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Can the public-private partnership solution achieve decarbonisation of healthcare infrastructures?

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TRABAJO FINAL DE MÁSTER

Can the public-private partnership solution achieve decarbonisation of healthcare infrastructures?

MEMORIA

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Résumé

Ce Projet de fin d'études a été réalisé pour répondre à la demande de combattre le changement climatique. Il est évident que des mesures d'impact sont nécessaires pour décarboniser le secteur industriel et la chaîne d'approvisionnement, mais nous avons voulu focaliser ce projet final sur le secteur des soins de santé, étant donné que l'empreinte carbone générée par le secteur équivaut à 4,4 % des émissions nettes mondiales, et en particulier, nous centrer dans les infrastructures de soins de santé.

Afin de répondre au besoin de changement dans ce secteur, le système de partenariat public-privé est présenté, et il est analysé si le développement de projets par cette méthode pourrait aider à la décarbonisation du secteur des soins de santé, en établissant des projets robustes avec un fort engagement à long terme, garantissant une empreinte carbone nette zéro.

Dans le deuxième chapitre, les particularités de cette méthodologie de projet sont présentées, en se concentrant sur des aspects importants tels que la structure contractuelle et les acteurs concernés, la répartition des risques entre les parties, les différents types de solutions PPP dans le secteur de la santé et l'état de l'art du secteur de la décarbonisation. Les principaux avantages du système sont présentés, tels que l'engagement à long terme, l'implication initiale de tous les acteurs dans le développement du projet ou l'accès à un déploiement de capital important.

Dans le chapitre 3, nous expliquons les raisons pour lesquelles le système de PPP pourrait favoriser le développement de projets avec un engagement fort en faveur de la décarbonisation de les infrastructures de santé. Il présente le haut degré de détail technique de la phase de sélection et les exigences que l'autorité peut fixer pour atteindre l'objectif de réduction nette des émissions de carbone. Il examine également en détail le système d'évaluation des appels d'offres, qui peut fortement pondérer la solution de qualité finale afin de garantir la décarbonisation, ainsi que le contrat de mécanisme de paiement de l'Autorité, qui prévoit des déductions pour la réalisation des objectifs et des performances énergétiques dès la phase initiale du projet, afin de garantir le respect des contrats dans le but de renforcer la résilience du système de santé.

Finalement, le chapitre 4 présente une étude de cas de l'hôpital de Toledo, un établissement dont la demande énergétique est élevée et qui a la possibilité d'introduire un système de production d'énergie pour éviter les pénalités imposées par la nouvelle loi espagnole sur les droits d'émission. Cela implique la décarbonisation d'un pourcentage élevé de la consommation d'énergie de l'hôpital et donne l'exemple à tous les projets de friches industrielles pour réaliser la décarbonisation avec un investissement rentable.

Pour conclure le projet de fin des études, nous vérifierons dans le chapitre 5 si nous avons répondu à la question et nous présenterons les conclusions auxquelles nous sommes parvenus, en résumant brièvement les particularités présentées dans chacune des sections.

Abstract

This Final Project has been carried out to support the need to tackle climate change. It is clear that impact measures are needed to decarbonise the industrial sector and the supply chain, but we wanted to focus this Final project on the Health Care sector, since the carbon footprint generated by the Health Care sector is equivalent to 4.4% of global net emissions, and in particular, in the healthcare infrastructures.

In order to respond to the need for change in this sector, the Public-private partnership system is presented, and it is analysed whether the development of projects by this method could help the decarbonisation of the healthcare sector, establishing robust projects with strong long term commitment, securing a net-zero carbon footprint.

In the second chapter, the particularities of this project methodology are presented, focusing on important aspects such as the contractual structure and the relevant actors, the distribution of risks between the parties, the different types of Healthcare PPP solutions currently on the market and the estate of art of the decarbonisation sector. The main benefits of the system are presented, such as the long-term commitment, the early involvement of all actors in the development of the project, the access to major capital deployment from the private sector or the flexibility of the PPP system to accommodate any changes and risks.

In chapter 3, we explain some of the reasons why the PPP system could favour the development of projects with a high commitment to the decarbonisation of the healthcare facility. It discusses the high degree of technical detail in procurement and the complex requirements that the Authority can set in order to meet the Net-zero carbon objective over the lifetime of the healthcare infrastructure. It also discusses in detail the tender evaluation system, which can heavily weight the final quality solution to ensure decarbonisation and also, the Authority's payment mechanism contract, which sets deductions for meeting energy targets and performance from the initial phase of the project, to ensure compliance with the contracts with the aim of increasing the resilience of the health system.

Finally, in chapter 4, a case study of the Toledo hospital is presented, an asset with a high energy demand that has the possibility to introduce an energy generation system to avoid the penalties imposed by the new Spanish law on emission rights and emission control. This implies the decarbonisation of a high percentage of the hospital's energy consumption and sets an example for all brownfield projects to achieve the decarbonization with a profitable investment.

To conclude the Master's thesis, we will check in chapter 5 whether we have answered the question and we will present the conclusions we have reached, summarising briefly the particularities presented in each of the chapters.

Resumen

Este Trabajo Fin de Máster se ha realizado para apoyar la necesidad de hacer frente al cambio climático. Es evidente que se necesitan medidas de impacto para descarbonizar el sector industrial y la cadena de suministro, pero este Trabajo Fin de Máster se va a centrar en el sector sanitario, ya que la huella de carbono generada por el sector Sanitario equivale al 4,4% de las emisiones netas globales, y en particular, nos centraremos en las infraestructuras sanitarias. Para dar respuesta a la necesidad de cambio en este sector, se presenta el sistema de Asociación Público-Privada (APP en adelante), y se analiza si el desarrollo de proyectos por este método podría ayudar a la descarbonización del sector sanitario, estableciendo proyectos robustos con un fuerte compromiso a largo plazo, asegurando una huella de carbono "net-zero".

En el capítulo 2, se presentan las particularidades de esta contratación alternativa, centrándose en aspectos importantes como la estructura contractual y los actores relevantes, la distribución de riesgos entre las partes, los diferentes tipos de soluciones de APP en hospitales y el estado del arte del sector respecto a la descarbonización. Se presentan las principales ventajas del sistema APP, como el compromiso a largo plazo, la implicación temprana de todos los actores en el desarrollo del proyecto, el acceso a un importante desembolso de capital del sector privado o la flexibilidad del sistema APP para adaptarse a cualquier cambio y riesgo.

En el capítulo 3, se explican algunas de las razones por las que el sistema de APP podría favorecer el desarrollo de proyectos con un alto compromiso con la descarbonización de las infraestructuras sanitarias. Se analiza el alto grado de detalle técnico en la contratación y los complejos requisitos que la autoridad puede establecer para cumplir el objetivo de carbono "net-zero" durante la vida útil de la infraestructura sanitaria. También se analiza en detalle el sistema de evaluación de las licitaciones, que puede ponderar en gran medida la solución final de calidad para garantizar la descarbonización y, asimismo, el método de pago de la autoridad, que establece deducciones por incumplir los objetivos energéticos y el rendimiento desde la fase inicial del proyecto, para garantizar el cumplimiento de los contratos con el objetivo de aumentar la resiliencia del sistema sanitario.

Por último, en el capítulo 4, se presenta un estudio del hospital de Toledo, un activo con una elevada demanda energética que tiene la posibilidad de introducir un sistema de generación de energía para evitar las penalizaciones impuestas por la nueva ley española sobre derechos de emisión y control de emisiones de carbono. Esto supone la descarbonización de un alto porcentaje del consumo energético del hospital y supone un ejemplo para todos los proyectos “brownfield”, para conseguir la descarbonización con una inversión rentable.

Para concluir el Trabajo de Final de Máster, comprobaremos en el capítulo 5 si hemos respondido a la pregunta y presentaremos las conclusiones a las que hemos llegado, realizando un breve resumen de las particularidades presentadas en cada uno de los apartados.

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1. Introduction.

It is becoming increasingly evident that the environmental crisis we are experiencing is leading to a global health crisis. The consequences of this crisis reach all countries, including economically developed countries through the degradation of air quality; the deterioration of drinking water quality; diseases caused by microbes living in water, soil, and air; lack of access to health care; and consequences caused by climate change and natural disasters.

According to the World Health organization, an estimated 12.6 million deaths each year are attributable to unhealthy environments. In addition to those mentioned above, we can include soil contamination; loss of biodiversity and natural spaces; the impact of ultraviolet rays as other causes of illness and death.

Infrastructure could also have major impact on global health, as not only does a lack of infrastructure lead to a less safe, less resourceful and less quality-of-life environment, but poor maintenance of existing infrastructure can aggravate the creation of unhealthy environments. Overcoming this requires general measures of allocation of resources at local and state level, which not only provide new infrastructure but also improve the maintenance of existing infrastructure.

In addition, these consequences are aggravated when dealing with communities in developing countries, with high population density and economic poverty.

We can see that there is a direct link between environmental degradation and a reduction in the quality of people's health, which is why, although all sectors must act and encourage a change, the Health Care sector must be one of the industrial leaders and must remain particularly strong on its decisions.

Through a variety of actions at a broad level, Health Leaders can show opportunities to take climate actions, showing these actions clearly in a way that reflects the urgency of the climate crisis. It is important to show that there is no time to lose.

We should not think that the Healthcare sector does not contribute to the problem and that its mobilisation is based on an act of empathy with other industrial sectors, since the carbon footprint generated by the Health Care sector is equivalent to 4.4% of global net emissions [1], with the biggest emitters being the United States, China, and the European Union. That is why adaptation in the health sector can play a leading role in climate change mitigation.

The economic benefits of reducing the climate footprint, meanwhile, are substantial. In recent years, health systems around the world have seen changing energy prices hit their budgets, and the cost of fossil fuels can be expected to continue to rise. In areas with less infrastructure and development, the high cost of traditional fossil fuels can present a barrier to healthcare, and energy conservation measures-as well as alternative energy sources-can potentially help remove this barrier by providing cheap and reliable energy.

This PFE introduces the Public-Private Partnership system and analyses whether through this system, the Healthcare sector can achieve a decarbonization that has a positive impact on the environment and people's health, combining actors from the private sector with actors from the public sector. In addition to present the environmental impact opportunities of the Project Finance, Public-Private Partnership system, this essay will present the economies that this system could bring with a long-term vision of a project and the correct allocation of risks between the parties involved.

2. Healthcare Sector particularities

It is necessary to understand that hospital energy use (for water heating, indoor air temperature control, lighting, ventilation, and numerous clinical processes) and the resulting harmful emissions, contribute significantly to climate change and unintentionally, contribute to respiratory and other health disorders in the communities they serve. In other words, not only does conventional electricity consumption imply a great cost within the operation of a health institution, but the increase in the health cost to society.

From the paper "Global Road Map for Health Care Decarbonization" produced by Health Care Without Harm (HCWH) and Arup [2], we can obtain key information on energy consumption forecasts within the healthcare sector. This paper analyzes the progression of MMT of CO_2 from 2014 to 2050 and explains 2 main pillars of action to reduce consumption and the Health Care carbon tendance.

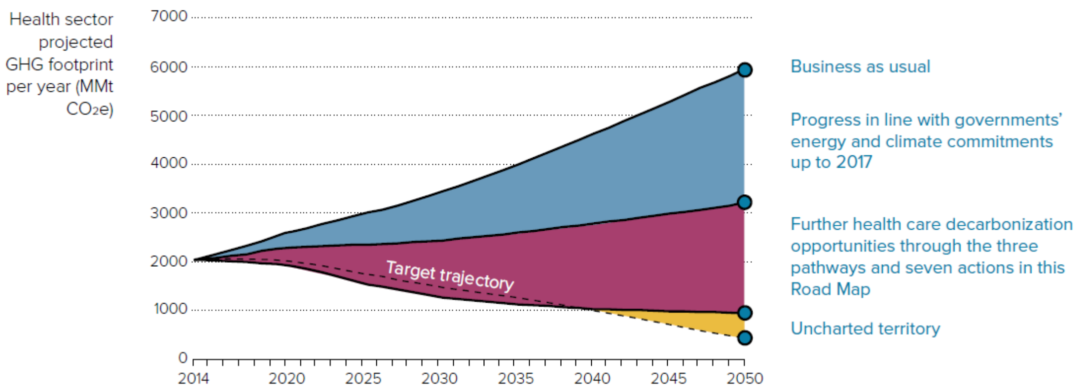


Figure 1 - Health Sector projected GHG footprint per year (MMt CO2). Source [2]

The first pillar of action corresponds to laws and regulations established by the governments of each country and climate summits to reduce consumption. However, political actions are strongly influenced by the economic activity of each country, and there is sometimes a strong reluctance to give up economic growth in favor of actions with a high impact on the environment. This is due to a lack of political authority. The models of consumption and industrial production used in both developed and developing countries, in which economic growth takes precedence over the environmental consequences, including the increase of greenhouse gases, global warming, pollution of land and aquifers and the loss of biodiversity as main characteristics.

In recent decades there has been a growing awareness of the serious social and economic consequences of the problems described above. It is clear that a solution to these environmental problems must be found, and this solution will most probably involve sustainable development.

Sustainable development is defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. In other words, sustainable development advocates growth today that does not condemn future generations to worse economic and environmental conditions than today.

Measures that directly affect the health care system and that can be directly imposed by governments can be, on the one hand, the obligation to reduce the average indoor temperature in winter and its corresponding increase in summer, the use of a fixed percentage of clean energy or the acquisition of new, more efficient equipment and on the other hand, a heavy investment in sustainable and resilience infrastructure that meets the energy efficiency requirements to comply with international energy targets.

The second pillar, as we can see in the previous graph, includes the decarbonisation opportunities that exist in the supply chain of hospital assets, existing hospital assets and new infrastructure, maintaining and increasing the level of patient care. These actions cannot be carried out without the collaboration of other sectors that contribute new technologies and solutions to achieve the Net Zero Carbon Target, but the healthcare sector and its professionals can act as pioneers in global progress.

It can be seen in the HCWH graph that the impact of these actions can match the impact of large social and governmental measures and should be on the agenda of all developers, builders, private investors, public investors and institutional investors, basically all those actors that make up the market and that can work together to bring these measures to reality.

In the following graph, we zoom in on the Health Care decarbonisation opportunities. We can find a description of 7 actions that make up the possibilities for the decarbonisation of the Health Care Sector, including each relevant weight in the total contribution.

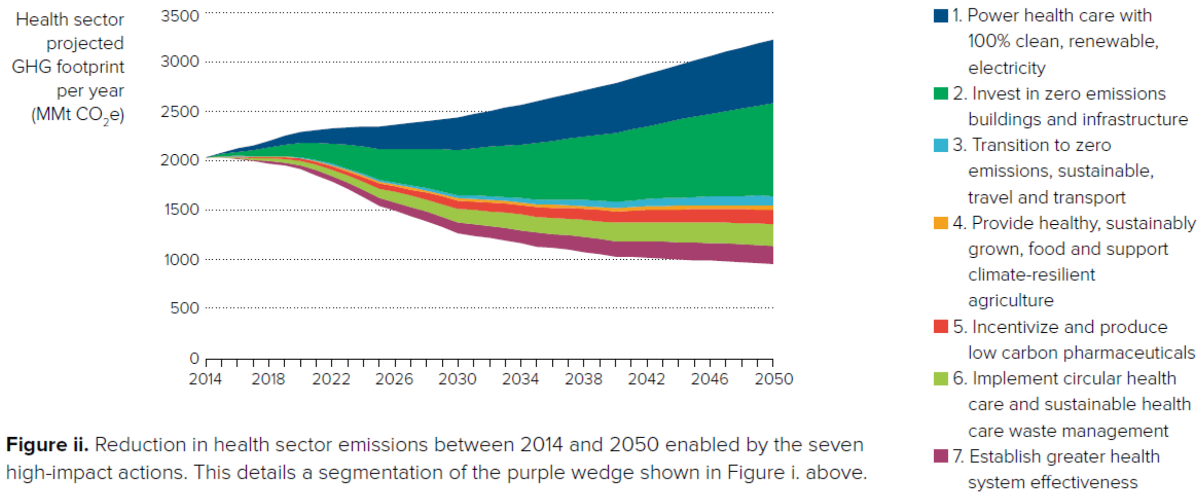


Figure 2 - Health Sector projected GHG footprint per year (MMt CO2) - Decarbonization opportunities. Source [2]

1. Power health care with 100% clean, renewable electricity – Ensure that facilities use 100% renewable energy, both from the grid and green energy produced directly through solutions implemented in the infrastructure itself.
2. Invest in zero emissions buildings and infrastructure – Major action to promote change in the sector. Both in terms of renovating existing facilities and making considerable savings, and in terms of building the new infrastructures needed to meet healthcare needs with net zero carbon emissions.

These two above-mentioned actions would have the greatest impact on emission reductions, as they act directly on the infrastructure and the focus of carbon emissions.

3. Transition to zero emissions, sustainable travel and transport – Hospital facilities need to be well connected and have a high transport flow. A sustainable public transport network around hospitals would reduce indirect carbon emissions.
4. Provide healthy, sustainably grown food – Efforts should be made to offer fresh and in-season food with zero residues.
5. Incentivize and produce low-carbon pharmaceuticals – The system must be based on sustainable and environmentally responsible medicines. Local products that do not depend on large supply chains and products produced with green energy can be an example of action in this field.

6. Implement circular health care and sustainable health care waste management – Hospital waste can lead to contamination and disease if not handled properly. Hospitals also generate chemical, pharmaceutical and radioactive waste, all in small quantities, which require special handling. On the other hand, hospitals also generate large quantities of common waste such as packaging, paper, food, etc. based on an article from "Salud sin Daño" (Residuos hospitalarios), this can account for about 80% of the waste stream.
7. Establish greater health system effectiveness – Improving system effectiveness by eliminating carbon-producing activities that do not provide value. It is also related to good training of hospital and building maintenance staff.

After considering these 7 targets, the paper "Global Road Map for Health Care Decarbonization" [2] estimates that emissions from the healthcare facility sector will remain above 1.1 Gigatons compared to the Net-Zero Carbon target to be achieved by 2050.

Bridging the gap will require scaling-up measurable health care climate action that we do not yet have at present. Research will play a key role in developing new methods of decarbonising healthcare facilities. The implementation of new technological solutions to reduce and control emissions in new infrastructure will need to be accompanied by a reinvention of the financial system that supports these types of investments. In the following sections we can see 3 key drivers for making the healthcare facility a priority.

The following three items show how the healthcare sector can be an exemplary leader for achieving decarbonisation, as the measures implemented on healthcare facilities can then be replicated in other social infrastructure projects or other sectors.

2.1. Decarbonization

The health sector is one of the most rapidly evolving sectors, both in developing countries and in the renovation of healthcare facilities in the most advanced countries. Global temperature control targets, such as the Paris Agreement, and efforts to limit climate change, must be intercepted in all sectors, and is directly related with the reduction in carbon emissions.

The decarbonisation of the healthcare system must be a priority, as an objective that goes hand in hand with environmental care is the well-being of people, directly related to the reduction of diseases and better quality of life.

In addition, there are many synergies between decarbonisation, resilience and health equity, and the health system should be a pioneer in implementing these objectives in its overall development strategy. Both in new infrastructure, existing health infrastructure and in the supply chain, which involves transport systems, logistics and industry.

2.2. Resilience

The resilience of a health system refers to its ability to withstand, tolerate, absorb, recover from, prepare for, or adapt to an adverse occurrence that causes damage, destruction, or loss. This includes physical infrastructure, personnel and staffing, supply chains, equipment and pharmaceutical stocks, and internal processes. In other words, this represents the process and mechanisms by which health systems can cope with an unexpected load (i.e., a pandemic emergency) without a critical degradation of health care delivery and with a reasonable return to "normal service". In an ideal resilience model, the system may even return to better-than-usual function by virtue of improved processes that are under the "stress test" of a disruption.

In practical terms, recovery may represent the return to elective surgery in a surgical setting, the time from triage to evaluation in an emergency department, or the acceptable time to bed assignment for a new inpatient.

Resilience is the process by which health, economic, and environmental systems can cope with change and disruption in such a way that they evolve and innovate together, to continue to provide healthy growth for the population. [3]

Resilience in health should be understood as a key component not only of population health, but also of economic "health". Without resilience incorporated into health care planning, the future system disruptions will be poorly absorbed, which will inevitably affect economic growth.

A zero-carbon emissions plan for the healthcare sector must develop in harmony with the system, community resilience and infrastructure to withstand the impacts of the climate crisis.

2.3. Health Equity

A climate-smart health care agenda must consider different levels of health access development, involving different countries and regions within each nation. Accelerating investment in the health system in areas where access to health services is not readily available is the main vehicle to be used to incorporate decarbonization measures. New infrastructure construction, supply chain organization and operational requirements should incorporate decarbonization plans to achieve the net zero carbon balance on infrastructure, at the same time as providing access to health care for all individuals.

Equal access to the healthcare service is not only achieved with greater investment in infrastructure in developing countries, optimizing bed occupancy minimizing length of stay streamlining service delivery and increasing home outreach services all play a role in attempts to lower health care delivery costs through cost-effective and efficient processes. This allows areas with public and private hospital services to have sufficient capacity to accommodate the needs of the population, and not deprive access to health care due to overcrowding or lack of health care personnel. [4]

3. Current Healthcare situation and European main targets for climate change

Decarbonization of the health care system ought to be built on the idea of common but with distinct obligations and capacities. High-income nations must act promptly and bear most of the responsibility for resolving the climate crisis since their health systems account for the biggest portion of global health care emissions.

Health care decarbonization should be based on the principle of common but with differentiated responsibilities and respective capabilities.

- High-income countries, whose health systems are most responsible for global health care emissions (per capita and historically), need to act most quickly and take the greatest responsibility for addressing the climate crisis.
- Middle-income countries must invest in health system development that takes them on a pathway to zero emissions and avoids replicating the carbon-intensive health delivery model of wealthier countries.
- Low-income countries need to deploy low-carbon and zero emissions technology that enhances their ability to develop their health systems and provide health access and services to all.

Ultimately, all health systems will need to be closing in on zero emissions by 2050. While those in developing countries might have a later emissions peak, all must begin navigating the transition now in order to avoid locking into a carbon-intensive development trajectory. This transition may require increased support from developed economies to strengthen the capacity of health systems in the developing world and improve their access to the necessary technology.

3.1. European main targets for climate change

Since the industrial revolution, there has been an average increase of global temperatures. The latest decade, from 2010 up to 2020, this increase has been even accentuated and this has been the warmest decade on record. In addition, 19 of the 20 warmest years have occurred since 2000.

It is evidenced that the increase of temperature is caused by greenhouse gas emissions (GHG) produced by human activity. If we compare the global average temperature to the pre-industrialized period, the currently figure is between 0,95 to 1,2 °C higher. The increase of temperature that the scientist fixed as dangerous for the climate and environment is 2°C, so the international communities are targeting to create measures to maintain the increase of temperature under this level. [5]

A European Green Deal
Striving to be the first climate-neutral continent

The European Green Deal has the objective of eliminating climate and environmental degradation by turning Europe into a resource-efficient and competitive economy, aiming to become the world's first carbon footprint neutral continent. The principal objectives of this agreement are the following:

- no net emission of greenhouse gases by 2050
- economic growth decoupled from resource use
- no people or places left behind

One third of the 1.8 trillion euros of investments from the EU's Next Generation Recovery Plan and the EU's seven-year budget will fund the European Green Deal. The European Green Deal will enhance the well-being and health of European society and future generations by delivering:

“All 27 EU Member States committed to turning the EU into the first climate neutral continent by 2050. To get there, they pledged to reduce emissions by at least 55% by 2030, compared to 1990 levels.”

The European Green Deal will enhance the well-being and health of European society and future generations by delivering:

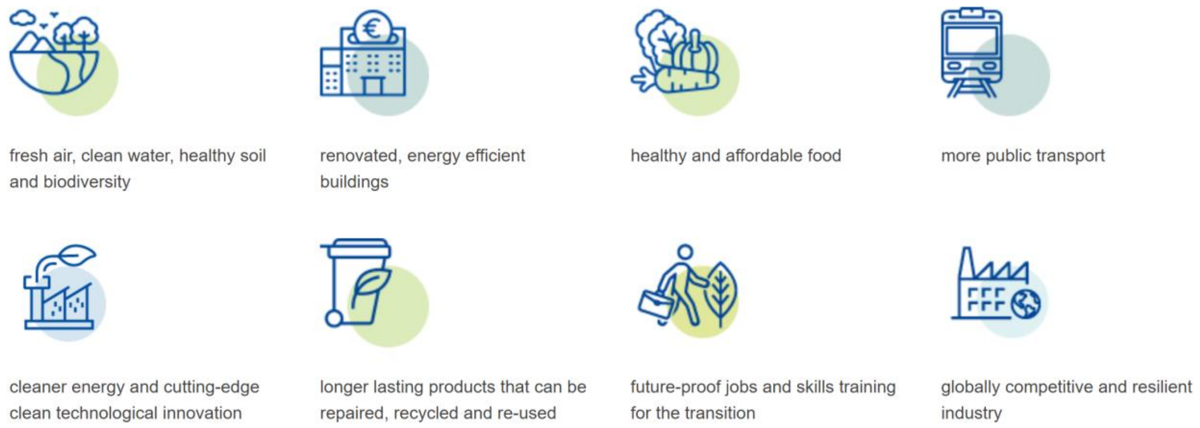


Figure 3 - European Green deal main objectives. Source [6]

As can be seen, some of the main pillars that the European Green Deal aims to provide are directly related to the topic of this Final Degree Project. From the target of creating renovated, energy efficient buildings, to the need for more public transport and the promotion of resilient industry. The main objective of this work is to find out if the PPP system can help the decarbonization of the infrastructure sector and directly contribute to make the European Green Deal a reality and reduce the carbon footprint by 55% in the next 10 years. [6] [7]

Paris Agreement
Bridge between today's policies and climate-neutrality before the end of the century.

Since the Kioto protocol was signed in 2005, governments evidence the need of developing a legally binding global treaty containing specific targets for all countries to reduce their carbon emissions and other actions to fight against the climate change.

The Paris Agreement was signed in December 2015 and covers all the aspects for fighting the climate change, from the mitigation measures on the main climate risks to the methodology for implementing new measures and adapt the economy and society to these changes. The priority of the agreement is to keep the global increase of temperature below 2ºC, comparing it to the pre-industrialization levels and making the necessary efforts to keep global warming levels below 1,5ºC. Some characteristics of the agreement are [8]:

- As mentioned, keep the increase of global temperature below 2ºC and do extra efforts to try to keep the temperature increase below 1,5ºC compared to pre-industrialization levels.

- All counties must prepare and communicate their plans to reach these objectives and must economically support this environmental plan. All countries should internally include domestic activities.
- A transparency system is included within the signed counties where they should disclose the progress, plans and compromise adopted.
- Each 5 years there will be a global balance of performance and results will be compared with the signed forecasts.
- A global objective is established to increase the adaptability capacity and reduce vulnerability to climate change, including economical support.
- Avoid or mitigate possible losses and damage caused by climate change.

As we can see, the Paris agreement includes all different activities to reduce the impact of the counties on the climate, limiting carbon emissions and controlling industrial activities. [9]

4. Infrastructure as main driver for decarbonization

As we have seen in the previous section, achieving net zero carbon in healthcare infrastructures would represent the largest reduction in emissions in the entire healthcare system. Energy efficiency measures are the easiest and most common means that hospitals and clinics can adopt to reduce costs, carbon emissions and improve human and environmental health.

These actions are present throughout the entire lifecycle of the infrastructure and can be implemented from the inception phase or in already built infrastructures.

- New Healthcare infrastructure actions: sustainability, resilience and green performance requirements must be established from the design of the infrastructure, aligning all project stakeholders and prioritising these environmental and social positive outcomes.
- Actions in existing infrastructure: actions in buildings already in operation are essential to decarbonise the healthcare system. There are numerous possibilities and there are specialised energy efficiency retrofit firms that can help to reduce the emissions of the healthcare facility to a minimum. The law is changing and penalties are being implemented for players with high emissions, who have to finance lifecycle actuations to reduce these emissions and avoid fines.

In order to be able to implement effective measures, infrastructures must be conceived and designed taking into account all phases of the project and all actors involved. The following graphic shows the step-by-step actions that an infrastructure should follow throughout the life of the asset in order to be carbon efficient, and how these phases are correlated with each other.

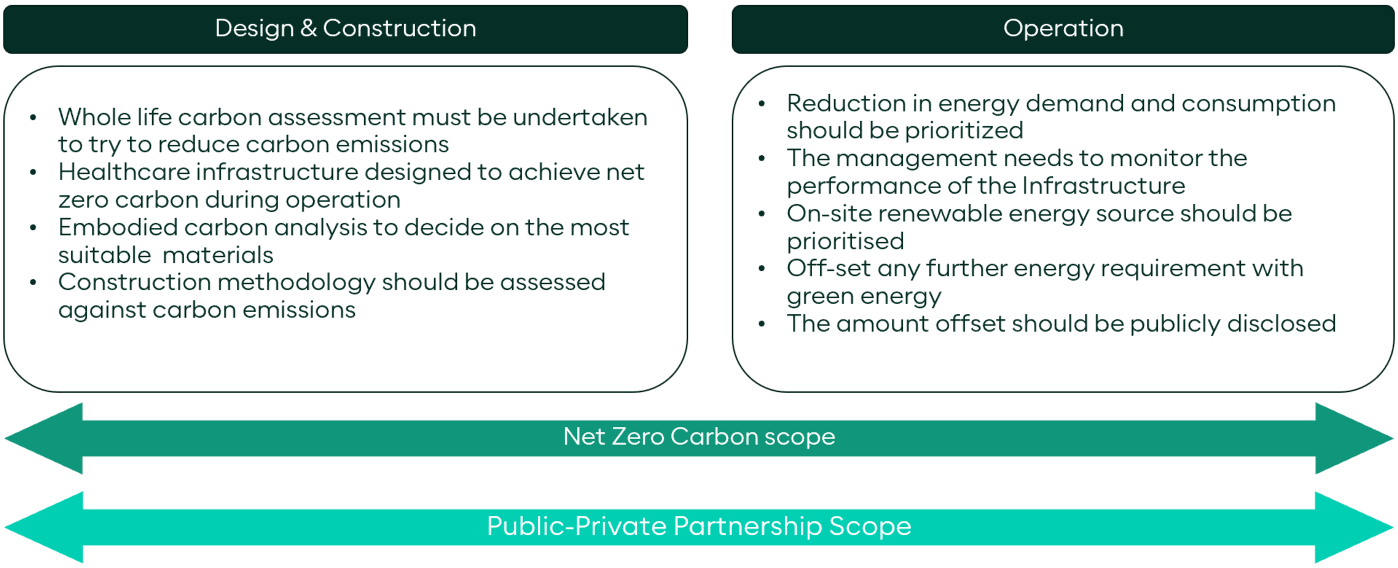


Figure 4 - Action throughout project phases to reduce and monitor carbon emissions. Personal Source

As shown in the graph, the Public-Private Partnership system manages to bring together all the actors involved in the project, contractually setting the energy, sustainability and efficiency requirements and targets that the facility will have to meet throughout the life of the infrastructure. The possibility that the operator of the hospital services, the maintenance operator and the management are involved provides great value and lessons learned from other projects in order to find solutions in the most efficient way.

5. Scope of the M.S. Thesis

After stating that infrastructures are responsible for a large amount of climate change emissions and presenting the public-private partnership system for project development, the focus of this M.S. Thesis will be on whether this project development system can collaborate and improve the approach of healthcare infrastructures towards the decarbonisation of their assets. The aim of the paper is to answer the following question raised in the thesis title: Can the public-private partnership solution achieve decarbonisation of healthcare infrastructures?

The M.S. Thesis will be structured in three more chapters: (i) Chapter 2. Introduction to PPP. Healthcare approach. In this chapter, we will present the general characteristics of the public-private partnership system, focusing on the different contractual structures we can have, with the focus on the application to the healthcare system. We will present the global actors developing these projects, and how a good risk sharing in projects can bring value for money to the public party procuring the Project. We will end this chapter with the state of the art of hospital infrastructures with Net-Zero carbon objectives and other social infrastructure buildings. (ii) Chapter 3. Developing PPP contractual structure to achieve decarbonisation of Healthcare Facilities. In this chapter we will describe the particularities by which the PPP system could control the achievement of the net-zero carbon from the initial phase to the operation of the asset. We will describe how designs are set with the collaboration of all project stakeholders, the evaluation methodology that promotes the quality of the solution rather than the price, but respecting clients affordability and the payment mechanism contract that is signed to introduce availability payment clauses and deductions for non-compliance with project outcomes, such as energy targets or performance failures. (iii) Chapter 4. Developer Perspective. Infrastructure solutions to achieve decarbonisation and value for money on brownfield healthcare developments. Finally, we will introduce an example of a healthcare facility currently in operation that is studying how cost-effective investment can reduce dependence on fossil fuels and eliminate a high percentage of carbon produced in operation. (iv) Chapter 5. Conclusion. Where we conclude the work and check whether the particularities described in the previous sections can ensure the achievement of net-zero carbon objectives.

Chapter 2. Introduction to PPP. Healthcare approach.

1. Introduction to PPP.

The Public-Private Partnership could be broadly defined as:

The PPP system consists of a long-term contract between a public entity and a private actor, for providing services or managing an asset, in which the private party assumes significant risk, responsibility and liability, and the remuneration is linked to performance, and comes from public funds.

[10] Public-Private Partnership contracts are long-term contracts of usually more than 15 years and can be extended up to 40-50 years for some infrastructures or services. Under the PPP contract, the private party retains the financial risk, technical risk and operational risk, and negotiates with the public party to manage macro-economic risks that do not directly depend on the SPV, such as political risk or tax risk. This system is known for having a lot of flexibility in structuring the contractual and financial structure of the project. Therefore, well-structured projects can deliver high value for money to the client while efficiently building a new infrastructure or developing a service throughout a full concession period. However, the sometimes-high complexity of combining different private and public actors, can lead to delays in tendering, awarding, and starting a project. The following table shows some of the benefits and limitations of this system:

Benefits	Limitation
Increases the return on investment in public infrastructure (Value for for money)	It represents relatively new concepts concepts that are not well understood in many countries
The Public Sector could easily channel their budget to social infrastructure.	Insufficient theoretical and practical experience of the public and private sectors to implement long-term projects
More efficient and reliable service delivery at lower cost	High bidding costs can limit competition
Avoids upfront capital costs for the public sector to develop the infrastructure	Bidding and negotiation processes are more complex and time-consuming
Lifecycle cost and project delivery time are reduced.	Political and social opposition may delay or cancel projects
Facilitates innovation and the introduction of new technologies	Financing costs are higher for the private sector than for the public sector.
The public sector can transfer risks related to the construction, financing and operation of projects to the private sector.	Accountability is reduced because information can be treated as confidential
Promote economic growth and improve employment opportunities	In certain sectors a monopoly situation may result with higher costs for the users of public services

Figure 5 - Policy analysis for improving performance of PPP projects in Vietnam. Source: [11]

Within the PPP model there are some classifications that make it possible to adapt the general PPP system to the particularity of each project. There are three terms that can broadly define PPPs: (i) the type of asset involved, (ii) the roles and obligations of the private operator and (iii) the way in which the operator is paid. "World Bank Group. Public-Private Partnerships. Reference Guide. Version 3" [12]:

(i) All PPPs involve some form of asset. If the project involves the design and construction of a new asset, these are called greenfield projects. The Private Finance Initiative (PFI) in the UK is based on this type of project, where the operator signs with the government to build, finance and maintain new public assets, such as social infrastructure, hospitals, schools or defence facilities. PPPs can also be developed to transfer some service of an already built asset from the public party, or another private party, to a third private actor, who takes over the management of the existing asset, these are called Brownfield projects.

(ii) A general characteristic of PPPs is that throughout the contract they go through different phases, be it the design phase, the construction phase or the operation phase. Associated with each of these phases are functions that the private operator may perform and for which it is wholly or partly responsible. Some functions that we see in projects include:

- Design or engineering work - includes the development of the project from scratch to the construction-ready phase. Depending on the client we may receive certain requirements to be met or even receive a reference design, which the bidders will have to adapt/improve to present their solution.
- Build or Refurbishment - Greenfield projects usually have the private party to construct the new asset and install the equipment. If the asset under contract already exists but needs to be refurbished, the private party usually takes care of this. We may have constraints that we need to be aware of and that may depend on the site where the work is to be carried out. These constraints may be environmental, social, time or resource constraints to carry out the work.
- Finance - With the construction or repair of infrastructure often comes private finance.
- Maintain - PPP contracts assign the maintenance of the infrastructure to the private party for the duration of the concession period. This is one of the functions that we will always observe in PPPs.
- Operate - Depending on the infrastructure, the private party may purchase some or all of the services. This is a function that varies for each of the types of infrastructure and even within the same type, such as PPPs involving Healthcare facilities, as the project can be structured in

such a way that the private party covers all services, including clinical services; that it does not include clinical services but it does cover the soft services, such as laundry, cafeteria, etc.; or that it only operates the heavy maintenance and collaborates with the client (or not) in routine maintenance.

(iii) A main characteristic of a Project is the way revenues are captured. A wide variety of authors show this typology as an important distinction between different PPPs. In example, "Yescombe, E.R., (2007), Public-private partnerships - Principles of policy and finance." [13] also describes a classification where he refers to those projects that hold demand risk and those that do not. If a project retains demand risk, it means that its revenues reside in the payment by users of a specific fee for the use of the infrastructure, such as tolls on roads, tunnels, or bridges. In the case of those who do not maintain demand risk, they fix with the authority an Availability payment for the whole concession period, which is usually subject to KPIs. This structure is typical for social infrastructure projects such as hospitals, schools, prisons, and some energy projects, but also a road project can receive a shadow toll, making it an Availability payment. The following table describes some of the differences between these two different types of project revenue sources.

Availability-Based (PPP Contract)	Demand-Based (Concession Contract)
There is an Availability Payment made by the Authority based on the Availability of the Infrastructure	Payments are made by the users based on the usage of the infrastructure
At Financial Close the Availability Payment is calculated taking into account costs, debt repayments, taxes and Sponsors Profit.	Amounts paid by the users are designed to cover the costs of the project, mostly exposing the company to a traffic risk
Periodicity of payments could vary from quarterly to semi-annual or yearly.	Payments will therefore directly vary with usage following availability or poor service issues
If construction programme is phased, there could be a % of the AP paid to the Project Company.	The traffic-risk is often mitigated by guaranteed mechanisms
The AP is usually subject to deductions based on KPI's (Energy targets, emissions, claims, performance…)	Transport infrastructures (roads, bridges, rail, ports, airports) often have a demand-based remuneration
Social infrastructures and energy projects often have an availability-based remuneration	Demand-based projects allow for a lower gearing than availability-based projects.
Availability-based projects allow for a higher gearing than demand-based projects and lower DSCR.	Demand-based need higher DSCR as the assumptions taken at FC could vary during the project term

Figure 6 - Differences between Availability-Based Contract and Demand-Based Contract. Personal source

In addition, there is a possibility to combine both contractual models, for example, when the customer ensures a certain level of revenues to the Project Company.

In a normal operating situation, revenues would be based on the usage of the asset, such as a toll, and only in the event that the usage predictions are not met and the Project Company does not reach a minimum revenue, the customer would pay the Project Company the amount necessary to ensure this minimum revenue.

This would also affect the accounting of the asset. Senior Debt accounting. However, if the asset has demand risk, the asset is recorded as a fixed asset and depreciates linearly with the relevant years or with the expected demand revenue profile.

These three terms can define public-private partnership projects very precisely but one of the characteristics that we could also highlight is the flexibility that this system has to be able to develop different types of contracts with different types of assets. It also includes the possibility to develop projects for different public or even private entities. Each of the projects will be different, both in terms of having different actors and in terms of the need they want to cover. In the end, there is a relationship in how each project is structured with the risk that each party is willing to take, since in order for a project to provide added value and be more efficient than a project financed directly by the state, each party must bear the risks that it can best manage and over which it has control.

This is why the public sector will try to transfer the functions (and risks) that it cannot control to the private sector, and the payment system will be in line with this transfer of risks and functions.

The world bank association has developed an exhaustive list of PPP contract types including the functions transferred from the public to the private party and also the method of payment for the project so that the private party can recover the capital injection and also repay the senior debt it may have borrowed to finance the project. [14]

Availability-Based (PPP Contract)	Type of Asset	Functions Transferred	Payment Source
Design-Build-Finance-Operate-Maintain (DBFOM); Design-Build-Finance-Operate (DBFO);Design-Construct Manage-Finance (DCMF)	New assset	As captured by contract name	Can be either government or user pays
Build-Operate-Transfer (BOT), Build-Own-Operate- Transfer (BOOT), Build-Transfer-Operate (BTO)	New assset	Typically, design, build, finance, maintain, and some or all operations	Can be either government or user pays
Rehabilitate-Operate-Transfer (ROT)	Existing asset	As above, but rehabilitate instead of build	Can be either government or user pays
Concession	New or existing asset	Design, rehabilitate, extend or build, finance, maintain, and operate—typically providing services to users	Usually user pays—in some countries, the private party might pay a fee to government or might receive a subsidy
Private Finance Initiative (PFI)	New assset	Design, build, finance, maintain— may include some operations, but often not providing services directly to users	Government pays
Operations and Maintenance (O&M)	Existing asset	Operations and maintenance	Government pays
Affermage	Existing asset	Maintain and operate, providing services to users	User pays—private party typically remits part of user fees to government to cover capital expenditures

Figure 7 - Infrastructure Contract Nomenclature. Source: Public-Private Partnership. Reference Guide. Version 3.

However, no matter how the project is structured, one of the most remarkable features of this system of structuring projects is the non-recourse financing. The Special Purpose Vehicle (SPV) that signs the long-term contract with the public party is created exclusively to develop the project and it has a balance sheet external to the stakeholders that own the company. The SPV is the one responsible for paying the lenders and assumes the risks of the project, so that no actor involved in the project can claim any compensation from the equity investors that take part in the SPV. The obligations of the SPV are detached from the obligations of the equity investors. The debt raised to finance construction and development is secured by the cash flows the project will generate over the project term.

The non-recourse financing allows the development companies to enter into larger transactions. However, the companies face intense procurements with lenders, that need to undertake a detailed Due Diligence on the project to ensure that it is robust enough to borrow debt and the assumptions taken to create the base case are coherent and easily achievable. This due diligence is done for the contractual/legal part of the project, the technical side, including traffic and demand analysis of the infrastructure and the insurance that the project company will take out to cover major risks that may be triggered throughout the life of the project.

This structure is optimal to raise debt for large projects with a high percentage of leverage, achieving in some projects up to 90% - 92% Gearing, and leaving the equity investor with only a minor % to invest in the project. Because the equity injected in the project is more expensive than the debt raised, the aim is to maximize the Gearing to obtain higher returns o the investment carried out.

On the other hand, and from a developer perspective, the financial costs that bear the project are usually more expensive than government borrowing, and corporate companies borrowings. The increase on financial costs and the transaction costs that the SPV born to create the contractual structure and undertake the proper due diligence could make the investment unattractive for small transactions.

The size of the project is directly related with the optimal way to structure the project, and that is why the PPP system may be unattractive for some smaller transactions, and they may prefer not to structure the project with a non-recourse project finance structure. Some large developers or large infrastructure companies may structure their project financing through traditional full recourse corporate financing or through limited recourse project financing.

Over the past 30 years, a wide range of governments, from high to low income, have increasingly pursued long-term public-private partnerships to provide services in sectors such as transport, energy and waste. The healthcare sector has started to structure some deals using the long-term PPP system at the same time as other sectors but since the early 2000s, there has been a rapid expansion.

The “Design, build, finance, maintain” model used extensively in the British healthcare facilities built under the Private Finance Facilities remain the most common, but they have set a robust baseline to for an increasing number of governments that are experimenting or exploring more challenging models, including the provision of clinical services under the private PPP partner framework. The challenges that are driving governments to further explore new models are directly related to sustainability, resilience, and quality of health services, as well as the need to provide the entire population with appropriate health care.

The Healthcare system faces numerous challenges to improve the quality and effectiveness of their services. In order to adapt the care to the demands of the patients, an increase of resilience and control within facilities in a day-to-day bases should be included in the project operational period and construction. Technology and digital solutions are to be implemented in the systems as the data provided by a facility could be used to organize in an efficient way the routine clinical and maintenance tasks. Moreover, this Data could be shared as lessons learn in the healthcare network and project could be, since inception, reducing costs and enhancing operations.

The Public-Private partnership solution can integrate those improvements to facilities, resulting in a betterment of the care provided. In the latest years PPP's projects where just focusing the refurbishment or replacement of facilities, to provide critical needs to population. The focus has been moved to a more detailed construction requirements to improve resilience, the clinical service delivery and control of the asset. The early involvement in the project also permits to define a roadmap for soft and hard maintenance during the full project term period.

Innovative solutions to achieve a net zero carbon solution at operational periods can easily be implemented with the PPP structure, focusing on the evaluation methodology for the offers, the construction requirements and KPI of the contracts that need to be agreed at an early stage of the development of the project between the Authority procuring the project and the Private partner who will develop the project.

2. Development Partner

The Public-Private partnership solution combines a heterogenic group of actors that will join to develop a specific project. The public party will award the project to a Project Company, formed by private development partners or a combination of public and private sponsors. Depending on the project, there could be different project requirements, but we can usually see in infrastructure development that the project included the design, construction, finance, operation, and maintenance. In order to cover all these requirements, a series of actors must enter into an agreement with the project company and the Public Client. In the following chart we can see a typical contractual structure of a project, but depending of the project, there could be other structures envisaged.

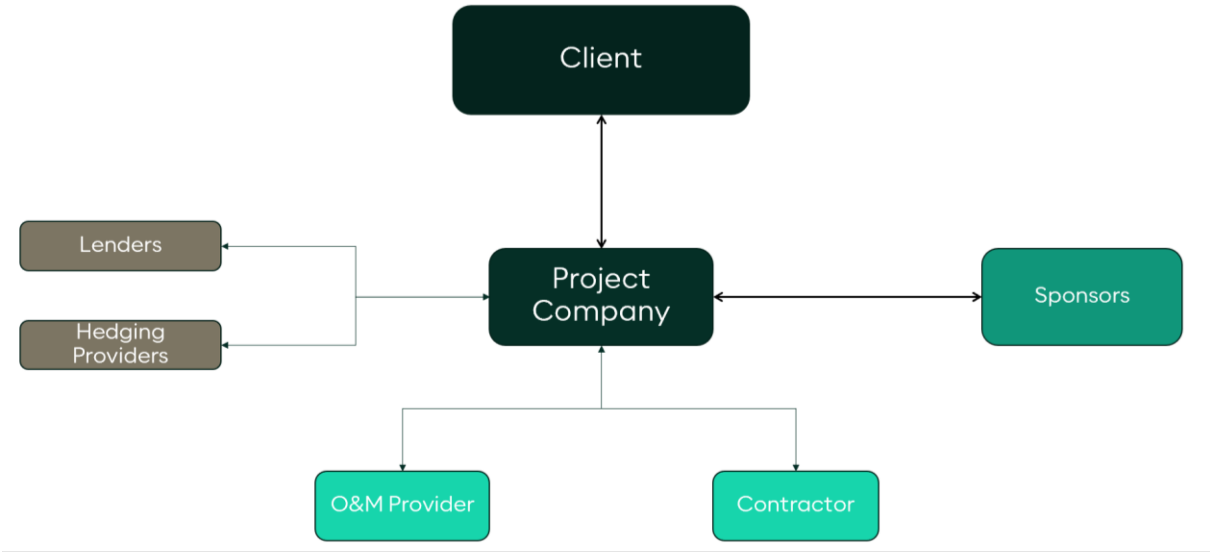


Figure 8 - Organizational Structure. Personal Source

- Client: Public Authority (Government, Council…) even though a private party can also develop a project through the Project finance solution, and the contractual structure would be similar.
- Project Company. The non-recourse financing characteristics make sponsors to create an independent Project Company own by sponsors and out of their balances. The Project is sustained by the main cash flows of the project, insurance and compensations with the client but there will be no recourse to the sponsors in case the project fails.
- Sponsors: Investors in the project, as industrial Sponsors or a combination of private and public actors. They are putting the equity of the project at risk to fund the costs, needs and requirements. Depending on the project, a sponsor usually should have previous experience in the sector, geography and with project of similar size. There are sometime joint venture of sponsors to combine experience and achieve to prequalify on the project.
- Lenders. Banks or Institutional Investors or Multilateral Banks lending the Project Company to Fund the costs, needs and requirements of the project. The PPP funding usually maximizes the leverage of the project to reduce the cost of capital. The WACC (Weighted Average Cost of Capital) formula is the one used to do the calculations:

$$\mathrm{WACC} = \left(\frac{E}{V} \times Re\right) + \left(\frac{D}{V} \times Rd \times (1 - Tc)\right)$$

E	Equity amount
D	Debt amount
V	Debt + Equity amount
Re	Cost of Equity in %

Rd	Cost of Debt in %
Tc	Tax rate

The possibility to raise more debt is directly related with the risk that the project face, and the Project Company will be able to raise more debt in a de-risk project with an Availability Payment from the Authority in place rather than a Demand-risk project bearing and bearing operational risk. The following calculations show how the cost of capital increase when more equity is required:

Re →	10%
Rd →	4%
Tc →	25%

- Debt to equity. 90% Gearing:
  $WACC = (10\% * 10\%) + (90\% * 4\% * (1 - 25\%))$= 3,7%
- Debt to equity. 60% Gearing:
  $WACC = (40\% * 10\%) + (60\% * 4\% * (1 - 25\%))$= 5,8%

- Hedge Providers. When the financing is provided by commercial banks and a floating tranche of debt, the project needs to hedge the risk and convert the Floating line into a fixed tranche. Usually, the Hedge providers are the same Lenders as in the Senior Debt lending side, or Orphan Swap providers can be invited to the project.
- O&M Provider: provides soft (O&M Costs) and hard maintenance (Lifecycle Costs)
- Contractor: Single Construction Company or Construction joint venture. Could be a Sponsor. Builds the asset to the required specifications, at a fixed price and schedule.

All these relationships between project stakeholders are governed by various contracts that are formalised before the project starts (or in the case of financing, before the first debt drawdown is made). Contracts can be defined in different categories:

1. Project Agreement: Contains all the information that regulates the project and contains all the payment mechanisms that are present in the project. It also describes the transfer of risks between the client and the project company, and describes the Design & costruction requirements that exist for the project. Together with the project agreement, a shareholder agreement is also signed between the stakeholders describing the governance of the project.

2. Subcontracts: any and the operator. These contracts contain all the responsibilities to be exercised by the subcontractors, description of the work, risks transferred from the project company, security package that the subcontractors put up as collateral to ensure that their performance will be in accordance with the project and also describe the payment mechanism for the services rendered, including whether these payments are subject to deductions or inflation.
3. Financial contracts: Contracts between the borrower (usually the project company) and the lenders, also including hedging contracts and pledges, intended to create a security interest over equity interests and promissory notes owned by the borrowers, its parent and its subsidiaries.

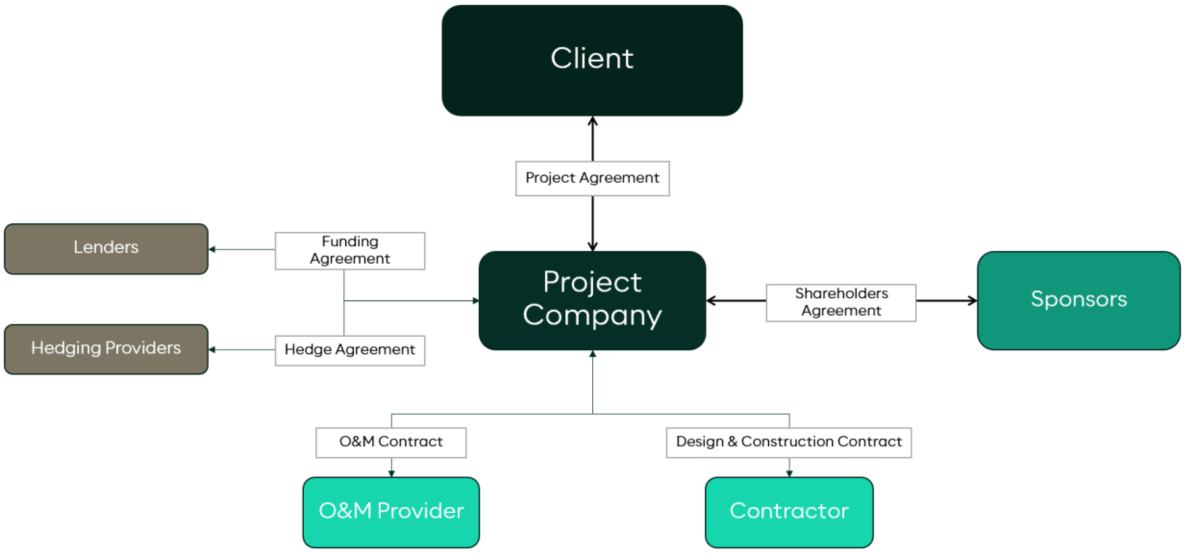


Figure 9 - PPP common contracts in a transaction. Personal Source

Finally, the following chart shows the normal cash flows you can find in a PPP organizational structure with an availability payment revenues scheme. In the following, in chronological order, we present how each of these cash flows comes into effect in the project.

During the construction period, the project company will fund the CAPEX costs, any operating costs during construction and financial costs (Senior debt interests, Arrangement fees and commitment fees) with Equity plus Senior debt. The gearing used in the project will depend on the risk that the project company will bear and the structure the company will put in place. Normally in project finance projects, gearing is maximized to obtain the highest return per equity invested in the project, although sometimes a balance can be found between return and deployment. In order to be able to mitigate the financial volatility on rates, the project company usually puts in place a hedging strategy to fix interests payment.

During operational phase, the client will start doing periodical payments to project co in order to:

1. The project company to pay all operational costs:
    - O&M costs
    - Maintenance Costs
    - Project Company costs
    - Insurance costs
    - Financial costs (e.g., Account fees, Security agent fees)
    - Other costs (e.g., taxes, audits, unexpected costs, audits)
2. The project company to repay the senior debt and pay any interests back to the Lenders
3. To repay any subordinated debt tranche the project could have in place
4. Fund any reserve account present in the project
5. Distribute the extra cash flow to the shareholders in form of Shareholder Loan, Dividends or an Upstream Loan.

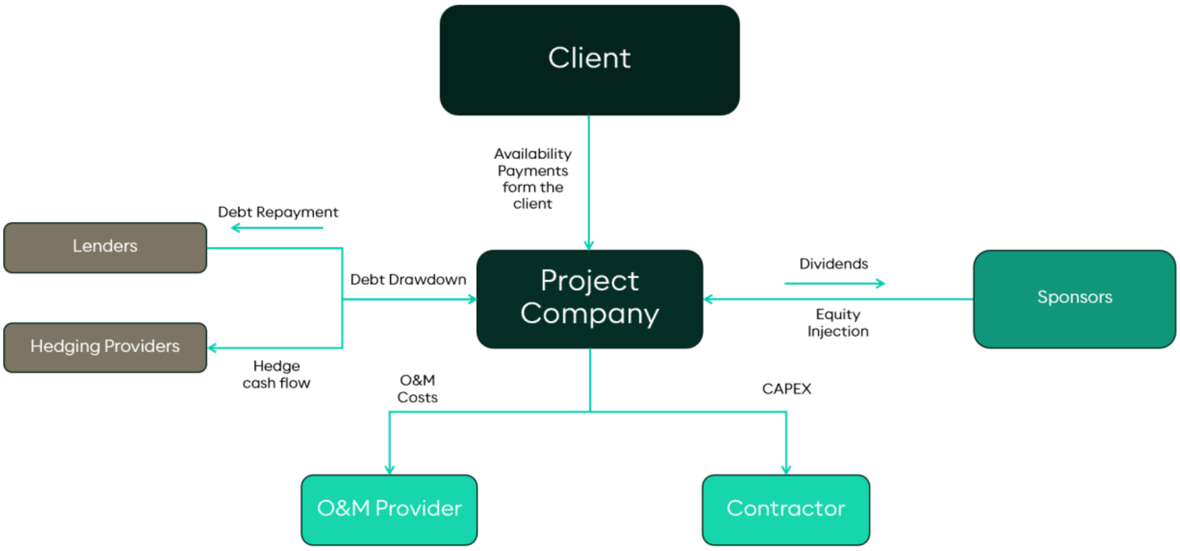


Figure 10 - Cash flows between actors in a PPP Project. Personal Source

Distributions to sponsors, in any form mentioned, are subject to the satisfaction of a cash flow statement defined in the financing contract and to the restrictions imposed by law, by accounting and by the Funders of the Project:

Legal/Accounting Restrictions		
Reduction of Equity to the legal minimum	Legal Reserve (annual allocation of 10% of Net Profit until 20% of share capital)	Dividends cannot be distributed if there has been a negative Net Profit in the year against which the dividends are backed against.
Carry forward of prior years' accumulated losses in the Balance Sheet	Dividends charged to the current year (interim dividends) are permitted subject to certain restrictions	Other statutory restrictions which have been agreed by the shareholders

Figure 11 - Legal & Accounting Restriction for distribution. Personal Source

PPP Restrictions			
Maximum leverage	Dividends are usually paid once a year, usually between March and August of the year (depends on the project terms)	The project must be into operation and all reserve accounts reserve accounts must be fully funded.	No Default
DSCR above a certain minimum minimum (figure depends on the project risk)	Minimum cash flow (certain number of months of O&M costs)	Equity must have been injected, Through SHL or Equity	In the case of SHL, there is normally a maximum interest rate to be paid. Check with the T&A advisor.

Figure 12 - PPP common restrictions to distribution. Personal Source

3. Risks in Infrastructure project

During the life of the infrastructure there are different phases of the project with different actors present and with different risks. Risk in an infrastructure project can be understood as the possibility that a negative event or impact will occur or that the results will be different from those anticipated by the project's actors. More specifically, risk is defined by the probability of the occurrence of an adverse event in the project and the magnitude of this event.

The situation of bearing a risk in a contractual structure does not only involve negative actions and situations. This can also be seen as an opportunity to obtain new benefits and to be able to take advantage of new situations that are posed to us collaterally by bearing a risk. This can be done by, for example, directly obtaining benefits from operating some part of an infrastructure, controlling a particular service or building the infrastructure itself in the first phase of its lifetime and that’s where some economies could be implemented in the project.

One of the biggest issue when we talk about risks that support an infrastructure project, developed with the PPP model, resides in its particular actors. A particular risk should be assigned to the part of the contractual structure that can best manage it. The issue in the bidding processes is that private developers, public administrations and private companies in the financial sector that develop projects, often assign risks to some participants that are not properly qualified to manage that risk but there exist an economic advantage, or that even that party is predisposed to bear a risk in order to submit an aggressive offer.

As a consequence of this problem, several years ago, the development of pre-established methods was started. One of them is developed by the Project Management Institute (PMI) which can be divided into four phases: identification, evaluation, response and documentation. The identification consists of detecting all the possible risks that may have a negative impact on the implementation of a project. The evaluation consists of classifying these previously identified risks with the probability of occurrence and the impact that they would generate. It is always necessary to analyze a project subjectively and not all the risks will impact in the same way on all the infrastructure or on all the geographical areas.

The response consists of the risk mitigation or elimination phase and documentation in the construction of a database to be able to continue evaluating these risks and to know the appropriate protocol to follow in the event that they are repeated. This technique has evolved and has been improved. Now, there exist many specific tools for each type of risk. The following is an overview of the risk management for transportation projects offered by the Washington State Department of Transportation in the United States of America [15]:

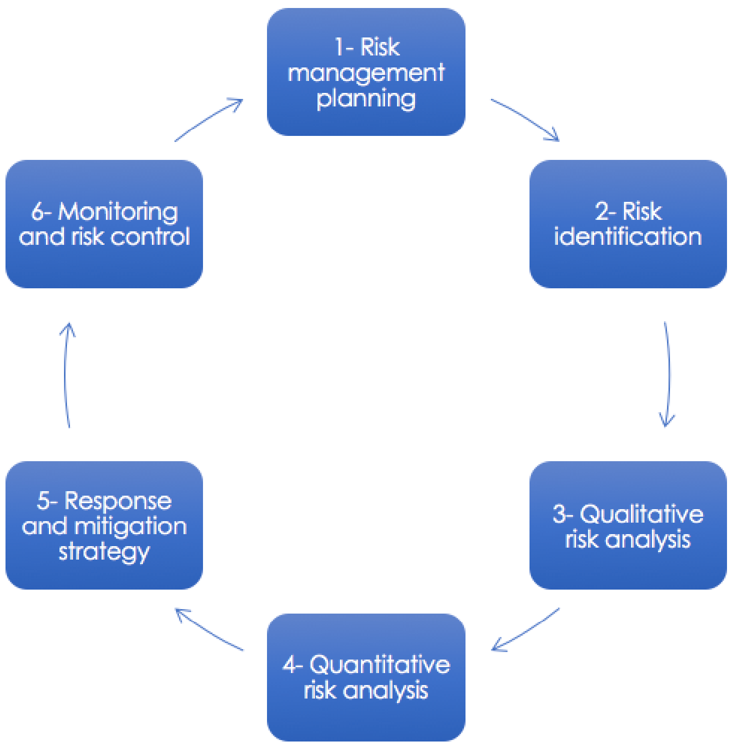


Figure 13 - Risk planning methodology. Source [15]

1- Risk Management Planning – Standard process that we could implement in similar projects in order to plan a risk strategy and methodology to describe risks throughout the life of the infrastructure. By preparing an early strategy we could transform the main risk of an infrastructure in opportunities for other actors in during the process.

2- Risk Identification. Identification of the main risks that a project could face. An analysis is performed by the same project team if is a minor project and expert help is hired in the case of a large project infrastructure.

In order to assess the importance of a risk, it is vital that a qualitative analysis and a quantitative analysis is undertake on each risk:

3- Qualitative Risk Analysis. A risk shouldn't be extremely destructive to be considered very harmful for a project. The evaluation of the probability of occurrence of the risks on large projects usually needs the help of external advise, but even in small projects the materialisation of several risks could put the project in danger.

4- Quantitative Risk Analysis. Thee numerical assessment of a risk is linked to the social and economic cost it may have on a project and an early analysis can help to prepare stakeholders to adopt realistic mitigation measures.

5- Response and Mitigation Strategy. Process of developing a risk response strategy. The aim is to increase and benefit from opportunities and to reduce threats.

6- Monitoring and Risk Control. Process of control and monitoring of the tasks that have been put in place to mitigate and eliminate risks.

Other documents used by other institutions follow a similar procedure in risk management. The Californian Department of transportation uses the following table to analyze the risk and put in place the best response. Mainly, you have to classify the risks into threats or opportunities and depends on that, you have different options to treat the risk:

Threats	Opportunities
Avoid. Risk can be avoided by eliminating the cause of the risk or by implementing the project in a different way. Not all risks can be avoided, in some cases this approach is expensive or time consuming. However, this response should be the first strategy considered.	**Take advantage**. This strategy aims to eliminate the uncertainty associated with a particular risk by making the opportunity happen. It is an aggressive response strategy, which is reserved for "golden opportunities" with a high probability of occurrence and high impact.
Transfer. It involves finding another party who is better able and willing to take responsibility for risk management should it occur. This strategy sometimes involves paying a premium and considering the cost-effectiveness for acceptance.	**Share**. Assign the opportunity of risk to the person best able to maximize the probability of occurrence, achieving greater benefits. Transferring threats and sharing opportunities are similar when using a third party.
Mitigate. Reduces the probability and/or impact of an adverse risk event within an acceptable threshold. Taking early action to mitigate a risk is often more effective than trying to repair the damage when the risk has occurred.	**Improve**. This response is intended to change the "size" of the positive risk. The opportunity is enhanced to increase the probability or impact of occurrence, so as to maximise project benefits.
Acceptance. This strategy is adopted when it is not possible or practical to respond to risks by other strategies. When the manager and the project team decide to accept a risk, they agree to take the risk if it occurs. A contingency plan, solution plan or contingency reserve can be developed for this eventuality.	

Figure 14 - Threats and opportunities. Source [16]

In some projects, certain factors play a vital role in financing them with the private sector. These factors include the macroeconomic situation of a country, procurement structure, financing sources, project characteristics, expected revenues, and risk distribution. These factors also determine if a project is bankable or not. For international projects with private sector funding, it is important to distribute responsibilities and risks to the party that can handle them best, whether public or private. The experience gained from PPP projects worldwide has established a strategy to distribute risks to avoid additional costs due to overvaluing risks. Political, financial, and legal risks are generally assumed by the government, while the private sector retains risks related to project design, construction, and operation.

4. Value for money.

The good distribution of these risks means that the risk should be assumed by the party that has the greatest capacity to manage them, either because of its experience in managing them or because of the availability of the resources necessary to mitigate and control them. To be able to distribute these risks, all the actors of the project must be aware of the existence of all the risks to which they are exposed in the project and be prepared to assume them, either in exchange for not managing other types of project risks or by receiving an appropriate premium based on: its cost, probability of occurrence and possible impact.

The optimal allocation of risks ensures the value for money of the project. VFM is one of the drivers of this type of contractual structure and it's the result of comparing the costs of a traditional project with the same project bid with a PPP structure.

On the part of the administration, this good allocation of risk is transformed into a great deal for society, obtaining through the realization of the project, a positive impact on it, for example by improving the transport capacity, by the improvement of energy consummation in cities, by improvement in health or by improvement in the management of some public service among other projects that are usually carried out under this contractual model; all this together with the elimination of the public risk usually managed by the administration. This is, together with cost optimization, the pillars of Value For Money. Here in the next figure we could see that VFM is all about risk allocation.

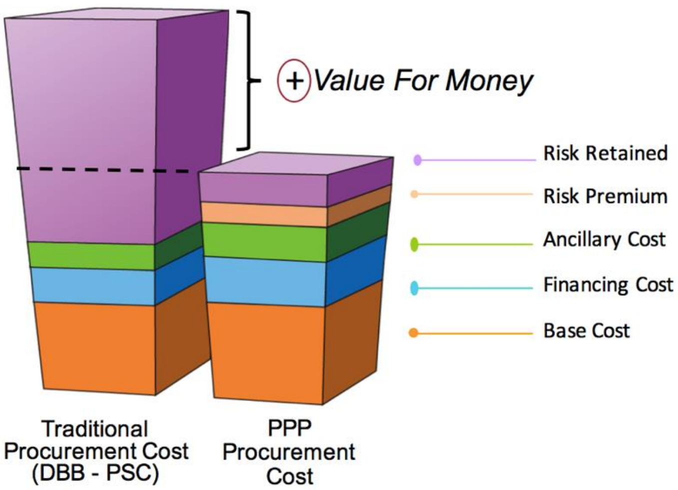


Figure 15 - Value for Money in Public-Private Partnerships. Source [17]

However, if we do not achieve an effective distribution of risks, the integrity of the project can be affected from the beginning to the end. Before closing the project, this distribution should be analyzed to avoid over costs and misunderstandings. Identifying good or bad risk distribution need not be a subjective task and must be addressed carefully. To achieve this, it is necessary for the people responsible to develop their professional criteria which, in turn, must be backed up by academic research and institutional experience.

5. Types of healthcare PPP solutions

The PPP model is particularly well adapted to hospital infrastructures as they are high priority projects for society and governments, where it is imperative that both clinical and non-clinical services are of high quality. The infrastructures require large capital injections, and these must meet outstanding levels of resilience. Furthermore, as they are energy-intensive infrastructures, they must be developed with ambitious energy and environmental targets, such as making the infrastructure net zero carbon emissions during operation.

With the PPP model, as we have previously mentioned, there exists a great degree of flexibility, and that is why each project can be perfectly adjusted to the needs of the public sector, as sometimes some have greater capacity than others and the private operator does not need to undertake all types of services, and only those that the authority cannot manage efficiently. Innovation in the sector is essential. Infrastructure progress to deliver higher quality services with reduced environmental impact and improved patient well-being can be achieved more easily with the research and competition that the private sector provides to the sector. These can be incorporated into new the new projects through high-level lessons learned.

Another thing that these models achieve is the long-term commitment of a private party, which must remain in the project in order to receive future availability payments and thus recover the investment. In addition, as the contracts are signed in the early stages of the project, even if this private party sells the asset, the next party entering the contractual structure must meet the same performance criteria to avoid deductions in the payment to be received in order to recover the investment in the project.

In the following section, three types of PPP healthcare models are presented, describing different ways of formalising this model between public and private parties, with the main difference being who undertakes the clinical services. All three models share some particularities, such as the collaboration between the public and private parties for the complete delivery of the healthcare service in the same asset and that this asset is owned by the correspondent Authority.

5.2. PPP Infrastructure model

This PPP model is the basic model on which most Helthcare PPP projects are based, where there is a private party responsible for design, construction, financing, operation and maintenance. These contracts typically run for 25-30 years, so that the private party can finance and operate over the long term. Clinical services are undertaken by the public party, but non-clinical services are the responsibility of the private party.

Figure 16 - Private party responsibilities in basic PPP model. Personal Source

These non-clinical services are often soft facility management services, which include e.g. cafeteria, laundry, administration, waste management and security among others. In a more complete scheme, the private part can also take over services such as laboratory or radiology. This model aims to increase the quality of the hospital's services. By awarding maintenance to a third party that does not have to deal with the delivery of clinical services, the efficiency in the delivery of non-clinical services and clinical support services can be increased, if these are included in the contractual structure.

With this model, public administrations can have access to private capital to develop large infrastructure projects and it also allows them to pay for the investment over a longer period of time and at the same time the infrastructure is amortized, which means that the public party would be paying directly for the services it offers to the public and ensures that there are no problems in the facility, as the private party is obliged to comply with performance KPIs. In addition, the private party gets an efficient structure where it can invest a large amount of capital, ensuring returns that will only be conditioned by the operational effectiveness of the capital, and will not be linked to clinical services or other KPIs that it cannot directly manage. The following organizational chart shows the contractual structure with the main services of each one.

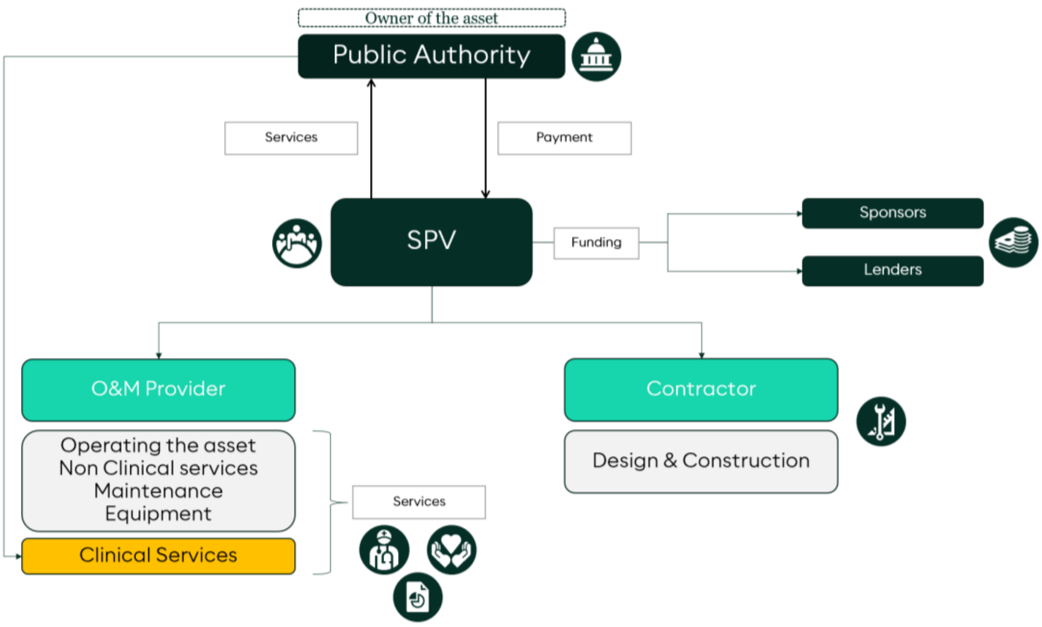


Figure 17 – Organisational structure and responsibilities in basic PPP model. Source [18]. Personal creation

5.3. Discrete Clinical Service model

In this model, the private party is contracted to deliver a range of specific clinical services e.g., clinical support services, special care services, laboratory services, radiology services. This light contractual model is used to increase the capacity of public administrations to deliver a range of services by contracting private third parties specialized in these services.

Figure 18 - Private party responsibilities in Discrete Clinical Service model. Personal Source

This private party must also finance any relevant actions or refurbishments to the healthcare asset in order to be able to undertake their services. The scope of the private party also usually includes the delivery of the necessary equipment and its maintenance or replacement. Finally, the hard maintenance of the infrastructure is also retained by the private party.

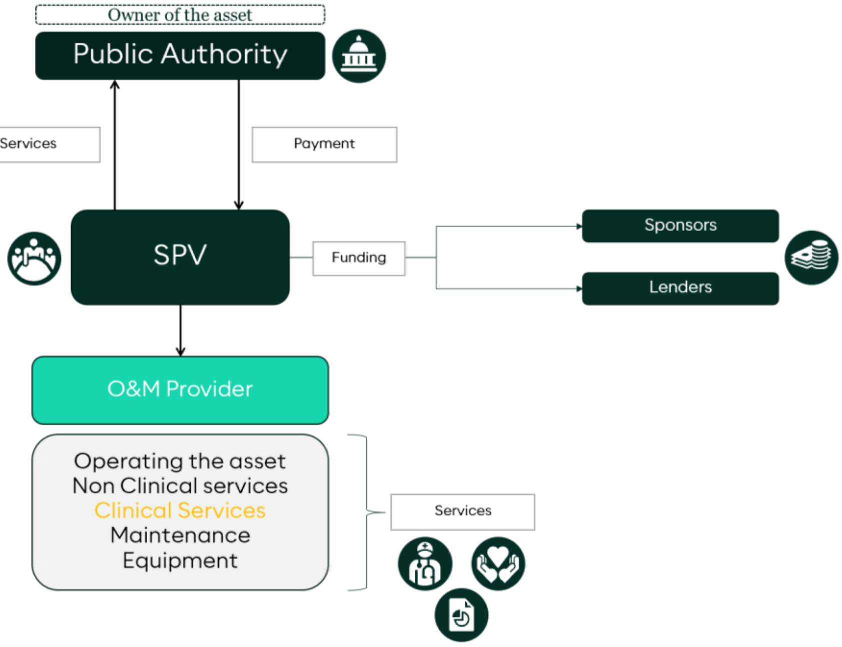
The main objectives of this contractual structure are to improve the management of specific clinical services and high demand services, to provide access to specific clinical services that the public party would not be able to provide on its own, and to mobilize the private party to get involved in the delivery of the services and to promote employment and competition, thus enabling the delivery of the services with adjusted cost and high quality.

This contractual system is increasingly used in developing countries and in areas where governments have limited staff or capacity to deliver specific services.

The Discrete Clinical Service model is typically for a duration of less than 10 years, shorter than the other two models presented. This is because the model secures free competition between private parties once the contract duration is over, thus allowing services to be re-tendered. This period is also in line with the lifecycle duration of the clinical equipment, so that each new operator can renew the clinical equipment when it enters the contract.

This contract would be on the limit of what is known as a PPP Project as the duration is shorter and the private operator does not usually have to contribute large amounts of capital investment. Another reason why these contracts might not be considered standard PPPs is risk sharing, as the private party retains the risk of demand for some of the clinical services it operates and also retains the risk of replacement of medical equipment, arguing for consideration as PPPs.

The following organizational chart shows the above contractual structure with the main services of each



one.

Figure 19 - Organisational structure and responsibilities in basic Discrete Clinical Service model. Source [18]. Personal creation

5.4. Integrated PPP Model

In the integrated model, the private party is contracted to design, build, finance, operate and deliver clinical services. This is the most complex system, where the private party has the greatest exposure to the project.

Figure 20 - Private party responsibilities in Integrated Model. Personal Source

It is a combination of the two systems mentioned above and aims to improve the quality and accessibility of the services offered in a healthcare facility, improve the overall management of the hospital, and take advantage of synergies between staff and infrastructure to deliver services more efficiently.

Like Infrastructure based PPP, this model is involved in the development of the project from its conception, so it can have a real impact on key decisions affecting the maintenance and operation of the asset, and thus deliver resilient and environmentally committed services and key energy targets set in the early stages of the project.

With the majority of services allocated in the private party, governments are taking advantage of the opportunity to internalize enhanced clinical service delivery and improve quality and access.

This system has been implemented in regions where the government has experience with PPPs, and can rely on private operators for the majority of services. It does not depend on the level of government incomes as we can see examples in Maseru, Lesotho the building of the" Queen 'Mamohato Memorial national referral hospital", first PPP of its kind in Africa and the first in a low-revenue country, and in Valencia, Spain referred to as the "Alzira model", that has been replicated in other 5 hospitals within the region.

In the Alzira model, they went a step further and got the private part to take over all primary care of patients, in the hospital and in the facility care centers in the district.

This involved lengthy negotiations at the political level because of the extensive responsibility transferred to the private sector, but has resulted in efficiencies between the facilities, a comprehensive approach to service delivery and an overall increase in quality.

The transfer of a hospital's clinical services must be taken into special consideration as it is a critical change that directly affects society, both patients and public health staff, civil servants, who see their public places reduced and enter into competition with the rest of the market for private places in these hospitals.

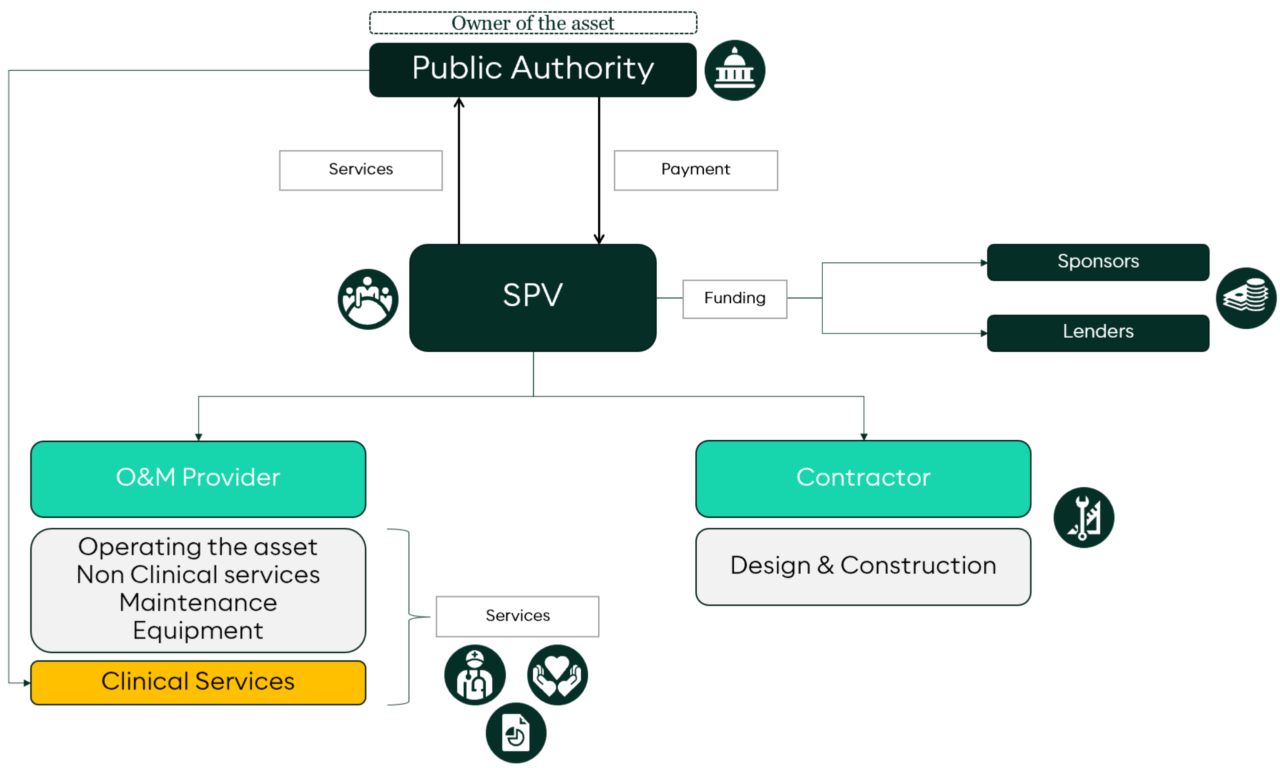


Figure 21 - Organisational structure and responsibilities in Integrated PPP model. Source [18]. Personal creation

5.5. Risk sharing between the three proposed models

Below is a table with a suggested risk allocation between the public and private parties for the three models presented. This allocation ensures that the risk is managed by the party that best controls it, so that it can be monitored and mitigated at all times. The four categories that have been defined are:

Types of risk	PPP Infrastructure model	Discrete Clinical Service model	Integrated PPP Model
Design risks			
Land acquisition and Planning	Public	Public	Public
Design	Private	Private	Private
Construction Risk			
Construction	Private	Private	Private
Cost overruns	Private	Private	Private
Completion delays	Private	Private	Private
Latent defects	Varies	Varies	Varies
General risks			
Force majeure	Shared	Shared	Shared
Changes in legislation/guidelines	Shared	Shared	Shared
Financing	Private	Private	Private
Operating risks			
Operating and maintenance costs	Private	Private	Private
Equipment	Varies	Private	Varies
Demand for Services	Public	Public	Varies
Labor and staff issues	Public	Shared	Private
Clinical performance	Public	Private	Shared

Figure 22 - Allocation of risks. Source [18]. Personal creation

6. Healthcare Decarbonization. State of art

The health care sector is leading the way to the net zero carbon economy in many counties, with new projects and actuations. It is crucial that the large and complex systems with high influence Identifying a route to net zero emissions. In the UK the NHS England aims to achieve net zero by 2050 [19]:

- For the carbon emissions NHS can control, they will reduce the emissions by 80% from 2028 to 2032.
- For the emission where NHS can influence, supply chain, subcontractors… NHS will reach net zero emission by 2045, and reduce by 80% from 2028 to 2032.

The English National Health Service is one became the first health system to include net zero ambition into their legislation.

A recent example of sustainable new healthcare infrastructure that has been promoted by NHS Orkney is Balfor Hospital in Orkney [20]. This is the first Scotland net zero carbon hospital. This facility has been delivered by Robertson with a cost of £65 million with sustainability as the main priority. The building is fully electric powered with air-to-water heat pumps generating hot water and heating. The building also accounts with 1200m2 of solar panels that reduce the dependency on the grid. The total are of the facility is 15 000 m2.

Figure 23 - Balfour Hospital. Source [20]

The procurement was launched with an specific message, that Orkney needed a rural hospital to cover medical needs and to pay attention to the community. The hospital was designed including people's needs first, with a view on sustainability, economy, and community.

Since the inception, the Balfour hospital has considered these principles. i.e., on construction phase, they have recruited up to 50 local people to enhance local economy; the construction materials they used to built the facility were available in the island, and this mitigated the risk of rely on external supply chain; the design of the facility took into account external landscape in order to reduce the impact on the environment and the materials and built form of the building and surrounding landscape, are simple, robust, easily sourced and maintained; all reflecting Orkney's heritage and ecology.

The operation of the projects will be done by Robertson Facilities Management for 25 years. This will enable us to create efficiencies on the management and operation of the project. In order to carry on impacting on the community, Robertson has integrated a community program to provide training, work experience, mentoring and support to the community for the following 25 years.

The hospital was awarded with the title of "Net Zero", first hospital in Scotland and a reference for the whole Healthcare decarbonization scheme.

The Balfour Hospital is a pioneer example of healthcare infrastructure Project but as we were mentioning, behind the project there is an institution already engaged with sustainability and resilience, that has clear targets and goals for the upcoming years to achieve the Net Zero carbon generation all over their healthcare business.

We have previously presented two global decarbonisation targets that governments have accepted to promote the reduction of carbon emissions by 2030 and to become completely carbon neutral by 2050. One campaign that is directly related to the healthcare projects is the Race to Zero campaign.

Race to Zero is a campaign organized by the United Nations that focuses on non-governmental actors, including private companies, cities, specific regions, financial institutions and educational institutions to take immediate action to reduce emissions by 2030 and deliver a healthier, fairer zero carbon world.

According to Health Care Without Harm, the campaign's healthcare partner, these are fourteen European healthcare providers participating in the Race to Zero campaign. Between them, they represent almost 900 hospitals and health centers.Capital Region of Denmark (Denmark)

Centre Hospitalier de Niort (France)

Evangelische Elisabeth Klinik (Germany)

Evangelisches Krankenhaus Hubertus (Germany)

Fachklinik Gaißach (Germany)

Krankenhaus Havelhöhe (Germany)

General Hospital of Syros (Greece)

Galician Health Service (Spain)

Hospital General La Mancha Centro (Spain)

Region Västra Götaland (Sweden)

Sussex Community NHS Foundation Trust (United Kingdom)

Manchester University NHS Foundation Trust (United Kingdom)

Newcastle upon Tyne Hospitals (United Kingdom)

NHS Highlands (United Kingdom)

These institutions should not only carry out actions on existing healthcare infrastructure, with the need to invest capital to carry out large lifecycle modifications and energy efficiency projects, but new infrastructure should be designed so that construction emits as few emissions as possible, and that during operation these assets are net zero carbon.

This presents an opportunity to implement business models that can be aligned with these zero carbon environmental targets. With the right structure, the PPP system could be developed contractually to achieve decarbonisation of Healthcare Facilities.

The PPP model appears to be able to incorporate all of these requirements from project conception through to operation. All stakeholders can benefit from the long-term approach and gain numerous economic and social efficiencies, as the programmes are developed over the life of the infrastructure and have a real impact.

Private sector expertise, continuous innovation and competitiveness in the sector can help to promote these infrastructures by meeting increasingly stringent requirements and promoting value for money at all stages of the project.

6.1. Other Net zero Carbon Buildings

The fact that infrastructure in the healthcare sector can be fully decarbonised is a positive sign, as all kinds of actions can be extrapolated to social infrastructure and other buildings with high energy consumption. In the same way, the healthcare sector should try to incorporate some of the energy efficiencies that have already been implemented in some net zero carbon certified buildings around the world [21].

Powerhouse Telemark, Porsgrunn, Norway

With its angular roof and glistening facade, this building has been conceived not only to operate with zero carbon emissions but also to offset the emissions generated after 60 years including its construction, demolition and the embodied-carbon of building materials.

Figure 24 - Powerhouse Telemark, Porsgrunn. Source [22].

The building has PV solar panels on the roof, generating 243,000 kilowatt-hours, enough to cover its own needs and offset some of the energy. Inside, heating and hot water are provided by heat pumps and onsite geothermal energy.

In the design of the infrastructure, the BREEAM system was used and achieved an "excellent" rating.

This building is designed to consume 70% less energy than other similar buildings, which is why it can cover its energy needs with its own generation. [22]

The Floating Office, Rotterdam, Netherlands

This building is designed by the architects "Powerhouse Company". It is conceived to be able to adapt to the climatic changes of the future, with a net zero carbon balance in the operation of the building. It is a floating building that is designed to adapt to different sea levels. The building is 1000m2.

At the design stage, it was awarded the BREEAM "Outstanding" certification, the highest category.

Figure 25 - The Floating Office, Rotterdam, Netherlands. Source [23]

It has some particularities that enhance its resilience and sustainability: it is built with a wooden structure that is fully recyclable and can be reused, it was assembled on-site and could be dismantled at any time to favour its reuse; solar panels on the roof produce enough energy to cover the needs of the building and to supply the remaining part; the harbour water is used in an integrated system to cool the building, thus reducing the need for conditioned air at the hottest time of the year [23].

In general, all buildings that have net zero carbon certifications tend to have some common characteristics:

- Reliance on renewable energy: A key factor to consider is that new buildings have to stop relying on the grid and have to produce their own energy with sustainability and green power generation, using solar PV, wind or biomass generation.
- Passive building design: Design is extremely important when conceiving a new infrastructure. In order to make the best use of natural resources, these buildings have in common large spaces open to natural light, including interior courtyards in order to generate the maximum possible perimeter exposure to natural light. Ventilation is also an important part of keeping the facility at the right temperature all year round, minimizing energy use.
- Effective management: the correct management of the infrastructure ensures that the right amount of heat, ventilation and light is generated in the building, avoiding overgeneration of energy and the corresponding waste. This minimizes carbon emissions and increases the efficiency of the building.
- Track performance: net zero certified buildings have a high capacity to measure emissions and collect data from the building for accurate calculation of emissions and carbon. To measure

emissions, IoT (Internet of Things) systems and sensors that measure everything from the temperature in each zone to air quality are often implemented. These sensors are automatic and provide reliable information to all project stakeholders for performance tracking.

- Maintenance approach: It is important from the design phase to think about the materials to be used and the maintenance/replacement they will need. Good foresight and proper daily maintenance can help to reduce the number of actions and equipment replacements that are associated with high carbon emissions.
- Recognition: In order to certify that the infrastructure is indeed net zero carbon, an internationally recognised certification such as BREEAM should be chosen.

All these common characteristics should be set at an early stage of the project and should be set up as requirements for the entire lifetime of the infrastructure. In the following, we will look at how the PPP system and the longterm approach to hospital infrastructure can help to meet these strict requirements, from the design phase through construction and operation. The important thing is that all project stakeholders share the same philosophy and that both the public and private parties focus on building a sustainable and resilient healthcare facility.

Chapter 3. Developing PPP contractual structure to achieve descarbonisation of Healthcare Facilities.

1. Introduction. Main drivers of PPP to achieve decarbonization.

In this chapter, we are going to go deeper into the characteristics of the PPP contractual system that can favour the decarbonisation of a healthcare facility over other procurement procedures. The main advantage is that all these particularities and flexibilities that this system offers must be negotiated with all the actors of the project before the signature of the contracts, the financial close and the beginning of the construction, or even in the same procurement when the competition between the different participants is taking place.

The early design involvement of all project participants helps to develop the project according to the needs of each one, for example, not only the constructor will be aware of the design, but also the operator, who is the person who will run the asset. This particularity is combined with the Design and construction Requirements that exist in the contracts with the client, and that must be complied with. These design and construction requirements focus on all aspects of construction and are also increasingly focused on technology and innovation requirements. Allowing all of these features to be set is very useful for healthcare facilities as high technology and monitoring requirements, although more expensive than other considerations, can be set in advance and must be met by all participants.

As a public process, there is always a competition between the pre-qualified participants to deliver a bid, and it is in this case that the PPP method also has a great added value, as the evaluation criteria chosen must correspond to the requirements of the project. It is not the same to evaluate an asset with economic criteria, as we are seeing in common public design and construction procurements, rather then involving quantitative variables combined with qualitative requirements such as environmental, quality, management, community benefits, legal and risk allocation or design requirements.

All these characteristics can be reflected in contracts, as contractual negotiation considers the whole life of the asset and better risk allocation between parties.

2. General Design Approach.

The early involvement in the design and construction stage of all the parties in Project Finance helps to define an infrastructure that satisfies Client, Shareholders, Subcontractors, and other Third Parties requirements. The healthcare sector benefits from this approach as there are significant important implications of the infrastructure in the subsequent operation, both in terms of facilitating the daily life of patients and healthcare staff, as well as the performance of the building itself.

In the following sections we are going to elaborate on the BREEAM certification, a sustainable construction certificate and the RIBA stages of design development during conception, designed and construction phases. Next figure shows the link between BREEAM "New Construction" (NC) assessment and certification stages and the RIBA Outline Plan of Work:

2.1. RIBA Stages

The RIBA (Royal Institute of British Architects) Plan of Work is a formal method of organizing a project from conception to operation. It describes the process of briefing, designing, constructing and operating building projects into eight stages and explains the stage outcomes, core tasks and information exchanges required at each stage. [24].

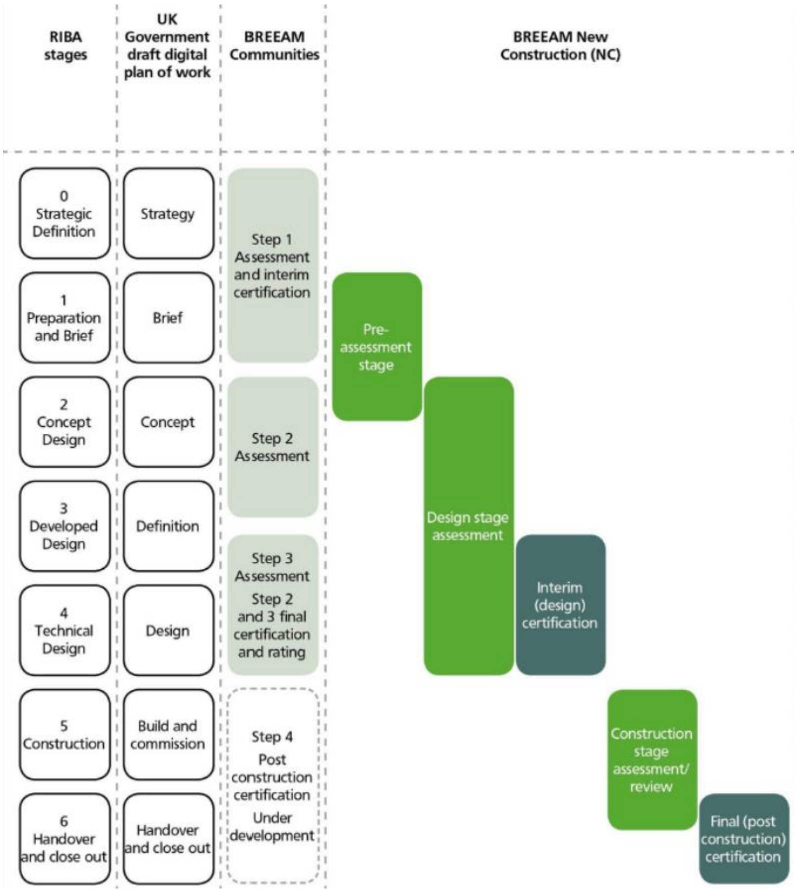


Figure 26 - Relation between BREEAM "New Construction" (NC) assessment and certification stages and the RIBA Outline Plan of Work. Source: Sustain Quality presentation

The RIBA Plan of Work is a neutral process that is not defined to support any particular type of procurement and can be used indifferently in classical competition systems as well as in project finance procurements. Internationally, other plans of work or roadmaps exist for design and construction, handover and beyond. These processes often have some differences with the RIBA system:

- Some international processes are indifferent to procurement and are only focused on the design of the asset.

- The different steps are not always clear, although other international systems divide the design phase into 2-4 stages, there is not always a comprehensive definition of what is required in each of the phases.
- A few processes incorporate from the outset the identification of the need for the construction of the project, as well as the possibility of using information from previous projects to develop the current project.
- Not all consider the infrastructure use phase and relate asset performance to the design and construction phase.

All these plans, even if they include different project phases, have a common goal, provide the project team with guidance to promote consistency from one phase to the next, and offer essential guidance to clients conducting their construction project.

In the following table we can see some examples of other methods that are used throughout the world and are accepted by law.

	Pre-Design		Design				Construction	Handover	In Use	End of Life
RIBA (UK)	0	1	2		3	4	5	6	7	
	Strategic Definition	Preparation and Brief	Concept Design	NOT USED	Developed Design	Technical Design	Construction	Handover & Close Out	In Use	NOT USED
ACE (Europe)	0	1	2.1	2.2	2.3	2.4	3		4	5
	Initiative	Initiation	Concept Design	Preliminary Design	Developed Design	Detailed Design	Construction	NOT USED	Building Use	End of Life
AIA (USA)			-		-	-	-			
	NOT USED	NOT USED	Schematic Design	NOT USED	Design Development	Construction Documents	Construction	NOT USED	NOT USED	NOT USED
APM (Global)	0	1	2		3	4	5	6	7	
	Strategy	Outcome Definition	Feasibility	NOT USED	Concept Design	Detailed Design	Delivery	Project Close	Benefits Realisation	NOT USED
Spain			-			-	-	-		
	NOT USED	NOT USED	Proyecto Básico	NOT USED	NOT USED	Proyecto de Ejecución	Dirección de Obra	Final de Obra	NOT USED	NOT USED

Figure 27 – International Plan of Work Methodologies. Source [24]

These processes are directly related to the development of public-private partnership projects, as a bid is usually structured so that all participants develop the technical design of the infrastructure at the same level of detail in order to have a competent bid and ensure that post being awarded with the project the winner cannot then have variations in the tendered price. The interesting point about the incorporation of working methodologies such as RIBA is that they already take into account minimum sustainability and decarbonisation standards, and the private developer must design the infrastructure to meet these requirements, otherwise he will not be able to obtain the necessary certification to bid or to build.

In the same week that the UK government announced legislation to make the country net zero emissions by 2050, RIBA joined the global environmental and climate emergency declaration. In September 2030, RIBA announced a new publication "RIBA 2030 Climate Challenge", which helps project designers and developers to improve the resilience and sustainability levels of projects by improving project KPIs and outcomes. This guide helps projects to report against the three basic pillars of sustainability on which PPP projects procurements are based, environmental, social and economic. These are the main UN Sustainable Design Goals Outcomes.

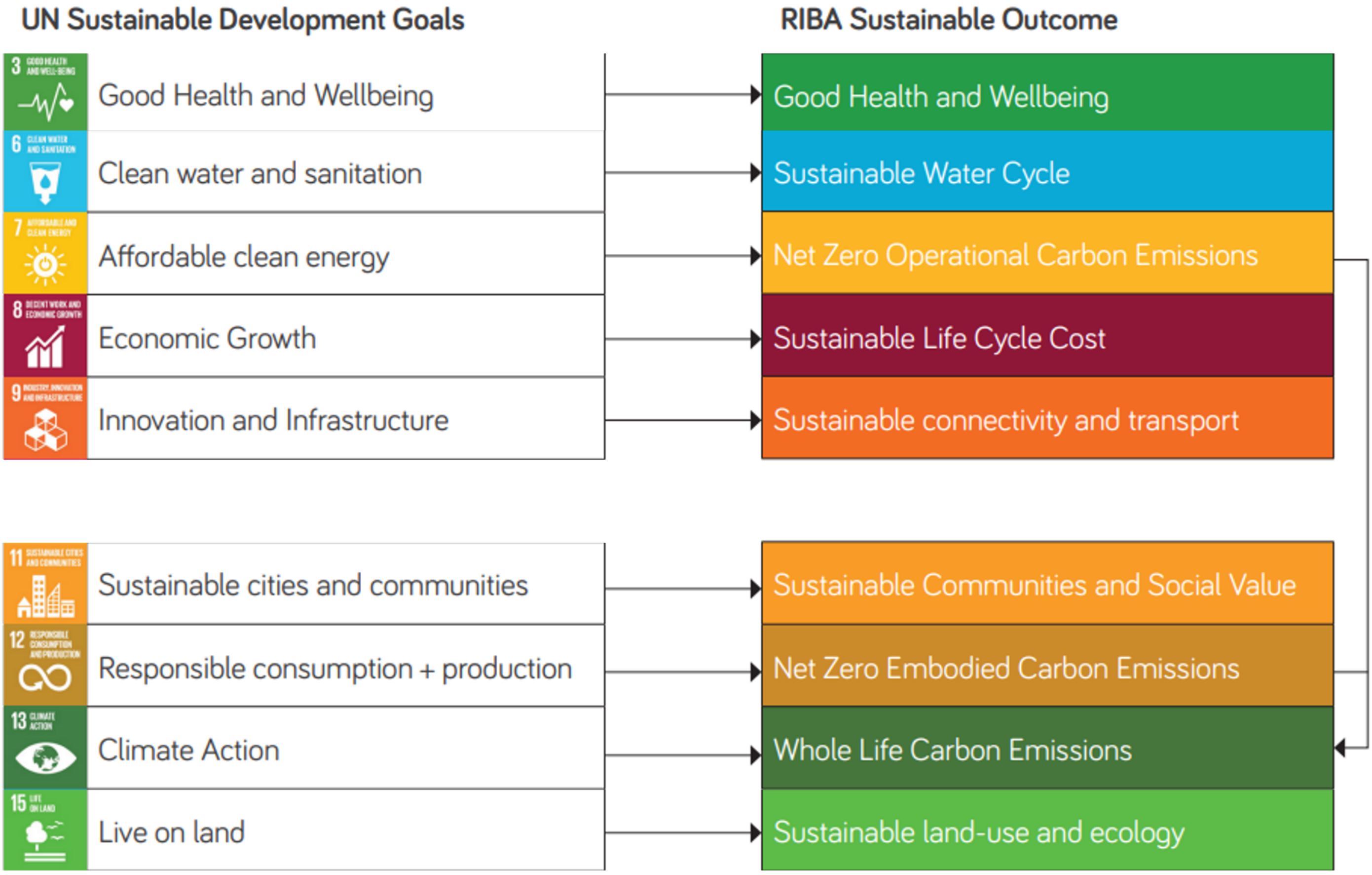


Figure 28 – SGG Outcomes of the RIBA plan of work. Source [25]

The healthcare sector impacts all three aspects of sustainability. Although the economic benefit of operators in the private sector can be seen to be related to the social benefit of access to these hospital services, healthcare also impacts the environment as they are located in large areas (urban and peri-urban) and are, as explained in chapter 1, one of the largest consumers of energy. The link between the environmental and social pillars is demonstrated by the deterioration of patients' health caused by the pollution to which hospitals and their emissions contribute.

It is essential that hospitals cut their carbon footprints but this cannot impact on the quality of hospital services, the resilience of the health system, accessibility for patients or excessive increase of construction and maintenance costs.

By applying a specific methodology such as RIBA, we are able to obtain from the inception of the project which are the main project outcomes that we have to measure, evaluate, analyse and monitor, to verify that the hospital, designed to meet net-zero carbon requirements.

The PPP system helps to ensure that these consumption and emission targets can be set from the start of the project for the construction and operation phases of the project and that, as explained later in this paper, penalties for the private parts of the project can be included in the pre-determined fees. The dialogue that often takes place in the procurement phase helps to align commercial, environmental and social outcomes between the private and public parties, enabling the development of a high-impact project with tangible benefits for society.

2.2. BREEAM assessment

The BREEAM (Building Research Establishment Environmental Assessment Method) is a UK certification that measures performance of a building from an environmental perspective. In order to get the certificate, an expert will measure and assess the following criteria on your building.

- energy management;
- the level of pollution in buildings;
- water management
- waste recovery;
- the use of innovative processes;
- people management;
- access to sustainable transport;
- health and well-being of residents.

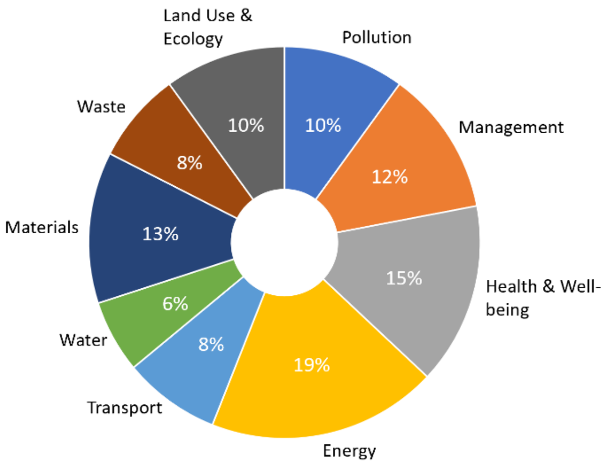


Figure 29 - Breakdown of BREEAM measurements. Source [26]

Analyzing the criteria, this certificate is not only focused on objective aspects related to environment and performance but also has a human aspect, which makes it suitable for the design of social infrastructure such as healthcare facilities, as the need for resilience, well-being of patients and medical staff are important elements of the development.

There exist some other certifications to valorize the environmental performance of a building, like the HQE (Haute Qualité Environnementale), but it is only recognise in France. However, the BREEAM assessment is already accepted in more than eighty counties. The BREEAM certificate is an international standard in bids and design procurements that intends to achieve an environmental engineering and architecture.

The BREEAM 2018 rating benchmarks for Construction projects stands for:

Table 1 - BREEAM Rating. Source [26]

Unclassified	Pass	Good	Very Good	Excellent	Outstanding
<30	≥30	≥45	≥55	≥70	≥85

Usually in PPP procurements, participants' designs will be expected to achieve, as minimum, an “Excellent" BREEAM rating for the building, when assessed against BREEAM New Construction, Non-Domestic Buildings, the reference for new infrastructure buildings. The evaluation methodology can also include reference to the ambition of “Outstanding” level of performance. The outstanding criteria should come with the client’s approval, because to reach these quality standards, the project requires a greater economic investment, due to the incorporation of innovative solutions and outstanding materials.

The BREEAM process is present throughout the design and construction period, and in order to have an assessment, it also analyses the operating period. Due to these characteristics, the BREAAM is an adequate certification to include in the PPP procurement, that goes from the very beginning of the project conception with a long-term vision for the operation phase.

To facilitate compliance and give comfort to the Client, at the end of the construction a verification and completion testing could be undertaken by an independent tester who must be satisfied that the works are compliant with the energy efficiency requirements set out in the Project Documentation, prior to the issuing of any certificate of completion.

As per the requirements mentioned, in order to obtain the Certificate of Completion of the facility, the independent tester must be satisfied that the facilities demonstrate compliance with the energy performance requirements (which will essentially be the greater of a BREEAM (2018) Excellent level of performance including, in most of the PPP cases, the reduction of CO2 emissions and the commitments bid by the Project Company in the Compliance with its energy proposals at procurement stage.

2.3. Carbon Neutrality target. Construction and operation. Embodied carbon

In order to ensure robust performance throughout the life cycle of a healthcare facility, a Whole Life Carbon (WLC) approach should be considered, defined as [27]:

Whole Life-Cycle Carbon (WLC) emissions are the carbon emissions resulting from the. construction and the use of a building over its entire life, including its demolition and. disposal.

This assessment calculates the operational carbon emissions for the development from energy use, as well as its upfront and embodied carbon emissions, i.e. those associated with raw material extraction, manufacture and transport of building materials, construction and the emissions associated with maintenance, repair and replacement as well as dismantling, demolition and eventual material disposal.

Carbon emissions from operational phase of an infrastructure has been the subject of regulation, targets and requirements for some time, and has historically been the primary focus of reducing the impact of infrastructure projects.

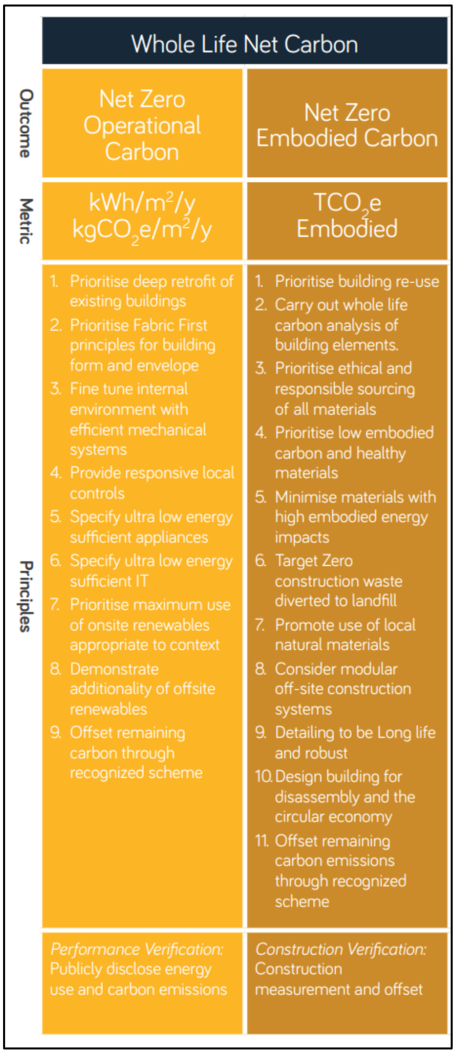


Figure 30 - Whole Life Net Carbon Outcomes explanation. Source [24]

This focus has been lately expanded to include carbon emission associated with construction materials, denominated Embodied Carbon.

40-50% of the total carbon emissions for buildings over their lifetime are caused by the embodied carbon with increasing energy efficiency within buildings and an increasingly decarbonized electricity supply building operational carbon emission are being acknowledged to be rapidly reducing as this occurs the significance of embodied carbon emissions increases and the potential for reduction of overall carbon emissions through structural design choice and material selection becomes greater [28].

Carbon dioxide reduction is achieved by minimising the amount of new or recycled materials used in construction and maximising reuse or recycling (reducing waste) wherever feasible. The frequency of component replacement also determines the carbon footprint, which is why emphasis is placed on life cycle assessment.

The RICS professional statement: "Whole Life Carbon Assessment (WLC) for the Build Environment" [29], released in 2017, seeks to standardize WLC assessment and enhance consistency in outputs by providing guidance on implementing the broad appraisal methodology set out in the section: Sustainability of Construction Works. The Framework proposed a methodology for achieving zero carbon throughout the lifetime of an infrastructure. It sets out two pathways; net zero carbon in construction (embodied) and operation.

The methodology 'Net zero carbon in construction' requires the measure of the carbon emissions at the end of the construction process in order to calculate the whole life carbon assessment and set up a offset strategy to get to the net zero carbon objective. Net zero carbon for both construction and operation is a priority for the framework. The framework suggests the following approach to delivering net zero development:

Reduce Construction Impacts

- A whole life carbon assessment should be undertaken and disclosed for all construction projects to drive carbon reductions.
- The embodied carbon impacts from the product and construction stages should be measured and offset at practical completion.

Reduce Operational Energy Use

- Reductions in energy demand and consumption should be prioritised over all other measures.
- In-use energy consumption should be calculated and publicly disclosed on an annual basis.

Increase Renewable Energy Supply

- On-site renewable energy source should be prioritised.
- Off-site renewables should demonstrate additionality.

Offset Any Remaining Carbon

- Any remaining carbon should be offset using a recognised offsetting framework.
- The number of offsets used should be publicly disclosed.

The definitions from the UKGBC framework [30] for construction and operation area as follows:

- Net zero in construction – *"when the amount of carbon emissions associated with the building's product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy".*
- Net zero in operation – *"when the amount of carbon emissions associated with the buildings operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and power from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset".*

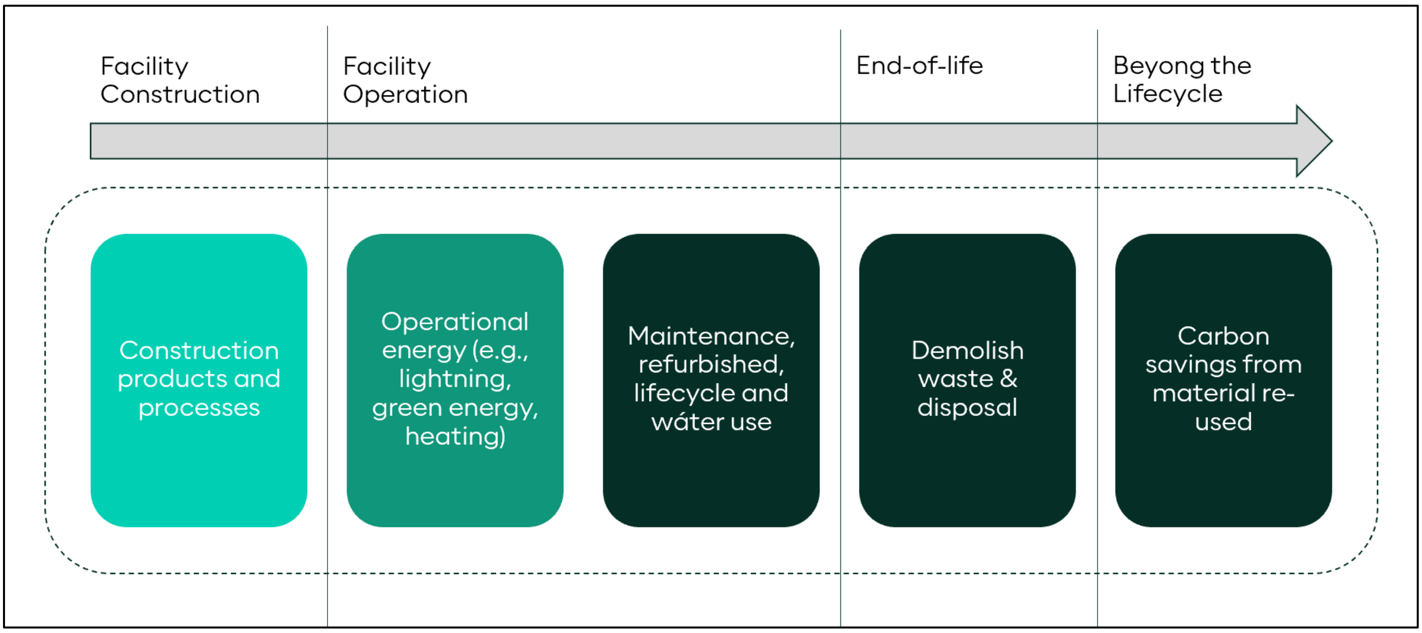


Figure 31 – Carbon implication throughout the Life of a Healthcare Facility. Personal source

UKGBC also has a new guideline regarding procurements and offsetting the energy to get to the net zero carbon goal during the whole life off the asset. The offsetting and procurement guidance should be taken into account in the conception stage in all different building types, and we could also implement this strategy in the healthcare sector facilities with different, sizes, and ownership scopes where annual public disclosure of energy use, generation and carbon offsets is possible [30].

Any building wishing to claim alignment with the Net Zero Carbon buildings framework definition, either for construction or operation, must comply with the renewable procurement and offsetting guidance. As part of this baseline report indicative routes to net zero carbon have been proposed, which align with this guidance.

The net embodied carbon dioxide figure of a building can be improved by avoiding over-specifying materials and maximising the lifetime of the materials already selected [31]. There are several options:

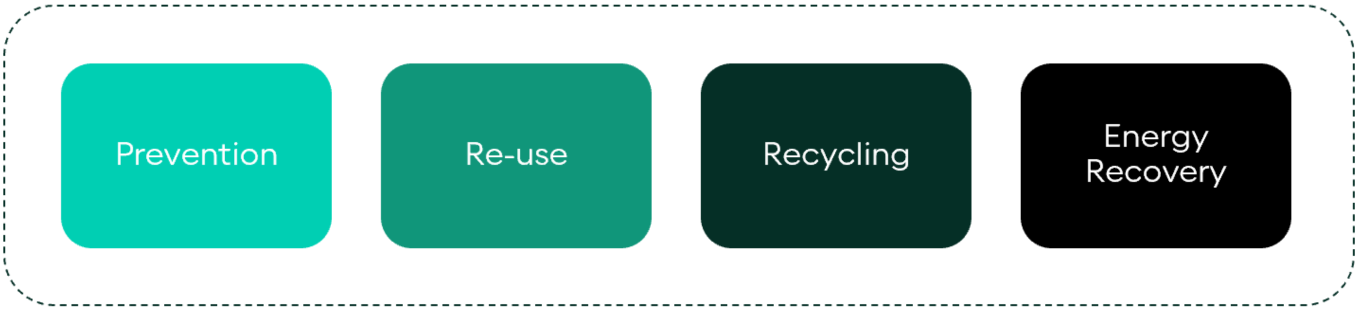


Figure 32 – Actions to reduce the embodied carbon in a building. [31]

- Prevention. A design philosophy based on the idea of avoiding the overuse of materials, e.g. by using structural repetition.
- Reuse. Reuse of a component in an application of equal quality or value to the original, e.g. a brick reused as a brick.
- Recycling. Recovery and reworking of a used material into a component of equal quality to the original, e.g. structural steel melted and reformed for use as structural steel.
- Energy recovery and other types of recovery. For example, using waste materials as fuel or as feedstock for composting.

The role of the design team is to specify which products and materials meet the sustainability and cost objectives. The role of the builder is to add value on the engineering side and to organise the various aspects of the procurement process at the construction site.

Responsible suppliers consider the full life cycle of materials and their impact on surrounding communities, as well as the carbon footprint. The focus here is on the impact of purchased materials and their impact on climate change. Suppliers need to be able to identify the source of key components and therefore the ones under which they are sourced. the raw materials were extracted and the material produced. While it is important to know the origins of the components, it is also important to know that any 'added value' that is added to the supply chain must also be supply chain must also be committed to sustainability. This can be determined by environmental management system certifications and performance records can be also checked against [31].

The environmental guidelines to be followed in the construction phase should be specified in the tender documents. Some examples are shown below:

1- In order to promote innovation, specify materials and equipment based on performance.
2- Use recycled materials.

3- As far as possible, use local and regional materials.

4- Use local labour and subcontractors as far as possible.

5- Use rapidly renewable, sustainable materials, e.g. local timber.

6- Select adhesives and wood-based products with limits on volatile organic compounds

7- Use new materials with a low carbon footprint.

Protection against obsolescence is about anticipating the changes that the building will experience during its lifetime. The ease of separating the structure from the building envelope, the building services and the spatial plan are the services of the building and the spatial plan are at the heart of a simple and effective protection that isthat is simple and cost-effective. that is simple and cost-effective.

The concept of slack adjustment envisages the separation of the elements of a building according to life span, so that if several elements are attached to each other, the one with the shortest life span does not compromise others with the shortest life span. does not compromise others with a longer service life. Typically, the services of a building are expected to last about 15-25 years; the glazing, cladding and façade, approximately 20-30 years; the structure and foundations more than 50 years [31].

In order to anticipate that a building will be flexible in the future, it is necessary to consider possible changes in the use of existing spaces. These will be reflected in changes in dimensions and possible increases in operational loads (live loads). There may also be special requirements associated with the installation of new equipment, i.e. new opening of services and limitations on vibration levels. The following is a summary of the issues to be considered:

- load
- light
- floor to ceiling height (prop)
- vibration and other service requirements
- separation of services, structure and finishes ("snug fit")
- provisions for exposure and alteration of structure
- possibility for extension/extension, especially in vertical direction
- provision for openings for changes in circulation and services
- ease of maintenance and durability
- timeless building envelope
- reconfiguration of the interior layout, e.g. adoption of a modular plan.

Anticipating full flexibility for the future is neither cost-effective nor efficient, in terms of carbon footprint. A balanced judgement is required. For example, if concrete block masonry is used in non-load-bearing partitions, some of the partitions could be made load-bearing to minimize total material use. However, the addition of load-bearing walls reduces the flexibility of the structure with respect to possible changes, and is therefore usually not in line with the philosophy of "protection against obsolescence".

3. Digital solution to deliver sustainability and care

Smart health facilities will achieve greater efficiency in the facility by conserving resources, lowering costs, increasing efficiency in operations and reducing carbon emissions.

The opportunity to design a smart healthcare facility with an end-to-end focus in a PPP project favours the implementation of solutions that focus on improving patient care while delivering sustainability and resilience. The contractor is in continuous contact with the service provider, and together, through previous experience, customer requirements and private sector innovation, they develop smart building techniques to achieve these objectives.

A new healthcare facility needs to have a flexible core infrastructure, with a smart buildings infrastructure that allows the overlaid patient care needs to change and update as required during the life of the Hospital, including green solutions and environmental care. The core Infrastructure directly supports the requirements for a digital philosophy of allowing both the building and clinical digital functions to support the Hospital's requirements and ultimately the patient experience. Objectives that need to be achieved jointly between the building construction and the clinical services in all healthcare facilities include [Company information]:

- Creating straightforward digital access to the client, enabling patients and carers to manage their healthcare needs.
- Enabling clinicians to access and interact with patient records wherever they are.
- Decision Support and artificial intelligence (AI) to enable application of best practice and standardisation of care.
- Use predictive techniques to better understand the population and therefore ensuring the hospital and trust is changing to meet the changing demand, including energy demands and sustainability in operations
- Reduce administration burden.
- Be able to effectively measure healthcare facility consumption and anomalies.

Smart technology will deliver substantial return on investment by providing insights which can be used by the service provider teams to improve the performance of the building, delivered by smart buildings examples include:

- Occupancy sensing gives visibility on how spaces and beds are used, reducing the needs when spaces are not in used, providing energy efficiencies. Cleaning workflows and HVAC (Heating, ventilation, and air conditioning) strategies are optimised based on usage or room bookings.
- Digital work orders allow patients or staff the ability to quickly place and view maintenance requests, improving response time.
- A central software layer will enhance the integration of all building systems, examples include building management system solutions, Security, Lighting and footfall sensing.

Below are some key strategic pillars that the developers should be focused on, and that procurements should take into considerations when evaluating different offers, as the smart digital solutions will enable the project to perform with controlled emissions, sustainability and resilience [Company information]:

Patient and Staff Experience – The patient and staff experience should extend beyond the healthcare facilities with patient engagement starting and finishing electronically from home to continue monitoring them. Artificial Intelligence (AI) and smart building solutions are baked into the design of the building to support the clinical delivery such as monitoring people in rooms and visitor tracking.

Digital Information Systems – The Client should have a wide range of systems that focus on both clinical activities as well as corporate systems. A digital information system will aid with the reduction of the onsite footprint of the data center, moving the modern services towards to the cloud.

Smart Buildings and User Personas – New healthcare facilities have a unique opportunity to embrace technology and create smart spaces that revolutionize the operational model and deliver the next era of highly adaptable patient-focused care. A Smart Building should have:

- Flexible and Open Infrastructure
- Full Integration of Business Packages: Including medical and operational
- Mobile and Accessible Data: Give patients and staff access to information they need across multiple devices and locations.

Core Infrastructure – The developers should create a fully coordinated, flexible passive infrastructure, ensuring the structured cabling system is designed with flexibility, diversity and reliability, with future requirements embedded. Creating a common digital platform that will underpin the healthcare systems and patient and staff experience, ensuring it will seamlessly integrate with the healthcare facility new network.

Innovation in a digital solution will provide a sustainable operation by using the available databases and software. Databases will provide information on the life-cycle cost of materials in terms of energy or carbon dioxide. Carbon dioxide will be a constraint on design; specifications will be based on performance rather than a prescriptive approach, to allow the necessary flexibility.

Within the PPP procurement, organizations can form partnerships and alliances both within and across industries, including contractors, service providers, public authorities ando other private developers. This approach can provide access to the expertise, data, capabilities, experience, investment, and scale that a single organization might lack. No single health system, whether public or private, possesses a complete set of digital transformation tools. While technology giants have the necessary tools, they often lack deep knowledge of the healthcare industry.

By broadening the concept of partnering beyond the traditional healthcare ecosystem, including disruptive startups, and private equity/venture capital firms, organizations can unlock opportunities for cost savings, operational efficiencies, improved care access and affordability, strengthened data security and cyber controls, and clinical innovation, leading to improved population health outcomes, maximising sustainability and minimizing carbon emissions and environmental impacts.

4. Evaluation criteria

The following section represents a key pillar of the PPP system's approach to the development of environmentally and socially sustainable projects. Through the analysis of the common evaluation systems we will be able to see whether a change in the way the preferred bidder is chosen can really incentivise participants to deliver competitive bids that include ambitious targets for environmental impact reduction and carbon footprint reduction, acting from the beginning of the conception to the end of the concession.

Depending on the size of the project, the project evaluation method may vary, as the client's priorities change. Current bid evaluation methods can be: simple scoring method evaluation, net present value method, multi-criteria analysis, decision analysis technique and combined methods. In small projects, simpler tendering and evaluation processes are often used, where the simple evaluation method can be used, with pre-defined criteria that all bids are checked for compliance, and the bidder with the highest score is awarded the contract.

For projects where the technical solution is not very relevant, the net present value method can be relied upon, as it directly compares the cost of one solution against another.

For larger projects, multi-criteria evaluation methods are often used, to take into account each of the factors in a complex project, such as technical solution, social impact or economic cost. Different countries and clients may use different evaluation techniques, for example, the UK combines the net present value method with multi-criteria evaluation, both in the Project Finance Initiative (PFI) model and in the Mutual Investment Model recently used in the Wales region.

Public-Private Partnership projects often represent large infrastructure projects that can have a high impact on the environment and the social environment. This is why the analysis of projects by the net present value of the customer's availability payments has to be taken into account but should not be the only critical determining factor in the decision making process.

What the client is looking for with the privatization of part of the services of a hospital, for example, is the improvement of the service quality of a clinical aspect, routine maintenance or lifecycle maintenance over the life of the infrastructure. This is why it is not only possible to use a cost evaluation system, as this would leave out the qualitative aspect of why the client may have chosen to tender a project under the PPP method. A cost-benefit analysis may be the best solution in such cases.

When evaluating bids, it is important to have established in advance the main criteria against which a comparison between the competing bids will be made. The figure below provides a list of a wide variety of evaluation criteria classified into four categories: financial; technical; safety, health and environment; and management. In many cases it is desirable to assign weights that reflect the relative importance of each criterion or set of criteria or categories.

Category	Principal Criteria
Financial	- Financial solution - Net present value - Proposed tariff/toll and adjustment mechanism - Proposed construction, operation and maintenance costs - Internal rate of return - Financial robustness of the company - Investment programme - Concession period - Proposed risk capital - Proposed financial commitments of shareholders
Technical	- Qualifications and experience of design and construction - Compliance with client requirements - Contractors and subcontractors - Compliance with design requirements - Construction programme - Maintenance scheme - Quality assurance and quality management system
Safety, health and environment	- Compliance with laws and regulations - Environmental impact mitigation proposal - Air and water pollution control - Environmental performance record - Protection of cultural and archaeological assets - Occupational safety and health proposal
Management	- Project management skills - Management qualifications and experience - Coordination system within the consortium - Leadership and allocation of responsibilities within the consortium - Working relationships between participants

Figure 33 - Principal evaluation criteria description. Source [32]

In the case of PPP projects, it is important that the client reflects on the objectives it wants to achieve and what criteria it wants to weigh differently. The procurement documents should contain all this information so that bidders can prepare their bids accordingly. In the case of health sector infrastructures, it is essential that criteria beyond economic ones are considered. All the above-mentioned criteria are of great importance when creating a healthcare project, but in order to achieve a sustainable infrastructure, respectful with the environment and with the necessary technical characteristics to meet the minimum requirements of sustainability, the technical part of the evaluation must be overweighted, even above the economic part.

In the following section, we will make a proposal for the economic evaluation of tenders in order to safeguard the economic interests of the client and to guarantee a high competitiveness for the remaining qualitative part.

In healthcare project procurements, qualitative criteria should be implemented to accompany the quantitative part in the evaluation. The aim is to develop a fair evaluation system to guarantee the competitiveness between the participants in order to provide the client with an affordable solution and to overweight the technical part so that sustainable requirements and targets with zero carbon emissions goals can gain importance and must be fulfilled in order to avoid a definite loss of points.

We have recently seen in the market different weights for the quantitative part of the total offer evaluation. Depending on the type of infrastructure, government affordability for the project or the level of innovation aimed for the project, we can see a wide range of % in the market. In order to focus our research considering a Healthcare facility, we can look at the current MIM (Mutual Investment Model) developed in United Kingdom, an innovative model to invest in economic, social and transportation infrastructure. Some features of this model that make it ideal for comparison with our study topic of Health-care facilities and carbon reduction, both in the construction and operation phases are [33]:

- Welsh Government can decide to invest in the project company up to a fix percentage before the closing date;
- There is a focus on enhancing local communities and Community benefits proposals are scored and required;
- Revenues by the project company come from fix payments from the Authority that will cover cost of construction, maintenance and financing the project.
- MIM scheme goal with social infrastructure has high environmental standards.
- Long Term commitment to partnership
- Ability to raise finance and identify the most appropriate form of funding.
- Ability to manage complex supply chains with different subcontractors and third parties.

The MIM model is a benchmark in the Healthcare sector as it is a model with a clear risk-sharing approach based on the fundamentals of PPP projects. It is also a bankable model, as all three projects that have been developed have been awarded. In the case of the A465 road widening project "A465 Heads of the Valleys Dualling Abergavenny to Hirwaun - Sections 5 (Dowlais to A470) and 6 (A470 to Hirwaun) Project" and "Welsh School Partnership" have already reached financial close and are in the process of construction, and in the case of the new hospital "Velindre Cancer centre", the tender has already been carried out and awarded, and the financial closing is being prepared. These projects have been implemented in close dialogue with the authorities, which has allowed the construction and operational risks to be assessed and shared between the private and public sectors. In these projects, the share of the price evaluation was different [Company information]:

Table 2 – Weighting of the qualitative and quantitative evaluation. Source [Company Information]

Project	Qualitative Evaluation	Quantitative Evaluation
A465	55%	45%
WEP	70%	30%
Velindre Cancer Centre	70%	30%

We can see that in the case of the A465, the economic evaluation had a higher weight in the final decision, this is due to the fact that it is an infrastructure with less social exposure and an operation without excessive energy consumption. In the other two cases, the WEP model and the Velindre Cancer Centre, correspond to social infrastructure examples and are facilities that need high reliance and innovative technical solutions in order to reach zero carbon targets over the life of the infrastructure. To continue with the analysis of the bid evaluation, we will take the following distribution as the optimal solution:

Table 3 - Selection criteria chosen for the study.

Scoring criteria	Qualitative Evaluation	Quantitative Evaluation
Healthcare Infrastructure PPP	70%	30%

4.1. Price Evaluation

In the environment of healthcare projects structured with PPP, the usual solution is to size an availability payment that covers the costs of the project, including the debt repayment and the return that the shareholder wishes to obtain or has tendered for in that period.

To evaluate the bids, the method typically used is the Net Present Value (NPV) of the availability periods over the life of the project. This allows an assessment to be made in the present of the cash flows that the client must deploy to pay for the infrastructure construction and operation during the whole life of the Project. The discount factor used is related to the cost of capital and risk of the project, and it is the customer who has to provide the number in the procurement documents.

The NPV formula for a stream of cash flows is:

$$NPV = \sum_{t=0}^{n} \frac{ASP_n}{(1+i)^t}$$

ASP_n	Annual Service Payment
i	discount rate, or desired rate of return
t	number of time periods that will be calculated

For the evaluation of the price score, a methodology used in the MIM model has been to compare the highest bid with the other bids, and to award the highest bid the maximum number of points, deducting the points of the other bidders.

$$Price\ Score = 30\% - \left(3\ x\ \frac{Participant\ NPV\ Solution - Lowest\ NPV\ Solution}{\text{Lowest NPV Solution}}\right) \text{x } 30\%$$

A particularity of this method is the weighting given to the percentage of points lost. We have carried out an analysis of the suitability of this multiplier, and whether it is too strict to disregard the qualitative offer.

Appendix 1 – Price Factor Analysis
$Price\ Score = 30\% - \left(1\ x\ \frac{Participant\ NPV\ Solution - Lowest\ NPV\ Solution}{\text{Lowest NPV Solution}}\right) \text{x } 30\%$
$Price\ Score = 30\% - \left(2\ x\ \frac{Participant\ NPV\ Solution - Lowest\ NPV\ Solution}{\text{Lowest NPV Solution}}\right) \text{x } 30\%$
$Price\ Score = 30\% - \left(3\ x\ \frac{Participant\ NPV\ Solution - Lowest\ NPV\ Solution}{\text{Lowest NPV Solution}}\right) \text{x } 30\%$

Multiplying Factors Analysis		
$F(x > 100) = 0{,}3 - \left(3\ x\ \frac{x - 100}{100}\right) \text{x } 0{,}3\%$	$F(x > 100) = 0{,}3 - \left(2\ x\ \frac{x - 100}{100}\right) \text{x } 0{,}3\%$	$F(x > 100) = 0{,}3 - \left(1\ x\ \frac{x - 100}{100}\right) \text{x } 0{,}3\%$

Table 4 - Equations data. Personal source

Factor = 3		
Δ	x	y
0,0%	100	30
1,0%	101	29,1
2,0%	102	28,2
3,0%	103	27,3
4,0%	104	26,4
5,0%	105	25,5
6,0%	106	24,6
7,0%	107	23,7
8,0%	108	22,8
9,0%	109	21,9
10,0%	110	21
11,0%	111	20,1
12,0%	112	19,2
13,0%	113	18,3
14,0%	114	17,4
15,0%	115	16,5
16,0%	116	15,6
17,0%	117	14,7
18,0%	118	13,8
19,0%	119	12,9
20,0%	120	12

Factor = 2		
Δ	x	y
0,0%	100	30
1,0%	101	29,4
2,0%	102	28,8
3,0%	103	28,2
4,0%	104	27,6
5,0%	105	27
6,0%	106	26,4
7,0%	107	25,8
8,0%	108	25,2
9,0%	109	24,6
10,0%	110	24
11,0%	111	23,4
12,0%	112	22,8
13,0%	113	22,2
14,0%	114	21,6
15,0%	115	21
16,0%	116	20,4
17,0%	117	19,8
18,0%	118	19,2
19,0%	119	18,6
20,0%	120	18

Factor = 1		
Δ	x	y
0,0%	100	30
1,0%	101	29,7
2,0%	102	29,4
3,0%	103	29,1
4,0%	104	28,8
5,0%	105	28,5
6,0%	106	28,2
7,0%	107	27,9
8,0%	108	27,6
9,0%	109	27,3
10,0%	110	27
11,0%	111	26,7
12,0%	112	26,4
13,0%	113	26,1
14,0%	114	25,8
15,0%	115	25,5
16,0%	116	25,2
17,0%	117	24,9
18,0%	118	24,6
19,0%	119	24,3
20,0%	120	24

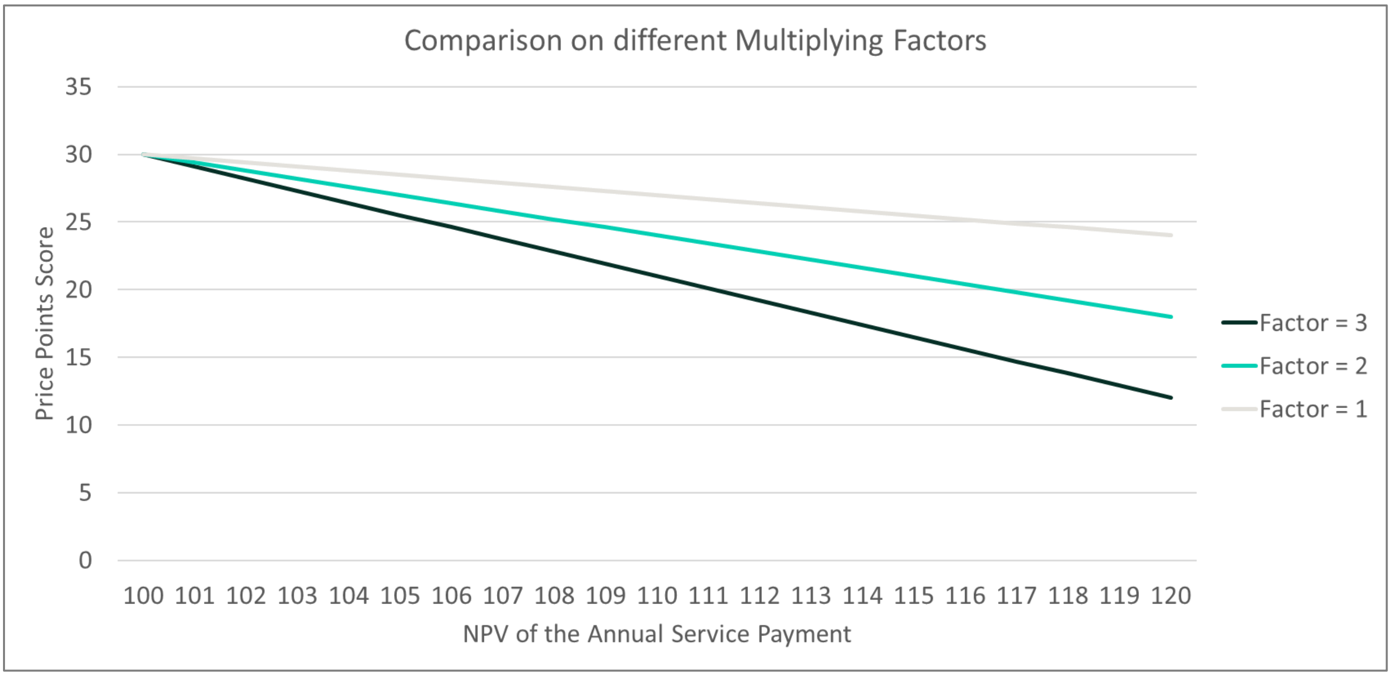


Figure 34 - Representation of the lose of points in the price evaluation. Personal Source

As a reference scenario, let's take a 20% variation of the economic offer between several participants in order to do the assessment. The evaluation method should be designed to maintain economic competitiveness without being definitive in the final solution. In PPP processes, the procurement documentation is usually very clear, and few variations are accepted during the tender phase.

This is why the participants are usually aligned on technical offers, this being crucial in a healthcare tender. However, we note that in the event that a consortium chooses to deliver an economically lower solution without taking into account some of the technical aspects, it would be very difficult for the other participants to compensate for this large difference in points, even if they have comfortably fulfilled all technical requirements. We conclude this section by introducing a modification to the price analysis equation the MIM model uses to evaluate healthcare tenders, opting for the multiplier factor 2, which is found to be the average of the three options analyzed, in the expectation that the non-economic criteria will gain more prominence.

$$Price\ Score = 30\% - \left(2\ x\ \frac{Participant\ NPV\ Solution - Lowest\ NPV\ Solution}{\text{Lowest NPV Solution}}\right) \text{x } 30\%$$

Figure 35 - Equation selected as the most appropriate for a healthcare facility. Personal Source

4.2. Quality Evaluation

Once the price evaluation formula that guarantees competitiveness among the different participants has been established, we move on to choosing the qualitative criteria that will make up the total evaluation of the offer. It is essential that the evaluation criteria are adjusted to the requirements of the offer. In this case, in order to design a sustainable healthcare facility with net zero emissions during operation, sustainable and resilient, the technical part must be highly weighted.

The purpose of the evaluation methodology is to provide a structured and auditable approach to evaluating the Final Tenders submitted by the Participants. The evaluation methodology should:

- Conform with all relevant statutory and regulatory requirements and best practice;
- be robust, objective and transparent;
- provide a framework that will facilitate a comprehensive review of each final tender; and
- provides a clear audit trail.

The quality award criterion should been further divided into different award sub-criteria, in case of the MIM project the Velindre cancer Centre, this were the six award sub-criteria inside the quality section:

- Community Benefits -
- Strategy, Quality and Management;
- The Hospital;
- Facilities Management;
- Legal; and
- Commercial.

The award sub-criteria will also be evaluated by the client against a number of pass/fail requirements which should be clearly described, in order to evaluate whether the participant's final tender is compliant with the stated requirements. It should be identified which parts of the final tenders are scored with a minimum pass/fail threshold.

If a participant scores a "Fail" for any quality question, then the client shall exclude the participant from further participation in the procurement process, regardless of its performance in the other areas which are being evaluated.

Each project will have to decide on which approach they want to follow in terms of weight criteria but in order to have a robust technical solution, the technical deliverables, where the participant will demonstrate acceptance of Client's requirements and compliance with sustainable targets need to be highly scored and shall include pass/fail questions with the minimum criteria.

In order to align the evaluation methodology with the sustainable requirements we are looking for in this analysis, an overview of the minimum technical requirements is explained

4.3. Technical Requirements

As mentioned in this paper, one of the main characteristics of PPPs is the early involvement of all participants, including the Client, who come together to deliver a project that includes both the construction phase and the operation phase.

One of the advantages is that the Client, prior to launching the procurement, has been able to analyse and define the technical requirements that the bidders and the one awarded will have to meet. This is vital in a project where we want it to be highly sustainable and resilient, aiming for net zero carbon emissions during the operation phase, and with minimum embodied carbon impact.

Participants should deliver an efficient and high quality service which puts the patient at the centre, enabled by a motivated and supported workforce, where research drives quality, and technology improves experience. The participant should also promote sustainable development by demonstrating an integrated approach to the social, environmental and economic well-being of the area served, now and for future generations. Therefore, the participants' design development teams should be structured with the necessary skills and abilities embedded and supported and have a track record of innovation and challenging current construction methodology.

The client has different options to provide the participants with an example of a solution that meets the minimum requirements. One approach would be to produce a reference design that the participants can use as a basis for their design. They will provide the reference design, all design and construction requirements, energy and carbon emission targets and minimum certificates that the solution must meet, such as a minimum BREEAM level.

Regarding the required levels of energy efficiency, in order for the healthcare facility to comply with the established limits, verifications and controls must be foreseen on the asset at the end of the construction and during the operation phase, since with the underperformance of the participant, some deductions will be applied in the availability payment, as we will see in the following section.

The Client should set a net target of [XX]kWh/m^2 in respect of the design and construction of the heathcare facilities. This target should be properly considered by the participants as it will become a contractual figure to be complied with for the duration of the concession.

In order to achieve a good performance, the Client should ask the participants to be innovative in their approach to energy efficiency requirements, in order to meet high level policy objectives.

The technical issues scored will be assessed with reference to a cross section of technical deliverables and Facility management deliverables, in order to analyse whether the solution provides the Client with the whole life approach it is looking for with the procurement.

Technical deliverables are then proposed to be analysed with the pass/fail method, as they describe the participant's acceptance of the main requirements to meet the quality, sustainability, resilience and carbon objectives, including quality of the solution.

Table 5 - Technical deliverables proposal for a healthcare procurement. Company Source

Nº	Deliverable	Target
1	Integration with Client Policies and operations	Participants shall submit their proposals setting out how the design proposals will allow integration and alignment with the Client's Policies, procedures and clinical services delivered by the Client. This shall include details of how the design proposals will allow participant ensure that its services during the Operational Term and aligned with the Client's strategy
2	Technical Documents	Compliance with: - Design Requirements - Construction Requirements - Energy Efficiency Strategy
3	Construction Methodology	Participants shall submit their proposals explaining how will they deliver and/or procure delivery of the works, including its construction strategy on a phased basis (where relevant). These participant proposals shall address how the construction phase of the project will be managed and shall include methodologies covering the activities needed, management, monitoring, whole phase strategy , materials, ground strategy and protocols to deliver the works
4	BREEAM	A BREEAM assessment in respect of participant's solution and supporting commentary from an expert;
5	Technical Costs	Personnel and material costs the participant is considering during construction
6	IM&T Strategy	Participants shall submit their Proposals confirming how they will achieve full compliance with the requirements of the Client's Construction Requirements in respect of IM&T (Information Management & Technology)
7	Full Planning Permission	In case of the UK, there is a requirement to certificate that your solution is compliant with government strategy and should get Planning Approval. In this deliverable participants should confirm that their design solution is acceptable to the planning authority and compliant with the requirements
8	Equipment Responsibility	Participants need to confirm they accept the Client's strategy regarding the Equipment
9	Key Clinical Equipment	Participants need to confirm they accept the Client's strategy regarding the Clinical equipment

If a participant scores "FAIL" in any of the pass/fail questions, that participant shall be excluded from further participation in the procurement process regardless of its performance in the other areas which are being evaluated.

In addition to these deliverables to be provided by the participant, scored deliverables shall also be provided to explain in general terms the approach the participant takes with respect to some of the Client's priority requirements.

In healthcare facilities, it is essential that the participant explains their approach to patients, staff and the general public, including brief descriptions of social activities where the project may have an impact. In this section it is often asked to clarify how the participant can create an excellent working environment for staff, while providing efficient and high quality service to patients. Also the patient experience in the facility, access, patient day-to-day and patient movement through the hospital.

There will also be a set of deliverables that will outline the participant's approach to providing high efficiency in the hospital, how the design has been adapted to maintain the quality of the hospital with low maintenance and how the adjacencies have been designed to maximise the structural efficiency of the building. It will explain the digital solution adopted and how temperature and energy metering is foreseen to regulate the hospital's consumption. Finally, this set of deliverables should present the flexibility of the facility to accommodate new services and possible future changes in the structure, an important requirement due to the long-term nature of the project.

Finally, the participant will have to demonstrate that it has developed a green and resilient hospital, and that it can meet these conditions throughout its lifetime. Some questions that could be answered are:

- How far does the participant's proposal exceed the technical regulations, guidance and minimum standards in the Client construction requirements?
- How resilient is the design in normal and emergency situations? What capacity and back-up systems have been considered?
- Has the design considered the services delivered within the building when considering resilience? Have details of safety, security and life critical services been considered under supply failure scenarios?
- How far does the design support and enhance biodiversity and the natural environment of the Site?
- How the Participant's solution optimises sustainable and low to zero carbon energy solutions, addressing the need for reducing energy demand at source, providing for highly efficient active energy systems and incorporating effective low to zero carbon technologies.

- How far does the design use natural resources, what are the projected carbon and energy savings in using this methodology?
- How far does the design support sustainable transport and a Green Travel Plan?
- How far do the materials used in the design minimise their environmental impact over their lifetime (production, maintenance, disposal.)?
- How does the design and construction minimise the production of waste materials and manage them to minimise their impact on the environment?

In order to be able to evaluate these open-ended responses, a clear rubric with the scope of each score is needed. The proposal below suggests a way to make the analysis of these scored questions objective.

Table 6 - Description of the selection criteria. Company Source

Score	Categorisation	Description
0	**Unacceptable** Leading to exclusion from participation	No response is received or the submission received sets out a response which: (a) is substantially incomplete and/or fails to justify why the relevant question has not been addressed in most or all of deliverables identified as not addressing the question in the Participant's response; (b) fails to address all, or substantially all, of the relevant question in the deliverables identified as addressing the question in the participant's response; (c) provides a very low level of confidence to the Client in respect of the quality and fitness for purpose of the response, with a very low level of quality, detail, clarity and relevance to the question asked; (d) provides a very low level of confidence to the Client that all, or nearly all, aspects of the response can be delivered by the participant; (e) provides a very low level of confidence to the Client that the participant's solution will meet the relevant Client's Requirements; and/or (f) suggests an unacceptable risk allocation to the Client when considered against the Clients' Requirements and on a value for money basis.
3	**Poor**	The submission received sets out a response which: (a) is incomplete and/or fails to justify why the relevant question has not been addressed in some or all of deliverables identified as not addressing the question in the participant's response; (b) fails to address all, or substantially all, of the relevant question in the deliverables identified as addressing the question in the Participant's response;

Score	Categorisation	Description
		(c) provides a low level of confidence to the Client in respect of the quality and fitness for purpose of the response, with a low level of quality, detail, clarity and relevance to the question asked; (d) provides a low level of confidence to the Client that all, or nearly all aspects of the submission can be delivered by the Participant, taking into account the level of demonstration; (e) provides a low level of confidence to the Client that the Participant's solution will meet the relevant Clients' Requirements; and/or (f) provides a high risk allocation to the Client when considered against the Client's Requirements and on a value for money basis.
5	**Satisfactory**	The submission received sets out a response which: (a) is complete and justifies why the relevant question has not been addressed in any of deliverables identified as not addressing the question in the participant's response; (b) addresses all, or substantially all, of the relevant question in the deliverables identified as addressing the question in the participant's response; (c) provides a satisfactory level of confidence to the Client in respect of the quality and fitness for purpose of the response, with a satisfactory level of quality, detail, clarity and relevance to the question asked; (d) provides a satisfactory level of confidence to the Client that all, or nearly all, aspects of the submission can be delivered by the participant, taking into account the level of demonstration; (e) provides a satisfactory level of confidence to the Client that the Participant's solution will meet the relevant Client's Requirements; and (f) provides a satisfactory risk allocation to the Client when considered against the Client's Requirements and on a value for money basis.
8	**Good**	The submission received sets out a response which: (a) is complete and fully justifies why the relevant question has not been addressed in any of deliverables identified as not addressing the question in the participant's response; (b) addresses all, or substantially all, of the relevant in the deliverables identified as addressing the question in the participant's response; (c) provides a good level of confidence to the Client in respect of the quality and fitness for purpose of the response, with a good level of quality, detail, clarity and relevance to the question asked; (d) provides a good level of confidence to the Client that all, or nearly all, aspects of the submission can be delivered by the participant, taking into account the level of demonstration;

Score	Categorisation	Description
		(e) provides a good level of confidence to the Client that the participant's solution will meet the relevant Client's Requirements; and (f) provides a low/no risk allocation to the Client when considered against the Client's Requirements and on a value for money basis.
10	**Excellent**	The submission received sets out a response which: (a) is complete and fully justifies why the relevant question has not been addressed in any of deliverables identified as not addressing the question in the participant's response; (b) addresses all of the relevant question in the deliverables identified as addressing the question in the participant's response; (c) provides full confidence to the Client in respect of the quality and fitness for purpose of the response, with a very high level of quality, detail, clarity and relevance to the question asked; (d) provides full confidence to the client that all aspects of the submission can be delivered by the participant, taking into account the level of demonstration; (e) provides full confidence to the Client that the Participant's solution will meet the relevant Client's Requirements; and (f) provides no additional risk allocation to the Client when considered against the Client's Requirements and on a value for money basis.

If a participant scores "Unacceptable" in the evaluation of the scored questions, then this shall be deemed a "FAIL" and that participant shall be excluded from further participation in the procurement process regardless of its performance in the other areas which are being evaluated.

The competitive dialogue between participants and the client during the procurement enables all offers top be aligned and therefore, after several sessions with the client knowing what, it is difficult to score "Unacceptable" on any deliverable, and conversely, all participants are very competitive and it is difficult to score points of difference.

5. Payment mechanism. Deductions

Earlier in this paper we defined the different types of revenues that a project could have, with their advantages and disadvantages. The choice of a project based on a revenue method depends on whether the public authority's objective is to achieve a higher level of use of the asset. In our case study, the Health Care sector is a perfect example of an Availability Based contract, as the government cannot incentivise the use of a hospital and therefore the payment of the hospital to the private party for construction and operation will be made on a regular basis with figures already fixed at the pre-financial closure stage.

This availability payment will be used to pay for operational costs, maintenance, repayment of the senior debt that has been borrowed for the construction of the project and the return of the shareholder.

This section will explain how the payments received by the private party in each period of the project are sized, including the different deductions that may occur if a number of conditions or performance requirements are not met.

5.1. Monthly Service Payments

One of the main methods of receiving an availability payment is on a monthly basis, based on the calculation of an annual fee updated with inflation. For the monthly calculation, the following simple formula can be used, as it calculates proportionally the fee that the private operator should receive, including deductions for past months that have already been certified with the authority and invoices for costs that have been agreed to be paid by the administration, such as electricity charges.

$$MSP_n = \left(\frac{ASP_n}{12} \times F\right) - \sum D_{n-2} + PTC$$

MSP_n	is the Monthly Service Payment for the Contract Month "n"
ASP_n	Annual Service Payment
F	ASP Step up Factor. $F = \sum(P_x x C_x)$
$\sum D_{n-2}$	is the sum of deductions in respect of performance of the services during the contract month that was two (2) months prior to contract month "n"
PTC	PTC – Other Costs due for which uncontested supporting invoices are available from the project company's suppliers

5.1.1. Step-up factor

It is possible that the healthcare facility may have to be built phasing, so that some parts of the building can be opened quickly or, if it is a large facility, it can enter the testing and operational phase gradually, without having a major cost of time impact.

$$F = \sum(P_x x C_x)$$

P_x	Px = The percentage of the Annual Service Payment attributable to each Phase, as set out in the table below:

Phase	%
From the Phase i Actual Completion Date	[•]
From the Phase i+n Actual Completion Date	[•]
Total	100%

C_x	To take into account the exact days of each period and the end of the project: $$\frac{dr_n}{dm_n}$$ **dr_n** = total number of Days between the Payment Commencement Date or the end of the operation. **dm_n** = total number of Days in Contract Month "n".

5.2. Annual Service Payment

With the following formula we can calculate the Annual Service Payment for any Contract Year "n". In procurement selection processes, it is usually required to bid back some of the main inputs to the business case.

The ASP defines the quantitative evaluation score of the bid, as we have explained in previous sections. The following formula takes that bid back number set as ASP0 and applies the inflation on it to extrapolate that real input for the rest of the project term years.

$$ASP_n = ASP_0 x(1 - IF) + \left[(ASP_0 x IF) x [Inflation\ Rate_n]\right]$$

ASP_n	Annual Service Payment
ASP_0	is the value for the Annual Service Payments stated at the beginning of the contracts, subject to any adjustments made from time to time in accordance with inflation and the conditions describes in the above formula;
IF	IF is the indexation factor that facilitate the achievement of a “natural hedge” (where the proportion of the Annual Service

Payment subject to indexation is in line with the proportion of costs that are inflated)

$$IF = \frac{\sum_{i=0}^{n}[Total\ Indexed\ Costs\ in\ Real\ Terms_i]}{\sum_{i=0}^{n}[Total\ fixed\ Costs_i]}$$

$Inflation\ Rate_n$ Compound index from the beginning of the contract up to period "n" , it can be described depending on the final solution achieved as:

$$\left[1 + \frac{(RPIx_n - RPIx_0)}{RPIx_0}\right]$$

5.2.1. Inflation formula description

Inflation is described on the basis of the RPI index, which is mostly used in the UK, but depending on the geography of the project, it will have to be adapted to the corresponding benchmark in each country. In the case of healthcare facilities, it is not usual to resort to a specific inflation index for revenues, although in order to apply it to costs we could take some reference index such as e.g. the energy index for electricity prices.

In addition, the application of 100% inflation is usually under discussion with the client and an approach that is being followed in some PPPs project sin UK to improve competitive bidding is to inflate revenues so that any inflation impact does not cause variation in the operator's returns, thus achieving a "natural hedge" between revenues and costs. This would improve the base case as the NPV of the project flows would end up being lower.

It is a commercial decision for each private developer to make, although the authority can also include it as a requirement, thus achieving a higher value for money by only paying for operational costs and a fixed return to the operator.

$$\left[1 + \frac{(RPIx_n - RPIx_0)}{RPIx_0}\right]$$

$RPIx_n$	RPIxn is the value of the [Retail Prices Index All Items Excl Mortgage Interest] published or determined with respect to the prior month of the beginning of the contracts.
$RPIx_0$	RPIxo is the [Retail Prices Index All Items Excl Mortgage Interest with respect to the Base Date.

Resulting the following formula of the Annual Service Payment:

$$ASP_n = ASP_0 x(1 - IF) + \left[(ASP_0 xIF)x\left[1 + \frac{(RPIx_n - RPIx_0)}{RPIx_0}\right]\right]$$

As we have seen in the Monthly Service Payment calculation, there are some deductions that apply when calculating the private partner's net revenue. In a healthcare facility it is very easy to distinguish between two types of deductions that can control the operational performance of the project: (i) deductions for poor performance of the healthcare facility, where it can be the inoperability of some area of the hospital or department or for having a performance failure that are described in the project documentation, or (ii) deductions that come from non-compliance with the established limits of energy consumption or emissions cap of the healthcare facility. In the following two sections, we will describe these two types of deductions.

5.3. Performance Deductions from monthly service payments

In this section, we describe two types of deductions that materialise when the private operator has a performance or availability failure. These are described by contract and the application of these deductions on the monthly fee will also come with a series of limits so as not to jeopardise the viability of the contracts and therefore of the project.

These two deductions are very important to control in a healthcare facility the level of total performance and if the private party is complying with the contract conditions as it is obliged to comply with a series of reporting clauses, cleanliness, mitigation measures and availability of all services and departments.

For example, one way to apply these deductions in contracts could be as follows. In any Contract Month where the value of deductions (∑Dn-2) exceeds the value of ASP_n/12, the Monthly Service Payment due by the Client shall be an amount equal to PTC (the costs the client is paying monthly to the operator) for that Contract Month but the Client shall, in calculating the Monthly Service Payment in respect of the following and (to the extent necessary) any subsequent Contract Months, be entitled to carry forward and set off the amount of such excess against the amount by which the value of ASP_n//12 exceeds the value of ∑Dn-2 (as such values are calculated in the following Contract Month and any subsequent Contract Months) for a period of up to twelve Contract Months, or, if earlier, until the amount of such excess has been set-off in full.

5.3.1. Deductions for Performance Failures

The amount of the Deduction in respect of a Performance Failure is calculated using the following formula. The values have been obtained from a specific project in the UK but these are negotiated between the parties with the relevant benchmarks for similar projects and the specific commercial case.

D = PFD x DP

D	means the amount of the Deduction in respect of the Performance Failure; and
PFD	a. in the case of a Minor Performance Failure, the sum of £ [30.00], index linked; b. in the case of a Medium Performance Failure, the sum of £ [75.00], index linked; and c. in the case of a Major Performance Failure, the sum of £ [200.00], index linked.

Usually, no Deduction may be made by the Client from the Monthly Service Payment for the relevant Contract Month in respect of any Minor Performance Failure if the total number of Minor Performance Failures which have occurred in the relevant Contract Month is not more than a limited amount negotiated during procurement phase.

In addition, where two [2] or more Performance Failures occur in a functional area during a session, only the Performance Failure that results in the highest Deduction will apply.

5.3.2. Deductions for Availability Failures

Availability deductions are crucial to encourage the operator to keep all departments of the healthcare facility operational. This could be the biggest difference with any other social infrastructure as we are talking about patients who need to have quality services available in an effective way. The resilience of the healthcare infrastructure must be planned from the inception of the project and for it to last for the life of the concession the performance risk must be borne by the private party and is usually passed on to the operator. Below is a form of calculation that could be used to penalise for availability failures.

D = SUA x SUR

SUA (Service Units Affected)	means the total service units of the functional areas affected by an Availability Failure

SUR (Service Unit Rate)	means, for Contract Year "n", the amount in Pounds Sterling calculated by the formula:

$$SUR = \left(\frac{3xASPn}{Daily\ SUF\ x\ Days\ in\ a\ contract\ year}\right)$$

Where Daily SUF (Service Units of the Facilities) means the aggregate number of Gross Service Units (GSU) each day in the relevant period, in respect of Functional Areas on each relevant Day,

where the Gross Service Units per Day for each Functional Area shall be calculated by multiplying the GSU for the Functional Area, set out at the contract, by the total number of sessions within the Core Times for that Functional Area on any given Day.

There are some conditions and ratchets that are used in the evaluation of the availability failures, i.e. where the relevant Functional Area is unavailable but can be used, the Deduction for the Availability Failure shall be reduced by 50%.

In addition, if the number of GSUs affected by an Availability Failure are deemed high impact functional areas, the SUR shall be multiplied by [1.5] in each Deduction.

FUNCTIONAL AREAS AND GSUs example

Department	Functional Area	Days/week	Sessions	GSUs
Radiotherapy	Interview room	7	3	12
Imaging & Nuclear Medicine	Clinical supplies store	5	2	6
Inpatient Units (Entrance & Reception)	Room	5	2	16
Inpatient Units (Isolation)	Bedroom	7	3	25
Outpatients & Therapy	Laboratory	5	2	25
Pharmacy	Clinical Trials Returns	5	2	12

5.4. Operational Energy Performance Monitoring

In order to control the energy performance of the healthcare facility, it is necessary to have a rigorous control of the outcomes in short periods of time, in order to be able to intervene in the case of noticing any normal deviation of consumption. In the case of energy, in the procurement phase, an Annual Energy Target must be established in order to be able to report against this figure.

The advantage of the PPP system is that from the beginning of the project all the actors are on board and can intervene in the decision, especially the project operator, as ultimately, he is the one who will most likely bear the risk. This is why the operator is also involved in the design decisions and often has a guide of "tips" for the project designer and constructor.

- The "Annual Energy Target" is the target volume of energy consumption (measured in kWhs per annum) that Project Co must achieve during the Operational Term, broken down by fuel type as follows:
- Heating $Fuel_n$ - refers to the part of the healthcare facility that is powered by fossil fuels.
- Electricity - refers to the part of the healthcare facility that is powered by electricity.
- Annual Energy Target of [Other $Fuel_n$] – [***] kWh per annum
- Annual Energy Target of Electricity - [***] kWh per annum

The measurement period is post-construction, but normally there is a monitoring period where the healthcare facility is coming into operation and settling its consumption. This period of time can last 1 or 2 years and at the end, with the overall calculation, an adjustment can be made to the Annual Energy Target, assuming to pay the difference during the project term.

As presented above, both before and during the Monitoring Period there shall be no annual energy adjustment as a result of any operational energy performance failures at the Facilities, but the consumption of energy during the Monitoring Period shall be measured against performance standards.

5.4.1. Calculation of Energy Gainshare Adjustment

An Energy Gainshare Adjustment is calculated to encourage the improvement of the operator's performance and promote internal investment in the same facility during the construction years. However, the customer usually introduces a % cap in the gainshare mechanism so that it does not fully favour the operator. The following formula can calculate the total gain for the private party.

$$\boldsymbol{EnGS} = [\mathbf{0.5}]\left[\sum(\boldsymbol{Under}\ Consumption\ of\ [Heating\ Fuel_n] \times AUC_{HFn}) + (\boldsymbol{Under}\ Consumption\ of\ Electricity\ \times AUC_E)\right]$$

$\boldsymbol{Under}\ Consumption\ of\ [Heating\ Fuel_n]$	means the volume of Energy Consumption that lies between [three (3)%] below the Annual Energy Target of [Heating Fueln] and the Operational Energy Performance of [Heating Fueln] in kWh per annum for the relevant Energy Year
$\boldsymbol{Under}\ Consumption\ of\ Electricity$	means the volume of Energy Consumption that lies between [three (3)%] below the Annual Energy Target of Electricity and the Operational Energy Performance of Electricity in kWh per annum for the relevant Energy Year;
AUC_{HFn}	means the Average Unit Cost of [Heating $Fuel_n$]
AUC_E	means the Average Unit Cost of electricity

The Average Unit Cost for each Fuel Type can be calculated using the formula below:

$$UC = \frac{(SC + US)}{U}$$

- **AUC** means the Average Unit Cost for a Fuel Type;
- SC means the aggregate of all standing charges, levies, taxes and all other sums invoiced to the project by its suppliers (and treated as a PTC) in respect of the supply of [Fuel Type] during the [previous twelve (12) Contract Months];
- **US** means the aggregate of all sums invoiced to Project Co by its suppliers (and treated as a PTC) in respect of the supply of Units of Energy of a Fuel Type during the [previous twelve (12) Contract Months], being, in respect of each form of Energy, a price per Unit multiplied by the number of Units of that [Fuel Type] actually supplied;
- **U** means the aggregate number of Units of Energy of a Fuel Type actually consumed in respect of the Facilities in the course of the period from the previous twelve (12) Contract Months.

5.4.2. Calculation of Energy Painshare Adjustment

In the same manner that the Client promotes the reduction of consumption, it also sanctions the operator if he does not achieve the performance that he established in the procurement phase. This is the most important deduction to control that the facility is a resilient asset and that over the years it will not lose energy efficiency.

This is why the facility must be designed with high quality standards so that with continuous maintenance and without major investments during the life of the project the healthcare facility can maintain the contracted levels of energy targets.

$$\boldsymbol{EnPS} = \Big[\sum (\boldsymbol{Over}\ Consumption\ of\ [Heating\ Fuel_n] \times AUC_{HFn}) + (\boldsymbol{Over}\ Consumption\ of\ Electricity\ \times AUC_E)\Big]$$

$\boldsymbol{Over}\ Consumption\ of\ [Heating\ Fuel_n]$	means the volume of Energy Consumption that lies between [three (3)%] above the Annual Energy Target of [Heating Fuel$_n$] and the Operational Energy Performance of [Heating Fuel$_n$] in kWh per annum for the relevant Energy Year
$\boldsymbol{Over}\ Consumption\ of\ Electricity$	means the volume of Energy Consumption that lies between [three (3)%] above the Annual Energy Target of Electricity and the Operational Energy Performance of Electricity in kWh per annum for the relevant Energy Year;
AUC_{HFn}	means the Average Unit Cost of [Heating Fuel$_n$]
AUC_E	means the Average Unit Cost of electricity

5.4.3. Measurement

An essential part of PPP projects is the reporting that is done so that all parties are aware of the progress and performance of the assets. Reporting requirements and meetings should also be set prior commencement of the project. Penalties require controlled reporting and any delays are associated with performance failures.

In accordance with the performance standards contained in the project documentation, the private party shall monitor and report the actual Energy consumption for the Facilities (by Fuel Type) against the target Energy consumption levels for the Facilities (by Fuel Type) in accordance with the service level specification stablish in the documentation and the energy management plan, in respect of each contract month.

Usually, the private party shall provide to the Client a summary of actual Energy Consumption in respect of each [Fuel Type] at the Facilities, at the end of each Contract Month, in the form of a certificate.

5.5. Operational Emissions Performance Monitoring

In order to control the emissions caused by the hospital, deductions are also introduced during operation. The methodology is similar to the one we have explained of the deductions for non-compliance with the

Annual Energy target and the same figure gives the Annual Emissions Target. The deductions will be calculated in the case of underperformance of the healthcare facility.

The Annual Emissions Target is comprised of:

$$\boldsymbol{Annual\ Emissions\ Target\ of}\ [\boldsymbol{HFn}] = Annual\ Energy\ Target\ of\ [Heating\ Fueln] \times EF_{HFn}$$

$$\boldsymbol{Annual\ Emissions\ Target\ of\ Electricity} = Annual\ Energy\ Target\ of\ Electricity \times EF_E$$

EF_{HFn}	means the Emissions Factor of [Heating Fueln] per tonnes of CO2 / kWh
EF_E	means the Emissions Factor of Electricity per tonnes of CO2 / kWh

5.5.1. Calculation of Emissions Gainshare Adjustment

As discussed in the previous section, if the operator has an overperformance in the ahealthcare facility, this is compensated with a monetary adjustment in the calculation of the Monthly Service Payment. This adjustment is also weighted with a 50% reduction against the total profit.

$$\boldsymbol{EmPS} = [0{,}5]\left[\sum(\boldsymbol{Under}\ Emissions\ of\ [Heating\ Fuel_n]) + (\boldsymbol{Under}\ Emissions\ of\ Electricity)\right]$$

$\boldsymbol{Under}$ $Emissions\ of\ [Heating\ Fuel_n]$	means the volume of Emissions that lies between the Annual Emissions Target and [five (5)%] below the Annual Emissions Target of [Heating $Fuel_n$] and the Operational Emissions Performance of [Heating Fueln] in tonnes of CO2 per annum for the relevant Emissions Year
$\boldsymbol{Under}$ $Emissions\ of\ Electricity$	means the volume of Emissions that exceed [five (5)%] below the Annual Emissions Target of Electricity and the Operational Emissions Performance of Electricity in tonnes of CO_2 per annum for the relevant Emissions Year.

The making of any Emissions Gainshare Adjustment shall not affect the Annual Service Payment for the purposes of the application of indexation.

5.5.2. Calculation of Emissions Painshare Adjustment

The calculation of the painshare adjustment is also done in a similar way, we can observe the following formula:

$$\boldsymbol{EmPS} = \left[\sum(\boldsymbol{Over}\ Emissions\ of\ [Heating\ Fuel_n]) + (\boldsymbol{Over}\ Emissions\ of\ Electricity)\right]$$

$\boldsymbol{Over}$ $Emissions\ of$ $[Heating\ Fuel_n]$	means the volume of Emissions that lies between the Annual Emissions Target and [five (5)%] above the Annual Emissions Target of [Heating Fuel$_n$] and the Operational Emissions Performance of [Heating Fuel$_n$] in tonnes of CO2 per annum for the relevant Emissions Year
$\boldsymbol{Over}$ $Emissions\ of$ $Electricity$	means the volume of Emissions that exceed [five (5)%] above the Annual Emissions Target of Electricity and the Operational Emissions Performance of Electricity in tonnes of CO_2 per annum for the relevant Emissions Year.

Chapter 4. Developer Perspective. Infrastructure solutions to achieve decarbonisation and value for money on brownfield healthcare developments.

1. Renewable energy solutions to reduce or compensate carbon emissions

This Directive ("Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC") establishes a scheme for greenhouse gas emission allowance trading within the European Community in order to promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner.

The following Directive provides for further, deeper reductions in greenhouse gas emissions to help achieve the levels of reductions considered scientifically necessary to avoid dangerous climate change.

This Master's thesis has focused on Healthcare facilities projects developed by the Public-Private partnership method, and how procurement can help to design projects that from construction to operation can reduce CO2 emissions and achieve specific objectives such as operating with a negative carbon balance.

However, there are actions that can be carried out in existing projects, where current emissions can be reduced and thus reduce the penalties that the aforementioned directive may have on the project. These actions, in addition to reducing the hospital's carbon emissions and reducing the penalties imposed, can also present long-term internal savings in the payment of the consumption.

In the following, we will show a practical example of the application of this law on a hospital infrastructure in Spain, and see how these institutions can currently make modifications to the same infrastructure in order to compensate or reduce the total CO2 emissions and reduce the penalties for the emission rights that must be paid.

Toledo Hospital is located in the east of Toledo, in the autonomous community of Castilla-La Mancha (central Spain). The 246,000m2 public hospital has an 835-bed capacity serving a population of 430,000 people across the Toledo provinces.

Figure 36. Toledo's Hospital figures. Company source

Figure 37 - Toledo's Hospital. Source [34]

The project also includes the operation of non-clinical services for the "Complejo Hospitalario Universitario de Toledo (CHUT)", which includes eight facilities.

The hospital is considered one of the largest in Europe, as well as the most relevant healthcare project to be developed in the history of Castilla-La Mancha, both for its architectural value, and its size and capacity. The infrastructure offers 250 outpatient and examination rooms, 25 operating theatres (among other facilities), and features a heliport and 1,800 parking spaces.

Operations and maintenance are performed by Toledo Opco, which has subcontracted most of the services (except the car parks) to third-party subcontractors. These relationships are typically back-to-back.

Revenues are mainly availability-based. The public counterparty is the Castilla La Mancha region (BBB-). These payments are subject to performance deductions, which are passed down to the Opco and then again to the subcontractors. Payments are indexed to "Indice de Garantía de Competitividad" (IGC), which is a synthetic price index based on the variation between Spain's CPI and the EU's CPI. Payments are invoiced on a monthly basis. [Confidential company information].

The main objective of this analysis would be:

- Improve the degree of decarbonisation of the hospital complex.
- Avoid or reduce costs arising from the payment of emission rights.

- Avoid or reduce the risk of cost overruns due to increases in the price of natural gas due to its high historical volatility.

The thermal demand of the facility is 145/105ºC superheated water at 8 bar(g) to serve Heating + Sanitary Hot Water Support + Humidification. The installations that the hospital has to provide energy are:

Table 7 - Hospital installations. Company information source

Existing Installation	Uds.	Total MWt
Natural Gas Boiler	4 uds. X 7 MWt 1 uds. X 3 MWt 1 uds. X 1,6 MWt	32,6 MWt
Generating Groups	4 uds. X 5 MWt	20 MWt
Total		**52,6 MWt**

For the calculation of the total demand, we only have the complete figure for the year 2021, which corresponds to a low load year as the hospital was in operation and was not fully operational. In order to extrapolate to a typical calculation year, we will apply a 10% increase to the maximum demand between the project demand and the one that occurred in the test year 2021.

Table 8 - Energy Demand. Company information

Months	kWh PCS Demand			
	Project Calculations	2021 Data	%	10% Margin over Project Calculations
January	5 647 250	2 665 217	47,19%	6 211 975
February	4 575 002	898 104	19,63%	5 032 502
March	3 779 533	980 140	25,93%	4 157 486
April	3 321 703	923 777	27,81%	3 653 873
May	1 935 826	861 312	44,49%	2 129 409
June	1 365 794	901 655	66,02%	1 502 373
July	1 043 427	919 922	88,16%	1 147 770
August	872 099	1 064 355	122,05%	959 309
September	1 498 353	1 585 677	105,83%	1 744 245
October	2 178 905	2 362 185	108,41%	2 598 404
November	3 258 576	4 015 939	123,24%	4 417 533
December	5 312 839	4 953 066	93,23%	5 844 123
TOTAL	**34 789 307**	**22 131 349**		**39 399 001**

According to the project data, the demand in the year at low load was 22 131 MWh PCS/y of natural gas. The estimated demand using 100% of the capacity by applying this 10% increase to the higher of [Low load year demand; Basic project demand] is 39 399 MWh PCS/y of natural gas.

In order to obtain the CO2 emissions corresponding to this demand, we take as a multiplying factor what is stipulated in the document "factores de emisión. registro de huella de carbono, compensación y proyectos de absorción de dióxido". As we can see in appendix 2, the figures are from 2007 to 2021. The figure for natural gas does not vary over the years and therefore we will take this same assumption for the calculation with the current date of 2023.

Table 9 - CO2 emissions rate for natural gas

CO2 emissions rate for natural gas (kgCO2e/ud)	2007-2021	Hipothesis 2023
Natural Gas (kWhPCS)	0,182	0,182

$$\boldsymbol{Emisions} = 39\,399\ \mathrm{MWh}\frac{\mathrm{PCS}}{\mathrm{a}} * 0{,}182 = \mathbf{7\,170{,}61}\ \boldsymbol{tCO}$$

With this information and considering the law, we can see the penalties and exclusion rights that apply to the Toledo Hospital:

- As we can see in the table above, the total amount of MWt IS 52.6, therefore it would be within the regulatory framework of the EU ETS (Emissions Trading System) Emissions Market (>20MWt).
- As a hospital, even if its 52.6 MWt exceeds the 35 MWt legal limit, Toledo Hospital is entitled to opt-out (Calculations below).
  - The opt-out would have an extra bonus of around 65% of the emissions but requires the establishment of a mitigation pathway with Energy saving measures to justify the savings of the remaining 35% or so. It would be applied in the next phase 2026-30.
- Free allocation of emissions is a method of assigning emission allowances in the EU ETS, whereby a certain quantity of allowances is allocated to certain installations and EU ETS operators free of charge. Currently, 100% of emission allowances are given free of charge to eligible installations operating in sectors or sub-sectors at risk of carbon leakage, to help them remain competitive with installations located in other countries. For the remaining industrial sectors and sub-sectors with no risk of carbon leakage, the free allocation will be gradually reduced to zero by 2030.
  - Toledo Hospital would be in the latter case, where there is no risk of carbon leakage. In the following table we can see the assumptions used for the analysis distributed by year.

To calculate forecasted emissions, a free allocation of 20% of total emissions is assumed, while this figure is reduced by 3% from 2026 to 2030.

Table 10 – Estimated cost of emissions in a scenario with no energy savings measures applied. Personal calculations

Year	Forecasted Emissions [tCO2/a]	Free allocation [tCO2/a]	Net-Emisionss [tCO2/a]	Estimated cost of emissions [€]				Increase
				30 €/U	60 €/U	90 €/U	120 €/U	
2023	7 171	1 434	5 736	€ 172 095	€ 344 189	€ 516 284	€ 688 379	-
2024	7 171	1 434	5 736	€ 172 095	€ 344 189	€ 516 284	€ 688 379	0%
2025	7 171	1 434	5 736	€ 172 095	€ 344 189	€ 516 284	€ 688 379	0%
2026	7 171	1 219	5 952	€ 178 548	€ 357 096	€ 535 645	€ 714 193	3,75%
2027	7 171	1 004	6 167	€ 185 002	€ 370 003	€ 555 005	€ 740 007	3,61%
2028	7 171	789	6 382	€ 191 455	€ 382 911	€ 574 366	€ 765 821	3,49%
2029	7 171	574	6 597	€ 197 909	€ 395 818	€ 593 727	€ 791 635	3,37%
2030	7 171	359	6 812	€ 204 362	€ 408 725	€ 613 087	€ 817 450	3,26%
Total	**57 365**	**8 246**	**49 119**	**€ 1 473 560**	**€ 2 947 121**	**€ 4 420 681**	**€ 5 894 241**	**-**

Opt-out scenario with an extra bonus of around 65% of the emissions

Table 11 - Estimated cost of emissions in a scenario with energy savings measures applied. Personal calculations

Year	Forecasted Emissions [tCO2/a]	Free allocation [tCO2/a]	Net-Emisionss [tCO2/a]	Estimated cost of emissions [€]				Increase
				30 €/U	60 €/U	90 €/U	120 €/U	
2026	7 171	5 880	1 291	€ 38 721	€ 77 443	€ 116 164	€ 154 885	-
2027	7 171	5 306	1 864	€ 55 931	€ 111 862	€ 167 792	€ 223 723	44,44%
2028	7 171	4 733	2 438	€ 73 140	€ 146 280	€ 219 421	€ 292 561	30,77%
2029	7 171	4 159	3 012	€ 90 350	€ 180 699	€ 271 049	€ 361 399	23,53%
2030	7 171	3 585	3 585	€ 107 559	€ 215 118	€ 322 677	€ 430 237	19,05%
Total	**35 853**	**23 663**	**12 190**	**€ 365 701**	**€ 731 402**	**€ 1 097 103**	**€ 1 462 804**	**-**

The annual cost in emission allowances, according to the current situation, is estimated to be between 400 and 1000 k€/a, depending on free allocations and a price scenario of 60-120 €/EUA.

In order to accurately estimate the demand, it would be necessary to obtain recent historical data on hospital demand and peak demand to be able to size the solutions. The Toledo hospital performed an analysis in 2021 which we will take as a reference, even though the hospital will be at low load:

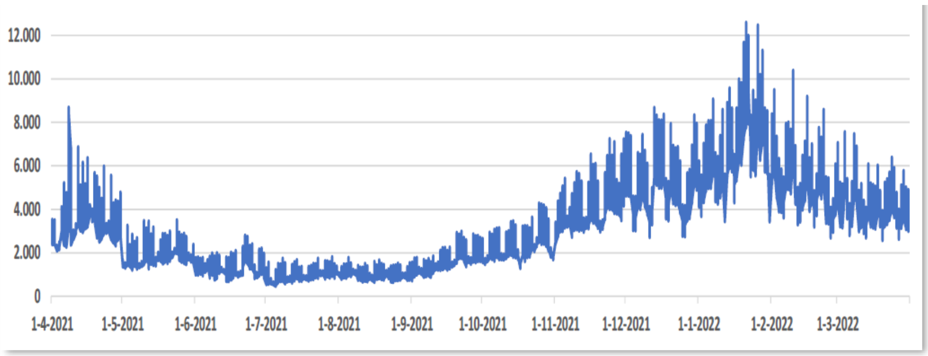


Figure 38 - Energy demand modelised. Source : Company information

Different solutions to reduce emissions can be envisaged:

a) Administrative power reduction

Table 12 - New possible installations to avoid counting. Personal calculations

Installations	Units	Proposed Units	Total MWt	New Total	Law Applicable
Natural Gas Boiler	4 uds. X 7 MWt	2 uds. X 7 MWt	32,6 MWt	14 MWt	14 MWt
	1 uds. X 3 MWt	1 uds. X 3 MWt		3 MWt	3 MWt
	1 uds. X 1,6 MWt	1 uds. X 1,6 MWt		1,6 MWt	-
erating Group	4 uds. X 5 MWt	7 uds. X 2,9 MWt	20 MWt	20,2 MWt	-
Total			**52,6 MWt**	**38,8 MWt**	**17 MWt**

This solution consists of cancelling 2 boilers of 7 MW. According to the maximum peaks of this winter that we can see in the graph above, the maximum demand with natural gas boiler that this solution would offer was reached a few times: 2x7 MW + 3MW +1.6MW = 18.6MW. This solution would not be included in the law as the installed capacity would be below 20MWt, as the 1.6 MWt boiler would not be included as it would be less than 3 MWt and the total sum would be less than 20 MWt.

The total power of the new configuration would be close to that required at peak demand and with some additional energy savings measures it would probably be able to provide service. However, the risk of insufficient power in abnormal peaks or not having back-up in the event of a breakdown would be very high. In conclusion, with this solution we would have:

- 100% of the cost of emission rights would be avoided.
- Risk of insufficient back-up to cover thermal demand at certain times.
- Economic savings, but no environmental benefits.
- The same risk of volatility of natural gas would be maintained.
- Adaptation and purchase of new generators would be costly.
- Uncertainty in the face of any change in regulations that could make this solution ineffective in the future.

With these approximate data we can conclude that this would not be a viable solution for the hospital.

b) Solar thermal energy:

This solution offers clear disadvantages that do not make it optimal for the Toledo hospital.

- Low coverage without surplus (seasonality of production completely inverse to demand).
- It would occupy potentially useful space for photovoltaic, which offers much greater profitability and maturity of the technology.

- Need for subsidy support for a high percentage of the CAPEX required.

Option chosen – Biomass installation

Advantages of the recommended option

- Will allow virtually 100% avoidance of emissions cost
- Lower energy price than natural gas and more stable
- Low power needed for high coverage
- Large space available in the vicinity of the hospital

In addition, some other considerations regarding the energy market sensibility and the evolution of the emissions law and restrictive emissions limits:

- Natural gas: Very pronounced natural gas fluctuations and high future price uncertainty.
- Biomass: much more controlled price fluctuations, especially in the BOOT model (ENGIE framework agreements).
- Emissions: upward trend that will continue to weigh on the income statement if no action is taken.

Approximate calculation of power needed to install biomass:

Table 13 - Biomass Calculations. Personal calculations

	Calcs.	Units
Capacity	7	MWt
Average efficiency	87%	%
Hours in a year	8760	hours
Efficiency	85%	%
Time in use	70%	%
MWh production	31 742	MWt
MWh Demand	39 399	MWt
Cobertura	**81%**	**%**

With the appropriate capacity calculated, we can establish different options that meet the performance and analyse their possible pros and cons.

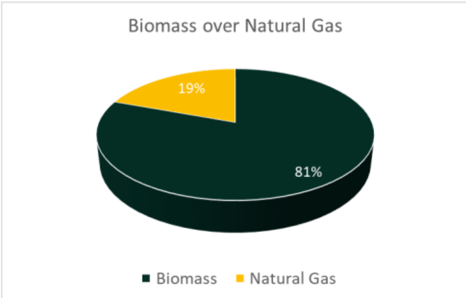
Table 14 - Analysis of different solutions

Configuration	In favour	Against
1 x 7MW	Lower investment than 2 boilers	Low underload modulation insufficient in summer Higher unavailability (maintenance or breakdowns)
2MW + 5MW	Greater versatility in modulation	Worse operability as they are not homogeneous
2 x 3,5MW	Good modulation versatility Homogeneous equipment improves O&M	Worse modulation than 2 boilers of different power

Having chosen the proposed green solution of installing two 3.5 MWt biomass boilers, the Toledo hospital would be left with the following energy distribution between biomass and the rest of the installations.

Table 15 - Future situation in Toledo's Hospital. Personal creation

Future situation in Toledo's Hospital		
	Biomass	Natural Gas
Heating capacity (MWt)	2x3,5MWt	4x7MWt + 3MWt + 1,6MWt
Production (MWt)	31 742	7 657
%	81%	19%



With this biomass solution, we would reduce the dependence on natural gas to only 19% of the total MWt the hospital needs to operate. This would not only bring economic benefits but also environmental benefits, greatly reducing the hospital's CO2 emissions.

There are numerous options that can be adapted to other hospitals of different sizes and in other geographies and laws such as the Emission Rights Act are pushing private operators to change and improve sustainability.

However, the concessionaire must also ensure that this new investment to reduce future penalty costs can also have economic benefits in addition to the obvious environmental and social benefits. In the following section, we will show a contractual structure where an Energy developer could enter into a partnership with the hospital of Toledo to operate the biomass plants and perform the integral maintenance of the installed biomass boilers.

The following organisational chart sets out the contractual clauses for supply, maintenance and consumption between the New Toledo Hospital and an Energy Company.

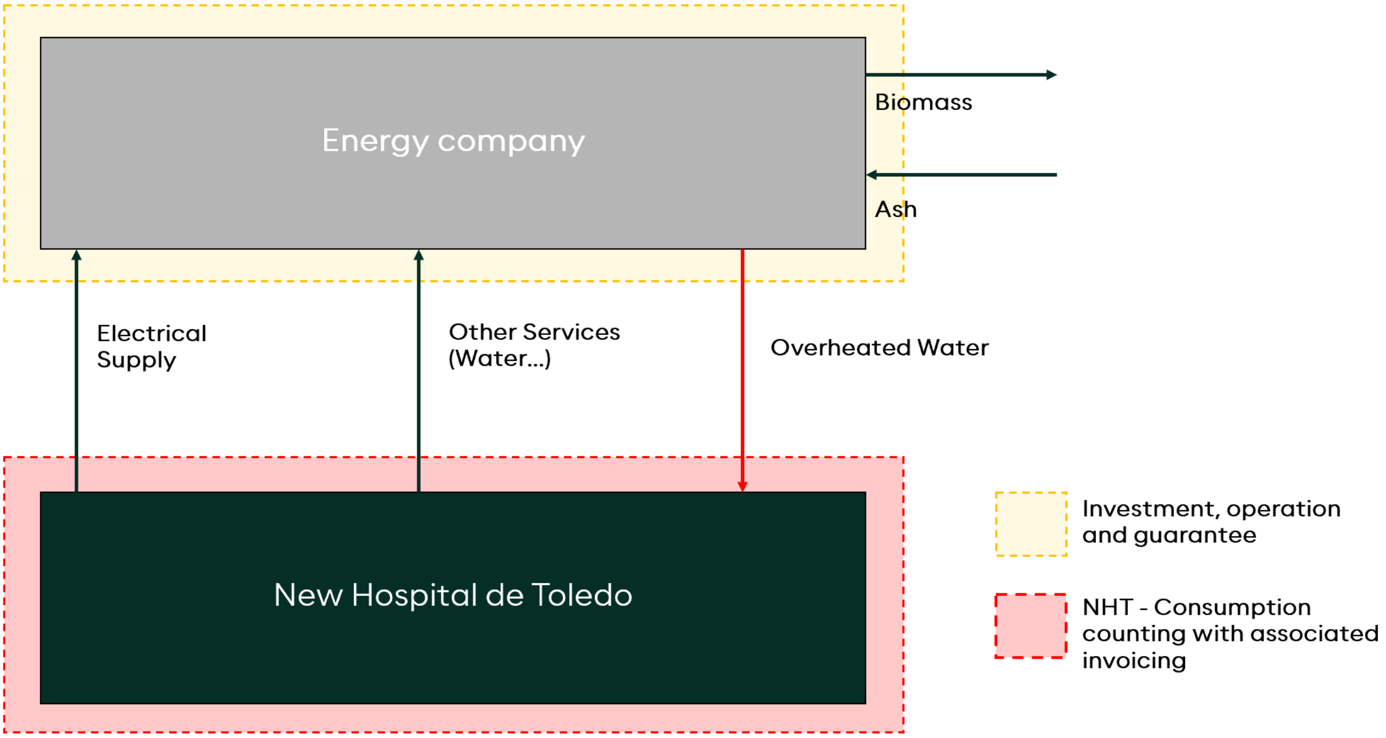


Figure 39 - Commercial case for the biomass installation. Personal creation

Table 16 - Contract proposal. Personal creation

Contract Item	Energy Company	Toledo's Hospital
Investment	X	
Woodchip supply	X	
Ash and waste management	X	
Thermal energy consumption		x
Maintenance	x	

Operating phase to be agreed (duration of 5-25 years)

- Sale of superheated water under agreed quality conditions agreed quality conditions.
- Guarantee of Sanitary heated water supply through biomass.
- Comprehensive operation and maintenance of the plant:
  - Management of fuel supply and management of ashes
  - Preventive, technical-legal and corrective maintenance.
  - Integral operation with 24-hour monitoring service.

With this contractual structure, Toledo Hospital will not be responsible for the performance and supply of energy and supply and will only have to control the consumption coming from the biomass boiler.

Chapter 5. Conclusion

This chapter brings together the conclusions of the aspects presented in the previous chapters, in order to answer the question posed by this work, Can the public-private partnership solution achieve decarbonisation of healthcare infrastructures?

First of all, we have seen that the infrastructures of the healthcare system are in urgent need of decarbonisation in order to contribute globally to the necessary reduction of carbon emissions and to fight against the environment.

The particularity of these infrastructures is that the actions to decarbonise them must also consider environmental, economic and social factors, which are three basic pillars where healthcare has an impact. These actions should maintain the high quality of clinical services with the highest possible resilience. New healthcare infrastructure projects should also ensure community healthcare equity with high accessibility.

As we have explained, the public-private partnership system has features that can help to set these requirements from an early stage of the project, thus helping to achieve decarbonisation and sustainability of facilities. In particular, we have identified four basic drivers to secure decarbonisation:

- Design Approach - from the initial phase all stakeholders will ensure that the healthcare facility is designed with the requirements set by the client, to achieve an overall decarbonisation of the infrastructure, taking into account the embodied carbon during construction and an operational "Net-zero" carbon.
- The hospital's digital solution is essential to measure, evaluate, and monitor the performance of our asset during operation, in order to take action in the event of underperformance or over consumption.
- Evaluation methodology - the PPP system remains flexible in the weighting of the evaluation criteria, being able to give maximum value to the quality, sustainability and resilience criteria that are fundamental to healthcare infrastructure. This evaluation also takes into account economic criteria to ensure the affordability of the project and that is why we have concluded to use a formula that maintains economic competitiveness while respecting the scoring of the quality criteria.
- Strong contractual commitment by the private operator with the payment mechanism, where the necessary deductions will be established to ensure transparent consumption in accordance with

the procurement phase bid back figures. This contract will also ensure the performance of the private party with penalties for any performance or availability failure.

Having analysed the possibilities offered by the PPP system of projects, we can say that a well-structured and flexible process can definitely help to achieve decarbonisation in these infrastructures.

In addition, after presenting these particularities, we can say that the PPP system needs the collaboration and commitment of the public and private sector throughout the life of the project. The private actor will not invest time and resources in bidding for PPP projects with low certainty of public sector commitment.

Political changes also represent a potential risk for project stakeholders, therefore, in the realisation of healthcare infrastructure projects, we must ensure that they follow national and local policies and that they are broadly supported publicly. Some of the characteristics that should prevail for the success of a project are transparency, a strong legislative environment and regulatory framework, public sector capacity to develop projects and stakeholder engagement. The projects must also comply with the affordability limits of the Client.

The public sector must also ensure contract completeness in defining the decarbonisation scheme and ensure that the project meets the requirements of sustainability, environmental, economic and social care. They must also show flexibility in the negotiations to ensure that the project is well defined between the private and the public sector.

We therefore conclude by saying that the public-private partnership system can definitely support and contribute to healthcare infrastructures to meet the strict requirements of decarbonisation and sustainability, but that there must be public goodwill for developing a tailored procurement, and settle detailed requirements that will be key to ensure the decarbonisation of the healthcare infrastructures for the whole project term.

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ANNEXES

Annex 1

$$Price\ Score = 30\% - \left(1\ x\ \frac{Participant\ NPV\ Solution - Lowest\ NPV\ Solution}{\text{Lowest NPV Solution}}\right) \text{x } 30\%$$

Winning NPV	**200**

(NPV of the Annual Service Payment to be paid under the Project Agreement)

Winning Price Mark	**30**
Winning Quality Mark	**70**

Compare NPV in %	**1**
1% Represents --> Pts	0,30

	£ 200	£ 202,0	£ 204,0	£ 206,0	£ 208,0	£ 210,0	£ 212,0	£ 214,0	£ 216,0	£ 218,0	£ 220,0	£ 222,0	£ 224,0	£ 226,0	£ 228,0	£ 230,0	
	Increase on Winning NPV (in millions)																
Quality Mark	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	**Quality Mark % Down**
70	100,0	99,7	99,4	99,1	98,8	98,5	98,2	97,9	97,6	97,3	97,0	96,7	96,4	96,1	95,8	95,5	0%
65	95,0	94,7	94,4	94,1	93,8	93,5	93,2	92,9	92,6	92,3	92,0	91,7	91,4	91,1	90,8	90,5	-7%
60	90,0	89,7	89,4	89,1	88,8	88,5	88,2	87,9	87,6	87,3	87,0	86,7	86,4	86,1	85,8	85,5	-14%
55	85,0	84,7	84,4	84,1	83,8	83,5	83,2	82,9	82,6	82,3	82,0	81,7	81,4	81,1	80,8	80,5	-21%
50	80,0	79,7	79,4	79,1	78,8	78,5	78,2	77,9	77,6	77,3	77,0	76,7	76,4	76,1	75,8	75,5	-29%
45	75,0	74,7	74,4	74,1	73,8	73,5	73,2	72,9	72,6	72,3	72,0	71,7	71,4	71,1	70,8	70,5	-36%
40	70,0	69,7	69,4	69,1	68,8	68,5	68,2	67,9	67,6	67,3	67,0	66,7	66,4	66,1	65,8	65,5	-43%
35	65,0	64,7	64,4	64,1	63,8	63,5	63,2	62,9	62,6	62,3	62,0	61,7	61,4	61,1	60,8	60,5	-50%
30	60,0	59,7	59,4	59,1	58,8	58,5	58,2	57,9	57,6	57,3	57,0	56,7	56,4	56,1	55,8	55,5	-57%
25	55,0	54,7	54,4	54,1	53,8	53,5	53,2	52,9	52,6	52,3	52,0	51,7	51,4	51,1	50,8	50,5	-64%
20	50,0	49,7	49,4	49,1	48,8	48,5	48,2	47,9	47,6	47,3	47,0	46,7	46,4	46,1	45,8	45,5	-71%
15	45,0	44,7	44,4	44,1	43,8	43,5	43,2	42,9	42,6	42,3	42,0	41,7	41,4	41,1	40,8	40,5	-79%
10	40,0	39,7	39,4	39,1	38,8	38,5	38,2	37,9	37,6	37,3	37,0	36,7	36,4	36,1	35,8	35,5	-86%
5	35,0	34,7	34,4	34,1	33,8	33,5	33,2	32,9	32,6	32,3	32,0	31,7	31,4	31,1	30,8	30,5	-93%
0	30,0	29,7	29,4	29,1	28,8	28,5	28,2	27,9	27,6	27,3	27,0	26,7	26,4	26,1	25,8	25,5	-100%

Corresponding Price Mark

$$Price\ Score = 30\% - \left(2\ x\ \frac{Participant\ NPV\ Solution - Lowest\ NPV\ Solution}{\text{Lowest NPV Solution}}\right)\ \text{x}\ 30\%$$

Winning NPV	200

(NPV of the Annual Service Payment to be paid under the Project Agreement)

Winning Price Mark	30
Winning Quality Mark	70

Compare NPV in %	1
1% Represents --> Pts	0,60

Quality Mark	£ 200	£ 202,0	£ 204,0	£ 206,0	£ 208,0	£ 210,0	£ 212,0	£ 214,0	£ 216,0	£ 218,0	£ 220,0	£ 222,0	£ 224,0	£ 226,0	£ 228,0	£ 230,0	Quality Mark % Down
	Increase on Winning NPV (in millions)																
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	
70	100,0	99,4	98,8	98,2	97,6	97,0	96,4	95,8	95,2	94,6	94,0	93,4	92,8	92,2	91,6	91,0	0%
65	95,0	94,4	93,8	93,2	92,6	92,0	91,4	90,8	90,2	89,6	89,0	88,4	87,8	87,2	86,6	86,0	-7%
60	90,0	89,4	88,8	88,2	87,6	87,0	86,4	85,8	85,2	84,6	84,0	83,4	82,8	82,2	81,6	81,0	-14%
55	85,0	84,4	83,8	83,2	82,6	82,0	81,4	80,8	80,2	79,6	79,0	78,4	77,8	77,2	76,6	76,0	-21%
50	80,0	79,4	78,8	78,2	77,6	77,0	76,4	75,8	75,2	74,6	74,0	73,4	72,8	72,2	71,6	71,0	-29%
45	75,0	74,4	73,8	73,2	72,6	72,0	71,4	70,8	70,2	69,6	69,0	68,4	67,8	67,2	66,6	66,0	-36%
40	70,0	69,4	68,8	68,2	67,6	67,0	66,4	65,8	65,2	64,6	64,0	63,4	62,8	62,2	61,6	61,0	-43%
35	65,0	64,4	63,8	63,2	62,6	62,0	61,4	60,8	60,2	59,6	59,0	58,4	57,8	57,2	56,6	56,0	-50%
30	60,0	59,4	58,8	58,2	57,6	57,0	56,4	55,8	55,2	54,6	54,0	53,4	52,8	52,2	51,6	51,0	-57%
25	55,0	54,4	53,8	53,2	52,6	52,0	51,4	50,8	50,2	49,6	49,0	48,4	47,8	47,2	46,6	46,0	-64%
20	50,0	49,4	48,8	48,2	47,6	47,0	46,4	45,8	45,2	44,6	44,0	43,4	42,8	42,2	41,6	41,0	-71%
15	45,0	44,4	43,8	43,2	42,6	42,0	41,4	40,8	40,2	39,6	39,0	38,4	37,8	37,2	36,6	36,0	-79%
10	40,0	39,4	38,8	38,2	37,6	37,0	36,4	35,8	35,2	34,6	34,0	33,4	32,8	32,2	31,6	31,0	-86%
5	35,0	34,4	33,8	33,2	32,6	32,0	31,4	30,8	30,2	29,6	29,0	28,4	27,8	27,2	26,6	26,0	-93%
0	30,0	29,4	28,8	28,2	27,6	27,0	26,4	25,8	25,2	24,6	24,0	23,4	22,8	22,2	21,6	21,0	-100%

Corresponding Price Mark

$$Price\ Score = 30\% - \left(3\ x\ \frac{Participant\ NPV\ Solution - Lowest\ NPV\ Solution}{\text{Lowest NPV Solution}}\right) \text{x } 30\%$$

Winning NPV	200

(NPV of the Annual Service Payment to be paid under the Project Documentation)

Winning Price Mark	30
Winning Quality Mark	70

Compare NPV in %	1
1% Represents --> Pts	0,90

	£ 200	£ 202,0	£ 204,0	£ 206,0	£ 208,0	£ 210,0	£ 212,0	£ 214,0	£ 216,0	£ 218,0	£ 220,0	£ 222,0	£ 224,0	£ 226,0	£ 228,0	£ 230,0	
	Increase on Winning NPV (in millions)																
Quality Mark	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	**Quality Mark % Down**
70	100,0	99,1	98,2	97,3	96,4	95,5	94,6	93,7	92,8	91,9	91,0	90,1	89,2	88,3	87,4	86,5	0%
65	95,0	94,1	93,2	92,3	91,4	90,5	89,6	88,7	87,8	86,9	86,0	85,1	84,2	83,3	82,4	81,5	-7%
60	90,0	89,1	88,2	87,3	86,4	85,5	84,6	83,7	82,8	81,9	81,0	80,1	79,2	78,3	77,4	76,5	-14%
55	85,0	84,1	83,2	82,3	81,4	80,5	79,6	78,7	77,8	76,9	76,0	75,1	74,2	73,3	72,4	71,5	-21%
50	80,0	79,1	78,2	77,3	76,4	75,5	74,6	73,7	72,8	71,9	71,0	70,1	69,2	68,3	67,4	66,5	-29%
45	75,0	74,1	73,2	72,3	71,4	70,5	69,6	68,7	67,8	66,9	66,0	65,1	64,2	63,3	62,4	61,5	-36%
40	70,0	69,1	68,2	67,3	66,4	65,5	64,6	63,7	62,8	61,9	61,0	60,1	59,2	58,3	57,4	56,5	-43%
35	65,0	64,1	63,2	62,3	61,4	60,5	59,6	58,7	57,8	56,9	56,0	55,1	54,2	53,3	52,4	51,5	-50%
30	60,0	59,1	58,2	57,3	56,4	55,5	54,6	53,7	52,8	51,9	51,0	50,1	49,2	48,3	47,4	46,5	-57%
25	55,0	54,1	53,2	52,3	51,4	50,5	49,6	48,7	47,8	46,9	46,0	45,1	44,2	43,3	42,4	41,5	-64%
20	50,0	49,1	48,2	47,3	46,4	45,5	44,6	43,7	42,8	41,9	41,0	40,1	39,2	38,3	37,4	36,5	-71%
15	45,0	44,1	43,2	42,3	41,4	40,5	39,6	38,7	37,8	36,9	36,0	35,1	34,2	33,3	32,4	31,5	-79%
10	40,0	39,1	38,2	37,3	36,4	35,5	34,6	33,7	32,8	31,9	31,0	30,1	29,2	28,3	27,4	26,5	-86%
5	35,0	34,1	33,2	32,3	31,4	30,5	29,6	28,7	27,8	26,9	26,0	25,1	24,2	23,3	22,4	21,5	-93%
0	30,0	29,1	28,2	27,3	26,4	25,5	24,6	23,7	22,8	21,9	21,0	20,1	19,2	18,3	17,4	16,5	-100%

Corresponding Price Mark

Annex 2

Emission factors in CO2e (kgCO2e/unit)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gasóleo C (l)	2,898	2,898	2,898	2,898	2,898	2,898	2,898	2,898	2,898	2,898	2,898	2,898	2,898	2,898	2,898
Gasóleo B (l)	2,726	2,726	2,726	2,726	2,726	2,726	2,726	2,726	2,726	2,726	2,726	2,726	2,726	2,726	2,726
Gas natural (kWh_{PCS})*	0,182	0,182	0,182	0,182	0,182	0,009	0,182	0,161	0,182	0,182	0,183	0,183	0,181	0,182	0,182
Fuelóleo (l)	3,031	3,031	3,031	3,031	3,031	3,031	3,031	3,031	3,031	3,031	3,031	3,031	3,031	3,031	3,031
LPG (l)	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545	1,545
Gas propano (kg)	2,966	2,966	2,966	2,966	2,966	2,966	2,966	2,966	2,966	2,966	2,966	2,966	2,966	2,966	2,966
Gas butano (kg)	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996
Gas manufacturado (kg)	0,881	0,881	0,881	0,881	0,881	0,881	0,881	0,881	0,881	0,881	0,881	0,881	0,881	0,881	0,881
Biogás (kg)**	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001
Biomasa madera (kg)**	0,137	0,137	0,137	0,137	0,137	0,137	0,137	0,137	0,137	0,137	0,137	0,137	0,137	0,137	0,137
Biomasa pellets (kg)**	0,171	0,171	0,171	0,171	0,171	0,171	0,171	0,171	0,171	0,171	0,171	0,171	0,171	0,171	0,171
Coque de petróleo (kg)	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183
Coque de carbón (kg)	3,036	3,036	3,036	3,036	3,036	3,036	3,036	3,036	3,036	3,036	3,036	3,036	3,036	3,036	3,036
Hulla y antracita (kg)	3,138	3,138	3,138	3,138	3,138	3,138	3,138	3,138	3,138	3,138	3,138	3,138	3,138	3,138	3,138
Hullas subituminosas (kg)	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340

* Emission factor of natural gas expressed in kgCO2/kWhPCS (gross calorific value). The conversion factor of 0.901 is used for the change from PCS to PCI.

** The use of biomass (wood, pellets or biogas) as fuel is considered CO2 neutral as it is of biogenic origin, but it will produce CH4 and N2O emissions. For the calculations, the CO2 emission factor shall be assumed to be 0 kgCO2/kg. The CO2 emission factors irrespective of biogenic origin would be: for biogas 1.369 kgCO2/kg, for wood 1.617 kgCO2/kg and for pellets 2.025 kgCO2/kg.