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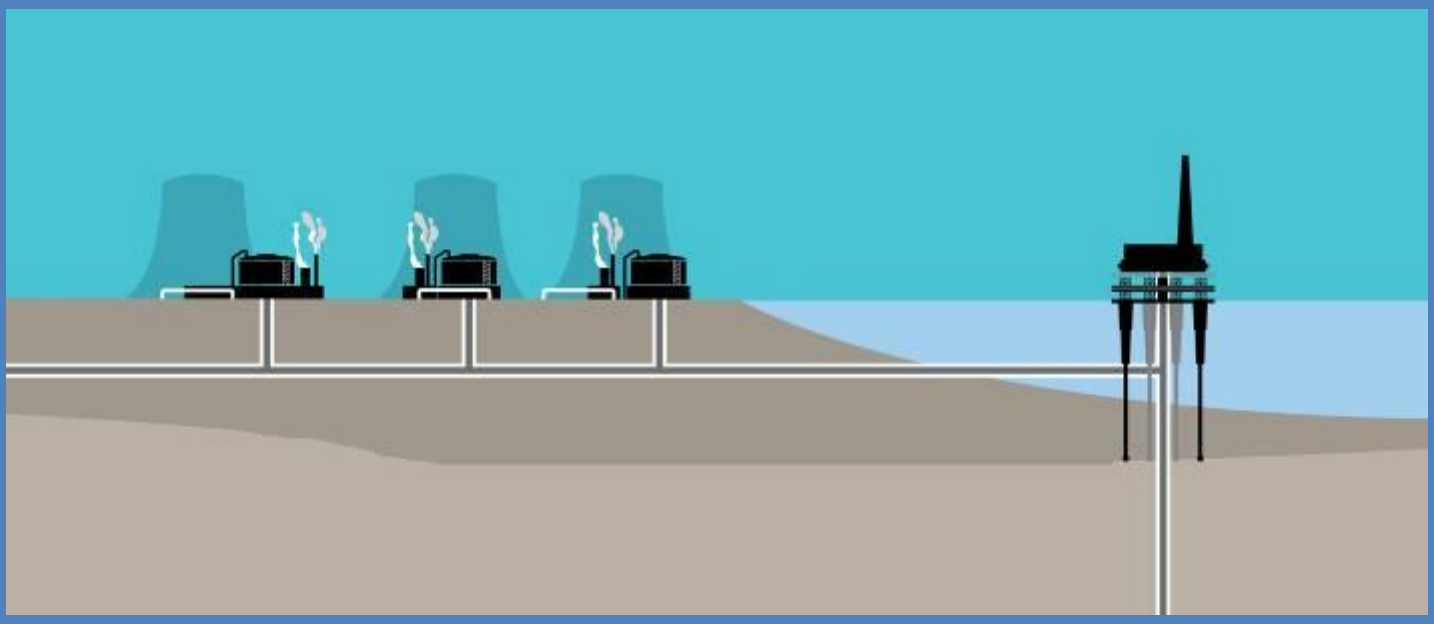

Capacity Charging Mechanism for Shared CO_2 Transportation and Storage Infrastructure

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Date: 5 May 2013

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Abbreviations and Glossary

CCS	Carbon Capture and Storage
CO_2	Carbon Dioxide
GB	Great Britain
NGC	National Grid Carbon
SO	System Operator of the shared infrastructure system
The Institute	Global CCS Institute
UK	United Kingdom
In this report the words and phrases below have the meanings described on their right	
CCS Directive	DIRECTIVE 2009/31/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the geological storage of carbon dioxide…
Mark up	a profit margin applied to a cost which is recovered within a period over which the cost of finance associated with that cost is insignificant.
Rate of Return	a profit margin applied to a cost which is recovered over a period, or after a period, which is of sufficient length that the cost of finance associated with the cost is significant.

1 INTRODUCTION

National Grid is an internationally recognised leader in the safe development and operation of large capacity, multi-user, energy transmission systems. In the UK, National Grid owns and operates the electricity and gas transmission infrastructure at the centre of Britain's energy system and in the North Eastern states of the USA, National Grid provides gas and electricity directly to millions of customers. National Grid Gas runs Britain's high pressure gas transmission system as well as four of its eight gas distribution networks, delivering gas to 11 million homes and businesses. National Grid Electricity Transmission runs Britain's electricity transmission system. National Grid also owns and operates a number of other energy related business in the UK, including LNG importation facilities and National Grid Carbon Limited.

National Grid Carbon Limited (NGC) is a wholly owned subsidiary of National Grid engaged in the development of carbon dioxide (CO_2) transportation and storage infrastructure in the UK as part of the emerging Carbon Capture and Storage (CCS) industry. NGC wishes to develop such infrastructure as multi-user systems in the most efficient manner possible and in a way that supports the growth of the CCS industry in the UK.

The Global CCS Institute aims to accelerate the adoption of carbon capture and storage (CCS), a key solution in mitigating climate change and providing energy security. It brings together projects, policy-makers and researchers to overcome challenges facing CCS.

The Institute uses the lessons learnt by CCS projects around the world to provide information to a broader audience, thus enhancing the understanding of technical, economic, financial, commercial, and engagement issues facing CCS project developers. It works collaboratively to build and share the expertise necessary to ensure that CCS can make a significant impact on reducing the world's greenhouse gas emissions. One of the ways in which the Institute achieves its aims is by providing funding support to CCS projects around the world in return for Targeted reports that the Institute disseminates for the benefit of the broader CCS community.

This Report is in four parts:

Part 1 provides: firstly, some background discussion regarding a wide range of issues associated with the development of, and charging for, CCS infrastructure capacity; and, secondly, introduces a fictitious but representative regional CCS infrastructure development case study that will be used throughout this Targeted Report in order to illustrate the operation of the mechanisms and the concepts discussed.

Part 2 sets out a commercial charging mechanism for the development and use of assets connecting a system user's carbon dioxide source to a shared CCS infrastructure system.

Part 3 sets out a commercial charging mechanism for the development of, access to, and subsequent use of, a shared CCS infrastructure system.

Part 4 contains an exploration of a number of options for varying the proportional allocation of system development and operational costs between members of a shared CCS infrastructure system user group and discussion regarding the possible effects of the application of those options on the development of CCS infrastructure specifically and the CCS industry generally.

Parts 2 and 3 are drafted in the form of a formal System Code. This has been done to provide the greatest clarity with regard to the rights and obligations of the system operator and the system users. Some explanatory commentary and discussion is included, in italic font, in those Parts.

1.1 ASSUMPTIONS

For the purposes of developing the capacity charging mechanism concepts presented in this Report the following assumptions have been made with respect to the development and operation of the infrastructure system and the mechanism itself:

- the infrastructure system will be built, owned and operated by a system operator providing carbon dioxide transportation and storage services to other organisations;
- capacity will be offered to multiple users in any CO_2 transportation or storage system developed;
- each user of the shared capacity system will require a physical connection to that system. To the extent that such connection is provided, operated, maintained or decommissioned by the infrastructure system owner/operator, the charges for those services will be charged in accordance with a non-discriminatory and transparent charging methodology; and
- the system will be subject to a third party access regime similar to that under European law, i.e. one which requires that access to carbon dioxide transportation and storage infrastructure must be provided by the operator of that system in an open, fair, non-discriminatory and transparent manner, to third parties seeking such access.

Part 1 – Background Discussion and Case Study

2 BACKGROUND DISCUSSION

2.1 BACKGROUND

It is now widely accepted that the emission into the atmosphere of large quantities of anthropogenic CO_2 is a major contributory factor to the threat of significant and detrimental climate change. A large proportion of this CO_2 is emitted from fossil fuel burning electricity generating plants and other carbon intensive industrial processes. The continued operation of these plants and processes is essential for the maintenance of the economies and standards of living of the people living in the countries in which they are located.

This situation creates an obvious tension between the imperative for CO_2 emissions be reduced and the desire to continue industrial operations which maintain high standards of living but generate large quantities of CO_2. CCS offers a way to remove this tension by allowing the continued production of CO_2 without the emission of that CO_2 to atmosphere and the associated affects on the climate. The development of CCS is therefore increasingly recognised as being a key technology if energy security and economic growth are to be maintained without incurring damaging climate change.

There are many technical challenges associated with the successful development and operation of CCS systems. However, significant amounts of effort have now been, and continue to be, put in to addressing these challenges and it is currently considered extremely unlikely that any insuperable technical problems remain which could render CCS at industrial scale technically infeasible. National Grid Carbon, for example, continues to carry out a large CO_2 transportation and storage research and development programme, part funded through the EU European Energy Programme for Recovery (EEPR).

Similarly, the legal impediments to the development of CCS projects are increasingly being removed. In Europe, and the UK specifically, there is now a reasonably well developed framework of legislation and regulation within which CCS projects can develop. It is also becoming increasingly clear how non-CCS-specific law, particularly planning and consenting regulation, will be applied to CCS. As examples of the progress in these areas: National Grid Carbon have been granted a Carbon Dioxide Appraisal and Storage Licence[1] and have completed an Agreement for Lease with The Crown Estate[2] with respect to a storage site it is developing in the Southern North Sea and, in addition, it has carried out public consultations and environmental impact studies, and formally notified the Planning Inspectorate, as part of the development consent acquisition process[3] with regard to carbon dioxide pipeline routings and onshore plant installations.

[1] Granted under The Storage of Carbon Dioxide (Licensing) Regulations 2010 as required by the Energy Act 2008.

[2] As required under the terms of the Licence and in accordance with the powers granted by the Energy Act 2008.

[3] Under the auspices of the Planning Act 2008 as amended by the Localism Act 2011. For further information see www.ccshumber.co.uk.

With the technical and legal barriers and risks associated with CCS diminishing, difficulties with developing a sound commercial case for the development and operation of CCS infrastructure now represent the most serious obstacles to the growth of the CCS industry. One significant difficulty is associated with the unattractive combination of high development cost (incorporating necessary high risk premiums) coupled with revenue streams based upon carbon prices which are currently low and which have future value trends that are difficult to predict. In the UK, the government has recognised this problem and is currently progressing a number of measures to financially support the UK's first, full-scale, CCS projects. However, this support is intended to endure for only the relatively short term and, if the industry is to continue to grow once state support is no longer available, must be replaced by cost reduction and increased certainty of operational revenues. National Grid Carbon is constantly seeking ways to deliver these.

2.2 Infrastructure Economies of Scale

One way in which significant reductions in the cost of CCS may be achieved is by realising the potential economies of scale associated with the sharing, by several operators of separate CO_2 generating plants, of a single CO_2 transportation and storage infrastructure system. Such sharing reduces the cost of the provision of transportation and storage services to each individual plant operator because the costs per unit capacity associated with the development and operation of single, large capacity, infrastructure assets and plant are lower than those associated with the development and operation of multiple, smaller capacity, assets or plants of the same aggregate capacity.

There are two elements to the available economy of scale: firstly, the larger the capacity of the system being developed the greater the capacity over which the fixed costs of project development can be distributed and hence the lower the cost-per-unit-capacity associated with the fixed costs of running the project; and, secondly, as the capacity of the system being developed increases, the cost of providing each additional unit of capacity (i.e. the marginal cost of capacity) decreases. This means that, when considering the development of a single infrastructure system in isolation, generally, as the capacity of the system under development increases, the incremental cost of providing each subsequent unit of capacity will decrease[4].

The cost per unit capacity used is also decreased by the sharing of services and personnel associated with operating a single combined infrastructure system rather than several separate systems.

However, despite these economies of scale, the marginal cost of providing additional system capacity is never zero. Therefore, if it is proposed to construct such additional capacity for future use, as is, by definition, necessary if the infrastructure is to be built to accommodate industry expansion, then there will be an increase in the aggregate cost of the project as a whole and that additional cost may not be covered by any of the initial users of the system. This conflicts with the need to keep the absolute costs of the initial infrastructure development of CCS projects as low as possible.

[4] The upward capacity range in which economies of scale can be achieved is restricted. In the case of some asset types, scale economies become negative above a certain capacity (e.g. pipelines) and for others, maximum capacity is physically or technically restricted (e.g. storage reservoirs).

This problem is alleviated to some extent by the fact that not all of the assets required to provide the anticipated peak capacity of the system need be constructed in the first phase of the system's development. Some system components, those which will not be required until that point in the future when the system is to operate at above the initially required capacity, need not be procured and installed until they are required. These component parts would typically include: some rotating machinery; offshore facilities; and wells. This delay in procurement delays the project's initial capital outlay and thereby improves the project's cash flow requirements.

2.3 Other Arguments for Infrastructure Sharing

As set out above, currently the primary driver for the development of shared CCS infrastructure is cost reduction. However, there are a number of other strong arguments in favour of the development of CCS infrastructure with the design flexibility to provide capacity to the CCS market as it develops.

Reduces Barriers to Entry

The lack of available CCS infrastructure capacity on known terms is a major barrier to operators of large CO_2 emitting plants taking the decision to invest in CO_2 capture plant and installing CCS.

Such operators have an in-depth understanding of the costs and revenues associated with the operation of their plants going forward, including a view with regard to the cost of carbon that their business will have to bear. The cost of installing and operating CO_2 capture and compression facilities for each operator's plant are also discoverable if study work is carried out. But there would be a cost associated with this and there is little incentive for plant operators to commit to this expenditure if they have no way of knowing what the cost of CO_2 disposal would be and therefore cannot complete the business case calculation for the installation of CCS to their plant.

The knowledge that CO_2 disposal services are available, and the price of procuring them, would remove this lack of information and allow CCS investment decisions to be made.

Reduces Community and Environmental Disruption and Cost

The development of large scale infrastructure has a significant impact on the environment and communities in and around the area in which the infrastructure is constructed. Some of these impacts are negative and some are positive, some short-term and some long-term, but they are all disruptive and, at least with regard to the disruption they cause, are unwelcome.

It is therefore preferable that the duration and occurrence of infrastructure construction works should be minimised. Achievement of this aim is furthered if the infrastructure installed in any particular region has, or has the flexibility to be modified to have, the maximum capacity that might reasonably be required by the CO_2 emitters in that region over the design life of the infrastructure.

Creates and Protects Industry and Employment

The existence of an effective taxation on CO_2 emissions, in the form of the EU ETS, imposes operational costs on CO_2 emitting businesses which are both onerous and uncertain going forward. If an industrial operator can produce its products in a jurisdiction in which carbon costs do not apply and transport those products into the same markets that it currently supplies then there will be a

commercial pressure for that operator to relocate or, if it is considering establishing a new plant, to locate that plant in the jurisdiction in which carbon emissions are free.

The availability of CCS infrastructure militates against this effect by reassuring industrial operators that the possibility of avoiding carbon costs is available at a predictable and affordable cost.

2.4 Developing Optimal System Capacity

Some assets (the 'Keystone Assets') cannot be retrofitted or have their capacity increased after the system's initial construction. These must therefore be constructed and installed, with a capacity equal to the peak design capacity of the system as a whole, during the first phase of the infrastructure system's development. Notable Keystone Assets include: shared pipelines, offshore support structures and future equipment installation space (both onshore and offshore). The cost of installing the system's peak design capacity into the Keystone Assets and, to some extent, the cost of building sufficient up-scaling flexibility into the other assets constructed during the first phase of the project, will incur costs which are additional to the cost of developing a system with a capacity only sufficient for the initial system user or users.

Nevertheless, in order to capture the maximum economies of scale and provide system capacity for the maximum number of commercially viable system users (the 'optimum system capacity'), an infrastructure design which incorporates the flexibility for capacity expansion to the optimum system capacity must be produced and therefore those elements of the system which are Keystone Assets must be built with the optimum system capacity incorporated during the systems initial development.

This requirement poses two questions: firstly, what is the optimum system capacity, and secondly, how can the development of infrastructure with that capacity be financed? These two issues are highly and circularly interdependent: the optimum system capacity is dependent upon the demand for that capacity; this, in turn, is dependent upon the cost per unit capacity in the system; which is dependent upon the system capacity (as this governs the economies of scale achieved).

The circular nature of this interdependence suggests the need for the adoption of an iterative process for the discovery of the optimum system capacity. There are practical challenges with carrying out a fully iterative market demand discovery process, however, National Grid Carbon has a wealth of expertise in the discovery of market demand for infrastructure system capacity and is developing a market demand discovery process specifically aimed at the demand for CCS infrastructure capacity.

2.5 Disincentives Against Shared System Use

In the discussion above it is implied that a CCS project developer would always wish to use shared infrastructure when it is available. There are, however, a number of perceived disadvantages associated with the utilisation of shared infrastructure, primarily these are : the associated increase in technical and commercial complexities; the potential increase in operational constraints; and the risk of interference or interruption to one user's operations due to the actions or omissions of another user.

All of these issues can be satisfactorily addressed by the shared-system operator via development and application of suitable contractual and technical frameworks; nevertheless the negative value attached to them by CCS developers persists.

This being the case, a CCS developer's decision making process, when considering infrastructure sharing, includes a comparison of the reduction of overall project costs to be gained against the perceived increase in cost and risk incurred.

2.6 Capacity Charging Mechanism

As part of its development of a market discovery process, NGC has considered how the costs associated with the provision of capacity in, and transportation services through, a CO_2 transportation system, might, most effectively, be distributed across a suite of charges and between those using the system. In particular, and for the reasons given above, NGC has been developing concepts for a capacity charging mechanism which would enable the developers of UK's first CCS projects to design and build CO_2 transportation and storage systems which have the flexibility, including the correctly sized Keystone Assets, to provide the optimum system capacity when it is required.

This Targeted Report Shares NGC's conceptual thinking for such a capacity charging mechanism for CCS transportation and storage infrastructure. Whilst the thinking stems from NGC's direct participation as a CCS transport and storage infrastructure proponent in the UK, the concepts are presented and discussed in a way that is intended to facilitate understanding and stimulate further consideration of the issues by a wide audience having regard to jurisdictions outside of the UK. The concepts discussed do not represent NGC's final or recommended capacity charging mechanism for general or specific use. Equally, a number of the assumptions made and calculation methodologies used (e.g. with regard to payment periods and profit recovery mechanisms) have been selected, to some degree, arbitrarily and might be replaced with alternatives without altering the structure or principles of the capacity charging mechanism generally. NGC continues development work in this subject area particularly in the context of the evolving structure of state and market support mechanisms for CCS in the UK. The development of a capacity charging mechanism for application to CO2 infrastructure must consider the legal and regulatory context within which that mechanism will operate and any legal restrictions or requirements placed upon the developer / operator of such infrastructure. This section provides a brief discussion of the main areas of CCS affecting legislation and regulation that have been considered in the process of developing the capacity charging mechanism concepts included in this report.

2.7 Legal and Regulatory Context

2.7.1 Third Party Access

The European CCS Directive[5] deals, inter alia, with the provision of third party access to CO_2 transport networks and storage sites. The Directive requires[6] that European Member States shall

[5] DIRECTIVE 2009/31/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006

[6] Ibid. at Article 21.

take the necessary measures to ensure that third parties wishing to do so are able to obtain access to CO_2 transport networks and to storage sites and that such access should be provided in a transparent and non-discriminatory manner and that the objectives of fair and open access are applied.

Third party access can be refused on certain grounds, however Member States are required to take the measures necessary to ensure that an operator refusing access on the grounds of lack of capacity or a lack of connection makes any necessary enhancements as far as it is economic to do so or when a potential system user is willing to pay for them, provided this would not negatively impact on the environmental security of the transport and geological storage of CO_2[7].These third party access requirements of the Directive have been transposed into UK law by the CCS Third Party Access Regulations[8]. The third party access model upon which the Regulations are based is taken from the third party access regime applied to on and offshore oil, gas and chemicals pipelines and associated infrastructure. This model provides that third parties who potentially may wish to procure access to relevant infrastructure shall be informed of the development of new infrastructure as well as available capacity in that which already exists. Any third party may apply to the system developer / operator seeking that the new infrastructure be constructed with the system capacity it requires, or that it be given access to the spare capacity in the existing infrastructure, whatever is applicable. If the third party's request is refused, or granted on terms which are not acceptable to the third party, then the third party may apply to the Secretary of State for a notice that it be provided with access to the system on the terms stipulated in the notice.

The Regulations also contain some guidance regarding the basis upon which the access terms incorporated in the notice will be derived[9]. This includes broad guidance regarding the way in which different categories of system development costs would be regulated.

For the reasons given above, the Regulations have a significant interrelation with both the mechanisms for charging for capacity in CCS infrastructure and the stages of development at which third parties are likely to declare their desire to acquire access to such capacity.

2.7.2 Consenting

The construction of infrastructure and plant in the UK (both onshore and offshore) requires the consent of a number of statutorily empowered bodies. These consents come in the form of various approvals, licences and permissions and ensure a large range of statutory rules with respect to, inter alia: right to develop; protection of others' interests; environmental protection; and health and safety, are complied with.

The acquisition of a number of these consents requires lengthy application procedures and/or studies to be carried out, the basis of which must be known at the time at which the application for

[7] It is worth noting that the Directive requires that, in a report to be submitted by 31 March 2015, a number of issues are to be assessed, including the experience with regard to the Directive's provisions on third party access, and a proposal for revision of the Directive made, where appropriate. This obviously introduces the potential that the third party access provisions of the Directive might be significantly amended in the foreseeable future.

[8] S.I. 2011/2305 Environmental Protection The Storage of Carbon Dioxide (Access to Infrastructure) Regulations 2011.

[9] Further guidance on the basis of derivation of access terms is expected from the UK Government's Department of Energy and Climate Change.

the consent is submitted. In some cases, a material alteration to the basis of the application will necessitate a full or partial re-application.

The basis upon which an application is made might be altered by a change in infrastructure system capacity or specification. This means that amendments to a system's design capacity brought about by the introduction of an additional user, part-way through the consent application process, has the potential to delay the relevant development project, increase consenting costs and, in some circumstances, lead to the potential refusal of consents that would otherwise be granted.

Hence the addition of capacity to a system's basis of design, to accommodate one system user, may adversely impact the provision of system capacity and services to other system users and the magnitude of such impact will vary depending upon the point in the project at which the increase in capacity is made.

There is therefore a significant interrelation between an infrastructure development project's consenting programme and the ability of that project to accommodate requests for additional system capacity, and the cost associated with such accommodation, at various points in the project's progress. This must be reflected in both the procedure followed to secure system users and the mechanism which governs the charges levied for system capacity.

2.7.3 Emissions Trading Schemes / Enhanced Oil Recovery / Taxation Schemes

European law establishes a greenhouse gas emissions trading scheme which commoditises CO_2 emissions by creating a requirement for generators of large quantities of CO_2 to purchase and submit EU Emissions Trading Scheme Allowances ('EUA's') in proportion to the amount of CO_2 which that generator emits to atmosphere. Amendments to the scheme, designed to facilitate the development of CCS, provide that the requirement to submit EUA's is avoided if the CO_2 in question is captured and permanently stored[10]. It is a fundamental of the economics of all European CCS projects that the savings generated by this avoidance is a significant revenue stream for those projects.

In the case of some CCS projects, the ETS related revenue stream described above may be intended to be augmented by the sale of the CO_2 captured as part of the project's operations. In most cases the CO_2 is planned to be injected into a hydrocarbon reservoir with the object of increasing the recovery of hydrocarbons from that reservoir. This is known as enhanced oil recovery (EOR).

With respect to CCS/EOR projects, the level of oil revenue related taxes charged to a project also has a potentially significant effect on that project's economics. This area of tax legislation is one that changes regularly in the UK as the Government attempts to encourage continued investment in the UK oil and gas production thereby maintaining the associated tax revenues.

The cost of capturing a given quantity of CO_2, and, where relevant, of delivering and injecting that CO_2 into a hydrocarbon reservoir will vary from project to project. This creates a situation in which the price at which CO_2 transportation and, where relevant, storage services are affordable varies

[10] See 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, as amended.

from project to project. This situation raises questions regarding how a capacity charging mechanism should be designed to balance fairness in the charges made to all system users with a desire to develop a system with sufficient, affordable, capacity for users with less favourable, but still potentially viable, project economics.

2.7.4 Electricity Market Reform

The current proposals for the reform of the UK's electricity market envisage the provision of revenue support to electricity generators operating CCS via a system of Feed-in Tariff Contracts for Differences (CfD's).

Therefore, based upon a similar rationale to that described in section 2.7.3 above, it may prove necessary to consider whether a CCS infrastructure system capacity charging mechanism should generate levels of charges which reflect the amount of CfD support received by each system user.

2.7.5 State aid and Competition Law

As well as the CCS specific legal issues discussed above, there are a number of more general legal areas which have been considered in the development of the capacity charging mechanism concept presented in this report. These include:

State aid: injudicious charging mechanism design might lead to criticism that state support, the primary purpose of which has received State aid approval, is being used to cross-subside a project or aim for which State aid has not been approved.

Competition Law: the avoidance of market distortion is one of the main purposes of the European Union and accordingly the prohibition of anti-competitive practices is an aim which underpins much of the EU acquis communautaire[11] and penalties for breach of competition law are potentially severe. This must be borne in mind when designing a mechanism to set charges for access to high capital cost infrastructure (traditionally the subject of a 'natural monopoly') the use of which has the potential to significantly affect the price of the products produced by its users (electricity, steel, cement, etc) and therefore the markets for those products.

2.8 Market Discovery

As mentioned above in section 2.4, the capacity charging mechanism concepts described in this report are part of a wider body of work being carried out by National Grid Carbon. This work includes considering the design of a market demand discovery process specifically aimed at discovering the demand for CCS infrastructure capacity in a particular geographical region in order to ascertain the optimum capacity of an infrastructure system designed for that region.

It is not the purpose of this Report to discuss market demand discovery in any great detail. However, there is a close interrelation between demand for capacity in a system and the capacity charging mechanism applied to that system. The way in which the relevant charging mechanism shares economies of scale between system users, and the way in which it allows for the variation of system capacity value across the range of potential system users, are particularly important factors in this regard.

[11] The acquis communautaire is the complete collection of legal instruments comprising the laws of the European Union.

It is also worth mentioning here that the particularities of the legal and commercial framework in which CCS projects are developing (some of which are discussed above) will mean that, in order to be effective, a market demand discovery exercise with respect to CCS infrastructure will be different to that used for other infrastructure networks and, as the chosen capacity charging mechanism is a key component in the demand discovery exercise, the design of the capacity charging mechanism must take into consideration these commercial particularities.

2.8.1 Options

One area of difficulty, when trying to define the optimum system capacity of an infrastructure system with a long operational life, is that a proportion of potential system users will not require access to system capacity until a significant period after the infrastructure is developed. At the time of the system's development, the magnitude of the peak capacity requirement, the date at which it will be required, and whether such requirement will transpire at all, can be uncertain. This generates a difficulty in deciding: firstly whether the relevant potential user's capacity should be built into the system; and, secondly, if it should be, then how it will be financed.

Neither the system developer nor the potential system user wish to finance the construction of stranded asset capacity but, equally, neither wishes to lose the opportunity to construct potentially valuable system capacity at the significant discount in cost generated by the economies of scale achieved by incorporating that capacity in a system currently under development.

One method of alleviating this difficulty is for the system developer to share the risk of speculative investment in system capacity with potential future system users by offering those users the option to access the capacity they need, when they need it, in return for a payment to secure that option. This payment (the 'option price') would partially fund the development of the relevant additional capacity in the system and, in the event that the potential system user (the 'option holder') wishes to exercise the option then it would pay a further charge (the 'option exercise fee').

Once the relevant system user had exercised its option then it would enter into a transportation (and, if relevant, storage) services contract and start to pay system capacity charges as determined by the system capacity charging mechanism. Therefore, to ensure contractual certainty, the capacity charging mechanism would have to be part of the option contract. For this reason, if the CCS infrastructure system developer intends to offer capacity options to potential future system users, then the requirements of the system of option contracts briefly described above must be taken into consideration when designing the capacity charging mechanism which will be applied to the system. In particular, the capacity charging mechanism must deal with the charges that will be levied for system capacity throughout the duration of the option contract as well as the transportation (and storage) services contract which would stem from it.

2.8.2 Pre-Emption Rights

For an infrastructure system developer wishing to accurately predict the optimum capacity it should develop one major difficulty lies in obtaining reliable information from potential future system users regarding the magnitude of the future capacity they may require, the probability of that requirement becoming actual and the value (i.e. tenable price) of that capacity.

That this difficulty should exist appears initially counter-intuitive: there would seem to be adequate incentive for large CO_2 emitting plant operators to supply reliable future capacity demand

information to the developers of CCS infrastructure as those operators should wish the infrastructure to be constructed with adequate capacity for their purposes. However, for commercial sensitivity, resource constraint and, possibly, negotiating strategy reasons, reliable predictions by emitters of the probability and magnitude of their future demand for capacity in a proposed infrastructure system, let alone the value of that system capacity, are, in practice, difficult to obtain.

A potential scheme for overcoming this problem is to offer pre-emption rights over the use of speculatively constructed system capacity. Instead of asking the market of potential future users how much capacity they want and what they might be willing to pay for it, the system developer asks what they would be willing to pay to have the right to have first-refusal on spare capacity in the system. In the light of this information, the developer may, or may not, chose to build into the system, on a speculative basis, some or all of the system capacity for which demand is indicated.

The scheme could operate on a quasi-auction basis, with offers to purchase pre-emption rights invited for acceptance during a prescribed period prior to a deadline date. Unlike an option contract scheme (as described above), offers received during the pre-emption rights process would not oblige the developer to build any of the capacity for which future demand might be indicated. However, the bidders would be ranked in an order based upon their bid prices and, to the extent that the developer did build any spare capacity, the bidders would, in their ranking order, have the pre-emption right to acquire the capacity (or, possibly, an option of the capacity) they specified in their bid.

Each bidder's pre-emption rights would endure for a pre-determined period at the end of which they would be required to take-up or refuse those rights. If refused, the rights would pass to the next ranked bidder until all the spare capacity had been allocated. Bidders that are offered pre-emption rights would be obliged to pay their bid price whether or not they take up the pre-emption rights.

In order to ensure both commercial and contractual certainty as well as the application of fair and non-discriminatory access, users acquiring access to capacity via a pre-emption rights scheme would be charged for that access in accordance with the system's capacity charging mechanism. Therefore, if a pre-emption rights scheme were to be used for market discovery prior to the development of a CCS infrastructure system, then the relevant capacity charging mechanism should include provisions regarding the charging for access acquired under that pre-emption rights scheme.

2.9 Physical and Non-Physical Investors

When designing a capacity charging mechanism for a multi-user CCS infrastructure system, the question of whether system capacity can be acquired by parties that do not intend to make direct physical use of the system is a significant issue. The UK's CCS legal framework suggests that the legislature's intention is that capacity in CCS infrastructure should be freely tradable and it may be that this implies that it is also the intention that investment in CCS system by 'non-physical investors' should be encouraged.

For the purposes of developing the capacity charging mechanism concepts presented in this report it has been assumed that parties wishing to acquire system capacity rights for investment purposes (i.e. in order to sell on those rights at a premium) would be permitted to do so.

2.10 Cost Recovery Mechanisms

The system developer will incur expenditure in developing, owning and operating a Shared Infrastructure System. The system developer may recover this expenditure, plus a reasonable level of return, via a combination of fees, charges and capital contributions, as described below.

2.10.1 Fees

The system developer may recover a proportion of the expenditure it makes and liabilities it incurs due to its development, operation and decommissioning of the Shared Infrastructure System via a fee.

Fees are most likely to be used to recover the system developer's internal costs, sub-contractor costs and other non-capital expenditure.

The level of a particular fee would be the value of the relevant expenditure made plus a percentage mark-up.

Fees would be paid in instalments over a payment period agreed between the SO and the System User (herein the 'Fee Payment Period').

Fees would be based upon the present value, at the start of the Fee Payment Period, of the expenditure made, or the estimate of the expenditure yet to be made, by the system developer in performing the actions to which the fee applies. Where the value of a fee is based upon an estimate of expenditure, the actual fee may be calculated based upon actual expenditure.

Fees may be paid by the System User at the end of the month in which the relevant expenditure is made by the system developer or paid by the System User in arrears.

Fees paid in arrears or late would be subject to a finance charge.

2.10.2 Charges

The SO may recover a proportion of the expenditure it makes and liabilities it incurs due to its development, operation and decommissioning of the Shared Infrastructure System via charges.

Charges are most likely to be used to recover capital expenditure.

Charges would be paid in instalments over a payment period (herein the 'Charge Payment Period') agreed between the SO and the System User.

Charges shall be based upon the present value, at the start of the Charge Payment Period, of the expenditure made, or the estimate of the expenditure yet to be made, by the SO in performing the actions to which the charge applies.

Charges shall include a finance charge in order to provide the SO with a reasonable rate of return on the capital employed, liability incurred and/or risk taken in performing the actions to which the charge applies.

Charges paid late shall be subject to a finance charge/interest.

2.10.3 Capital Contributions

The System User may make capital contributions to offset the amount of expenditure upon which fees and charges are based, thereby reducing the level of the relevant fee or charge.

The level of capital contribution made to offset the amount of expenditure upon which fees and charges are calculated may be unrestricted (i.e. a System User may pay on or before the first day of the relevant payment period the whole of the sum upon which a fee or charge is based, thereby reducing the fee or charge to zero), or may be restricted, dependent upon the commercial model agreed between the SO and the System User. Any restrictions upon capital contributions should be included in the Transportation (and Storage) Services Agreement made between the SO and the System User.

3 CASE STUDY MULTI-USER INFRASTRUCTURE PROJECTS

In order to provide context for the concepts presented and discussed in this Targeted Report, and to provide an example project which can be used to demonstrate the charging methodologies described in it, two case study projects are presented in this section.

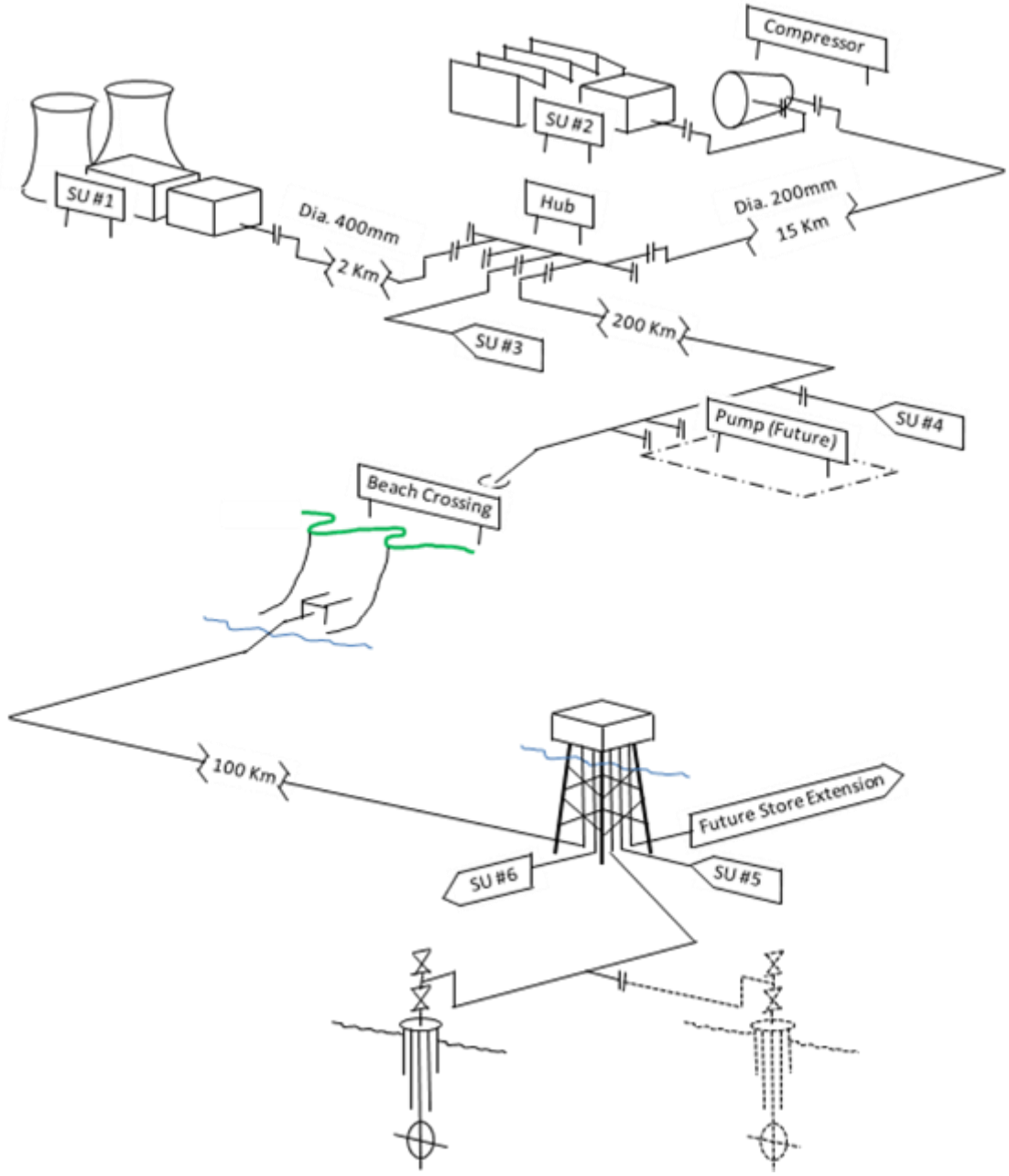
The first case study is hypothetical and is designed to illustrate the characteristics and requirements of some of the broad range of system user types and the requirements that they would have of a CCS infrastructure system. This hypothetical case study is used throughout the rest of this Targeted Report to illustrate and demonstrate the application of the concepts and methods described.

The second case study is a real project: the UK's Yorkshire and Humber CO_2 Cluster Project.

3.1 HYPOTHETICAL CASE STUDY

The precise arrangements for the provision of, and charging for, infrastructure system capacity to any particular system user, and the quantum of cost reduction associated with infrastructure sharing on any particular project, is project specific; however, an example system, by way of a case study, provides a useful basis for considering the issues arising for the developer of a multi-user shared infrastructure system, particularly those issues associated with capacity charging. Such a case study system is described in the diagram and text below. This hypothetical case study will be used throughout the rest of this Targeted Report in order to illustrate and demonstrate the application and operation of the concepts and methods discussed.

Figure 1 – Hypothetical Case Study Schematic



3.2 Description of the Hypothetical Case Study

Within this report the Hypothetical case study is intended as a basis for achieving two aims:

1) To examine the infrastructure needs of six generic types of system users ('SU's') in order to better understand the issues arising and works required when developing infrastructure to provide future system users, of each type considered, with the system capacity they will require and access to that capacity; and
2) To demonstrate the application of the capacity charging principles described later in this Targeted Report to an example infrastructure system.

It should be noted that the details of each system user type considered (including the scope of supply of those system users) are specified here for the purposes of example only and are not intended to be prescriptive with respect to the requirements or scopes of supply of any particular system user type.

3.2.1 System Scheme Overview and Assumptions

The hypothetical scheme shown in Figure 1 above is based largely upon the model which is expected to be prevalent in western European countries. Accordingly, it incorporates an offshore storage site.

It is assumed that the water depth at the storage site will be relatively shallow and that the offshore facilities will be installed on a jacket. For conformity across all wells, and the simplicity of calculation this brings, it has been assumed that all wells will be sub-sea completions tied-back to the jacket.

It is assumed that the capacity of the storage site, both from a point of view of total pore-space and injectivity, is sufficient to accommodate the requirements of the identified System Users. It should be noted that, if the capacity demands of further system users exceeded the capacity of the initial storage site and led to a requirement for a second separate storage site, then the incremental costs associated with the development of that site and its connection to the wider system would produce a step change in the cost curves depicted in figure 8 and described in section 9. The distribution of these additional costs across all System Users is a complexity which is not considered in this report.

The storage site facilities receive CO_2 primarily from onshore system users via a single shared trunk pipeline. The possibility of delivery of CO_2 to the storage site by ship is recognised by the inclusion of system user SU#5.

Connection to the main pipeline may be via a shared collection hub or via dedicated injection branches where this would offer a more sensible solution.

It is assumed that the entire infrastructure system will normally operate at temperatures and pressures at which CO_2 is in its dense phase. The potential for the provision of booster pumping at the pipeline beach-crossing, possible in some designs, is recognised by the inclusion of a site for this purpose in the scheme design.

3.2.2 System Users

The types of system user included in the case study are as follows:

SU #1

System User #1 is a large scale, fossil-fuel fired, electricity generating plant. It is assumed that the plant operator will design and construct the CO_2 capture, treatment and compression plant within the power plant's battery limits and provide export CO_2 into the infrastructure system at the thermodynamic conditions and to the compositional specification required by the system operator. It is also assumed that the necessary flow metering and specification monitoring equipment will be provided and operated by the System User, i.e. the electricity generation plant operator.

SU #2

System User #2 is a large scale industrial plant producing CO_2 as a bi-product of its manufacturing processes. It is assumed that the plant operator will design and construct its own CO_2 capture and

treatment plant, including flow metering and composition monitoring, but that the compression and associated plant to increase the pressure of the CO_2 to that required for injection into the export pipeline would be provided by the infrastructure system operator.

The fuel type, industrial process and capture technology used by SU's #1 and #2 are not specified as they are relatively unimportant within the context of the purpose of this case study. This said, it is should be noted that the level and type of CO_2 stream contaminants associated with different fuel, industrial process, capture and treatment technologies have the potential to make specific demands of the transportation and storage system. The cost and complexity of removing these contaminants to low levels may prove prohibitive to a potential system user's CCS development project. If this were to be the case, and the only commercially feasible option was for the plant operator to export its CO_2 with a specific level of contaminant, then an infrastructure system developer would have to take these specific requirements into consideration, in particular the cost of meeting them, when deciding whether to design its system to provide capacity for some generation types and industrial emitters. This consideration is particularly relevant to industrial processes but similar arguments also apply to all other types of system users.

SU #3

System User #3 is a party that secures a specific amount of system capacity in the transportation and storage infrastructure downstream of an injection point at a flow amalgamation hub which is shared by other users.

SU #4

System User #4 has the same characteristics as SU #3 except that it does not inject CO_2 into the system at a shared hub facility but has its own pipeline injection branch. In this case it is assumed, for the sake of simplicity, that the injection point is onshore, just upstream of the pipeline beach-crossing point, but this need not be the case, and it may be that a system user would procure an injection branch at any point along the onshore, or offshore, pipeline.

SU #5

System User #5 is a party using the system operator's storage infrastructure without using its transportation infrastructure. It has been assumed, for the purposes of this case study, that SU #5 would inject CO_2 into the system via a riser onto a facilities platform. There are a number of other configurations which might be adopted, both for the offshore facilities and for the point of injection into the system.

SU #6

System User #6 is peculiar in as much as it is taking CO_2 out of the system instead of injecting CO_2 into it. This system user type is included to ensure that CO_2 off-take for enhanced oil recovery is included within capacity charging mechanism considerations.

Non-physical System Users

A system developer considering what capacity to build into the various elements of its system should consider the potential that there may be demand for system capacity from parties wishing to acquire system capacity with a view to sub-letting that capacity to future system users at a profit. For the purposes of this Targeted Report it is assumed that such non-physical system users would

either be of the SU #3, SU #5 or SU#6 type; they are therefore not considered further, as a separate system user type, within this Targeted Report.

3.2.3 System User's Use of System Components

Each system user's requirements with regard to capacity in each infrastructure component, and, if that capacity is to be provided at some future date, to what extent that provision depends upon expenditure at the time of initial system development and how that expenditure is financed, will all affect the arrangements for the provision of that capacity and the mechanism used to charge for it.

The system users' use of the various components in the case study system is as follows:

System User	Compression	Connection Assets	Flow Amalgamation Hub	Onshore Pipeline	Future Booster Pumps	Beach Crossing	Offshore pipeline	Offshore facilities	Subsea & wells
SU #1	X	X	√	√	√	√	√	√	√
SU #2	√	√	√	√	√	√	√	√	√
SU #3	X	X	√	√	√	√	√	√	√
SU #4	X	X	X	√	√	√	√	√	√
SU #5	X	X	X	X	X	X	X	√	√
SU #6	X	X	X	X	X	X	X	√	X

Table 1 – Hypothetical Case Study System Users

3.2.4 Costing Estimating Norms and Assumptions

In order to effectively illustrate some of the concepts discussed in this Targeted Report and to demonstrate the application of some of the charging mechanism principles discussed, it is helpful to use worked examples which incorporate cost data. There are a number of such worked examples included in this Targeted Report. The cost data used is based upon cost estimating norms that are a combination of publically available data and figures based upon cost analyses carried out by National Grid Carbon.

The cost estimates used in this Targeted Reported are intended to be indicative of the magnitude of costs associated with the provision of transportation and storage infrastructure capacity to the various system users considered in the report. The cost estimates are based upon generic assumptions regarding the range of technologies and assets which might be used by a system user of each type considered; they are not based upon any specific system design and are not the result of any detailed cost breakdown analysis for any particular design.

However, it is assumed that the accuracy of the costs presented in this Targeted Report is sufficient to provide a useful basis for understanding both:

- the way in which capacity dependant and capacity independent costs might be distributed across a range of system users; and
- the variation in cost of providing system infrastructure capacity to various system user types.

The following cost estimating assumptions have been used:

- SU #1 has a peak CO_2 export flowrate of 5x10^6 tonnes/year;
- SU #2 has a peak CO_2 export flowrate of 1x10^6 tonnes/year;
- Onshore and offshore transportation will be in dense phase;
- Pipeline flow velocities will be 1.5 m/sec;
- Storage site water depth will be typical for the southern North Sea; and
- Pre-tax cost of capital is 12% real.

3.3 Example Project – National Grid Carbon's Humber Cluster Development

The UK's White Rose Project would take CO_2 captured from a new-build coal-fired power station at the Drax site in North Yorkshire and transport it by pipeline to a saline aquifer storage site situated in the southern North Sea. The project involves Alstom, Drax Power, BOC and National Grid. National Grid Carbon Limited ('NGC') will develop and operate the transportation and storage infrastructure and the storage site. As part of the project, NGC wishes to develop this infrastructure in a way in which its capacity can be efficiently expanded to meet the demands of the market for CO_2 disposal as the CCS industry develops.

The Yorkshire and Humber region is an ideal location for the development of shared CCS infrastructure due to its high concentration of power stations and large industrial plants in close proximity to offshore storage and EOR opportunities beneath the North Sea. The region produces more than 45 Mt CO_2 per year from large point sources, including fossil fuel power stations, oil and gas refineries and industrial processes. This is equivalent to around a third of the UK energy sector's total annual CO_2 emissions.

Work on the project is progressing well. In early 2010, National Grid began screening the southern North Sea for high quality candidate storage sites to serve the Yorkshire and Humber region. As a result of this exercise, the selected preferred storage site is a deep saline aquifer known as 5/42.

The preferred onshore route corridor for the initial trunk pipeline and locations of associated above-ground transport infrastructure has also now been finalised, based on feedback from two rounds of public consultation during 2011 and 2012 (see Figure 2 below).

In addition, in February 2013, the UK's first ever CO_2 appraisal and storage licence was granted for the 5/42 storage site and an associated Agreement for Lease was completed with the The Crown Estate (the party holding the storage site's property rights).

The next stage is to carry out exploratory drilling and reservoir appraisal of the target storage structure. This will be done during 2013. Following analysis of the results, it will then be possible to

further define the site's storage capacity, the basis of design for the facilities and infrastructure and to acquire the information necessary for storage permit application.

The current design concept for the transportation and storage facilities and infrastructure is to provide multiple system users [12] with access to the shared pipeline at a common onshore hub. This hub is situated so as to provide a convenient point of access into the system for a pipeline bringing CO_2 from emitters in the South Humber Bank area[13]. Provision will also be made for an offshore hub near the 5/42 storage location to facilitate the reception and distribution of CO_2, which may include future connections to emitters from mainland Europe and/or to EOR areas and other storage sites.

Figure2: Yorkshire and Humber CCS Cluster – pipeline corridors and storage location

Further information on the Yorkshire and Humber CCS Cluster can be found on the National Grid website for cross-country Yorkshire and Humber CO_2 capture, transportation and storage project: www.ccshumber.co.uk.

[12] E.g. the Don Valley Power Project near Doncaster.

[13] E.g. C.Gen's proposed new IGCC plant at Killingholme.

Part 2 – Statement of Connection Charging Methodology

4 SYSTEM CONNECTION COSTS AND CHARGES

4.1 DISCUSSION

Each physical user[14] of a multi-user infrastructure system require a physical connection between its carbon dioxide generating plant and that system. This connection will transport the user's carbon dioxide from an entry point, typically at the battery limit of the user's plant, to the point at which the carbon dioxide is injected into the main infrastructure system.

The assets which comprise the connection (compression, pipework, valving, filtering, metering, fluid composition analytical equipment, etc.) must be designed and constructed, the connection to the shared infrastructure system must be made and the assets must be operated and maintained. These scopes of work could, potentially, be carried out by any combination of a number of parties: the user; the shared system operator; and/or their sub-contractors. In any event there will be a number of physical and operational interfaces between the system user's plant, the connection assets and the shared infrastructure system, as well as between the system user, the shared infrastructure system operator and their respective sub-contractors and agents.

This Part sets out a methodology for: the procurement of the development of connection assets; where and how the various physical and contractual interfaces might be situated; and how the costs of developing the connection assets, and of connecting the connection assets to the shared system, would be recovered.

CCS Specific Considerations

The provision of connection assets is a requirement to be met by the operator and users of all infrastructure system and many of the issues arising from this requirement are common to many infrastructure system types. There are however a number of connection asset issues which are peculiar to CCS infrastructure and/or are particularly important or problematic when connecting to CCS infrastructure. These are briefly discussed below.

Flow Measurement

In most CCS infrastructure system capacity charging models some part of the charge paid by the System User will be calculated based upon actual system usage by that System User. It is therefore necessary, to ensure that these charges are proper, for the flow of CO_2 injected into the infrastructure system by the relevant System User to be measured.

This flow measurement issue is not an unusual one for infrastructure system operators to be faced with and issues such as: provision and operation of metering systems; and calibration and auditing requirements, are relevant to CCS systems but are not peculiar to them and are not discussed further here.

[14] There may, at some stage, be system 'users' which are 'non-physical' i.e. persons trading system capacity without themselves owning CO2 which is transported or stored.

One issue that is peculiar to CCS is that of the transport of CO_2 as a dense phase fluid (as opposed to a liquid or gaseous phase fluid) and the technical challenges this raises for accurate flow measurement[15]. Whilst this issue does not necessitate the provision or operation of the metering system by either the System User or the System Operator it seems probable that the System Operator's expertise in the metering of dense phase CO_2 across its system would militate against the provision or operation of that metering by the System User.

A second, associated, CCS specific metering issue stems from the existence of any statutory fiscal metering requirements. Such requirements are likely in any jurisdiction which has a carbon emissions trading system, or other carbon emissions taxation system, and in which the use of CCS is considered as carbon emissions abatement for the purposes of that system[16]. Where such statutory metering requirements exist, failure to satisfy, and continue to satisfy, those requirements will constitute a risk to the operability of the project and therefore, depending upon the capacity charging mechanism used, the revenue stream of the System Operator. In such cases it is likely that the System Operator would wish to provide and operate the fiscal metering system.

It is also worth noting, with regard to flow metering, that the ease with which metering uncertainty specifications can be conformed with is dependent, to a significant extent, upon the level of fluctuation over time in the flowrate being measured as well as the range of flowrates over which measurement is to be made. These flowrate fluctuation and range characteristics will be different for different types of system users.

Fluid Composition Monitoring and Control

In order to protect the integrity of the transportation and storage infrastructure, the System Operator will specify a fluid composition specification with which the System Users' CO_2 will have to comply for injection of that CO_2 into the infrastructure system to be permissible. A fluid composition monitoring system will be required to ensure that this fluid composition specification is continuously complied with. Provision and operation of such a composition monitoring system is technically challenging and, for similar reasons as described above with regard to metering, it seems likely that it would be the responsibility of the System Operator to do this.

The type and amount of contaminants in the CO_2 stream will vary significantly from system user to system user, with key influencing factors being the plant or process generating the CO_2 and the technique used to capture it. Different System User's CO_2 are likely to have different propensities to high levels of a different undesirable contaminants. The emphasis on monitoring different components in the CO_2 stream fluid assay will therefore vary from system user to system user. A similar observation can be made with respect to the temperature and pressure of different system users' CO_2, although these properties are more easily measured than fluid composition.

[15] Not all CCS infrastructure schemes will transport carbon dioxide in dense phase however it is likely that this will be the preferred, and therefore usual, practice.

[16] For example see: Commission Regulation 601/2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council esp. Art.49.

Design Specification

As well as the fluid compositional specification mentioned above, the infrastructure System Operator will make certain specifications with regard to the way in which connection assets are designed, constructed and operated. An area of specification peculiar to CCS is potentially that of the solids content in the fluid stream, both at the inlet point and also due to the cleanliness and potential corrosion products of the connection assets. Prevention of solids contamination in CCS infrastructure is important due to the potential for solids to have a deleterious effect on the injectivity characteristics of the storage wells.

If fluid cleanliness to the required specification cannot be assured then it is possible that filtration system may be required as part of the storage facilities. The provision of such a system, and the offshore installation space it requires, would be costly. This issue would be of particular interest in the case of System User #5.

Control and Safety System Integration

The connection assets include the interface between the control and safety systems of the System User's plant and the infrastructure system17. The level of signal and data sharing across this interface and, in particular, the level of executive action which each system might have over the other, will vary from system user to system user. Automatic alarm and emergency shut-down initiation across this interface will be of particular interest due to the potential for such actions to adversely affect the operation of both the CO2 generating plant and the infrastructure system. It is possible that the increased safety action response times associated with the reduced 'line-pack' capability of dense phase transportation systems when compared to gaseous phase systems, will necessitate a level of automatic inter-system executive action which is greater than that implemented on, for example, natural gas transmission systems. If this does prove to be the case then there are significant commercial implications associated with the forced shut-down of plant and systems which will have to be dealt with contractually. The level of integration, and cross-system executive action that is required, will vary from system user to system user.

4.2 Statement of Connection Charging Methodology - Connection Works

The term Required Works shall include but not be limited to: engineering, procurement and construction of materials and systems including but not limited to: pipework; valves, fittings and pipework associated assets; electrical; instrumentation; control and safety systems; civil works including roadways, drainage, lighting and fencing; and project management and support.

4.2.1 Extent of Connection Works

As a minimum the shared infrastructure system operator (the 'SO') shall carry out all Required Works associated with any modification to the shared infrastructure system (the 'Minimum Works').

The SO may also carry out, in addition to the Minimum Works, the Required Works for the provision of all or part of the infrastructure assets connecting the System User's assets and the shared infrastructure system (the 'Additional Connection Works').

[17] 'Control' in this case includes data acquisition. It is also possible that there will be some connection of fire and gas systems.

The extent of the Minimum Works and the Additional Connection Works shall be agreed between the SO and the relevant System User.

The Minimum Works and Additional Connection Works shall together comprise the Connection Works.

To the extent that infrastructure assets connecting the System User's assets to the shared infrastructure system are provided by the System User (the 'System User Connection Works') then these works shall be designed, constructed and operated in accordance with all system interface specifications provided by the SO.

System User Connection Works shall not be operated, maintained or decommissioned by the SO unless otherwise agreed by the SO.

4.2.2 Land and Development Consents

In all cases, the land required to accommodate the Connection Works, and all consents necessary for the development of the Connection Works on that land, shall be acquired by the relevant System User.

4.3 Connection Agreement

Before any Connection Works are carried out by the SO, the relevant System User shall agree to pay the Connection Charge for the agreed payment period and shall enter into a Connection Agreement with the SO in order to secure such payment.

In order to derive the technical and cost estimation information required for the drafting of the Connection Agreement, it will be necessary for the SO to carry out conceptual study work. The System User shall agree to pay the costs incurred by the SO in carrying out that conceptual study work plus a reasonable mark up and the SO may require the System User to enter into a Conceptual Study Agreement with the SO in order to secure such payment.

4.3.1 Payment Period

Costs incurred by the SO in carrying out any conceptual study work and/or pursuant to any Conceptual Study Agreement shall be immediately recoverable from the System User.

The duration of the Connection Agreement and the period over which the Connection Charge shall be calculated and paid shall be agreed between the System User and the SO.

4.4 Connection Charge

The Connection Charge shall be calculated in order to allow the SO to recover, with a reasonable rate of return, all of the following:

- all costs incurred by the SO in performing the Connection Works (excluding any conceptual study costs);
- the present value of the cost of decommissioning the assets provided by the Connection Works;

- where applicable, the cost of other one-off and exceptional works required to be made to the assets provided by the Connection Works during the period of the Connection Agreement;
- normal operations and maintenance costs; and
- exceptional operations and maintenance costs.

The period of payment over which the connection charge is calculated and paid shall be agreed between the SO and the system user.

The connection charge shall be paid in yearly instalments the magnitude of which shall be calculated over a payment period agreed between that System User and the SO.

The connection charge shall be paid annually in arrears.

The System User shall pay its applicable annual Connection Charge in full for the entire agreed period of payment regardless of the actual amount of use that is made of the connection except that for any period or periods during which the availability of the shared infrastructure system is below a target system availability level (as agreed between the System User and SO) the connection charge shall be reduced in proportion to that reduction in availability.

4.4.1 Costs of Connection Works

The connection charges applicable to a particular System User shall include only those costs of Connection Works associated with the provision of assets for the dedicated and sole use of that System User.

For the avoidance of doubt, connection charges shall include the costs associated with any modifications required to be made to the relevant shared CO_2 transportation or storage infrastructure system as a result of the connection. These shall include but not be limited to, the addition of pipeline tees, compressor and pumping system modifications and control and safety system modifications.

If the Connection Works include modifications to the shared CO_2 transportation and storage infrastructure system which benefit multiple system users, then a methodology for the sharing of the cost of those modifications between those system users may be included in the final capacity charging mechanism.

4.4.1.1 Estimated v Actual Costs

The cost of performing the Connection Works shall be estimated by the SO as part of the conceptual study works.

That part of the connection charge attributable to the performance of the Connection Works shall be calculated on the basis of the actual cost of the Connection Works.

4.4.2 Costs of Connection Decommissioning Works

The scope, cost and date of decommissioning the assets provided by the Connection Works shall be estimated by the SO as part of the conceptual study works.

The present value at the start of the payment period of the estimated cost of decommissioning the assets provided by the Connection Works shall be calculated at the start of the payment period. This present value shall be the cost of decommissioning the Connection Works for the purposes of the calculation of the Connection Charge.

A mechanism for the updating of the decommissioning component of the Connection Charge may be included in the capacity charging mechanism. Such a mechanism might include the provision of a financial security for decommissioning costs above those estimated and included in the Connection Charge.

N.B. It should be noted here that the outturn costs of the decommissioning works may not be known until after the expiry of the Connection Agreement. Where this is the case, unless suitable provisions are added to the Connection Agreement to avoid it, the SO will bear decommissioning cost overrun risk.

4.4.3 Costs of Connection Amendment Works

In the event that modifications to the connection assets are made, either as a result of a request by the System User, or developments to the shared system necessitating such modifications, then the costs incurred by the SO in making those modifications, plus a reasonable rate of return on capital employed, shall be recovered by the SO via the addition to the connection charge of a commensurate charge distributed over the remainder of the payment period.

4.4.4 Costs of Normal O&M

The scope and the annual cost of the normal operation and maintenance of the assets provided by the Connection Works shall be estimated by the SO as part of the conceptual study.

This estimated scope and annual cost shall include fixed and variable operations and maintenance costs.

This estimated scope and annual cost shall be included in the Connection Agreement.

This estimated cost, re-valued using an indexation method to be agreed between the System User and the SO, may be used as the normal operation and maintenance cost included in the initial Connection Charge. Alternatively, and depending upon the agreed allocation of cost recovery risk, the Connection Agreement could provide for the normal O&M component of the Connection Charge to be updated in accordance with actual normal O&M costs as they are incurred.

4.4.5 Costs of Exceptional O&M

In the event that operation or maintenance actions are required that are not included in the scope of normal operations and maintenance included in the Connection Agreement then those costs, plus a reasonable mark-up and rate of return on capital employed, shall be recovered by the SO via the addition of a commensurate charge distributed over the remainder of the payment period.

4.5 THE BASIC ANNUAL CONNECTION CHARGE FORMULA

The annual connection charge shall be calculated using the following formulae:

N.B. Note that the following formulae yield a constant nominal payment over the Payment Period. They are based upon the general formula for constant periodic repayment (R) of a principal sum (P) over a number of periods (n) where a nominal discount (or interest) rate of (D) applies:

*R = P * (D+(D/(((1+D)^n)-1))).*

This method of payment calculation may not be preferred by the parties in all cases and alternatives may be agreed.

For the first year of the payment period:

$$ACC_{n=1} = ((ExACC_{PV} - CC_{n=0})(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} - 1)))) + ACC_{NOMn}$$

For all subsequent years in the payment period:

$$ACC_{n} = ((ExACC_{Rn} + ExAMC_{PVn} + ExEOM_{PVn} - CC_{n})(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} - 1)))) + ACC_{NOMn}$$

Where:

$ExACC_{PV}$	=	present value, at the start of the payment period, of the net expenditure upon which the initial Annual Connection Charge is based;
$ExACC_{Rn}$	=	residual amount of $ExACC_{PV}$ remaining to be recovered at start of year n;
$ExAMC_{PVn}$	=	present value, at the start of year n, of the net expenditure made by the SO in completing amendment works in year n (if any) calculated in accordance with section 4.9 below;
$ExEOM_{PVn}$	=	present value, at the start of year n, of the net expenditure made by the SO in completing exceptional operation and maintenance works in year n (if any) calculated in accordance with section 4.10 below;
ACC_{NOMn}	=	annual connection normal operation and maintenance charge calculated in accordance with section 4.8 below;
$CC_{n=0}$	=	Capital contribution (if any) made at start of payment period;
CC_{n}	=	Capital contribution (if any) made at start of year n;
DR_{Nn}	=	Nominal Annual Discount Rate applicable to the Connection Works in year n;
Np	=	number of years in the payment period; and
n	=	year of payment period for which repayment is being calculated.

and:

$$ExACC_{PV} = ExCWC_{PV} + ExDWC_{PV}$$

where:

$ExCWC_{PV}$ and $ExDWC_{PV}$ are calculated in accordance with sections 4.6 and 4.7 below respectively

and:

$ExACC_{Rn} = ExACC_{Rn-1} (1+ DR_{Nn}) - ACC_{n-1}$

where:

$ExACC_{Rn-1}$ = $ExACC_{Rn}$ for year previous to year n (and, for the avoidance of doubt, for the second year in the payment period this is equal to $ExACC_{PV} – CC_{n=0}$); and

ACC_{n-1} = ACC_n for year previous to year n,

and:

$DR_{Nn} = ((1+DR_R)*(1+RPI_{AAn}))-1$

where:

DR_R = Real Annual Discount Rate applicable to the Connection Works; and

RPI_{AAn} = Annual Average Retail Prices Index inflation for year n.

4.6 Connection Works Charge Expenditure

The present value, at the start of the payment period, of the net expenditure made by the SO in completing the connection works shall be calculated using the following formula:

$ExCWC_{PV} = \sum^{m=1}_{Me} (ExCWC_m / F_{DRNm})$

where:

$ExCWC_m$ = net nominal expenditure related to the Connection Works in month m (i.e. actual expenditure less any capital contributions in month m);

Me = Total number of months in the EPC Period i.e. the period up to the start of the payment period;

m = month in EPC Period or payment period; and

DR_{Nm} = the monthly equivalent nominal discount rate applicable to the Connection Works in month m,

and:

$F_{DRNm} = (F_{DRNm+1}/(1+DR_{Nm+1}))$ in all months in the EPC Period except the final month; and

$F_{DRNm} = 1$ in the final month of the EPC Period (i.e. month before the start of the payment period)

where:

F_{DRNm} = Monthly Nominal Discount Rate Factor for month m;

F_{DRNm+1} = Monthly Nominal Discount Rate Factor for the month immediately following month m;

DR_{Nm} = Nominal Monthly Equivalent Discount Rate applicable to the Connection Works in month m.

DR_{Nm+1} = Monthly Equivalent Nominal Discount Rate applicable to the Connection Works in the month immediately following month m.

Noting that when estimating the Connection Charge, the net monthly expenditure levels input into the above formula must be in nominal terms.

An example of the application of this calculation is given in Annex 10.2.

4.7 Decommissioning Works Charge Expenditure

For the purposes of calculating the decommissioning works related part of the annual connection charge, the present value at the start of the payment period of the estimated cost of decommissioning the assets provided by the Connection Works shall be equal to, the estimated cost of decommissioning those assets in real terms at the date that the estimation is carried out, inflated to its nominal value at the date of the start of the payment period. An inflation index for the purposes of this calculation shall be included in the Connection Agreement.

For example, using the Retail Price Index (RPI):

$ExDWC_{PV} = ExDWC_{Est} * ((RPI_{SPP})/(RPI_{DOE}))$

where:

$ExDWC_{Est}$	=	Estimated cost of decommissioning the assets provided by the Connection Works;
RPI_{SPP}	=	Retail Prices Index at date of start of payment period; and
RPI_{DOE}	=	Retail Prices Index at date of decommissioning cost estimate.

N.B. Note that this methodology potentially leaves the SO taking risks associated with inaccuracies in the estimated cost of decommissioning and the assumed future indexation rates. The parties may prefer to incorporate a mechanism to rectify any under, or over, recovery by the SO introduced into the Connection Charge by such inaccuracies.

4.8 Normal Operations and Maintenance Charge

The annual charge for the normal operations and maintenance actions to be taken by the SO as set out in the Connection Agreement shall be calculated using the following formula:

$ACC_{NOMn} = ACC_{NOMEst} * ((RPI_n)/(RPI_{DOE}))$

where:

ACC_{NOMEst}	=	Estimated cost of the normal operation and maintenance of the assets provided by the Connection Works;
RPI_n	=	Retail Prices Index at end of year n of payment period; and
RPI_{DOE}	=	Retail Prices Index at date of estimate of normal operation and maintenance costs.

4.9 Amendment Works Charge Expenditure

The present value, at the start of year n, of the net expenditure made by the SO in completing amendment works to the assets provided by the Connection Works shall be calculated using the following formula:

$ExAMC_{PVn} = \sum^{m=1}_{Me} (ExAMC_m / F_{DRNm})$

where:

$ExAMC_m$ = net relevant expenditure in month m (i.e. actual expenditure less any capital contributions in month m);

Me = Total number of months in the period of the Amendment Works plus the period between the end of the period of the Amendment Works and the final month of year n-1;

m = month in period of the Amendment Works plus the period between the end of the period of the Amendment Works and the final month of year n-1;

n = year following the year in which all expenditure on the Amendment Works is completed; and

DR_{Nm} = Nominal Monthly Equivalent Discount Rate applicable to the Amendment Works in month m,

and:

$F_{DRNm} = (F_{DRNm+1}/(1+DR_{Nm+1}))$ in all months in the period of the Amendment Works plus the period between the end of the period of the Amendment Works and the final month of year n-1; and

$F_{DRNm} = 1$ in final month of year n-1,

where:

F_{DRNm} = Monthly Nominal Discount Rate Factor for month m;

F_{DRNm+1} = Monthly Nominal Discount Rate Factor for the month immediately following month m;

DR_{Nm} = Nominal Monthly Equivalent Discount Rate applicable to the Amendment Works in month m.

DR_{Nm+1} = Monthly Equivalent Nominal Discount Rate applicable to the Amendment Works in the month immediately following month m.

Noting that the value of DR_{Nm} may vary through the period of the Amendment Works.

4.10 Exceptional Operations and Maintenance Expenditure

The present value, at the start of year n, of the net expenditure made by the SO in completing exceptional operations and maintenance actions on the assets provided by the Connection Works shall be calculated using the following formula:

$$ExEOM_{PVn} = \sum_{m=1}^{Me} (ExEOM_m / F_{DRNm})$$

where:

$ExEOM_m$ = net relevant expenditure incurred carrying out exceptional operations and maintenance expenditure in month m (i.e. actual expenditure less any capital contributions in month m);

Me = Total number of months in the period of the relevant exceptional operations and maintenance actions plus the period between the end of the period of the relevant exceptional operations and maintenance period and the final month of year n-1;

m = month in the period of the relevant exceptional operations and maintenance actions plus the period between the end of the period of the relevant exceptional operations and maintenance period and the final month of year n-1;

n = year following the year in which all expenditure on the relevant exceptional operations and maintenance actions is completed; and

DR_{Nm} = the monthly equivalent nominal discount rate applicable to the exceptional operations and maintenance actions in month m,

and:

$F_{DRNm} = (F_{DRNm+1}/(1+DR_{Nm+1}))$ in all months in the period of the Amendment Works plus the period between the end of the period of the Amendment Works and the final month of year n-1; and

$F_{DRNm} = 1$ in final month of year n-1,

where:

F_{DRNm} = Monthly Nominal Discount Rate Factor for month m;

F_{DRNm+1} = Monthly Nominal Discount Rate Factor for the month immediately following month m;

DR_{Nm} = Nominal Monthly Equivalent Discount Rate applicable to the exceptional operations and maintenance actions in month m.

DR_{Nm+1} = Monthly Equivalent Nominal Discount Rate applicable to the exceptional operations and maintenance actions in the month immediately following month m.

Noting that the value of DR_{Nm} may vary through the period of the exceptional operations and maintenance actions.

4.11 Capital Contributions

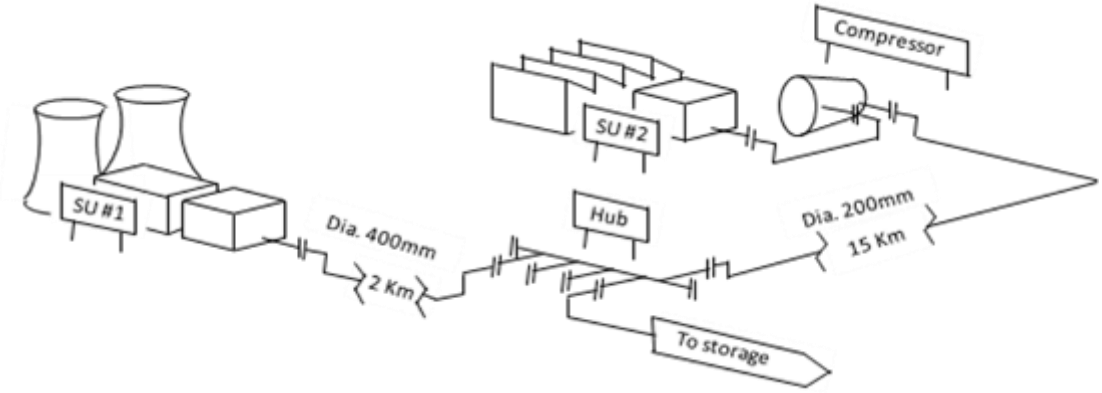
The System User may chose to fund any proportion of the capital cost of the connection by making one or more capital contributions to the SO.

N.B. Depending upon the business model of the SO, it may wish to constrain the amount of capital contributions that can be made by the system user.

4.12 Case Study Example

The practical application of the connection charging methodology described above is demonstrated below using a part of the Case Study introduced earlier in this Targeted Report as described in the following illustration.

Figure3 - System User Connection Assets



Considering the connection assets of SU #1 and SU #2:

System User #1 – Connection Charges

Assuming:

- $ExCWC_{PV}$ - Present value at commencement of connection charge payment period of total capital expenditure on connection assets (Pipeline (2km x 400mm N.B.) including pig traps and valving. (Filtration, metering and composition monitoring supplied by system user)) = £8m;
- $ExDWC_{PV}$ - Present value at commencement of connection charge payment period of estimated decommissioning cost = £2m;
- $CC_{n=0}$ - Capital contribution made by SU #1 to capital expenditure = £5m prior to connection charge commencement with no further capital contributions thereafter;
- Connection charges are to be paid for 10 years (i.e. n = 10);
- ACC_{NOMn} - Estimated annual normal operation and maintenance charge = £75,000 (Present value at start of connection charge payment period);
- Inflation is assumed to be 3% per annum for the first ten years of connection charge payments;
- There is no requirement for any exceptional operations or maintenance expenditure during the first ten years of connection charge payments (i.e. $ExAMC_{PVn} = 0$); and
- There are no amendment works carried out to the connection works during the first ten years of connection charge payments (i.e. $ExEOM_{PVn} = 0$).

Then:

$ExACC_{PV} = ExCWC_{PV} + ExDWC_{PV}$

(£8,000,000 + £2,000,000) = £10,000,000

and:

DR_{Nn} = ((1.12)*(1.03))-1 = 15.36%

Therefore (in this case for all years in connection charge payment period):

ACC = ((£10,000,000 - £5,000,000)(0.1536+(0.1536/((1.1536^10)-1))) + ACC_{NOMn}

= £1,009,966 + ACC_{NOMn}.

and:

ACC_{NOMn} for each year in connection charge payment period =

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
£77,250	£79,568	£81,955	£84,413	£86,946	£89,554	£92,241	£95,008	£97,858	£100,794

Table 2

Therefore, for each year in connection charge payment period, the total annual connection charge (ACC_n) would be:

Year 1	Year 2	Year 3	Year 4	Year 5
£1,087,216	£1,089,533	£1,091,920	£1,094,379	£1,096,912
Year 6	Year 7	Year 8	Year 9	Year 10
£1,099,520	£1,102,206	£1,104,974	£1,107,824	£1,110,760

Table 3

System User #2 – Connection Charges

Assuming:

- $ExCWC_{PV}$ - Present value at commencement of connection charge payment period of total capital expenditure on connection assets (Compressor station, pipeline (15km x 200mm N.B.) including pig traps and valving. (Filtration, metering and composition monitoring supplied by system user)) = £160m;
- $ExDWC_{PV}$ - Present value at commencement of connection charge payment period of estimated decommissioning cost = £20m;
- $CC_{n=0}$ - Capital contribution made by SU #2 to capital expenditure = £50m prior to connection charge commencement with no further capital contributions thereafter;
- Connection charges are to be paid for 10 years (i.e. n = 10);
- ACC_{NOMn} - Estimated annual normal operation and maintenance charge = £375,000 (Present value at start of connection charge payment period);
- Inflation is assumed to be 3% per annum for the first ten years of connection charge payments;

- There is no requirement for any exceptional operations or maintenance expenditure during the first ten years of connection charge payments (i.e. $ExAMC_{PVn} = 0$); and
- There are no amendment works carried out to the connection works during the first ten years of connection charge payments (i.e. $ExEOM_{PVn} = 0$).

Then:

$ExACC_{PV} = ExCWC_{PV} + ExDWC_{PV}$

(£160,000,000 + £20,000,000) = £180,000,000

and:

$DR_{Nn} = ((1.12)*(1.03))-1 = 15.36\%$

Therefore (in this case for all years in connection charge payment period):

$ACC = ((180,000,000 – 50,000,000)(0.1536+(0.1536/((1.1536^10)-1))) + ACC_{NOMn}$

$= £26,259,115 + ACC_{NOMn}$.

and:

ACC_{NOMn} for each year in connection charge payment period =

Year 1	Year 2	Year 3	Year 4	Year 5
£386,250	£397,838	£409,773	£422,066	£434,728
Year 6	Year 7	Year 8	Year 9	Year 10
£447,770	£461,203	£475,039	£489,290	£503,969

Table 4

Therefore, for each year in connection charge payment period, the total annual connection charge (ACC_n) would be:

Year 1	Year 2	Year 3	Year 4	Year 5
£26,645,365	£26,656,952	£26,668,887	£26,681,181	£26,693,843
Year 6	Year 7	Year 8	Year 9	Year 10
£26,706,884	£26,720,317	£26,734,154	£26,748,405	£26,763,083

Table 5

Part 3 – Statement of Shared System Charging Methodology

5 SHARED SYSTEM COSTS AND CHARGES

This section discusses the costs involved with the development, operation and decommissioning of shared CO_2 transportation and storage infrastructure and under what heads of charge those costs might be recovered from System Users.

5.1 SHARED INFRASTRUCTURE SYSTEM RELATED COSTS

The costs of developing, operating and decommissioning CO_2 transportation and storage infrastructure fall into a number of categories. These are described below.

5.1.1 Capital Expenditure (Capex)

Capex includes the cost of developing the infrastructure from concept through to commissioning and hand-over to operations. Some pre-project research and development costs, decommissioning and post-operations costs may also be allocated to Capex. A high level listing of Capex costs is included in Annex 1 at 10.1 below.

5.1.2 Fixed Operational Expenditure (Fixed Opex)

Fixed Opex includes those costs which are incurred after commissioning has been completed and hand-over to operation has occurred and which are independent of the level of throughput through the system e.g. operations team manhours, insurances, routine inspections and maintenance, etc.

5.1.3 Variable Operational Expenditure (Variable Opex)

Variable Opex includes those operational costs that are directly attributable and proportional to the actual throughput of the system (energy costs, consumable costs, operational hours related maintenance, etc.).

In the case of a CO_2 transport system the variable opex metric is likely to be a cost per tonne of CO_2 throughput and in the case of a CO_2 storage system the variable opex metric will be tonnes of CO_2 stored. These costs may be standardised for all CO_2 streams (i.e. regardless of composition subject to being within specification), alternatively, it may be more suitable for variable opex to include a correction factor that allows for the quality of the CO_2 mixture throughput or stored and the effect that levels of harmful mixture components might have on the life of the relevant assets and/ or cost of operation[18].

5.1.4 Financial Security

In the case of CCS systems developed with the territory of an EU Member State, Article 19 of the European CCS Directive requires that, before any permit to commence CO_2 storage is granted, the operator of the relevant storage site shall establish a financial security instrument of sufficient value to cover all of the obligations included in the relevant storage permit (n.b. this does not apply to transportation infrastructure). The obligations that must be covered by the financial security include: those of the storage site operator during the storage site closure and post-closure periods; and those

[18] The inclusion of such a CO2 quality correction factor would not imply that CO2 mixtures with any composition would be permitted to enter the shared infrastructure system. In all events there would be a CO2 specification outside the limits of which CO2 would not be allowed to enter the shared infrastructure system under any circumstances.

associated with the storage site's designation as an Installation for the purposes of the European ETS Directive (i.e. the cost of purchase of EUA's commensurate with any CO_2 emissions (including eventual leaks) from the storage site).

The requirement to maintain a financial security in respect of a storage site ceases at the point at which the responsibility for that site is transferred to the relevant member state as provided for in the CCS Directive.

The financial security covers both fixed and variable costs and the CCS Directive requires that its value is periodically adjusted to ensure that it is sufficient to cover all relevant permit obligations at all times. The project cost associated with maintaining the financial security will therefore include a fixed and variable element and will be two-way i.e. subject to the financial security not being called upon and the deduction of costs associated with the setting up and management of the security, financial security costs will be returned to the storage operator, and therefore system user, at some stage.

How the cost of financial security provision will be covered and what types of financial securities are suitable has been the subject of much debate and the European Commission has published a guidance document that is specific to this subject[19]. Within the constraints of this guidance, it is for each European Member State to select the methods by which the Article 19 requirements are to be met within their territory. The financial security requirements of the Directive have been transposed into UK law but the transposition remains silent on the level to which (if any) the state might underwrite any financial security instrument. Such underwriting, or something analogous to it, may yet transpire and, therefore, the arrangements that will be used in the UK to meet the Article 19 requirements and the costs associated with this are not currently clear. Nevertheless it is currently considered likely that this cost category will constitute a significant project cost.

With regard to jurisdictions outside of the EU the statutory imposition of financial security obligations analogous to those described above should be considered.

5.1.5 Post-Closure Obligations

With regard to CCS projects developed within the territory of an EU Member State, subject to certain conditions, the CCS Directive provides for the eventual transfer of all legal obligations relating to a storage site to be transferred to the relevant Member State. The Directive also requires, under Article 20, that, before such transfer takes place, the relevant storage operator should make finances available (the 'financial mechanism') to the member state to cover certain costs to be incurred post transfer. The value of the financial mechanism shall be sufficient to meet the monitoring requirements set out in the CCS Directive for, as a minimum, a period of 30 years after the transfer of obligations has taken place. The European Commission has published guidelines in regard to the financial mechanism[20].

[19] European Commission Document – Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide. Guidance Document 4 – Article 19 Financial Security and Article 20 Financial Mechanism.

[20] Ibid.

The level of post-transfer monitoring requirements applicable to any particular storage site depends, to some degree, upon the amount of CO_2 stored in the site. The costs associated with Article 20 obligations are therefore partially fixed and partially variable. Also, it is unclear whether, in the event that the financial mechanism funds were not fully utilised, remaining funds would be returned to the storage operator. The financial mechanism fund may therefore be a two-way project revenue stream.

With regard to jurisdictions outside of the EU the statutory imposition of storage site post-closure obligations analogous to those described above should be considered.

5.1.6 Decommissioning

Decommissioning costs are those associated with the making safe, deconstruction, removal and disposal of assets once those assets are permanently withdrawn from service and the returning of the site upon which the assets were situated to a state as required by the relevant development consent and prevailing legislation. In some scenarios assets will not be removed but will be made safe and either moth-balled or permanently decommissioned in-situ; in such cases the costs of carrying out these operations would be included in the decommissioning cost.

5.2 Heads of Charges

The aggregate charge for the development and use of a CO_2 transportation and storage system could be broken down into separate and distinct heads of charges in various ways. The number of heads of charges used and the allocation of costs to each head is intrinsically linked with the operation of the capacity charging mechanism which the system operator intends to apply as they have the potential to fundamentally effect the ways in which system users can be incentivised to invest in and use system capacity.

The design of the heads of charges may also be affected by legal or regulatory factors. In the UK, for example, regulations regarding third party access to CO_2 transport and storage infrastructure[21] *indicate that, with regard to GB, three separate charges under the following heads are foreseen by the legislature:*

- *EPC Charge;*
- *Capacity Rights Charge; and*
- *Use of System Charge.*

As suggested above, this three charge system is one of many that might be applied and different charge breakdowns would offer different advantages and disadvantages. However, for the purposes of this Targeted Report, the three charge system set out above will be considered in order to demonstrate the potential that the number of charges, and the allocation of costs to them, has to influence and facilitate investment in, and use of, the infrastructure system.

[21] Ibid. 8

5.2.1 EPC Charge

For the purposes of this example, the EPC Charge covers the costs associated with the engineering, procurement and construction of system capacity. The EPC Charge may also include those pre-project kick-off concept and development costs which are to be recovered as part of the project as well as any other asset associated costs and costs of risks (e.g. decommissioning costs, post-closure risks, etc.).

Depending upon the financing arrangements associated with that part of the system capacity in question, the EPC Charge may be recovered during, or at the end of, the EPC period, or, alternatively, may be recovered over a period covering all, or only a part of, the life of the infrastructure asset.

The EPC Charge in this section 5 relates to the Shared System EPC Charge (SSEC) in section 6 below.

5.2.2 Capacity Rights Charge

For the purposes of this example, the Capacity Rights Charge is the charge associated with the acquisition of the right to use a proportion of the capacity in the shared infrastructure system. This charge is likely to include, inter alia, fixed operational and maintenance costs, i.e. those costs which are incurred due to the operation of the assets but which are not related to the level of system throughput, e.g. pipeline surveys.

The calculation of this charge may depend upon whether the party obtaining the rights to use the system capacity has, or has not, paid for the EPC cost of the system capacity, via the EPC Charge or otherwise.

The Capacity Rights Charge may also include those pre-project kick-off concept and development costs which are to be recovered as part of the project as well as asset associated costs and risk premiums (e.g. decommissioning costs, post-closure risks, etc.).

In cases where a party is entering into an agreement for the provision of infrastructure capacity (via the EPC Charge or otherwise) it is likely that that party would wish, simultaneously, to obtain the right to use that capacity, and would therefore become liable to pay the associated Capacity Rights Charge. It is however not inevitable that the party paying the EPC charge, and thereby funding the development of the system capacity, should be the same party paying the Capacity Rights Charge, and thereby obtaining the rights to use that capacity; the two charges are, therefore, separate and distinct.

The Capacity Rights Charge in this section 5 relates to the Shared System Capacity Rights Charge (SSRC) in section 7 below.

5.2.3 Use of System Charge

An obligation to pay the Use of System Charge is incurred by physically using capacity in the asset i.e. the transportation or storage of a quantity of CO_2 in the infrastructure system. This charge would cover the variable cost of asset use (incremental fuel cost, incremental financial security and insurance costs, etc).

The Use of System Charge in this section 5 relates to the Shared System Use of System Charge (SSUC) in section 8 below.

5.2.4 Recovery of EPC Charge and Capacity Rights Charge on £/Tonne Basis

Some proportion of the EPC Charge and Capacity Rights Charge may be recovered on a £/tonne transported or stored basis (as opposed to a single payment or series of pre-determined periodic payments). Where this is the case, if the SO wishes to absolutely ensure cost recovery and insulate itself entirely from demand risk, a commitment would be required, on the part of the System User, to pay for the use of a specified level of system capacity over a specified period, whether that System User actually used that level of capacity or not (i.e. a 'Take or Pay' arrangement). Alternatively, depending upon the SO's appetite for demand risk, some proportion of the EPC Charge and Capacity Rights Charge could be included as part of the Use of System Charge without the System User's commitment to actually use the system to any specific extent (i.e. a 'Pay as You Go' model). Whatever the specific details of any allocation of EPC Charges and Capacity Rights Charges payments via the Use of System Charge, and despite such payments being paid on a £/tonne basis, they are not considered in this Targeted Report as part of the Use of System Charge.

5.3 Division of System Costs into Heads of Charges

In order to calculate the level of each of the charges, under the three heads of charges identified in section 5.2 above, for any given project, configuration or scenario, the costs detailed in section 5.1 above must be allocated to each of those heads. There is some flexibility with regard to this allocation. Certain categories of costs might tenably be allocated to more than one of the heads of charges.

This flexibility may prove an important tool in achieving efficiently sized infrastructure. For example a system developer/operator may wish to:

- manipulate the cash-flow and financing requirements of system users by allocating costs to charges which would be paid during operations, once the system user has its own operational revenues, rather than front-end loading system user's financial models with costs payable prior to the start of system operations;

- alter the magnitude and allocation of demand risk via the amount of costs allocated to charges which are exposed to that category of risk;

- set the level of cost allocated to any party funding the development of infrastructure capacity without the intention to physically use or trade that capacity (e.g. a State or philanthropic NGO wishing to procure the development of CCS infrastructure capacity for environmental or legal / regulatory compliance reasons);

- create a fair and equitable allocation of costs to those parties funding the initial system development (who would pay the EPC Charge and the Capacity Rights Charge) and those parties taking up capacity coming available later in the life of existing assets (who would pay only the Capacity Rights Charge); and / or

- affect the pricing of 'system capacity option contracts' where the option price and exercise price were synonymous with, or set in proportion to the EPC Charge and Capacity Rights Charge.

A system developer / operator may wish to design its system of charges in a certain way in order to influence the investment behaviour of system users. However there may also be legal or regulatory

factors which influence the charging system design and the allocation of costs to heads of charges. For example, in GB, the Carbon Dioxide (Access to Infrastructure) Regulations 2011[22], coupled with the guidance given by DECC regarding the likely attitude of the Secretary of State as to the level of return on investment that should be made under each head of charge, suggest that different regulatory regimes will apply to the pricing of each of the three heads of charges. One consequence of this is that the allocation of costs between the three heads of charges has the potential to influence investment in and use of system capacity by altering the price of: constructing incremental system capacity; acquiring capacity rights; and system utilisation. This is further discussed below.

5.3.1 The Carbon Dioxide (Access to Infrastructure) Regulations 2011

The Regulations provide that, when granting a consent for the development of a CO_2 pipeline, store and/or associated plant and equipment, the Secretary of State, Infrastructure Planning Commission (IPC) or Scottish ministers, as applicable, may, if there is evidence to believe that there is sufficient demand, include in that consent conditions which vary the capacity, design and, in certain circumstances, the routing of the relevant assets.

If such conditions are added to any consent then a notice may be served, on the party requesting the relevant variations, requiring that that party should pay to the holder of the consent such sums as are necessary 'for the purpose of defraying so much of the costs of constructing the relevant infrastructure as is attributable to the variation'. Current opinion is that this phrase fetters the Secretary of State's discretion with respect to the amount of costs he may require a party requesting infrastructure modifications to pay in return for those modifications being made. This opinion is based upon the rationale that the regulation requires that the Capex costs attributable to the construction of the incremental capacity requested by a third party must be charged to that third party without the addition of a share of the hypothetical cost of building the infrastructure without the additional capacity requested i.e. the third party must be charged for the capacity it acquires at true incremental cost rather than proportional shared cost. It is suggested that the incremental costs specified by the Regulations would be construed as those that constitute the EPC Charge identified in section 5.2 above.

The Regulations also provide that, upon application from a third party seeking access to CO_2 transportation and storage infrastructure, the Secretary of State or Scottish ministers, as applicable, may serve a notice granting the relevant third party the access it seeks. This notice of grant may:

'contain provision authorising one or more of the owners to recover from the applicant payments by way of consideration for any right secured by the notice of amounts specified in the notice or determined in accordance with the notice'; and may also contain provisions which,

'regulate the charges which may be made for the exercise of any right secured by the notice'.

It should be noted that neither of these phrases appear to fetter the Secretary of State's discretion with respect to the basis or level of the consideration and charges, but does provide that their level shall be regulated by the Secretary of State.

[22] Ibid. 8

It is suggested that the consideration and charges mentioned in the two phrases above would be construed as those which constitute the Capacity Rights Charge and Use of System Charge (as identified in section 5.2 above) respectively.

If the above suggestions are correct then it can be seen that the allocation of costs to the EPC Charge head would exclude the recovery of sums greater than those based upon incremental cost whilst the allocation of costs to the Capacity Rights Charge and the Use of System Charge would allow greater latitude for the application of a premium associated with the risk taken by the system operator in speculatively investing in the assets.

With regard to each particular infrastructure system, the final scheme of charges, and allocation of costs to those charges, will be based upon a balance between the system operator's commercial aims and strategy and the legal and regulatory framework prevailing in the relevant jurisdiction.

5.4 Example Allocation of Costs to Heads of Charges for Incremental Capacity

The following allocation of costs to heads of charges[23] is suggested as one potential option for the allocation of costs to charges, for a 'second-comer' system user requesting the construction of additional capacity into an infrastructure system under development.:

5.4.1 EPC Charge

Costs: Incremental EPC
Additional 'whole project' risk premium attributable to the Incremental EPC

5.4.2 Capacity Rights Charge

Costs Incremental Fixed Opex
Additional 'whole project' risk premium attributable to Incremental Fixed Opex
Article 19 Financial Security Fixed Costs
Article 20 Financial Mechanism Fixed Costs
Incremental Decommissioning Costs
Additional 'whole project' risk premium attributable to Incremental Decommissioning costs

5.4.3 Use of Capacity Charge

Costs Attributable Variable Opex
Proportional Maintenance Premium (or proportional sharing of outturn maintenance costs).
Article 19 Financial Security Variable Costs
Article 20 Financial Mechanism Variable Costs

5.4.4 Risk Premiums

In the above cost allocation example there are three cost categories which include the 'additional 'whole project' risk premium' associated with capex, opex and decommissioning cost. These cost categories are included specifically for, and will apply only to, 'second-comer' system users, i.e. all those system users which are not Anchor Tenants.

[23] Based upon the three charge model described above.

The reason for the inclusion of these three cost categories is that the introduction of 'second-comers' onto the infrastructure system increases the complexity of the system's operation and thereby increases the risk of loss of service availability across the system as a whole. This increase in risk affects not only the relevant 'second-comer' system user, but all other system users as well.

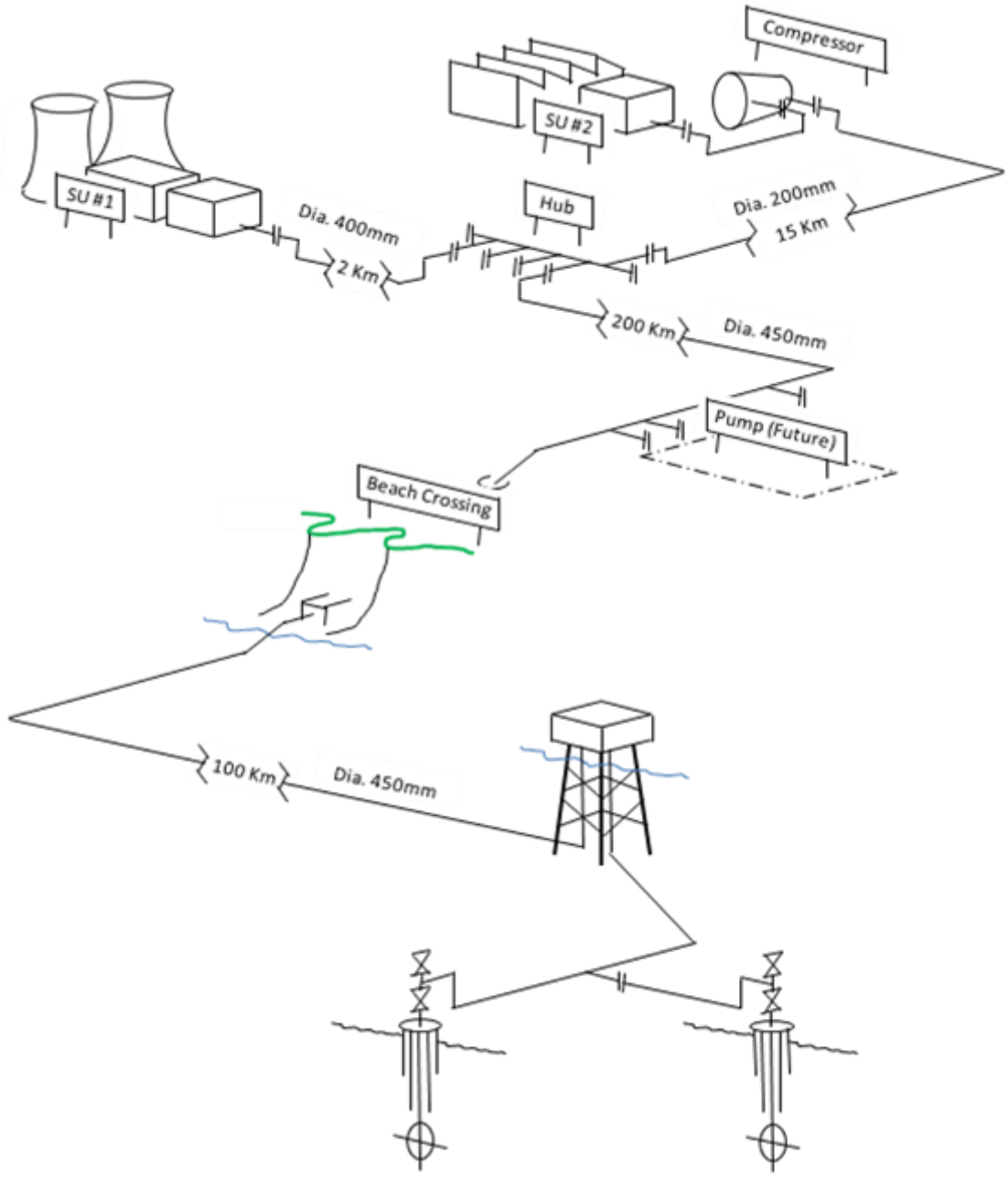
There is a cost associated with bearing this incremental 'whole chain' risk and it is possible that the system operator may wish to allocate all, or some, of this cost to the 'second-comer' system user whose addition to the system increased the risk and therefore incurred the cost. The 'risk premium' cost category provides a section, in the cost breakdown of the charges applicable to 'second-comer' system users, into which this cost can be inserted.

Whether, and to what degree, 'second-comers' will be expected to bear the 'additional 'whole project' risk premium', and how that risk premium is calculated, will depend upon the specifics of the payment mechanism. It may be, for example, that a system operator would, in an attempt to maximise demand for system capacity, choose, to some degree, to bear the cost of these risk premiums itself in order to increase the attractiveness of system use to prospective 'second-comer' system users.

5.5 CASE STUDY EXAMPLE

The practical application of the example allocation of project costs to heads of charges described above is demonstrated below using the following scheme which is based upon the Case Study introduced earlier in this Targeted Report.

Figure 4 - Example Scheme - Two User System



The example below is based upon the scheme shown above and demonstrates three options for the distributions of costs across the three heads of charges described in section 5.2 above:

- *Option 1 – The amount of costs allocated to the EPC Charge is maximised. There is no Capacity Rights Charge. Only that variable operating expenditure which is directly attributable to each system user is included in that system user's Use of System Charge;*
- *Option 2 – This reflects the cost to charges breakdown suggested in section 5.4 (*Example Allocation of Costs to Heads of Charges for Incremental Capacity) *above; and*
- *Option 3 – the amount of cost allocated to the EPC Charge is minimised and the Use of System Charge is also kept relatively low. This loads cost into the Capacity Rights Charge.*

Cost to Charge Allocation Table

Cost Breakdown Category	***Cost to SU#1***	***Cost to SU#2***	***Cost to Charge Allocation Option (Examples)***		
	£m		***Option 1***	***Option 2***	***Option 3***
Incremental EPC	*617.50*	*66.50*	*EPC Charge*	*EPC Charge*	*EPC Charge*
Additional 'whole project' risk premium attributable to the Incremental EPC	*61.75*	*6.65*	*EPC Charge*	*EPC Charge*	*Cap Rights Charge*
Incremental Fixed Opex	*570.00*	*70.00*	*EPC Charge*	*Cap Rights Charge*	*Cap Rights Charge*
Additional 'whole project' risk premium attributable to Incremental Fixed Opex	*57.00*	*7.00*	*EPC Charge*	*Cap Rights Charge*	*Cap Rights Charge*
Article 19 Financial Security Fixed Costs	*2.00*	*0.00*	*EPC Charge*	*Cap Rights Charge*	*Cap Rights Charge*
Article 20 Financial Mechanism Fixed Costs	*100.00*	*0.00*	*EPC Charge*	*Cap Rights Charge*	*Cap Rights Charge*
Incremental Decommissioning Costs	*132.00*	*10.00*	*EPC Charge*	*Cap Rights Charge*	*Cap Rights Charge*
Additional 'whole project' risk premium attributable to Incremental Decommissioning costs	*13.20*	*1.00*	*EPC Charge*	*Cap Rights Charge*	*Cap Rights Charge*
Attributable Variable Opex	*6.58*	*1.32*	*UoS Charge*	*UoS Charge*	*UoS Charge*
Proportional Maintenance Premium (or proportional sharing of outturn maintenance costs).	*28.50*	*3.50*	*EPC Charge*	*UoS Charge*	*Cap Rights Charge*
Article 19 Financial Security Variable Costs	*75.00*	*15.00*	*EPC Charge*	*UoS Charge*	*UoS Charge*
Article 20 Financial Mechanism Variable Costs	*0.00*	*0.00*	*EPC Charge*	*UoS Charge*	*UoS Charge*
Totals	***1,664***	***181***			

Charges for Options 1 – 3

Option 1	*£m*	
EPC Charge	*1,657*	*180*
Cap Rights Charge	*0*	*0*
UoS Charge	*7*	*1*

Option 2	*£m*	
EPC Charge	*679*	*73*
Cap Rights Charge	*874*	*88*
UoS Charge	*110*	*20*

Option 3	*£m*	
EPC Charge	*618*	*67*
Cap Rights Charge	*964*	*98*
UoS Charge	*82*	*16*

Table 6

Assumptions

For the purposes of the allocation of costs to the two system users in the above example, it has been assumed that:

- *The system is being developed in GB;*
- *SU#2 will pay incremental costs only (i.e. there will be no sharing of capacity independent costs across system users – these will be borne entirely by SU#1 as the Anchor Tenant);*
- *(for this example only) the compressor required by SU#2 will be outside of the scope of work of the infrastructure system operator;*
- *both system users will secure and use infrastructure capacity rights for 20 years;*
- *all system development and decommissioning costs will be covered by SU#1 and SU#2 combined during the 20 year period in which they use the system;*
- *the flow amalgamation hub would be installed as part of a single user system;*
- *the 450mm pipelines downstream of the Hub would be 400mm for SU#1 alone;*
- *the 'future' pumping station will be needed for around 10 years and its energy cost is included in the variable operational expenditure for SU#1;*
- *No additional wells or reservoir capacity are required to accommodate SU #2 onto the system; and*
- *SU #2 comes to the project during its development consenting period.*

Discussion

Option 1 – This option, as would be expected, produces a high EPC Charge and low Use of System Charge. This may be preferable to a system developer / operator if it is to take some system availability / demand risk in the form of losing revenue if the predicted level of system use is not achieved (for example if it intends to offer system capacity on a 'Pay-as-you-Go' basis).

This option may also be attractive to a system developer if the EPC costs of developing the infrastructure (and therefore the EPC Charge or some portion of it) are to be met by a party wishing to see CCS infrastructure capacity made available for environmental or societal reasons (i.e. State or benevolent NGO funded capacity) as it would yield low cost system use and thereby encourage system use take-up.

For a project being developed within a jurisdiction where third-party system users had a statutory right to acquire system capacity at true incremental cost, a high EPC Charge may be divisive if it is perceived as representing incremental cost.

If system users coming onto the system after the first 20 years of use (in this example) were to be charged on the same basis as the initial system users, then the absence of Capacity Rights Charge in this option would prevent the system operator from charging those follow-on system users for the acquisition of rights to use the system. This is likely to be an unattractive option for a system operator which is basing is business development plan on the life of the infrastructure assets rather than the initial 20 year utilisation period.

Option 2 – This option demonstrates how one suggested balance of cost allocation between the EPC Charge and Capacity Rights Charge might be considered to deal equitably with the system operator and all system users. It provides for a significant amount of cost to be allocated to the Capacity Rights Charge, allowing for State (or NGO) funded capacity development to be lower cost than in option 1 (as such a funder would pay the EPC Charge only) and for 'second-comer' users to be properly charged for acquiring capacity in existing assets.

If the EPC Charge and Capacity Rights Charge are to be recovered at different times during the project, for example, if the EPC Charge were to be recovered on an up-front or fixed annual fee basis and the Capacity Rights Charge were to be recovered in proportion to actual system usage, then the balance of cost allocation between the two charges could significantly affect the cash-flow/financing and risk allocation of the project.

In jurisdictions where the statutory rules applied to charges for the development of system capacity are different to those applied to charges for the acquisition of rights to use system capacity, an increased level in the Capacity Rights Charge may prove attractive to the system operator.

The balance of cost allocation between EPC Charge and Capacity Rights Charge may also prove important in circumstances in which a system developer / operator intends to offer potential system users 'Option Contracts' under which the option and exercise prices are based upon the levels of EPC Charge and Capacity Rights Charge.

The costs distribution in option 2 also yields a high Use of System Charge. Such an outcome would have obvious implications for magnitudes of risk if a system operator were exposed to system availability and/or demand risk.

Option 3 – This option is included to illustrate an extreme of the cost allocation spectrum in which the Capacity Rights Charge were maximised. Comments with respect to this option can generally be extrapolated from those made with regard to option 2.

6 STATEMENT OF THE SHARED SYSTEM EPC CHARGE

6.1 PRINCIPLES

For the purposes of this section 6 it is assumed that the following principles will be applicable to the development, operation and decommissioning of the Shared Infrastructure System.

The Shared System EPC Charge (SSEC) reflects the cost of the development of those parts of the CO_2 transportation and storage infrastructure system the use of which is shared by two or more System Users (the Shared Infrastructure System).

Capacity in a Shared Infrastructure System shall be developed by the SO in consideration of the commitment by the relevant System Users to pay the relevant part of the SSEC[24]. I.e. in return for the payment of (or commitment to pay) the SSEC which relates to the capacity requested by a system user, the system operator will ensure that the overall capacity of the shared system which is developed includes the available capacity which the system user has requested. It is important to note that, in the three-charge methodology applied for the purposes of this example, payment of the SSEC alone does not give the system user the right to use the capacity it has procured to be constructed. Such right will be secured by the payment of the Shared System Capacity Rights Charge. In practice, it is likely that most system users procuring the development of system capacity by paying the SSEC will also wish to acquire the right to use that capacity, however, it is useful to have the two charges separate in order that, for example:

- *if a 'system user' wished to ensure that spare system capacity was built without wishing to have rights over it (such as a State or NGO wishing to ensure that CCS developed for environmental reasons); or*
- *a system user were to use capacity coming available after the end of a period of use secured by the initial system user (i.e. the take-up of ullage becoming available during the life of the infrastructure system),*

then a clearly defined definition for the calculation of both the SSEC and the Capacity Rights Charge would be essential if fair and transparent charging for system capacity were to be demonstrated.

The System User shall not receive any primary property ownership of any part of the Shared Infrastructure System as a result of its commitment to pay the relevant SSEC and the SO shall, at all times, retain ownership of the assets comprising the Shared Infrastructure System. The relevant System User may acquire, under the provisions of a Transport (and Storage) Services Agreement, the rights to use capacity in the Shared Infrastructure System by committing to pay a Capacity Rights Charge. See section 7 below for further details.

The SSEC calculation methodology presented in this section 6 may be used to derive both the SSEC for the whole of the Shared Infrastructure System and the SSEC for that capacity in the Shared Infrastructure System that is procured by each System User. The SSEC that is calculated depends

[24] The SO might choose to develop some system capacity on a speculative, or semi-speculative (option) basis. This contingency is not relevant within the context of this section, which deals only with capacity that is constructed on the basis of firm contracts for its use.

upon the costs which are input into the calculation. The methodology for distributing, between the various System Users, the costs upon which the SSEC is based, is discussed in section 9 below. It is however worth noting here that, that part of the total system SSEC which is attributable to each System User may, or may not, be proportionate to the ratio of the Shared Infrastructure System capacity procured by that System User and the total Shared Infrastructure System capacity.

The SSEC may be recovered by a combination of: project services fee ('ASEP'); charge for capital employed by the SO ('ASEC') and periodic capital contributions by the System User. For further detail on this principle see section 2.10.

The method of derivation of the SSEC shall be included in the contract, made between the SO and the System User, which governs the development and use of the Shared Infrastructure System (the Transport (and Storage) Services Agreement).

The initial SSEC shall be calculated based upon the present value of the SO's net expenditure during the period between the start of project expenditure and the date of the commissioning sign-off of the Shared Infrastructure System (the 'EPC Period'). If the SO incurs expenditure associated with the development of the Shared Infrastructure System after the date of that system's commissioning sign-off, then that expenditure shall, in the month that it is made, be added to the expenditure sum upon which the SSEC is calculated.

If there is a period of Shared Infrastructure System non-availability between the commissioning sign-off of the Shared Infrastructure System and the commissioning sign-off / availability of the CCS system as a whole, then any associated amendments to the arrangements for the payment of the SSEC during that period shall be as set out in the non-availability provisions of the Transport (and Storage) Services Agreement.

6.2 Derivation of Shared System EPC Charge (SSEC)

6.2.1 Costs Included in Shared System EPC Charge

For the purposes of example in this Targeted Report, the SSEC payable by the System Users is based upon the following costs:

- *Project development costs;*
- *Project management and project services;*
- *Land acquisition and development;*
- *Engineering, procurement and construction including system commissioning;*
- *EPC risk premiums (including, where single System User SSEC is being calculated, any risk premiums incurred across the whole Shared Infrastructure System as a result of the development of the system capacity procured by that System User); and*
- *any and all other EPC costs associated with the provision of capacity in the Shared Infrastructure System to the System Users.*

6.2.2 Fees and Capital Charges

The SSEC is a combination of two charges as follows[25]:

- *A Project Service Fee which reflects the costs incurred by the SO in managing and supporting the development of the Shared Infrastructure System plus a reasonable amount of profit; and*
- *A Capital Charge which reflects the cost of capital provided by the SO (if any) to finance the cost of the development of the Shared Infrastructure System plus a reasonable rate of return.*

6.2.3 Indicative and Actual Project Services Fees and Capital Charges

The Transport (and Storage) Services Agreement will include indicative fees and charges as well as methods for the calculation of actual fees and charges based upon outturn costs and present values at the date when charges are calculated.

The Transport (and Storage) Services Agreement may include performance incentive schemes which include risk and reward sharing aspects based upon the difference between estimated and outturn costs.

6.2.4 Capital Contributions and Periodic Payments during the EPC Period

The System User may make, during and/or at the end of the EPC Period:

- *capital contributions to the cost of the development of the relevant part of the Shared Infrastructure System; and*
- *periodic payments to offset the SO's expenditure in developing the relevant part of the CO_2 transportation and storage infrastructure system.*

Capital contributions and periodic payments may be made to offset the expenditure which is the basis of the Project Service Fee and/or the expenditure which is the basis of the SSEC Capital Charge.

6.2.5 Period and Payment of SSEC

The SSEC applying to each System User shall be paid in monthly instalments over a payment period agreed between that System User and the SO (the 'SSEC Payment Period').

The SSEC Payment Period shall start on the day after the last day of the EPC period.

The SSEC applying to each System User shall be paid monthly in arrears.

6.2.6 Calculation of the SSEC Project Services Fee

The SSEC Project Services Fee shall be calculated in two stages:

- *Firstly the present value, at the start of the SSEC Payment Period, of the net expenditure upon which the SSEC Project Services Fee is based is calculated;*
- *Secondly, that value is used as the basis of the SSEC Project Services Fee.*

[25] What proportion of the SSEC is recoverable via the two charges will vary from project to project and depends largely upon the financing model which is adopted for the project.

This two-stage methodology allows capital contributions towards EPC project services costs made prior to the start of the SSEC Payment Period to be netted off from the total expenditure value before the SSEC Project Services Fee is calculated.

6.2.6.1 Net Value of Expenditure

The present value, at the start of the SSEC Payment Period, of the net expenditure upon which the Project Services Fee is based shall be calculated using the following general formula:

$ExSEP_{PV} = \sum^{m=1}_{Me} (ExSEP_m / F_{DRNm})$

where:

$ExSEP_m$	=	net EPC Project Services expenditure in month m;
Me	=	Total number of months in the EPC Period; and
m	=	month in EPC Period or SSEC Payment Period,

and:

$ExSEP_m = (ExSEP_{mGross} * MU) - CC_{ExSEP}$

where:

$ExSEP_{mGross}$	=	Gross EPC Project Services expenditure in month m;
MU	=	Fee mark-up percentage; and
CC_{ExSEP}	=	Capital contributions to EPC Project Services expenditure in month m (if any),

and:

$F_{DRNm} = (F_{DRNm+1}/(1+DR_{Nm+1}))$ in all months in the EPC Period except the final month; and

$F_{DRNm} = 1$ in final month of EPC Period (i.e. month before the start of the SSEC Payment Period)

where:

F_{DRNm}	=	Monthly Nominal Discount Rate Factor for month m;
F_{DRNm+1}	=	Monthly Nominal Discount Rate Factor for the month immediately following month m;
DR_{Nm}	=	Monthly Nominal Equivalent Discount Rate applicable to the EPC Project Services in month m.
DR_{Nm+1}	=	Monthly Equivalent Nominal Discount Rate applicable to the EPC Project Services in the month immediately following month m.

and:

$DR_{Nm} = (1 + DR_{Nn})^{1/12} – 1,$

and:

$DR_{Nn} = ((1+DR_R)*(1+RPI_{AAn}))-1$

where:

DR_{Nn}	=	Nominal Annual Discount Rate applicable to the Shared Infrastructure System EPC project services in year n;
DR_R	=	Real Annual Discount Rate applicable to the EPC Project Services; and
RPI_{AAn}	=	Annual Average Retail Prices Index inflation for year n.

Noting that when estimating the SSEC Project Services Fee, the net monthly expenditure levels input into the above formula must be in nominal terms.

6.2.6.2 SSEC Project Services Fee

The SSEC Project Services Fee is calculated using the following general formulae:

For the first year of the SSEC Payment Period:

$$ASEP_{n=1} = (ExSEP_{PV} – CC_{n=0})(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} – 1)))$$

For all subsequent years in the SSEC Payment Period:

$$ASEP_n = (ExSEP_{Rn} – CC_n)(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} – 1)))$$

where:

$ExSEP_{Rn}$	=	residual amount of $ExSEP_{PV}$ remaining to be recovered at start of year n;
$CC_{n=0}$	=	Capital contribution (if any) made at start of SSEC Payment Period;
CC_n	=	Capital contribution (if any) made at start of year n;
Np	=	number of years in the SSEC Payment Period; and
n	=	year of SSEC Payment Period for which repayment is being calculated.

and:

$$ExSEP_{Rn} = ExSEP_{Rn-1} (1+ DR_{Nn}) - ASEP_{n-1}$$

where:

$ExSEP_{Rn-1}$	=	$ExSEP_{Rn}$ for year previous to year n (and, for the avoidance of doubt, for the second year in the SSEC Payment Period this is equal to $ExSEP_{PV}– CC_{n=0}$); and
$ASEP_{n-1}$	=	$ASEP_n$ for year previous to year n,

With respect to the relevant Shared Infrastructure System, the allocation of costs upon which each System User's SSEC Project Services Fee is based is discussed in section 9 below.

6.2.7 Calculation of the SSEC Capital Charge

The Annual SSEC Capital Charge payable for each shared part of the Shared Infrastructure System shall be calculated in two stages:

- *Firstly the present value, at the start of the SSEC Payment Period, of the net expenditure upon which the SSEC Capital Charge is based is calculated;*

- *Secondly, that value is used as the basis of the SSEC Capital Charge.*

This two-stage methodology allows capital contributions towards EPC capital costs made prior to the start of the SSEC Payment Period to be netted off from the total expenditure value before the SSEC Capital Charge is calculated.

6.2.7.1 Net Value of Expenditure

The present value, at the start of the SSEC Payment Period, of the net expenditure upon which the SSEC Capital Charge is based shall be calculated using the following general formula:

$ExSEC_{PV} = \sum^{m=1}_{Me} ((ExSEC_m - CC_{ExSEC}) / F_{DRNm})$

where:

$ExSEC_m$	=	EPC Capital expenditure in month m;
Me	=	Total number of months in the EPC Period;
m	=	month in EPC Period or SSEC Payment Period; and
CC_{ExSEP}	=	Capital contributions to EPC Project Services expenditure in month m (if any),

and:

$F_{DRNm} = (F_{DRNm+1}/(1+DR_{Nm+1}))$ in all months in the EPC Period except the final month; and

$F_{DRNm} = 1$ in final month of EPC Period (i.e. month before the start of the SSEC Payment Period)

where:

F_{DRNm}	=	Monthly Nominal Discount Rate Factor for month m;
F_{DRNm+1}	=	Monthly Nominal Discount Rate Factor for the month immediately following month m;
DR_{Nm}	=	Monthly Nominal Equivalent Discount Rate applicable to the EPC Project Services in month m.
DR_{Nm+1}	=	Monthly Equivalent Nominal Discount Rate applicable to the EPC Project Services in the month immediately following month m.

where:

$DR_{Nm} = (1 + DR_{Nn})^{1/12} – 1,$

and:

$DR_{Nn} = ((1+DR_R)*(1+RPI_{AAn}))-1$

where:

DR_{Nn}	=	Nominal Annual Discount Rate applicable to the Shared Infrastructure System EPC Works in year n;
DR_R	=	Real Annual Discount Rate applicable to capital invested by THE SO in the EPC Works; and

RPI_{AAn} = Annual Average Retail Prices Index inflation for year n.

Noting that when estimating the SSEC Capital Charge, the net monthly expenditure levels input into the above formula must be in nominal terms.

6.2.7.2 SSEC Capital Charge

The Annual SSEC Capital Charge is calculated using the following general formulae:

For the first year of the SSEC Payment Period:

$$ASEC_{n=1} = (ExSEC_{PV} – CC_{n=0})(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} – 1)))$$

For all subsequent years in the SSEC Payment Period:

$$ASEC_n = (ExSEC_{Rn} – CC_n)(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} – 1)))$$

where:

$ExSEC_{Rn}$ = residual amount of $ExSEC_{PV}$ remaining to be recovered at start of year n;
$CC_{n=0}$ = Capital contribution (if any) made at start of SSEC Payment Period;
CC_n = Capital contribution (if any) made at start of year n;
Np = number of years in the SSEC Payment Period; and
n = year of SSEC Payment Period for which repayment is being calculated.

and:

$$ExSEC_{Rn} = ExSEC_{Rn-1} (1+ DR_{Nn}) - ASEC_{n-1}$$

where:

$ExSEC_{Rn-1}$ = $ExSEC_{Rn}$ for year previous to year n (and, for the avoidance of doubt, for the second year in the SSEC Payment Period this is equal to $ExSEC_{PV}– CC_{n=0}$); and
$ASEC_{n-1}$ = $ASEC_n$ for year previous to year n,

With respect to the relevant Shared Infrastructure System, the allocation of costs upon which each System User's SSEC Capital Charge is based is discussed in section 9 below.

7 STATEMENT OF THE SHARED SYSTEM CAPACITY RIGHTS CHARGE

7.1 PRINCIPLES

The Shared System Capacity Rights Charge (SSRC) reflects the cost of acquiring the right to use capacity in the Shared Infrastructure System, where that cost is over and above the EPC cost of developing the Shared Infrastructure System.

Rights to use Shared Infrastructure System capacity shall be acquired, under a Transport (and Storage) Services Agreement made between the SO and the System User, in consideration of payment of the SSRC by the System User, for a fixed and definite period (the 'Capacity Rights Period'). Ownership of those capacity rights shall be analogous to a lease and the primary (freehold) ownership of the Shared Infrastructure System shall at all times remain with the SO. At the end of the Capacity Rights Period, the SO, subject to any provisions of the Transport (and Storage) Services Agreement, shall have full property rights over the relevant capacity in the Shared Infrastructure System.

The SSRC calculation methodology presented in this section 7 may be used to derive both the SSRC for the whole of the Shared Infrastructure System and the SSRC for that capacity in the Shared Infrastructure System that is procured by each System User. The SSRC that is calculated depends upon the costs which are input into the calculation. The methodology for distributing, between the various System Users, the costs upon which the SSRC is based, is discussed in section 9 below. It is however worth noting here that, that part of the total system SSRC which is attributable to each System User may, or may not, be proportionate to the ratio of the Shared Infrastructure System capacity usage right procured by that System User and the total Shared Infrastructure System capacity.

The SSRC may be recovered by a combination of project services fee ('ASRP'), charge for capital employed by the SO ('ASRC') and periodic capital contributions by the System User or DECC. For further detail on this principle see section 2.10 below.

The method of derivation of the SSRC shall be included in the contract, made between the SO and the System User, for the development and use of the Shared Infrastructure System (the Transport (and Storage) Services Agreement).

If there is a period of Shared Infrastructure System non-availability between the commissioning sign-off of the Shared Infrastructure System and the commissioning sign-off / availability of the CCS system as a whole, then any associated amendments to the arrangements for the payment of the SSEC during that period shall be as set out in the non-availability provisions of the Transport (and Storage) Services Agreement.

7.2 DERIVATION OF SHARED SYSTEM CAPACITY RIGHTS CHARGE

7.2.1 Costs Included in Shared System Capacity Rights Charge

For the purposes of example in this Targeted Report, the SSRC payable by each System User is based upon the following costs:

- *Project management and project services during the SSRC Payment Period;*
- *Fixed Opex;*
- *Article 19 Financial Security Fixed Costs;*
- *Article 20 Financial Mechanism Fixed Costs;*
- *Decommissioning Costs;*
- *Any risk premium (including, where single System User SSEC is being calculated, any risk premiums incurred across the whole Shared Infrastructure System as a result of the development of the system capacity procured by that System User); and*
- *any and all other fixed operational and asset related costs associated with the provision of capacity in the Shared Infrastructure System to the System Users.*

7.2.2 Fees and Capital Charges

The SSRC is a combination of two charges as follows:

- *A Project Service Fee which reflects the costs incurred by the SO in managing and supporting the operations, maintenance and decommissioning of the Shared Infrastructure System plus a reasonable amount of profit; and*
- *A Capital Charge which reflects the cost of capital provided by the SO (if any) to finance the costs upon which the SSRC is based plus a reasonable rate of return.*

7.2.3 Indicative and Actual Project Services Fees and Capital Charges

The Transport (and Storage) Services Agreement will include indicative fees and charges as well as methods for the calculation of actual fees and charges based upon outturn costs and present values at the date when charges are calculated.

The Transport (and Storage) Services Agreement may include performance incentive schemes which include risk and reward sharing aspects based upon the difference between estimated and outturn costs.

7.2.4 Capital Contributions and Periodic Payments during the SSRC Payment Period

The System User may make, at the start of or during the SSRC Payment Period, capital contributions and periodic payments to offset the expenditure which is the basis of the SSRC Project Service Fee and/or the predicted expenditure which is the basis of the SSRC Capital Charge.

7.2.5 Period and Payment of SSRC

The SSRC applying to each System User shall be paid by the System User in monthly instalments over a payment period agreed between that System User and the SO (the 'SSUC Payment Period').

The SSRC Payment Period shall start on the day after the last day of the EPC period.

The SSRC applying to each System User shall be paid monthly in arrears.

7.2.5.1 The SSRC Period

The costs upon which the SSRC Capacity Rights Charge is based may be incurred during: the SSRC Payment Period; the life of the relevant Shared Capacity System asset; the decommissioning period; the post closure period; and any extended liability period (the 'SSRC Period').

7.2.6 Calculation of the SSRC Project Services Fee

The SSRC Project Services Fee System shall be calculated in two stages:

- *Firstly the present value, at the start of the SSRC Payment Period, of the net expenditure upon which the SSRC Project Services Fee is based is estimated;*
- *Secondly, that value is used as the basis of the SSEC Project Services Fee calculation.*

This two-stage methodology allows the relevant System User or DECC to make capital contributions to reduce the amount of the net expenditure sum which is the basis of the SSRC Project Services Fee and thereby reduce the level of that Fee over the SSRC Payment Period.

7.2.6.1 Allowing for Outturn Costs

An indicative SSRC Project Services Fee shall be included in the Transport (and Storage) Services Agreement. That indicative SSRC Project Services Fee is based upon an estimate of several categories of costs. At the date of each payment of the SSRC Project Services Fee some of those costs will have crystallised and will be known ('outturn') costs (e.g. Ongoing Project Management and Fixed Opex), whilst some will remain as future liabilities (e.g. management of decommissioning).

If, at the date of calculation of an SSRC Project Services Fee, outturn values are known for any of the costs making up that Fee, then those outturn values shall be substituted for the relevant estimated values in the calculation of that fee.

The Transport (and Storage) Services Agreement may include performance incentive schemes which include risk and reward sharing aspects based upon the difference between the estimated and outturn value of the costs which contribute to the SSRC Project Services Fee.

7.2.6.2 Net Value of Expenditure

The present value, at the start of the SSRC Payment Period, of the estimated net expenditure upon which the SSRC Project Services Fee is based shall be calculated using the following general formula:

$$ExSRP_{PV} = \sum^{m=1}_{Me} ((ExSRP_m * MU) / F_{DRNm})$$

where:

$ExSRP_m$	=	net estimated capacity rights related Project Services expenditure in month m;
Me	=	Total number of months in the SSRC Period;
MU	=	Fee mark-up percentage; and
m	=	month in the SSRC Period,

and:

F_{DRNm} = 1 in the first month of the SSRC Period; and

$F_{DRNm} = (F_{DRNm-1} * (1+DR_{Nm-1}))$ in all months in the SSRC Period except the first month,

where:

F_{DRNm}	=	Monthly Nominal Discount Rate Factor for month m;

F_{DRNm-1} = Monthly Nominal Discount Rate Factor for the month immediately before month m;

DR_{Nm} = Monthly Equivalent Nominal Discount Rate applicable to the SSRC Project Services in month m.

DR_{Nm-1} = Monthly Equivalent Nominal Discount Rate applicable to the SSRC Project Services in the month immediately before month m.

and:

$$DR_{Nm} = (1 + DR_{Nn})^{1/12} - 1,$$

and:

$$DR_{Nn} = ((1+DR_R)*(1+RPI_{AAn}))-1$$

where:

DR_{Nn} = Nominal Annual Discount Rate applicable to the SSRC Project Services in year n;

DR_R = Real Annual Discount Rate applicable to the SSRC Project Services; and

RPI_{AAn} = Annual Average Retail Prices Index inflation for year n.

Noting that when estimating the SSRC Project Services Fee, the net monthly expenditure levels input into the above formula must be in nominal terms.

7.2.6.3 SSRC Project Services Fee

The SSRC Project Services Fee is calculated using the following general formulae:

For the first year of the SSRC Payment Period:

$$ASRP_{n=1} = (ExSRP_{PV} - CC_{n=0})(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} - 1)))$$

For all subsequent years in the SSRC Payment Period:

$$ASRP_n = (ExSRP_{Rn})(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} - 1)))$$

where:

$ExSRP_{Rn}$ = residual amount of $ExSRP_{PV}$ remaining to be recovered at start of year n;

$CC_{n=0}$ = Capital contribution (if any) made at start of SSRC Payment Period;

Np = number of years in the SSRC Payment Period; and

n = year of SSRC Payment Period for which repayment is being calculated.

and:

$$ExSRP_{Rn} = (ExSRP_{Rn-1} (1+ DR_{Nn})) - ASRP_{n-1} + CS_n$$

where:

$ExSRP_{Rn-1}$	=	$ExSRP_{Rn}$ for year previous to year n (and, for the avoidance of doubt, for the second year in the SSRC Payment Period this is equal to $ExSRP_{PV} – CC_{n=0}$);
$ASRP_{n-1}$	=	$ASRP_n$ for year previous to year n; and
CS_n	=	Correction Sum to correct for any difference between estimated and outturn costs (where these are known),

With respect to the relevant Shared Infrastructure System, the allocation of the costs upon which each System User's SSRC Project Services Fee is calculated shall be as described in section 9 below.

7.2.7 Calculation of the SSRC Capital Charge

The SSRC Capital Charge payable for the Shared Infrastructure System shall be calculated in two stages:

- *Firstly the present value, at the start of the SSRC Payment Period, of the estimated net expenditure upon which the SSRC Capital Charge is based is calculated;*
- *Secondly, that value is used as the basis of the SSRC Capital Charge.*

This two-stage methodology allows the relevant System User or DECC to make capital contributions to reduce the amount of the net expenditure sum which is the basis of the SSRC Capital Charge and thereby reduce the level of that Charge over the SSRC Payment Period.

7.2.7.1 Allowing for Outturn Costs

An indicative SSRC Capital Charge shall be included in the Transport (and Storage) Services Agreement. That indicative SSRC Capital Charge is based upon an estimate of several categories of costs. At the date of each payment of the SSRC Capital Charge some of those costs will have crystallised and will be known ('outturn') costs (e.g. Fixed Opex),whilst some will remain as future liabilities (e.g. Decommissioning capex).

If, at the date of calculation of an SSRC Capital Charge, outturn values are known for any of the costs making up that Charge, then those outturn values shall be substituted for the relevant estimated values in the calculation of that fee.

7.2.7.2 Net Value of Expenditure

The present value, at the start of the SSRC Payment Period, of the estimated net expenditure upon which the SSRC Capital Charge is based shall be calculated using the following general formula:

$$ExSRC_{PV} = \sum^{m=1}_{Me} ((ExSRC_m - CC_{ExSRC}) / F_{DRNm})$$

where:

$ExSRC_m$	=	SSRC Capital expenditure in month m;
Me	=	Total number of months in the SSRC Period;
m	=	month in SSRC Period; and
CC_{ExSRP}	=	Capital contributions to SSRC Capital expenditure in month m (if any),

and:

F_{DRNm} = 1 in the first month of the SSRC Period; and

$F_{DRNm} = (F_{DRNm-1} * (1+DR_{Nm-1}))$ in all months in the SSRC Period except the first month,

where:

F_{DRNm}	=	Monthly Nominal Discount Rate Factor for month m;
F_{DRNm-1}	=	Monthly Nominal Discount Rate Factor for the month immediately before month m;
DR_{Nm}	=	Monthly Equivalent Nominal Discount Rate applicable to the SSRC Capital Expenditure in month m.
DR_{Nm-1}	=	Monthly Equivalent Nominal Discount Rate applicable to the SSRC Capital Expenditure in the month immediately before month m.

where:

$DR_{Nm} = (1 + DR_{Nn})^{1/12} – 1,$

and:

$DR_{Nn} = ((1+DR_R)*(1+RPI_{AAn}))-1$

where:

DR_{Nn}	=	Nominal Annual Discount Rate applicable to the SSRC Capital Expenditure in year n;
DR_R	=	Real Annual Discount Rate applicable to the SSRC Capital Expenditure; and
RPI_{AAn}	=	Annual Average Retail Prices Index inflation for year n.

Noting that when estimating the SSRC Capital Charge, the net monthly expenditure levels input into the above formula must be in nominal terms.

7.2.7.3 SSRC Capital Charge

The SSRC Capital Charge is calculated using the following general formulae:

For the first year of the SSRC Payment Period:

$ASRC_{n=1} = (ExSRC_{PV} – CC_{n=0})(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} – 1)))$

For all subsequent years in the SSRC Payment Period:

$ASRC_n = (ExSRC_{Rn} – CC_n)(DR_{Nn} + (DR_{Nn} /((1 + DR_{Nn})^{(Np-n+1)} – 1)))$

where:

$ExSRC_{Rn}$	=	residual amount of $ExSRC_{PV}$ remaining to be recovered at start of year n;
$CC_{n=0}$	=	Capital contribution (if any) made at start of SSRC Payment Period;
CC_n	=	Capital contribution (if any) made at start of year n;
Np	=	number of years in the SSRC Payment Period; and
n	=	year of SSRC Payment Period for which repayment is being calculated.

and:

$ExSRC_{Rn} = ExSRC_{Rn-1} (1+ DR_{Nn}) - ASRC_{n-1}$

where:

$ExSRC_{Rn-1}$ = $ExSRC_{Rn}$ for year previous to year n (and, for the avoidance of doubt, for the second year in the SSRC Period this is equal to $ExSRC_{PV} – CC_{n=0}$); and

$ASRC_{n-1}$ = $ASEP_n$ for year previous to year n,

With respect to the relevant Shared Infrastructure System, the allocation of the costs upon which each System User's SSRC Capital Charge is discussed in section 9 below.

8 STATEMENT OF THE SHARED SYSTEM USE OF SYSTEM CHARGE

8.1 PRINCIPLES

The Shared System Use of System Charge (SSUC) reflects, with respect to the Shared Infrastructure System, those costs which are wholly and directly attributable to the act of transporting and/or storing CO_2 in the Shared Infrastructure System.

The SSUC shall take the form of a charge per quantity (e.g. £/Tonne) of CO_2 transported and/or stored.

The method of derivation of the SSUC shall be included in the contract, made between the SO and the System User, for the development and use of the Shared Infrastructure System (the 'Transport (and Storage) Services Agreement').

If there is a period of Shared Infrastructure System non-availability between the commissioning sign-off of the Shared Infrastructure System and the commissioning sign-off / availability of the CCS system as a whole, then any associated amendments to the arrangements for the payment of the SSEC during that period shall be as set out in the non-availability provisions of the Transport (and Storage) Services Agreement.

8.2 DERIVATION OF SHARED SYSTEM USE OF SYSTEM CHARGE

8.2.1 Costs Included in Shared System Use of System Charge

For the purposes of example in this Targeted Report, the SSUC payable by each System User is based upon the following costs:

- *Attributable Variable Opex*
- *Proportional Maintenance Premium (or proportionate sharing of outturn maintenance costs).*
- *Article 19 Financial Security Variable Costs*
- *Article 20 Financial Mechanism Variable Costs*

8.2.2 Indicative and Actual Project Services Fees and Capital Charges

The Transport (and Storage) Services Agreement will include indicative SSUC fees and charges, as well as methods for the calculation of actual SSUC fees and charges based upon outturn costs and present values at the date when the fees and charges are calculated.

The Transport (and Storage) Services Agreement may include performance incentive schemes which include risk and reward sharing aspects based upon the difference between estimated and outturn costs.

8.2.3 Period and Payment of SSUC

The SSUC applicable to each System User shall be paid by that System User monthly in arrears for the duration of the period during which CO_2 is transported and/or stored in the relevant Shared Infrastructure System (the 'SSUC Payment Period').

The SSUC Payment Period shall start on the day after the last day of the EPC period.

The SSUC shall be calculated monthly based upon the actual system usage by each System User.

8.2.4 Calculation of the SSUC

The SSUC shall be calculated using the following formula:

$SSUC_m = ExSUC_m * (1 + DR_{Nm})$

where:

$SSUC_m$	=	Shared System Use of System Charge for month m (payable at end of month m+1);
$ExSUC_m$	=	actual operational expenditure in month m;
m	=	month within Payment Period for which $SSUC_m$ is being calculated; and
DR_{Nm}	=	Monthly Equivalent Nominal Discount Rate applicable to the SSUC in month m,

and:

$DR_{Nm} = (1 + DR_{Nn})^{1/12} - 1,$

where:

DR_{Nn}	=	Nominal Annual Discount Rate applicable to the SSUC in year n;

and:

$DR_{Nn} = ((1+DR_R)*(1+RPI_{AAn}))-1$

where:

DR_R	=	Real Annual Discount Rate applicable to the SSUC;
RPI_{AAn}	=	Annual Average Retail Prices Index inflation for year n; and
n	=	year within Payment Period for which $SSUC_m$ is being calculated.

Note: the above assumes that monthly opex is recovered on a month in arrears basis. Other repayment bases would require an amendment to the above formula.

Note: the above assumes that the variable costs of Art.19 and Art.20 costs can be easily included in the operational expenditure for each month. It is possible that this will not be the case and that the above formula may require amendment when more is known regarding the nature of these two costs.

Part 4 – Discussion of Associated Topics

9 ALLOCATION OF COSTS TO MULTIPLE USERS.

This section discusses how the costs which are the basis of the overall SSEC, SSRC and SSUC for the shared infrastructure system might be divided between the various users of the system in a multiple user scenario.

For the purposes of the discussion in this section it is assumed that the developer of an infrastructure system will wish to maximise its profits and therefore to develop a system with the largest capacity that can be sold into the market at the developer's required rate of return (the 'Optimum System Capacity'). The capacity charging mechanism which engenders the development of a system with the Optimum System Capacity is the 'Optimum Capacity Charging Mechanism'.

9.1 DISCUSSION

In any scenario where two or more System Users were to procure Shared Infrastructure System capacity, a question would arise as to how the costs and liabilities of developing, operating and decommissioning the shared system should be distributed amongst those System Users.

For the purpose of analysis of this question it is useful to consider the System User (or, alternatively, group of System Users) which commits first to take Shared Infrastructure System capacity (provided that such commitment is sufficient to make the Shared Infrastructure System development project commercially viable) as the 'first-comer' or 'Anchor Tenant', and those System Users that commit to take Shared Infrastructure System capacity after the Anchor Tenant (i.e. after the point at which the project is commercially viable) as 'Second-comers' or 'Follow-on Users'.

It is worth emphasising the conceptual importance of the requirement that the Anchor Tenant's commitment to procure system capacity should be considered sufficient for the system developer to take the decision to develop the system. This requirement means that a system with only the capacity required by the Anchor Tenant might tenably be developed and that the capacity required by the Follow-on Users is additional to the capacity of 'Anchor Tenant's system' alone.

Referring to Figure 6 below, if the costs of developing, operating and decommissioning a system with only the capacity required by the Anchor Tenant are termed the 'Anchor Costs', then a central issue regarding the distribution of the costs associated with developing, operating and decommissioning a system with the capacity required by all System Users (i.e. the Anchor Tenant and the Follow-on Users) is whether that part of the Anchor Costs which are independent of the system's capacity (i.e. which do not increase as the system's capacity increases - the 'Capacity Independent Costs'), should be borne entirely by the Anchor Tenant alone or shared with the Follow-on Users and, if Follow-on Users are to bear some proportion of Capacity Independent Costs, how this proportion should be calculated.

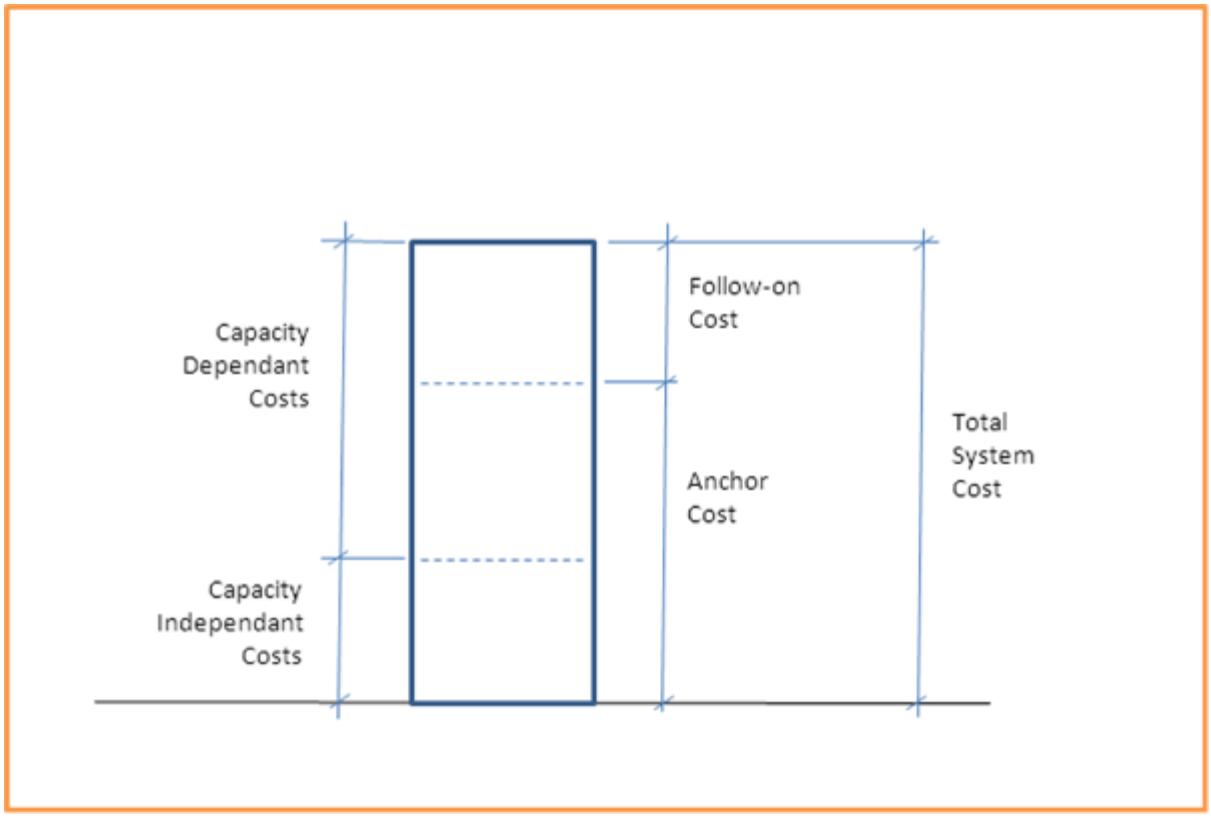


Figure 6 – Anchor Costs / Follow-on Costs / Capacity Costs Breakdown

Capacity Independent Costs would typically include the costs of establishing, administering, managing and providing the project services required to perform an infrastructure development project of the relevant type to the degree that these costs are independent of the capacity of the infrastructure system that is being developed.

In the case of an actual system development, agreed methods for identifying and allocating confirmed Capacity Independent Costs would be required. However, for the purposes of example in this Targeted Report, a theoretical level of Capacity Independent Costs will be considered.

Theoretical Capacity Independent Costs

For the purposes of the analysis that underpins this report, it has been considered that, on a plot of system capacity versus aggregate cost of capacity for a given project, the Capacity Independent Cost is the value at which the curve, extrapolated to the vertical axis, crosses that axis (i.e. the cost of performing a theoretical project developing a system with zero capacity).

To illustrate this method, referring to Figure 6 below, for any given system a cost vs. capacity curve can be derived and the curve will, generally, take the form of that shown. Whatever the capacity of the system actually developed the capacity independent costs will be the same i.e. as shown. However, the actual constructed system capacity will affect the total system cost and the capacity dependant costs. So, for example, if a system with the capacity indicated by the dotted line were to be developed the total system cost, capacity independent costs and capacity dependant costs would be as shown.

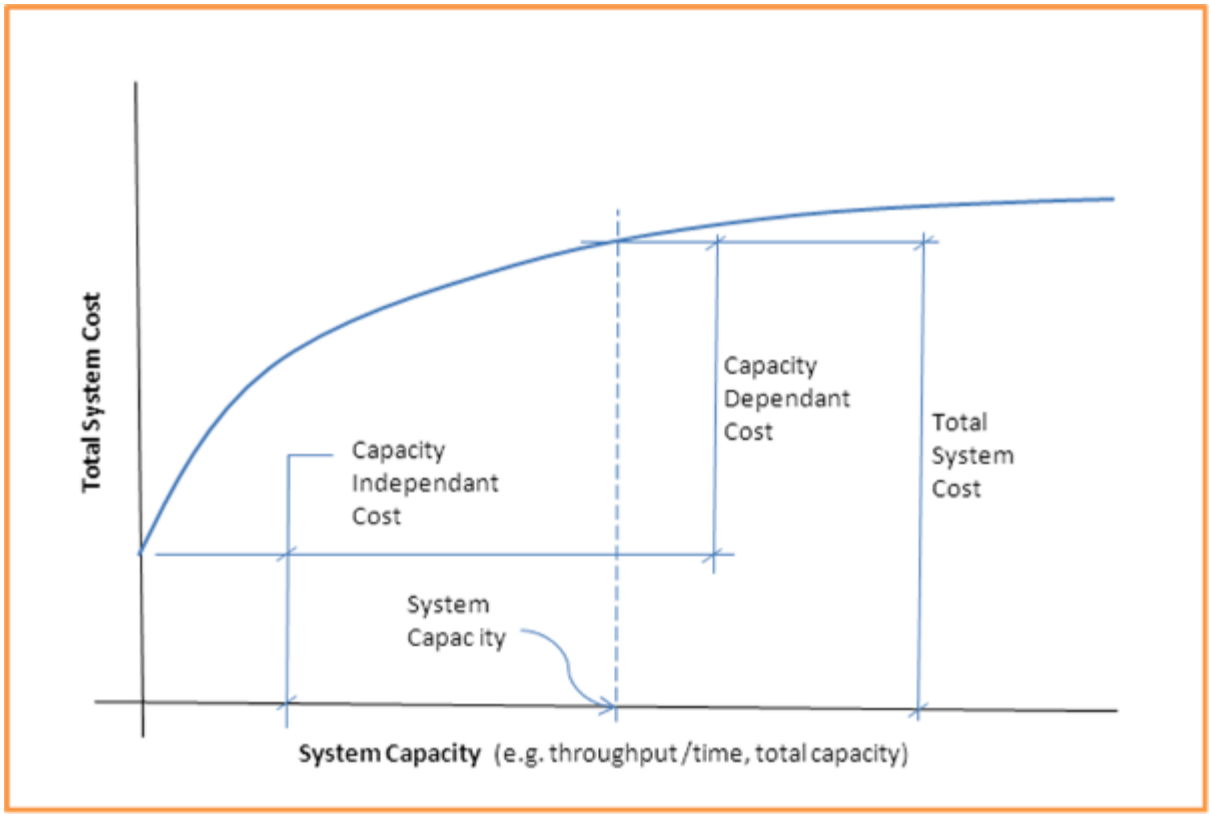


Figure 6 - Sharing Capacity Independent Costs Between System Users

The Effect of Capacity Independent Cost Sharing on Eventual System Capacity

The methodology for the sharing of Capacity Independent Costs across System Users which is declared prior to the Shared Infrastructure System's development, will affect the marginal price of procuring capacity in that system. The level of this marginal price is likely to affect the extent of demand for Shared Infrastructure System capacity as it is likely that the demand for that capacity will alter with its price and that, as marginal price increases, certain potential demand will be priced out of the market and lost.

If Capacity Independent Costs were to be borne entirely by the Anchor Tenant then this would allow Follow-on Users to purchase incremental system capacity at the true incremental cost of that capacity. This cost would be significantly lower than the cost allocated to the Anchor Tenant for the same quantity of capacity (refer to Figure 6 above). This should allow some parties to procure capacity in the Shared Infrastructure System that otherwise would have been unwilling to do so (i.e. those potential System Users that would not have been able to afford to purchase Shared Infrastructure System capacity if they had been required to share the Capacity Independent Costs). This, in turn, should facilitate the development of a Shared Infrastructure System with a capacity greater than would be the case if Capacity Independent Costs were shared across all System Users. It is suggested therefore that a capacity charging mechanism which allocated all of the Capacity Independent Costs to the Anchor Tenant should engender the development of a shared infrastructure system with a capacity closer to that of the Optimum System Capacity than if the Capacity Independent Costs were to be shared across all System Users.

Sharing Economies of Scale Amongst System Users

The rationale described above extends into the way in which economies of scale are shared amongst System Users. In general, as the capacity of the Shared Infrastructure System increases, the true marginal costs of developing, operating and decommissioning each additional increment of capacity, decreases. This is due to the economies of scale associated with developing, operating and decommissioning larger systems as opposed to smaller ones. This means that if capacity costs were to be allocated on a truly incremental basis to each subsequent party to procure capacity, then, as the system capacity increased the price at which each subsequent Follow-on User could procure Shared Infrastructure System capacity would decrease. If each Follow-on User was allowed to procure and use system capacity at its true incremental cost, then this should mean that the greatest number of System Users would be able to afford to procure capacity in the Shared Infrastructure System and that the market would therefore signal the development of the economically optimum Shared Infrastructure System capacity.

Disincentives Associated with a Marginal Capacity Price which is Inversely Proportional to System Capacity

The above described cost distribution / pricing methodology has a significant drawback with regards to the discovery of market demand for capacity in the Shared Infrastructure System. A reduction in capacity price with increasing system capacity represents a disincentive to early procurement of capacity because the price at which a potential System User would be able to procure the system capacity it seeks would reduce the later it procures that capacity[26]. This drawback must be dealt with in the design of any market demand discovery and/or capacity marketing exercises which are carried out with regard to the Shared Infrastructure System.

An alternative methodology, at the opposite end of the scale of sharing Capacity Independent Costs and system economies of scale between System Users would be to share those costs between all System Users, in exact proportion to the system capacity they own. This sharing methodology would remove the 'early-mover' disincentive and, by distributing the advantages of the economies of scale associated with increasing system capacity across all System Users, should incentivise early movers to actively encourage additional parties to acquire system capacity. Under this cost sharing system, the average cost of capacity would be the basis of the price of capacity paid by all System Users.

However, this second Pricing Mechanism model would create a market signal which is likely to lead to the development of a Shared Infrastructure System with a capacity which is less than the optimum. This is because the marginal price of capacity achieved by this model would be higher than that achieved by the first-described model and hence the opportunity to secure the investment of those potential System Users that are willing to acquire system capacity only at a price somewhere between the prices set by the two cost sharing models described would be lost.

[26] Depending upon the financing terms, and particularly the terms of any State funding, applying to the development of the Shared Infrastructure System, there may also be requirements and/or restrictions placed upon the application of State aid if the benefit if that aid is passed on through cost shared mechanisms such as those discussed.

Therefore, based upon the above, in order to develop the Optimal Capacity Charging Mechanism it is necessary to balance the need to drive down as far as is tenable the marginal price of capacity (to enable capacity to be procured by as many System Users as possible), whilst avoiding disincentives on potential Anchor Tenants and early-mover Follow-on Users to come forward and procure capacity.

When considering how this might be achieved, it should also be noted that, as discussed in section 5 above, there may be legal requirements that potential users of CO_2 transport and storage infrastructure should be provided with access to that infrastructure in a transparent and non-discriminatory manner applying objectives of fair and open access.

These issues and suggested methods of identifying the Optimal Charging Mechanism are the subject of ongoing development by NGC.

9.2 Capacity Dependant and Independent Cost Distribution

As described above the distribution of Capacity Independent Costs across the System User group is predicted to be an important factor in influencing the demand for capacity in a Shared Infrastructure System. This section sets out formulae for the calculation of Capacity Independent Costs distribution based upon pre-determined / fixed Capacity Independent Costs Sharing Factors ('CICSF's').

It is intended that the use of these CICFS's should provide a clear and transparent method of representing the intended distribution of Capacity Independent Costs in order that various distributions of these costs, and the effect that this has on the level of charges that will be levied on each System User, can be properly understood. This method of illustrating the effect of the distribution of Capacity Independent Costs may also be used as part of any market demand discovery exercise to investigate the effect of various proposed CICSF's on total market demand.

The formulae in this section have been generated by NGC as part of its modelling of the commercial aspects of Shared CCS Infrastructure Systems.

In the case where the entire Capacity Independent Charge was charged to the Anchor Tenant the capacity charge for the Anchor Tenant would be:

$$CC_{AT} = CDC_{ATCap} + CIC \quad [1]$$

and, for each subsequent user,

$$CC_{Usern} = CDC_{MarginalUsernCap} \quad [2]$$

In the case where capacity independent costs were shared between the Anchor Tenant and other system users the capacity charge for the Anchor Tenant would be:

$$ATCIC_{price} = (CIC / (ATCap + \Sigma_{u1 \rightarrow n} (UsernCap_n / CICSFn_n))) \quad [3a]$$

$$CC_{AT} = CDC_{ATCap} + (ATCIC_{price} \times ATCap) \quad [3b]$$

and, for each subsequent user,

$UnCIC_{price} = (ATCIC_{price} / CICSFn)$ [4a]

$CC_{Usern} = CDC_{IncUsernCap} + (UnCIC_{price} \times UsernCap)$ [4b]

where:

CIC	=	Capacity Independent Costs
CDC	=	Capacity Dependent Costs
$ATCIC_{price}$	=	Unit price for Anchor Tenant's Capacity Independent Costs
$UnCIC_{price}$	=	Unit price for User 'n's Capacity Independent Costs
CC_{AT}	=	Total Capacity Costs for Anchor Tenant
CC_{Usern}	=	Total Capacity Costs for User 'n'
$CDC_{IncUsernCap}$	=	Capacity Dependent Incremental Cost for User 'n''s capacity
CDC_{ATCap}	=	Capacity Dependent Incremental Cost for Anchor Tenant's capacity
ATCap	=	Anchor Tenant's Capacity
UsernCap	=	User 'n''s Capacity
CICSFn	=	Capacity Independent Cost Sharing Factor for User 'n'

The Capacity Independent Cost Sharing Factor for each Follow-on User 'n' (*CICSFn)* is therefore the multiple that the Anchor Tenant will pay towards the Capacity Independent Costs as compared to User 'n' for each unit of capacity it procures (i.e. if *CICFn* for User 1 is equal to 2 then, for each unit of capacity that user 1 procures, the Anchor Tenant will pay twice as much towards Capacity Independent Costs as that Follow-on User 'n').

The following is a worked example of the application of the above formulae to a hypothetical Shared Infrastructure System and group of Shared Users (note that the figures used in this worked example are not associated with the Hypothetical Case Study presented in section 3 above.

System User	System User's System Capacity (MT/yr)		CICSF	Total System Cost (£m)	CDC (£m)	CIC (£m)	CIC (per Unit of Capacity) (£m)	CIC (Total) (£m)	Total CC (£m)	Total CC per Tonne
		Cumulative								
Anchor Tenant	5	5	1	219.7	77.3	103.8	10.59	53.0	130.3	26.05
User1	5	10	2	219.7	23.2	103.8	5.30	26.5	49.7	9.93
User2	3	13	10	219.7	7.7	103.8	1.06	3.2	10.9	3.64
User3	2	15	1	219.7	7.7	103.8	10.59	21.2	28.9	14.43
TOTAL	**15**							**103.8**	**219.7**	**14.65**

Table 7 – Worked Example Data – Application of Capacity Independent Cost Sharing Factors.

$ATCIC_{price} = (CIC / (ATCap + \Sigma_{u1 \rightarrow n} UsernCap / CICSFn))$ [3a]

$ATCIC_{price} = (103.8 / (5 + (5 / 2) + (3 / 10) + (2 / 1)))$

$ATCIC_{price} = 10.59$

so, $CC_{AT} = CDC_{ATCap} + (ATCIC_{price} \times ATCap)$ [3b]

$CC_{AT} = 77.3 + (10.59 \times 5) = 130.3$

So for User1:

$UnCIC_{price} = (ATCIC_{price} / CICSFn)$ [4a]

$UnCIC_{price} = (10.59 / 2) = 5.30$

$CC_{Usern} = CDC_{MarginalUsernCap} + (UnCIC_{price} \times UsernCap)$ [4b]

$CC_{Usern} = 23.2 + (5.30 \times 5) = 49.7$

Etc.

9.3 Case Study Examples of the Application of Various Capacity Charging Mechanisms

This section presents a number of worked examples of the concepts discussed in section 9 above. The examples are based upon the hypothetical case study described in sections 3.1 and 3.2 above the overall scheme drawing for which is reproduced below for ease of reference.

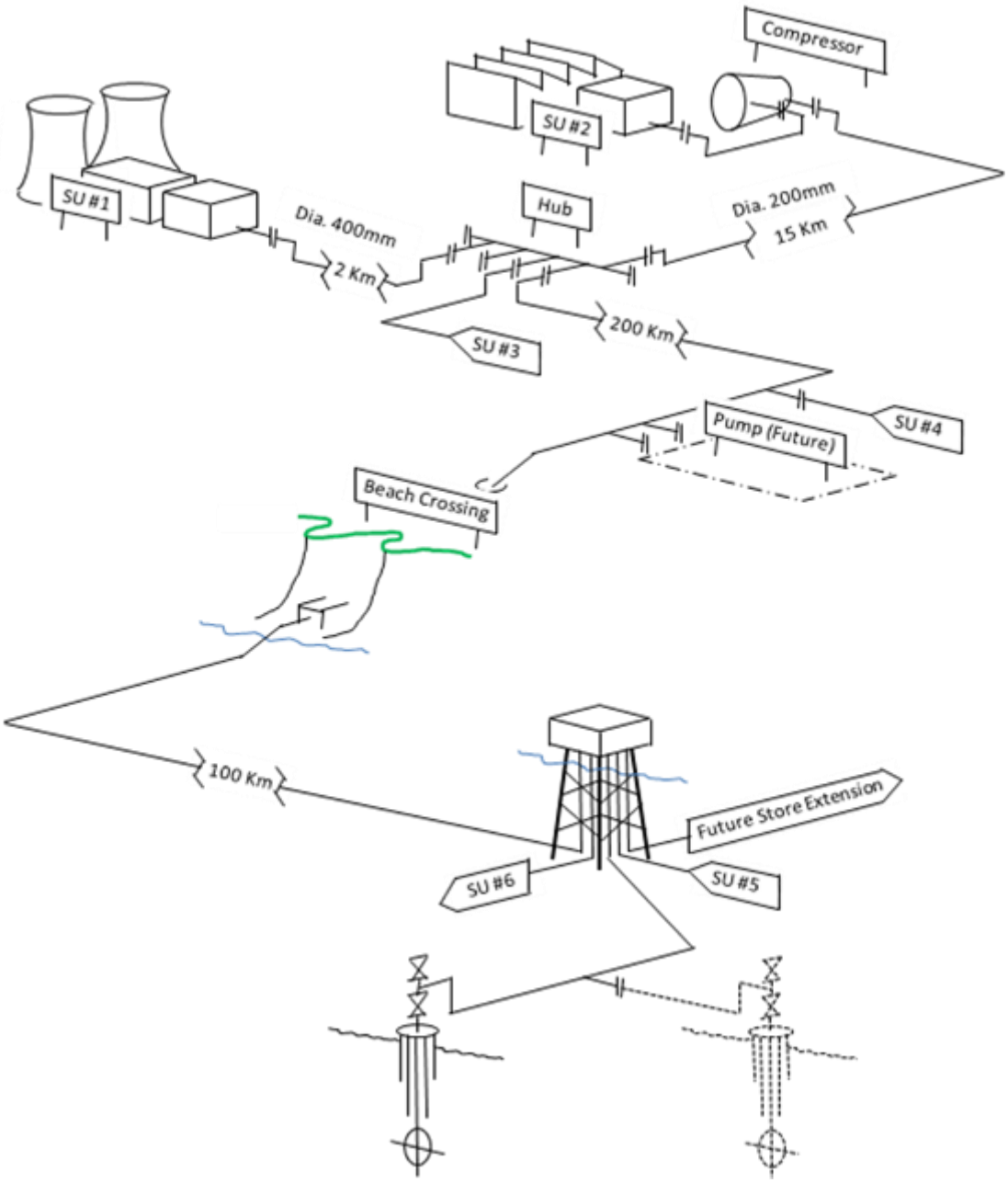


Figure 7 – Hypothetical Case Study Schematic

System User Capacity Requirements

The following table presents the system capacity requirements of each System User in the Hypothetical Case Study and the effect that the incremental capacity requirement of each System User has on the sizing of the shared pipeline. It is assumed that SU#1 is the Anchor Tenant and that each subsequent System User procures system capacity sequentially (in their numerical order).

It should be noted that the total cumulative system throughput including SU#5 (i.e. 18 MT/yr) only applies to the storage facilities and that the total cumulative throughput capacity of the transportation system (i.e. main pipeline) is 12 MT/yr.

	SU#1	SU#2	SU#3	SU#4	SU#5	SU#6
System throughputs (MT/yr)	**5**	**1**	**3**	**3**	**6**	**10**
Connection pipeline dia. (mm)	**400**	**200**	**300**	**300**	**450**	**n/a**
Total throughput (cumulative)	**5**	**6**	**9**	**12**	**18**	**n/a**
Shared pipeline dia. (mm) -based upon total cumulative throughput	**400**	**450**	**550**	**600**	**n/a**	**n/a**

Table 8 – Hypothetical Case Study – System User Capacities and Associated Infrastructure Sizing

System Costs

Tables 9 and 10 below present the breakdown of the development costs, fixed operational costs and decommissioning / post-operational costs associated with the Hypothetical Case Study infrastructure system. Variable operational costs and post-operational costs are not included as, in all scenarios considered in this Targeted Report, all System Users will be charged these on a direct costs plus basis in proportion with their actual use of the system. Table 9 includes the costs associated with the compressor plant required by SU#2, Table 10 does not.

The costs associated with the Anchor Tenant's (SU#1's) capacity in the system are split into Capacity Independent Costs and Capacity Dependant Costs. The costs associated with the Follow-on User's (SU#2 thru 6's) capacity are incremental, based upon a cumulative increase in the system capacity with the addition of each System User (as described above) and, by definition, all Capacity Dependant.

All of the costs presented have been estimated using costs estimation data and methods developed in-house by NGC specifically for application to the development, operation and decommissioning of CCS transportation and storage infrastructure systems. As a basis for the preparation of the cost presented, a number of assumptions have been made, the details of which are not given in this Targeted Report. Therefore, whilst NGC believes that the costs presented are representative of the true costs associated with the Hypothetical Case Study system, these costs alone are not suitable as the basis of extrapolation or inference for the purposes of estimating the cost of a different system.

Cost Breakdown Category	SU#1		SU#2	SU#3	SU#4	SU#5	SU#6
	£m						
	CIC	CDC	CDC	CDC	CDC	CDC	CDC
Incremental EPC	475.0	142.5	175.50	82.00	35.00	2.00	2.00
Additional 'whole project' risk premium attributable to the Incremental EPC	47.50	14.25	17.55	8.20	3.50	0.20	0.20
Incremental Fixed Opex	476.00	94.00	290.00	32.00	22.00	0.50	0.50
Additional 'whole project' risk premium attributable to Incremental Fixed Opex	47.60	9.40	29.00	3.20	2.20	0.05	0.10
Article 19 Financial Security Fixed Costs	2.00	0.00	0.00	0.00	0.00	0.00	0.00
Article 20 Financial Mechanism Fixed Costs	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Incremental Decommissioning Costs	99.00	33.00	32.00	7.10	3.50	1.00	1.00
Additional 'whole project' risk premium attributable to Incremental Decommissioning costs	9.90	3.30	3.20	0.71	0.35	0.10	0.10
Totals(£m)	**1,257**	**296**	**547**	**133**	**67**	**4**	**4**
Grand Total (£m)	**1,257**	**1,553**	**2,101**	**2,234**	**2,300**	**2,304**	**2,308**

Table 9 – Hypothetical Case Study – Costs Breakdown – SU#2 Compression Plant Costs Included

Cost Breakdown Category	SU#1		SU#2	SU#3	SU#4	SU#5	SU#6
	£m						
	CIC	CDC	CDC	CDC	CDC	CDC	CDC
Incremental EPC	475.0	142.5	66.50	82.00	35.00		2.00
Additional 'whole project' risk premium attributable to the Incremental EPC	47.50	14.25	6.65	8.20	3.50	0.20	0.20
Incremental Fixed Opex	476.00	94.00	70.00	32.00	22.00	0.50	0.50
Additional 'whole project' risk premium attributable to Incremental Fixed Opex	47.60	9.40	7.00	3.20	2.20	0.05	0.10
Article 19 Financial Security Fixed Costs	2.00	0.00	0.00	0.00	0.00	0.00	0.00
Article 20 Financial Mechanism Fixed Costs	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Incremental Decommissioning Costs	99.00	33.00	10.00	7.10	3.50	1.00	1.00
Additional 'whole project' risk premium attributable to Incremental Decommissioning costs	9.90	3.30	1.00	0.71	0.35	0.10	0.10
Totals(£m)	**1,257**	**296**	**161**	**133**	**67**	**2**	**4**
Grand Total (£m)	**1,257**	**1,553**	**1,715**	**1,848**	**1,914**	**1,916**	**1,920**

Table 10 – Hypothetical Case Study – Costs Breakdown – SU#2 Compression Plant Costs Not Included

The graph below shows the plot of total system cost versus system throughput for the Hypothetical Case Study shared infrastructure system. The costs in Table 10, i.e. excluding SU#2's compressor

costs, have been used as the compressor plant is not shared infrastructure and therefore the relatively large costs associated with it tend to mask the graph's illustrative value with regard to the trend of shared system cost versus capacity.

As SU#5 and SU#6 require infrastructure capacity in the storage facilities only (i.e. not in the transportation facilities / pipelines) the cost data for these system users has not been included in the graph below

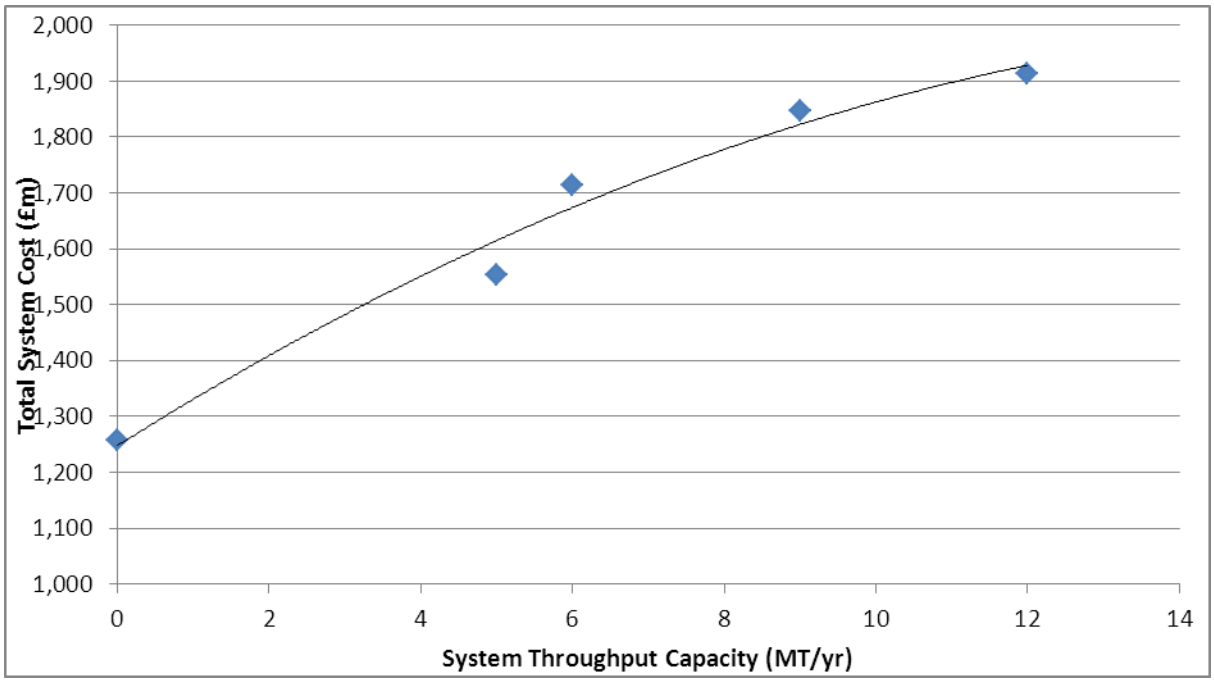


Figure 8 – Hypothetical Case Study – Total System Cost vs. System Capacity

Distribution of Costs Using Various Cost Sharing Mechanisms

Table 11 below presents the distribution of costs across the six System Users in the Hypothetical Case Study resulting from various cost sharing mechanisms.

It should be noted that, under each individual cost sharing mechanism, the sum of the total costs allocated to all system users is always the same and is equal to the Grand Total system cost in Table 10 above i.e. £m 1,920.

Basis of Distribution of Costs		SU#1	SU#2	SU#3	SU#4	SU#5	SU#6
Cost Sharing Mechanism 1 -AT bears all CIC - EoS unshared	Cost per unit of Capacity	310.69	161.15	44.40	22.18	0.31	0.39
	Total cost per user	1553.45	161.15	133.21	66.55	1.85	3.90
Cost Sharing Mechanism 2 -Average sharing of CIC - EoS unshared	Cost per unit of Capacity	104.18	206.04	89.30	67.08	45.20	45.28
(CIC shared across all users)	Total cost per user	520.91	206.04	267.89	201.23	271.21	452.83
Cost Sharing Mechanism 3 -Average sharing of CIC - EoS unshared	Cost per unit of Capacity	129.12	230.98	114.24	92.02	70.14	0.39
(CIC shared across all users ex. SU#6)	Total cost per user	645.62	230.98	342.71	276.05	420.85	3.90
Cost Sharing Mechanism 4 -Average sharing of CIC - EoS unshared	Cost per unit of Capacity	164.04	265.90	149.15	126.93	0.31	0.39
(CIC shared across all users ex. SU#5 & #6)	Total cost per user	820.20	265.90	447.46	380.80	1.85	3.90
Cost Sharing Mechanism 5 -AT bears all CIC - EoS shared	Cost per unit of Capacity	306.18	54.78	54.78	54.78	0.31	0.39
(CIC shared across all users ex. SU#5 & #6)	Total cost per user	1530.90	54.78	164.34	164.34	1.85	3.90
Cost Sharing Mechanism 6 -AT bears all CIC - EoS shared	Cost per unit of Capacity	288.02	36.62	36.62	36.62	36.62	0.39
(CIC shared across all users ex. SU#6)	Total cost per user	1440.11	36.62	109.87	109.87	219.74	3.90
Cost Sharing Mechanism 7 -Average sharing of CIC - EoS shared	Cost per unit of Capacity	159.53	159.53	159.53	159.53	0.31	0.39
(CIC shared across all users ex. SU#5 & #6)	Total cost per user	797.65	159.53	478.59	478.59	1.85	3.90

Table 11 – Distribution of Costs resulting from Various Cost Sharing Mechanisms.

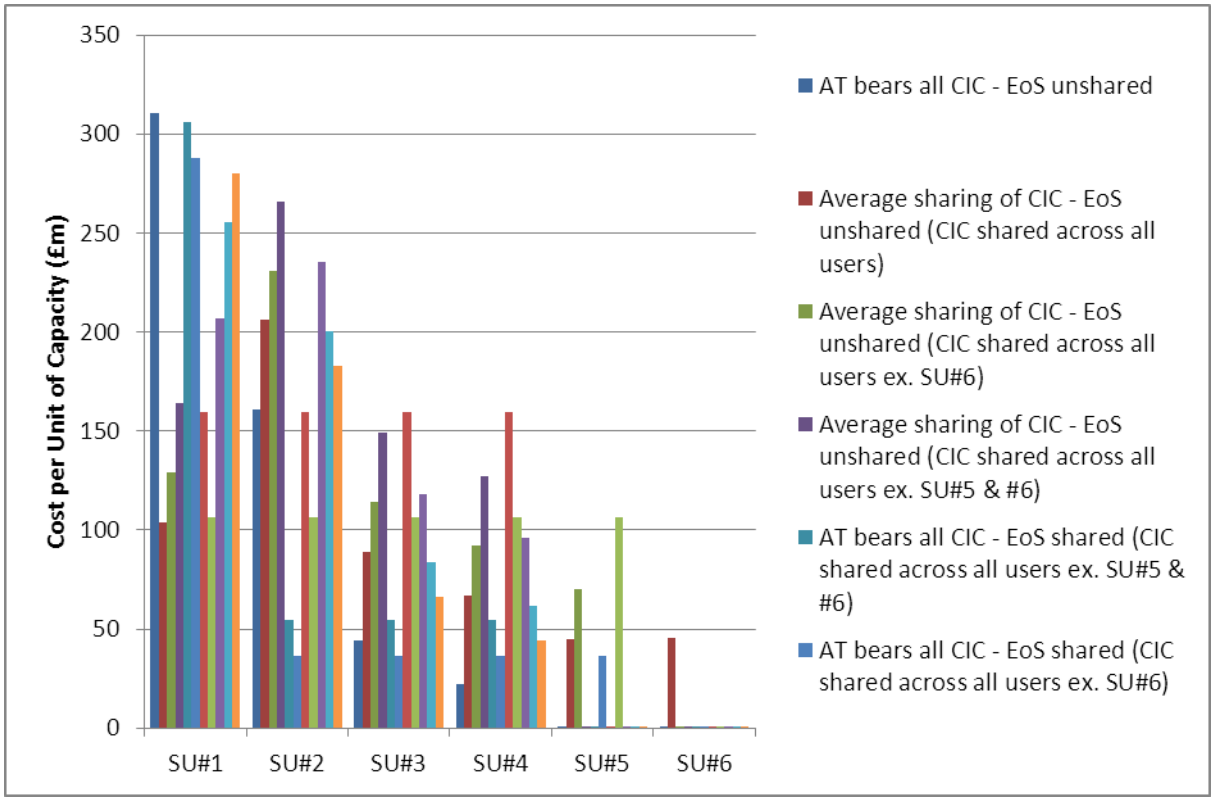


Figure 9 – Cost per Unit Capacity allocated to each System User under various Cost Sharing Mechanisms – By System User

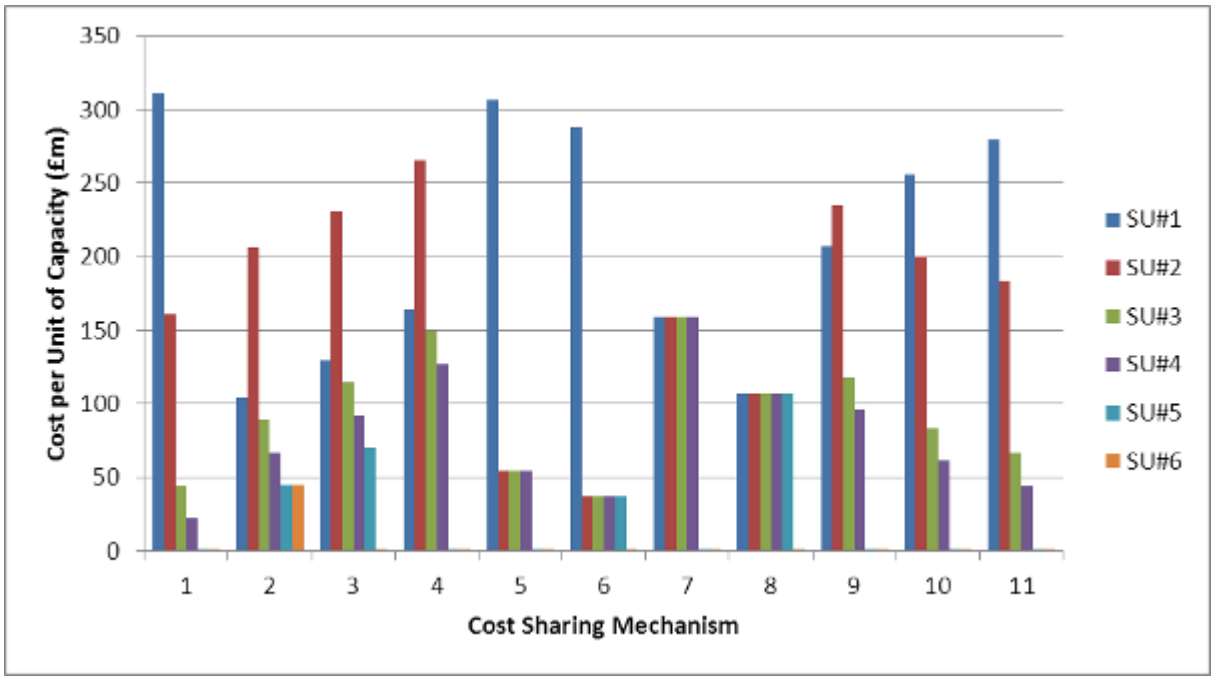


Figure 10 – Cost per Unit Capacity allocated to each System User under various Cost Sharing Mechanisms – By Cost Sharing Mechanism

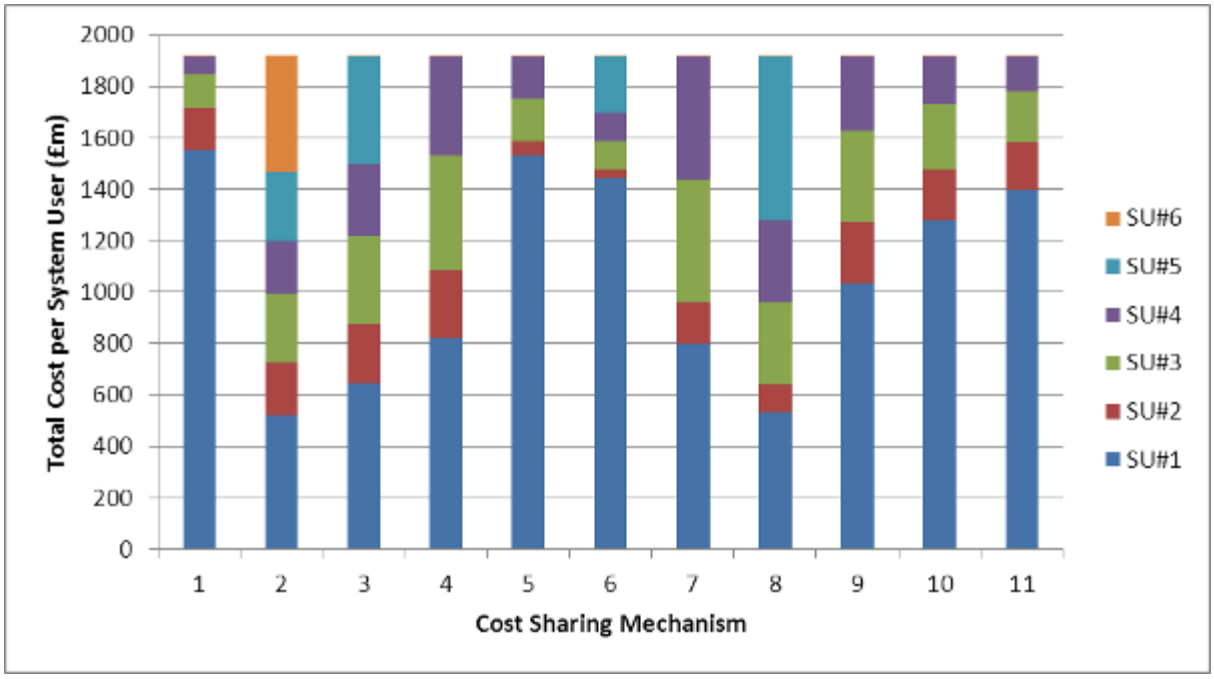


Figure 11 – Total Costs allocated to each System User under various Cost Sharing Mechanisms

10 ANNEXES

10.1 ANNEX 1 – CAPEX COST CATEGORIES

Project Engineering, Management and Administration

- Internal (the SO)
- Internal (SO sub-contractors)
- External

R&D (Chargeable to project)

Insurances

Technology licences and other IP costs

Permits and Consents (including land acquisition and pipeline crossings)

- Onshore
- Offshore

Procurement, Construction and Installation

- Control, filtering, sampling and metering AGI
- Onshore Pipeline (inc block v/v's and pigging facilities)
- Compression plant
- Pumping plant
- Beach Crossing
- Offshore Pipeline
- Jacket and Dry facilities (as applicable)
- Subsea facilities and infield flowlines
- Wells, completions and wellheads.
- Control, telecoms and business systems (inc. DCS and SCADA as applicable)

Mechanical completion and commissioning (inc. manuals, training and handover)

Operations

- Fixed Costs
- Variable Costs

MMV

- Pre-handover
- Post-handover

Decommissioning

10.2 ANNEX 3 – CONNECTION WORKS CHARGE CALCULATION

The following table gives an example of the calculation of the present value of monthly expenditure as described in section 4.6 above.

In the following example the monthly nominal expenditures are based upon a smeared annual real expenditure of 3 over a connection asset development project with an EPC Period of one year. Negative values are expenditures.

													Start of Payment Period >
RPI_{AAn}	RPI	3%											
DR_R	DR (Real)	15%											
DR_{Nn}	DR (Nom)	18.450%											
DR_{Nm}	DR (Nom)(monthly)	1.421%											
	EPC Period Month		1	2	3	4	5	6	7	8	9	10	11	12
			1/1/12	1/2/12	1/3/12	1/4/12	1/5/12	1/6/12	1/7/12	1/8/12	1/9/12	1/10/12	1/11/12	1/12/12
F_{DRNm}			0.8562	0.8684	0.8807	0.8933	0.906	0.9188	0.9319	0.9451	0.9586	0.9722	0.986	1
$ExCWC_m$	Monthly nominal expenditure		-0.25	-0.2506	-0.2512	-0.2519	-0.2525	-0.2531	-0.2537	-0.2543	-0.255	-0.2556	-0.2562	-0.2569
$ExCWC_m$ / F_{DRNm}			-0.292	-0.2886	-0.2853	-0.282	-0.2787	-0.2755	-0.2723	-0.2691	-0.266	-0.2629	-0.2599	-0.2569
$ExCWC_{PV}$	Present value at start of Payment Period of expenditure upon which CWC is based.													-3.289

and the following table shows the repayment schedule per year of a 10 year Payment Period.

n	Payment Period year		1	2	3	4	5	6	7	8	9	10
$ExCWC_{PV}$	PV of expenditure ('Principal')	-3.289										
C_{CWn}	Annual Charge		£0.74	£0.74	£0.74	£0.74	£0.74	£0.74	£0.74	£0.74	£0.74	£0.74
			-	-	-	-	-	-	-	-	-	-
$ExCWC_{Rn}$	Principal remaining after repayment	-3.289	£3.15	£2.99	£2.80	£2.57	£2.30	£1.98	£1.61	£1.16	£0.63	£0.00