

Revised Cost Benefit Assessment

WG 25th November 2013

Background

- The GC0035 consultation presented a view of the costs and benefits of changing RoCoF protection settings to 1.0Hzs^{-1}
 - The benefits identified were associated with Balancing Services Cost savings
 - Estimated at £10m pa with an upper range of £100mpa
 - The costs identified were the costs of making a protection setting change on generators at stations of 5MW and greater
 - a total of ~£7.5m consisting of
 - the costs of changing protection settings at £1.5m
 - The costs of site-specific risk assessments at £2.3m
 - The costs of mitigation where necessary at £3.7m

Questions Raised in Responses

- The following points were raised in responses
 1. Do the benefits of a change for $\geq 5\text{MW}$ plant alone outweigh the costs?
 2. Do the benefits outweigh the costs of implementing a setting change for all distributed generators (ie including plant $< 5\text{MW}$)?
 3. What's the impact of adopting a different setting (eg 0.5Hzs^{-1})?
 4. What are the additional costs for new generators?
 5. What is the cost of damage to generators due to an increase in risk under new settings?

Components of the Revised CBA

- The revised CBA is intended to address these points and is made up of the following components
 - An updated projection of Balancing Services costs
 - under the current constraint (0.125Hzs^{-1}) including
 - the cost of managing existing infeed loss risks
 - the cost of managing new infeed loss risks
 - the cost of managing to a limit of 0.5Hzs^{-1}
 - An updated view of implementation costs for plant at stations of $\geq 5\text{MW}$
 - An estimate of implementation costs for plant at stations of $< 5\text{MW}$

Components of the Revised CBA

- The revised CBA does not include
 - The cost of damage to generators due to a change in protection settings
 - This cost would be significant for the party concerned
 - feedback suggests ~£100k per incident
 - However, successful completion of the recommended site-specific risk assessment will minimise this risk of damage occurring
 - The cost of the risk assessment is included in the CBA
 - Additional costs to new connectees of new settings
 - No additional costs have been identified

Approach of the Revised CBA

- The CBA is required to quantify the case for a proposed change to the Distribution Code and ERG59
- There are many uncertainties in the evaluation, for example
 - Model uncertainties for future system conditions
 - Incomplete information
- The CBA therefore needs to capture the possibility of a worst case outcome
 - Savings in system costs (Balancing Services) at the low end of our range
 - Implementation costs at the high end of our estimates
- It does not represent a forecast or a statement of expectations

Cost of Implementation

- Generators at stations of $\geq 5\text{MW}$
 - GC0035 Consultation set out costs associated with
 - Changing settings at 150 sites (approx 50% assumed to use RoCoF rather than vector shift or other methods)
 - Of these, 90 were assumed to be synchronous generators and needed a site-specific assessment
 - 40% of these (~20% of the total synchronous generator population) were assumed to require mitigation

	Protection Setting Change	Site Specific Risk Assessment	Mitigation
Max Number of Sites	150	90	36
Cost Per Site	.010	.025	.100
Sum (£m)	1.50	2.250	3.600

Cost of Implementation

- Generators at stations of $\geq 5\text{MW}$
 - Latest view of generator data (approx 50% complete)
 - 54 sites with RoCoF, 29 of which are synchronous generators

LoM Protection Setting Info at DG of 5MW and above (Data Gathered up to October 2013)

Capacity (MW)	WPD SW	WPD WM	WPD EM	NPG Y	NPG N	ENW	SP M	Total
RoCoF <0.2	117		29			89	149	384
RoCoF ≥ 0.2	95	115	40	29	38	115	41	473
VS	120	61	160	23	37	31	70	502
I/T	66			20	17	54		157
Other	78	131	19	154	147	442	30	1001
Total	476	307	248	226	239	731	290	2516

Number of Sites

RoCoF <0.2	12		1			4	5	22
RoCoF ≥ 0.2	7	7	2	2	3	7	4	32
Other	24	15	9	14	14	9	5	90
Total	43	22	12	16	17	20	14	144

RoCoF Sites	19	7	3	2	3	11	9	54
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Synchronous Generator Sites With RoCoF

RoCoF <0.2	3		1			4	3	11
RoCoF ≥ 0.2	3	7	1	2	1	3	1	18
Total	6	7	2	2	1	7	4	29

Cost of Implementation

- Generators at stations of $\geq 5\text{MW}$
 - Latest view of generator data is consistent with the initial view presented of £7.5m
 - For the purposes of this CBA, it would be prudent to assume a maximum cost of £10m

Cost of Implementation

- Generators at stations of <5MW
 - Number of sites
 - Up to 6GW of capacity
 - Includes over 1.5GW of solar
 - Excluding domestic solar, an average capacity per site of ~1MW would suggest ~4,000 sites
 - Loss of Mains Protection technique
 - Worst case assumption is that 50% use RoCoF
 - Domestic PV assumed to use proprietary protection techniques
 - General characteristics
 - Smaller, lighter synchronous machines
 - Limited use of voltage control capability
 - Simpler installations
 - Costs per site
 - A range of costs are plausible from a simple setting change to significant plant change
 - Assumed to be significantly less than replacing plant

Cost of Implementation

- Generators at stations of <5MW
 - Taking a view of different plausible scenarios

Range Based on Different Site Number and Cost Assumptions

	High	Medium	Low
Max Number of Sites	5000	4000	3000
Proportion with RoCoF	50%	40%	25%
Cost Per Site (£k)	10	5	1
Sum (£m)	25.000	8.000	.750

Hybrid Approach applied to 4,000 Sites

	Major Work	Complex	Simple	Total
Max Number of Sites	250	1000	2750	4000
Proportion with RoCoF	50%	50%	50%	
Cost Per Site (£k)	100	10	1	
Sum (£m)	12.500	5.000	1.375	18.875

- Highest value calculated is £27.5m
- £30m adopted as the plausible worst case for the purposes of this assessment

Projected Balancing Services Costs

- Costs for managing RoCoF constraints with a limit of 0.125Hzs^{-1} have been calculated up to 2025/26
- Model uses 2012/13 generation data
 - Wind generation output has been disaggregated and scaled each year in accordance with the “Slow Progression” scenario
 - No demand growth
 - Excludes the effect of Solar PV

Baseline GB Wind Capacity In Scenario (MW)

2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
10,063	11,288	12,286	12,949	13,804	14,607	16,217	17,472	18,743	20,960	23,316	25,293	28,306

- Costs calculated for
 - Existing infeed loss risks
 - New infeed loss risks
 - A RoCoF limit of 1.0Hzs^{-1}
 - A RoCoF limit of 0.5Hzs^{-1}

Projected Balancing Services Costs

- Three views created, Best, Central and Worst
 - Best view assumes good trading capability, increasing synchronous plant flexibility and reduced wind generation output
 - Central view assumes average trading capability and increasing synchronous plant flexibility
 - Worst view assumes average trading capability, no development in plant flexibility, windier conditions and earlier connection of new infeed losses
- A weight of 30%, 60% and 10% has been applied to each
- Cost of Carbon has not been included

Projected Balancing Services Savings

RoCoF Balancing Services Cost Projection Scenario Summary

All Costs £m (2013/14 prices)

		2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Total Cost of Managing Existing Infeed Loss Risks	Best	9.0	10.4	29.3	31.1	34.5	28.9	51.1	59.7	71.2	122.1	179.9	187.0	281.8
	Central	9.6	11.4	56.1	59.5	66.2	53.8	95.6	113.6	132.9	218.5	305.7	297.7	419.5
	Worst	10.4	12.4	60.8	65.4	72.9	81.2	151.6	182.0	224.2	500.1	730.5	959.3	1,391.7
Total Cost Including New Infeed Loss Risks	Best	9.0	10.4	29.3	31.1	149.8	146.1	182.3	328.4	483.7	580.7	814.6	841.2	966.0
	Central	9.6	11.4	56.1	59.5	184.2	294.6	364.9	390.2	557.3	692.4	962.4	975.1	1,130.9
	Worst	10.4	12.4	60.8	184.0	314.8	328.0	428.2	607.6	662.1	1,152.0	1,409.5	1,661.5	2,130.3
Total Cost if Settings are Changed for >=5MW plant only	Best	8.1	9.3	26.1	27.7	146.0	142.9	176.8	322.3	477.0	572.6	805.7	833.4	957.5
	Central	8.6	10.2	50.3	53.4	177.4	289.1	355.5	379.8	545.9	679.4	948.1	963.5	1,118.2
	Worst	9.4	11.2	55.0	177.8	307.9	320.2	415.3	593.2	646.3	1,130.3	1,385.7	1,636.2	2,102.7
Total Cost of Limiting RoCoF to 0.5Hz ⁻¹	Best	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.7	13.8	62.3
	Central	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.1	17.6	49.0	170.0
	Worst	.0	.0	.0	.0	.0	.0	.0	.0	.0	11.6	51.1	118.5	376.9
Scenario Weighting	Best	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Central	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Worst	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

All Costs £m (2013/14 prices)

Total Balancing Services Cost Summary

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Total Cost of Managing Existing Infeed Loss Risks	9.5	11.2	48.5	51.6	57.3	49.1	87.8	104.2	123.5	217.8	310.4	330.6	475.4
Total Cost Including New Infeed Loss Risks	9.5	11.2	48.5	63.5	187.0	253.4	316.5	393.4	545.7	704.8	962.8	1,003.6	1,181.3
Total Cost if Settings are Changed for <5MW plant only	8.5	10.1	43.5	58.1	181.0	248.4	307.9	383.9	535.2	692.4	949.2	991.8	1,168.4
Total Cost if Limit is set to 0.5Hz/s	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.8	16.2	45.4	158.4

For info:

Baseline GB Wind Capacity In Scenario

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Baseline GB Wind Capacity In Scenario	10,063	11,288	12,286	12,949	13,804	14,607	16,217	17,472	18,743	20,960	23,316	25,293	28,306

The cost of energy trading to reduce I/C imports, Priced at £20/MWh

The cost of energy to synchronise and create room for additional machines to provide inertia, priced at £150/MWh

The net annual cost accounting for occasions where trading is not possible

The cost of energy to synchronise and create room for additional machines to provide inertia to maintain a 660MW unit loss withstand, priced at £150/MWh

The cost of managing outages (eg busbar outages) including demand risks

Balancing Services Cost Projection (0.125Hz⁻¹ Limit)

£m	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Infeed Loss Curtailment by Trade Ability to Trade	4.3	5.0	5.8	6.1	6.8	7.4	12.3	13.6	14.8	20.6	22.5	24.1	26.0
Additional Syncs Alternative	241.4	289.7	333.4	354.7	394.4	303.9	519.8	575.7	634.5	684.5	753.9	561.6	613.7
Net Cost	6.6	7.9	38.6	41.0	45.5	37.0	63.0	69.8	76.7	87.0	95.6	77.8	84.8
Additional Syncs to meet Gen Unit Size Limi	.0	.0	.0	.0	.0	.0	4.0	12.2	21.4	92.2	166.7	184.6	296.3
Planned/Unplanned Contingencies	3.0	3.6	17.5	18.5	20.6	16.8	28.5	31.6	34.7	39.4	43.3	35.2	38.4
Total (Existing Infeed Risks)	9.6	11.4	56.1	59.5	66.2	53.8	95.6	113.6	132.9	218.5	305.7	297.7	419.5
Number of Larger Loss Risks					1	2	2	2	3	3	4	4	4
Curtailment of Larger Loss	.0	.0	.0	.0	118.1	240.8	269.4	276.6	424.4	473.9	656.7	677.5	711.4
Additional Sync for Larger Loss	.0	.0	.0	.0	3,623.7	4,945.5	5,376.6	5,489.1	8,359.4	6,769.3	9,375.9	6,433.2	6,721.0
Total Including New Infeed Risks	9.6	11.4	56.1	59.5	184.2	294.6	364.9	390.2	557.3	692.4	962.4	975.1	1,130.9

Action required on 135 nights, 30 days and 47 evenings at ~1.7GW per occasion

Action required on 166 nights, 44 days and 80 evenings at ~2GW per occasion

Balancing Services Cost Projection (5MW and above only)

£m	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Planned/Unplanned Contingencies Saving	1.0	1.2	5.8	6.1	6.8	5.5	9.4	10.4	11.5	13.0	14.3	11.6	12.7
Total Cost	8.6	10.2	50.3	53.4	177.4	289.1	355.5	379.8	545.9	679.4	948.1	963.5	1,118.2

Balancing Services Cost Forecast (0.5Hz⁻¹ Limit)

£m	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Number of Larger Baseload Loss Risks									1	1	1	1	1
Curtailment of Larger Loss (0.5)	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.1	17.6	49.0	170.0
Additional Sync for Larger Loss (0.5)	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.8	10.3	14.7	42.9
Net Cost	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.1	17.6	49.0	170.0

The cost of curtailing new larger losses priced at £150/MWh

The cost of energy to synchronise and create room for additional machines to provide inertia priced at £150/MWh (deemed uneconomic and disregarded)

The cost of curtailing new large baseload loss priced at £2,000/MWh

The cost of energy to synchronise and create room for additional machines to provide inertia priced at £150/MWh

Central Case

Implementation Costs vs Savings

All Costs £m (2013/14 prices)

Total Balancing Services Cost Summary

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Total Cost of Managing Existing Infeed Loss Risks	9.5	11.2	48.5	51.6	57.3	49.1	87.8	104.2	123.5	217.8	310.4	330.6	475.4
Total Cost Including New Infeed Loss Risks	9.5	11.2	48.5	63.5	187.0	253.4	316.5	393.4	545.7	704.8	962.8	1,003.6	1,181.3
Total Cost if Settings are Raised to 0.5Hz ⁻¹ or above for >=5MW plant only	8.5	10.1	43.5	58.1	181.0	248.4	307.9	383.9	535.2	692.4	949.2	991.8	1,168.4
Total Cost if Limit is set to 0.5Hz ⁻¹	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.8	16.2	45.4	158.4

Total Achievable Savings

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Cumulative Savings (1Hz ⁻¹): 2017 Completion					187.0	440.4	756.8	1,150.2	1,695.9	2,400.8	3,363.5	4,367.1	5,548.5
Cumulative Savings (1Hz ⁻¹ >=5MW only): 2016 Completion				5.3	11.2	16.3	24.9	34.4	44.8	57.2	70.9	82.7	95.6
Opportunity lost for a setting change to 0.5Hz ⁻¹ compared to 1Hz ⁻¹				.0	.0	.0	.0	.0	.0	1.8	16.2	45.4	158.4

Implementation Cost

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Generators at Stations of >=5MW													
Cost		5.0	5.0										
Cumulative Cost		5.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Generators at Stations of <5MW													
Cost			15.0	15.0									
Cumulative Cost		.0	15.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Total													
Cost		5.0	20.0	15.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Cumulative Cost		5.0	25.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0

- Points to note

- Break even is achieved in the first year if settings are raised for all plant to 1.0Hz⁻¹
- Break even is achieved in 2 years if only plant >=5MW is modified
- A lower setting makes a re-visit likely at which point the costs of making a change will be different

Conclusions

- The savings that can be achieved by changing RoCoF protection settings are large
 - £760m by 2020 according to the “central” cost case
 - £114m by 2020 with no new infeed risks under the “best” cost case
 - £1,000m by 2020 under the “worst” cost case
- The maximum estimated costs of implementing a change are significantly less at ~£40m
- A change for plant of $\geq 5\text{MW}$ only, delivers savings which are big enough to offset costs but leaves significant costs to be incurred
- The 0.5Hzs^{-1} limit becomes significant after 2020
 - Potential for transitional options for some plant
 - A general setting at this level would require a re-visit from 2017/18
- Working to a limit of 0.125Hzs^{-1} on an enduring basis is not an option