with the given factor of the R&B division method. By combining these, the final *influence factor* is calculated for the six different scenario combinations:

- **Scenario 1 A** | **EPC** - R&B division ***Method A*** (equal R&B division)
- **Scenario 1 B** | **EPC** - R&B division ***Method B*** (R&B division based on % project turnover)
- **Scenario 2 A** | **EOPC** - R&B division ***Method A*** (equal R&B division)
- **Scenario 2 B** | **EOPC** - R&B division ***Method B*** (R&B division based on % project turnover)
- **Scenario 3 A** | **EOPC + CP** - R&B division ***Method A*** (equal R&B division)
- **Scenario 3 B** | **EOPC + CP** - R&B division ***Method B*** (R&B division based on % project turnover)

Per given scenario (performance-based and R&B division method combination), an overview of the influence factor per expert group will be given. This will lead to an overview per scenario with the influencing attributes and the specific influence of each attribute to the certain scenario, which consist of the performance contracts and associating mutual R&B division method.

4. Assigning attributes as 'highly influencing'

The obtained influence factors will determine whether or not a certain attribute could be assigned as 'highly influencing' in the given scenarios. A set threshold for the value of the influence factor will determine this. The threshold will be based on previous studies (e.g. (Wu & Fang, 2011; Glumac, Han, Smeets, & Schaefer, 2011)), where a similar Fuzzy Delphi Methodology (FDM) has been applied. In these studies, the influence values are also determined following a 10-points scale. In order to set a threshold applicable for this research, several steps are conducted to determine the ensured threshold:

- Based on previous researches, a determined threshold *(r)* by experts is set as 7,00 (e.g. (Glumac, Han, Smeets, & Schaefer, 2011; Wu & Fang, 2011)) or as 70% (Chen & Chang, 2006). The threshold of *r* = 7,00 (70%) is given by conducting the Fuzzy Delphi Methodology where a scale is implemented between 1 and 10. In this research, a influence scale from 1 to 10 is included, and based on these previous researches, the threshold is accepted as *r* = 7,00 in relation to a scale from 1 to 10.

- The influence factor in this research is translated into a ratio, which indicates the influence of the specific attribute. The ratio is set as a value between 0 and 1, according to the initial values of 1 to 10. This means that the threshold for this study will be set to r = 0,7 per performance-based scenario and risk and benefit division method independently (1,2,3, and A, B).
- The calculation of the ratio for each combined performance-based scenario and R&B division method (1A, 1B, 2A, 2B, 3A, 3B), is based on a multiplied ratio. In order to make the threshold applicable in this research, the threshold will be multiplied as well, according to the calculated influence ratio in each scenario (1A, 1B, 2A, 2B, 3A, 3B). The threshold for the six different scenarios which will be applied in this research will be set as: r = 0,7 x 0,7 = **0,49**;

  This threshold will be used when considering the determined influence of each attribute in the six different scenario combinations. This threshold indicates whether or not an attribute could be given as 'highly influencing', based on the vision of a single expert group.
- This research will also give insights into the attributes which are 'highly influencing', considered by all expert groups together. The threshold will be adjusted according to the combined influences of attributes by all expert groups together: threshold Contractor (P1) x threshold Engineer/Consultant (P2) x threshold Energy supplier (P3), given as r = 0,49 x 0,49 x 0,49 = **0,117649 (+/- 0,12)**

As conclusion of the threshold calculation steps, two important thresholds will be implemented in this study. Attributes are determined as 'highly influencing' for the six different scenario combinations of the performance-based scenario and R&B division methods (1A, 1B, 2A, 2B, 3A, 3B), given as:

- Threshold for each expert group opinion separately: r_{group} = **0,49**
- Threshold for the combined expert group opinion: r_{total} = **0,11765**

In case an attribute indicates a ***lower influence*** value than the threshold value, it does not mean this attribute is not considered as influencing. This is based on the fact that all attributes are to a certain extent considered as influencing (possibly low), as determined in previous researches. In case an attribute indicates a ***higher influence*** value than the threshold value, then this attribute will be considered as *'highly influencing'*, based on previous researches (e.g. (Glumac, Han, Smeets, & Schaefer, 2011))

4.2.5 Game Theoretical approach

Over the years many attempts have been made to approach human decision-making processes in a scientific way. In 1928 John van Neuman developed the formal conception of Game Theory when he published the Minimax Theorem, which is a decision rule for minimizing the possible loss of a worst-case scenario (Schwalbe & Walker, 2001). Together with Oscar Morgenstern (Neumann & Morgenstern, Theory of Games and Economic behavior, 1953) he published the book „Theory of Games and Economic Behaviour" in which they further elaborate on Game Theoretical principles (Schwalbe & Walker, 2001). Another important discovery was realized by John Forbes Nash, who wrote his dissertation 'Non-cooperative game' in which he elaborates on the 'equilibrium problem', which will later be known as the 'Nash-equilibrium'. The Nash-equilibrium describes the moment in which players (expert groups in this research) have chosen their strategy, such that a one-sided adaptation will not yield an improvement of the situation provided that all players act rationally (Slikker, 2014; Osborne, An introduction to Game Theory, 2000). The foundation laid by Neuman, Morgenstern and Nash resulted in the development of Game Theory, which can presently be described as a theorem which deals with decision making processes by different involved players (expert groups in this research).

The suitability of the Game Theoretical approach in this research is given in the previously conducted Literature Review (Chapter 3.4). Main aspects of this are the interdependencies and interactions between the different parties which could be researched (e.g. (Chapman & Corso, 2005; Arsenyan, Buyukozkan, & Feyzioglu, 2015). This interaction between the involved parties and the influence of the chosen strategies by the different parties makes this decision making more complex, where Game Theory could provide a solution (Barough, Shoubi, & Skardi, 2012). The suitability of Game Theory in this decision making process is also named by other researchers (e.g. (Javed, Lam, & Chan, 2014; Kargol & Sokol, 2008))

Starting points for the Game Model creation

The application of Game Theory in this study leads to the modeling of three different games. These games are according to the three performance-based scenarios created, as described in Chapter 4.2.2. The three performance contract scenarios are given in Figure 4.10, and are the basis input and starting point for the Game Theory models:

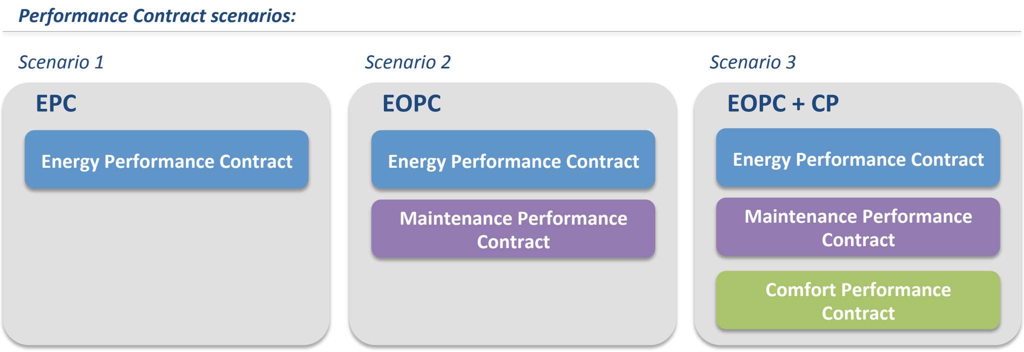


Figure 4.10 Performance contract scenarios

Each different *model* will be based on one of the given three scenarios. Derived of the approach in the research of Eriksson (2007), the payoffs in these models will be determined by the respondents (Eriksson, 2007).

The other starting point is the definition of the 'R&B division methods' that could be chosen in the different game models. Within these models, each expert group (as player) is able to choose between the two different risk and benefit division methods. These different methods are explained before and given as risk and benefit division *Method A* and *Method B* (Figure 4.11). The combination of the three different performance-based scenarios and the two possible risk and benefit division methods leads to six different combinations.

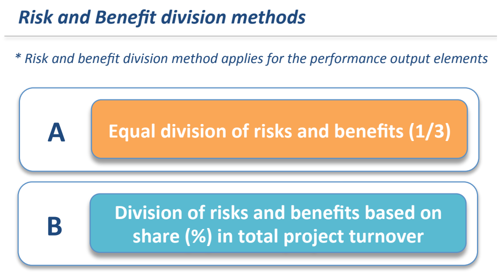


Figure 4.11 R&B division Method A and B

Within the game theoretical modeling, a three-player model will be used. Each expert group (player) has the possibility to choose between *Method A* and *Method B*. This leads to a 2 x 2 x 2 model, given as follows in Figure 4.12.

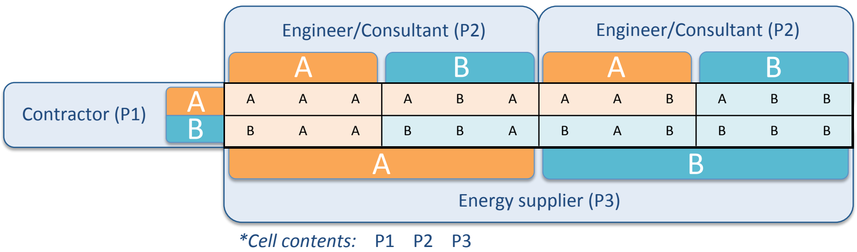


Figure 4.12 Three-player Game Theoretical model (2 x 2 x 2)

The given 2 x 2 x 2 game model has *8 outcomes* that are corresponding to the combination of the chosen risk and benefit division method of the different expert groups (players). Each cell *outcome* (Figure 4.12) could be expressed in eight different combinations, which are named as a *set* (Osborne, An introduction to Game Theory, 2000).

Payoff determination

The *payoff* and the *outcome* in Game Theory differ from each other. The outcome is influenced by the behavior of the players (expert groups here), where they have chosen their specific method decision. The outcome is the combined decision, named as '*strategy*', of what the players together represents (Samsura, Krabben, & Deemen, 2010; Peters, 2008). The payoff (value) is subsequent to this outcome and indicates the importance and value for the expert group what it received after the game has been played. In this study, the expected payoff is given as a preference value, which will be determined by the representing expert group itself.

The eight different combinations of the chosen methods (A and B) by each expert group, will lead to a certain payoff for each individual (type of) party. The payoff is given as the preference value of the decision maker in the game (Osborne, An introduction to Game Theory, 2000). Players are rationally willing to yield their highest payoff (Osborne, An introduction to Game Theory, 2000). This means that each player is acting and choosing the strategy set which is in accordance as much as possible to their preference. Based on this aspect, the theory of rational choice will apply, and is given by Osborne (2000) as follows: *"The action chosen by a decision-maker is at least as good, according to her preferences, as every other available action"* (Osborne, An introduction to Game Theory, 2000)

The preference value in each *set* (probably) differs for the different involved expert groups (players). As given by Eriksson (2007), the preference could be determined by respondents itself, who are representing the expert groups in this study (Contractor, Engineer/Consultant, and Energy supplier). The involved expert groups as players in this study: contractor, engineer/consultant, and energy supplier, will all have their own determined preference values in the different performance contract scenarios, according to the game models and associating *sets*. By asking these 'players' to their preference value in each different outcome, the respondents could indicate the expected value (pay-off) in a specific situation (Eriksson, 2007).

The outcome of each game model results in a final selected risk and benefit division (*Method A* or *Method B*). The preference of the different expert group for each set of outcome, will possibly be different. Parties could highly prefer a specific division *Method A* (equal R&B division) or division *Method B* (division based on share in project turnover). By applying the game theoretical model, the combined decisions of these expert groups (players) could be modeled. A three-player game is introduced in this study.
Given the vision of the experts (expert RHDHV, 2015), the mutual responsibility will be important in the outcome for a specific risk and benefit division method. Besides, assumed is the willingness of the involved parties to cooperate instead of rejecting the partnership opportunity. Based on these two points, the outcome of the created models will be resulting from the majority rule.
The game models could lead to outcomes A or B, while a single party is not choosing the same risk and benefit division as the final outcome. The majority rule will thus apply, and leads always to an outcome (A or B). The majority rule could apply in a n-Player game, where n > 2 (Neumann & Morgenstern, Theory of Games and Economic behavior, 1953). Derived from this, the 3-player game by implementing the majority rule, leads to a majority when at least 2 players make the same preferable decision (A or B). This assumption is set, because this majority rule leads always to an outcome of the different game models (A or B), as long as there is an obvious preferable decision for each player (A or B).
When transforming this majority rule to the game modeling, the outcome will be determined based on the given decision for each player (A or B) which leads to eight different *set* possibilities (8 combinations). In order to give a better understanding of the majority-rule, the optional sets and outcomes for each game model are given as follows in Figure 4.13.

Contractor (P1)	Engineer/Consultant (P2)	Energy supplier (P3)	*Outcome: R&B division method*
A	A	A	A
A	A	B	A
A	B	A	A
A	B	B	B
B	A	A	A
B	A	B	B
B	B	A	B
B	B	B	B

Figure 4.13 Game Theoretical *sets* and associating *outcome*

Each involved expert group (player) will be represented by a group of respondents (experts) who are working in the representing type of company: contractor, engineer/consultant, or as energy supplier. For each *set* (R&B division decisions combined), the preference value will be calculated for each expert group, by a general mean model, based on the equal perspective of the respondents in each expert group:

Formula 4.3 *Preference Value calculation*

$$U_{si} = \frac{1}{m}\sum_{n=1}^{m} U_{nsi}$$

U_{si} = Utility given as preference value, for scenario *s*, for expert group *i*
U_{nsi} = Utility given as preference value, for scenario *s*, for expert group *i, by respondent n*
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
n = Respondents in a expert group where *n* = 1,2,3,…,m
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Expected Utilization

The given preference of the respondents in each expert group (contractor, engineer/consultant, and energy supplier) could be considered as their preference utilization. This preference as such, will not give a sufficient payoff in these models. Each player (expert group here), considered as rational, is always looking for maximizing his expected utility (Parsons, Gmytrasiewicz, & Wooldridge, 2012). The probability of choosing a R&B division method will be combined to the given preference. This probability is based on whether R&B division *Method A* or *Method B* will be preferred by each expert group (player). The Expected Utility (EU) will determine this utilization, based on the value which indicates the preference value of each expert group. This preference value will be based on the consideration to prefer risk and benefit division *Method A* or *Method B*. Based on previous research (e.g. (Parsons, Gmytrasiewicz, & Wooldridge, 2012) the Expected utilization in this study will be given by formula 4.4.

Formula 4.4 *Expected Utility*

$$EU_{si} = \sum_{i=1}^{3} U_{si} * Pr_s$$

EU_{si} = Expected Utilization, for scenario *s*, for expert group *i*
U_{si} = Utility given as preference value, for scenario *s*, for expert group *i*
Pr_s = The probability factor, for choosing scenario *s*
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

As given in the formula of the Expected Utility, the probability factor will indicate 'probability' of a certain outcome in the game model. This probability factor is derived from the preference in the risk and benefit division methods. This preference is indicated by the respondent groups, expressed in a division of 100% between the two R&B division methods (A and B) in each included performance-based scenario separately. This expected preference is the probability factor for the specific expert group. Based on previous research (e.g. (Parsons, Gmytrasiewicz, & Wooldridge, 2012)), there are three conditions set concerning the probability factor:

- In each game model, the probability factor for choosing a certain R&B division method (A or B) is between 0 and 1 (where 100% indicates factor 1).
- It is not possible to have a probability factor of a certain R&B division method (A or B) which equals 0 or 1, which determines that one division method will not be an option in the game model.
- In each model with the two possible R&B division methods (A or B), $Pr_{sAi} + Pr_{sBi} = 1$ should always apply; where A is risk and benefit division *Method A* and B is *Method B* in scenario *s* of expert group *i.*

The probability factor of the three different expert group (players)' decision *(set)* will be transformed in the mutual probability factor. This will be realized by the given probability factor of each expert group given for each method (A and B) in each included performance-based scenario. For each *set*, the probability factor of the three different expert groups (players) will be multiplied and lead to a probability factor for each specific *set*. This probability factor could be considered as the expected chance for this specific outcome. The probability factor for each set, will be realized by the following formula (4.5), where in this example all expert groups choose *Method A*.

Formula 4.5 *Probability Factor, per set (Example Method A)*

$$Pr_{sAAA} = Pr_{sAi1} * Pr_{sAi2} * Pr_{sAi3}$$

Pr_{si} = The probability factor, for choosing scenario *s*, for expert group *i*
$_{sAAA}$ = in this example, the R&B division *Method A* is chosen by all expert groups, where s = 1,2,3
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

For each of the three performance contract scenarios, a game theoretical model matrix will be created. This model will provide eight different sets and associating outcomes. This will lead to eight different probability factors, according to each set in each game theoretical model. In order to give a better understanding of the determination of the probability factors for each set, an example of this is given in Figure 4.14.

	A	B
Contractor (P1)	0,3	0,7
Engineer/Consultant (P2)	0,1	0,9
Energy supplier (P3)	0,8	0,2

* Fictive figures

	Energy supplier (P3) A: Engineer/Consultant (P2) A	Energy supplier (P3) A: Engineer/Consultant (P2) B	Energy supplier (P3) B: Engineer/Consultant (P2) A	Energy supplier (P3) B: Engineer/Consultant (P2) B
Contractor (P1) A	0,3 x 0,1 x 0,8 = 0,024	0,3 x 0,9 x 0,8 = 0,216	0,3 x 0,1 x 0,2 = 0,006	0,3 x 0,9 x 0,2 = 0,054
Contractor (P1) B	0,7 x 0,1 x 0,8 = 0,056	0,7 x 0,9 x 0,8 = 0,504	0,7 x 0,1 x 0,2 = 0,014	0,7 x 0,9 x 0,2 = 0,126

**Cell contents:* probability factor P1 x probability factor P2 x probability factor P3

Figure 4.14 Probability factor calculation model (example with fictive figures)

Game Theoretical solutions

In other to bring up solutions for the Game Theory models, a three-way approach will be included. This three-way approach will be based on previous research (e.g. (Chiu, 2009; Sönmez, 2014), where these solutions are given as the main concepts to solve strategic games for the involved 'players'. The 'players' in this research are the three involved expert groups: contractor, engineer/consultant, and energy supplier. Based on this, this three-way approach will be considered for this research as applicable, in order to determine the equilibrium in the created games:

- Dominant strategies

  A dominant strategy will be present when a player (expert group in this research) yields the best payoff (for itself), independently the strategy another player will choose. This means that when all players will have a *dominant strategy*, from a rational perspective it will be naturally for each player to choose that strategy. This will lead to the equilibrium of the dominant strategies. (Chiu, 2009; Sönmez, 2014)
- Dominated strategies (iterative elimination)

  A dominated strategy will be present when a player (expert group in this research) has another strategy which yields an payoff at least as good (for itself), independently the strategy another player will choose. When a player has a dominant strategy, the other players' strategies will be dominated. In case a player has no dominant strategy, a dominated strategy could be (iteratively) eliminated in order to exclude this strategy in the game model. By iterative elimination of the dominated strategies, a possible dominant strategy could be found which leads to an equilibrium and game model solution. (Chiu, 2009; Sönmez, 2014)
- Nash equilibrium

  Game Theoretical models will not always lead to a strategy solution based on dominant strategies and the elimination of dominated strategies. Finding the Nash equilibrium could provide a solution for the strategic game. As given before, the Nash equilibrium will occur when none of the involved players (expert groups in this research) will unilaterally change to another strategy, given that the other players will act rationally. (Chiu, 2009; Sönmez, 2014; Slikker, 2014)

4.2.6 Explorative research: 'Success Value' modeling

In order to give insights in the expected success of the collaboration, the influences of the attributes will be linked to the game theoretical results. This will be provided by creating a utility function, where the influence of the attributes to the collaboration is included. As given before, the set problem statement for this study is not focusing to the financial business case. As set assumption, a decent business case will count for each set scenario. The focus in this study will be more to the collaborative aspect, and so taking into account the influences of the attributes to the 'value' a certain performance contract scenario will have for all involved parties. For this study, conclusions to the success of the scenarios will be determined by four elements:

- The preference in the different set performance contract scenarios;
- The probability factor of the preferred risk and benefit division method;

- The influences of attributes to the collaboration aspect of the performance-based scenarios in combination with the risk and benefit division methods;
- The (expected) occurrence of each specific attribute in a new project case.

The utility function based on these four elements, will provide a final utility value which indicates a 'success value' for the collaboration aspect; this for the set performance contract scenarios in combination with the (mutual) risk and benefit division methods. An overview of the linkage between the components of the Utility Function is given in a game tree in Appendix A11 *Utility Function 'Success Value' modeling Tree*. The calculation model (Formula 4.8 *Utility Function)* of the utility function will be further explained here. In order to provide a better understanding of the application of the utility function, influencing attributes, and 'success value' modeling in this explorative research section, the research model is shown in Figure 4.15 *Research Model phase 4 | Explorative Research*.

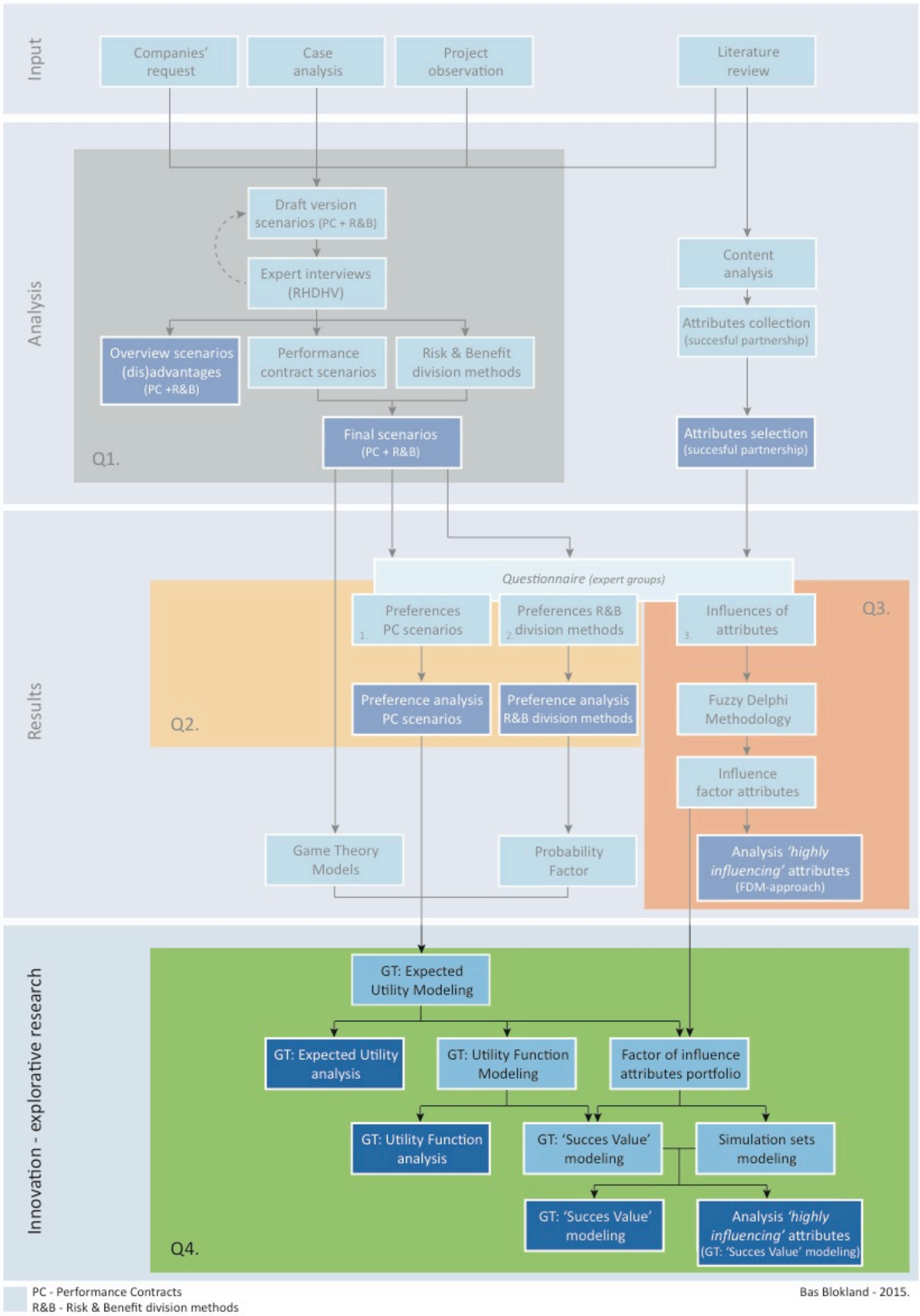


Figure 4.15 Research Model phase 4 | Explorative research

Factor of influence of attributes

First a factor (*wsi*) will be given, which indicates the influence of the attributes in a certain scenario *(s)*. This influence factor to each specific scenario combination (performance contracts and R&B division methods) will consist of two elements. First, the previous calculated influence factors of each attribute, in combination with a specific scenario combination, will provide a portfolio of the ten attributes with associating influences. Second, a new project case could be included in this influencing factor. This will be realized by determining the (expected) occurrence of each specific attribute. By combining the previous determined influence factor of all attributes to the (expected) occurring attributes, an occurring influence portfolio to the specific scenario combination (performance contracts and R&B division methods) could be realized. The formula, which will be used to calculate the total influence of included attributes to the specific scenario combination, will be given as follows:

Formula 4.6 *Influence factor of attributes*

$$\omega si = \sum_{i=1}^{3} \beta jsi * \, x jsi$$

ω_{si} = Factor of influencing attributes (all) in scenario *s*, for expert group *i*
β_{jsi} = Influence of Attribute *j* in scenario *s*, for expert group *i*
x_{jsi} = The level to which Attribute j in scenario s is present, for expert group *i*
j = attribute number where *j* = 1,2,3….,10
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

The factor X_{jsi} will be given as the level, a certain attribute (*j*) is occurring in a new case. When the involved parties have to determine the (expected) occurrence of each specific attribute in a new project case, the occurrence-rate should be determined as a value between 1 and 10. The reason for this is the association by respondents with the Dutch grading system, where a 6 will be interpreted as 'sufficient' (Analyticstool, 2013). By assessing a new project case, each attribute should be indicated whether or not it is occurring in a 'positive' or maybe 'negative' way. The assumption made for this occurrence-rate is based on the grading system: a value of 6 to 10 will be considered as minimal 'sufficient' and thus have a positive influence to the project cooperation; a value of 1 to 5 will be considered as 'insufficient' and thus have a negative influence to the project success. Derived from Formula 4.6 *Influence factor of attributes*, the factor X_{jsi} will be given as the level, a certain attribute (*j*) is occurring in a new case. First, the baseline model will be created where factor X_{jsi} should have a neutral value, which will be set as factor 1. Second, the occurrence-rate (negative or positive) of X_{jsi} will be given as an value between 0 and 2, with a neutral occurrence-rate of 1. This means that the rating scale of 1 to 10 will be transformed into the scale from 0 to 2. The occurrence-rate value X_{jsi} for a new project case will be determined by the following calculation matrix in Table 4.2.

Influence rate	Xjsi
1	0.2
2	0.4
3	0.6
4	0.8
5	1.0
6	1.2
7	1.4
8	1.6
9	1.8
10	2.0

Table 4.2 Occurrence-rate value (X_{jsi}) matrix

Utility function

The utility function created includes the influences of the attributes in the different scenario combinations (performance contracts and R&B division methods), as determined by the different expert groups (contractor, engineer/consultant, and energy supplier). The utility function will determine the payoff as 'success value' for the different expert groups. This is determined for the different included performance contract scenarios, the R&B division methods, and by taken into account the influences of the influencing attributes to the collaboration. The formula will be given as follows:

Formula 4.7 *Utility Function*

$$Psi = EUsi * \omega si$$

P_{si} = Payoff for scenario *s*, for expert group *i*
EU_{si} = Expected Utilization, for scenario *s*, for expert group *i*
ω_{si} = Factor of influencing attributes (all) in scenario *s*, for expert group *i*
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

The total utility function will determine the payoff as 'success value' for the different expert groups. This is determined for the different included performance contract scenarios, the R&B division methods, and by taken into account the influences of the influencing attributes to the collaboration. The formula will be given as follows:

Formula 4.8 *Utility Function (all components)*

$$P_{si} = \sum_{i=1}^{3} (U_{si} * Pr_{s}) * \sum_{i=1}^{3} (\beta_{jsi} * x_{jsi})$$

P_{si} = Payoff for scenario *s*, for expert group *i*
U_{si} = Utility given as preference value, for scenario *s*, for expert group *i*
Pr_{s} = The probability factor, for choosing scenario *s*
β_{jsi} = Influence of Attribute *j* in scenario *s*, for expert group *i*
x_{jsi} = The level to which Attribute j in scenario s is present, for expert group *i*
j = attribute number where *j* = 1,2,3….,10
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

As final result, the steps the different players (expert groups in this research) should take could be determined by this game theoretical approach. The '*strategy'* in Game Theory is defining the steps of action and instructions in the different possible situations (Samsura, Krabben, & Deemen, 2010). In this study, this 'strategy' will focus the success of the cooperation and how to positively influence this. Important for determining this 'strategy', is the way of acting of all involved parties. The influences to the success, will be dependent on the chosen or expected decision, the other 'players' will make (Peters, 2008) and the influencing attributes to the cooperation.
For this decision making process and determining the influencing attributes to the successful cooperation, Game Theory modeling (utility function) will bring up possible new insights.

Game Theoretical solutions

In other to bring up solutions for the Game Theory models, a three-way approach will be again included. This is similar to the approach for the Game Theoretical solutions, when modeling the games with the Expected Utility. This three-way approach will be based on previous research (e.g. (Chiu, 2009; Sönmez, 2014), where they are given as the main concepts to solve strategic games. The definition of these three approaches are comprehensively described in Chapter 4.2.6 *Explorative research: 'Success Value' modeling* and given as the following three approaches:

- Dominant strategies
- Dominated strategies (iterative elimination)
- Nash equilibrium

'Success value' modeling

Following to the previous created utility function, the influence of each attribute in a possible future project case will be analyzed. This will be realized by the similar utility function as described before:

Formula 4.8 *Utility Function (all components)*

$$P_{si} = \sum_{i=1}^{3} (U_{si} * Pr_{s}) * \sum_{i=1}^{3} (\beta_{jsi} * x_{jsi})$$

P_{si} = Payoff for scenario *s*, for expert group *i*
U_{si} = Utility given as preference value, for scenario *s*, for expert group *i*
Pr_{s} = The probability factor, for choosing scenario *s*
β_{jsi} = Influence of Attribute *j* in scenario *s*, for expert group *i*
x_{jsi} = The level to which Attribute j in scenario s is present, for expert group *i*
j = attribute number where *j* = 1,2,3….,10
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

The influence factor (X_{jsi}) indicates the occurrence of the attributes in a possible future project case. This factor will be first set as '1' (no influence) in order to create the baseline model. Thereafter, the analysis will make use of different simulations, in order to determine the influence to the modeled 'success value' for the collaboration.

In practice the involved parties have to determine the (expected) occurrence of each specific attribute in a new project case. The involved parties should rate the influence by a value between 1 and 10. Following the previous explanation in Chapter 4.2.6 *Explorative research: 'success Value' modeling*, a value of 6 to 10 will be considered as minimal 'sufficient' and thus have a positive influence to the project cooperation; a value of 1 to 5 will be considered as 'insufficient' and thus have a negative influence to the project success. As previously given in Table 4.2, the given value (between 1 and 10) is transformed to an influence factor on a scale of 0.2 (min) to 2 (max). This is according to the implemented influence factor in the utility function, where the baseline model for the utility function is created by an influence factor X_{jsi} as '1'.

Within this analysis, the influence of the different attributes in a possible future project case will be determined. This will be the most reliable, when implementing an existing case where the influences of the attributes are determined. Because of this explorative research directed to possible future projects, there are at this moment jet no practical cases that are implementable in this study. In order to provide results about the influences of attributes, a simulation model is created to obviate this. This finally leads to the modeling of the expected 'success values' (based on cooperation), by the (simulated) influences of the different attributes. The determination of the 'success value' in each simulation model will be provided by the outcome, which is given as Nash equilibrium. This means that the success values only will be given for the performance contract scenarios, where a risk and benefit division method is implemented (A or B) which is given as the modeled Nash equilibrium.
By these simulations, the most influencing attributes to the success value will be determined, and thus asking for the highest attention. The simulation model will be based on a three-way approach:

- Future scenario (project case) where the influencing attributes are rated relatively <u>low</u> in a new project case. This will be realized by rating 1 attribute as maximum and the rest of the attributes as minimum.
- Future scenario (project case) where the influencing attributes are rated relatively <u>high</u> in a new project case. This will be realized by rating 1 attribute as minimum and the rest of the attributes as maximum.
- Future scenarios (project case) where the influencing attributes are rated on each possible influence level. All attributes will be rated similar, where the rating value of 1 tot 10 will be set.

By simulating the success values in the different scenario combinations for each involved type of party (expert groups), the attributes (2) will be determined which should be managed closely the most for each involved party. When combining the success values of all involved parties together, a comparison will then be made with the single perspective of each expert group (involved party) separately. The results will be an overview of the attributes which are indicated as most influencing to the 'success value' for both, the single expert groups (involved party) and all involved parties together.

By the first two introduced simulation methods, the influence of an attribute separately is given. The third simulation set will be based on the total attribute portfolio influences. The influence of the given 'rating level' for a new project case to de success value will be determined. Each attribute will be set by a rate from 1 to 10, what results in a final 'success value'. This will be simulated for each performance contract scenario (1,2,3). This will result in an overview per performance contract scenario, where the change in 'success value' will be given. This change of the 'success value' is based on the different levels of rated attributes, simulated for a possible future project case.

4.3 Data Collection

4.3.1 Questionnaire

The collection of data will be conducted by the distribution of an online questionnaire. The type of respondents will be explained in Chapter 4.3.2. Mainly the needed time for answering the questionnaire is the reason of distributing an online version of the questionnaire. This makes it possible for respondents to answer the questionnaire at a moment they prefer. Other advantages like the ease of filling in the online questionnaire and the possibility to prepare the data analysis processing, will contribute to this decision of creating an online questionnaire. Disadvantages are considered like the expected response rate; this is based on the postponement of filling in the questionnaire and the non-personal contact method (Analyticstool, 2013). This is improved and obviated by making use of the personal network and the network of the company Royal HaskoningDHV. Besides, the length of the questionnaire will be kept as small as possible. Despite of some researchers who prove that length will not significantly influence the response rate (e.g. (Ganassali, 2008), a limited length of questionnaire is realized as much as possible in order to contribute to a more clear understanding by the respondents.
As given by Denscombe (2014), the web-based questionnaire consists of three phases: design of the questionnaire, the distribution of the questionnaire, and the data retrieval (Denscombe, 2014). Following these three elements, the data collection in this study by a questionnaire will be discussed.

Design of Questionnaire

The design of the questionnaire will be explained, by discussing the following parts the questionnaire consists of:

1. Introduction of research and scenarios
2. Preferences in performance contract scenarios
3. Expectation/preference in (mutual) risk and benefit division methods
4. Influences of attributes to the collaboration, regarding the given scenarios

The total overview of the questionnaire is given in Appendix A.3. This questionnaire is provided in Dutch, due to the Dutch nationality of the consulted experts as respondents. This will improve the readability of the questionnaire and decrease the chance of misunderstandings.

1. Introduction of research and scenarios

In order to improve the understanding of the respondents, a description is given of the purpose of the research and the expectations of the respondents. Within the introduction, a proper overview is given of the performance contract scenarios which are involved in this research, and the explanation of the risk and benefit division methods. The total introduction included in the questionnaire could be found in Appendix A.3.
The questionnaire will be filled in anonymous, where only the type of company will be further processed. Due to this, the respondents are asked to answer which type of company they are representing. Based on that, the respondents could be subdivided into the three groups of respondents: Contractor, Engineer/consultant, and Energy supplier. In order to improve the convenience of filling in the questionnaire, a dropdown menu is implemented for each answer (Denscombe, 2014).

2. Preferences in performance contract scenarios

The first questioning part of the questionnaire is concerning the preferences of the respondents, based on the three different performance contract scenarios. The three different performance-based scenarios are briefly explained. For each scenario, the respondent is asked to express their preference in a value between 1 and 10. This value indicates the '*Preference* value' for that certain performance-based scenario. This question will lead to a two-way result:

- The preference between the performance contract scenarios will be given, where after the three scenarios could be rated as 1st preferable, 2nd preferable, and 3rd preferable.
- The given preference value will indicate a certain ratio between the different performance contract scenarios; this ratio will not only indicate which scenario will be more preferable, but also provide information about the size of the deviating preferences.

In order to improve the convenience of filling in the questionnaire, a dropdown menu is implemented (Denscombe, 2014). Appendix A.3 gives an overview of the asked question to the respondents in the created Questionnaire.

3. Expectation/preference in (mutual) risk and benefit division methods

For the second part of the questionnaire, the risk and benefit division methods are introduced. The respondents are asked to give their expected preference of choosing a method to divide the risks and benefits of the performance based output. There are two possible methods to choose; *Method A* and *Method B*. Appendix A.3 gives an overview of the asked question to the respondents in the created Questionnaire. The respondent has to determine what their expected preference is of choosing a R&B division method (A and B), regarding the three different performance-based scenarios. The expected decision for division method A and B are questioned per performance-based scenario separately. The total of the percentage of decision A and decision B will be 100%. The respondents should indicate only an expected preference for *Method A,* where after the expected preference for *Method B* will automatically complete the total of 100%. In order to improve the convenience of filling in the questionnaire, a dropdown menu is implemented (Denscombe, 2014).

4. *Influences of attributes to the collaboration, regarding the given scenarios*

The third part of the questionnaire contains the input for the Fuzzy Delphi Methodology (FDM). This method, as described in Chapter 4.2.4, will translate the given influences of attributes to the performance-based scenarios into a single value, by taking the *fuzziness* of the respondents' opinion into account. Appendix A.3 gives an overview of the asked question to the respondents in the created Questionnaire. The respondents are asked to determine the influences of the attributes to the three performance contract scenarios (1,2,3) and to the two risk and benefit division methods. The influence of each attribute will be questioned for 5 different situations (*scenario 1, 2, and 3; and Method A and B*), and indicated by three values:

- *Low value* | This is the lowest value of the range, of which the respondent thinks the attribute could minimal influence the certain scenario.
- *Optimum value* | This is the value, which the respondent considers as optimal influence of this attribute in the certain scenario (between low and high value).
- *High value* | This is the highest value of the range, of which the respondent thinks the attribute could maximal influence the certain scenario.

The respondents indicate the influence by a value on a scale from 1 (very low influence) to 10 (very high influence), where Low < Optimum < High. In order to improve the convenience of filling in the questionnaire, a dropdown menu is implemented (Denscombe, 2014).

Distribution and retrieval

The distribution of the questionnaire is realized by email. By making use of the personal network and the network of the company Royal HaskoningDHV, specific respondents are selected. These respondents are working in the related field and type of companies, associating to the included expert groups (contractor, engineer/consultant, energy supplier) in this survey. Besides, the respondents are asked to distribute the questionnaire within their company to colleagues, who are acting in the field related to the research topic.

The data retrieval is realized by asking the respondents to send back the filled in questionnaire. This brings up an extra risk to a lower response rate. Nevertheless, by making use of the personal network and the network of the company Royal HaskoningDHV, the commitment to cooperate of the asked respondents is considered as relatively high. Besides, the respondents who are interested in this research results have the possibility to request the results of this study.

4.3.2 Respondents

Type of respondents

The consulted respondents involved in this research are working for the three researched types of companies: contractor, engineer/consultant, and an energy supplier. Based on this starting point, relatively big market parties are consulted about their willingness to participate in this research. In order to make the results more reliable, only respondents are selected who are representing their own type of company. Within these companies, the selection of consulted respondents is conducted by making use of the personal network of both: the company Royal HaskoningDHV and the researcher itself. Besides, retrieved form online searches for professionals with a relevant field of expertise, extra respondents are consulted. The personal network of both, the company Royal HaskoningDHV and the previously questioned respondents is used to select new respondents, and further distribute the questionnaire.

This is in accordance with the vision of Denscombe (2014), where the quality of selected respondents will be improved by this approach (Denscombe, 2014).

Field of experience (respondents individual)

This research is, among others, focusing to companies within the construction field who are considering the implementation of performance contracting. Affinity and specific knowledge, with regard to performance contracting in the construction industry, is essential in order to be able to answer the questionnaire. Both, the respondents' company and the respondent itself should have a certain experience and/or knowledge level within the field of performance contracting. The judgment about whether or not a respondent is eligible for answering the questionnaire, is based on their own opinion. The number of years experience is considered as less reliable than the opinion of the respondents itself.

Response rate

The response rate is influenced by several factors. During the period of answering, different respondents emphasized the necessity of specific experience and knowledge regarding, among others, performance contracting. Consequence to this is a lower response rate than expected on forehand. However, this will lead to a reliable selection of respondents with a (necessary) proper understanding of the research topic. Several steps are implemented in order to increase the expected response rate:

- The possibility for respondents to answer the questionnaire anonymous.
- The size of the questionnaire is kept as short as possible, where all the necessary information is given.
- Personal network is consulted of both, the company Royal HaskoningDHV and the previously questioned respondents. This based on the assumption, to create a higher commitment for responding to the request to participate in the research, which is necessary for this specific questioning.
- The questionnaire is repeatedly tested in order to improve the readability and lowering the chance of interpretation deviations.

Despite the given mitigating measures, some factors have led to a possible decrease in the expected response rate.

- In order to properly answer the questionnaire, specific experience and knowledge regarding, amongst others, performance contracting is necessary. This has lead to a decrease in the expected response by respondents who are eligible to answer the questionnaire.
- The drafted performance contract scenarios and cooperation by a consortium, should be relatively in line with the vision of the respondents. When this is deviating from the vision of the individual respondent, the respondent is less willing to answer the questionnaire. As example, the composed consortium of the three given parties (contractor, engineer/consultant, and energy supplier) could possibly be relatively hard to imagine for a type of company as an energy supplier who is not frequently acting in these type of partnerships.
- The Fuzzy Delphi Methodology included in this study is conducted by a triangular approach that could possibly lead to confusion among respondents. This approach will be established by validating each attribute, by giving three values. The three values are representing a range (Low and High) and a value which indicates the optimum. This three-value approach is by some respondents considered as (too) complex.

The total amount of respondents which is included in this research is 16. The respondents are representing three different of types of expert groups. The amount of respondents who are representing the contracting companies is 8, representing three different companies. The amount of respondents who are representing the engineering/consulting companies is 6, representing one company (RHDHV). The amount of respondents who are representing the energy suppliers is 2. The overall response rate is 36% (16 out of 45). This response rate is lower than expected beforehand. Reason for this is that some consulted experts have given their vision instead of filling in the questionnaire. This because of the previous explained main reason, where the experts considered themselves not as properly eligible for this questionnaire. Due to the anonymous processing of the collected data, the name of the specific companies is excluded here. There may be assumed that the selected companies included in this research are representing strong market parties in their own branch. Royal HaskoningDHV is representing the company as engineer/consultant. The reason for only consulting this company is that the conduction of this research is in cooperation with this company; this makes competitors less likely to cooperate.

4.4 Results

In accordance with the research model (Chapter 4.1. *Research Model introduction*), the most important results in this research will be explained. The results will be discussed in five paragraphs:

- 4.4.1 Evaluation of performance contract scenarios
- 4.4.2 Preferences in performance contract scenarios
- 4.4.3 Preferences in Risk and Benefit division methods
- 4.4.4 Influence of attributes to performance contracting scenarios (Fuzzy Delphi Methodology)
- 4.4.5 Game Theory: Expected Utility
- 4.4.6 Explorative Research: Utility Function
- 4.4.7 Explorative Research: 'Success Value' modeling

The research (calculation) model for the explained results is explained in Chapter 4 *Research model (4.1 – 4.3)*.

4.4.1 Evaluation of performance contract scenarios

By conducting expert interviews within the company Royal HaskoningDHV, the opinions of the different experts (experts RHDHV, 2015) are analyzed. The results of this analysis are given in an overview (Figure 4.16), by providing the advantages and disadvantages regarding the three created performance contract scenarios: EPC, EOPC, and EOPC + CP.

Scenario 1

EPC

Energy Performance Contract

Scenario 1 | EPC - *Energy Performance contract*

Advantages	Disadvantages
Relatively easy to apply in the current market. EPC is commonly known as contract form and could be implemented for relatively small sized projects	The set and realized Energy performance will be relatively low. Ambitious Energy performance is hard to realize because there is no control in maintenance for instance
More traditional model will make it easier to execute	The TCO approach is hard to implement, where mainly small adjustments will be realized
Applicable for small adjustments to realize energy savings	Hard to implement in large scale projects, where total control of the building is neccessary to provide an ambitious energy performance.
	High priority to set Energy Performance could lead to lower comfort level

Scenario 2

EOPC

Energy Performance Contract

Maintenance Performance Contract

Scenario 2 | EOPC - *Energy Performance and Maintenance Performance contract*

Advantages	Disadvantages
Maximum (more) control to Energy performance by including the maintenance aspect (lower risks)	High priority to set Energy Performance could lead to lower comfort level
Focus to technical aspects of the building and the behavior of the user is relatively good to control in this scenario by including *Maintenance Performance*	Answering only the Energy Performance request of the client, regarding cost-savings. Cost savings could be expanded by improvement of the comfort level.
Suitable for a long term based contract. It will stimulate to make (innovative) adjustments during the contract period in order to realize higher energy performance	

Scenario 3

EOPC + CP

Energy Performance Contract

Maintenance Performance Contract

Comfort Performance Contract

Scenario 3 | EOPC + CP - *Energy Performance Maintenance Performance, and Comfort Performance contract*

Advantages	Disadvantages
Ultimate performance and value delivery to the client (Energy Performance and productivity improvement for instance)	Monitoring (information) and control is essential in delivering the set performance level.
This scenario answers to the market request and the utilitzation of the associating opportunity for a consortium to anticipate to this by providing a distinctive value.	The users' behavior, satisfaction and perception is highly influencing the reached performance level. This users' behavior is harder to manage than technical aspects which leads to higher and different risks for the consortium.
Suitable for a long term based contract (essential). It will stimulate to make (innovative) adjustments during the contract period in order to realize higher energy performance.	High complexity of the partnership, based on more and possibly higher mutual responsibilities. This makes the involved parties interdependent of eachother, and asks for a proper cooperative partnership.
Consortium will probabaly think more from the clients' perspective. This will improve the clients trust in the partnership with the consortium. Besides, decisions will then be made more in line with the clients vision.	Market parties are reserved in providing a set comfort level because of the associating higher and different risks in comparisonto the other scenarios.
	Difficult to implement in small scale projects and thus for transformation of existing buildings.

Figure 4.16 Evaluation overview Performance contract scenarios

By conducting expert interviews within the company Royal HaskoningDHV, the opinions of the different experts (experts RHDHV, 2015) are analyzed. The results of this analysis are given in an overview (Figure 4.17), by providing the advantages and disadvantages regarding the two risk and benefit division methods: Method A (equal R&B division) and Method B (R&B division by share (%) in project turnover).

A Equal division of risks and benefits (1/3)

Risk and Benefit division Method A (equal R&B division)

Advantages	Disadvantages
Symbolic equivalency of parties	It is relatively hard to assign the risks to individual (execution) risks and mutual risks, and thus hard to subdivide them
Parties with a high share in turnover will have a relatively low share in risk responsibility	Parties with a low share in turnover will have a relatively high share in risk responsibility
Mutual responsibility for the whole project leads to high commitment of involved parties	High responsibility for mistakes of other parties
Equal benefit division leads to high commitment of parties to achieving the final objectives (high benefit)	Internal regulations of companies could reject the share of risks in responsibilities of others
Equal risk division leads to high commitment of parties regarding the mutual responsibilities, in order to improve eachothers tasks and actions.	
Parties are considered as more equal during the decision making processes	

B Division of risks and benefits based on share (%) in total project turnover

Risk and Benefit division Method B (R&B division by % share)

Advantages	Disadvantages
Tend to a more fair division of risks and associating responsibility; more effort-based	Influence to the decision making process is often related to the share in risks. This leads probably to an unequal influence to the decision making process.
Parties with a low share in turnover will have also a low share in risk responsibility	Turnover is mainly based on costs (material and labour) that are made. Level of knowledge and expertise are not taken into account and could provide then a misleading representation of the 'share' of each party.
Internal regulations of companies would accept more easy the 'fair' division of risks	The share in turnover will possibly provide a misleading representation of the influence to the final result.
Responsibilities will be assigned as much as possible to the involved parties	It is relatively hard to assign the risks to individual (execution) risks and mutual risks, and thus hard to subdivide them
A relatively lower interdependency for the risks and mistakes of others responsibilities in comparison to R&B division *Method A*	This will result possibly in a relatively lower commitment to the mitigation of risks.
	This will result possibly in a relatively lower commitment to the achievement of the mutual objectives

Figure 4.17 Evaluation overview R&B division Method A and B

4.4.2 Preferences in performance contract scenarios

Three different expert groups determined their preference value for the three different performance contract scenarios created in this research. Based on these three preference values, a comparison is made about the preferred scenarios. This means that for each expert group (contractor, engineer/consultant, energy supplier), the three performance contract scenarios are ranked as 1st, 2nd, and 3rd. The number of experts in each group is indicated as percentage.

Scenario 1 EPC | In Figure 4.18, the preference ranking of the three expert groups for performance contract scenario 1 *Energy Performance Contract* is given.

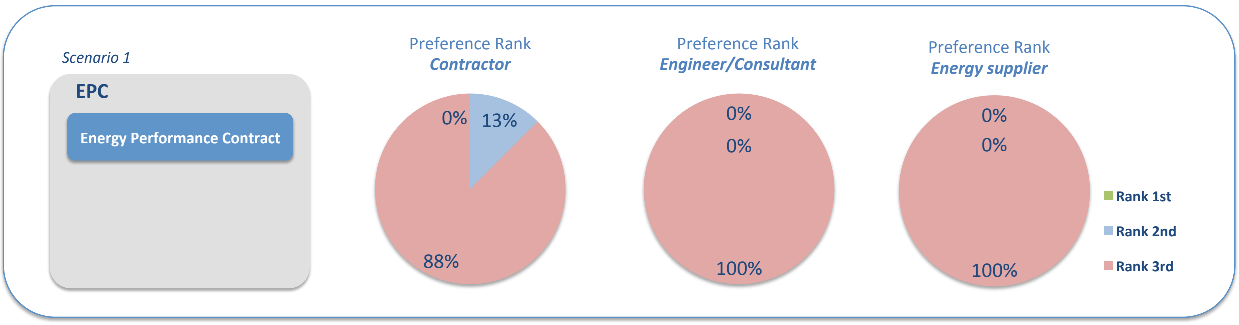


Figure 4.18 Results preference ranking | scenario 1 EPC

The performance contract scenario as *Energy Performance Contract (EPC)* is ranked mainly as third preferred. The experts group of 'contractors (P1)' ranked this scenario in 0% as 1st, 13% as 2nd, and 88% as 3rd. The experts group of 'engineer/consultant (P2)' ranked this scenario in 0% as 1st, 0% as 2nd, and 100% as 3rd. The experts group of 'energy supplier (P3)' ranked this scenario in 0% as 1st, 13% as 2nd, and 88% as 3rd. This means that mainly all experts in all expert groups prefer scenario 1 (EPC) the least. All experts as 'engineer/consultant' and 'energy supplier' ranked scenario 1 (EPC) as 3rd (last).

Scenario 2 EOPC | In Figure 4.19, the preference ranking of the three expert groups for performance contract scenario 2 *Energy Performance and Maintenance Performance Contract* is given.

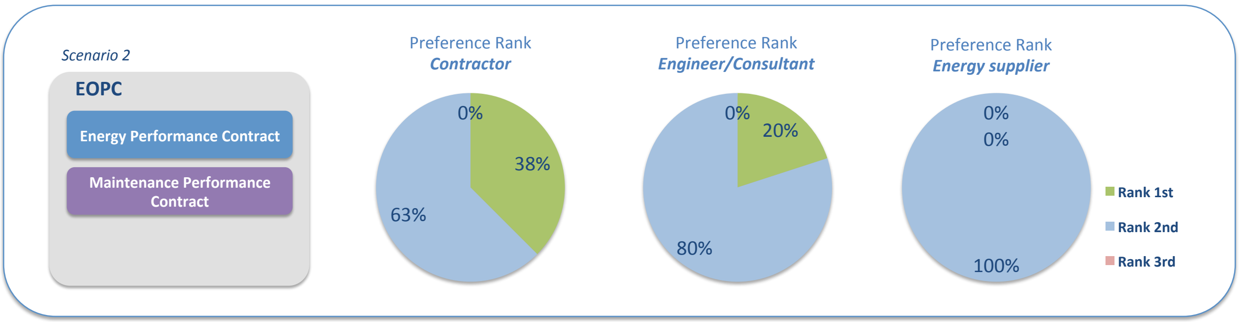


Figure 4.19 Results preference ranking | scenario 2 EOPC

The performance contract scenario as *Energy Performance and Maintenance Performance Contract (EOPC)* is ranked mainly as 2nd and 1st preferred. The experts group of 'contractors (P1)' ranked this scenario in 37,5% as 1st, 62,5% as 2nd, and 0% as 3rd. The experts group of 'engineer/consultant (P2)' ranked this scenario in 20% as 1st, 80% as 2nd, and 0% as 3rd. The experts group 'energy supplier (P3)' ranked this scenario in 0% as 1st, 100% as 2nd, and 0% as 3rd. This means that mainly all experts in all groups prefer scenario 2 (EOPC) as second and partially as first. All experts as 'energy supplier' ranked scenario 2 (EOPC) as 2rd. Within the expert group of the 'contractor' and the 'engineer/consultant', the clear preference is less obvious. Nevertheless, also these two expert groups ranked scenario 2 (EOPC) at least as 2nd which means that none of all experts consulted, ranked scenario 2 (EOPC) as third.

Scenario 3 EOPC + CP | In Figure 4.20, the preference ranking of the three expert groups for performance contract scenario 3 *Energy Performance, Maintenance Performance, and Comfort Performance* Contract is given.

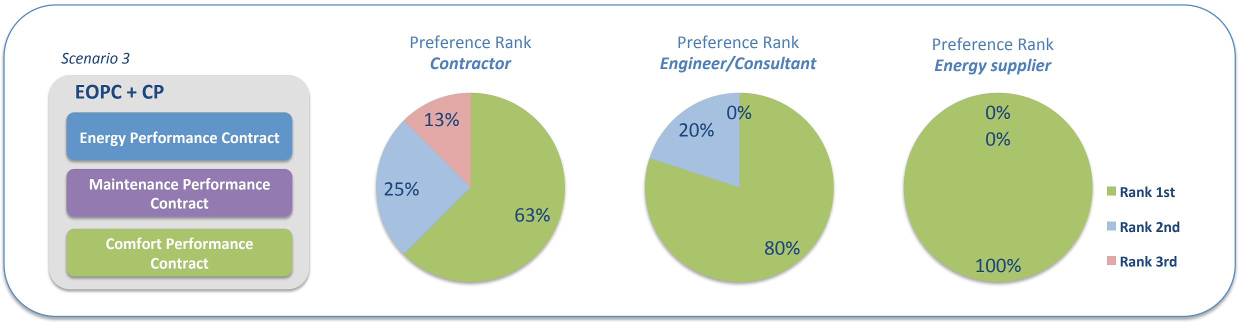
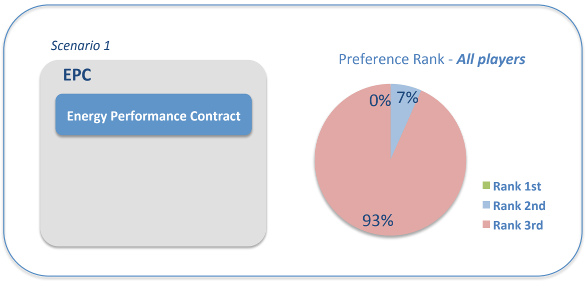


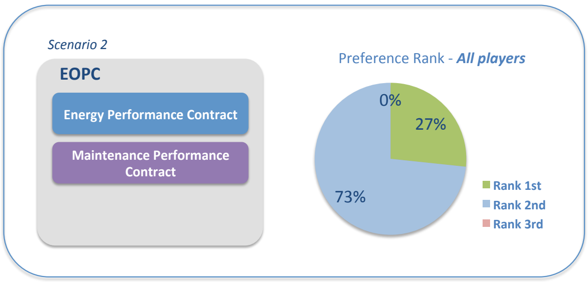
Figure 4.20 Results preference ranking | scenario 3 EOPC + CP

The performance contract scenario as *Energy Performance, Maintenance Performance, and Comfort Performance Contract (EOPC + CP)*, is ranked mainly as 1st and 2nd preferred. The experts group of 'contractors (P1)' ranked this scenario in 62,5% as 1st, 25% as 2nd, and 12,5% as 3rd. The experts group of 'engineer/consultant (P2)' ranked this scenario in 80% as 1st, 20% as 2nd, and 0% as 3rd. The experts group of 'energy supplier (P3)' ranked this scenario in 100% as 1st, 0% as 2nd, and 0% as 3rd. This means that mainly all experts in all groups prefer scenario 3 (EOPC + CP) the most (as first). All experts as 'energy supplier' ranked scenario 3 (EOPC + CP) as 1st. Within the expert group of the 'contractor' and the 'engineer/consultant', the clear preference is less obvious. Nevertheless, also these two expert groups ranked scenario 3 (EOPC + CP) mainly as first.

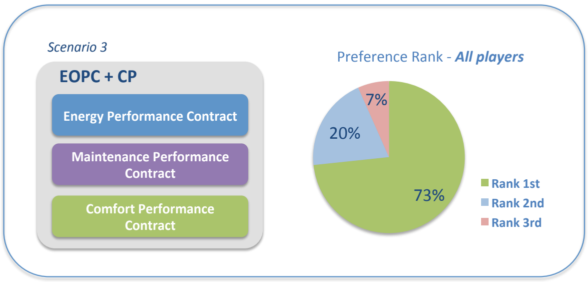
In order to provide more insights regarding the mutual preferences within the given partnership (contractor, engineer/consultant, energy supplier), the overall preferences of all expert groups is given for the three performance-based scenarios. The overview in Figure 4.21 is given as total rank preference of all experts (from all groups), per performance contract scenario.



Scenario 1, as *Energy Performance Contract (EPC)*, is given as least preferred by all consulted experts. The experts ranked this scenario in 0% as 1st, 7% as 2nd, and 100% as 3rd.



Scenario 2, as *Energy Performance and Maintenance Performance* Contract *(EOPC)*, is given mainly as 2nd preferred by all consulted experts. The experts ranked this scenario in 27% as 1st, 73% as 2nd, and 0% as 3rd.



Scenario 3, as *Energy Performance, Maintenance Performance, and Comfort Performance* Contract *(EOPC + CP)*, is given mainly as 1st preferred by all consulted experts. The experts ranked this scenario in 73% as 1st, 20% as 2nd, and 7% as 3rd.

Figure 4.21 Results preference ranking performance contract scenarios (All parties)

Conclusion of results | Preference rank of performance contract scenarios

Based on the total preference determination for the performance contract scenarios by all expert groups together, the Energy Performance Contract (scenario 1 - EPC) is clearly preferred the least in comparison to the two other performance-based scenarios. None of the consulted experts ranked the Energy Performance and Maintenance Contract (scenario 2 - EOPC) as third. Furthermore based on the opinion of all experts together, 73% of the experts indicate the Energy Performance, Maintenance Performance, and Comfort Performance Contract (scenario 3 - EOPC + CP) as most preferred. Based on this analysis, in general the performance contract scenarios could be ranked based on their preference rank by all consulted experts as follows:

1. *Energy Performance, Maintenance Performance, and Comfort Performance Contract (EOPC + CP)*
2. *Energy Performance and Maintenance Performance Contract (EOPC)*
3. *Energy Performance Contract (EPC)*

Preference value performance contract scenarios

The different expert groups determined their preference value for the three different performance contract scenarios. Based on these three preference values, a comparison is made about the preferred performance-based scenarios. The preference values are transformed by the steps described in Chapter 4.2.5 *Game Theoretical approach*, where the calculation model for the 'Payoff determination' is explained. The preference value refers to a 10-point scale, as questioned in the questionnaire to the different experts.

Scenario 1 EPC | In Figure 4.22, the preference values of the three expert groups for performance contract scenario 1 *Energy Performance Contract* are given.

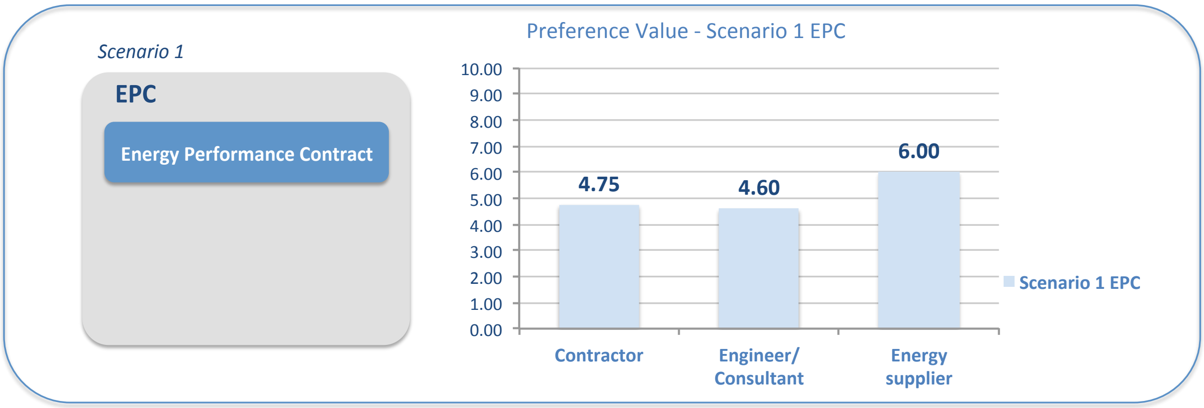


Figure 4.22 Results preference value | scenario 1 EPC

The performance contract scenario as *Energy Performance Contract (EPC)*, is ranked mainly as 3rd preferred by all expert groups as described previously. The expert group 'contractors (P1)' indicated a preference value to this scenario of 4,75 out of 10. The expert group 'engineer/consultant (P2) indicated a preference value to this scenario of 4,60 out of 10. The expert group 'energy supplier (P3)' indicated a preference value to this scenario of 6,00 out of 10. Following this results, the expert group 'energy supplier' indicated scenario 1 EPC, with a higher preference value than the expert group of the 'contractor' and the 'engineer/consultant'.

Scenario 2 EOPC | In Figure 4.23, the preference values of the three expert groups for performance contract scenario 2 *Energy Performance and Maintenance Performance* Contract are given.

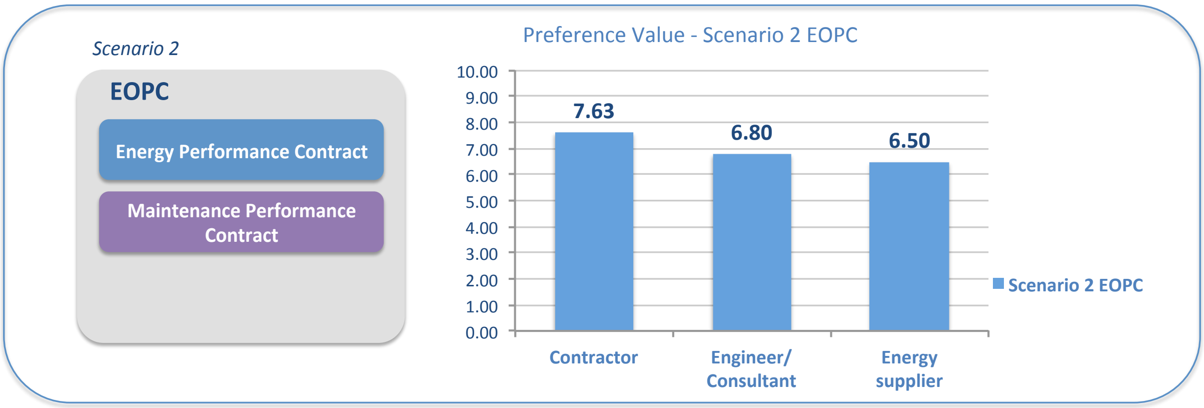


Figure 4.23 Results preference value | scenario 2 EOPC

The performance contract scenario *Energy Performance and Maintenance Performance Contract (EOPC)*, is ranked mainly as 2nd preferred by all expert groups as described previously. The expert group of 'contractors (P1)' indicated a preference value to this scenario of 7,63 out of 10. The expert group of 'engineer/consultant (P2) indicated a preference value to this scenario of 6,80 out of 10. The expert group of 'energy supplier (P3)' indicated a preference value to this scenario of 6,50 out of 10. Following these results, the expert group as 'contractor' indicated scenario 2 EOPC with a higher preference value, than the other two expert groups. The expert group of 'engineer/consultant' indicated scenario 2 EOPC with a slightly higher preference value than expert group 'energy supplier'. This results in the highest preference value in scenario 2 EOPC, by the 'contractor (P1)', followed by the 'engineer/consultant (P2)', and the lowest preference value is determined by the 'energy supplier (P3)'.

Scenario 3 EOPC + CP | In Figure 4.24, the preference values of the three expert groups for performance contract scenario 3 *Energy Performance, Maintenance Performance, and Comfort Performance* Contract are given.

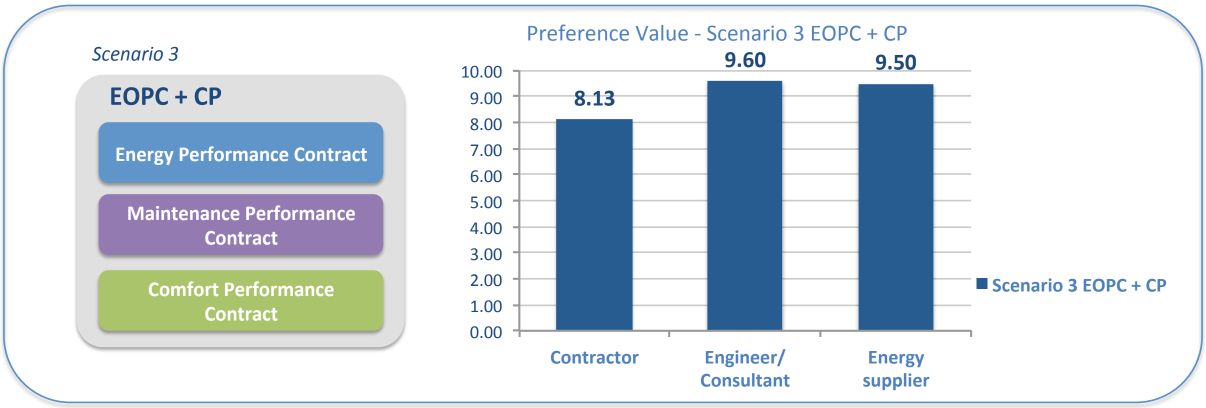


Figure 4.24 Results preference value | scenario 3 EOPC + CP

The performance contract scenario *Energy Performance, Maintenance Performance, and Comfort Performance Contract (EOPC + CP)*, is ranked mainly as 1st preferred by all expert groups as described previously. The experts group of 'contractors (P1)' indicated a preference value to this scenario of 8,13 out of 10. The expert group of 'engineer/consultant (P2) indicated a preference value to this scenario of 9,60 out of 10. The expert group of 'energy supplier (P3)' indicated a preference value to this scenario of 9,50 out of 10. Following these results, the expert group as 'engineer/consultant' and 'energy supplier' indicated scenario 3 EOPC + CP with a higher preference value, than the expert group of the 'contractor'. The expert group as engineer/consultant' and 'energy supplier' indicated scenario 3 EOPC + CP by a preference value which is relatively equal (9,60 vs. 9,50).

The total result of the preference value analysis in the different performance contract scenarios is given in Figure 4.25.

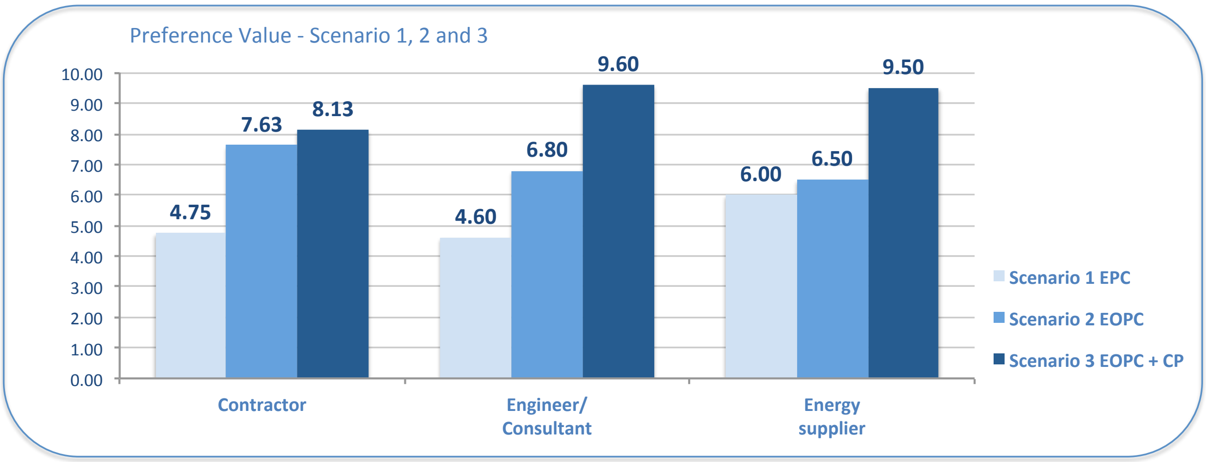


Figure 4.25 Results preference value performance contract scenarios (All parties)

Figure 4.25 shows a different preference value for each expert group, between the different performance-based scenario preferences. Each expert group indicates a clear distinction between the different performance contract scenarios. When combining the preference values of all experts, the overall vision of the expert groups could be described by the following result:

- Scenario 3 (EOPC + CP) as highest preference value (average of 9,08 out of 10)
- Scenario 2 (EOPC) as 2nd highest preference value (average of 6,98 out of 10)
- Scenario 1 (EPC) is given as lowest preference value (average of 5,12 out of 10)

Conclusion of results | Preference values for performance contract scenarios

Based on the given preference values by the three expert groups (contractor, engineer/consultant, energy supplier), for each performance-based scenario a clear distinction could be made in their preferences regarding these set performance contract scenarios:

- *The expert group 'contractor' prefers scenario 2 (EOPC) and scenario 3 (EOPC + CP). There is no big difference shown between the preferences for the expert group 'contractor (P1)' for these two performance-based scenarios.*
- *The expert group 'engineer/consultant' prefers scenario 3 (EOPC + CP).*
- *The expert group 'energy supplier' prefers scenario 3 (EOPC + CP). Scenario 1 (EPC) and scenario 2 (EOPC) are preferred relatively similar.*

By comparing the performance contract scenarios, all expert groups prefer the inclusion of Comfort Performance to the performance-based scenarios. Furthermore, the inclusion of only an Energy Performance Contract is given as lowest preferred for all expert groups. The expert groups 'contractor' and 'engineer/consultant' prefer clearly the inclusion of Maintenance Performance when an Energy Performance Contract will be implemented. For the expert group 'energy supplier', the inclusion of Comfort Performance is preferred in comparison to the other two performance-based scenarios.

4.4.3 Preferences in Risk and Benefit division methods

The three expert groups determined their preference for two specific set risk and benefit decisions methods. The two risk and benefit division methods *(Method A and Method B)* are comprehensively explained before (Chapter 4.2.2 *Performance-based scenarios determination*), and are given shown in Figure 4.26. Each expert group determined their preference of these division methods for each performance contract scenario separately. The number of experts in each group is given as a percentage of its associating group.

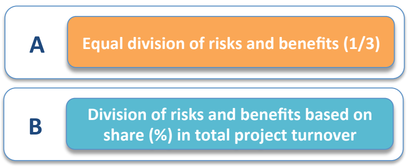


Figure 4.26 R&B division Method A and B

Preference comparison Risk and Benefit division methods

Scenario 1 EPC | In Figure 4.27, the preference in the risk and benefit division for the performance output, is given by the three expert groups for performance contract scenario 1 *Energy Performance Contract (EPC)*.

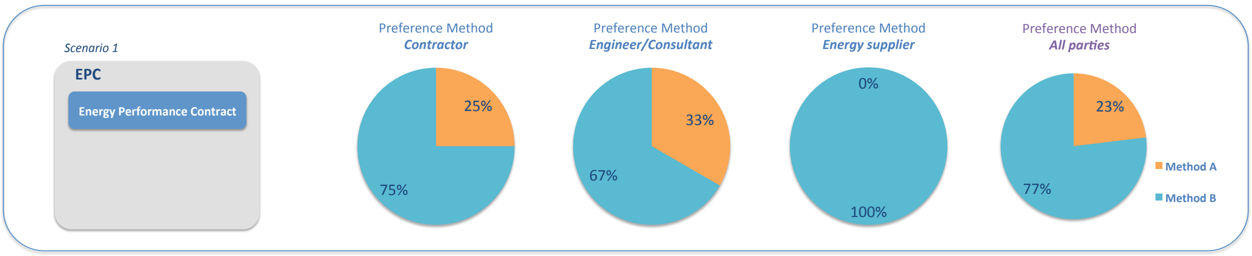


Figure 4.27 Results preferences in R&B division methods | scenario 1 EPC

The expert group of 'contractors (P1)' determined *Method A (equal R&B division)* as preferred by 25% and *Method B (R&B division by % share)* by 75%. The expert group of 'engineer/consultant (P2)' determined *Method A (equal R&B division)* as preferred by 33% and *Method B (R&B division by % share)* by 67%. As remark to this, two experts within this expert group indicated no preference between these different methods and are thus not included. The expert group of 'energy supplier (P3)' determined *Method A (equal R&B division)* as preferred by 0% and *Method B (R&B division by % share)* by 100%. The overall vision of the expert groups is given by a preference for the risk and benefit division *Method B (R&B division by % share)* by 77% and *Method A (equal R&B division)* 23% of the consulted experts.

Conclusion of results | Preferences for R&B division methods in performance contract scenario 1 (EPC)

By comparing the preferences regarding the R&B division Method A (equal R&B division) and Method B (R&B division by % share), the majority of all experts prefer in scenario 1 (EPC) R&B division Method B (R&B division by % share):

- *75% of the consulted experts as 'contractor' prefer R&B division Method B (R&B division by % share)*
- *67% of the consulted experts as 'engineer/consultant' prefer R&B division Method B (R&B division by % share)*

- *100% of the consulted experts as 'energy supplier' prefer R&B division Method B (R&B division by % share)*

By combining the overall preferences of all experts (all expert groups), 77% of the experts prefer R&B division Method B (R&B division by % share) and 23% of the experts prefer R&B division Method A (equal R&B division) in an Energy Performance Contract (scenario 1 - EPC). This makes R&B division Method B (R&B division by % share) for the involved experts group the most preferred R&B division method when an Energy Performance Contract (EPC) will be implemented.

Scenario 2 EOPC | In Figure 4.28, the preference in the risk and benefit division for the performance output, is given by the three expert groups for performance contract scenario 2 *Energy Performance and Maintenance Performance Contract (EOPC)*.

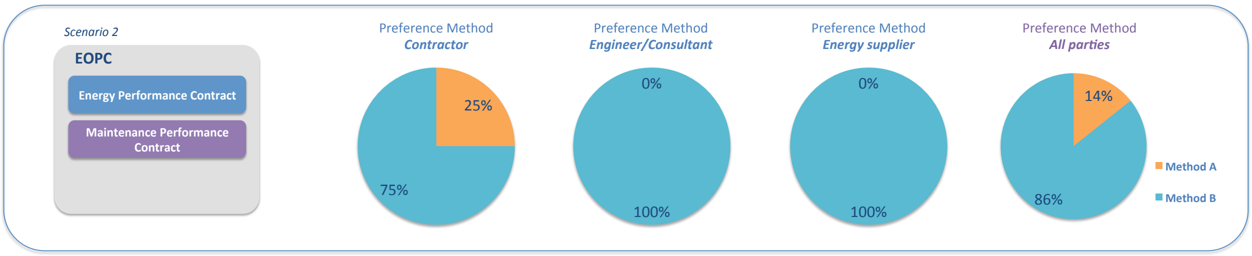


Figure 4.28 Results preferences in R&B division methods | scenario 2 EOPC

The expert group of 'contractors (P1)' determined *Method A (equal R&B division)* as preferred by 25% and *Method B (R&B division by % share)* by 75%. The expert group of 'engineer/consultant (P2)' determined *Method A (equal R&B division)* as preferred by 0% and *Method B (R&B division by % share)* by 100%. As remark to this, one expert within this expert group indicated no preference between these different methods and is thus not included. The expert group of 'energy supplier (P3)' determined *Method A (equal R&B division)* as preferred by 0% and *Method B (R&B division by % share)* by 100%. The overall vision of the expert groups is given by a preference for the risk and benefit division *Method B* by 86% and *Method A (equal R&B division)* 14% of the consulted experts.

Conclusion of results | Preferences for R&B division methods in performance contract scenario 2 (EOPC)

By comparing the preferences regarding the R&B division Method A (equal R&B division) and Method B (R&B division by % share), the majority of all experts prefer in scenario 2 (EOPC) R&B division Method B (R&B division by % share):

- *75% of the consulted experts as 'contractor' prefer R&B division Method B (R&B division by % share)*
- *100% of the consulted experts as 'engineer/consultant' prefer R&B division Method B (R&B division by % share)*
- *100% of the consulted experts as 'energy supplier' prefer R&B division Method B (R&B division by % share)*

By combining the overall preferences of all experts (all expert groups), 86% of the experts prefer R&B division Method B (R&B division by % share) and 14% of the experts prefer R&B division Method A (equal R&B division) in scenario 2 (EOPC). This makes R&B division Method B (R&B division by % share) for the involved experts group the most preferred R&B division method when an Energy Performance and Maintenance Performance Contract (EOPC) will be implemented.

Scenario 3 EOPC + CP | In Figure 4.29, the preference in the risk and benefit division for the performance output, is given by the three expert groups for performance contract scenario 3 *Energy Performance, Maintenance Performance, and Comfort Performance Contract (EOPC +CP)*.

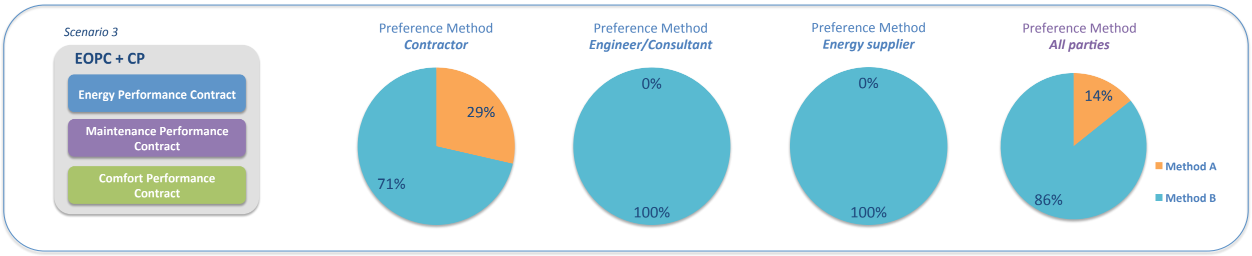


Figure 4.29 Results preferences in R&B division methods | scenario 3 EOPC + CP

The expert group of 'contractors (P1)' determined *Method A (equal R&B division)* as preferred by 29% and *Method B (R&B division by % share)* by 71%. As remark to this, one expert within this expert group indicated no preference between these different methods and is thus not included. The expert group of 'engineer/consultant (P2)' determined *Method A (equal R&B division)* as preferred by 0% and *Method B (R&B division by % share)* by 100%. As remark to this, also one expert within this expert group indicated no clear preference between these different methods and is thus not included. The expert group of 'energy supplier (P3)' determined *Method A (equal R&B division)* as preferred by 0% and *Method B (R&B division by % share)* by 100%. The overall vision of the expert groups is given by a preference for the risk and benefit division *Method B (R&B division by % share)* by 85% and *Method A (equal R&B division)* 15% of the consulted experts.

Conclusion of results | Preferences for R&B division methods in performance contract scenario 3 (EOPC + CP)
By comparing the preferences regarding the R&B division Method A (equal R&B division) and Method B (R&B division by % share), the majority of all experts prefer in scenario 3 (EOPC + CP) R&B division Method B (R&B division by % share):

- *75% of the consulted experts as 'contractor' prefer R&B division Method B (R&B division by % share)*
- *100% of the consulted experts as 'engineer/consultant' prefer R&B division Method B (R&B division by % share)*
- *100% of the consulted experts as 'energy supplier' prefer R&B division Method B (R&B division by % share)*

By combining the overall preferences of all experts (all expert groups), 85% of the experts prefer R&B division Method B (R&B division by % share) and 15% of the experts prefer R&B division Method A (equal R&B division) in scenario 3 (EOPC + CP). This makes R&B division Method B (R&B division by % share) for the involved experts group the most preferred R&B division method when an Energy Performance, Maintenance Performance, and Comfort Performance Contract (EOPC) will be implemented.

Conclusion of results | Preferences for R&B division methods in performance contract scenarios
Based on the given preferences for a R&B division method (A and B) of the three expert groups for each performance contract scenario, a clear distinction could be made in their preferences regarding the R&B division methods:

- *The expert group 'contractor' prefers in each set performance contract scenario R&B division Method B (R&B division by % share) more (75%) than Method A (equal R&B division). In each of the performance-based scenarios, the similar number of experts (contractor) prefers Method B (R&B division by % share) more (75%) than Method A (equal R&B division).*
- *The expert group 'engineer/consultant' prefers in each set performance contract scenario, R&B division Method B (R&B division by % share) more than Method A (equal R&B division). Only in scenario 1 (EPC), a part of the experts (engineer/consultant) prefers R&B division Method A (equal R&B division). When the Energy Performance Contract will be expanded with Maintenance Performance (and Comfort Performance), all experts as engineer/consultant prefer R&B division Method B (R&B division by % share).*
- *The expert group 'energy supplier' prefers in each set performance contract scenario, R&B division Method B (R&B division by % share) more (100%) than Method A (equal R&B division). None of the experts as 'energy supplier (P3)' prefers R&B division Method A (equal R&B division) more than R&B division Method B (R&B division by % share).*

The majority within all expert groups prefers R&B division Method B (R&B division by % share) above Method A (equal R&B division) in each set performance contract scenario. However, the expert group 'contractor' is the most differing in their opinion, where around a quarter of the consulted experts prefers R&B division Method A (equal R&B division) above Method B (R&B division by % share) in each set performance-based scenario. A part of the experts within the expert group 'engineer/consultant' prefers Method A (equal R&B division) above Method B (R&B division by % share) when only an Energy Performance Contract is included (scenario 1 – EPC). When Maintenance Performance (and Comfort Performance) is included in the performance-based scenarios, all experts (engineer/consultant) prefer R&B division Method B (R&B division by % share). All consulted experts of expert group 'energy supplier (P3)' prefer R&B division Method B (R&B division by % share) above Method A (equal R&B division) in each given performance contract scenario.

Probability Factor

The given number of experts who prefer *Method A* or *Method B*, as risk and benefit division method in each performance contract scenario, indicates only the compared preference of the two methods. This is derived from the given preference percentage (%) between *Method A (equal R&B division)* and *Method B (R&B division by % share)*, determined by each expert for each performance contract scenario. This preference, expressed in a percentage, will be transformed in the probability factor. This probability factor will be given as ratio between *Method A (equal R&B division)* and *Method B (R&B division by % share)*, determined for each expert group in each performance contract scenario separately. The calculation model for this probability factor is given in Chapter 4.2.5 *Game Theoretical Approach*. As explained in this chapter (4.2.5), the probability factor will be an input component of the Expected Utility calculation.

Scenario 1 EPC | As given in Figure 4.30, the preference percentage (%) for *Method A (equal R&B division)* and *Method B (R&B division by % share)* are for each expert group transformed in a probability factor. The given probability factors (for A and B) determined by each expert group, will be applicable for scenario 1 *Energy*

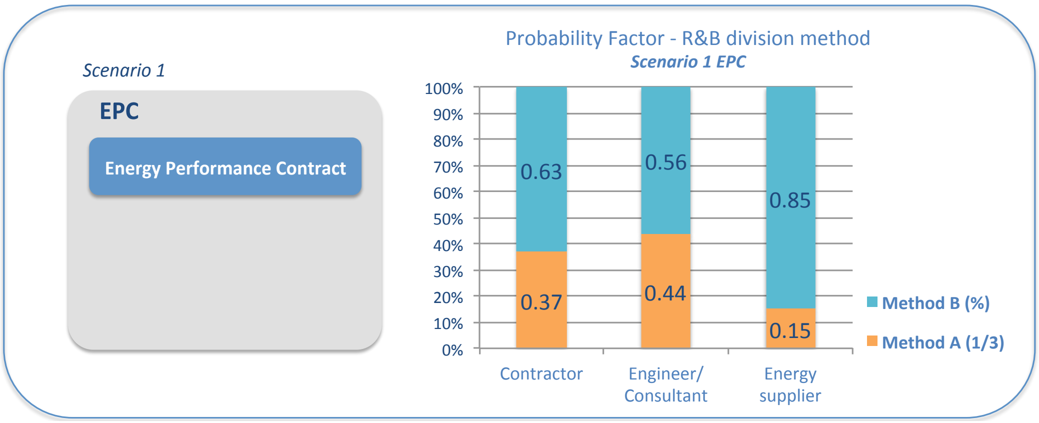


Figure 4.30 Probability factor R&B division method | scenario 1 EPC

Performance Contract (EPC).

The probability factor for the expert group of 'contractors (P1)' is given for *Method A (equal R&B division)* as 0.37 and for *Method B (R&B division by % share)* as 0.63. The probability factor for the expert group of 'engineer/consultant (P2)' is given for *Method A (equal R&B division)* as 0.44 and for *Method B (R&B division by % share)* as 0.56. The probability factor for the expert group of 'energy supplier (P3)' is given for *Method A (equal R&B division)* as 0.15 and for *Method B* as 0.85.

Scenario 2 EOPC | As given in Figure 4.31, the preference percentage (%) for *Method A (equal R&B division)* and *Method B (R&B division by % share)* are for each expert group transformed in a probability factor. The given probability factors (for A and B) determined by each expert group, will be applicable for scenario 2 *Energy Performance and Maintenance Performance Contract (EOPC).*

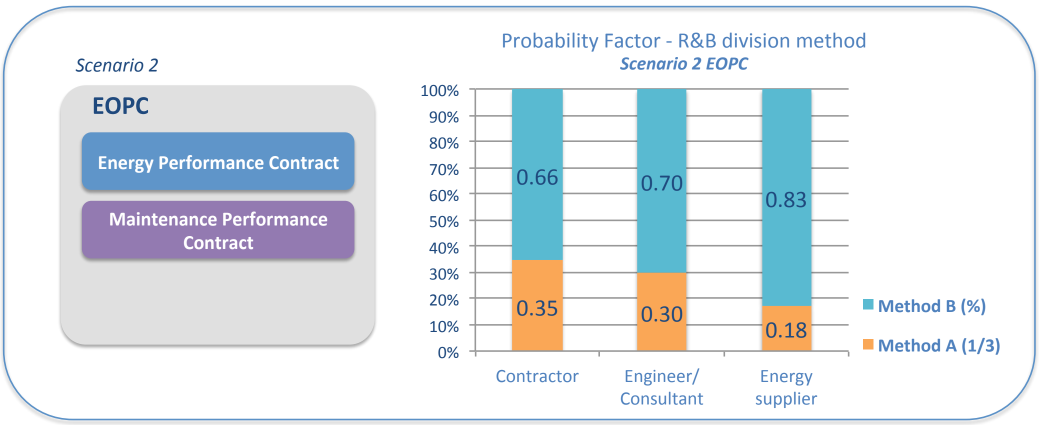


Figure 4.31 Probability factor R&B division method | scenario 2 EOPC

The probability factor for the expert group of 'contractors (P1)' is given for *Method A (equal R&B division)* as 0.345 and for *Method B (R&B division by % share)* as 0.655. The probability factor for the expert group of 'engineer/consultant (P2)' is given for *Method A (equal R&B division)* as 0.30 and for *Method B (R&B division by % share)* as 0.70. The probability factor for the expert group of 'energy supplier (P3)' is given for *Method A (equal R&B division)* as 0.175 and for *Method B (R&B division by % share)* as 0.825.

Scenario 3 EOPC + CP | As given in Figure 4.32, the preference percentage (%) for *Method A (equal R&B division)* and *Method B (R&B division by % share)* are for each expert group transformed in a probability factor. The given probability factors (for A and B) determined by each expert group, will be applicable for scenario 3 *Energy Performance, Maintenance Performance, and Comfort Performance Contract (EOPC + CP).*

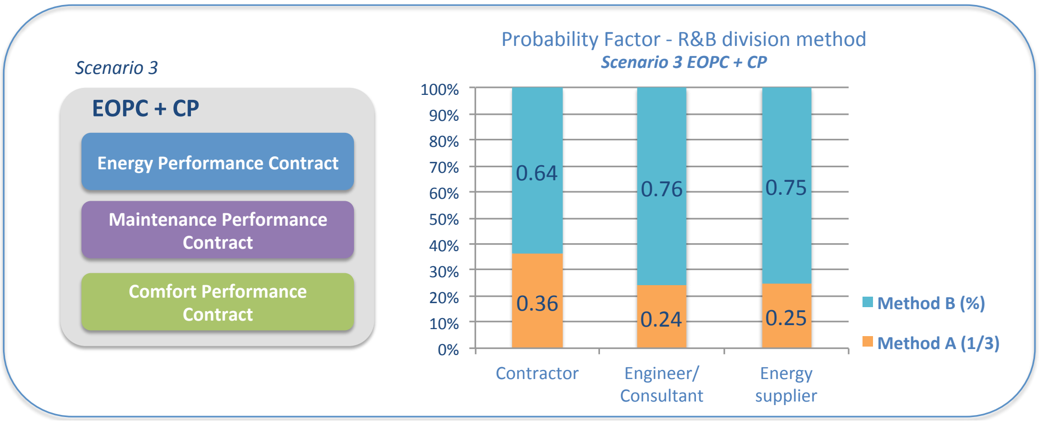


Figure 4.32 Probability factor R&B division method | scenario 3 EOPC + CP

The probability factor for the expert group of 'contractors (P1)' is given for *Method A (equal R&B division)* as 0.345 and for *Method B (R&B division by % share)* as 0.655. The probability factor for the expert group of 'engineer/consultant (P2)' is given for *Method A (equal R&B division)* as 0.30 and for *Method B (R&B division by % share)* as 0.70. The probability factor for the expert group of 'energy supplier (P3)' is given for *Method A (equal R&B division)* as 0.175 and for *Method B (R&B division by % share)* as 0.825.

The probability factors as given, will be implemented in the Game Theoretical approach. This will be further explained in Chapter 4.4.5 *Game Theory: Expected Utility*.

4.4.4 Influence of attributes to performance contracting scenarios (Fuzzy Delphi Methodology)

This paragraph provides insights to which attributes could be considered as 'highly influencing'. The determination whether or not an attribute is 'highly influencing' to a certain performance-based scenario, is realized by the judgment of the respondents of the different expert groups. The influence of each attribute in each performance contract scenario is given as a single number, based on the Fuzzy Delphi Methodology as comprehensively explained in Chapter 4.2.4 *Fuzzy Delphi Methodology*. Based on the steps in this chapter (4.2.4), the opinion of the respondents is translated into the given results below. First each performance contract scenario will be discussed by giving the results of the 'highly influencing' attributes (Chapter 4.4.4). Thereafter, the determined 'highly influencing' attributes for the performance contract scenarios will be given and discussed for each scenario separately.

Influences to performance contract scenarios – Single expert group estimation

The results of the influences of the attributes to each combination of a performance contract scenario (1,2,3) and a risk and benefit division method (A and B), will be given in this paragraph. As given in Chapter 4.2.4 *Fuzzy Delphi Methodology*, a threshold is set for the influence factor of each attribute, which indicates whether or not an attribute may be considered as 'highly influencing'. The threshold which will be handled here, is given as follows:

- Threshold for each expert group opinion separately: r_{group} = **0,49**

In Figure 4.33 to Figure 4.38 an overview will be given about the influences of attributes in each specific performance contract scenario in combination with the R&B division methods (A and B). The influence of attributes will be considered separately for each expert group. For each expert group, the ten attributes are ranked (1 to 10) based on their influence to the set combination of the performance contract scenario and R&B division method.

Figure 4.33 to Figure 4.38 shows also for each expert group (Contractor, Engineer/Consultant, Energy supplier), the influence ratio of each single attribute. The calculation model of the influence ratio is explained in Chapter 4.2.4 *Fuzzy Delphi Methodology*. As given in this chapter (4.2.4), the threshold which indicates whether or not a certain attribute is given as ‘highly influencing’ is set as r_{group} = 0,49. In each figure (4.33 to 4.38), the red threshold line indicates this threshold value. This will make clear which attributes could be considered as ‘highly influencing’ attributes.

Scenario 1 (EPC) *Risk and Benefit division Method A*

Scenario (s)		Attribute (j)		Contractor Ratio total	Contractor Rank	Engineer/Consultant Ratio total	Engineer/Consultant Rank	Energy supplier Ratio total	Energy supplier Rank
1	A	1	*Trust between the partners within the partnership*	0,383	6	0,600	1	0,693	1
		2	*Highly committed parties within the partnership*	0,422	4	0,378	6	0,360	7
		3	*A proper communication (model) between the partners*	0,382	7	0,334	8	0,312	8
		4	*Clear understanding of personal objectives within the partnership of all parties*	0,453	1	0,531	3	0,513	3
		5	*Good and existing relationship between the parties*	0,417	5	0,438	4	0,550	2
		6	*Support and strong commitment of top-management level*	0,360	8	0,377	7	0,396	5
		7	*Strong similarities in the vision and culture of the different parties*	0,322	10	0,244	10	0,187	10
		8	*Complete transparency and sharing of information*	0,433	3	0,540	2	0,463	4
		9	*Strong market parties within the partnership*	0,328	9	0,269	9	0,301	9
		10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,442	2	0,395	5	0,390	6

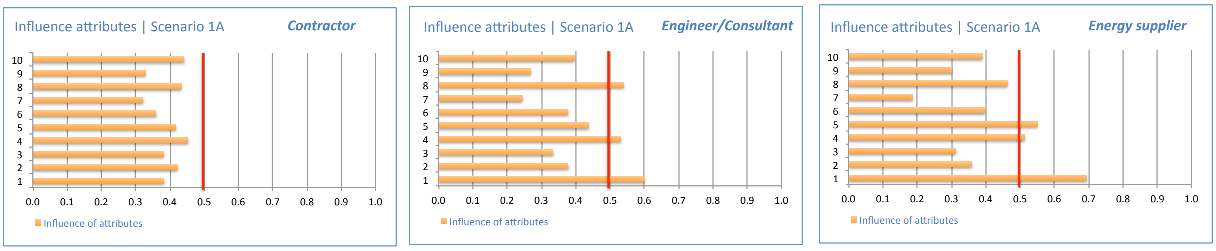


Figure 4.33 Results influence factor of attributes | scenario 1 EPC; R&B division method A

The influences of ten attributes are determined for scenario 1 (EPC) in combination with R&B division *Method A (equal R&B division)*. The analysis of the opinion of the expert groups results in the following ‘highly influencing’ attributes:

Table 4.3 Results 'highly influencing' attributes | scenario 1 EPC; R&B division method A

Scenario 1A | (EPC)	R&B Method A
Expert group: Contractor (P1)	No attributes are considered as ‘highly influencing’ in this scenario
Expert group: Engineer/consultant (P2)	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A8: Complete transparency and sharing of information between the partners within the partnership
Expert group: Energy supplier (P3)	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership

Scenario 1 (EPC) *R&B division Method B*

Scenario (s)		Attribute (j)		Contractor Ratio total	Contractor Rank	Engineer/Consultant Ratio total	Engineer/Consultant Rank	Energy supplier Ratio total	Energy supplier Rank
1	B	1	*Trust between the partners within the partnership*	0,357	8	0,556	1	0,627	1
		2	*Highly committed parties within the partnership*	0,422	3	0,354	6	0,389	5
		3	*A proper communication (model) between the partners*	0,379	7	0,289	8	0,293	8
		4	*Clear understanding of personal objectives within the partnership of all parties*	0,453	1	0,478	2	0,433	3
		5	*Good and existing relationship between the parties*	0,412	4	0,453	3	0,550	2
		6	*Support and strong commitment of top-management level*	0,390	6	0,315	7	0,301	7
		7	*Strong similarities in the vision and culture of the different parties*	0,350	9	0,233	10	0,193	10
		8	*Complete transparency and sharing of information*	0,406	5	0,433	4	0,360	6
		9	*Strong market parties within the partnership*	0,314	10	0,265	9	0,293	9
		10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,431	2	0,428	5	0,390	4

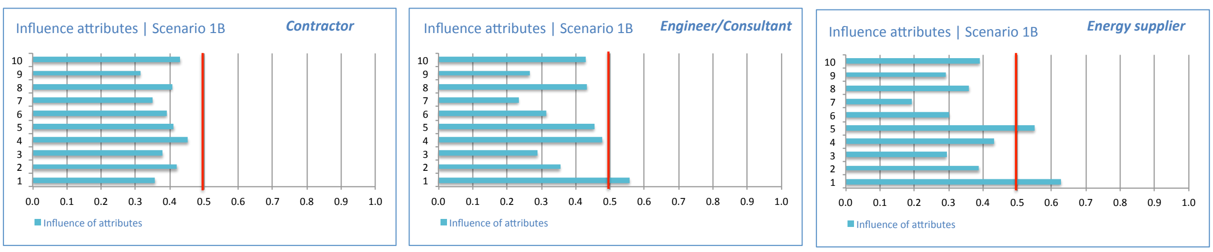


Figure 4.34 Results influence factor of attributes | scenario 1 EPC; R&B division method B

The influences of ten attributes are determined for scenario 1 (EPC) in combination with R&B division *Method B (R&B division by % share)*. The analysis of the opinion of the expert groups results in the following 'highly influencing' attributes:

Table 4.4 Results 'highly influencing' attributes | scenario 1 EPC; R&B division method B

Scenario 1B | (EPC)	R&B Method B
Expert group: Contractor (P1)	No attributes are considered as 'highly influencing' in this scenario
Expert group: Engineer/consultant (P2)	A1: Trust between the partners within the partnership
Expert group: Energy supplier (P3)	A1: Trust between the partners within the partnership A5: Good and existing relationship between the partners within the partnership

Scenario 2 (EOPC) *Risk and Benefit division Method A*

Scenario (s)		Attribute (j)		Contractor Ratio total	Contractor Rank	Engineer/Consultant Ratio total	Engineer/Consultant Rank	Energy supplier Ratio total	Energy supplier Rank
2	A	1	*Trust between the partners within the partnership*	0,391	7	0,647	1	0,766	1
		2	*Highly committed parties within the partnership*	0,396	6	0,483	6	0,442	7
		3	*A proper communication (model) between the partners*	0,412	5	0,385	8	0,349	9
		4	*Clear understanding of personal objectives within the partnership of all parties*	0,456	3	0,569	3	0,600	2
		5	*Good and existing relationship between the parties*	0,431	4	0,496	5	0,562	3
		6	*Support and strong commitment of top-management level*	0,382	8	0,498	4	0,524	5
		7	*Strong similarities in the vision and culture of the different parties*	0,339	10	0,298	10	0,233	10
		8	*Complete transparency and sharing of information*	0,467	2	0,587	2	0,538	4
		9	*Strong market parties within the partnership*	0,343	9	0,307	9	0,369	8
		10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,473	1	0,406	7	0,455	6

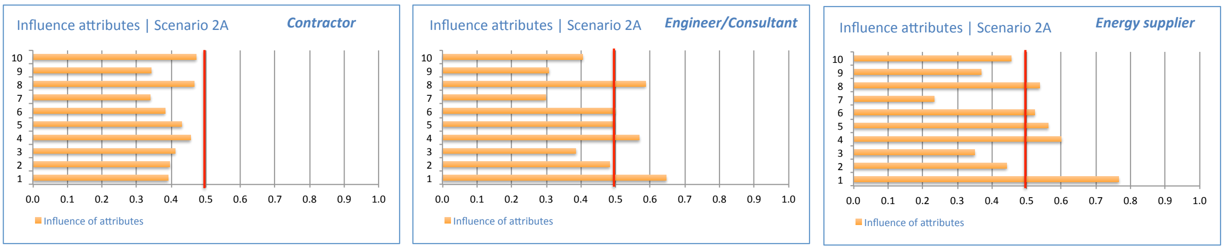


Figure 4.35 Results influence factor of attributes | scenario 2 EOPC; R&B division method A

The influences of ten attributes are determined for scenario 2 (EOPC) in combination with R&B division *Method A (equal R&B division)*. The analysis of the opinion of the expert groups results in the following 'highly influencing' attributes:

Table 4.5 Results 'highly influencing' attributes | scenario 2 EOPC; R&B division method A

Scenario 2 | (EOPC)	R&B Method A
Expert group: Contractor (P1)	No attributes are considered as 'highly influencing' in this scenario
Expert group: Engineer/consultant (P2)	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership A6: Support and strong commitment of top-management level A8: Complete transparency and sharing of information between the partners within the partnership
Expert group: Energy supplier (P3)	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership A6: Support and strong commitment of top-management level A8: Complete transparency and sharing of information between the partners within the partnership

Scenario 2 (EOPC) *Risk and Benefit division Method B*

Scenario (s)		Attribute (j)		Contractor Ratio total	Contractor Rank	Engineer/Consultant Ratio total	Engineer/Consultant Rank	Energy supplier Ratio total	Energy supplier Rank
2	B	1	*Trust between the partners within the partnership*	0,364	9	0,600	1	0,692	1
		2	*Highly committed parties within the partnership*	0,396	7	0,453	5	0,478	4
		3	*A proper communication (model) between the partners*	0,409	6	0,333	8	0,329	9
		4	*Clear understanding of personal objectives within the partnership of all parties*	0,456	2	0,513	3	0,507	3
		5	*Good and existing relationship between the parties*	0,425	4	0,514	2	0,562	2
		6	*Support and strong commitment of top-management level*	0,414	5	0,417	7	0,399	7
		7	*Strong similarities in the vision and culture of the different parties*	0,369	8	0,284	10	0,242	10
		8	*Complete transparency and sharing of information*	0,438	3	0,471	4	0,418	6
		9	*Strong market parties within the partnership*	0,328	10	0,302	9	0,359	8
		10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,461	1	0,439	6	0,455	5

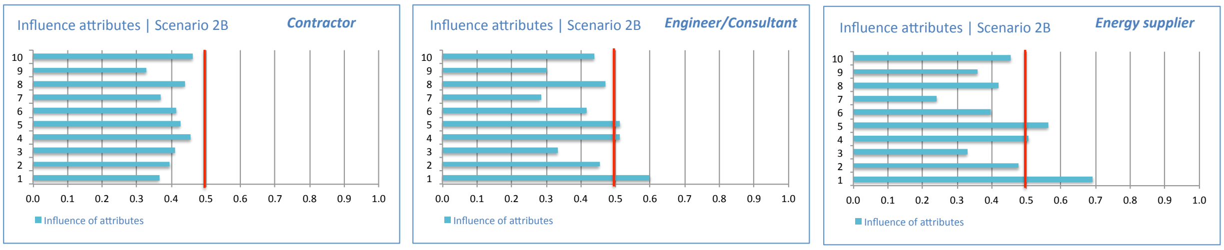


Figure 4.36 Results influence factor of attributes | scenario 2 EOPC; R&B division method B

The influences of ten attributes are determined for scenario 2 (EOPC) in combination with R&B division *Method B (R&B division by % share)*. The analysis of the opinion of the expert groups results in the following 'highly influencing' attributes:

Table 4.6 Results 'highly influencing' attributes | scenario 2 EOPC; R&B division method B

Scenario 2 | (EOPC)	R&B Method B
Expert group: Contractor (P1)	No attributes are considered as 'highly influencing' in this scenario
Expert group: Engineer/consultant (P2)	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership
Expert group: Energy supplier (P3)	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership

Scenario 3 (EOPC + CP) *Risk and Benefit division Method A*

Scenario (s)		Attribute (j)		Contractor Ratio total	Contractor Rank	Engineer/Consultant Ratio total	Engineer/Consultant Rank	Energy supplier Ratio total	Energy supplier Rank
3	A	1	*Trust between the partners within the partnership*	0,378	8	0,660	1	0,766	1
		2	*Highly committed parties within the partnership*	0,380	7	0,528	6	0,442	7
		3	*A proper communication (model) between the partners*	0,428	4	0,442	7	0,349	9
		4	*Clear understanding of personal objectives within the partnership of all parties*	0,464	2	0,575	3	0,613	3
		5	*Good and existing relationship between the parties*	0,414	5	0,548	5	0,574	4
		6	*Support and strong commitment of top-management level*	0,385	6	0,562	4	0,613	2
		7	*Strong similarities in the vision and culture of the different parties*	0,350	9	0,307	10	0,280	10
		8	*Complete transparency and sharing of information*	0,450	3	0,607	2	0,550	5
		9	*Strong market parties within the partnership*	0,345	10	0,316	9	0,379	8
		10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,481	1	0,411	8	0,520	6

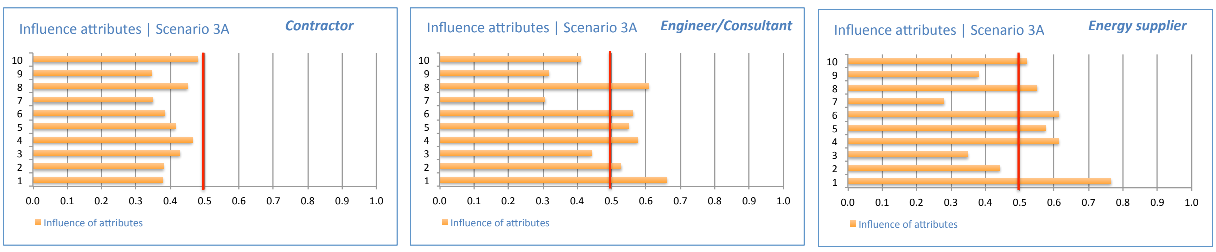


Figure 4.37 Results influence factor of attributes | scenario 3 EOPC + CP; R&B division method A

The influences of ten attributes are determined for scenario 3 (EOPC + CP) in combination with R&B division *Method A (equal R&B division)*. The analysis of the opinion of the expert groups results in the following ‘highly influencing’ attributes:

Table 4.7 Results 'highly influencing' attributes | scenario 3 EOPC + CP; R&B division method A

Scenario 3 | (EOPC + CP)	R&B Method A
Expert group: Contractor (P1)	No attributes are considered as ‘highly influencing’ in this scenario
Expert group: Engineer/consultant (P2)	A1: Trust between the partners within the partnership A2: Highly committed parties within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership A6: Support and strong commitment of top-management level A8: Complete transparency and sharing of information between the partners within the partnership
Expert group: Energy supplier (P3)	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership A6: Support and strong commitment of top-management level A8: Complete transparency and sharing of information between the partners within the partnership A10: Extremely detailed description of tasks and responsibilities in contractual agreements

Scenario 3 (EOPC + CP) *Risk and Benefit division Method B*

Scenario (s)		Attribute (j)		Contractor Ratio total	Contractor Rank	Engineer/Consultant Ratio total	Engineer/Consultant Rank	Energy supplier Ratio total	Energy supplier Rank
3	B	1	*Trust between the partners within the partnership*	0,352	9	0,606	1	0,679	1
		2	*Highly committed parties within the partnership*	0,380	8	0,417	6	0,411	7
		3	*A proper communication (model) between the partners*	0,425	3	0,329	8	0,302	9
		4	*Clear understanding of personal objectives within the partnership of all parties*	0,464	2	0,518	2	0,475	3
		5	*Good and existing relationship between the parties*	0,409	6	0,508	4	0,538	2
		6	*Support and strong commitment of top-management level*	0,417	5	0,492	5	0,447	4
		7	*Strong similarities in the vision and culture of the different parties*	0,381	7	0,271	10	0,226	10
		8	*Complete transparency and sharing of information*	0,422	4	0,513	3	0,438	5
		9	*Strong market parties within the partnership*	0,330	10	0,316	9	0,331	8
		10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,469	1	0,400	7	0,423	6

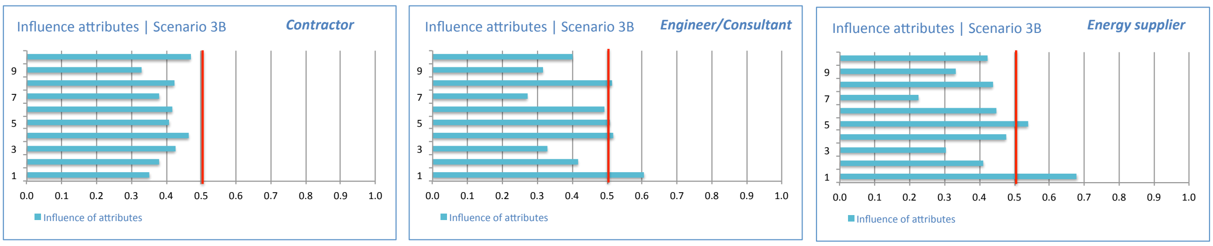


Figure 4.38 Results influence factor of attributes | scenario 3 EOPC + CP; R&B division method B

The influences of ten attributes are determined for scenario 3 (EOPC + CP) in combination with R&B division *Method B (R&B division by % share)*. The analysis of the opinion of the expert groups results in the following ‘highly influencing’ attributes:

Table 4.8 Results 'highly influencing' attributes | scenario 3 EOPC + CP; R&B division method B

Scenario 3 | (EOPC + CP)	R&B Method B
Expert group: Contractor (P1)	No attributes are considered as ‘highly influencing’ in this scenario
Expert group: Engineer/consultant (P2)	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership A6: Support and strong commitment of top-management level A8: Complete transparency and sharing of information between the partners within the partnership
Expert group: Energy supplier (P3)	A1: Trust between the partners within the partnership A5: Good and existing relationship between the partners within the partnership

Conclusion of results | Determined 'highly influencing' attributes (per expert group)

Based on the analyzed results of the Fuzzy Delphi Methodology in this study, insights to the 'highly influencing' attributes are provided regarding the performance contract scenarios and the included risk and benefit division methods.

- *When comparing the set performance contract scenarios, the number of determined 'highly influencing' attributes is increasing, when the scenarios consist of more performance-based components. This means that when Maintenance Performance and Comfort Performance (expanding with performance-based contracts) are included, the influences to the collaboration aspect are becoming more important.*
- *When comparing the included R&B division methods (A and B), the number of determined 'highly influencing' attributes is increasing, when the scenarios consist of R&B division Method A (equal R&B division). This means that dividing the risks and benefits (of performance output) more equally between the partners, the influences to the collaboration aspect are becoming more important.*
- *When a performance contract scenario consists of more performance-based components and is applying R&B division Method A (equal R&B division), the number of determined 'highly influencing' attributes is the highest in this conducted research. When the risk and benefit division will be realized by an equal division method (R&B division Method A) for Scenario 3 as Energy Performance, Maintenance Performance, and Comfort Performance contract; the collaboration within this scenario combination will be the most influenced by the included attributes.*

Influences to performance contract scenarios – Mutual estimation of expert groups

In this paragraph, an adjustment to the previous analysis will be made. In previous paragraph, the influence of attributes is determined for each expert group (involved party) separately. The analysis in this chapter translates the estimation by each expert group (involved party) in a combined mutual estimation about the influences of each attribute. As given in Chapter 4.2.4 *Fuzzy Delphi Methodology*, a threshold is set for the influence factor of each attribute, which indicates whether or not an attribute may be considered as 'highly influencing'. The threshold which will be handled here, is given as follows:

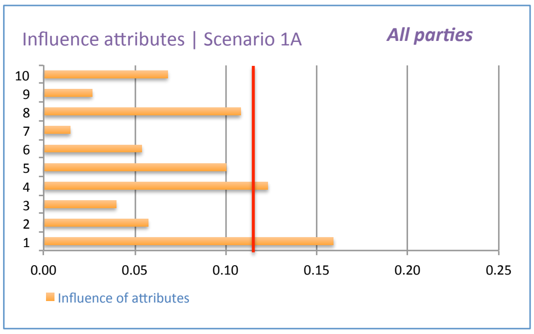
- Threshold for the combined expert group opinion: r_{total} = **0,11765**

The total overview of the influence factors and the ranking of attributes in each performance contract scenario, is given in Appendix A5. An overview of the influences of all attributes, expressed against the six different scenario combinations (performance contract and R&B division method combinations), is given in Appendix A6. In this paragraph, only the results will be given which indicate whether or not an attribute is given as 'highly influencing'. This will be, similar to previous paragraph, indicated by a graph. This will make clear which attributes could be considered as 'highly influencing' attributes. Figure 4.39 to Figure 4.44 shows the influence ratio of each single attribute, given as combination of the estimation of all consulted experts. The calculation model of the influence ratio is explained in Chapter 4.2.4 *Fuzzy Delphi Methodology*. As given in this chapter (4.2.4), the threshold which indicates whether or not a certain attribute is given as 'highly influencing' is set as r_{total} = **0,11765**. In each figure (4.39 to 4.44), this threshold value is again indicated by the red threshold line.

Scenario 1 (EPC)

Risk and Benefit division Method A

The influences of ten attributes are determined for scenario 1 (EPC) in combination with R&B division *Method A (equal R&B division)*. The analysis of the combined opinion of the expert groups results in the following 'highly influencing' attributes:



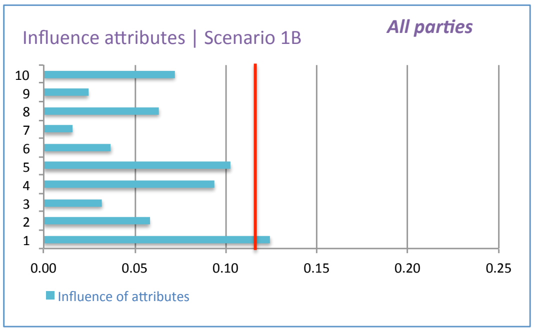
Scenario 1A | (EPC)	R&B Method A
Expert group: All together	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties

Figure 4.39 Results 'highly influencing' attributes for all parties | scenario 1 EPC; R&B division method A

Scenario 1 (EPC)

R&B division Method B

The influences of ten attributes are determined for scenario 1 (EPC) in combination with R&B division *Method B (R&B division by % share)*. The analysis of the combined opinion of the expert groups results in the following 'highly influencing' attribute:



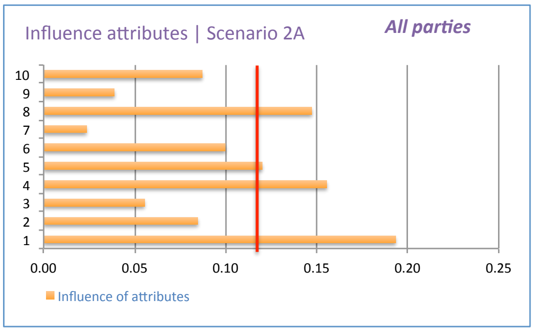
Scenario 1B | (EPC)	R&B Method B
Expert group: All together	A1: Trust between the partners within the partnership

Figure 4.40 Results 'highly influencing' attributes for all parties | scenario 1 EPC; R&B division method B

Scenario 2 (EOPC)

Risk and Benefit division Method A

The influences of ten attributes are determined for scenario 2 (EOPC) in combination with R&B division *Method A (equal R&B division)*. The analysis of the combined opinion of the expert groups results in the following 'highly influencing' attributes:



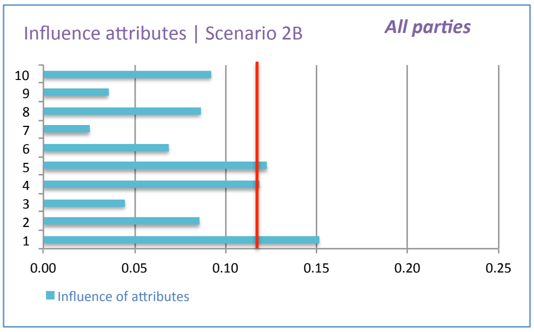
Scenario 2 | (EOPC)	R&B Method A
Expert group: All together	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership A8: Complete transparency and sharing of information between the partners within the partnership

Figure 4.41 Results 'highly influencing' attributes for all parties | scenario 2 EOPC; R&B division method A

Scenario 2 (EOPC)

Risk and Benefit division Method B

The influences of ten attributes are determined for scenario 2 (EOPC) in combination with R&B division *Method B (R&B division by % share)*. The analysis of the combined opinion of the expert groups results in the following 'highly influencing' attributes:

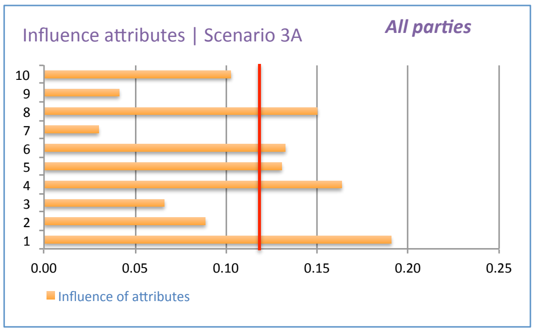


Scenario 2 | (EOPC)	R&B Method B
Expert group: All together	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership

Figure 4.42 Results 'highly influencing' attributes for all parties | scenario 2 EOPC; R&B division method B

Scenario 3 (EOPC + CP)

Risk and Benefit division Method A



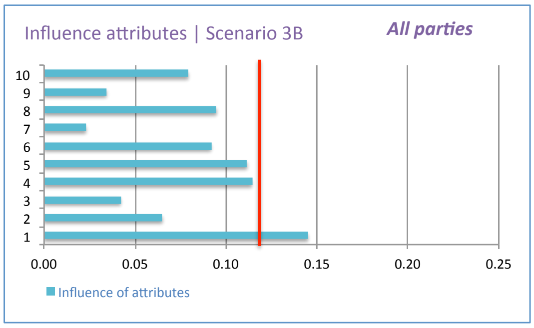
The influences of ten attributes are determined for scenario 3 (EOPC + CP) in combination with R&B division *Method A (equal R&B division)*. The analysis of the combined opinion of the expert groups results in the following 'highly influencing' attributes:

Scenario 3 | (EOPC + CP)	R&B Method A
Expert group: All together	A1: Trust between the partners within the partnership A4: Clear understanding of personal objectives within the partnership of all parties A5: Good and existing relationship between the partners within the partnership A6: Support and strong commitment of top-management level A8: Complete transparency and sharing of information between the partners within the partnership

Figure 4.43 Results 'highly influencing' attributes for all parties | scenario 3 EOPC + CP; R&B division method A

Scenario 3 (EOPC + CP)

Risk and Benefit division Method B



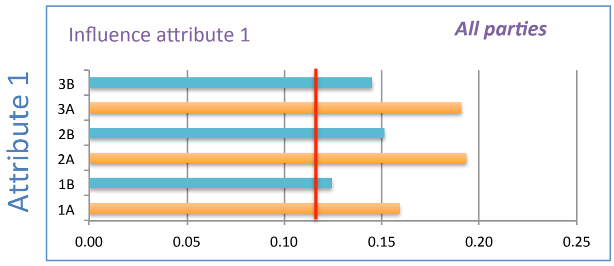
The influences of ten attributes are determined for scenario 3 (EOPC + CP) in combination with R&B division *Method B (R&B division by % share)*. The analysis of the combined opinion of the expert groups results in the following 'highly influencing' attribute:

Scenario 3 | (EOPC + CP)	R&B Method B
Expert group: All together	A1: Trust between the partners within the partnership

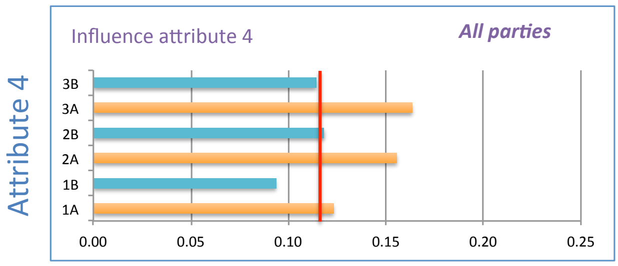
Figure 4.44 Results 'highly influencing' attributes for all parties | scenario 3 EOPC + CP; R&B division method B

As final result of this analysis, the following four attributes are given as 'highly influencing' in at least two different performance contract scenarios in combination with the risk and benefit division methods:

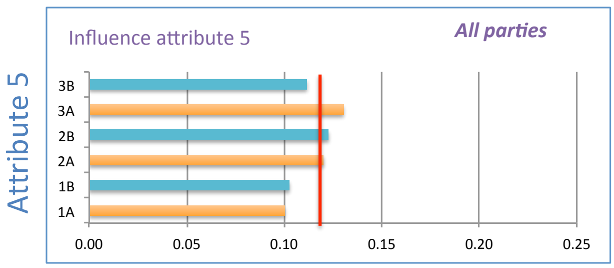
"Trust between the partners within the partnership"



"Clear understanding of personal objectives within the partnership of all parties"



"Good and existing relationship between the partners within the partnership"



"Complete transparency and sharing of information between the partners within the partnership"

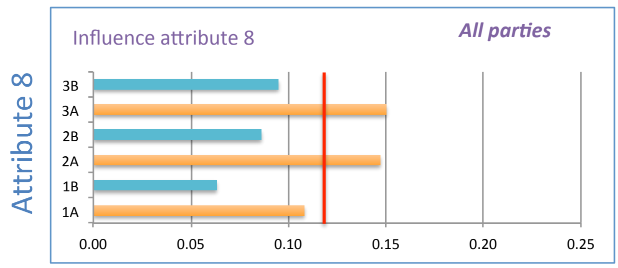


Figure 4.45 Final Results 'highly influencing' attributes for all parties in performance contracting

Conclusion of results | Determined 'highly influencing' attributes (all expert groups)

When comparing the different performance contract scenarios and R&B division methods by the analyzed results of the Fuzzy Delphi Methodology, concluding remarks will be given regarding the mutual estimation of all expert groups (contractor, engineer/consultant, energy supplier):

- *All set performance contract scenarios in combination with either R&B division Method A or B, one attribute is for each scenario combination determined as 'highly influencing: A1 "Trust between the partnership within the partnership".*
- *When comparing the set performance contract scenarios, the number of determined 'highly influencing' attributes is increasing when the scenarios consist of more performance-based components. This is for both, R&B division Method A and B, the case when comparing scenario 1 (EPC) to scenario 2 (EOPC).*
  In case of R&B division Method B (R&B division by % share), scenario 3 (EOPC + CP) shows less 'highly influencing' attributes than in scenario 2 (EOPC). In general, the implementation of Maintenance Performance will lead to a higher number of 'highly influencing' attributes; when implementing Comfort Performance, the number of 'highly influencing' attributes will increase only when R&B division Method A (equal R&B division) is applied.

R&B division Method A (equal R&B division)

- *When comparing the three performance contract scenarios in combination with R&B division Method A (equal R&B division), two attributes are determined as 'highly influencing': A1 "Trust between the partners within the partnership" and A4 "Clear understanding of personal objectives within the partnership of all parties".*
- *In case of the inclusion of Maintenance Performance (and Comfort Performance) in scenario 2 (EOPC) and scenario 3 (EOPC + CP), two extra attributes are determined as 'highly influencing': A5 "Good and existing relationship between the partners within the partnership" and A8 "Complete transparency and sharing of information between the partners within the partnership. By including Maintenance Performance, these two attributes (A5 & A8) become more influencing.*
- *In case of the inclusion of Comfort Performance in scenario 3 (EOPC + CP), one extra attribute is determined as 'highly influencing': A6 "Support and strong commitment of Top-management level". By including Comfort Performance, this attribute (A6) becomes more influencing.*

R&B division Method B (R&B division by % share)

- *When comparing the three performance contract scenarios in combination with R&B division Method B (R&B division by % share), one attribute is determined as 'highly influencing': A1 "Trust between the partnership within the partnership".*
- *Only in case of scenario 2 (EOPC) in combination with R&B division Method B (R&B division by % share), two extra attributes are determined as 'highly influencing': A4 "Clear understanding of personal objectives within the partnership of all parties" and A5 "Good and existing relationship between the partners within the partnership". By including Maintenance Performance, these two attributes (A4 & A5) become more influencing.*
- *When comparing scenario 2 (EOPC) to scenario 3 (EOPC + CP) in combination with R&B division Method B (R&B division by % share), the inclusion of Comfort Performance will lead to less 'highly influencing' attributes. Attribute A4 "Clear understanding of personal objectives within the partnership of all parties" and A5 "Good and existing relationship between the partners within the partnership" are only 'highly influencing' for scenario 2 (EOPC) in combination with R&B division Method B (R&B division by % share). By including Comfort Performance, these two attributes (A4 & A5) become less influencing.*

In general, in case performance contract scenarios become more comprehensive (more performance contract components), new (more) attributes are considered as 'highly influencing'. This applies mainly when implementing an equal risk and benefit division method, like the given R&B division Method A (equal R&B division). The inclusion of Maintenance Performance leads to higher influences to the collaboration aspect of the given attributes. The inclusion of Comfort Performance leads to higher influences to the collaboration aspect of the given attributes, when an equal division of the risks and benefits (performance output) is implemented.

4.4.5 Game Theory: Expected Utility

Introduction results Expected Utility Game Theory models

In this chapter, the results of the 'Expected Utility' modeling will be given by implementation of Game Theory. The Expected Utility (EU) modeling in this study will determine the expected value (collaboration aspect) a certain performance contract scenario outcome will have when implementing the different risk and benefit division methods. This is based on the given preferences by each expert group (involved party). The preference is derived from both, the preference in performance contract scenarios and the preferences in the associating risk and benefit decision methods. The determination of the Expected Utilization in this study is comprehensively explained in Chapter 4.2.5 *Game Theoretical approach* by implementing Formula 4.4 *Expected Utility*.

As given in the formula of the Expected Utility, the probability factor will indicate the 'probability' of a certain outcome in the game model. This probability factor is derived from the preference analysis in the risk and benefit division methods (A and B). The decision of R&B division *Method A* and *Method B*, is expressed in a *set* (Table 4.9), which results in a specific outcome of the Game Theoretical model. Table 4.9 shows a matrix wherein for each *set* (in each performance contract scenario) the probability factor is given. The total calculation matrix is given in Appendix A7.

Table 4.9 Probability factor matrix

Probability Factor *(Set)*			
R&B Decision Set*:	Scenario 1 EPC	Scenario 2 EOPC	Scenario 3 EOPC + CP
A - A - A	0,024	0,018	0,022
A - A - B	0,138	0,085	0,065
A - B - A	0,031	0,042	0,069
A - B - B	0,176	0,199	0,207
B - A - A	0,042	0,034	0,038
B - A - B	0,236	0,162	0,115
B - B - A	0,053	0,080	0,121
B - B - B	0,300	0,378	0,363

** Set indicates decision of: Contractor - Engineer/Consultant - Energy supplier*

Each *set* (combined decisions of 'players') is related to an *outcome* in the game theoretical model. The relation between each *set* and an *outcome* is modeled in Figure 4.46. The decision by each expert group (player) for a certain risk and benefit division method (A or B), is leading to the mutual decision (*set)*. The eight outcomes are expressed in each cell (Figure 4.46) as: decision P1 (contractor), decision P2 (engineer/consultant), decision P3 (energy supplier).

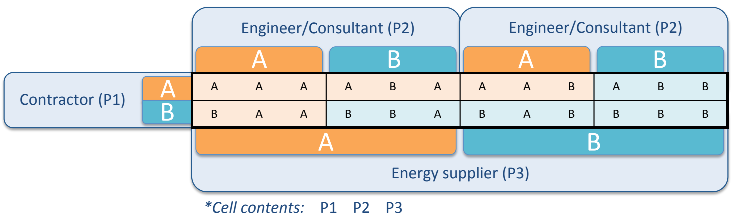


Figure 4.46 Three-player Game Theoretical model

In Figure 4.47, Figure 4.48 and Figure 4.49, the three performance contract scenarios including the Expected Utilities are given in three Game Theory models. The Expected Utility is calculated by Game Theoretical modeling, following the previous given formula. For each performance contract scenario (1,2,3), a Game Theoretical model is given where for each involved expert group the Expected Utility is calculated. Within the Game Theoretical model, for each *outcome (8)*, the EU is given as: EU Contractor (P1), EU Engineer/Consultant (P2), EU Energy supplier (P3).

Each Game Theoretical model will be analyzed by obtaining a game theoretical solution. As explained in Chapter 4.2.5 *Game Theoretical approach*, a three-way approach will be included in order to find the game theoretical solution. The purpose of these approaches is to find for each game model the (Nash) equilibrium. The three approaches are comprehensively discussed in Chapter 4.2.5 *Game Theoretical approach*, and given as follows:

- Dominant strategies
- Dominated strategies (iterative elimination)
- Nash equilibrium

Game Theory: Expected Utility results

Scenario 1 EPC | Energy Performance Contract

Expected Utility – Game model

		Energy supplier (P3): A		Energy supplier (P3): B	
		Engineer/Consultant (P2): A	Engineer/Consultant (P2): B	Engineer/Consultant (P2): A	Engineer/Consultant (P2): B
Contractor (P1)	A	0,12 0,11 0,10	0,15 0,14 0,12	0,66 0,63 0,55	0,83 0,81 0,70
	B	0,20 0,19 0,17	0,25 0,24 0,21	1,12 1,09 0,94	1,43 1,38 1,20

*Cell contents: P1 P2 P3

In Figure 4.47, the game theoretical modeling of the Expected Utility is given. The analysis overview of the game theoretical solutions, as described in Chapter 4.2.5, is given in Appendix A8. The three approaches lead to the final equilibrium results in Figure 4.47.

Game Theoretical solution approach:	Contractor (P1)	Engineer / Consultant (P2)	Energy supplier (P3)	Game Theoretical solution:
Dominant strategies:	Dominant P1 B	Dominant P2 B	Dominant P3 B	Equilibrium: B B B
Dominated strategies: (iterative elimination)	Eliminate P1 A	Eliminate P2 A	Eliminate P3 A	Equilibrium: B B B
Nash Equilibrium:	Nash Eq. P1 B	Nash Eq. P2 B	Nash Eq. P3 B	Nash Equilibrium: B B B

Figure 4.47 Results Expected Utility modeling | scenario 1 EPC

Scenario 2 EOPC | Energy Performance and Maintenance Performance Contract

Expected Utility – Game model

		Energy supplier (P3): A		Energy supplier (P3): B	
		Engineer/Consultant (P2): A	Engineer/Consultant (P2): B	Engineer/Consultant (P2): A	Engineer/Consultant (P2): B
Contractor (P1)	A	0,14 0,12 0,12	0,32 0,29 0,27	0,65 0,58 0,56	1,52 1,35 1,30
	B	0,26 0,23 0,22	0,61 0,55 0,52	1,24 1,10 1,05	2,88 2,57 2,46

*Cell contents: P1 P2 P3

In Figure 4.48, the game theoretical modeling of the Expected Utility is given. The analysis overview of the game theoretical solutions, as described in Chapter 4.2.5, is given in Appendix A8. The three approaches lead to the final equilibrium results in Figure 4.48.

Game Theoretical solution approach:	Contractor (P1)	Engineer / Consultant (P2)	Energy supplier (P3)	Game Theoretical solution:
Dominant strategies:	Dominant P1 B	Dominant P2 B	Dominant P3 B	Equilibrium: B B B
Dominated strategies: (iterative elimination)	Eliminate P1 A	Eliminate P2 A	Eliminate P3 A	Equilibrium: B B B
Nash Equilibrium:	Nash Eq. P1 B	Nash Eq. P2 B	Nash Eq. P3 B	Nash Equilibrium: B B B

Figure 4.48 Results Expected Utility modeling | scenario 2 EOPC

Scenario 3 EOPC + CP | Energy Performance, Maintenance Performance, and Comfort Performance Contract

Expected Utility – Game model

		Energy supplier (P3): A		Energy supplier (P3): B	
		Engineer/Consultant (P2): A	Engineer/Consultant (P2): B	Engineer/Consultant (P2): A	Engineer/Consultant (P2): B
Contractor (P1)	A	0,18 0,21 0,21	0,56 0,66 0,65	0,53 0,63 0,62	1,68 1,98 1,96
	B	0,31 0,37 0,36	0,98 1,16 1,15	0,93 1,10 1,09	2,95 3,49 3,45

*Cell contents: P1 P2 P3

In Figure 4.49, the game theoretical modeling of the Expected Utility is given. The analysis overview of the game theoretical solutions, as described in Chapter 4.2.5, is given in Appendix A8. The three approaches lead to the final equilibrium results in Figure 4.49

Game Theoretical solution approach:	Contractor (P1)	Engineer / Consultant (P2)	Energy supplier (P3)	Game Theoretical solution:
Dominant strategies:	Dominant P1 B	Dominant P2 B	Dominant P3 B	Equilibrium: B B B
Dominated strategies: (iterative elimination)	Eliminate P1 A	Eliminate P2 A	Eliminate P3 A	Equilibrium: B B B
Nash Equilibrium:	Nash Eq. P1 B	Nash Eq. P2 B	Nash Eq. P3 B	Nash Equilibrium: B B B

Figure 4.49 Results Expected Utility modeling | scenario 3 EOPC + CP

Conclusion of results | Expected Utility modeling

As final result of the game theoretical modeling of the Expected Utility, three approaches lead to a Game Theoretical solution in each performance contract scenario:

- *For scenario 1 Energy Performance Contract (EPC, a Nash equilibrium is present for the outcome of R&B division method BBB (R&B division Method B for each expert group).*
- *For scenario 2 Energy Performance and Maintenance Performance Contract (EOPC), a Nash equilibrium is present for the outcome of R&B division method BBB (R&B division Method B for each expert group).*
- *For scenario 3 Energy Performance, Maintenance Performance, and Comfort Performance Contract (EOPC + CP), a Nash equilibrium is present for the outcome of R&B division method BBB (R&B division Method B for each expert group).*

This means that for all of the three performance contract scenarios, the strategic solution will be to select R&B division Method B (R&B division by % share). This is resulting from the Game Theoretical modeling of the Expected Utility for each involved expert group, where the present Nash equilibrium indicates the best solution for all involved parties (players).

4.4.6 Explorative Research: Utility Function

In this chapter, the results of the 'Utility Function' will be given by Game Theoretical modeling. In order to give insights to the expected successful collaboration, the influences of the attributes will be linked to the previous game theoretical results (Expected Utility). The result will be a created utility function, in which the influence of the attributes is included. By taking into account the influences of the attributes to the Expected Utility, each performance contract scenario will have a determined 'value' for all involved parties. This 'value' will be considered as a 'success value', and based on four components:

- The preference in the different set performance contract scenarios;
- The probability factor of the preferred risk and benefit division method;
- The influences of attributes to the collaboration aspect of the performance-based scenarios in combination with the risk and benefit division methods;
- The (expected) occurrence of each specific attribute in a new project case.

Influence factor of attributes

Following the steps described in Chapter 4.2.6 *Explorative research: 'Success Value' modeling*, the factor of influencing attributes will be included. First a factor (W_{si}) will be given, which indicates the influence of the attributes in a certain performance contract scenario *(s)*. Second, a new project case could be linked to this influence factor. This will be realized by determining the (expected) occurrence of each specific attribute in a new project case. By combining the previous determined influence factor (β_{jsi}) of all attributes to the (expected) occurring attributes (X_{jsi}), an influence portfolio of the attributes to the specific scenario combination (performance contracts and R&B division method) could be created. The formula which will be used to calculate the total influence (W_{si}) to each specific performance contract scenario, is discussed in Chapter 4.2.6 *Explorative research: 'Success Value' modeling*, and given as Formula 4.6 *Influence factor of attributes*.

The factor X_{jsi} will be given as the level, a certain attribute (*j*) is occurring in a new case. In order to create a baseline model, factor X_{jsi} is set as '1' (no influence). The factor of influence (W_{si}) to each performance contract scenario given by each expert group (player), is given in Figure 4.50.

Influence factor of attributes *(X_{jsi} = 1)*				
		Contractor	Engineer/ Consultant	Energy supplier
Scenario	*R&B Method*	ω_{s1}	ω_{s2}	ω_{s3}
1 EPC	A	0,393	0,404	0,406
1 EPC	B	0,391	0,375	0,374
2 EOPC	A	0,408	0,461	0,474
2 EOPC	B	0,406	0,427	0,436
3 EOPC + CP	A	0,406	0,489	0,500
3 EOPC + CP	B	0,404	0,453	0,460

Figure 4.50 Influence factor matrix '*Baseline model*'

Utility Function

The total utility function will determine the payoff as 'success value' for the different expert groups (players) in the different performance contract scenarios. As given before, the components where this is based on are the preferences in performance contract scenarios, R&B division methods, influence factor of attributes, and occurrence of attributes in a new project case. The previously described influence of attributes is included in this utility function, which is given as Formula 4.8 *Utility Function.*

Following this formula, the three performance contract scenarios are modeled in three game theory models. For each performance contract scenario (1,2,3), a game theoretical model is given where for each involved expert group (contractor, engineer/consultant, energy supplier) the Payoff (success value) is calculated by the given utility function. Within the Game Theoretical model, for each *outcome (8)*, the Payoff (P) is expressed in a cell as: Payoff contractor, Payoff engineer/consultant, Payoff energy supplier.

Each Game Theoretical model will be analyzed again by obtaining a game theoretical solution. As explained in Chapter 4.2.6 *Explorative research: 'Success Value' modeling*, the three-way approach will be included again, in order to find the game theoretical solution.

- Dominant strategies
- Dominated strategies (iterative elimination)
- Nash equilibrium

Game Theory: Utility Function results

Scenario 1 EPC | Energy Performance Contract

Utility Function ($X_{jsi} = 1$) – Game model

	Energy supplier (P3): A						Energy supplier (P3): B					
	Engineer/Consultant (P2): A			Engineer/Consultant (P2): B			Engineer/Consultant (P2): A			Engineer/Consultant (P2): B		
Contractor (P1) A	0,05	0,05	0,04	0,06	0,05	0,05	0,26	0,26	0,21	0,33	0,30	0,26
Contractor (P1) B	0,08	0,08	0,07	0,10	0,09	0,09	0,44	0,44	0,35	0,56	0,52	0,45

*Cell contents: P1 P2 P3

In Figure 4.51, the game theoretical modeling of the Payoff (success value) is given. The analysis overview of the game theoretical solutions, as described in Chapter 4.2.5, is given in Appendix A9. The three approaches lead to the final equilibrium results in Figure 4.51.

Game Theoretical solution approach:	Contractor (P1)	Engineer / Consultant (P2)	Energy supplier (P3)	Game Theoretical solution:
Dominant strategies:	Dominant P1 B	Dominant P2 B	Dominant P3 B	Equilibrium: B B B
Dominated strategies: (iterative elimination)	Eliminate P1 A	Eliminate P2 A	Eliminate P3 A	Equilibrium: B B B
Nash Equilibrium:	Nash Eq. P1 B	Nash Eq. P2 B	Nash Eq. P3 B	Nash Equilibrium: B B B

Figure 4.51 Results Utility Function modeling | scenario 1 EPC

Scenario 2 EOPC | Energy Performance and Maintenance Performance Contract

Utility Function ($X_{jsi} = 1$) – Game model

	Energy supplier (P3): A						Energy supplier (P3): B					
	Engineer/Consultant (P2): A			Engineer/Consultant (P2): B			Engineer/Consultant (P2): A			Engineer/Consultant (P2): B		
Contractor (P1) A	0,06	0,06	0,06	0,13	0,12	0,13	0,27	0,27	0,24	0,62	0,58	0,56
Contractor (P1) B	0,11	0,11	0,11	0,25	0,23	0,25	0,50	0,51	0,46	1,17	1,10	1,07

*Cell contents: P1 P2 P3

In Figure 4.52, the game theoretical modeling of the Payoff (success value) is given. The analysis overview of the game theoretical solutions, as described in Chapter 4.2.5, is given in Appendix A9. The three approaches lead to the final equilibrium results in Figure 4.52.

Game Theoretical solution approach:	Contractor (P1)	Engineer / Consultant (P2)	Energy supplier (P3)	Game Theoretical solution:
Dominant strategies:	Dominant P1 B	Dominant P2 B	Dominant P3 B	Equilibrium: B B B
Dominated strategies: (iterative elimination)	Eliminate P1 A	Eliminate P2 A	Eliminate P3 A	Equilibrium: B B B
Nash Equilibrium:	Nash Eq. P1 B	Nash Eq. P2 B	Nash Eq. P3 B	Nash Equilibrium: B B B

Figure 4.52 Results Utility Function modeling | scenario 2 EOPC

Scenario 3 EOPC + CP | Energy Performance, Maintenance Performance, and Comfort Performance Contract

Utility Function ($X_{jsi} = 1$) – Game model

	Energy supplier (P3): A						Energy supplier (P3): B					
	Engineer/Consultant (P2): A			Engineer/Consultant (P2): B			Engineer/Consultant (P2): A			Engineer/Consultant (P2): B		
Contractor (P1) A	0,07	0,10	0,10	0,23	0,30	0,33	0,22	0,31	0,29	0,68	0,90	0,90
Contractor (P1) B	0,13	0,18	0,18	0,40	0,53	0,57	0,38	0,54	0,50	1,19	1,58	1,59

*Cell contents: P1 P2 P3

In Figure 4.53, the game theoretical modeling of the Payoff (success value) is given. The analysis overview of the game theoretical solutions, as described in Chapter 4.2.5, is given in Appendix A9. The three approaches lead to the final equilibrium results in Figure 4.53.

Game Theoretical solution approach:	Contractor (P1)	Engineer / Consultant (P2)	Energy supplier (P3)	Game Theoretical solution:
Dominant strategies:	Dominant P1 B	Dominant P2 B	Dominant P3 B	Equilibrium: B B B
Dominated strategies: (iterative elimination)	Eliminate P1 A	Eliminate P2 A	Eliminate P3 A	Equilibrium: B B B
Nash Equilibrium:	Nash Eq. P1 B	Nash Eq. P2 B	Nash Eq. P3 B	Nash Equilibrium: B B B

Figure 4.53 Results Utility Function modeling | scenario 3 EOPC + CP

Conclusion of results | Utility Function modeling

As final result of the game theoretical modeling of the utility function, three approaches lead to a Game Theoretical solution in each performance contract scenario:

- *For scenario 1 Energy Performance Contract (EPC), a Nash equilibrium is present for the outcome of R&B division method BBB (R&B division Method B for each expert group).*
- *For scenario 2 Energy Performance and Maintenance Performance Contract (EOPC), a Nash equilibrium is present for the outcome of R&B division method BBB (R&B division Method B for each expert group).*
- *For scenario 3 Energy Performance, Maintenance Performance, and Comfort Performance Contract (EOPC + CP), a Nash equilibrium is present for the outcome of R&B division method BBB (R&B division Method B for each expert group).*

This means that for all of the three performance contract scenarios, the strategic solution will be to select R&B division Method B (R&B division by % share). This is resulting from the Game Theoretical modeling of the utility function for each involved expert group, where the present Nash equilibrium indicates the best solution for all involved parties (players). Within this utility function, the influences of the attributes are included in order to model a 'success value' for the cooperation.

4.4.7 Explorative Research: 'Success Value' modeling

Following to the previous created utility function, the influence of each attribute in a possible future project case will be analyzed. This will be realized by the similar utility function as in Chapter 4.4.6, as comprehensively explained in Chapter 4.2.6 *Explorative research: 'Success Value' modeling*. The utility function is given as Formula 4.8 *Utility Function.*

The difference between the analysis in this chapter (4.4.7) and the analysis in Chapter 4.4.6, is the determination of the occurring influence factor (X_{jsi}). This occurring influence factor of the attributes in a possible future project case will be adjusted. Given the previous baseline model, (X_{jsi}) was set as '1'. The analysis in this chapter will make use of different simulations, in order to determine the influence to the modeled 'success value' for the (expected) cooperation.

Simulation modeling: Success values

In practice the involved parties have to determine the (expected) occurrence of each specific attribute in a new project case. The involved parties should rate the occurrence of each attribute by a value between 1 and 10. Following the explanation in Chapter 4.2.6 *Explorative research: 'Success Value' modeling*, a value of 6 to 10 will be considered as minimal 'sufficient' and thus have a positive influence to the project cooperation; a value of 1 to 5 will be considered as 'insufficient' and thus have a negative influence to the project success. As given in the model explanation in Chapter 4.2.6 *Explorative research: 'Success Value' modeling*, the given value (between 1 and 10) is transformed to an influence factor on a scale of 0.2 (min) to 2 (max). This is according to the implemented influence factor in the utility function in Chapter 4.4.6, where the baseline model for the utility function is created by an influence factor X_{jsi} set as '1'.

Within this analysis, the influence of the different attributes in a possible future project case will be determined. This analysis will be the most reliable, when implementing an existing case where the occurring influences of the attributes could be determined. Because of this explorative research directed to possible future projects, there are at this moment yet no practical cases that are implementable in this study. In order to provide results about the influences of attributes and to validate these, a simulation model is created to obviate this. This finally leads to the modeling of the expected 'success values' (based on cooperation), by the (simulated) influences of the different attributes. The determination of the 'success value' in each simulation model, will be provided by the *outcome* which is given as Nash equilibrium (*set* BBB, as proven in Chapter 4.4.6 *Explorative research: Utility Function*). This means that the success values only will be given for the performance contract scenarios, where a risk and benefit division is implemented by *Method* B (based on % share of project turnover). By these simulations, the most influencing attributes to the success value will be determined. The determined 'most influencing' attributes asking then for the highest attention regarding a new project case. The simulation model will be based on a three-way approach:

- Future scenario (project case) where the influencing attributes are rated relatively <u>low</u> in a new project case. This will be realized by rating 1 attribute as maximum and the rest of the attributes as minimum.

- Future scenario (project case) where the influencing attributes are rated relatively high in a new project case. This will be realized by rating 1 attribute as minimum and the rest of the attributes as maximum.
- Future scenarios (project case) where the influencing attributes are rated on each possible influence level. All attributes will be rated similar, where the rating value of 1 tot 10 will be implemented.

Results 'Success value' simulation of highly influencing attributes

In order to determine which attributes are influencing the 'success values' the most, two different simulation sets are created. The first simulation set will focus to a future performance contract scenario (project case) where the influencing attributes are rated relatively low in a new project case. The second simulation set will focus to a future performance contract scenario (project case) where the influencing attributes are rated relatively high in a new project case. The simulation sets are given as:

Simulation number 1 to 10:

- 1 attribute is having the maximum possible influence (10 out of 10)
- The rest of the attributes (9 att.) is having the minimum possible influence (1 out of 10)

This first simulation set (number 1 to 10) determines the success values, when most of the attributes are rated low. This indicates which attributes should be managed closely when the overall expectation about the influencing attributes, is relatively low (bad). The higher the 'success value' in a simulation is, the more influence the 'deviating attribute' (in comparison to the rest) has to the success value. This means that this attribute should be managed closely, in case the influencing attributes are rated relatively low in a new project case.

Simulation number 11 to 20:

- 1 attribute is having the minimum possible influence (10)
- The rest of the attributes (9 att.) is having the maximum possible influence (1)

This second simulation set (11 to 20) determines the success values, when most of the attributes are rated high. This indicates which attributes should be managed closely when the overall expectation about the influencing attributes, is relatively high (good). The lower the 'success value' in a simulation is, the more influence the 'deviating attribute' (in comparison to the rest) has to the success value. This means that this attribute should be managed closely, in case the influencing attributes are rated relatively high in a new project case.

The results of the simulation runs are given in Table 4.10. For each performance contract scenario (1,2,3) is the 'success value' determined by the given simulation runs (total of 20). The highlighted cells determine the simulation runs, which have the biggest influence to the success value for that specific expert group as involved party.

Table 4.10 Results 'Success Value' simulation

Simulation nr.	Attributes number, where X_{jsi} = Min. (1)	Max. (10)	Scenario 1 - EPC: Contractor	Scenario 1 - EPC: Engineer/ Consultant	Scenario 1 - EPC: Energy supplier	Scenario 2 - EOPC: Contractor	Scenario 2 - EOPC: Engineer/ Consultant	Scenario 2 - EOPC: Energy supplier	Scenario 3 - EOPC + CP: Contractor	Scenario 3 - EOPC + CP: Engineer/ Consultant	Scenario 3 - EOPC + CP: Energy supplier
1	Rest	1	0,0773	**0,0911**	**0,0843**	0,1607	**0,1878**	**0,1953**	0,1617	**0,2648**	**0,2812**
2	Rest	2	0,0836	0,0728	0,0662	0,1670	0,1633	0,1618	0,1675	0,2383	0,2336
3	Rest	3	0,0795	0,0664	0,0581	0,1696	0,1417	0,1362	0,1766	0,2114	0,1970
4	Rest	4	**0,0865**	**0,0843**	0,0697	**0,1786**	0,1734	0,1666	**0,1842**	0,2436	0,2427
5	Rest	5	0,0826	0,0821	**0,0787**	0,1728	**0,1736**	**0,1754**	0,1733	**0,2549**	**0,2557**
6	Rest	6	0,0805	0,0692	0,0588	0,1707	0,1570	0,1485	0,1749	0,2324	0,2312
7	Rest	7	0,0768	0,0606	0,0489	0,1621	0,1321	0,1197	0,1678	0,1877	0,1868
8	Rest	8	0,0821	0,0803	0,0638	0,1753	0,1663	0,1519	0,1760	0,2362	0,2217
9	Rest	9	0,0729	0,0640	0,0580	0,1532	0,1359	0,1415	0,1570	0,1931	0,2070
10	Rest	10	**0,0844**	0,0797	0,0662	**0,1797**	0,1608	0,1580	**0,1852**	0,2263	0,2433
11	1	Rest	1,865	**1,642**	**1,404**	3,915	**3,510**	**3,373**	4,006	**5,071**	**5,027**
12	2	Rest	1,834	1,725	1,483	3,884	3,620	3,520	3,977	5,190	5,239
13	3	Rest	1,854	1,757	1,523	3,872	3,726	3,646	3,934	5,319	5,422
14	4	Rest	**1,821**	**1,672**	1,466	**3,829**	3,574	3,497	**3,898**	5,166	5,197
15	5	Rest	1,839	1,682	**1,427**	3,857	**3,572**	**3,457**	3,949	**5,115**	**5,137**
16	6	Rest	1,849	1,742	1,519	3,867	3,651	3,583	3,941	5,218	5,250
17	7	Rest	1,867	1,788	1,572	3,906	3,777	3,734	3,974	5,444	5,477
18	8	Rest	1,842	1,690	1,494	3,844	3,606	3,567	3,936	5,200	5,297
19	9	Rest	1,887	1,770	1,523	3,952	3,757	3,618	4,029	5,414	5,370
20	10	Rest	**1,831**	1,692	1,483	**3,824**	3,632	3,537	**3,893**	5,247	5,195

* *Simulation runs (2) which have the biggest influence to the success value; This determines which attributes should be managed closely*

By simulating the success values in the different performance contract scenarios for each expert group (involved party), the attributes could be determined which should be managed closely. Because of the previously determined Nash equilibrium by Game Theoretical modeling, this success value counts only for the risk and benefit division *Method B* (based on % share of project turnover). For each expert group, the two most important attributes are given, which is analyzed for each performance contract scenario separately. The overview of the *'highly influencing'* attributes to the 'success value' for each expert group separately, is given in Table 4.11.

Table 4.11 Results 'highly influencing' attributes by 'Success Value' modeling

Scenario 1 | (EPC)		*Energy Performance Contract*
Expert group: Contractor (P1)	RANK 1st	A4: Clear understanding of personal objectives within the partnership of all parties
	RANK 2nd	A10: Extremely detailed description of tasks and responsibilities in contractual agreements
Expert group: Engineer/consultant (P2)	RANK 1st	A1: Trust between the partners within the partnership
	RANK 2nd	A4: Clear understanding of personal objectives within the partnership of all parties
Expert group: Energy supplier (P3)	RANK 1st	A1: Trust between the partners within the partnership
	RANK 2nd	A5: Good and existing relationship between the partners within the partnership
Scenario 2 | (EOPC)		*Energy Performance and Maintenance Performance Contract*
Expert group: Contractor (P1)	RANK 1st	A10: Extremely detailed description of tasks and responsibilities in contractual agreements
	RANK 2nd	A4: Clear understanding of personal objectives within the partnership of all parties
Expert group: Engineer/consultant (P2)	RANK 1st	A1: Trust between the partners within the partnership
	RANK 2nd	A5: Good and existing relationship between the partners within the partnership
Expert group: Energy supplier (P3)	RANK 1st	A1: Trust between the partners within the partnership
	RANK 2nd	A5: Good and existing relationship between the partners within the partnership
Scenario 3 | (EOPC + CP)		*Energy Performance, Maintenance Performance, and Comfort Performance Contract*
Expert group: Contractor (P1)	RANK 1st	A10: Extremely detailed description of tasks and responsibilities in contractual agreements
	RANK 2nd	A4: Clear understanding of personal objectives within the partnership of all parties
Expert group: Engineer/consultant (P2)	RANK 1st	A1: Trust between the partners within the partnership
	RANK 2nd	A5: Good and existing relationship between the partners within the partnership
Expert group: Energy supplier (P3)	RANK 1st	A1: Trust between the partners within the partnership
	RANK 2nd	A5: Good and existing relationship between the partners within the partnership

Table 4.12 Results 'Success Value' simulation *(All parties)*

Simulation nr.	Attributes number, where X_{jsi} = Min. (1)	Max. (10)	Scenario 1 - EPC All Parties	Scenario 2 - EOPC All Parties	Scenario 3 - EOPC + CP All Parties
1	Rest	1	0,2527	0,5438	0,7077
2	Rest	2	0,2226	0,4921	0,6394
3	Rest	3	0,2040	0,4475	0,5849
4	Rest	4	0,2405	0,5186	0,6705
5	Rest	5	0,2433	0,5218	0,6840
6	Rest	6	0,2086	0,4761	0,6385
7	Rest	7	0,1862	0,4139	0,5423
8	Rest	8	0,2261	0,4935	0,6339
9	Rest	9	0,1949	0,4306	0,5571
10	Rest	10	0,2304	0,4985	0,6548
11	1	Rest	4,9107	10,7972	14,1030
12	2	Rest	5,0424	11,0240	14,4058
13	3	Rest	5,1342	11,2432	14,6748
14	4	Rest	4,9592	10,8998	14,2610
15	5	Rest	4,9482	10,8864	14,2004
16	6	Rest	5,1105	11,1006	14,4095
17	7	Rest	5,2271	11,4165	14,8946
18	8	Rest	5,0260	11,0172	14,4336
19	9	Rest	5,1799	11,3272	14,8133
20	10	Rest	5,0062	10,9939	14,3342

* *Simulation runs (2) which have the biggest influence to the success value; This determines which attributes should be managed closely the most*

When combining the success values of all expert groups together (contractor, engineer/ consultant, energy supplier), a comparison will be made with the single perspective of each expert group separately. The combined success values for each performance contract scenario are given in Table 4.12. The highlighted cells determine the simulation runs, which show the biggest influence to the total success value of all involved parties (expert groups) together.

When combining the results of all expert groups together, there are two attributes given as most important to manage closely. These attributes are in all of the three performance contract scenarios shown as *'highly influencing'*, and given in Table 4.13.

Table 4.13 Results 'highly influencing' attributes for *all parties* by 'Success Value' modeling

Scenario 1 | (EPC)		*Energy Performance Contract*
Expert group: All together	RANK 1st	A1: Trust between the partners within the partnership
	RANK 2nd	A5: Good and existing relationship between the partners within the partnership
Scenario 2 | (EOPC)		*Energy Performance and Maintenance Performance Contract*
Expert group: All together	RANK 1st	A1: Trust between the partners within the partnership
	RANK 2nd	A5: Good and existing relationship between the partners within the partnership
Scenario 3 | (EOPC + CP)		*Energy Performance, Maintenance Performance, and Comfort Performance Contract*
Expert group: All together	RANK 1st	A1: Trust between the partners within the partnership
	RANK 2nd	A5: Good and existing relationship between the partners within the partnership

Conclusion of results | Determined 'highly influencing' attributes by 'Success Value' modeling

The analysis of the influences of the attributes to the 'success value' modeling provides insights for each expert group separately.

Contractor | *The priorities of the given influencing attributes are differing for performance contract scenario 1 (EPC) and the other two performance contract scenarios (EOPC and EOPC + CP) for the expert group 'contractor'. In all set performance-based scenarios, the attributes A4 and A10 are given as most influencing. However, in scenario 1 (EPC) attribute A4 is ranked 1st and A10 is ranked 2nd. In scenario 2 (EOPC) and scenario 3 (EOPC + CP), attribute A10 is ranked 1st and attribute A4 is ranked 2nd.*

- *Attribute A4 is given as 'a clear understanding of personal objectives within the partnership of all parties'.*
- *Attribute A10 is given as 'an extremely detailed description of tasks and responsibilities in contractual agreements'.*

This makes that when including Maintenance Performance and Comfort Performance, the expert group 'contractor' gives a higher priority to the detailed description of tasks and responsibilities in contractual agreements.

Engineer/Consultant | *In each set performance contract scenario, the most important attribute for the expert group of 'engineer/consultant' is A1 (ranked 1st). There is a difference between the 2nd ranked attributes in the three performance contract scenarios. Scenario 1 (EPC) shows as 2nd ranked attribute A4, where scenario 2 (EOPC) and 3 (EOPC + CP) show a 2nd ranked attribute A5.*

- *Attribute A1 is given as 'trust between the partners within the partnership'.*
- *Attribute A4 is given as 'a clear understanding of personal objectives within the partnership of all parties'.*
- *Attribute A5 is given as 'a good and existing relationship between the partners within the partnership'.*

This makes that when including Maintenance Performance and Comfort Performance, the expert group 'engineer/consultant' gives a higher priority to the existing relationship between the involved parties. When only an Energy Performance Contract is included, the clear understanding of the personal objectives of the involved parties has more priority.

Energy supplier | *In each performance contract scenario, the most important attributes for the expert group of 'energy supplier' are A1 and A5.*

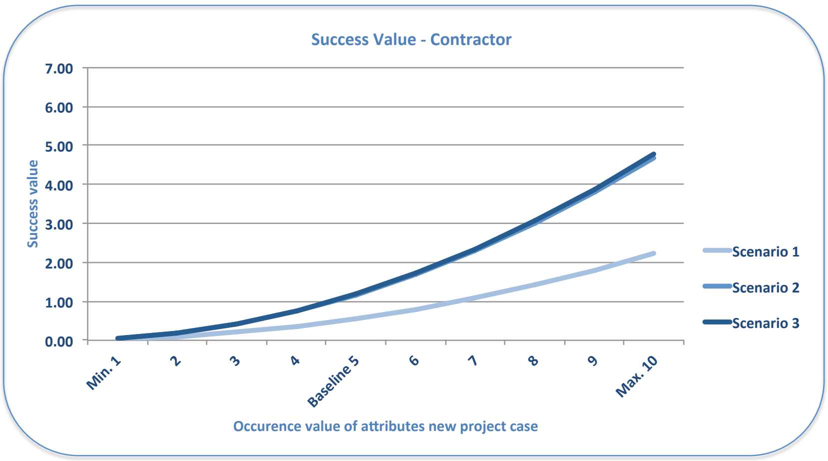
- *Attribute A1 is given as 'trust between the partners within the partnership'.*
- *Attribute A5 is given as 'a good and existing relationship between the partners within the partnership'.*

This makes that whether or not the different performance components (Energy, Maintenance, Comfort) are included, there is no differences in the priority shown for the expert group of 'energy supplier'.

Results 'Success value' simulation of performance contract scenarios

The previously conducted analysis provides insights to the influence of an individual attribute to the 'success value' of cooperation. A new simulation set will be given, where the influence of the given 'rating level' will be determined. This 'rating level' is simulating a possible occurring attribute influence level, in a future project case. The analysis of the success values is shown in Figure 4.54 (Success Value - Contractor), Figure 4.55 (Success Value - Engineer/Consultant), and Figure 4.56 (Success Value - Energy supplier). Within this simulation, each attribute is set by a rate from 1 to 10 what results in a final 'success value' for the cooperation.

'Success Value' simulation | Contractor



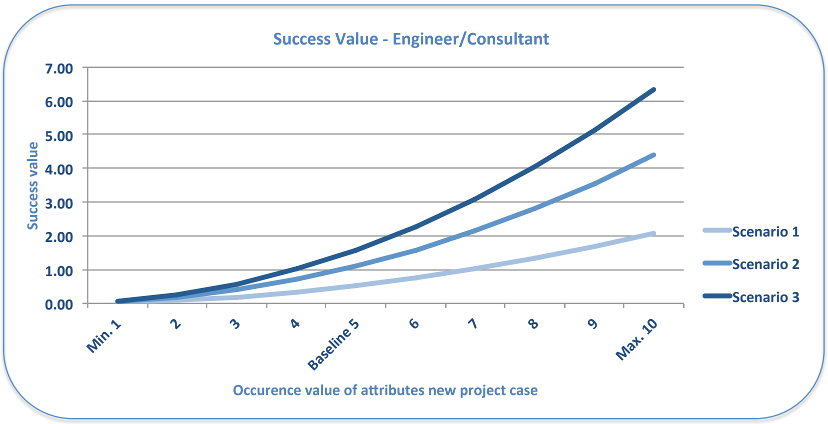
Success Value - Contractor

Xjsi =	Scenario 1	Scenario 2	Scenario 3
Min. 1	0,02	0,05	0,05
Baseline 5	0,56	1,17	1,19
Max. 10	2,23	4,68	4,77

Figure 4.54 Results 'Success Value' simulation | Contractor

As shown in Figure 4.54, a relatively big difference is shown between the success value of scenario 1 (EPC) and the other two performance contract scenarios (EOPC and EOPC + CP). The results for scenario 2 (EOPC) and scenario 3 (EOPC + CP) are for the expert group 'contractor' almost similar. The success value of the minimum influence, baseline influence, and the maximum influence of attributes is also shown in Figure 4.54 for each performance contract scenario. The total overview of the success values, regarding each attribute influence set, is given in Appendix A10.

'Success Value' simulation | Engineer/Consultant



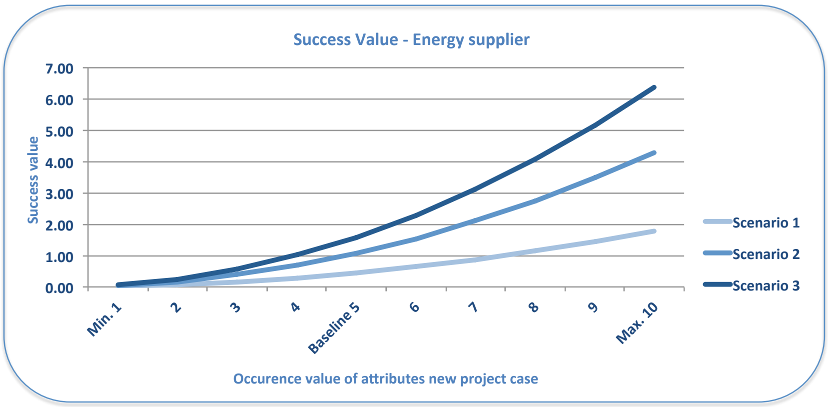
Success Value - Engineer/Consultant

Xjsi =	Scenario 1	Scenario 2	Scenario 3
Min. 1	0,02	0,04	0,06
Baseline 5	0,52	1,10	1,58
Max. 10	2,07	4,40	6,33

Figure 4.55 Results 'Success Value' simulation | Engineer/Consultant

As shown in Figure 4.55, a relatively big difference is shown between the success values of performance contract scenario 1 (EPC), scenario 2 (EOPC), and scenario 3 (EOPC + CP). The success value of the minimum influence, baseline influence, and the maximum influence of attributes is also shown in Figure 4.55 for each performance contract scenario. The total overview of the success values, regarding each attribute influence set, is given in Appendix A10.

'Success Value' simulation | Energy supplier



Success Value - Contractor

X_{jsi} =	Scenario 1	Scenario 2	Scenario 3
Min. 1	0,02	0,04	0,06
Baseline 5	0,45	1,07	1,59
Max. 10	1,80	4,29	6,35

Figure 4.56 Results 'Success Value' simulation | Energy supplier

As shown in Figure 4.56, a relatively big difference is shown between the success values of performance contract scenario 1 (EPC), scenario 2 (EOPC), and scenario 3 (EOPC + CP). The success value of the minimum influence, baseline influence, and the maximum influence of attributes is also shown in Figure 4.56 for each performance contract scenario. The total overview of the success values, regarding each attribute influence set, is given in Appendix A10.

Conclusion of results | 'Success Value' modeling of future project cases

The analysis of the 'success value' in the three different performance contract scenarios is conducted by making use of a simulation model. The influences to the 'success value' by a possible given 'rating level' of an attribute in a new project case, is determined by this analysis.

Contractor | *The result of the modeled 'success value' for the expert group 'contractor' gives a relatively big difference between scenario 1 EPC (relatively low) and scenario 2 EOPC and 3 EOPC + CP which are modeled almost similar. This makes the inclusion of Maintenance Performance (EOPC) leading to a higher 'success value' result for the expert group 'contractor'. Besides, the inclusion of Comfort Performance (EOPC + CP) will lead also to a high 'success value' result for the expert group 'contractor'.*

Engineer/Consultant | *The result of the modeled 'success value' for the expert group 'engineer/consultant (P2)' gives a*

Figure 4.57 Results 'Success Value' simulation | Energy supplier

relatively big difference between scenario 1 EPC (relatively low), scenario 2 EOPC (between relatively low and high), and scenario 3 EOPC + CP (relatively high). This makes the inclusion of Maintenance Performance and Comfort Performance (EOPC + CP) leading to a higher 'success value' result for the expert group 'engineer/consultant'.

Energy supplier | *The result of the modeled 'success value' for the expert group 'energy supplier (P3)' gives also a relatively big difference between scenario 1 EPC (relatively low), scenario 2 EOPC (between relatively low and high), and scenario 3 EOPC + CP (relatively high). This makes the inclusion of Maintenance Performance and Comfort Performance (EOPC + CP) leading to a higher 'success value' result for the expert group 'energy supplier'.*

When having an identical occurring influence of an attribute in a future project case, scenario 3 (EOPC + CP) will provide the highest 'success value' for the collaboration, based on the results for each expert group. This results in the highest potential 'success value' for scenario 3 where Energy Performance, Maintenance Performance, and Comfort Performance are implemented (EOPC + CP) and a risk and benefit division methods is implemented, based on the share (%) in project turnover.

4.5 Discussion

4.5.1 Research limitations

Evaluating the conducted research, some limitations were arising during the research process. The limitations to this study are subdivided in seven different topics. Some of the limitations are partially obviated, in order to improve quality of this research.

Response Rate

Regarding the respondents included in this study, a couple remarks could be made. As given in Chapter 4.3.2 *Respondents*, the response rate in this research is lower than expected (36%). The main cause for this is that several consulted experts have given their vision instead of filling in the questionnaire. At one hand this has contributed to the research, by the extra provided information and included vision of these experts. On the other hand, the amount of respondents which filled in the questionnaire was lower than expected. Overall could be stated that an increase of the included experts as respondent, the reliability of this study will increase.

Representing experts

Mainly the expert group of *energy suppliers* is insufficiently represented, which should be taken into account by the given conclusions. The expert group who is representing the company type engineer/consultant is insufficiently represented as well, from a scientific perspective when applying Fuzzy Delphi Methodology. The cause for the low number of respondents in this expert group is due to the representing company. Only the company Royal HaskoningDHV is representing the company as engineer/consultant. The reason for only consulting this company is that the conduction of this research is in cooperation with this company. The number of consulted experts within the company is lower than the desired number of experts, regarding the Fuzzy Delphi Methodology approach. However, the research is conducted in cooperation with the company RHDHV and only experts are included with affinity with the research topic. This makes the company Royal HaskoningDHV assumed as properly representing their own company, but it is not representing a sufficient number of experts as engineer/consultant.

Biased experts

The representing company RHDHV for the expert group of engineer/consultant, also brings up a possible extra limitation to this study. By using different companies for each expert group, the general opinion of the expert group could be analyzed. Regarding the expert group of the engineer/consultant, only experts of the company Royal HaskoningDHV are consulted. This could lead to a possible biased opinion. It is consequently unclear or the analyzed opinion of these experts are either from the perspective of an engineer/consultant in general, or only from the perspective of the company RHDHV. This is mainly a limitation from the scientific point of view. Due to the fact that this research is in cooperation with the company RHDHV, the value of the research results for this company is not influenced by this limitation.

Practical applicability

A limitation in this study could be given about the practical applicability of the results. First, some assumptions within the study are possibly different in practice. An example of this is the inclusion of the majority rule, in the game theoretical modeling in order to determine the final R&B division method outcome. Theoretically (based on previous research e.g.) this could be properly included in this study. Nevertheless, in practice the decision for a final R&B division method will be resulting from a possible negotiation process. This makes the results about the R&B division method in this study still applicable, regarding the preferences of the involved expert groups. However, the possible practical effect following the negotiation process could be different and should be taken into account.

Further, another limitation in this study could be given about this practical applicability. The performance-based scenarios included in this research are consisting of performance contracts and an associating risk and benefit division. The scope of this research and the given information about the performance-based scenarios is relatively general explained and focused to a specific case. This is at one hand to make the study more generic applicable, in accordance to the given specific case. At the other hand, dependent of each new project case, other conditions could influence the applicability of the given results in this study. Based on the information provided in the created performance contract scenarios, the conclusions could be included in a new (similar) project case. However, the results and conclusion should always be reviewed and possibly translated to practice and reality, to make it applicable for the new specific project case.

Interpretation of attributes

In this study, the influences of different attributes are determined. Several previous studies are conducted in order to determine the attributes which are (highly) influencing to partnerships. The inclusion of the results of previous studies, into this research could be given as a limitation. This because of the deviations between the previous conducted studies and this research. In order to obviate this, the reanalyzing of the selected (possibly) influencing attributes is conducted. This determines whether or not the selected attributes are indeed and to what extent, influencing to the collaboration in the set performance contract scenarios in this research. Besides, the selection of attributes is based on a content analysis. This indicates the number of studies that considers a certain attribute as influencing. The selection is conducted for attributes that are considered as influencing in at least three previous studies, directed to the relatively similar field of study.

Another limitation regarding the selected influencing attributes concerns the possible interpretation deviations. The selected attributes are described as general and possibly multiple interpretable. This could be an issue when respondents are interpreting the attributes in a total different way. In order to obviate this, first the background information and case explanation is comprehensively given in the questionnaire. This will make it easier for respondents to link the attributes to the specific study case, and decrease the deviation of interpretation. A more important measure to obviate this as much as possible, is the implementation of the Fuzzy Delphi Methodology (FDM). By making use of the Fuzzy Delphi Methodology, the most important advantage is that it takes this 'fuzziness' into account of the different expert groups, which are involved in this research. Besides by assigning three values (low, optimal, high) to the influence of an attribute, more information about the possible influence is obtained.

Determining the 'success value' of collaboration

The given analysis to determine the 'success values' for the collaboration within the partnership is based on a couple of elements. These elements are the preferences in performance contracting, preferences in R&B division, determined influences of attributes, and the expected occurrence of these attributes in a new project case. As given in the problem statement and scope description, these will not be the only elements that are leading to a 'successful partnership'. The scope of this research is focusing to the collaborative aspect within the partnership, and thus the success value is based on this starting point. Given the experts (experts RHDHV), the most essential element in order to make estimations about the 'total success of a project' is given as the (financial) business case. A decent business case should always be present. This business case inclusion is not a part of the scope of this research. By improving the success of collaboration, the final success of the project could be influenced, but a decent business case should be present. Future research could focus to merging the financial business case to the collaborative aspect, included in this study. The given 'success value' should thus interpreted, based on the given elements influencing the collaboration within the partnership.

Model validation

The given model structure in this study is consisting of several element where most of them are based on previous research and properly applicable. Nevertheless, there are some assumptions established in order to connect the different components of the created research model. For instance, the established utility function is composed of the expected utility and the influences of attributes. This consists in total of four elements. The ratio between these elements within the utility function is given as assumption. By implementing new studies to this possible ratio of elements in the set utility function, the reliability will improve.

In order to further improve the reliability and accuracy of this study, the validation is essential. The validation of the applied model will be the most reliable, when implementing an existing case where the influences of the attributes are determined. Because of this explorative approach in this research directed to possible future projects, there are at this moment jet no practical cases that are implementable in this study. In order to obviate the essential validation, two main approaches are included in this study. First, different experts of the company Royal HaskoningDHV reviewed the important elements regarding the created performance-based scenarios. Second, different simulation sets are included in order to provide insights in the possible results for a future project case. The validation by comparing to previous cases will definitely improve the reliability of this study. Nevertheless, due to the explorative approach the conducted measures will be partly obviate the essential validation.

4.5.2 Further research

The results and conclusions provided in this research will form some starting points for future research. Different possible follow-up studies are given and some future research in order to obviate the previously explained limitations.

Link with business cases

Given the vision of the experts (among others experts RHDHV) the business case is essential in order to determine whether or not a project will be successful. In this study the focus to the collaboration aspect is researched. Following the vision of the experts, a decent business case is essential and therefore set as assumption in this study, in order to research the collaboration aspect. Future research could provide more insights in the possible success factors for the set performance contract scenarios. The combination of the business case of performance contracting components to the collaboration aspects could provide insights into the opportunities of the performance-based developments in the construction industry.

The Game Theoretical approach will be highly suitable when including the (financial) business case in the given research model. By GT modeling, the final utility can be expressed in a financial outcome, where the collaboration aspects are taken into account. In order to combine these aspects, a more total view of this opportunity by performance contracting could be given. The inclusion of the business case to the 'success value' modeling by a Game Theoretical approach could result in financial figures modeling. This more financial oriented modeling will lead to a more decent substantiation of a possible decision to take in practice. Mainly regarding the practical applicability, financial figures for the business case are essential.

The inclusion of the business case to the model of this study could be implemented in different situations. It could be obviously implemented for the given problem statement in this study, regarding the optimization of the municipalities' (corporate) real estate properties. But also the implementation of these results to different specific branches is definitely possible and could be researched.

Risk and benefit division methods

In this study, two methods are introduced to divide risks and benefits in case of performance contractual agreements. Of course there are several options to divide the risks and benefits between the involved parties. At one hand, expanding the number of R&B division methods in the set research model, a more complete view could be given about more possible 'successful' R&B division methods.
At the other hand, a in depth study to the possible occurring risks and benefits regarding performance contracting will contribute to the results in this study. This could be realized by specifying the occurring risks and benefits in more detail and the impact tot the 'success' of the project case. This could lead to a more comprehensive and substantiated result of the 'success value' modeling.

Comfort Performance

The performance contract scenarios created for this study are relatively general. Besides, only three combinations of the components *Energy Performance, Maintenance Performance*, and *Comfort Performance* are established. Given the results of this study, the inclusion of *Comfort Performance* is given as market opportunity and possibly asks for further research. By focusing to the relatively recent development of *Comfort Performance* (contract), anticipation to this development could be optimized. By making use of scientifically research, success factors of *Comfort Performance* could be indicated. The combination between the further researches to *Comfort* Performance could be made with the results of this study. Modeling the business case and success factors of *Comfort Performance* will bring up new insights and possibly an improved anticipation to this market opportunity.

Validating

Following the limitation of 'model validation', the validation of the created model could be conducted by future research. By including existing project cases, inline with the problem statement of this study, the 'success value' modeling could be optimized. This optimization will lead to a more reliable and accurate modeling of the 'success' of collaboration. By improving the model by the inclusion of practical cases, the model could be optimized and thus possibly lead to an improvement of the practical application.

Prediction model

Another possibility for future research is the further development of the model into a prediction model. Important for a prediction model is the availability of data to validate the prediction model, hereby implementing data of practical cases. A prediction model could succeed the previously described future research possibilities where the 'success value' model will be optimized. By predicting the collaboration aspect for a future project case, on forehand measurements could be established to improve the expected success of the project. This study provides a starting point for this prediction model and gives already insights to these possible measurements to take. Subsequently, the inclusion of possible other success factors and the (financial) business case into the prediction model could be researched. The prediction model fits well with the Game Theoretical approach included in this study. This approach provides insights in the expected outcomes of different performance contract scenarios and possible actions the involved parties could take. Further development of a prediction model will lead to a more comprehensive and applicable model to predict the 'success' in a future project case.

5 Conclusion

5.1 Conclusion Research (sub) Questions

The main objective of this research is providing insights in possible improvements to the successful collaboration within a researched partnership (contractor, engineer/consultant, energy supplier); this in combination with the possible implementation of performance contracting. The achievement of this objective will lead to insights in the opportunity to answer the request of municipalities to optimize their real estate property performance in a sustainable way. The main objective of this research will be given as final conclusion and achieved by answering the main research question:

> *In which way could the successful collaboration be optimized for a partnership-solution, which optimizes the municipalities' property performance in a sustainable way?*

This chapter will provide first the conclusion of the four research sub questions. The conclusions of these research sub questions are leading to the final conclusion in this study, where the main research question will be answered.

> ***Q1** Which possible scenarios could be established, where performance contracting will be implemented and leading to a mutual responsibility within the partnership?*

The researched scenarios in this study are consisting of three main components:

- Partnership formation
  Consortium consisting of: Contractor, Engineer/consultant, and Energy supplier
- Performance contract scenarios
  Energy Performance; Maintenance Performance; Comfort Performance
- Mutual risk and benefit division Methods (performance output)
  Equal R&B division; or R&B division based on share (%) in total project turnover

First, the concluding scenarios are shown in Figure 5.1, where after the components of the scenarios will be further specified. The three scenarios are given in Figure 5.1 as three performance contract scenarios (EPC, EOPC, and EOPC + CP) and two risk and benefit division Methods (A and B), based on the given partnership formation (Contractor, Engineer/consultant, Energy supplier):

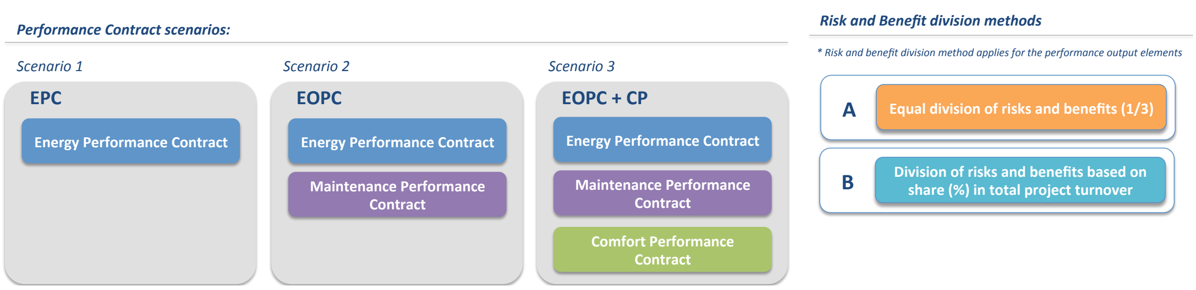


Figure 5.1 Performance contract scenarios and R&B division methods

Partnership formation

As appropriate partnership formation, the collaboration between a contracting party, engineering (consulting) party, and energy supplying party is determined as appropriate. This is arising from the 'responsibility elements' as part of the municipalities' project request, to optimize the municipalities' real estate properties performance in a sustainable way. The contractor will be main responsible for the *Build* component, the engineer/consultant will be main responsible for the *Design* component, and the energy supplier for the *(sustainable) Energy* component. These three main components are essential for implementing performance contracting, where the *'Design'*, *'Build'*, and *'(sustainable) Energy supply'* components are interdependent and should properly integrate in order to realize a set performance output. The coherence between these components *(Design, Build, (sustainable) Energy supply)* to realize the set performance output *(Energy, Maintenance, and Comfort)*, asks for a successful collaboration.

Performance contracting

By including *Energy Performance*, *Maintenance Performance*, and *Comfort Performance* in the performance-based scenarios, three important recent performance contract developments are included. The implementation of an *Energy Performance contract* is determined as a suitable performance contract scenario. A proper addition to this, will be the combination between the *Energy Performance contract and a Maintenance Performance contract*, with as main reason the associating increased level of control to the building (performance) installations. As third scenario, the inclusion of *Comfort Performance* is determined as a suitable solution following the recent development of the market requests. By the inclusion of *Comfort Performance*, a (more) total building performance solution will be provided. The main reasons therefore are the guaranteed *Comfort Performance*, which leads to an increase in the users' satisfaction and subsequently to an increase in productivity of employees. All included performance contract scenarios are determined as highly suitable for the client (municipality in this study), based on the of two main advantages:

- Cost savings (energy savings and an increased employee productivity),
- Building performance guarantee which provides less uncertainties and risks to the client

Mutual risk and benefit division methods (performance output)

A proper collaboration between the involved parties is essential in order to deliver the set performance by the performance contract scenarios. The 'mutual responsibility', consequentially of the implementation of the performance contract scenarios, is dependent on the collaboration aspect between the partners. Two risk and benefit methods are determined as suitable, in order to implement the mutual responsibility for the performance output.

- An equal division of the risks and benefits between the involved parties (1/3)
- A risk and benefit division based on the share (%) each involved party has in the total project turnover (%)

> ***Q2** Which insights could be given about the preferences to the created scenarios, consisting of performance-based components and the associating mutual responsibilities?*

Preference in performance contract scenarios

The concluding preferences for the performance contract scenarios are similar for the three involved parties together (contractor, engineer/consultant, energy supplier); ranking the scenarios based on the preferences is set as follows:

1. *Energy Performance, Maintenance Performance and Comfort Performance contract*
2. *Energy Performance and Maintenance Performance contract*
3. *Energy Performance contract*

Providing conclusions of the perspective of the single involved parties regarding the preferred performance-based scenarios, will be important for the collaboration between the three involved parties, as shown in Table 5.1.

Table 5.1 Concluding preferences for the performance contract scenarios

Performance contract scenarios:	Energy Performance Contract	Energy Performance and Maintenance Performance Contract	Energy Performance, Maintenance Performance, and Comfort Performance Contract
Contractor:	LOW	HIGH	HIGH
Engineer/consultant:	LOW	MODERATE	HIGH
Energy supplier:	LOW	LOW	HIGH

Based on the analyzed preferences (Low – Moderate – High) of the three involved parties (contractor, engineer/consultant, energy supplier), the following concluding recommendations could be given:

- The inclusion of *Maintenance Performance* when implementing an *Energy Performance Contract* is essential.
- The inclusion of *Comfort Performance* into the implementation of performance contracted is highly preferred by the 'engineer/consultant' and 'energy supplier'.

In order to properly interpret and substantiate the given conclusions, some remarks, conditions and further explanations are given:

- The essential inclusion of *Maintenance Performance* when implementing an *Energy Performance Contract* and/or a *Comfort Performance contract* is based on the necessary higher level of control to the building installations (e.g. experts RHDHV, 2015; (Roskam, 2013)).
- By including the maintenance component (*Maintenance Performance)* in a long-term partnership, larger investments for relatively bigger and more innovative projects could and probably will be established (e.g. experts RHDHV, 2015).
- The preferred inclusion of *Comfort Performance* by the researched involved parties, is in line with the recent market requests, based on the total improvement and desired building performance. This leads to cost savings (energy savings; and increased employee productivity) and performance guarantees provides less uncertainties and risks for the client (e.g. experts RHDHV, 2015; (World Green Building Council, 2014; DGMR, n.d.)).
- Implementing *Comfort Performance* and so providing a complete (high) performance level of the building, will lead to an established balance between all incorporated building performance elements. As example, focusing mainly to limited energy consumption could possibly lead to a lower realized comfort performance.
- Realization of *Comfort Performance* is relatively hard in comparison to the other performance contracts (e.g. experts RHDHV, 2015; (DGMR, n.d.; World Green Building Council, 2014)). Important influencing elements to the performance output could be relatively hard to regulate, like *users' behavior* for instance. *Users satisfaction* is also difficult to regulate and to affect, and at the same time an important criteria to determine the delivered comfort performance.

Preference in risk and benefit division (mutual responsibility of performance output)

Concluding from the researched vision of the involved parties (contractor, engineer/consultant, energy supplier), the preference of the risk and benefit division methods (performance output) is linked to the performance contract *scenarios*:

- The majority of the experts of the involved parties determined for each included performance contract scenario a most appropriate risk and benefit division based on the share (%) in project turnover.
- When more performance contracts are implemented, a risk and benefit division based on the share (%) in total project turnover will be more appropriate than an equal division of the risks and benefits, based on the given preferences of the consulted experts.

Contractor | There is no link shown between the preference for a specific risk and benefit division method and the different performance *contracts* for the 'contractor'. A consistent part (+/- 25%) of the expert group 'contractor' prefers an equal division of the risks and benefits in each performance contract scenario.

*Engineer/*consultant | A risk and benefit division method based on the share in project turnover becomes more appropriate when more performance *contracts (Maintenance and/or Comfort)* are implemented than only an Energy Performance Contract, for the 'engineer/consultant'. When only an *Energy Performance Contract* is implemented, the part of the 'engineer/consultant' experts (33%) prefers an equal division of the risks and benefits. When more Performance contracts are implemented, all experts (engineer/consultant) prefer a risk and benefit division based on the share (%) in project turnover.

Energy supplier | There is no link shown between the preference for a specific risk and benefit division method and the different performance *contracts* for the 'energy supplier'. In each performance contract scenarios, all experts (energy supplier) prefer a risk and benefit division based on the share (%) in the project turnover.

In order to properly interpret and substantiate the given conclusions, some remarks, conditions and further explanations are given:

- The relatively high percentage of the expert group 'contractor' for an equal risk and benefit division could be possibly explained by their responsibility for the '*Build*' component. The '*Build*' component will lead to a relatively big share in the project turnover. This leads subsequently to a bigger share in the risks for the 'contractor', in comparison to the situation where the R&B are equally divided (e.g. experts RHDHV, 2015).

- By including an equal risk and benefit division method in this study, the profits could be relatively high for the single parties with a relative small share in the project. The determined strong preferences for the risk and benefit division based on the share (%) in the project turnover, could possibly resulting from the associating relatively smaller risk share it will provide for the single parties with a relatively small share in the project turnover. This is also shown in the higher determined preferences for the risk and benefit division based on the share (%) in project turnover, when more performance contracts are incorporated (higher risks).
- The relatively low preferences for an equal risk and benefit division methods is possibly a result of the companies' internal (risk-averse) policies.
- Only two risk and benefit division methods are incorporated, based on the assumption to make the involved parties mutual responsible for the risks and benefits of the performance output.

> ***Q3*** *Which attributes will be considered as influencing attributes to a successful collaboration within a set partnership composition, concerning the performance-based scenarios, by a Fuzzy Delphi Methodology approach?*

'Highly influencing' attributes

Concluding of the mutual estimation of all consulted experts (contractor, engineer/consultant, energy supplier), the 'highly influencing' attributes are determined by the Fuzzy Delphi Methodology. For the researched performance contract scenarios in combination with the risk and benefit division methods, the sensitivity is the highest for the following four attributes:

- Trust between the partners within the partnership
- Clear understanding of personal objectives within the partnership of all parties
- Good and existing relationship between the partners within the partnership
- Complete transparency and sharing of information between the partners within the partnership

Change in importance of attributes

The researched sensitivity of the scenario components (performance contracts and risk and R&B division methods) for the attributes influences, leads to the following conclusions:

- When a performance contract scenario contains *Maintenance Performance (and Comfort Performance)*, the *'understanding of the personal objectives of the involved parties'* becomes more important. This is in comparison to an *Energy Performance Contract*.
- When an equal division of risks and benefits is implemented, and a performance contract scenario contains *Maintenance Performance (and Comfort Performance)*, the *'good and existing relationship between the involved parties'* becomes more important.
- When an equal division of risks and benefits is implemented, and a performance contract scenario contains *Maintenance Performance (and Comfort Performance)*, the *'transparency and sharing of information between the involved parties'* becomes more important.

The increase in importance of the given attributes is based on the increased (positive) influence of these attributes. The improved handling and management of these attributes, leads to a more successful collaboration when performance contracting is implemented.

General conclusions about the researched influences of the attributes are given as:

- When a performance contract scenario includes more performance contracts, the sensitivity for the researched influences of the attributes is increasing. Both, the level of influence will increase for the attributes, and the number of attributes which are indicated as 'highly influencing' will increase.
- When a performance contract scenario implements an equal division of the risks and benefits instead of a turnover (%) based division, the sensitivity for the researched influences of the attributes is increasing. Both, the level of influence will increase for the attributes, and the number of attributes which are indicated as 'highly influencing' will increase.
- When a performance contract scenario includes more performance contracts in combination with an equal division of the risks and benefits, the sensitivity for the researched influences of the attributes is increasing.

Both, the level of influence will increase for the attributes, and the number of attributes which are indicated as 'highly influencing' will increase.

The increased sensitivity for the influences of the attributes asks for an improved (more intensive) handling and management of all attributes. Mainly high attention should be given to the determined 'highly influencing' attributes.

By including more performance contracts, an increased sensitivity to the influences of attributes is shown, which will be based on three elements:

- Increase of the necessary control to the performance output (e.g. experts RHDHV, 2015; (Roskam, 2013))
- Increase of mutual risks when more performance contracts are included (e.g. experts RHDHV, 2015; (Tang, Shen, & Cheng, 2010; Hwang, Zhao, & Gay, 2013))
- Essential coherence between the parties and their responsibilities (*Build, Design, (sustainable) Energy supply)* in order to realize the performance-based output (e.g. experts RHDHV, 2015).

> ***Q4.*** *To what extent will the researched influence of attributes to performance-based scenarios, give insights in the successful collaboration within the set partnership composition, by a game theoretical approach?*

By researching the influences of the attributes to the performance-based scenarios, the Game Theoretical approach provides new insights to the successful collaboration aspect. The conclusions are given as:

- Contractor | The 'success value' of collaboration is as highest for both: the '*Energy Performance* and *Maintenance Performance contract'* and the '*Energy Performance, Maintenance Performance,* and *Comfort Performance contract'*.
- Engineer/consultant | The success value of collaboration for the *'Energy Performance, Maintenance Performance, and* Comfort Performance contract' is as highest.
- Energy supplier | The success value of collaboration for the '*Energy Performance, Maintenance Performance,* and *Comfort Performance'* contract is as highest.

Following the 'success value' modeling, the attributes which are the most important for each single involved party (expert group) are given for the highest 'success value' scenario, *Energy Performance, Maintenance Performance and Comfort Performance contract* in combination with a R&B division based on the share (%) in project turnover:

Contractor:

- *Extremely detailed description of tasks and responsibilities in contractual agreements*
- *Clear understanding of personal objectives of all parties within the partnership*

Engineer/consultant:

- *Trust between the partners within the partnership*
- *Good and existing relationship between the partners within the partnership*

Energy supplier:

- *Trust between the partners within the partnership*
- *Good and existing relationship between the partners within the partnership*

The determined important influencing attributes ask for an improved (more intensive) handling and management of these attributes by all involved parties (contractor, engineer/consultant, energy supplier) in order to positively influence the successful collaboration.

When comparing the different performance contract scenarios, the 'success value' modeling by a Game Theoretical approach provides new conclusions (comparing to the Fuzzy Delphi Methodology approach) to the importance of the influencing attributes for each involved party:

- Contractor | The '*detailed description of tasks and responsibilities in contractual agreements'* becomes more important (highest priority), when an *Energy Performance Contract* will be expanded with *Maintenance Performance (and Comfort Performance)*.
- Engineer/consultant | The '*good and existing relationship between the involved parties'* becomes more important than the *'clear understanding of the personal objectives of the involved parties'*, when an *Energy Performance Contract* will be expanded with *Maintenance Performance (and Comfort Performance)*.

- Energy supplier | There is no difference shown in the importance of the attributes, by comparing the different performance contract scenarios.

In order to properly interpret and substantiate the given conclusions, some remarks, conditions and further explanations are given:

- By using the 'success value modeling' by a Game Theoretical approach, more aspects are taken into account than in the Fuzzy Delphi Methodology-approach (research sub question 3). Both approaches indicate the sensitivity of the performance contract scenarios to the influencing attributes. The 'success value' modeling (Game Theoretical approach) provides more insights to the sensitivity of the successful collaboration to the influencing attributes.
- The 'success value' modeling by a Game Theoretical approach is an explorative research which will and should be further optimized in future research.
- The provided conclusions about the 'success value' modeling apply only for a risk and benefit division method based on the share (%) in the total project turnover, which is previously determined as most appropriate in the researched performance contract scenarios.
- The 'success value' modeling is focusing to the collaboration aspect. However, the business case is an essential element in whether or not the project will be successful (e.g. experts RHDHV, 2015). By improving the success of collaboration by a better handling and management of the influencing attributes, the success of the project could be improved (e.g. experts RHDHV, 2015).

Main Research Question

The conclusions of the four search sub questions are leading to the final conclusion by answering the following main research question:

> *In which way could the successful collaboration be optimized for a partnership-solution,*
> *which optimizes the municipalities' property performance in a sustainable way?*

Regarding the implementation of performance contracting and the associating risk and benefit division (performance output), the following conclusions are set:

- The inclusion of *Maintenance Performance* is essential when implementing an *Energy Performance*, or a *Comfort Performance contract*.
- The *Energy Performance, Maintenance Performance, and Comfort Performance contract* is determined in this study as most appropriate, of the researched performance contract scenarios.
- A risk and benefit division (performance output) based on the share (%) in project turnover is determined in this study as most appropriate for the given performance contract scenario.

In order to improve the (successful) collaboration in performance contracting, the following attributes ask for the highest priority by improving the handling and management of these attributes:

1. Good and existing relationship between the partners within the partnership
2. Trust between the partners within the partnership
3. Clear understanding of personal objectives within the partnership of all parties
4. A detailed description of tasks and responsibilities in contractual agreements

In order to properly interpret the given conclusions, some conditions and further explanations are given:

- The implementation of an *Energy Performance, Maintenance Performance, and Comfort Performance contract* is combined by a risk and benefit division method based on the share (%) in the total project turnover.
- The concluded priority of the attributes counts for the collaboration aspect of the involved consortium parties: Contractor, Engineer/consultant, and Energy supplier.
- The research and given conclusion is based on the implementation of performance contracting with a mutual responsibility for the associating risks and benefits; this in order to optimize the municipalities' property performance in a sustainable way, by the given consortium partners.

5.2 Research contribution

The findings in this study will contribute by its practical, social, and scientific relevance. The concluding contribution of this research is described by its practical contribution, societal contribution, and scientific contribution.

Practical contribution

- This study provides new insights into performance contracting for private parties, which is indicated as a relatively recent market development and opportunity.
- The data collection by consulting experts of private market parties will provide a good reflection of reality (reliable). This will contribute to the further practical implementation of the findings in this study.
- The company Royal HaskoningDHV is highly involved in the conducted research. This results in a proper translation of practical issues into this research. Besides, the findings of this research will possibly contribute to the collaboration aspect in future performance contracting partnerships of the company Royal HaskoningDHV.

Social contribution

- This study is based on the current market request of municipalities, regarding the optimization of the performance of their real estate properties. The findings in this study could contribute to the future sustainable optimization of these properties by performance contracting, by private party involvement.
- The implementation of performance contracting for the optimization of the municipalities' real estate properties, could lead to more innovative and sustainable solutions. This will contribute to the sustainable ambition and objectives municipalities nowadays have set.
- Following the governmental and more local (municipalities) objectives regarding sustainability, the environmental and sociological responsibilities to this will be more exposed. Providing insights to sustainable-related solutions, a contribution will be delivered to the awareness and possibly final implementation of sustainable and innovative solutions.

Scientific contribution

- The data collection for this study is conducted by consulting experts of different private market parties. This makes a proper link between practice and the scientific substantiation provided by this research. Besides, consulting different experts about their own opinion and perspective will provide a proper reflection of reality and contribute to the reliability of the data.
- A new approach is introduced in this study to model the influences of the attributes to the collaboration aspect. The findings in this study show a difference between the 'expected influence' of attributes (opinion of experts by Fuzzy Delphi Methodology), and the influences of attributes to a modeled 'success value' by a Game Theoretical approach. The provided new approach to determine the influences of attributes to the 'success' of the collaboration, determines for each expert group the most influencing attributes, despite the possibility that the experts rate these influences low. Further improvement and optimization of this approach is necessary by implementing real project cases. Nevertheless, the starting points for modeling the 'success value' for the collaboration is set, when performance contracting is implemented.

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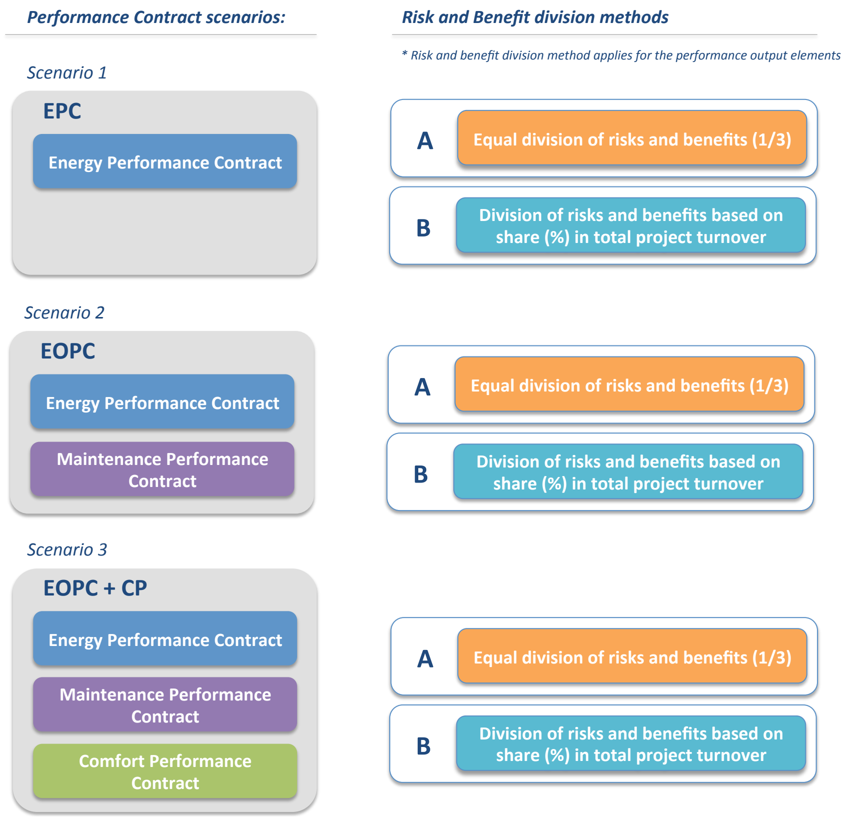
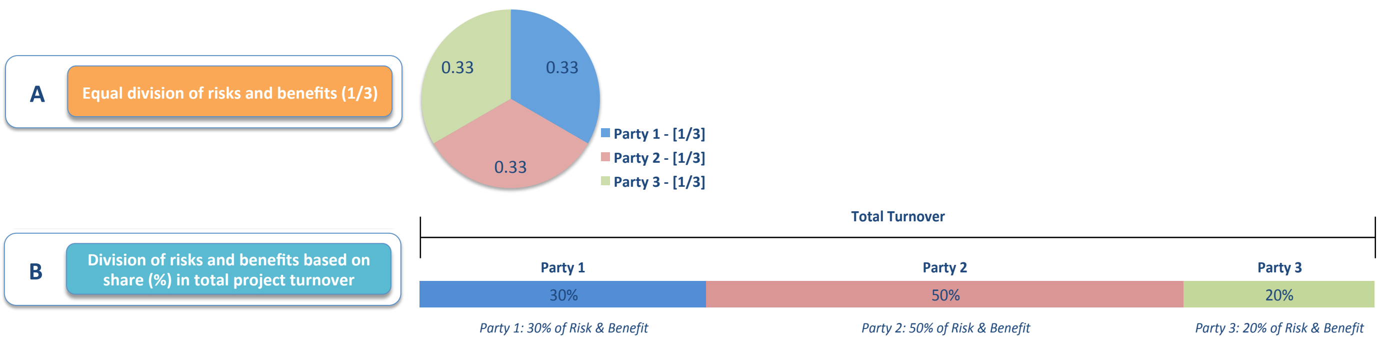
Appendices

A1 | Scenario overview

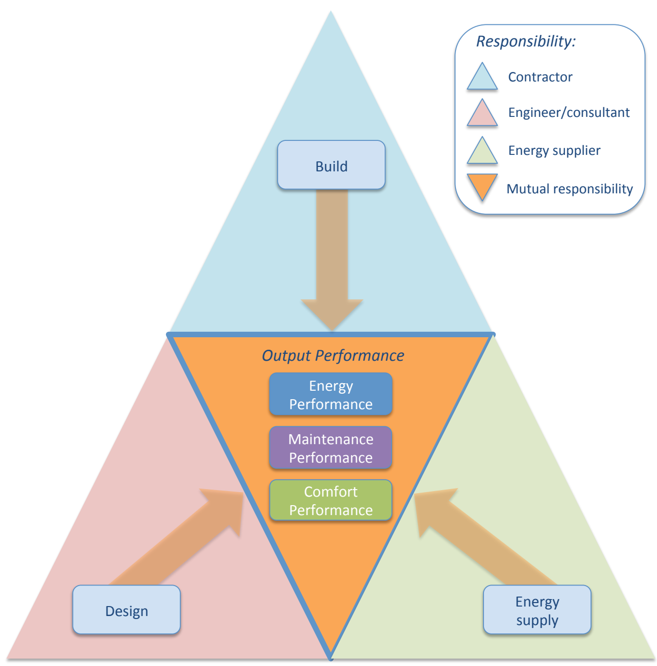
Performance contract scenarios in combination with risk and benefit division *Method A* and *Method B*





Responsibility division

Responsibility division of the involved parties (expert groups: contractor, engineer/ consultant, energy supplier). This figure shows the mutual responsibility for the performance-based output: Energy Performance, Maintenance Performance, and Comfort Performance. Each involved party has a main responsibility for the performance output and besides an added mutual responsibility for the performance to deliver.



A2 | Formula overview of the Research model

Formula 4.1 *Triangular Fuzzy Number*

$$Tjsi = \mathrm{X}_{jsi} + \mathrm{Y}_{jsi} + \mathrm{Z}_{jsi}$$

Where,

$$Xjsi = \mathrm{Min_j}\ \{\mathrm{X_{njsi}}\}$$

$$Yjsi = \frac{1}{m}\sum_{n=1}^{m} \mathrm{Y_{njsi}}$$

$$Zjsi = \mathrm{Min_j}\ \{\mathrm{Z_{njsi}}\}$$

T_{jsi} = Overall (triangular) influence of attribute *j* in scenario *s* determined by respondent group *i*
X_{jsi} = 'Low value' as influence of attribute *j* in scenario *s* determined by respondent group *i*
Y_{jsi} = 'Optimum value' as influence of attribute *j* in scenario *s* determined by respondent group *i*
Z_{jsi} = 'High value' as influence of attribute *j* in scenario *s* determined by respondent group *i*
j = attribute number where *j* = 1,2,3….,10
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
n = Respondents in a expert group where *n* = 1,2,3,…,m
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Formula 4.2 *Defuzzification*

$$\alpha jsi = \frac{Tjsi}{3}$$

α_{jsi} = Influence of Attribute *j* in scenario *s*, for expert group *i*
T_{jsi} = Overall (triangular) influence of attribute *j* in scenario *s* determined by respondent group *i*
j = attribute number where *j* = 1,2,3….,10
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Formula 4.3 *Preference Value calculation*

$$Usi = \frac{1}{m}\sum_{n=1}^{m} \mathrm{U_{nsi}}$$

U_{si} = Utility given as preference value, for scenario *s*, for expert *i*
U_{nsi} = Utility given as preference value, for scenario *s*, for expert *i, by respondent n*
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
n = Respondents in a expert group where *n* = 1,2,3,…,m
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Formula 4.4 *Expected Utility*

$$EU\mathrm{si} = \sum_{i=1}^{3} \mathrm{U_{si}} * Prs$$

EU_{si} = Expected Utilization, for scenario *s*, for expert group *i*
U_{si} = Utility given as preference value, for scenario *s*, for expert group *i*
Pr_s = The probability factor, for choosing scenario *s*
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Formula 4.5 *Probability Factor, per set (Example Method A)*

$$Pr_{sAAA} = Pr_{sAi1} * Pr_{sAi2} * Pr_{sAi3}$$

Pr_{si} = The probability factor, for choosing scenario *s*, for expert group *i*
$_{sAAA}$ = in this example, the R&B division *Method A* is chosen by all expert groups, where s = 1,2,3
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Formula 4.6 *Influence factor of attributes*

$$\omega si = \sum_{i=1}^{3} \beta jsi * \chi jsi$$

ω_{si} = Factor of influencing attributes (all) in scenario *s*, for expert group *i*

β_{jsi} = Influence of Attribute *j* in scenario *s*, for expert group *i*

x_{jsi} = The level to which Attribute j in scenario s is present, for expert group *i*

j = attribute number where *j* = 1,2,3….,10

s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)

i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Formula 4.7 *Utility Function*

$$Psi = EUsi * \omega si$$

P_{si} = Payoff for scenario *s*, for expert group *i*

EU_{si} = Expected Utilization, for scenario *s*, for expert group *i*

ω_{si} = Factor of influencing attributes (all) in scenario *s*, for expert group *i*

s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)

i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Formula 4.8 *Utility Function (all components)*

$$Psi = \sum_{i=1}^{3} (Usi * Prs) * \sum_{i=1}^{3} (\beta jsi * \chi jsi)$$

P_{si} = Payoff for scenario *s*, for expert group *i*

U_{si} = Utility given as preference value, for scenario *s*, for expert group *i*

Pr_s = The probability factor, for choosing scenario *s*

β_{jsi} = Influence of Attribute *j* in scenario *s*, for expert group *i*

x_{jsi} = The level to which Attribute j in scenario s is present, for expert group *i*

j = attribute number where *j* = 1,2,3….,10

s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)

i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

A3 | Questionnaire Design

The Questionnaire is distributed to experts of the three involved parties (expert groups) in this research: Contractor, Engineer/consultant, and Energy supplier. The questionnaire consists of four components which will be given in this appendix:

1. Introduction of research and scenarios
2. Preferences in performance contract scenarios
3. Expectation/preference in (mutual) risk and benefit division methods
4. Influences of attributes to the collaboration, regarding the given scenarios

A3.1 Questionnaire Introduction

Introductie

Uitleg

Hartelijk dank voor uw deelname aan dit afstudeeronderzoek voor de Technische Universiteit Eindhoven in samenwerking met Royal HaskoningDHV. Voordat er verdere uitleg volgt over de questionnaire, wil ik vast benadrukken dat de door u ingevulde resultaten anoniem verwerkt zullen worden! De totale invultijd van deze questionnaire zal ongeveer 20 minuten bedragen. Na het invullen van de questionnaire, wil ik u vragen het bestand op te slaan en terug te mailen naar b.blokland@student.tue.nl. Indien er tijdens het invullen van de questionnaire zich problemen voordoen, dan is er uiteraard de mogelijkheid om contact op te nemen met Bas Blokland via:

b.blokland@student.tue.nl

Onderzoek introductie
De situatie die ten grondslag ligt aan dit onderzoek richt zich op de mogelijkheden voor (private) marktpartijen, om te helpen bij de verduurzaming van het vastgoed van gemeenten. Hierbij zullen de verbeteringen voornamelijk op het gebied van duurzaamheid en comfort zijn binnen deze gebouwen, aan de hand van verschillende prestatie contracten. Binnen het onderzoek zullen enkele elementen bekeken worden die mogelijk invloed hebben op de succesvolle samenwerking, in de vorm van een consortium. Voor het consortium geldt het uitgangspunt, deze samen te stellen op basis van drie type bedrijven: een aannemer/bouwer, een ingenieur/consultant en een energie leverancier.

Questionnaire introductie
De questionnaire zal bestaan uit 3 onderdelen, waarbij de invultijd van het eerste onderdeel 3 minuten, het tweede onderdeel 5 minuten en het derde onderdeel 10 minuten zal bedragen. Bij elk onderdeel van deze questionnaire is een uitleg gegeven welke vermeld staat in de grijze vakken. Alle vragen dienen ingevuld te worden in de rode cellen binnen de oranje vakken. Elke vraag kan beantwoord worden door middel van een scroll-down menu, door de in te vullen cel te selecteren en vervolgens via het pijltje een antwoord (getal) te selecteren.

Voordat de questionnaire begint, wil ik nogmaals benadrukken dat de door u gegeven antwoorden anoniem verwerkt zullen worden. Echter zal enkel het type bedrijf gebruikt worden, waarbij ik u wil vragen onderstaand te selecteren onder welk type bedrijf u valt:

Vraag

Type bedrijf: *(scroll-down menu)*

Drie type bedrijven:
Aannemer / Bouwer
Ingenieur / Consultant
Energie leverancier

Uitleg

Case introductie
Zoals bovenstaand beschreven, is de achtergrond situatie voor dit onderzoek de verduurzaming van het vastgoed van gemeenten. Het ontwerp, de bouw en de levering van energie zullen onder de uitvoeringsverantwoordelijkheid vallen van de verschillende partijen. Er zijn 3 scenario's gecreëerd gebaseerd op de gedeelde verantwoordelijkheid in de te leveren prestatie output door het consortium. Hierin ligt de focus op de prestatie contracten omtrent energie, onderhoud en comfort.

Als uitgangspunt voor het consortium is een lange termijn samenwerking (ca. 10 jaar) waarin verduurzaming bij gemeenten wordt gerealiseerd. De samenwerking tussen de gemeenten en het consortium zal buiten beschouwing gelaten worden in deze questionnaire, los van het feit dat deze langdurig zal zijn (ca. 10 jaar) en op basis van de gegeven prestatie contracten.

Drie scenario's zullen onderstaand onderscheiden worden op basis van de te leveren prestatie output:

Scenarios:

Scenario 1	*Scenario 2*	*Scenario 3*
EPC	**EOPC**	**EOPC + CP**
Energie Prestatie Contract	Energie Prestatie Contract	Energie Prestatie Contract
	Onderhoud Prestatie Contract	Onderhoud Prestatie Contract
		Comfort Prestatie Contract

Uitleg

De drie scenario's zijn opgesteld aan de hand van verschillende prestatie contracten en zullen worden aangeduid als:
- Scenario 1: **EPC** - Energie Prestatie Contract
- Scenario 2: **EOPC** - Energie Prestatie en Onderhoud Prestatie Contract
- Scenario 3: **EOPC + CP** - Energie Prestatie, Onderhoud Prestatie en Comfort Prestatie Contract
  De Comfort Prestatie zal gericht zijn op het thermisch comfort, licht comfort en de lucht kwaliteit.

Als uitgangspunt, zal het beheer en de monitoring om de prestaties te leveren, bewerkstelligd worden door het consortium.

A3.2 Questionnaire Part 1 | Preferences in performance contract scenarios

QUESTIONNAIRE - Deel 1 *(3 minuten)*

Uitleg

In dit eerste gedeelte van de questionnaire, wordt u gevraagd om uw voorkeur aan te geven voor de verschillende scenario's in de gegeven situatie. Hierbij dient u een vergelijking te maken tussen de 3 verschillende scenario's, en aan elk een (voorkeurs) waarde toekennen. U wordt gevraagd om op basis van de gegeven informatie een waarde te geven tussen 1 (Extreem weinig voorkeur) tot 10 (Extreem veel voorkeur), door gebruik te maken van het scroll-down menu in iedere rode cel.

Vul onderstaand alle rode cellen in, met een waarde tussen 1 (Extreem weinig voorkeur) en 10 (Extreem veel voorkeur), wat uw voorkeurswaarde aanduidt:

		Voorkeurs Waarde	
Scenario 1	1 EPC		*(scroll-down menu)*
Scenario 2	2 EOPC		*(scroll-down menu)*
Scenario 3	3 EOPC + CP		*(scroll-down menu)*

Scenarios:

Scenario 1

EPC
- Energie Prestatie Contract

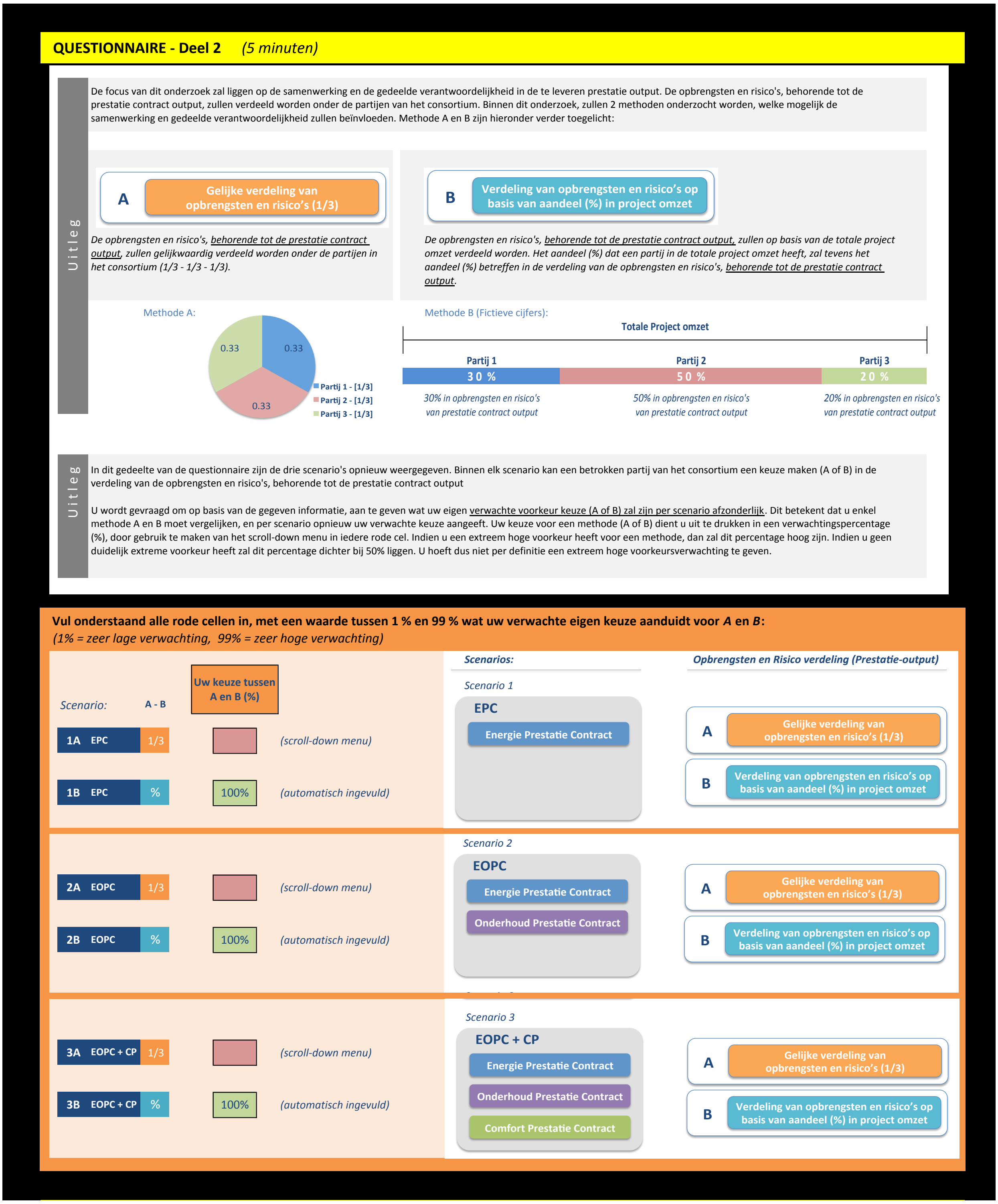
Scenario 2

EOPC
- Energie Prestatie Contract
- Onderhoud Prestatie Contract

Scenario 3

EOPC + CP
- Energie Prestatie Contract
- Onderhoud Prestatie Contract
- Comfort Prestatie Contract

A3.3 Questionnaire Part 2 | Expectation/preference in (mutual) risk and benefit division methods



QUESTIONNAIRE - Deel 2 *(5 minuten)*

Uitleg

De focus van dit onderzoek zal liggen op de samenwerking en de gedeelde verantwoordelijkheid in de te leveren prestatie output. De opbrengsten en risico's, behorende tot de prestatie contract output, zullen verdeeld worden onder de partijen van het consortium. Binnen dit onderzoek, zullen 2 methoden onderzocht worden, welke mogelijk de samenwerking en gedeelde verantwoordelijkheid zullen beïnvloeden. Methode A en B zijn hieronder verder toegelicht:

A Gelijke verdeling van opbrengsten en risico's (1/3)

De opbrengsten en risico's, behorende tot de prestatie contract output, zullen gelijkwaardig verdeeld worden onder de partijen in het consortium (1/3 - 1/3 - 1/3).

B Verdeling van opbrengsten en risico's op basis van aandeel (%) in project omzet

De opbrengsten en risico's, behorende tot de prestatie contract output, zullen op basis van de totale project omzet verdeeld worden. Het aandeel (%) dat een partij in de totale project omzet heeft, zal tevens het aandeel (%) betreffen in de verdeling van de opbrengsten en risico's, behorende tot de prestatie contract output.

Methode A:

0.33 | 0.33 | 0.33

Partij 1 - [1/3]
Partij 2 - [1/3]
Partij 3 - [1/3]

Methode B (Fictieve cijfers):

Totale Project omzet

Partij 1	Partij 2	Partij 3
30 %	50 %	20 %
30% in opbrengsten en risico's van prestatie contract output	*50% in opbrengsten en risico's van prestatie contract output*	*20% in opbrengsten en risico's van prestatie contract output*

Uitleg

In dit gedeelte van de questionnaire zijn de drie scenario's opnieuw weergegeven. Binnen elk scenario kan een betrokken partij van het consortium een keuze maken (A of B) in de verdeling van de opbrengsten en risico's, behorende tot de prestatie contract output

U wordt gevraagd om op basis van de gegeven informatie, aan te geven wat uw eigen verwachte voorkeur keuze (A of B) zal zijn per scenario afzonderlijk. Dit betekent dat u enkel methode A en B moet vergelijken, en per scenario opnieuw uw verwachte keuze aangeeft. Uw keuze voor een methode (A of B) dient u uit te drukken in een verwachtingspercentage (%), door gebruik te maken van het scroll-down menu in iedere rode cel. Indien u een extreem hoge voorkeur heeft voor een methode, dan zal dit percentage hoog zijn. Indien u geen duidelijk extreme voorkeur heeft zal dit percentage dichter bij 50% liggen. U hoeft dus niet per definitie een extreem hoge voorkeursverwachting te geven.

Vul onderstaand alle rode cellen in, met een waarde tussen 1 % en 99 % wat uw verwachte eigen keuze aanduidt voor *A* en *B*:
(1% = zeer lage verwachting, 99% = zeer hoge verwachting)

Scenario:	A - B	Uw keuze tussen A en B (%)		*Scenarios:*	*Opbrengsten en Risico verdeling (Prestatie-output)*
1A EPC	1/3		*(scroll-down menu)*	*Scenario 1* EPC: Energie Prestatie Contract	**A** Gelijke verdeling van opbrengsten en risico's (1/3)
1B EPC	%	100%	*(automatisch ingevuld)*		**B** Verdeling van opbrengsten en risico's op basis van aandeel (%) in project omzet
2A EOPC	1/3		*(scroll-down menu)*	*Scenario 2* EOPC: Energie Prestatie Contract, Onderhoud Prestatie Contract	**A** Gelijke verdeling van opbrengsten en risico's (1/3)
2B EOPC	%	100%	*(automatisch ingevuld)*		**B** Verdeling van opbrengsten en risico's op basis van aandeel (%) in project omzet
3A EOPC + CP	1/3		*(scroll-down menu)*	*Scenario 3* EOPC + CP: Energie Prestatie Contract, Onderhoud Prestatie Contract, Comfort Prestatie Contract	**A** Gelijke verdeling van opbrengsten en risico's (1/3)
3B EOPC + CP	%	100%	*(automatisch ingevuld)*		**B** Verdeling van opbrengsten en risico's op basis van aandeel (%) in project omzet

QUESTIONNAIRE - Deel 3 *(10 minuten)*

Uitleg

Invloeden op de scenario's

In dit gedeelte van de questionnaire worden de invloeden van 10 verschillende elementen op de samenwerking onderzocht. U wordt gevraagd om per element in drie waarden aan te geven wat de invloed is op de verschillende prestatie contract scenario's. Deze drie waarden bestaan uit een range (laag en hoog) en een gemiddelde waarde:

- **LOW value**: Dit is de laagste waarde van de range, welke u inschat dat het element minimaal van invloed is op het desbetreffende scenario
- **NORMAL value**: Dit is de waarde waarvan u inschat dat het element een gemiddelde invloed heeft op het desbetreffende scenario (tussen Low en High)
- **HIGH value**: Dit is de hoogste waarde van de range, welke u inschat dat het element maximaal van invloed is op het desbetreffende scenario

U wordt gevraagd om een waarde te geven tussen **1** (Vrijwel geen invloed) tot **10** (Extreem veel invloed), door gebruik te maken van het scroll-down menu in iedere rode cel.

Met betrekking tot de scenario's, dient u de invloed in eerste instantie af te wegen op basis van de te leveren prestatie contract output. Welke verandering zal er plaatsvinden in de invloed van de elementen, wanneer prestatie contracten voor het onderhoud en comfort toegevoegd worden? Vervolgens dient u de invloed af te wegen op basis van de methoden (A en B) om de de opbrengsten en risico's (behorende tot de prestatie contract output) te verdelen.

Het overzicht van de 3 scenario's en de 2 methoden is onderstaand nogmaals herhaald, waarna u vervolgens wordt gevraagd om alle rode cellen in te vullen:

Scenarios:

Scenario 1

EPC
- Energie Prestatie Contract

Scenario 2

EOPC
- Energie Prestatie Contract
- Onderhoud Prestatie Contract

Scenario 3

EOPC + CP
- Energie Prestatie Contract
- Onderhoud Prestatie Contract
- Comfort Prestatie Contract

Opbrengsten en Risico verdeling (Prestatie-output)

A — Gelijke verdeling van opbrengsten en risico's (1/3)

B — Verdeling van opbrengsten en risico's op basis van aandeel (%) in project omzet

Vul onderstaand alle rode cellen in, met een waarde tussen 1 en 10 wat de invloed aanduidt op het desbetreffende scenario (1, 2 & 3) : *(1 = Vrijwel geen invloed, 10 = Extreem veel invloed)*

	Element 1	Element 2	Element 3	Element 4	Element 5	Element 6	Element 7	Element 8	Element 9	Element 10
	Vertrouwen tussen de partners binnen het partnership	Sterke commitment van de partijen binnen het partnership	Een zeer goed ingerichte communicatie (model) tussen de partners	Duidelijkheid tussen de partijen over de doelstelling binnen het partnership	Een goede en al bestaande samenwerking tussen de partijen	Support en sterke commitment van het top-management level	Veel overeenkomsten tussen de partijen in hun bedrijfsvisie en cultuur	Volledige transparantie en informatie deling tussen de partijen	Betrokken partijen in het partnership die een sterke positie hebben binnen de markt	Zeer gedetailleerde beschrijving van verantwoordelijkheden in een contractuele overeenkomst
Scenario:	LOW / NORMAL / HIGH	LOW / NORMAL / HIGH	LOW / NORMAL / HIGH	LOW / NORMAL / HIGH	LOW / NORMAL / HIGH	LOW / NORMAL / HIGH	LOW / NORMAL / HIGH	LOW / NORMAL / HIGH	LOW / NORMAL / HIGH	LOW / NORMAL / HIGH
1 EPC										
2 EOPC										
3 EOPC + CP										

Vul onderstaand de rode cellen in, met een waarde tussen 1 en 10 wat de invloed aanduidt op de desbetreffende methode (A & B) : *(1 = Vrijwel geen invloed, 10 = Extreem veel invloed)*

Methode:	Element 1	Element 2	Element 3	Element 4	Element 5	Element 6	Element 7	Element 8	Element 9	Element 10
A 1/3										
B %										

Dit is het einde van de Questionnaire. Allereerst, hartelijk dank voor uw medewerking in dit onderzoek!

Als laatste zou ik u willen vragen dit bestand op te slaan en vervolgens terug te mailen naar: b.blokland@student.tue.nl

A4 | Calculation model 'Triangular Fuzzy number' and 'Defuzzification'

Formula 4.1 *Triangular Fuzzy Number*

$$T_{jsi} = X_{jsi} + Y_{jsi} + Z_{jsi}$$

Where,

$$X_{jsi} = \mathrm{Min}_j \{X_{njsi}\}$$

$$Y_{jsi} = \frac{1}{m} \sum_{n=1}^{m} Y_{njsi}$$

$$Z_{jsi} = \mathrm{Min}_j \{Z_{njsi}\}$$

T_{jsi} = Overall (triangular) influence of attribute *j* in scenario *s* determined by respondent group *i*
X_{jsi} = 'Low value' as influence of attribute *j* in scenario *s* determined by respondent group *i*
Y_{jsi} = 'Optimum value' as influence of attribute *j* in scenario *s* determined by respondent group *i*
Z_{jsi} = 'High value' as influence of attribute *j* in scenario *s* determined by respondent group *i*
j = attribute number where *j* = 1,2,3….,10
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
n = Respondents in a expert group where *n* = 1,2,3,…,m
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Formula 4.2 *Defuzzification*

$$\alpha_{jsi} = \frac{T_{jsi}}{3}$$

α_{jsi} = Influence of Attribute *j* in scenario *s*, for expert group *i*
T_{jsi} = Overall (triangular) influence of attribute *j* in scenario *s* determined by respondent group *i*
j = attribute number where *j* = 1,2,3….,10
s = Scenario where *s* = 1A, 1B, 2A, 2B, 3A, 3B (A and B are R&B division methods)
i = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Scenario (s)	Attribute (j)	Contractor (P1)					Engineer/consultant (P2)					Energy supplier (P3)				
		X_{js1}	Y_{js1}	Z_{js1}	T_{js1}	α_{js1}	X_{js2}	Y_{js2}	Z_{js2}	T_{js2}	α_{js2}	X_{js3}	Y_{js3}	Z_{js3}	T_{js3}	α_{js3}
1	1	2	6,50	10	18,50	6,17	5	7,25	10	22,25	7,42	6	9,00	9	24,00	8,00
	2	3	7,38	10	20,38	6,79	3	6,00	8	17,00	5,67	3	6,50	8	17,50	5,83
	3	2	5,50	10	17,50	5,83	3	5,25	8	16,25	5,42	3	5,50	8	16,50	5,50
	4	3	7,13	10	20,13	6,71	4	7,00	10	21,00	7,00	4	8,50	8	20,50	6,83
	5	3	6,00	10	19,00	6,33	3	5,75	10	18,75	6,25	6	6,50	10	22,50	7,50
	6	2	6,25	10	18,25	6,08	2	5,75	7	14,75	4,92	2	6,50	7	15,50	5,17
	7	1	4,75	10	15,75	5,25	2	4,75	7	13,75	4,58	3	4,00	5	12,00	4,00
	8	3	6,25	10	19,25	6,42	3	7,25	10	20,25	6,75	3	7,50	8	18,50	6,17
	9	2	5,13	10	17,13	5,71	2	4,25	8	14,25	4,75	3	4,50	8	15,50	5,17
	10	3	6,63	10	19,63	6,54	3	6,50	10	19,50	6,50	4	7,00	7	18,00	6,00
2	1	2	6,88	10	18,88	6,29	6	8,00	10	24,00	8,00	7	9,50	10	26,50	8,83
	2	2	7,13	10	19,13	6,38	5	7,75	9	21,75	7,25	5	7,50	9	21,50	7,17
	3	3	5,88	10	18,88	6,29	4	6,75	8	18,75	6,25	4	6,50	8	18,50	6,17
	4	3	7,25	10	20,25	6,75	5	7,50	10	22,50	7,50	5	9,00	10	24,00	8,00
	5	3	6,63	10	19,63	6,54	4	7,25	10	21,25	7,08	6	7,00	10	23,00	7,67
	6	3	6,38	10	19,38	6,46	5	6,50	8	19,50	6,50	5	7,50	8	20,50	6,83
	7	1	5,63	10	16,63	5,54	3	5,75	8	16,75	5,58	4	5,00	6	15,00	5,00
	8	4	6,75	10	20,75	6,92	4	8,00	10	22,00	7,33	4	8,50	9	21,50	7,17
	9	2	5,88	10	17,88	5,96	2	5,25	9	16,25	5,42	4	6,00	9	19,00	6,33
	10	4	7,00	10	21,00	7,00	3	7,00	10	20,00	6,67	5	8,00	8	21,00	7,00
3	1	1	7,25	10	18,25	6,08	6	8,50	10	24,50	8,17	7	9,50	10	26,50	8,83
	2	1	7,38	10	18,38	6,13	5	8,75	10	23,75	7,92	5	7,50	9	21,50	7,17
	3	3	6,63	10	19,63	6,54	4	7,50	10	21,50	7,17	4	6,50	8	18,50	6,17
	4	3	7,63	10	20,63	6,88	5	7,75	10	22,75	7,58	5	9,50	10	24,50	8,17
	5	2	6,88	10	18,88	6,29	5	8,50	10	23,50	7,83	6	7,50	10	23,50	7,83
	6	3	6,50	10	19,50	6,50	5	7,00	10	22,00	7,33	6	8,00	10	24,00	8,00
	7	1	6,13	10	17,13	5,71	3	6,25	8	17,25	5,75	5	6,00	7	18,00	6,00
	8	3	7,00	10	20,00	6,67	4	8,75	10	22,75	7,58	4	9,00	9	22,00	7,33
	9	2	6,00	10	18,00	6,00	2	5,75	9	16,75	5,58	4	6,50	9	19,50	6,50
	10	4	7,38	10	21,38	7,13	3	7,25	10	20,25	6,75	6	9,00	9	24,00	8,00
A	1	2	6,63	10	18,63	6,21	6	8,25	10	24,25	8,08	8	8,00	10	26,00	8,67
	2	2	6,63	10	18,63	6,21	5	7,00	8	20,00	6,67	5	5,50	8	18,50	6,17
	3	3	6,63	10	19,63	6,54	4	6,50	8	18,50	6,17	4	5,00	8	17,00	5,67
	4	3	7,25	10	20,25	6,75	5	7,75	10	22,75	7,58	5	7,50	10	22,50	7,50
	5	3	6,75	10	19,75	6,58	4	7,00	10	21,00	7,00	6	6,00	10	22,00	7,33
	6	2	5,75	10	17,75	5,92	6	7,00	10	23,00	7,67	7	6,00	10	23,00	7,67
	7	2	6,38	10	18,38	6,13	3	6,00	7	16,00	5,33	3	4,00	7	14,00	4,67
	8	3	7,25	10	20,25	6,75	6	8,00	10	24,00	8,00	6	7,50	9	22,50	7,50
	9	3	5,25	9	17,25	5,75	3	5,00	9	17,00	5,67	4	4,50	9	17,50	5,83
	10	3	7,25	10	20,25	6,75	2	6,25	10	18,25	6,08	4	6,50	9	19,50	6,50
B	1	1	6,38	10	17,38	5,79	6	7,50	9	22,50	7,50	6	8,50	9	23,50	7,83
	2	2	6,63	10	18,63	6,21	4	6,75	8	18,75	6,25	5	7,00	8	20,00	6,67
	3	3	6,50	10	19,50	6,50	3	6,00	7	16,00	5,33	3	6,00	7	16,00	5,33
	4	3	7,25	10	20,25	6,75	4	7,50	9	20,50	6,83	4	8,00	7	19,00	6,33
	5	3	6,50	10	19,50	6,50	5	6,75	10	21,75	7,25	6	6,00	10	22,00	7,33
	6	3	6,25	10	19,25	6,42	4	6,25	9	19,25	6,42	4	6,50	7	17,50	5,83
	7	3	7,00	10	20,00	6,67	3	5,25	7	15,25	5,08	3	4,50	7	14,50	4,83
	8	3	6,00	10	19,00	6,33	3	7,25	9	19,25	6,42	3	7,50	7	17,50	5,83
	9	2	5,50	9	16,50	5,50	3	4,75	9	16,75	5,58	3	5,00	9	17,00	5,67
	10	3	6,75	10	19,75	6,58	4	6,75	9	19,75	6,58	4	7,50	8	19,50	6,50

A5 | Overview influence factors and ranking of attributes (mutual estimation per scenario)

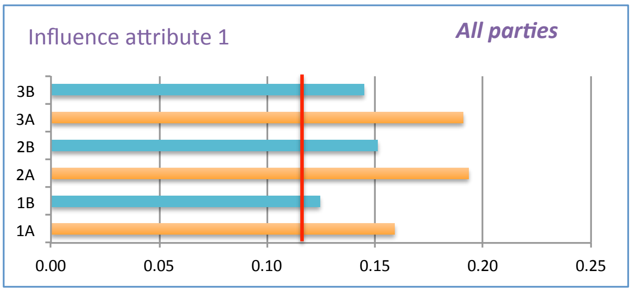
Influence of attributes

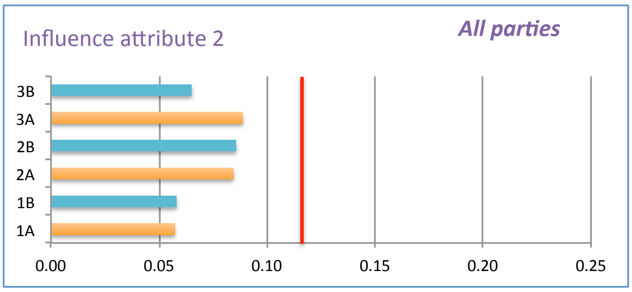
Scenario		Attribute		All players		All players	
(s)		(j)		Ratio Total (P1 x P2 x P3)	Rank	Highly influencing (Threshold = 0,1176)	
1	A	1	Trust between the partners within the partnership	0,159	1	1	INFLUENCING
		2	Highly committed parties within the partnership	0,057	6	0	
		3	A proper communication (model) between the partners	0,040	8	0	
		4	Clear understanding of personal objectives within the partnership of all parties	0,123	2	1	INFLUENCING
		5	Good and existing relationship between the parties	0,100	4	0	
		6	Support and strong commitment of top-management level	0,054	7	0	
		7	Strong similarities in the vision and culture of the different parties	0,015	10	0	
		8	Complete transparency and sharing of information	0,108	3	0	
		9	Strong market parties within the partnership	0,027	9	0	
		10	Extremely detailed description of tasks and responsibilities in contractual agreements	0,068	5	0	
1	B	1	Trust between the partners within the partnership	0,124	1	1	INFLUENCING
		2	Highly committed parties within the partnership	0,058	6	0	
		3	A proper communication (model) between the partners	0,032	8	0	
		4	Clear understanding of personal objectives within the partnership of all parties	0,094	3	0	
		5	Good and existing relationship between the parties	0,103	2	0	
		6	Support and strong commitment of top-management level	0,037	7	0	
		7	Strong similarities in the vision and culture of the different parties	0,016	10	0	
		8	Complete transparency and sharing of information	0,063	5	0	
		9	Strong market parties within the partnership	0,024	9	0	
		10	Extremely detailed description of tasks and responsibilities in contractual agreements	0,072	4	0	
2	A	1	Trust between the partners within the partnership	0,193	1	1	INFLUENCING
		2	Highly committed parties within the partnership	0,085	7	0	
		3	A proper communication (model) between the partners	0,055	8	0	
		4	Clear understanding of personal objectives within the partnership of all parties	0,155	2	1	INFLUENCING
		5	Good and existing relationship between the parties	0,120	4	1	INFLUENCING
		6	Support and strong commitment of top-management level	0,100	5	0	
		7	Strong similarities in the vision and culture of the different parties	0,024	10	0	
		8	Complete transparency and sharing of information	0,147	3	1	INFLUENCING
		9	Strong market parties within the partnership	0,039	9	0	
		10	Extremely detailed description of tasks and responsibilities in contractual agreements	0,087	6	0	
2	B	1	Trust between the partners within the partnership	0,151	1	1	INFLUENCING
		2	Highly committed parties within the partnership	0,086	6	0	
		3	A proper communication (model) between the partners	0,045	8	0	
		4	Clear understanding of personal objectives within the partnership of all parties	0,118	3	1	INFLUENCING
		5	Good and existing relationship between the parties	0,123	2	1	INFLUENCING
		6	Support and strong commitment of top-management level	0,069	7	0	
		7	Strong similarities in the vision and culture of the different parties	0,025	10	0	
		8	Complete transparency and sharing of information	0,086	5	0	
		9	Strong market parties within the partnership	0,036	9	0	
		10	Extremely detailed description of tasks and responsibilities in contractual agreements	0,092	4	0	
3	A	1	Trust between the partners within the partnership	0,191	1	1	INFLUENCING
		2	Highly committed parties within the partnership	0,089	7	0	
		3	A proper communication (model) between the partners	0,066	8	0	
		4	Clear understanding of personal objectives within the partnership of all parties	0,163	2	1	INFLUENCING
		5	Good and existing relationship between the parties	0,130	5	1	INFLUENCING
		6	Support and strong commitment of top-management level	0,133	4	1	INFLUENCING
		7	Strong similarities in the vision and culture of the different parties	0,030	10	0	
		8	Complete transparency and sharing of information	0,150	3	1	INFLUENCING
		9	Strong market parties within the partnership	0,041	9	0	
		10	Extremely detailed description of tasks and responsibilities in contractual agreements	0,103	6	0	
3	B	1	Trust between the partners within the partnership	0,145	1	1	INFLUENCING
		2	Highly committed parties within the partnership	0,065	7	0	
		3	A proper communication (model) between the partners	0,042	8	0	
		4	Clear understanding of personal objectives within the partnership of all parties	0,114	2	0	
		5	Good and existing relationship between the parties	0,112	3	0	
		6	Support and strong commitment of top-management level	0,092	5	0	
		7	Strong similarities in the vision and culture of the different parties	0,023	10	0	
		8	Complete transparency and sharing of information	0,095	4	0	
		9	Strong market parties within the partnership	0,035	9	0	
		10	Extremely detailed description of tasks and responsibilities in contractual agreements	0,079	6	0	

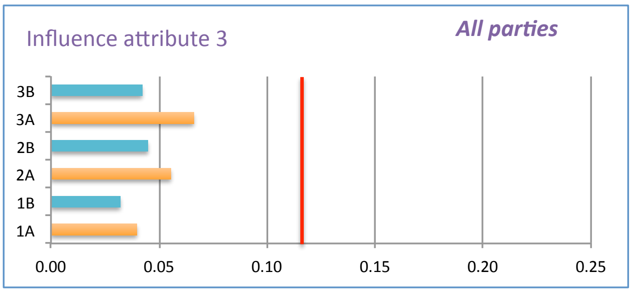
A6 | (6.1) Overview influence factors and ranking of attributes (mutual estimation per attribute)

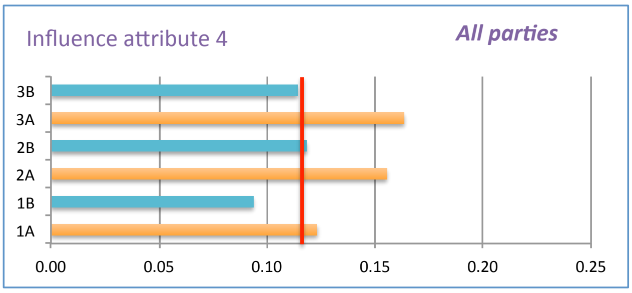
Scenario		Attribute		All players		All players	
(s)		(j)		Ratio Total (P1 x P2 x P3)	Rank	Highly influencing (Threshold = 0,1176)	
1A	A	1	*Trust between the partners within the partnership*	0,159	1	1	INFLUENCING
1B	B	1	*Trust between the partners within the partnership*	0,124	1	1	INFLUENCING
2A	A	1	*Trust between the partners within the partnership*	0,193	1	1	INFLUENCING
2B	B	1	*Trust between the partners within the partnership*	0,151	1	1	INFLUENCING
3A	A	1	*Trust between the partners within the partnership*	0,191	1	1	INFLUENCING
3B	B	1	*Trust between the partners within the partnership*	0,145	1	1	INFLUENCING
1	A	2	*Highly committed parties within the partnership*	0,057	6	0	
1	B	2	*Highly committed parties within the partnership*	0,058	6	0	
2	A	2	*Highly committed parties within the partnership*	0,085	7	0	
2	B	2	*Highly committed parties within the partnership*	0,086	6	0	
3	A	2	*Highly committed parties within the partnership*	0,089	7	0	
3	B	2	*Highly committed parties within the partnership*	0,065	7	0	
1	A	3	*A proper communication (model) between the partners*	0,040	8	0	
1	B	3	*A proper communication (model) between the partners*	0,032	8	0	
2	A	3	*A proper communication (model) between the partners*	0,055	8	0	
2	B	3	*A proper communication (model) between the partners*	0,045	8	0	
3	A	3	*A proper communication (model) between the partners*	0,066	8	0	
3	B	3	*A proper communication (model) between the partners*	0,042	8	0	
1	A	4	*Clear understanding of personal objectives within the partnership of all parties*	0,123	2	1	INFLUENCING
1	B	4	*Clear understanding of personal objectives within the partnership of all parties*	0,094	3	0	
2	A	4	*Clear understanding of personal objectives within the partnership of all parties*	0,155	2	1	INFLUENCING
2	B	4	*Clear understanding of personal objectives within the partnership of all parties*	0,118	3	1	INFLUENCING
3	A	4	*Clear understanding of personal objectives within the partnership of all parties*	0,163	2	1	INFLUENCING
3	B	4	*Clear understanding of personal objectives within the partnership of all parties*	0,114	2	0	
1	A	5	*Good and existing relationship between the parties*	0,100	4	0	
1	B	5	*Good and existing relationship between the parties*	0,103	2	0	
2	A	5	*Good and existing relationship between the parties*	0,120	4	1	INFLUENCING
2	B	5	*Good and existing relationship between the parties*	0,123	2	1	INFLUENCING
3	A	5	*Good and existing relationship between the parties*	0,130	5	1	INFLUENCING
3	B	5	*Good and existing relationship between the parties*	0,112	3	0	
1	A	6	*Support and strong commitment of top-management level*	0,054	7	0	
1	B	6	*Support and strong commitment of top-management level*	0,037	7	0	
2	A	6	*Support and strong commitment of top-management level*	0,100	5	0	
2	B	6	*Support and strong commitment of top-management level*	0,069	7	0	
3	A	6	*Support and strong commitment of top-management level*	0,133	4	1	INFLUENCING
3	B	6	*Support and strong commitment of top-management level*	0,092	5	0	
1	A	7	*Strong similarities in the vision and culture of the different parties*	0,015	10	0	
1	B	7	*Strong similarities in the vision and culture of the different parties*	0,016	10	0	
2	A	7	*Strong similarities in the vision and culture of the different parties*	0,024	10	0	
2	B	7	*Strong similarities in the vision and culture of the different parties*	0,025	10	0	
3	A	7	*Strong similarities in the vision and culture of the different parties*	0,030	10	0	
3	B	7	*Strong similarities in the vision and culture of the different parties*	0,023	10	0	
1	A	8	*Complete transparency and sharing of information*	0,108	3	0	
1	B	8	*Complete transparency and sharing of information*	0,063	5	0	
2	A	8	*Complete transparency and sharing of information*	0,147	3	1	INFLUENCING
2	B	8	*Complete transparency and sharing of information*	0,086	5	0	
3	A	8	*Complete transparency and sharing of information*	0,150	3	1	INFLUENCING
3	B	8	*Complete transparency and sharing of information*	0,095	4	0	
1	A	9	*Strong market parties within the partnership*	0,027	9	0	
1	B	9	*Strong market parties within the partnership*	0,024	9	0	
2	A	9	*Strong market parties within the partnership*	0,039	9	0	
2	B	9	*Strong market parties within the partnership*	0,036	9	0	
3	A	9	*Strong market parties within the partnership*	0,041	9	0	
3	B	9	*Strong market parties within the partnership*	0,035	9	0	
1	A	10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,068	5	0	
1	B	10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,072	4	0	
2	A	10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,087	6	0	
2	B	10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,092	4	0	
3	A	10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,103	6	0	
3	B	10	*Extremely detailed description of tasks and responsibilities in contractual agreements*	0,079	6	0	

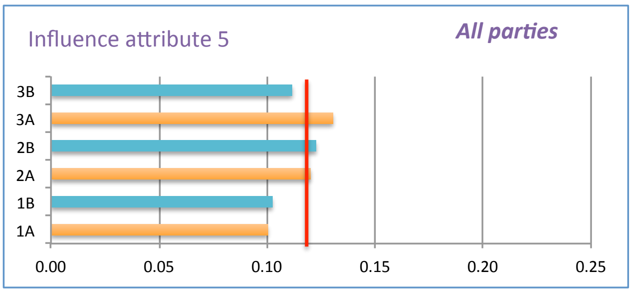
A6 | (6.2) Visualization of determined 'highly influencing' attributes

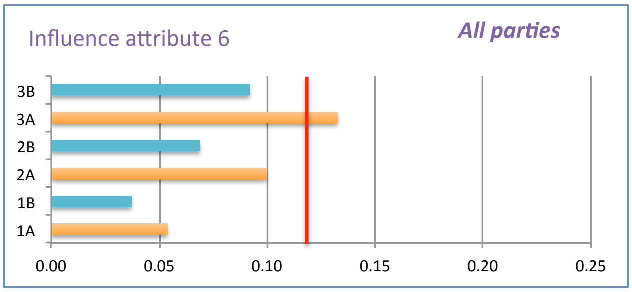


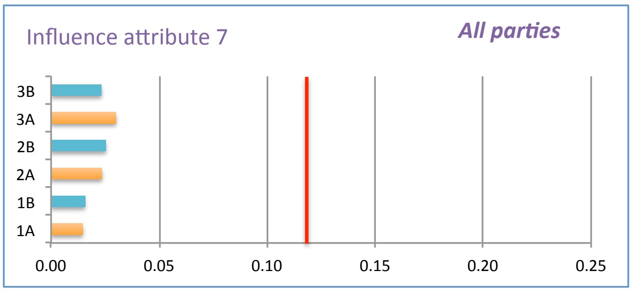


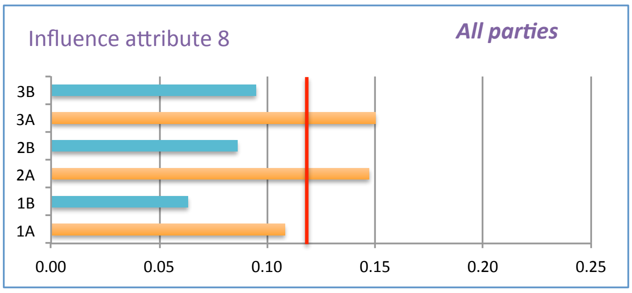


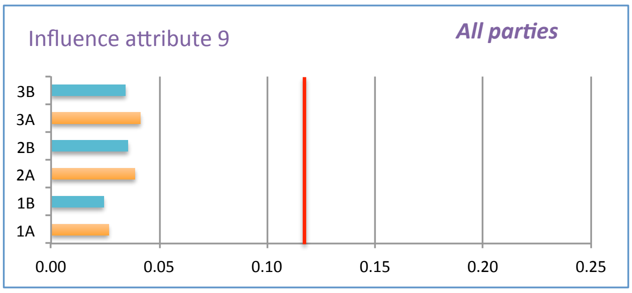


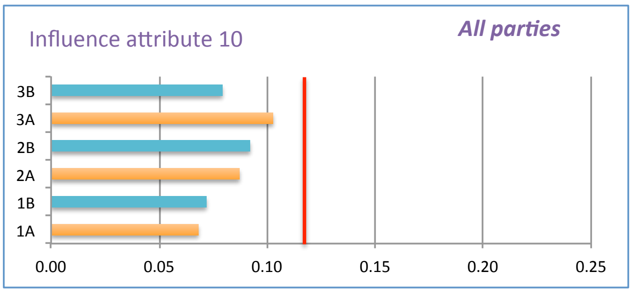












A7 | Calculation model 'Probability Factor'

Formula 4.5 *Probability Factor, per set (Example Method A)*

$$Pr_{sAAA} = Pr_{sAi1} * Pr_{sAi2} * Pr_{sAi3}$$

Pr_{si} = The probability factor, for choosing scenario *s*, for expert group *i*

$_{sAAA}$ = in this example, the R&B division *Method A* is chosen by all expert groups, where s = 1,2,3

$_{i}$ = Expert group where *i* = 1, 2, 3 (Contractor, Engineer/Consultant, Energy supplier)

Probability Factor (single player)

	Scenario 1		Scenario 2		Scenario 3	
	A	B	A	B	A	B
Player 1	0,37	0,63	0,35	0,66	0,36	0,64
Player 2	0,44	0,56	0,30	0,70	0,24	0,76
Player 3	0,15	0,85	0,18	0,83	0,25	0,75

Probability Factor — Scenario 1

Player 1		Player 2		Player 3		Probability factor:	
A	0,37	A	0,44	A	0,15	AAA	0,024
A	0,37	A	0,44	B	0,85	AAB	0,138
A	0,37	B	0,56	A	0,15	ABA	0,031
A	0,37	B	0,56	B	0,85	ABB	0,176
B	0,63	A	0,44	A	0,15	BAA	0,042
B	0,63	A	0,44	B	0,85	BAB	0,236
B	0,63	B	0,56	A	0,15	BBA	0,053
B	0,63	B	0,56	B	0,85	BBB	0,300

Probability Factor — Scenario 2

Player 1		Player 2		Player 3		Probability factor:	
A	0,35	A	0,30	A	0,18	AAA	0,018
A	0,35	A	0,30	B	0,83	AAB	0,085
A	0,35	B	0,70	A	0,18	ABA	0,042
A	0,35	B	0,70	B	0,83	ABB	0,199
B	0,66	A	0,30	A	0,18	BAA	0,034
B	0,66	A	0,30	B	0,83	BAB	0,162
B	0,66	B	0,70	A	0,18	BBA	0,080
B	0,66	B	0,70	B	0,83	BBB	0,378

Probability Factor — Scenario 3

Player 1		Player 2		Player 3		Probability factor:	
A	0,36	A	0,24	A	0,25	AAA	0,022
A	0,36	A	0,24	B	0,75	AAB	0,065
A	0,36	B	0,76	A	0,25	ABA	0,069
A	0,36	B	0,76	B	0,75	ABB	0,207
B	0,64	A	0,24	A	0,25	BAA	0,038
B	0,64	A	0,24	B	0,75	BAB	0,115
B	0,64	B	0,76	A	0,25	BBA	0,121
B	0,64	B	0,76	B	0,75	BBB	0,363

A8 | Game Theory: Expected Utility strategic solutions

A8.1 SCENARIO 1 | Energy Performance Contract

Scenario 1 | EPC

Expected Utility – Game model

		Energy supplier (P3): A						Energy supplier (P3): B					
		Engineer/Consultant (P2)						Engineer/Consultant (P2)					
		A			B			A			B		
Contractor (P1)	A	0,12	0,11	0,10	0,15	0,14	0,12	0,66	0,63	0,55	0,83	0,81	0,70
	B	0,20	0,19	0,17	0,25	0,24	0,21	1,12	1,09	0,94	1,43	1,38	1,20

**Cell contents:* P1 P2 P3

Dominant Strategies - Expected Utility [Scenario 1 - EPC]					
Player 1:		Player 2:		Player 3:	
AAA>BAA	B	AAA>ABA	B	AAA>AAB	B
ABA>BBA	B	BAA>BBA	B	BAA>BAB	B
AAB>BAB	B	AAB>ABB	B	ABA>ABB	B
ABB>BBB	B	BAB>BBB	B	BBA>BBB	B
Dominant P1:	B	Dominant P2:	B	Dominant P3:	B

Dominated Strategies - Expected Utility [Scenario 1 - EPC]					
Player 1:		Player 2:		Player 3:	
AAA<BAA	A	AAA<ABA	A	AAA<AAB	A
ABA><BBA	A	BAA<BBA	A	BAA<BAB	A
AAB<BAB	A	AAB<ABB	A	ABA<ABB	A
ABB<BBB	A	BAB<BBB	A	BBA<BBB	A
Eliminate P1:	A	Eliminate P2:	A	Eliminate P3:	A

Nash Equilibrium - Expected Utility [Scenario 1 - EPC]

P1	P2	P3	Player 1:	Player 2:	Player 3:	*Nash Equilibrium:*
A	A	A	B	B	B	-
A	A	B	B	B	B	-
A	B	A	B	B	B	-
A	B	B	B	B	B	-
B	A	A	B	B	B	-
B	A	B	B	B	B	-
B	B	A	B	B	B	-
B	B	B	B	B	B	YES

A8.2 SCENARIO 2 | Energy Performance and Maintenance Performance Contract

Scenario 2 | EOPC

Expected Utility – Game model

		Energy supplier (P3): A						Energy supplier (P3): B					
		Engineer/Consultant (P2): A			Engineer/Consultant (P2): B			Engineer/Consultant (P2): A			Engineer/Consultant (P2): B		
Contractor (P1)	A	0,14	0,12	0,12	0,32	0,29	0,27	0,65	0,58	0,56	1,52	1,35	1,30
	B	0,26	0,23	0,22	0,61	0,55	0,52	1,24	1,10	1,05	2,88	2,57	2,46

*Cell contents: P1 P2 P3

Dominant Strategies - Expected Utility [Scenario 2 - EOPC]

Player 1:		Player 2:		Player 3:	
AAA>BAA	B	AAA>ABA	B	AAA>AAB	B
ABA>BBA	B	BAA>BBA	B	BAA>BAB	B
AAB>BAB	B	AAB>ABB	B	ABA>ABB	B
ABB>BBB	B	BAB>BBB	B	BBA>BBB	B
Dominant P1:	B	Dominant P2:	B	Dominant P3:	B

Dominated Strategies - Expected Utility [Scenario 2 - EOPC]

Player 1:		Player 2:		Player 3:	
AAA<BAA	A	AAA<ABA	A	AAA<AAB	A
ABA><BBA	A	BAA<BBA	A	BAA<BAB	A
AAB<BAB	A	AAB<ABB	A	ABA<ABB	A
ABB<BBB	A	BAB<BBB	A	BBA<BBB	A
Eliminate P1:	A	Eliminate P2:	A	Eliminate P3:	A

Nash Equilibrium - Expected Utility [Scenario 2 - EOPC]

P1	P2	P3	Player 1:	Player 2:	Player 3:	*Nash Equilibrium:*
A	A	A	B	B	B	-
A	A	B	B	B	B	-
A	B	A	B	B	B	-
A	B	B	B	B	B	-
B	A	A	B	B	B	-
B	A	B	B	B	B	-
B	B	A	B	B	B	-
B	B	B	B	B	B	YES

A8.3 SCENARIO 3 | Energy Performance, Maintenance Performance, and Comfort Performance Contract

Scenario 3 | EOPC + CP

Expected Utility – Game model

	Energy supplier (P3): A						Energy supplier (P3): B					
	Engineer/Consultant (P2): A			B			Engineer/Consultant (P2): A			B		
Contractor (P1): A	0,18	0,21	0,21	0,56	0,66	0,65	0,53	0,63	0,62	1,68	1,98	1,96
Contractor (P1): B	0,31	0,37	0,36	0,98	1,16	1,15	0,93	1,10	1,09	2,95	3,49	3,45

**Cell contents:* P1 P2 P3

Dominant Strategies - Expected Utility [Scenario 3 - EOPC + CP]					
Player 1:		Player 2:		Player 3:	
AAA>BAA	B	AAA>ABA	B	AAA>AAB	B
ABA>BBA	B	BAA>BBA	B	BAA>BAB	B
AAB>BAB	B	AAB>ABB	B	ABA>ABB	B
ABB>BBB	B	BAB>BBB	B	BBA>BBB	B
Dominant P1:	B	Dominant P2:	B	Dominant P3:	B

Dominated Strategies - Expected Utility [Scenario 3 - EOPC + CP]					
Player 1:		Player 2:		Player 3:	
AAA<BAA	A	AAA<ABA	A	AAA<AAB	A
ABA><BBA	A	BAA<BBA	A	BAA<BAB	A
AAB<BAB	A	AAB<ABB	A	ABA<ABB	A
ABB<BBB	A	BAB<BBB	A	BBA<BBB	A
Eliminate P1:	A	Eliminate P2:	A	Eliminate P3:	A

Nash Equilibrium - Expected Utility [Scenario 3 - EOPC + CP]

P1	P2	P3	Player 1:	Player 2:	Player 3:	*Nash Equilibrium:*
A	A	A	B	B	B	-
A	A	B	B	B	B	-
A	B	A	B	B	B	-
A	B	B	B	B	B	-
B	A	A	B	B	B	-
B	A	B	B	B	B	-
B	B	A	B	B	B	-
B	B	B	B	B	B	YES

A9 | Game Theory: Utility Function (success value modeling) strategic solutions

A9.1 SCENARIO 1 | Energy Performance Contract

Scenario 1 | EPC

Utility Function (X_{jsi} = 1) – Game model

	Energy supplier (P3): A						Energy supplier (P3): B					
	Engineer/Consultant (P2): A			Engineer/Consultant (P2): B			Engineer/Consultant (P2): A			Engineer/Consultant (P2): B		
Contractor (P1): A	0,05	0,05	0,04	0,06	0,05	0,05	0,26	0,26	0,21	0,33	0,30	0,26
Contractor (P1): B	0,08	0,08	0,07	0,10	0,09	0,09	0,44	0,44	0,35	0,56	0,52	0,45

*Cell contents: P1 P2 P3

Dominant Strategies - Utility Function [Scenario 1 - EPC]					
Player 1:		Player 2:		Player 3:	
AAA>BAA	B	AAA>ABA	B	AAA>AAB	B
ABA>BBA	B	BAA>BBA	B	BAA>BAB	B
AAB>BAB	B	AAB>ABB	B	ABA>ABB	B
ABB>BBB	B	BAB>BBB	B	BBA>BBB	B
Dominant P1:	B	Dominant P2:	B	Dominant P3:	B

Dominated Strategies - Utility Function [Scenario 1 - EPC]					
Player 1:		Player 2:		Player 3:	
AAA<BAA	A	AAA<ABA	A	AAA<AAB	A
ABA><BBA	A	BAA<BBA	A	BAA<BAB	A
AAB<BAB	A	AAB<ABB	A	ABA<ABB	A
ABB<BBB	A	BAB<BBB	A	BBA<BBB	A
Eliminate P1:	A	Eliminate P2:	A	Eliminate P3:	A

Nash Equilibrium - Utility Function [Scenario 1 - EPC]

P1	P2	P3	Player 1:	Player 2:	Player 3:	*Nash Equilibrium:*
A	A	A	B	B	B	-
A	A	B	B	B	B	-
A	B	A	B	B	B	-
A	B	B	B	B	B	-
B	A	A	B	B	B	-
B	A	B	B	B	B	-
B	B	A	B	B	B	-
B	B	B	B	B	B	YES

A9.2 SCENARIO 2 | Energy Performance and Maintenance Performance Contract

Scenario 2 | EOPC

Utility Function ($X_{jsi} = 1$) – Game model

	Energy supplier (P3): A		Energy supplier (P3): B	
Contractor (P1)	**Engineer/Consultant (P2): A**	**Engineer/Consultant (P2): B**	**Engineer/Consultant (P2): A**	**Engineer/Consultant (P2): B**
A	0,06 0,06 0,06	0,13 0,12 0,13	0,27 0,27 0,24	0,62 0,58 0,56
B	0,11 0,11 0,11	0,25 0,23 0,25	0,50 0,51 0,46	1,17 1,10 1,07

**Cell contents:* P1 P2 P3

Dominant Strategies - Utility Function [Scenario 2 - EOPC]

Player 1:		Player 2:		Player 3:	
AAA>BAA	B	AAA>ABA	B	AAA>AAB	B
ABA>BBA	B	BAA>BBA	B	BAA>BAB	B
AAB>BAB	B	AAB>ABB	B	ABA>ABB	B
ABB>BBB	B	BAB>BBB	B	BBA>BBB	B
Dominant P1:	B	Dominant P2:	B	Dominant P3:	B

Dominated Strategies - Utility Function [Scenario 2 - EOPC]

Player 1:		Player 2:		Player 3:	
AAA<BAA	A	AAA<ABA	A	AAA<AAB	A
ABA><BBA	A	BAA<BBA	A	BAA<BAB	A
AAB<BAB	A	AAB<ABB	A	ABA<ABB	A
ABB<BBB	A	BAB<BBB	A	BBA<BBB	A
Eliminate P1:	A	Eliminate P2:	A	Eliminate P3:	A

Nash Equilibrium - Utility Function [Scenario 2 - EOPC]

P1	P2	P3	Player 1:	Player 2:	Player 3:	*Nash Equilibrium:*
A	A	A	B	B	B	-
A	A	B	B	B	B	-
A	B	A	B	B	B	-
A	B	B	B	B	B	-
B	A	A	B	B	B	-
B	A	B	B	B	B	-
B	B	A	B	B	B	-
B	B	B	B	B	B	YES

A9.3 SCENARIO 3 | Energy Performance, Maintenance Performance, and Comfort Performance Contract

Scenario 3 | EOPC + CP

Utility Function (X_{jsi} = 1) – Game model

	Energy supplier (P3): A						Energy supplier (P3): B					
	Engineer/Consultant (P2): A			Engineer/Consultant (P2): B			Engineer/Consultant (P2): A			Engineer/Consultant (P2): B		
Contractor (P1): A	0,07	0,10	0,10	0,23	0,30	0,33	0,22	0,31	0,29	0,68	0,90	0,90
Contractor (P1): B	0,13	0,18	0,18	0,40	0,53	0,57	0,38	0,54	0,50	1,19	1,58	1,59

**Cell contents:* P1 P2 P3

Dominant Strategies - Utility Function [Scenario 3 - EOPC + CP]

Player 1:		Player 2:		Player 3:	
AAA>BAA	B	AAA>ABA	B	AAA>AAB	B
ABA>BBA	B	BAA>BBA	B	BAA>BAB	B
AAB>BAB	B	AAB>ABB	B	ABA>ABB	B
ABB>BBB	B	BAB>BBB	B	BBA>BBB	B
Dominant P1:	B	Dominant P2:	B	Dominant P3:	B

Dominated Strategies - Utility Function [Scenario 3 - EOPC + CP]

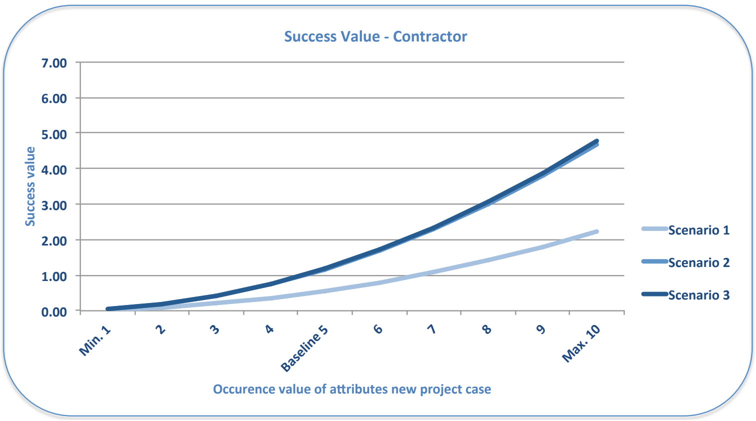
Player 1:		Player 2:		Player 3:	
AAA<BAA	A	AAA<ABA	A	AAA<AAB	A
ABA><BBA	A	BAA<BBA	A	BAA<BAB	A
AAB<BAB	A	AAB<ABB	A	ABA<ABB	A
ABB<BBB	A	BAB<BBB	A	BBA<BBB	A
Eliminate P1:	A	Eliminate P2:	A	Eliminate P3:	A

Nash Equilibrium - Utility Function [Scenario 3 - EOPC + CP]

P1	P2	P3	Player 1:	Player 2:	Player 3:	*Nash Equilibrium:*
A	A	A	B	B	B	-
A	A	B	B	B	B	-
A	B	A	B	B	B	-
A	B	B	B	B	B	-
B	A	A	B	B	B	-
B	A	B	B	B	B	-
B	B	A	B	B	B	-
B	B	B	B	B	B	YES

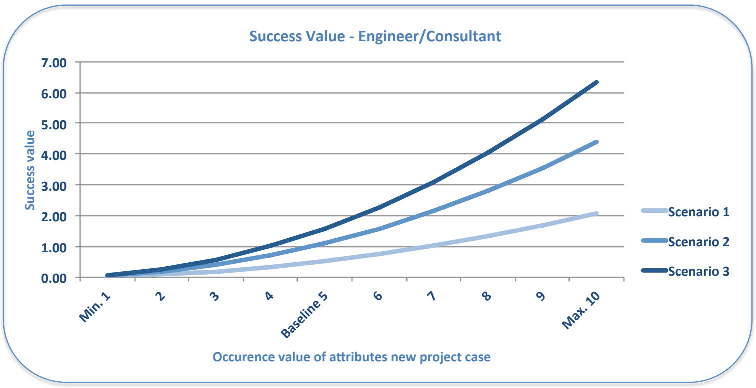
A10 | Simulation results 'Success Value' modeling (attribute influences in a new project case)

	Scenario 1			Scenario 2			Scenario 3		
Xjsi =	Contractor	Engineer/ consultant	Energy supplier	Contractor	Engineer/ consultant	Energy supplier	Contractor	Engineer/ consultant	Energy supplier
Min. 1	0,02	0,02	0,02	0,05	0,04	0,04	0,05	0,06	0,06
2	0,09	0,08	0,07	0,19	0,18	0,17	0,19	0,25	0,25
3	0,20	0,19	0,16	0,42	0,40	0,39	0,43	0,57	0,57
4	0,36	0,33	0,29	0,75	0,70	0,69	0,76	1,01	1,02
Baseline 5	0,56	0,52	0,45	1,17	1,10	1,07	1,19	1,58	1,59
6	0,80	0,75	0,65	1,68	1,58	1,54	1,72	2,28	2,29
7	1,09	1,02	0,88	2,29	2,16	2,10	2,34	3,10	3,11
8	1,43	1,33	1,15	2,99	2,81	2,75	3,06	4,05	4,07
9	1,81	1,68	1,46	3,79	3,56	3,47	3,87	5,12	5,15
Max. 10	2,23	2,07	1,80	4,68	4,40	4,29	4,77	6,33	6,35



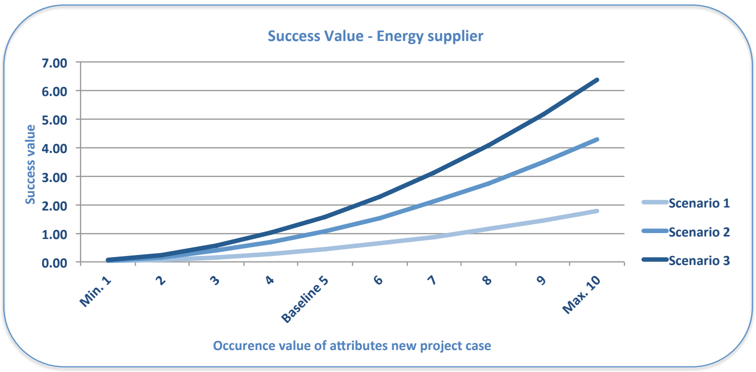
Success Value - Contractor

Xjsi =	Scenario 1	Scenario 2	Scenario 3
Min. 1	0,02	0,05	0,05
Baseline 5	0,56	1,17	1,19
Max. 10	2,23	4,68	4,77



Success Value - Engineer/Consultant

Xjsi =	Scenario 1	Scenario 2	Scenario 3
Min. 1	0,02	0,04	0,06
Baseline 5	0,52	1,10	1,58
Max. 10	2,07	4,40	6,33



Success Value - Contractor

Xjsi =	Scenario 1	Scenario 2	Scenario 3
Min. 1	0,02	0,04	0,06
Baseline 5	0,45	1,07	1,59
Max. 10	1,80	4,29	6,35

A11 | Utility Function 'Success Value' modeling Tree