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ECONOMIC BENEFITS ANALYSIS

Capacity to Customers (C_2C)

Deliverable 2.1

Methodology for the Cost Benefit Analysis of the C_2C Solution

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Abstract

Recently, Electricity Northwest Limited (ENWL) proposed the "Capacity to Customers" (C_2C) solution as a novel alternative to distribution network reinforcement that is expected to release untapped network capacity, reduce power losses, and defer (or even avoid) costly network reinforcement. This would be achieved via the automation of the normally open point (NOP), operation of the NOP to become normally closed (i.e., changing the configuration of the radial networks to rings), and procurement of DR that would be called only during emergency conditions.

Apart from the technical challenges associated with the potential of the C_2C interventions to meet its targets, also the economic perspective of the C_2C solution needs to be understood as yet. In this respect, given the context of adopting an operational strategy to substitute for asset, it is critical to identify a suitable framework that can properly quantify the different economic benefits and costs associated to C_2C.

In light of the above, this work seeks to set the basis for a general framework for the economic assessment of the C_2C solution. For such purpose, the existing framework used to assess investments at the distribution network level, namely, Ofgem's RIIO-ED1 Cost Benefit Analysis (CBA) approach and its relevant templates, is reviewed and considered as a starting point.

The results of the preliminary analyses conducted for different scenarios indicate that, in order to properly capture the value associated to the C_2C solution, the framework should be capable of (i) properly considering the number of uncertainties associated to possible futures; (ii) including all the relevant components that can play a role in a CBA from different perspectives; (iii) quantifying the costs and benefits of different competing options on a like for like basis, possibly taking into account available optimisation engines. A scenario and optimisation based framework consistent with Ofgem's CBA is then developed and illustrated using an existing distribution network (Farnworth) as a case study example, in which the C_2C solution is currently being tested. The proposed framework is capable of highlighting the conditions that can render the C_2C solution economically attractive. This framework and all results and conclusions will be expanded upon in the rest of the project.

Table of Contents

List of Figures

List of Tables

Acronyms

C_2C	Capacity to Customers
CBA	Cost Benefit Analysis
CI	Customer Interruptions
CML	Customer Minutes Lost
DNO	Distribution Network Operator
DR	Demand Response
ENWL	Electricity Northwest Limited
NOP	Normally Open Point
NPC	Net Present Cost
NPV	Net Present Value
OSD	Optimum investment Scheme from the DNO-only's perspective
OSS	Optimum investment Scheme from the Society-and-DNO's perspective
WACC	Weighted Average Cost of Capital

1 Document Objectives and Content

The main aim of the “Economic Benefit Analysis” work package within the capacity to customers (C_2C) project is to develop a fundamental understanding of the economic rationale to implement C_2C solutions in existing distribution networks.

The main objectives of this work are to:

- Review the adequacy of existing frameworks (developed for the evaluation of investments in distribution network assets) for the assessment of the C_2C solution;
- Based on the outputs of the review, define the bases for an investment assessment framework that can properly quantify the benefits and costs associated with the C_2C solution;
- Illustrate the characteristics of the framework via the analysis of several examples; and
- Identify some of the conditions that favour or discourage the use of the C_2C solution.

2 Background

This section provides a brief summary of the C_2C solution and the technical information used as inputs for the economic assessment of the C_2C solution.

2.1 The C_2C solution

The C_2C solution is a corrective control philosophy based on demand response (DR) proposed by Electricity North West Limited (ENWL) [1]. The solution is meant to (i) release existing untapped emergency network capacity for the operation of the system, thus effectively deferring or even averting network reinforcements; (ii) reduce power losses (and as a result release some additional marginal capacity) and associated emissions at the distribution level; and (iii) decrease customer minutes lost (interruptions for more than three minutes, also considering that shorter interruptions are currently not regulated).

The C_2C solution is meant to achieve the above-mentioned effects via two main actions. Firstly, the normally open points (NOP) located between neighbouring networks would be automated and the NOP would be operated normally closed creating a ring (view Figure 1).

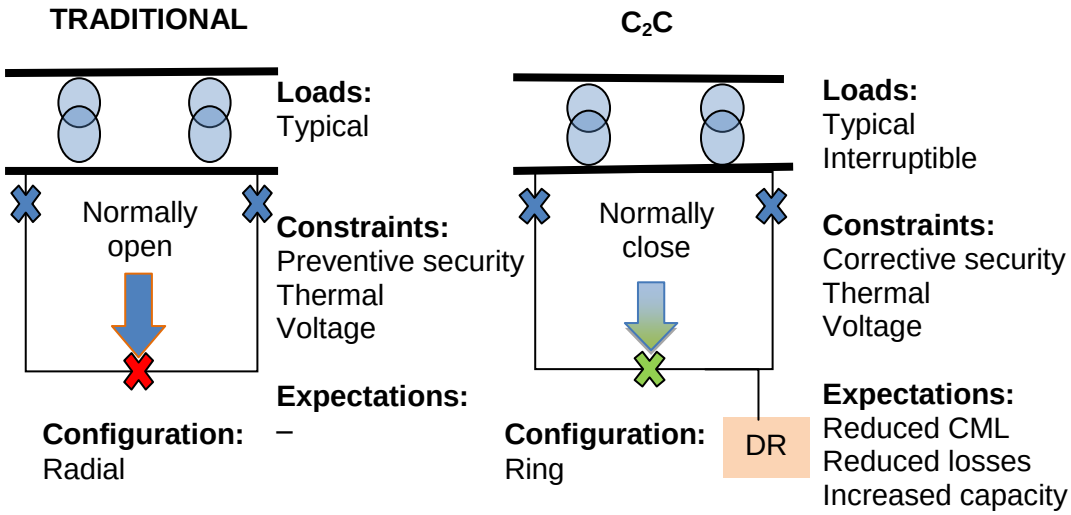

Figure 1: Traditional and C_2C networks

Typically, the NOP is only closed manually during emergency conditions to supply customers in an adjacent radial network that have been disconnected due to a contingency (this operation is analogous to N-1 security considerations and is typically put in place so as to ensure complying with the Engineering Recommendations P2/6 [2]). Under the C_2C solution, the NOP would be normally closed, changing the configuration of the networks from two radials to a ring. On the one hand, the ring configuration is expected to reduce network losses and redistribute power flows (potentially alleviating the burden of some lines and releasing capacity). On the other hand, more customers would be exposed to short term interruptions (i.e., interruptions that would normally affect a single radial feeder would now affect both feeders that form the ring). However, this is not considered an issue, as system restoration (now including an automated NOP) would normally occur within three minutes (the threshold that is currently regulated) and total

expected customer minutes lost should be less than in the system without the automated NOP. Secondly, DR would be called to manage voltage or thermal constraints that may arise after a contingency occurs. Hence, in principle if sufficient corrective DR is available, N-1 security considerations (or other security criteria such as the P2/6 engineering recommendations) can be relaxed so that the capacity of the network becomes limited by thermal or voltage considerations during normal operations as opposed to the preventive security constraints that would normally limit the network capacity even during normal operation (basically, according to the current preventive security recommendations from the P2/6 planning standards, a substantial spare headroom is left under normal operation in both radial feeders so that each of them can supply customers on the other following a contingency and after closure of the NOP). It is important to note that in any case the maximum capacity expansion allowed in the two feeders' set would be determined by DR alone irrespectively of the network configuration (i.e., radial or ring) since, following a contingency, both networks would switch to the same configuration (i.e., radial supply with the NOP closed caused by the disconnection of a circuit that suffered the contingency).

2.2 Main technical inputs for this study

This economic study uses as inputs the results of a series of technical studies of the C_2C solution, including:

- **Network capacity**: The maximum capacity for the distribution network under different conditions was determined via AC power flows estimations. The different conditions considered were the configuration of the network (i.e., two radials or a ring), different demand increase alternatives (e.g., evenly distributed or point loads at specific nodes) and security criteria (i.e., P2/6 engineering considerations and short term emergency ratings of 20% for up to two hours).

- **Power losses**: Annual power losses (calculated based on an hourly resolution) were estimated using real data measured from different sites where the C_2C solution is currently being tested and available for few months, which were then extrapolated to the whole year by using the aggregated UK demand profiles as the relevant scaling factor serving as an estimator to generate the missing demand data in the time series.

- **Network reinforcements**: Several alternative strategies were formulated to reinforce the networks to meet security, thermal or voltage constraints after specific demand increases. The traditional reinforcement philosophy is to be used as a benchmark for the assessment of the C_2C solution. The annual power losses associated to the reinforced networks were also calculated.

3 Ofgem's CBA framework

The economic assessment of the C_2C solution must be consistent with existing frameworks for the assessment of other distribution network solutions. Therefore, the C_2C solution should in first place be assessed using the CBA framework introduced by Ofgem for the new RIIO-ED1 price control [3]. This section provides an overview of the CBA, presents an example of its application, and evaluates the adequacy of the framework to assess the C_2C solution.

3.1 Generalities of Ofgem's CBA framework

Ofgem's CBA framework compares the economic costs associated to proposed network solutions (e.g., the C_2C solution) with those of a baseline in a specific scenario, with the objective of identifying the most convenient investments. The baseline comprises least cost network reinforcements triggered every time demand increases and reaches the maximum capacity of the network (the baseline could also be the option to "do nothing" if no reinforcements are needed). The CBA is set to consider the costs perceived directly by Distribution Network Operators (DNOs) (e.g., investments in network reinforcements, payments for DR, costs of automation, and so forth), while it also provides the option to either consider or neglect social costs (e.g., associated to further reductions of customer minutes lost[1], and losses and emissions reductions, amongst others).

According to Ofgem's CBA framework, the costs perceived by the DNO ( ) are the sum of expensed investments ( ) (part of the investments that can be recovered immediately), depreciation (part of the capitalized investment ( ), that can be recovered over time) and the cost of capital ( ) (a profit based on the regulated asset value and the pre-tax Weighted Average Cost of Capital (WACC)). The investments represent all costs associated to the solution under assessment. This procedure is summarized by (1) - (6).

(1)

(2)

(3)

(4)

[1] It is consider that DNOs are penalised from exceeding predefined thresholds for CI and CML, while not perceiving any benefits or costs from reducing the CI or CML below the thresholds. Under the assumption that the CI and CML are always below the thresholds, all cash flows related CI or CML reductions are categorised as societal parameters.

(5)

(6)

where represents the *n*-th intervention's investment associated to a network solution at period .

The social costs are calculated in a more straightforward manner with (7) as the sum of costs associated with losses ( ), emissions ( ), and customer interruptions ( ) and minutes lost ( ).

(7)

Finally, the costs are discounted[2] and used to calculate the net present cost (NPC). As discussed before, the assessment can be performed including only the costs of the DNO (normal DNO perspective) or with both DNO and society costs (society and DNO perspective) as shown by (8) and (9), respectively.

(8)

(9)

Considering that the DNOs may not receive direct economic incentives from minimising social costs, it would be natural to use the *NPCd* rather than the *NPCs*. However, it is reasonable to assume that some incentives might be out in place at a later stage if Ofgem is encouraging the consideration of social costs within distribution network reinforcement planning practices. Also, it could be of interest to both the Regulator and the DNO to assess how different interventions would affect the cash flows considering also "external" costs and benefits. In light of this, both the DNO-only's and society-and-DNO's perspectives are considered in the studies presented in this work.

It is important to mention than the original CBA framework assesses investment decisions based on the net present value (NPV) criterion rather than the NPC[3]. The NPV has the advantage of intrinsically comparing any network solution with the baseline (i.e., if the NPV is greater than zero, the solution under consideration is a better option than the baseline, and vice versa); however, it has the disadvantage of hiding the characteristics of the baseline, which may make the assessment process complicated to understand. Accordingly, for illustrative purposes only, and without

[2] Ofgem defined a discount rate for discounting cash flows expected within 30 years in the future (3.5%), and a second discount rate for cash flows expected afterwards (3.5%).

[3] The difference is that the NPV is calculated based on the costs of a given network solution minus the costs of the baseline (i.e., benefits), whereas the NPC is calculated with the costs of the specific network solution alone.

affecting the results of the CBA (the baseline is always calculated to facilitate a direct comparison), the NPC criterion is used.

3.2 Illustrative example of Ofgem's CBA framework

Let us consider as an illustrative example that ENWL want to evaluate the option to implement the C_2C solution in a distribution network (Farnworth) based on: a cost of 162k£ for reinforcing the substation; a cost of 19k£ for upgrading the network to enable the C_2C solution; a payment of 22k£/MWp for DR, 177 and 88 annual expected customer interruptions (CI) respectively for the original and C_2C networks; 60 customer minutes lost (CML) per CI; the demand growth scenario shown in Figure 2 (i.e., demand increases constantly due to, e.g., the electrification of the transports sector) and the assumptions shown in Table 1, Table 2 and Table 3. Refer to Appendix A and Appendix B for the complete information used to populate the CBAs.

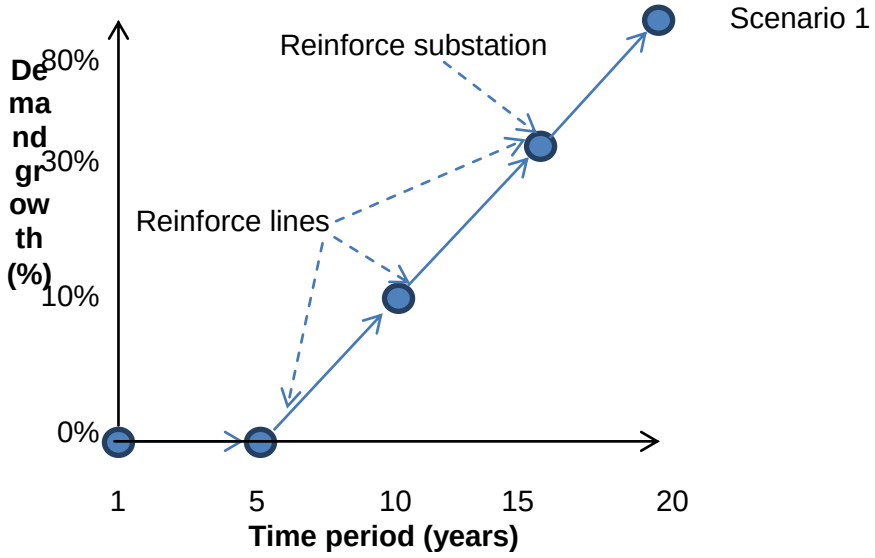

Figure 2: Demand growth scenario 1 for the Farnworth system[4]

Table 1: Capacities and costs associated with reinforcements in the Farnworth system

Reinforcement option	Added capacity	Costs (k£)[5,6]		
		to reinforcement option 1	to reinforcement option 2	to reinforcement option 3
0*	–	11.19	11.21	18.87
1	10%	–	18.87	29.77
2	30%	–	–	29.77
3	80%	–	–	–

*This is the current design of the network.

[4] Note that, for illustrative purposes, the vertical axis ("Demand growth (%)" is not presented in scale.
[5] It is important to note that these reinforcement costs are relatively low when compared with the costs associated to the C_2C solution (i.e., 19 k£ for automation and 22 k£/MWp for DR). Thus, the C_2C solution is less likely to be used when planning the network based on the normal perspective of the DNO.
[6] The costs are presented as a matrix with the different initial designs of the network (or reinforcement option used) in the different rows and the potential new design (i.e., new reinforcement option to be implemented) in the different columns.

Table 2: CBA parameters as suggested by Ofgem

Parameter	Unit	Value
Discount rate ≤ 30 years	(%)	3.5
Discount rate > 30 years	(%)	3.0
Assumed asset life	(years)	45

Table 3: CBA parameters as suggested by ENWL

Parameter	Unit	Value
WACC	(%)	4.2
Price for losses	(£/MWh)	48.42
Price for CI	(£s per interruption)	0.38
Price for CML	(£s per minute lost)	1.79

Considering that the definition of the baseline dictates that the network should only be reinforced when needed and only at the lowest cost (i.e., the network is reinforced based on the lowest cost reinforcement available whenever demand reaches a threshold), the baseline will involve (i) reinforcing the network using option 1 (view Table 1) in year 6 (11.19k£), (ii) reinforcing the network using option 2 in year 11 (18.87k£), (iii) reinforcing the substation in year 15 (162k£) and (iv) reinforcing the network using option 3 in year 16 (29.77k£). The C_2C solution would involve an investment in network automation (19k£) in year 1[7]. The results of the CBA for these investments schemes are shown in Table 4 and Table 5. The tables show the expected *NPCd* and *NPCs* of the baseline and C_2C solution for different years (i.e., different planning horizons).

Table 4: NPC of baseline and C_2C based investments in scenario 1

year	*NPCd* (k£)		*NPCs* (k£)	
	Baseline	C_2C	Baseline	C_2C
5	0	7	45	36
10	3	16	89	75
15	25	42	151	133
20	59	104	229	237
45	141	740	466	1020

Table 5: Losses, CML and DR costs for the baseline and C_2C solution in scenario 1

year	Value of losses (k£/year)		Value of CML (k£/year)		DR costs (k£/year)
	Baseline	C_2C	Baseline	C_2C	C_2C
5	3	3	4	2	0
10	3	4	4	2	11
15	4	5	4	2	30
20	8	10	4	2	79
45	8	10	4	2	79

In this example, the baseline is preferred over the C_2C solution based on the *NPCd* (DNO-only's perspective) (i.e., excluding social benefits), as the C_2C can be deemed a costly solution compared to the relatively low reinforcement costs considered in this example. The C_2C may also be expensive when compared with the alternative to reinforce the substation, particularly if significant DR levels are needed.

[7] This year is chosen to enable immediate social benefits (e.g., losses and emissions reductions) rather than due to capacity constraints.

In contrast, the results of this example based on the *NPCs* (society-and-DNO's perspective) show that the C_2C solution can be attractive for lower levels of load growth (see years 5 to 15 in Table 4). The main reason for this (as suggested by the information in Table 5) would be the CML savings (and marginal losses benefits) during the first five years of the project owing to NOP closed operation when DR payments were null. During these years, the C_2C solution resulted in significant *NPCs* savings compared to the baseline. However, the difference decreased as the C_2C solution became more costly (i.e., higher losses and DR payments) until the baseline became the least costly solution. Actually, in this example, the C_2C solution provides relatively little benefits from losses reductions. The C_2C solution does provide some marginal losses reductions compared to the initial network (without any reinforcements); although this reduction in losses is only marginal and cannot be appreciated in Table 5. Furthermore, losses in the original system after implementing the C_2C solution (i.e., the ring) are in any case higher than those of the radials after being reinforced and significantly higher than initial levels (i.e., more than threefold).

This example may suggest that the C_2C solution may be an attractive short-term alternative (or to handle small demand increases) if social benefits are considered[8]. However, these results may change for other systems, for instance where losses and reliability cost reductions from the C_2C solution were to be more significant and/or network reinforcement costs were to be higher, so that the C_2C solution could be beneficial on a wider timescale and for both DNO-only's and society-and-DNO's perspectives.

Worth noticing further is that a CBA as carried out above only provides a snapshot assessment of the C_2C solution in a particular scenario and tells nothing about what would happen if the actual scenario that materialises in the future would be different. Hence, this approach is not deemed adequate to: (i) deal with the expected uncertainty in demand growth, amongst others; (ii) capture the value of flexibility that the C_2C solution could provide to delay or defer investments in other network solutions if other scenarios were to materialise; (iii) identify whether or not it would be convenient to implement the C_2C at a different time or in combination with other network solutions (e.g., reinforcements) also considering the unfolding of scenarios and (partial) solution of uncertainty with time. In light of this, Ofgem's CBA framework has been automated and extended to address several scenarios (view section 4) and later combined with an optimisation procedure to identify optimum deployment timing and combinations with other solutions based on particular criteria (view section 5).

[8] These are also cases where the *NPCd* difference is negligible, implying that little incentives would be required to encourage DNOs to pursue social benefits (in this case via investing in the C_2C solution).

4 Scenario based CBA

As hinted in the previous section, a single demand growth scenario is not sufficient for a comprehensive assessment of the C_2C solution. Relying on a single scenario for the CBA is arguable, especially when uncertainty (for instance in peak demand projection) is significant (as can occur in the current electricity sector due to electrification, efficiency improvements, and so forth). In the face of significant uncertainty, it may in fact be valuable to invest in solutions that can perform well in the case that the future scenario differs from the forecasts. Based on this, it is attractive to define several scenarios for the CBA.

In this section the CBA is therefore extended to address several illustrative scenarios for future load growth. In particular, following the previous example it is now assumed that the DNO formulates four scenarios for potential demand growth in the Farnworth network as shown in Figure 3.

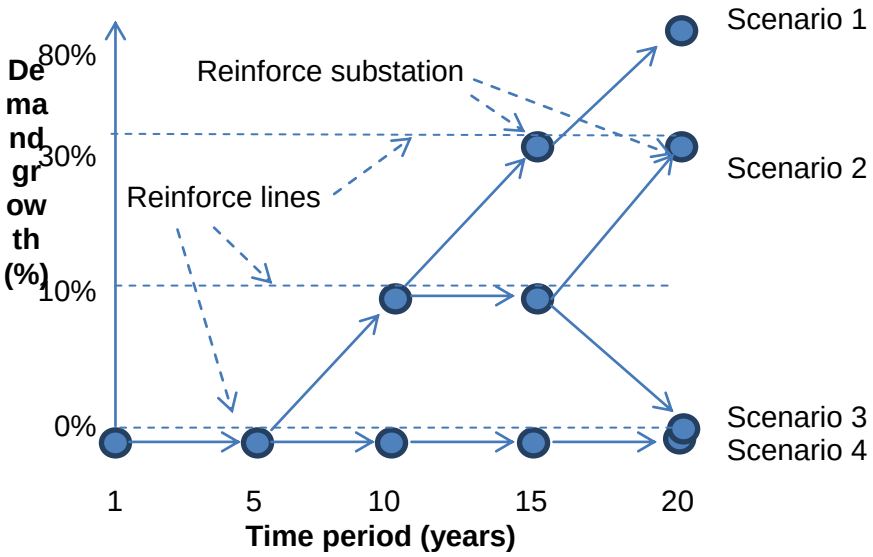

Figure 3: Four load growth scenarios for the Farnworth system[9]

The scenarios are used to illustrate how the C_2C solution can perform under completely different (but possible) circumstances. Scenario 1 was analysed in the previous section; whereas the other scenarios will be investigated below. The input parameter used to populate the CBAs for the investments shown in this section can be found in Appendix B and the associated *NPCd* and *NPCd* can be found in Appendix C.

4.1 The C_2C solution and baseline in scenario 2

In scenario 2, demand grows from year 5, although it stops increasing between years 10 and 15 (e.g., due to regulatory changes) and afterwards continues increasing until year 20 (e.g., due to new policies that engender electrification of other sectors such as transport and heating). The C_2C solution in this scenario involves an immediate investment in automation (19k£) and payments for DR. However, compared to scenario 1, less DR is needed from year 10 onwards due to the lower demand

[9] Note that, for illustrative purposes, the vertical axis ("Demand growth (%)" is not presented in scale.

growth. The baseline in this scenario involves (i) reinforcing the network using option 1 (view Table 1) in year 6 (11.19k£), (ii) reinforcing the network using option 2 in year 16 (18.87k£), and (iii) reinforcing the substation in year 20. The main outputs from the CBA of the baseline and C_2C solution in this scenario are shown in Table 6 and Table 7.

Table 6: NPC of baseline and C_2C based investments in scenario 2

year	*NPCd* (k£)		*NPCs* (k£)	
	Baseline	C_2C	Baseline	C_2C
5	0	7	45	36
10	3	16	89	75
15	5	33	127	120
20	24	62	181	177
45	102	317	371	523

Table 7: Losses, CML and DR costs for the baseline and C_2C solution in scenario 2

year	Value of losses (k£/year)		Value of CML (k£/year)		DR costs (k£/year)
	Baseline	C_2C	Baseline	C_2C	C_2C
5	3	3	4	2	0
10	3	4	4	2	11
15	3	4	4	2	11
20	4	5	4	2	30
45	4	5	4	2	30

As in scenario 1, this particular implementation of the C_2C solution is not attractive based on the *NPCd*. On the other hand, based on the *NPCs* the C_2C solution can be attractive to handle low demand growth levels that involve low DR payments or as a short term solution. However, high demand increases and associated DR costs render the C_2C solution generally unattractive in this scenario.

4.2 The C_2C solution and baseline in scenario 3

Similarly to scenario 2, in scenario 3 demand increases between year 5 and year 10, stops increasing between years 10 and 15 (e.g., due to regulatory changes). However, instead of increasing as in scenario 2, demand decreases from year 15 until reaching its initial value in year 20 (e.g., assuming new policies engender energy efficiency and/or use of shale gas or other energy sources for heating). In this scenario, the C_2C solution involves an immediate investment in automation (19k£) and DR payments from year 5 to year 20. The baseline only result in reinforcing the network using option 1 in year 6 (11.19k£). Results from the CBA of the baseline and C_2C solutions in scenario 3 can be seen in Table 8 and Table 9.

Table 8: NPC of baseline and C_2C based investments in scenario 3

year	*NPCd* (k£)		*NPCs* (k£)	
	Baseline	C_2C	Baseline	C_2C
5	0	7	45	36
10	3	16	89	75
15	5	33	127	120
20	6	50	159	160
45	10	94	255	269

Table 9: Losses, CML and DR costs for the baseline and C_2C solution in scenario 3

year	Value of losses (k£/year)		Value of CML (k£/year)		DR costs (k£/year)
	Baseline	C_2C	Baseline	C_2C	C_2C
5	3	3	4	2	0
10	3	4	4	2	11
15	3	4	4	2	11
20	3	3	4	2	0
45	3	3	4	2	0

Once again, the C_2C solution is not deemed attractive based on the *NPCd*. However, in this case, the C_2C solution is close to becoming a long-term solution based on the *NPCs* (it would become the preferred long-term alternative if load growth was marginally lower). This suggests that, apart from having the potential of becoming an attractive short-term alternative, the C_2C solution can be beneficial when demand increases are not maintained and demand may actually decrease sometime after increasing. Thus, the C_2C may potentially be an attractive alternative for the reinforcement of distribution networks subject to highly uncertain demand growth.

4.3 The C_2C solution and baseline in scenario 4

In this scenario, demand remains unchanged throughout the lifetime of the project (e.g., no particular policy change or technology development encourages load growth or decrease). The C_2C solution results in an immediate investment in automation (19k£) without any DR payments, whereas the baseline does not involve any investments ("do nothing" alternative). The results of the CBA associated to this scenario are presented in Table 10 and Table 11.

Table 10: NPC of baseline and C_2C based investments in scenario 4

year	*NPCd* (k£)		*NPCs* (k£)	
	Baseline	C_2C	Baseline	C_2C
5	0	7	45	36
10	0	10	85	67
15	0	13	121	95
20	0	15	151	118
45	0	20	248	189

Table 11: Losses, CML and DR costs for the baseline and C_2C solution in scenario 4

year	Value of losses (k£/year)		Value of CML (k£/year)		DR costs (k£/year)
	Baseline	C_2C	Baseline	C_2C	C_2C
5	3	3	4	2	0
10	3	3	4	2	0
15	3	3	4	2	0
20	3	3	4	2	0
45	3	3	4	2	0

As in all the previous scenarios under assessment, the immediate implementation of the C_2C solution is not deemed attractive compared to the baseline based on the *NPCd*. Nevertheless, the C_2C solution is now the preferred alternative based on the

NPCs throughout the planning horizon due to the associated social benefits and low DR costs (none). Once again, this suggests that the C_2C solution may perform better than traditional reinforcements when demand growth is low (or null in this case).

The results so far have highlighted the performance of the C_2C solution implemented immediately and in isolation under the different perspectives. In the next and final stage of this study, the CBA framework is further extended to address alternatives to implement the solution at different periods or in combination with other solutions.

5 Optimisation based CBA

In the final stage of the CBA framework addressed in this work, the alternative of implementing the C_2C solution at different time periods and/or in combination with network reinforcements is explored systematically. For this purpose an optimisation routine[10] was developed to identify the optimum investments in a given scenario based on a particular objective. This routine was used to identify the Optimum investment Scheme from the DNO-only's perspective (OSD) (i.e., the investment scheme with the lowest *NPCd*) and the Optimum investment Scheme from the Society-and-DNO's perspective DNO (OSS) (i.e., the investment scheme with the lowest *NPCs*). In other words, the OSD is similar to the baseline[11] as it will always seek the least cost solution; although the OSD can explore different investment timings and alternatives other than reinforcements (e.g., the C_2C solution) to minimise costs that would not be captured without having an optimisation engine as in the case studies carried out above. The OSS will focus on maximising benefits for both DNOs and society, which might result in oversizing the network, deploying automation, and so forth. In the next examples both the OSD and OSS were optimised based on a planning horizon of 45 years as recommended by Ofgem (other planning horizons can be used if needed). The input parameter used to populate the CBAs for the investments shown in this section and the associated *NPCd* and *NPCd* can be found in Appendix B and Appendix C respectively.

5.1 The OSD and OSS in scenario 1

In this scenario the OSD and OSS are the same. This means that there is a solution that is optimum based on both the *NPCd* and *NPCs*; thus no incentive would be needed to encourage DNOs to pursue social benefits. This solution involves reinforcing the network using option 3 (19k£) in year 6 (this provides enough capacity for demand throughout this scenario) and in reinforcing the substation in year 15. The main results of this study are shown in Table 12 and Table 13. More specifically, the columns under the *NPCd* heading in Table 12 indicate the NPC from a DNO'only's perspective when the relevant solutions are calculated based on OSD (i.e., the *NPCd* is minimised), OSS (i.e., the *NPCs* is minimised), and baseline, respectively, while the columns under the *NPCs* heading indicate the NPC from a society-and-DNO's perspective again when the relevant solutions are calculated based on OSD, OSS, and baseline, respectively.

Table 12: NPC of OSD and OSS in scenario 1

year	*NPCd* (k£)			*NPCs* (k£)		
	OSD	OSS	Baseline	OSD	OSS	Baseline
5	0	0	0	45	45	45
10	6	6	3	89	89	89
15	25	25	25	147	147	151
20	50	50	59	217	217	229
45	117	117	141	438	438	466

[10] The optimisation consists of an exhaustive search that explores all combinations of investments and returns the most attractive under given criteria.

[11] As a reminder, the baseline involves reinforcing the network using the lowest cost reinforcement available whenever demand reaches a given threshold. The baselines presented in this section are the same as those presented in section 4.

Table 13: Losses, CML and DR costs for the OSD and OSS in scenario 1

year	Value of losses (k£/year)		Value of CML (k£/year)		DR payment (k£/year)	
	OSD	OSS	OSD	OSS	OSD	OSS
5	3	3	4	4	0	0
10	3	3	4	4	0	0
15	4	4	4	4	0	0
20	8	8	4	4	0	0
45	8	8	4	4	0	0

In this case, the optimisation engine recommended a higher initial investment to oversize the network, which makes sense from both the DNO-only's perspective (i.e., a series of investments as in the baseline is more expensive) and from the society-and-DNO's perspective (i.e., losses and reliability costs are reduced when following this strategy).

The optimisation engine did not recommend the C_2C solution for a planning horizon of 45 years. However, if the planning horizon was changed to 20 years instead, the C_2C solution would have been proposed as part of the OSD (i.e., investment in option 2 (11k£) in year 6 and in the C_2C solution in year 15) and part of the OSS (i.e., investment in the C_2C solution immediately in year one and reinforcing the network using option 2 in year 6). This provides yet more evidence that suggests that the C_2C solution can be attractive as a short-term solution. See Appendix B and Appendix C for more information about this study.

5.2 The OSD and OSS in scenario 2

In this case, the OSD involves an investment in reinforcement option 2 (11k£) in year 6 and in the C_2C solution in year 20. The OSS recommends investing in option 2 and the C_2C solution immediately in year one. The results of the CBA of the OSD and OSS are shown in Table 14 and Table 15.

Table 14: NPC of OSD and OSS in scenario 2

year	*NPCd* (k£)			*NPCs* (k£)		
	OSD	OSS	Baseline	OSD	OSS	Baseline
5	0	11	0	45	38	45
10	3	16	3	88	71	89
15	5	21	5	126	100	127
20	8	24	24	162	129	181
45	30	43	102	265	230	371

Table 15: Losses, CML and DR costs for the OSD and OSS in scenario 2

year	Value of losses (k£/year)		Value of CML (k£/year)		DR payment (k£/year)	
	OSD	OSS	OSD	OSS	OSD	OSS
5	3	3	4	2	0	0
10	3	3	4	2	0	0
15	3	3	4	2	0	0
20	4	4	2	2	2	2
45	4	4	2	2	2	2

This time the OSD (i.e., based on the *NPCd*) recommended the use of the C_2C solution to avoid investments in a substation reinforcement. Previously (when considering the C_2C solution in isolation), this alternative was not attractive because of the high DR payment that was needed to support the network. However, this time, the network is reinforced so that a lower level of DR is needed (only to maintain demand within the capacity of the substation), which makes this alternative economically attractive. Therefore, the C_2C can also be attractive based on the *NPCd* (without considering social benefits) whenever it can defer (or avoid) a large investments (substation upgrade costs in this case) using acceptable (i.e., less costly) levels of DR.

The OSS follows a similar logic, although the network reinforcement is performed earlier (i.e., in year one) to minimise social costs (i.e., CML in this case as shown in Table 15). In this scenario, an incentive equivalent to 13k£ (from Table 15, *NPCd* difference between OSS and OSD at year 45) would be needed to encourage the DNO to follow the OSS.

It is relevant to note that as the OSD is optimised based on the *NPCd* and the OSS is optimised based on the *NPCs*, the *NPCd* of the OSD solution will always be the lowest for the year corresponding to the planning horizon (45 years in this case), whereas it will be the *NPCs* to always be the lowest in the OSS solution[12]. However, it can be deduced that even if a low *NPCs* can be guaranteed (as long as the assumptions of the assessment are reasonably accurate) with the OSS, the OSS cannot guarantee an acceptably low *NPCd*. Thus DNOs may require incentives in exchange for minimising social costs (e.g., deploying solutions based on the OSS rather than on the OSD or the baseline). See Appendix B and Appendix C for more information about this study.

5.3 The OSD and OSS in scenario 3

In this scenario, the OSD follows the baseline (i.e., other solutions were not cost effective). That is, the optimisation engine only recommended a network reinforcement based on option 1 (11k£) in year 6. The OSS involves immediate investments in the C_2C solution and reinforcement option 2 (11k£) (see section 4.2 for a description of the baseline in scenario 3). The results of the assessment of this scenario are presented in Table 16 and Table 17.

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Table 16: NPC of OSD and OSS in scenario 3

year	*NPCd* (k£)			*NPCs* (k£)		
	OSD	OSS	Baseline	OSD	OSS	Baseline
5	0	11	0	45	38	45
10	3	16	3	89	71	89
15	5	21	5	127	100	127
20	6	24	6	159	124	159
45	10	32	10	255	193	255

[12] This might not be the case for other years different for the planning horizon. For example, The *NPCd* of an OSD solution optimised for a planning horizon of 45 years will have the lowest *NPCd after 45 years (e.g., see* Table 12 and Table 14*)* but not necessarily for other years (e.g. see NPCd at five years in Table 12).

Table 17: Losses, CML and DR costs for the OSD and OSS in scenario 3

year	Value of losses (k£/year)		Value of CML (k£/year)		DR payment (k£/year)	
	OSD	OSS	OSD	OSS	OSD	OSS
5	3	3	4	2	0	0
10	3	3	4	2	0	0
15	3	3	4	2	0	0
20	3	3	4	2	0	0
45	3	3	4	2	0	0

The OSD chose the baseline as it is not attractive to oversize the reinforcement (as only one reinforcement is needed in this scenario) nor to invest in the C_2C solution (i.e., as mentioned before the C_2C is expensive compared to the low reinforcement costs considered in this example). The OSS once again recommends investing in option 2 and the C_2C solution immediately in year one, which is particularly attractive because no DR payments are needed due to the higher network capacity facilitated by the reinforcement. This time, in order to follow the OSS, the network operator would require 22k£ (form Table 16, *NPCd* difference between OSS and OSD at year 45). See Appendix B and Appendix C for more information about this study.

5.4 The OSD and OSS in scenario 4

In this case, the OSD chooses the baseline ("do nothing"), whereas the OSS once again recommends immediate investments in the C_2C solution and reinforcement option 2 (11k£). The main outputs of the CBA of the OSD and OSS (and the baseline) are presented in Table 18 and Table 19.

Table 18: NPC of OSD and OSS in scenario 4

year	*NPCd* (k£)			*NPCs* (k£)		
	OSD	OSS	Baseline	OSD	OSS	Baseline
5	0	11	0	45	38	45
10	0	16	0	85	69	85
15	0	21	0	121	96	121
20	0	24	0	151	119	151
45	0	32	0	248	187	248

Table 19: Losses, CML and DR costs for the OSD and OSS in scenario 4

year	Value of losses (k£/year)		Value of CML (k£/year)		DR payment (k£/year)	
	OSD	OSS	OSD	OSS	OSD	OSS
5	3	3	2	4	0	0
10	3	3	2	4	0	0
15	3	3	2	4	0	0
20	3	3	2	4	0	0
45	3	3	2	4	0	0

The OSD followed the baseline as there is no other option that can outperform the "do nothing" case (unless there is an option that can result in profits rather than costs) from the perspective of the DNO. The OSS chose the same strategy as in scenarios 2 and 3; that is, an immediate investments in the C_2C solution and reinforcement option 2 (11k£). This time the additional costs associated to the OSS are equivalent to 32k£. See Appendix B and Appendix C for more information about this study.

6 Concluding remarks

This work provided a preliminary overview of the existing framework for the assessment of asset investments in the distribution systems, namely Ofgem's RIIO-ED1 framework. An illustrative study was presented to exemplify the characteristics of the CBA framework and its adequacy to evaluate the C_2C solution. The outcome of the overview was that the existing CBA framework should be extended to address uncertainty and optimise the use of the C_2C solution and in combination with other solution.

Based on this and in order to exemplify further the above point, the base CBA was extended to address several scenarios and optimise investment decisions throughout the scenarios. The approach was illustrated with the objective of highlighting the factors that may drive or discourage the use of the C_2C solution.

Based on the results of the studies, we can conclude that the C_2C solution is more likely to become economically attractive when:

- the social benefits are considered for the CBA (i.e., *NPCs*),
- expected load growth is highly uncertain,
- a short-term solution to handle modest levels of demand growth is desired, and
- large investments (e.g., in a transformer) can be deferred or avoided via the use of a relatively small level of DR.

The conclusions presented are based on preliminary considerations, a relatively limited number of assumptions, and a partial set of data as yet. Further analyses will be run with improved data (e.g., dynamic CI, existing demand forecasts, other sources of uncertainty, and so forth) to support the conclusions from these preliminary findings. Also, a new methodology for a more suitable CBA framework will be proposed to take into account the potential value of DR to deal with uncertainty.

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[2] Allan R, Strbac G, Djapic P, Jarrett K. Developing the P2/6 Methodology. UMIST; report: DG/CG/00023/REP. Available from: http://www.sedg.ac.uk/Publication/DG%20Contribution%20to%20network%20security_R3.pdf ; 2013.

[3] Ofgem. Template CBA RIIO ED1 v4. 2013

Appendix A – Demand growth scenarios

Table 20: Demand growth scenarios data series

year	Demand growth (%)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	1.015625	1.015625	1.015625	0
7	3.200073	3.200073	3.200073	0
8	5.384521	5.384521	5.384521	0
9	7.56897	7.56897	7.56897	0
10	9.753418	9.753418	9.753418	0
11	13.74512	9.753418	9.753418	0
12	17.73682	9.753418	9.753418	0
13	21.72852	9.753418	9.753418	0
14	25.72021	9.753418	9.753418	0
15	29.71191	9.753418	9.753418	0
16	39.75891	13.74512	7.56897	0
17	49.80591	17.73682	5.384521	0
18	59.85291	21.72852	3.200073	0
19	69.8999	25.72021	1.015625	0
20	79.9469	29.71191	0	0
21	79.9469	29.71191	0	0
22	79.9469	29.71191	0	0
23	79.9469	29.71191	0	0
24	79.9469	29.71191	0	0
25	79.9469	29.71191	0	0
26	79.9469	29.71191	0	0
27	79.9469	29.71191	0	0
28	79.9469	29.71191	0	0
29	79.9469	29.71191	0	0
30	79.9469	29.71191	0	0
31	79.9469	29.71191	0	0
32	79.9469	29.71191	0	0
33	79.9469	29.71191	0	0
34	79.9469	29.71191	0	0
35	79.9469	29.71191	0	0
36	79.9469	29.71191	0	0
37	79.9469	29.71191	0	0
38	79.9469	29.71191	0	0
39	79.9469	29.71191	0	0
40	79.9469	29.71191	0	0
41	79.9469	29.71191	0	0
42	79.9469	29.71191	0	0
43	79.9469	29.71191	0	0
44	79.9469	29.71191	0	0
45	79.9469	29.71191	0	0

Appendix B – Investments, losses and CI used to populate the CBAs

B-1 Baseline investment schemes

Table 21: Investments data series for the baseline in the different scenarios

year	Standalone Investments (M£)				Annual investments (M£)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	-0.01119	-0.01119	-0.01119	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	-0.01887	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	-0.16177	0	0	0	0	0	0	0
16	-0.02977	-0.01887	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
20	0	-0.16177	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0

Table 22: Losses and CI data series for the baseline in the different scenarios

year	Losses (MWh/year)				CI (expected occurrences per year)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
2	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
3	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
4	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
5	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
6	-57.9055	-57.9055	-57.9055	-62.4068	-177.08	-177.08	-177.08	-177.08
7	-60.655	-60.655	-60.655	-62.4068	-177.08	-177.08	-177.08	-177.08
8	-63.4045	-63.4045	-63.4045	-62.4068	-177.08	-177.08	-177.08	-177.08
9	-66.154	-66.154	-66.154	-62.4068	-177.08	-177.08	-177.08	-177.08
10	-68.9035	-68.9035	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
11	-70.5046	-68.9035	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
12	-75.2951	-68.9035	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
13	-80.1676	-68.9035	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
14	-85.8935	-68.9035	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
15	-91.6194	-68.9035	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
16	-99.8971	-70.5046	-66.154	-62.4068	-177.08	-177.08	-177.08	-177.08
17	-115.038	-75.2951	-63.4045	-62.4068	-177.08	-177.08	-177.08	-177.08
18	-130.844	-80.1676	-60.655	-62.4068	-177.08	-177.08	-177.08	-177.08
19	-147.932	-85.8935	-57.9055	-62.4068	-177.08	-177.08	-177.08	-177.08
20	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
21	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
22	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
23	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
24	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
25	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
26	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
27	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
28	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
29	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
30	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
31	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
32	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
33	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
34	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
35	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
36	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
37	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
38	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
39	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
40	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
41	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
42	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
43	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
44	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08
45	-165.973	-91.6194	-55.156	-62.4068	-177.08	-177.08	-177.08	-177.08

B-2 C_2C Investment schemes

Table 23: Investments data series for the C_2C schemes in the different scenarios

year	Standalone Investments (M£)				Annual investments (M£)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	-0.019	-0.019	-0.019	-0.019	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	-0.00213	-0.00213	-0.00213	0
7	0	0	0	0	-0.00426	-0.00426	-0.00426	0
8	0	0	0	0	-0.00638	-0.00638	-0.00638	0
9	0	0	0	0	-0.00851	-0.00851	-0.00851	0
10	0	0	0	0	-0.01064	-0.01064	-0.01064	0
11	0	0	0	0	-0.01453	-0.01064	-0.01064	0
12	0	0	0	0	-0.01841	-0.01064	-0.01064	0
13	0	0	0	0	-0.0223	-0.01064	-0.01064	0
14	0	0	0	0	-0.02619	-0.01064	-0.01064	0
15	0	0	0	0	-0.03008	-0.01064	-0.01064	0
16	0	0	0	0	-0.03986	-0.01453	-0.00851	0
17	0	0	0	0	-0.04965	-0.01841	-0.00638	0
18	0	0	0	0	-0.05943	-0.0223	-0.00426	0
19	0	0	0	0	-0.06922	-0.02619	-0.00213	0
20	0	0	0	0	-0.079	-0.03008	0	0
21	0	0	0	0	-0.079	-0.03008	0	0
22	0	0	0	0	-0.079	-0.03008	0	0
23	0	0	0	0	-0.079	-0.03008	0	0
24	0	0	0	0	-0.079	-0.03008	0	0
25	0	0	0	0	-0.079	-0.03008	0	0
26	0	0	0	0	-0.079	-0.03008	0	0
27	0	0	0	0	-0.079	-0.03008	0	0
28	0	0	0	0	-0.079	-0.03008	0	0
29	0	0	0	0	-0.079	-0.03008	0	0
30	0	0	0	0	-0.079	-0.03008	0	0
31	0	0	0	0	-0.079	-0.03008	0	0
32	0	0	0	0	-0.079	-0.03008	0	0
33	0	0	0	0	-0.079	-0.03008	0	0
34	0	0	0	0	-0.079	-0.03008	0	0
35	0	0	0	0	-0.079	-0.03008	0	0
36	0	0	0	0	-0.079	-0.03008	0	0
37	0	0	0	0	-0.079	-0.03008	0	0
38	0	0	0	0	-0.079	-0.03008	0	0
39	0	0	0	0	-0.079	-0.03008	0	0
40	0	0	0	0	-0.079	-0.03008	0	0
41	0	0	0	0	-0.079	-0.03008	0	0
42	0	0	0	0	-0.079	-0.03008	0	0
43	0	0	0	0	-0.079	-0.03008	0	0
44	0	0	0	0	-0.079	-0.03008	0	0
45	0	0	0	0	-0.079	-0.03008	0	0

Table 24: Losses and CI data series for the C_2C schemes in the different scenarios

year	Losses (MWh/year)				CI (expected occurrences per year)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	-61.9789	-61.9789	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
2	-61.9789	-61.9789	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
3	-61.9789	-61.9789	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
4	-61.9789	-61.9789	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
5	-61.9789	-61.9789	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
6	-65.0692	-65.0692	-65.0692	-61.9789	-88.54	-88.54	-88.54	-88.54
7	-68.1594	-68.1594	-68.1594	-61.9789	-88.54	-88.54	-88.54	-88.54
8	-71.2497	-71.2497	-71.2497	-61.9789	-88.54	-88.54	-88.54	-88.54
9	-74.3399	-74.3399	-74.3399	-61.9789	-88.54	-88.54	-88.54	-88.54
10	-77.4302	-77.4302	-77.4302	-61.9789	-88.54	-88.54	-88.54	-88.54
11	-83.0771	-77.4302	-77.4302	-61.9789	-88.54	-88.54	-88.54	-88.54
12	-88.724	-77.4302	-77.4302	-61.9789	-88.54	-88.54	-88.54	-88.54
13	-94.4678	-77.4302	-77.4302	-61.9789	-88.54	-88.54	-88.54	-88.54
14	-101.219	-77.4302	-77.4302	-61.9789	-88.54	-88.54	-88.54	-88.54
15	-107.97	-77.4302	-77.4302	-61.9789	-88.54	-88.54	-88.54	-88.54
16	-124.963	-83.0771	-74.3399	-61.9789	-88.54	-88.54	-88.54	-88.54
17	-143.915	-88.724	-71.2497	-61.9789	-88.54	-88.54	-88.54	-88.54
18	-163.699	-94.4678	-68.1594	-61.9789	-88.54	-88.54	-88.54	-88.54
19	-185.092	-101.219	-65.0692	-61.9789	-88.54	-88.54	-88.54	-88.54
20	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
21	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
22	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
23	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
24	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
25	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
26	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
27	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
28	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
29	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
30	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
31	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
32	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
33	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
34	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
35	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
36	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
37	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
38	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
39	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
40	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
41	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
42	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
43	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
44	-207.679	-107.97	-61.9789	-61.9789	-88.54	-88.54	-88.54	-88.54
45	-207.679	-107.97	-61.9789	-61.9789	*88.54	-88.54	-88.54	-88.54

B-3 OSD

Table 25: Investments data series for the OSD in the different scenarios

year	Standalone Investments (M£)				Annual investments (M£)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	-0.01887	-0.01121	-0.01119	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	-0.16177	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
20	0	-0.019	0	0	0	-0.00167	0	0
21	0	0	0	0	0	-0.00167	0	0
22	0	0	0	0	0	-0.00167	0	0
23	0	0	0	0	0	-0.00167	0	0
24	0	0	0	0	0	-0.00167	0	0
25	0	0	0	0	0	-0.00167	0	0
26	0	0	0	0	0	-0.00167	0	0
27	0	0	0	0	0	-0.00167	0	0
28	0	0	0	0	0	-0.00167	0	0
29	0	0	0	0	0	-0.00167	0	0
30	0	0	0	0	0	-0.00167	0	0
31	0	0	0	0	0	-0.00167	0	0
32	0	0	0	0	0	-0.00167	0	0
33	0	0	0	0	0	-0.00167	0	0
34	0	0	0	0	0	-0.00167	0	0
35	0	0	0	0	0	-0.00167	0	0
36	0	0	0	0	0	-0.00167	0	0
37	0	0	0	0	0	-0.00167	0	0
38	0	0	0	0	0	-0.00167	0	0
39	0	0	0	0	0	-0.00167	0	0
40	0	0	0	0	0	-0.00167	0	0
41	0	0	0	0	0	-0.00167	0	0
42	0	0	0	0	0	-0.00167	0	0
43	0	0	0	0	0	-0.00167	0	0
44	0	0	0	0	0	-0.00167	0	0
45	0	0	0	0	0	-0.00167	0	0

Table 26: Losses and CI data series for the OSD in the different scenarios

year	Losses (MWh/year)				CI (expected occurrences per year)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
2	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
3	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
4	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
5	-62.4068	-62.4068	-62.4068	-62.4068	-177.08	-177.08	-177.08	-177.08
6	-52.0314	-55.228	-57.9055	-62.4068	-177.08	-177.08	-177.08	-177.08
7	-54.5013	-57.8495	-60.655	-62.4068	-177.08	-177.08	-177.08	-177.08
8	-56.9712	-60.4711	-63.4045	-62.4068	-177.08	-177.08	-177.08	-177.08
9	-59.4412	-63.0926	-66.154	-62.4068	-177.08	-177.08	-177.08	-177.08
10	-61.9111	-65.7142	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
11	-66.4245	-65.7142	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
12	-70.9378	-65.7142	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
13	-75.5285	-65.7142	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
14	-80.9234	-65.7142	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
15	-86.3183	-65.7142	-68.9035	-62.4068	-177.08	-177.08	-177.08	-177.08
16	-99.8971	-70.5046	-66.154	-62.4068	-177.08	-177.08	-177.08	-177.08
17	-115.038	-75.2951	-63.4045	-62.4068	-177.08	-177.08	-177.08	-177.08
18	-130.844	-80.1676	-60.655	-62.4068	-177.08	-177.08	-177.08	-177.08
19	-147.932	-85.8935	-57.9055	-62.4068	-177.08	-177.08	-177.08	-177.08
20	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
21	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
22	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
23	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
24	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
25	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
26	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
27	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
28	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
29	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
30	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
31	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
32	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
33	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
34	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
35	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
36	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
37	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
38	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
39	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
40	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
41	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
42	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
43	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
44	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08
45	-165.973	-91.2416	-55.156	-62.4068	-177.08	-88.54	-177.08	-177.08

B-4 OSS

Table 27: Investments data series for the OSS in the different scenarios

year	Standalone Investments (M£)				Annual investments (M£)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	0	-0.03021	-0.03021	-0.03021	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	-0.01887	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	-0.16177	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
20	0	0	0	0	0	-0.00167	0	0
21	0	0	0	0	0	-0.00167	0	0
22	0	0	0	0	0	-0.00167	0	0
23	0	0	0	0	0	-0.00167	0	0
24	0	0	0	0	0	-0.00167	0	0
25	0	0	0	0	0	-0.00167	0	0
26	0	0	0	0	0	-0.00167	0	0
27	0	0	0	0	0	-0.00167	0	0
28	0	0	0	0	0	-0.00167	0	0
29	0	0	0	0	0	-0.00167	0	0
30	0	0	0	0	0	-0.00167	0	0
31	0	0	0	0	0	-0.00167	0	0
32	0	0	0	0	0	-0.00167	0	0
33	0	0	0	0	0	-0.00167	0	0
34	0	0	0	0	0	-0.00167	0	0
35	0	0	0	0	0	-0.00167	0	0
36	0	0	0	0	0	-0.00167	0	0
37	0	0	0	0	0	-0.00167	0	0
38	0	0	0	0	0	-0.00167	0	0
39	0	0	0	0	0	-0.00167	0	0
40	0	0	0	0	0	-0.00167	0	0
41	0	0	0	0	0	-0.00167	0	0
42	0	0	0	0	0	-0.00167	0	0
43	0	0	0	0	0	-0.00167	0	0
44	0	0	0	0	0	-0.00167	0	0
45	0	0	0	0	0	-0.00167	0	0

Table 28: Losses and CI data series for the OSS in the different scenarios

year	Losses (MWh/year)				CI (expected occurrences per year)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	-62.4068	-52.3898	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
2	-62.4068	-52.3898	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
3	-62.4068	-52.3898	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
4	-62.4068	-52.3898	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
5	-62.4068	-52.3898	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
6	-52.0314	-55.0006	-55.0006	-52.3898	-177.08	-88.54	-88.54	-88.54
7	-54.5013	-57.6113	-57.6113	-52.3898	-177.08	-88.54	-88.54	-88.54
8	-56.9712	-60.222	-60.222	-52.3898	-177.08	-88.54	-88.54	-88.54
9	-59.4412	-62.8327	-62.8327	-52.3898	-177.08	-88.54	-88.54	-88.54
10	-61.9111	-65.4435	-65.4435	-52.3898	-177.08	-88.54	-88.54	-88.54
11	-66.4245	-65.4435	-65.4435	-52.3898	-177.08	-88.54	-88.54	-88.54
12	-70.9378	-65.4435	-65.4435	-52.3898	-177.08	-88.54	-88.54	-88.54
13	-75.5285	-65.4435	-65.4435	-52.3898	-177.08	-88.54	-88.54	-88.54
14	-80.9234	-65.4435	-65.4435	-52.3898	-177.08	-88.54	-88.54	-88.54
15	-86.3183	-65.4435	-65.4435	-52.3898	-177.08	-88.54	-88.54	-88.54
16	-99.8971	-70.2141	-62.8327	-52.3898	-177.08	-88.54	-88.54	-88.54
17	-115.038	-74.9848	-60.222	-52.3898	-177.08	-88.54	-88.54	-88.54
18	-130.844	-79.8371	-57.6113	-52.3898	-177.08	-88.54	-88.54	-88.54
19	-147.932	-85.5394	-55.0006	-52.3898	-177.08	-88.54	-88.54	-88.54
20	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
21	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
22	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
23	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
24	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
25	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
26	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
27	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
28	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
29	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
30	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
31	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
32	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
33	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
34	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
35	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
36	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
37	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
38	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
39	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
40	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
41	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
42	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
43	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
44	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54
45	-165.973	-91.2416	-52.3898	-52.3898	-177.08	-88.54	-88.54	-88.54

Appendix C – NPC time series

Table 29: *NPCd* and *NPCs* for the Baseline solution in the different scenarios

year	*NPCd* (M£)				*NPCs* (M£)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	0	0	0	0	-0.00965	-0.00965	-0.00965	-0.00965
2	0	0	0	0	-0.01898	-0.01898	-0.01898	-0.01898
3	0	0	0	0	-0.028	-0.028	-0.028	-0.028
4	0	0	0	0	-0.03672	-0.03672	-0.03672	-0.03672
5	0	0	0	0	-0.04515	-0.04515	-0.04515	-0.04515
6	-0.00153	-0.00153	-0.00153	0	-0.05477	-0.05477	-0.05477	-0.05345
7	-0.002	-0.002	-0.002	0	-0.06333	-0.06333	-0.06333	-0.06161
8	-0.00246	-0.00246	-0.00246	0	-0.07183	-0.07183	-0.07183	-0.06961
9	-0.00289	-0.00289	-0.00289	0	-0.08027	-0.08027	-0.08027	-0.07744
10	-0.0033	-0.0033	-0.0033	0	-0.08865	-0.08865	-0.08865	-0.08511
11	-0.00586	-0.00369	-0.00369	0	-0.09907	-0.09683	-0.09683	-0.0926
12	-0.00691	-0.00406	-0.00406	0	-0.10802	-0.10481	-0.10481	-0.09991
13	-0.00791	-0.00442	-0.00442	0	-0.11694	-0.11258	-0.11258	-0.10703
14	-0.00886	-0.00475	-0.00475	0	-0.12586	-0.12013	-0.12013	-0.11397
15	-0.02597	-0.00507	-0.00507	0	-0.15099	-0.12747	-0.12747	-0.1207
16	-0.03476	-0.0072	-0.00538	0	-0.1679	-0.13647	-0.13446	-0.12723
17	-0.04129	-0.00806	-0.00566	0	-0.18293	-0.1442	-0.14112	-0.13356
18	-0.04751	-0.00888	-0.00594	0	-0.19804	-0.15187	-0.14747	-0.1397
19	-0.05342	-0.00965	-0.0062	0	-0.21323	-0.1595	-0.15349	-0.14564
20	-0.05904	-0.02404	-0.00644	0	-0.22851	-0.18073	-0.15921	-0.15139
21	-0.06439	-0.029	-0.00668	0	-0.24319	-0.19231	-0.16473	-0.15693
22	-0.06947	-0.03372	-0.0069	0	-0.25724	-0.20339	-0.17004	-0.16228
23	-0.07431	-0.03821	-0.00711	0	-0.2707	-0.21401	-0.17515	-0.16743
24	-0.0789	-0.04248	-0.00731	0	-0.28357	-0.22418	-0.18007	-0.17238
25	-0.08326	-0.04654	-0.0075	0	-0.29586	-0.2339	-0.1848	-0.17714
26	-0.08741	-0.05041	-0.00768	0	-0.30759	-0.24318	-0.18934	-0.18171
27	-0.09134	-0.05408	-0.00785	0	-0.31876	-0.25204	-0.19369	-0.1861
28	-0.09507	-0.05757	-0.00801	0	-0.32939	-0.26049	-0.19786	-0.19029
29	-0.09862	-0.06089	-0.00816	0	-0.33947	-0.26853	-0.20184	-0.1943
30	-0.10198	-0.06404	-0.0083	0	-0.34903	-0.27618	-0.20565	-0.19813
31	-0.10568	-0.06751	-0.00846	0	-0.35954	-0.28462	-0.20987	-0.20237
32	-0.1092	-0.07083	-0.00861	0	-0.36952	-0.29266	-0.21391	-0.20643
33	-0.11256	-0.07399	-0.00875	0	-0.37897	-0.30033	-0.21777	-0.21031
34	-0.11576	-0.077	-0.00888	0	-0.3879	-0.30761	-0.22146	-0.214
35	-0.1188	-0.07987	-0.00901	0	-0.39632	-0.31453	-0.22497	-0.21752
36	-0.12169	-0.08261	-0.00913	0	-0.40445	-0.3212	-0.22838	-0.22094
37	-0.12443	-0.08522	-0.00925	0	-0.41228	-0.32762	-0.2317	-0.22426
38	-0.12704	-0.0877	-0.00935	0	-0.41983	-0.33381	-0.23491	-0.22748
39	-0.12952	-0.09005	-0.00945	0	-0.42711	-0.33977	-0.23803	-0.23062
40	-0.13187	-0.0923	-0.00955	0	-0.43413	-0.34551	-0.24105	-0.23366
41	-0.13411	-0.09443	-0.00964	0	-0.44089	-0.35105	-0.24399	-0.23662
42	-0.13622	-0.09646	-0.00973	0	-0.44742	-0.35638	-0.24684	-0.23949
43	-0.13823	-0.09838	-0.00981	0	-0.4537	-0.36151	-0.2496	-0.24228
44	-0.14012	-0.10021	-0.00988	0	-0.45976	-0.36646	-0.25228	-0.24498
45	-0.14192	-0.10195	-0.00995	0	-0.46559	-0.37122	-0.25489	-0.24761

Table 30: *NPCd* and *NPCs* for the C_2C solution in the different scenarios

year	*NPCd* (M£)				*NPCs* (M£)			
	Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**
1	-0.00308	-0.00308	-0.00308	-0.00308	-0.00946	-0.00946	-0.00946	-0.00946
2	-0.00404	-0.00404	-0.00404	-0.00404	-0.01658	-0.01658	-0.01658	-0.01658
3	-0.00496	-0.00496	-0.00496	-0.00496	-0.02346	-0.02346	-0.02346	-0.02346
4	-0.00583	-0.00583	-0.00583	-0.00583	-0.03009	-0.03009	-0.03009	-0.03009
5	-0.00666	-0.00666	-0.00666	-0.00666	-0.0365	-0.0365	-0.0365	-0.0365
6	-0.00774	-0.00774	-0.00774	-0.00745	-0.04326	-0.04326	-0.04326	-0.04283
7	-0.00914	-0.00914	-0.00914	-0.0082	-0.05043	-0.05043	-0.05043	-0.04906
8	-0.01093	-0.01093	-0.01093	-0.00891	-0.05807	-0.05807	-0.05807	-0.0552
9	-0.01316	-0.01316	-0.01316	-0.00959	-0.06622	-0.06622	-0.06622	-0.06122
10	-0.01587	-0.01587	-0.01587	-0.01023	-0.07491	-0.07491	-0.07491	-0.06713
11	-0.01931	-0.01887	-0.01887	-0.01084	-0.08449	-0.08378	-0.08378	-0.07291
12	-0.02357	-0.02212	-0.02212	-0.01143	-0.09502	-0.0928	-0.0928	-0.07855
13	-0.0287	-0.0256	-0.0256	-0.01198	-0.10657	-0.10192	-0.10192	-0.08405
14	-0.03477	-0.02928	-0.02928	-0.0125	-0.11921	-0.11112	-0.11112	-0.0894
15	-0.04181	-0.03314	-0.03314	-0.013	-0.13297	-0.12036	-0.12036	-0.09461
16	-0.05045	-0.03753	-0.03695	-0.01347	-0.14884	-0.13022	-0.12927	-0.09965
17	-0.06084	-0.04254	-0.04065	-0.01392	-0.16705	-0.14077	-0.13779	-0.10454
18	-0.07313	-0.04821	-0.04417	-0.01434	-0.18774	-0.15205	-0.14586	-0.10927
19	-0.08742	-0.0546	-0.04745	-0.01475	-0.21102	-0.16415	-0.15344	-0.11384
20	-0.10382	-0.06176	-0.05045	-0.01513	-0.23696	-0.17708	-0.16048	-0.11826
21	-0.1216	-0.06939	-0.05331	-0.01549	-0.26394	-0.19028	-0.16722	-0.12252
22	-0.14061	-0.07745	-0.05602	-0.01583	-0.2918	-0.2037	-0.17368	-0.12661
23	-0.16073	-0.08588	-0.05859	-0.01615	-0.32042	-0.21729	-0.17986	-0.13054
24	-0.18183	-0.09465	-0.06103	-0.01646	-0.34966	-0.231	-0.18577	-0.13431
25	-0.20379	-0.10371	-0.06335	-0.01675	-0.37941	-0.24479	-0.19141	-0.13792
26	-0.22651	-0.11302	-0.06555	-0.01702	-0.40955	-0.25862	-0.19679	-0.14137
27	-0.24988	-0.12255	-0.06763	-0.01728	-0.43997	-0.27245	-0.20192	-0.14467
28	-0.27381	-0.13225	-0.06961	-0.01752	-0.4706	-0.28625	-0.20679	-0.14781
29	-0.29822	-0.14211	-0.07148	-0.01775	-0.50133	-0.29999	-0.21142	-0.1508
30	-0.32302	-0.15208	-0.07326	-0.01797	-0.53208	-0.31363	-0.21581	-0.15364
31	-0.3522	-0.16377	-0.07521	-0.01821	-0.56776	-0.32935	-0.22065	-0.15676
32	-0.38124	-0.17538	-0.07707	-0.01843	-0.6029	-0.34476	-0.22525	-0.15972
33	-0.41013	-0.1869	-0.07883	-0.01864	-0.6375	-0.35986	-0.22961	-0.16253
34	-0.43884	-0.19833	-0.08051	-0.01884	-0.67154	-0.37465	-0.23374	-0.16518
35	-0.46737	-0.20966	-0.0821	-0.01903	-0.70501	-0.38913	-0.23765	-0.16769
36	-0.4957	-0.2209	-0.08361	-0.01921	-0.73814	-0.40341	-0.24141	-0.17011
37	-0.52381	-0.23202	-0.08505	-0.01938	-0.77092	-0.41751	-0.24503	-0.17247
38	-0.5517	-0.24304	-0.08641	-0.01954	-0.80335	-0.43141	-0.24851	-0.17475
39	-0.57936	-0.25395	-0.0877	-0.01969	-0.83542	-0.44512	-0.25186	-0.17696
40	-0.60677	-0.26474	-0.08892	-0.01983	-0.86711	-0.45864	-0.25509	-0.1791
41	-0.63393	-0.27542	-0.09008	-0.01996	-0.89844	-0.47196	-0.25819	-0.18118
42	-0.66083	-0.28598	-0.09117	-0.02008	-0.92938	-0.48509	-0.26118	-0.1832
43	-0.68745	-0.29641	-0.09221	-0.0202	-0.95994	-0.49803	-0.26405	-0.18515
44	-0.7138	-0.30673	-0.09318	-0.0203	-0.99012	-0.51077	-0.26681	-0.18704
45	-0.73986	-0.31692	-0.09411	-0.0204	-1.0199	-0.52332	-0.26947	-0.18888

Table 31: *NPCd* and *NPCs* for the OSD in the different scenarios

year	*NPCd* (M£)				*NPCs* (M£)			
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	0	0	0	0	-0.00965	-0.00965	-0.00965	-0.00965
2	0	0	0	0	-0.01898	-0.01898	-0.01898	-0.01898
3	0	0	0	0	-0.028	-0.028	-0.028	-0.028
4	0	0	0	0	-0.03672	-0.03672	-0.03672	-0.03672
5	0	0	0	0	-0.04515	-0.04515	-0.04515	-0.04515
6	-0.00258	-0.00153	-0.00153	0	-0.05556	-0.05466	-0.05477	-0.05345
7	-0.00338	-0.00201	-0.002	0	-0.06416	-0.06308	-0.06333	-0.06161
8	-0.00415	-0.00246	-0.00246	0	-0.07267	-0.07145	-0.07183	-0.06961
9	-0.00488	-0.0029	-0.00289	0	-0.0811	-0.07975	-0.08027	-0.07744
10	-0.00557	-0.00331	-0.0033	0	-0.08944	-0.08798	-0.08865	-0.08511
11	-0.00623	-0.0037	-0.00369	0	-0.09777	-0.09602	-0.09683	-0.0926
12	-0.00686	-0.00407	-0.00406	0	-0.1061	-0.10385	-0.10481	-0.09991
13	-0.00745	-0.00443	-0.00442	0	-0.11441	-0.11148	-0.11258	-0.10703
14	-0.00802	-0.00476	-0.00475	0	-0.12273	-0.11889	-0.12013	-0.11397
15	-0.02477	-0.00508	-0.00507	0	-0.14726	-0.12609	-0.12747	-0.1207
16	-0.03033	-0.00539	-0.00538	0	-0.16094	-0.13327	-0.13446	-0.12723
17	-0.03563	-0.00568	-0.00566	0	-0.17475	-0.14042	-0.14112	-0.13356
18	-0.04068	-0.00595	-0.00594	0	-0.18868	-0.14755	-0.14747	-0.1397
19	-0.04548	-0.00621	-0.0062	0	-0.20276	-0.15467	-0.15349	-0.14564
20	-0.05004	-0.0082	-0.00644	0	-0.21698	-0.1618	-0.15921	-0.15139
21	-0.05438	-0.00912	-0.00668	0	-0.23065	-0.16768	-0.16473	-0.15693
22	-0.05851	-0.01003	-0.0069	0	-0.24374	-0.17337	-0.17004	-0.16228
23	-0.06243	-0.01094	-0.00711	0	-0.25629	-0.17887	-0.17515	-0.16743
24	-0.06615	-0.01185	-0.00731	0	-0.2683	-0.18418	-0.18007	-0.17238
25	-0.06969	-0.01276	-0.0075	0	-0.27977	-0.1893	-0.1848	-0.17714
26	-0.07305	-0.01365	-0.00768	0	-0.29071	-0.19423	-0.18934	-0.18171
27	-0.07625	-0.01454	-0.00785	0	-0.30114	-0.19897	-0.19369	-0.1861
28	-0.07927	-0.01543	-0.00801	0	-0.31106	-0.20351	-0.19786	-0.19029
29	-0.08215	-0.0163	-0.00816	0	-0.32048	-0.20786	-0.20184	-0.1943
30	-0.08487	-0.01716	-0.0083	0	-0.3294	-0.21201	-0.20565	-0.19813
31	-0.08787	-0.01815	-0.00846	0	-0.33921	-0.21661	-0.20987	-0.20237
32	-0.09073	-0.01912	-0.00861	0	-0.34852	-0.22099	-0.21391	-0.20643
33	-0.09345	-0.02007	-0.00875	0	-0.35733	-0.22516	-0.21777	-0.21031
34	-0.09604	-0.021	-0.00888	0	-0.36566	-0.22912	-0.22146	-0.214
35	-0.09851	-0.02191	-0.00901	0	-0.37351	-0.23287	-0.22497	-0.21752
36	-0.10085	-0.0228	-0.00913	0	-0.38109	-0.23652	-0.22838	-0.22094
37	-0.10308	-0.02367	-0.00925	0	-0.3884	-0.24008	-0.2317	-0.22426
38	-0.10519	-0.02452	-0.00935	0	-0.39545	-0.24354	-0.23491	-0.22748
39	-0.1072	-0.02535	-0.00945	0	-0.40226	-0.24691	-0.23803	-0.23062
40	-0.1091	-0.02617	-0.00955	0	-0.40883	-0.25019	-0.24105	-0.23366
41	-0.11091	-0.02697	-0.00964	0	-0.41517	-0.25338	-0.24399	-0.23662
42	-0.11262	-0.02775	-0.00973	0	-0.42129	-0.25648	-0.24684	-0.23949
43	-0.11425	-0.02852	-0.00981	0	-0.42719	-0.25951	-0.2496	-0.24228
44	-0.11578	-0.02926	-0.00988	0	-0.43289	-0.26245	-0.25228	-0.24498
45	-0.11724	-0.03	-0.00995	0	-0.43838	-0.26531	-0.25489	-0.24761

Table 32: *NPCd* and *NPCs* for the OSS in the different scenarios

year	*NPCd* (M£)				*NPCs* (M£)			
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	0	-0.0049	-0.0049	-0.0049	-0.00965	-0.01079	-0.01079	-0.01079
2	0	-0.00643	-0.00643	-0.00643	-0.01898	-0.01802	-0.01802	-0.01802
3	0	-0.00788	-0.00788	-0.00788	-0.028	-0.02498	-0.02498	-0.02498
4	0	-0.00927	-0.00927	-0.00927	-0.03672	-0.03169	-0.03169	-0.03169
5	0	-0.01059	-0.01059	-0.01059	-0.04515	-0.03816	-0.03816	-0.03816
6	-0.00258	-0.01184	-0.01184	-0.01184	-0.05556	-0.04464	-0.04464	-0.04452
7	-0.00338	-0.01303	-0.01303	-0.01303	-0.06416	-0.05112	-0.05112	-0.05077
8	-0.00415	-0.01417	-0.01417	-0.01417	-0.07267	-0.0576	-0.0576	-0.05688
9	-0.00488	-0.01525	-0.01525	-0.01525	-0.0811	-0.06406	-0.06406	-0.06286
10	-0.00557	-0.01627	-0.01627	-0.01627	-0.08944	-0.07051	-0.07051	-0.0687
11	-0.00623	-0.01724	-0.01724	-0.01724	-0.09777	-0.07681	-0.07681	-0.0744
12	-0.00686	-0.01817	-0.01817	-0.01817	-0.1061	-0.08295	-0.08295	-0.07994
13	-0.00745	-0.01905	-0.01905	-0.01905	-0.11441	-0.08893	-0.08893	-0.08534
14	-0.00802	-0.01988	-0.01988	-0.01988	-0.12273	-0.09475	-0.09475	-0.09058
15	-0.02477	-0.02067	-0.02067	-0.02067	-0.14726	-0.1004	-0.1004	-0.09566
16	-0.03033	-0.02142	-0.02142	-0.02142	-0.16094	-0.10607	-0.10576	-0.10057
17	-0.03563	-0.02214	-0.02214	-0.02214	-0.17475	-0.11176	-0.11083	-0.10533
18	-0.04068	-0.02281	-0.02281	-0.02281	-0.18868	-0.11746	-0.11564	-0.10992
19	-0.04548	-0.02345	-0.02345	-0.02345	-0.20276	-0.12319	-0.12018	-0.11436
20	-0.05004	-0.0242	-0.02406	-0.02406	-0.21698	-0.12908	-0.12446	-0.11864
21	-0.05438	-0.02495	-0.02463	-0.02463	-0.23065	-0.13479	-0.12858	-0.12276
22	-0.05851	-0.02571	-0.02517	-0.02517	-0.24374	-0.14033	-0.13254	-0.12672
23	-0.06243	-0.02647	-0.02569	-0.02569	-0.25629	-0.14568	-0.13634	-0.13052
24	-0.06615	-0.02724	-0.02617	-0.02617	-0.2683	-0.15085	-0.13998	-0.13416
25	-0.06969	-0.028	-0.02663	-0.02663	-0.27977	-0.15583	-0.14347	-0.13765
26	-0.07305	-0.02876	-0.02707	-0.02707	-0.29071	-0.16062	-0.1468	-0.14098
27	-0.07625	-0.02952	-0.02748	-0.02748	-0.30114	-0.16523	-0.14999	-0.14417
28	-0.07927	-0.03028	-0.02786	-0.02786	-0.31106	-0.16964	-0.15303	-0.1472
29	-0.08215	-0.03103	-0.02823	-0.02823	-0.32048	-0.17387	-0.15591	-0.15009
30	-0.08487	-0.03177	-0.02857	-0.02857	-0.3294	-0.1779	-0.15866	-0.15284
31	-0.08787	-0.03263	-0.02895	-0.02895	-0.33921	-0.18237	-0.16168	-0.15586
32	-0.09073	-0.03347	-0.02931	-0.02931	-0.34852	-0.18662	-0.16455	-0.15873
33	-0.09345	-0.03429	-0.02964	-0.02964	-0.35733	-0.19067	-0.16728	-0.16146
34	-0.09604	-0.0351	-0.02996	-0.02996	-0.36566	-0.19451	-0.16987	-0.16405
35	-0.09851	-0.03589	-0.03026	-0.03026	-0.37351	-0.19814	-0.17231	-0.16649
36	-0.10085	-0.03667	-0.03055	-0.03055	-0.38109	-0.20168	-0.17467	-0.16885
37	-0.10308	-0.03743	-0.03082	-0.03082	-0.3884	-0.20512	-0.17696	-0.17114
38	-0.10519	-0.03817	-0.03107	-0.03107	-0.39545	-0.20848	-0.17918	-0.17336
39	-0.1072	-0.0389	-0.0313	-0.0313	-0.40226	-0.21174	-0.18132	-0.1755
40	-0.1091	-0.03962	-0.03153	-0.03153	-0.40883	-0.21492	-0.1834	-0.17758
41	-0.11091	-0.04032	-0.03174	-0.03174	-0.41517	-0.21801	-0.18541	-0.17959
42	-0.11262	-0.041	-0.03193	-0.03193	-0.42129	-0.22102	-0.18735	-0.18153
43	-0.11425	-0.04168	-0.03212	-0.03212	-0.42719	-0.22395	-0.18924	-0.18342
44	-0.11578	-0.04233	-0.03229	-0.03229	-0.43289	-0.2268	-0.19106	-0.18524
45	-0.11724	-0.04298	-0.03245	-0.03245	-0.43838	-0.22958	-0.19282	-0.187