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Safety, Resilience, and Reliability Working Group - Resilience

18/02/2020

OFG1161

Agenda

- Introductions and actions review (10-10:15)
- Exceptional Events (10:15-11:30)
- Short interruptions (11:30-13:00)
- Lunch (13:00-13:30)
- Worst Served customers (13:30 – 14:30)
- IIS targets (14:30-16:00)

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IIS Exceptional Events

SRRWG

18 February 2020

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Current arrangements

- Part of the IIS mechanism is the inclusion of two separate exceptional event criteria whereby the impacts of events meeting the specified definitions are excluded from the IIS mechanism and hence the calculation of associated revenues
- These form part of the overall risk sharing properties of the IIS scheme and are specified in CRC2D of the Distribution licence
- Conditions relating to the DNOs undertaking appropriate preventative and mitigating actions are included hence each claim for exemption needs to be assessed in detail

Severe Weather EE

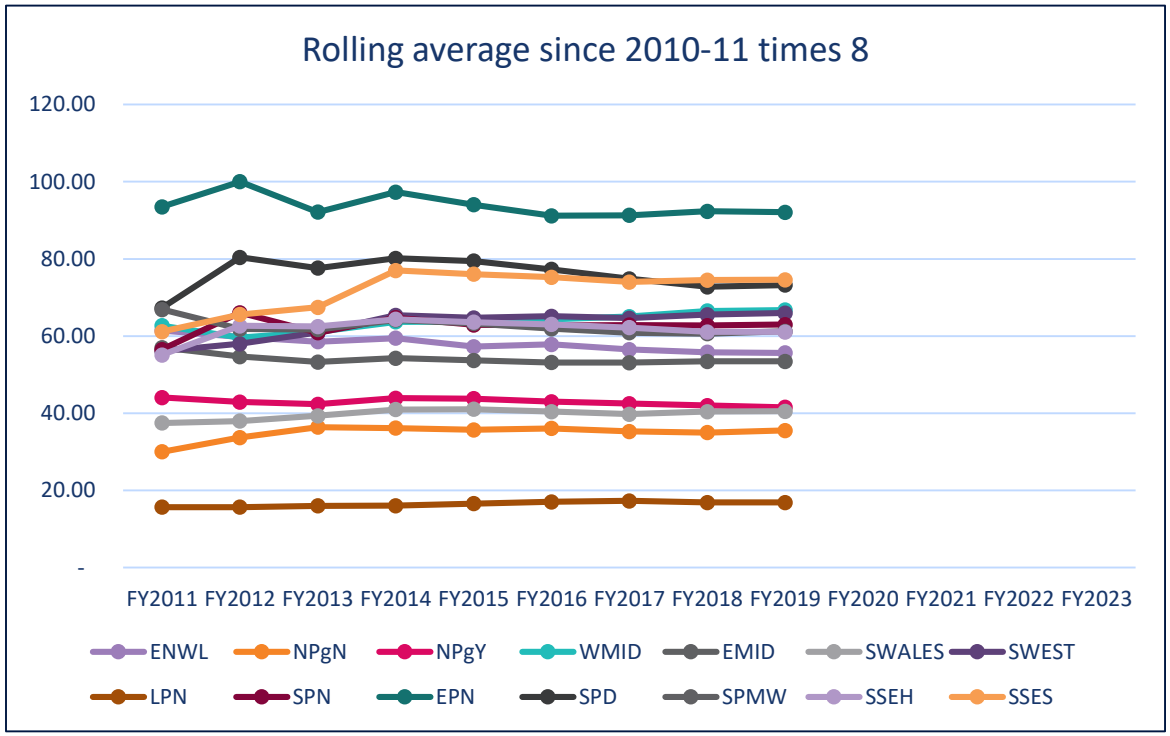
- Current licence definition

A2.1 For the purposes of paragraph 2D.31, an exceptional severe weather event:
(a) is deemed to begin at the beginning of a 24-hour period when the number of incidents caused by the event at distribution higher voltage in that period is equal to or greater than the commencement threshold number; and
(b) is deemed to end at the time determined by the Authority having regard to:
(i) such time as the licensee may have declared was the end of the severe weather event in its statement of facts;
(ii) the time of restoration of the last Customer off supply due to an LV incident linked to the underlying cause of the severe weather, (provided that all Customers off supply due to high voltage incidents linked to the underlying cause of the severe weather event have been restored); and
(iii) the end of a 48-hour period when the number of Customers off supply due to high voltage incidents linked to the underlying cause of the severe weather event has fallen to zero.

- Current threshold for severe weather is a single binary threshold set at eight times the daily average number of higher voltage faults
- It was designed to give some stability to the incentive arrangements, so that ‘uncontrollable’ impacts did not lead to annual performance (and incentive value) volatility but was set at a threshold such that ‘normal’ activity was not excluded
- This is both the simplest way to determine events, and provides consistency for historic data

Severe Weather EE

- Current exemption thresholds specified in the licence
- Updated analysis suggests little movement for most licensees



DNO	RIIO-ED1	RIIO-ED2 based on last nine years	Difference
ENWL	55	56	1
NPgN	37	36	-1
NPgY	40	42	2
WMID	63	67	4
EMID	64	53	-11
SWALES	41	41	-
SWEST	60	66	6
LPN	14	17	3
SPN	54	63	9
EPN	91	92	1
SPD	76	73	-3
SPMW	68	61	-7
SSEH	60	61	1
SSES	67	75	8

Severe Weather EE – issues highlighted

- A single threshold leads to binary consideration of event as ‘exempt’ or ‘non-exempt’
- There is no direct incentive to invest in resilience improvements which may convert exempted events into non-exempted ones though some non EE investment may have improved this area indirectly
- The 24-hour stipulation doesn’t cover many of the less severe but sustained storm events actually experienced and projected to increase in frequency with climate change
- The current format drives DNOs to prioritise incidents based on whether they are weather related, rather than repairing & restoring on a safety/service/security basis

Severe Weather EE – possible developments

Potential amendment	Pros	Cons
All incidents during an event should be claimable, and then could be replaced with an average level of performance or similar	• Massively simplifies the current process of determination and aligns better as thresholds are set using all incidents already)	
Introduce a tiered or tapered scheme, eg move threshold higher (say 12x daily mean) and introduce 50% relief of events (say) 6-12x daily mean	• As an industry we have been successful in reducing both CI and CML over the last 15+ years but as CI and CML figures now reach low levels the impact of smaller exceptional events (say those in the 6-12 daily mean HV size) have a much bigger impact on a DNO's performance. Therefore these smaller EEs have the ability to wipe out the incentive to invest to reduce CIs and CMLs. Having a two tier EE threshold would remove this risk.	In order to decide upon all of the variables of a scheme such as this, there is a lot of analysis required to show that it would function better than current arrangements, it would introduce lots of additional complexity to target setting and reporting
Introduce an either/or qualification relating to a longer timeframe to cover more persistent storm events, eg 8x daily mean for 24-hour period or 4x daily mean over a 72-hour period.	• More reflective of experience of storm events and associated customer impacts	As above, this would be complex to determine rules for, and report upon The historic data series would need to be restated to support
The methodology could revert back to an approach used in DPCR4 where the end of an event is defined as when fault volumes return to a daily average.	• This would automate part of the assessment process and would remove the subjective assessment of (and points of debate about) the end of the event	

Severe Weather EE – considerations

- Increasing the thresholds will reduce the number of exclusions that Ofgem has to consider but…
  - The actual performance used in target setting will need to contain previously excluded events below the new threshold. Any substantive changes will require a redetermination for every event during all years used for target setting
  - There may be an increase in the volatility of annual performance, making it more difficult for DNOs (and Ofgem) to explain the impact of actions to improve performance and show decreasing trends It also removes all historic ability to trend previous performance.
- Reducing the thresholds will increase the number of exclusions that Ofgem has to consider but…
  - The actual performance used in target setting will need to be adjusted
  - There may be a reduction in the volatility of annual performance, but 'normal' weather impacts could start to be being excluded from performance assessment. This is key, finding the balance to only ignore what is beyond the DNO's control and being able to set fair targets on that basis. If we exclude more incidents, then targets are reduced accordingly, or vice versa.

One-off EE

- Current licence definition

A3.1 For the purposes of paragraph 2D.34, the exceptionality requirements for an event not falling within paragraph 2D.31 are both of the following:
(a) the first requirement is that the occurrence of the event was a consequence of either**:**
(i) a cause external to the licensee (including an event arising from an incident on a Transmission System or other connected network, or from terrorism or vandalism), or
(ii) a cause internal to the licensee**:**
(a) that was not attributable to any culpable error by the licensee in relation to the installation, operation or maintenance of an asset forming part of its Distribution System, or
(b) the consequence of which could not reasonably have been avoided by the licensee;

(b) the second requirement is that the event contributes more than the relevant threshold amount to CIIS or CMLIS in a three-month period.

- The current threshold is 25,000 customers and 1,000,000 minutes and licensees are exposed to the performance up to these thresholds
- These were established to protect companies from large individual events that are truly beyond their control. The exemption process also includes an aspect of performance that companies are exposed to and hence encourages companies to look at preventing the circumstances occurring

One-off EE

- When translated into licensee CI and CML terms, the qualification criteria are expressed as the following in the licence;

Licensee	CIIS ** threshold amount	CMLIS ** threshold amount
ENWL	1.06	0.84
NPgN	1.58	1.26
NPgY	1.10	0.88
WMID	1.01	0.81
EMID	0.95	0.76
SWALES	2.26	1.80
SWEST	1.60	1.28
LPN	1.10	0.88
SPN	1.11	0.89
EPN	0.70	0.56
SPD	1.25	1.00
SPMW	1.68	1.34
SSEH	3.33	2.67
SSES	0.84	0.67

One-Off EE – issues highlighted

- Each event requires a bespoke assessment to identify whether the event was truly outside the control of a DNO
- There is no relationship between a DNO's IIS targets and the thresholds - the logic for why these were set at 25k/1m is unclear? SHEPD's in particular is impossible in reality.
- The thresholds should not be set based on CIIIS and CMLIS as this excludes any loss of infeed or Transmission events.

One-Off EE – possible developments

Potential amendment	Pros	Cons
The thresholds are currently based upon the size of an event (not the size of a company), but there could be scope to consider this in terms of a percentage of the overall company specific target (e.g. 1% of a company target).		• Doing it this way would mean very different size events qualify in respective DNOs – is this what the grid code would envisage? Also would possibly need to be updated on an annual basis if targets move during the period. Also require removal of such sized events from history – but the historical targets may not be the same as the new ones so there's a potential disconnect. • As severe weather regarding recalculating thresholds using existing data so thresholds aren't skewed
Additional clarity over the potential types of events which should be excluded, eg appropriateness of recent claims for months of snow		

SRR WG – short ints actions

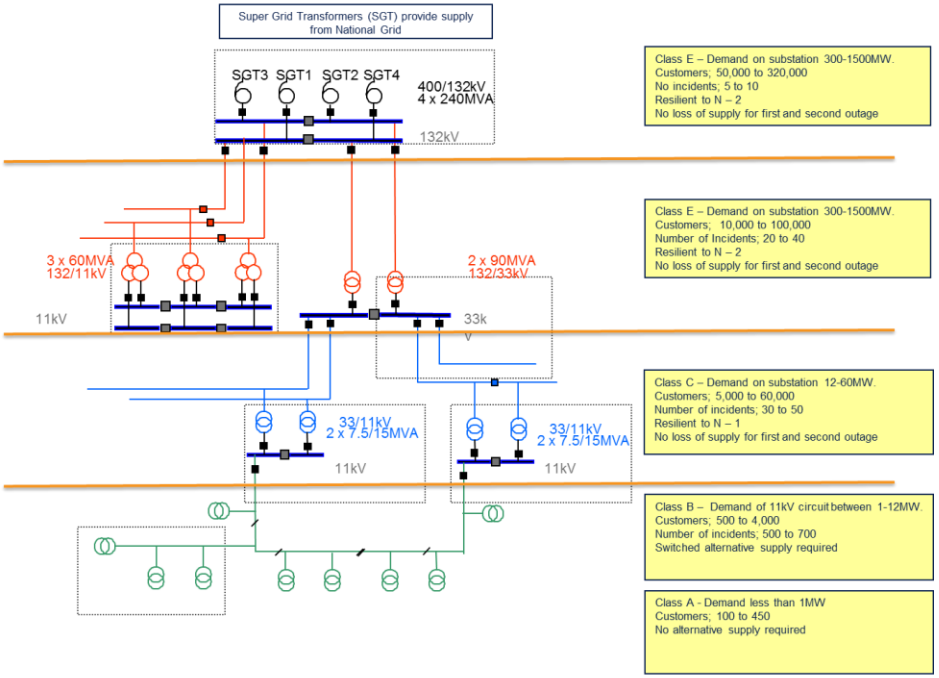
- What are short ints and what elements are controllable (UKPN)
- What is reported on short ints in ED1 (UKPN)
- What data we capture on short ints and could report relatively quickly in ED1 (UKPN)
- What happens if you amend the 3min boundary (SPEN)
- How you could incentivise short ints in ED2 (SPEN)
- What technologies are out there to help with short ints (S&C)
- What is the rest of the world doing (S&C)

What are short ints? (UKPN)

- This is the detailed section so please bear with us!

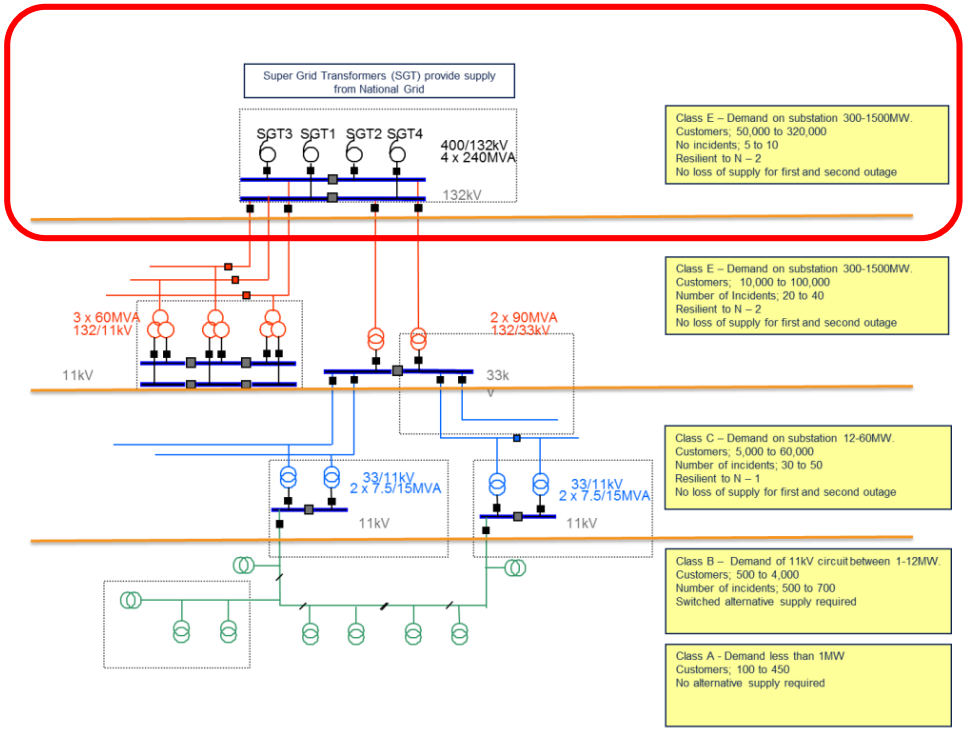
Under 3 Minute Interruptions

- 132kV DAR – Delayed Auto Reclose
- 132kV/EHV – Auto Close Scheme
- HV – Remote Control & Automation
- EHV – Auto Reclose
- HV – Auto Reclose
- LV – Auto Reclose



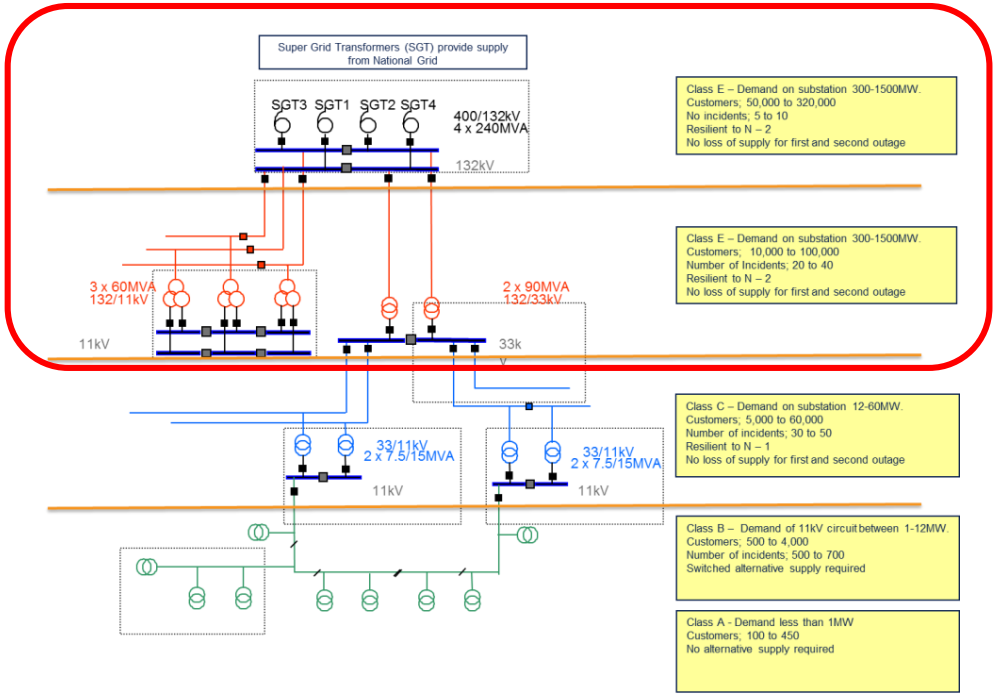
132kV DAR – Delayed Auto Reclose

- Used on 132kV overhead line circuits
- Normally will not result in any customer interruption
- Customers may see a dip in their supply
- Used on dual-circuit overhead lines and if one circuit is out or both circuit auto reclose customers will see an under 3 minute interruption
- Circuits/supplies restore from the same source
- Volumes are low



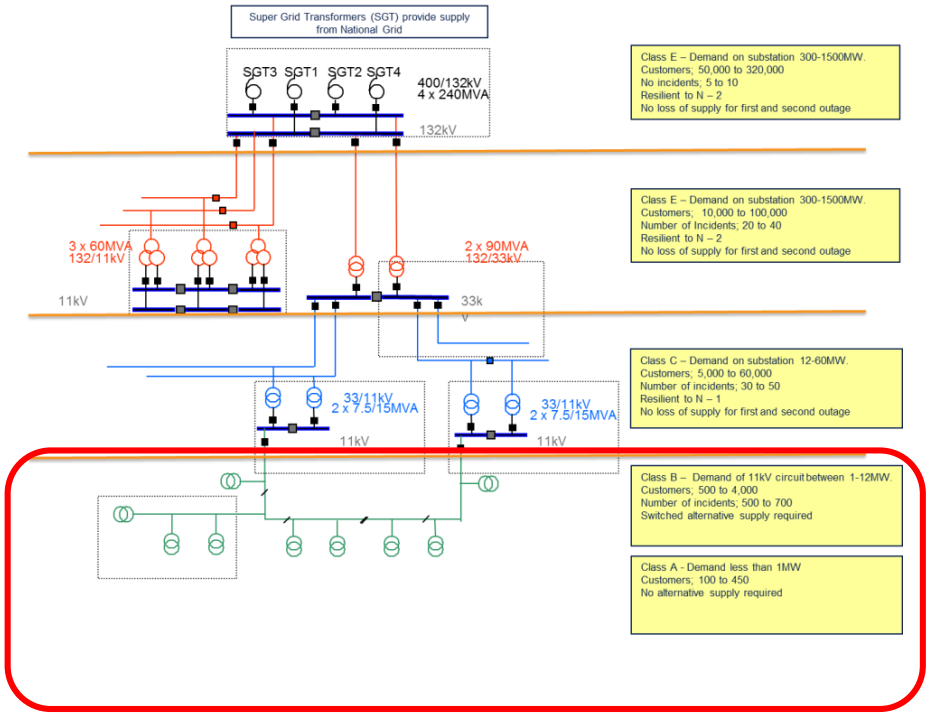
132kV/EHV – Auto Close Scheme

- Used on 132kV/EHV circuits/network, both overhead lines and underground
- Auto close/change over schemes are used to restore customer supplies under certain running conditions
- Auto close/change over schemes are used to optimise running condition, limiting the number of customers affected by a fault
- Auto close/changeover schemes are used to manage fault levels on networks with multiple infeeds/transformers
- Used to meet the requirements of P2/7
- Supplies restore from alternative circuits
- Volumes are low



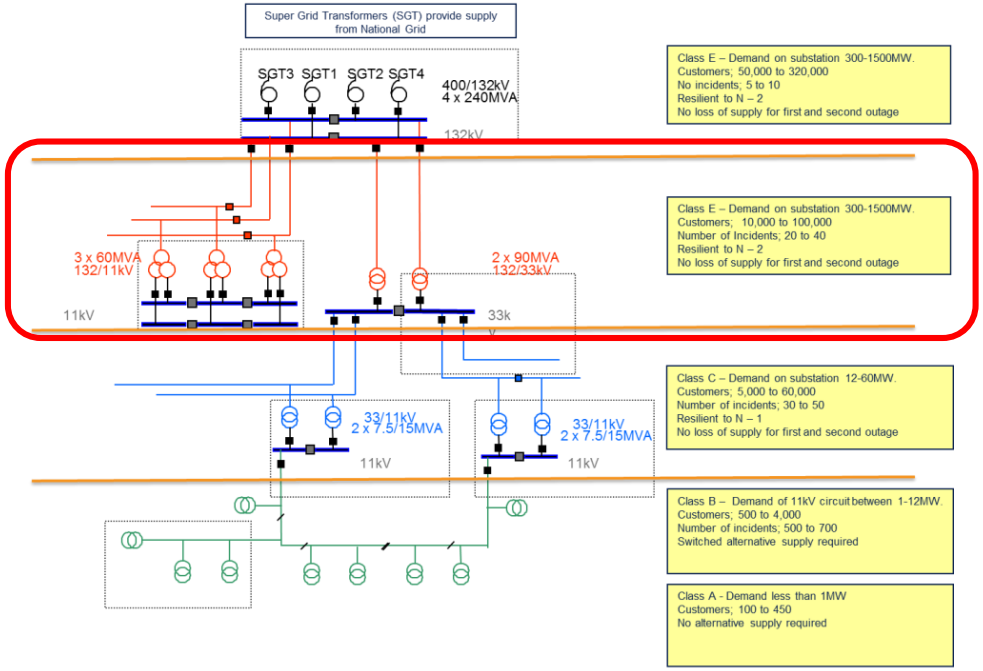
HV – Remote Control & Automation

- Used on HV circuits, both overhead line and underground
- Look to limit the impact of permanent fault
- Sectionalises the network to isolate faulty section of network
- Restores all supplies except for those affected by faulty section of network
- Where possible limits the number of customer impacted by the permanent
- Supplies restore from the same sources and/or alternative circuits
- High volume of customers are restored in under 3 minutes which would have been off for manual switching time in the past



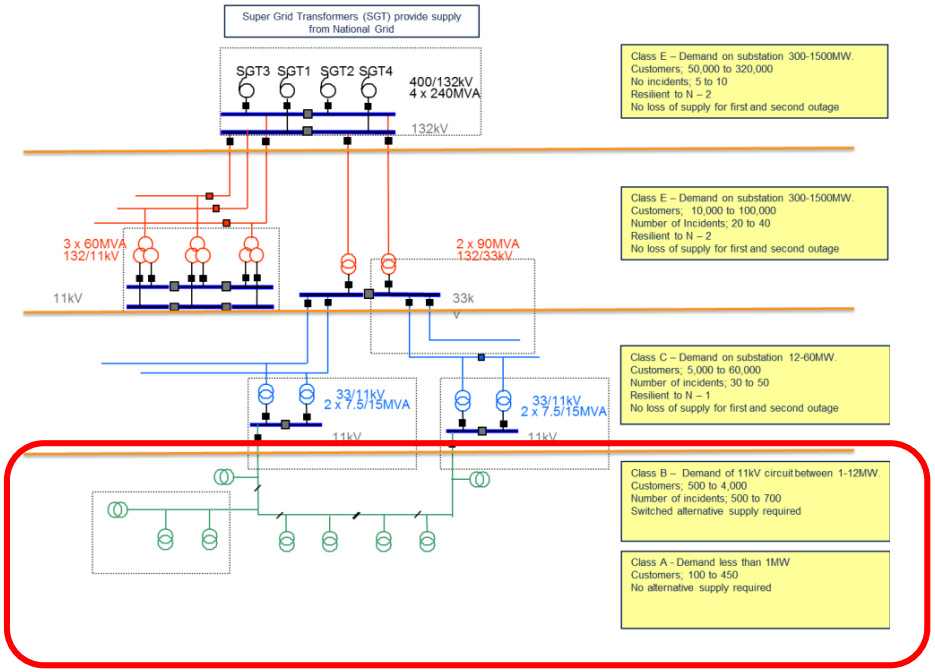
EHV – Auto Reclose

- Used on EHV overhead line circuits
- Depending on network running conditions will depend on whether see customer interruption
- Used on dual-circuit overhead lines and if one circuit auto-recloses customers are not affected
- Customers may see a dip in their supply
- If one circuit is out or both circuit auto reclose customers will see an under 3 minute interruption
- Circuits/supplies restore from the same source



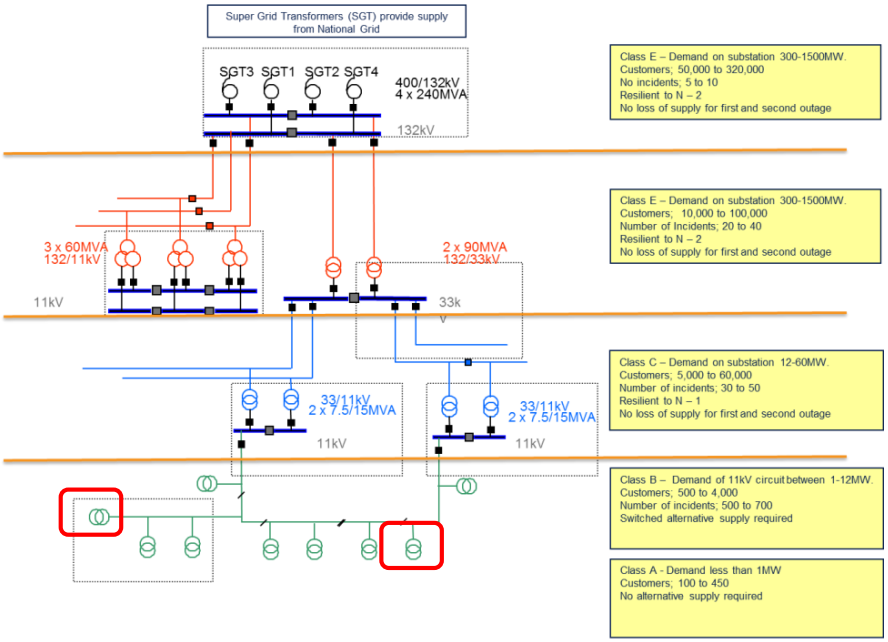
HV – Auto Reclose

- Used on HV overhead line circuits
- Auto-reclose operates for both source circuit breakers and inline pole mounted circuit breakers
- Restores customer in under 3 minutes for transient fault
- Non-affected customer may see a dip in their supply
- Circuits/supplies restored from the same source
- Limits the impact of severe weather events, wind and lightning
- High volumes



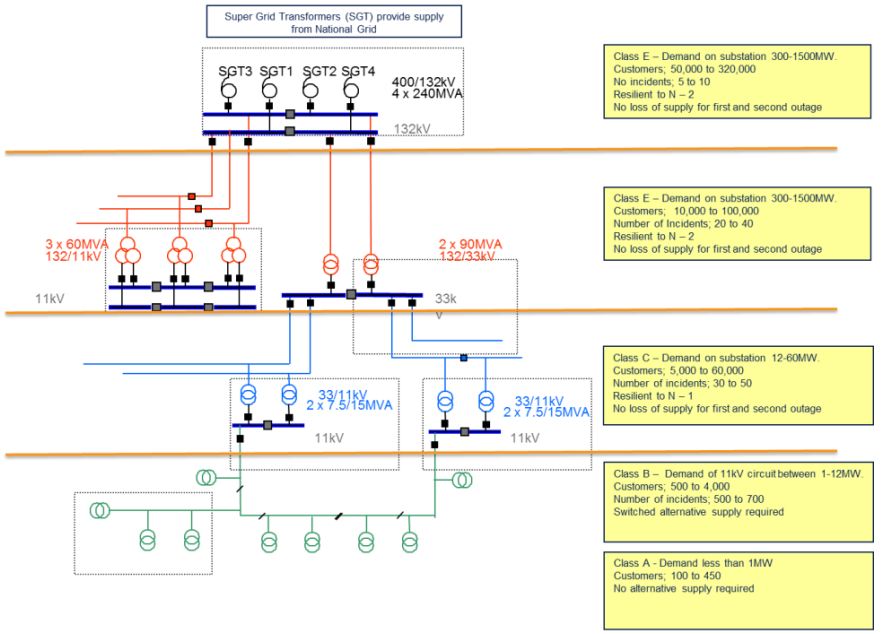
LV – Auto Reclose

- Used on LV circuits
- There are a high number of repeat faults on the LV network where the fault cannot be found the first time round
- Without auto-reclose customer would be off until an engineer gets to site
- Restores customers in under 3 minutes
- Circuits/supplies restored from the same source
- This is a new area for auto-reclose to be applied and has been introduced over past 3-5 year's
- This is an area where investment is continuing



Under 3 Minute Interruptions

- 132kV/EHV - Auto Close Scheme
  - Low volumes
- 132kV DAR - Delayed Auto Reclose
  - Low volumes
- HV - Remote Control & Automation
  - High volumes, but customers only see under 3 minute interruption would have been off for manual switching time in past.
- EHV - Auto Reclose
  - Medium volumes, but do not always impact customer
- HV - Auto Reclose
  - High volumes restore customer in under 3 minutes for transient fault
- LV - Auto Reclose
  - Latest development. Used on LV underground network to restore customers affected by repeat faults. Would have been off for switching time in the past. Investment is continuing



What elements are controllable (UKPN)

- 132kV DAR – Delayed Auto Reclose
  - The volumes are low and in most cases no customer are interrupted
  - Very little opportunity to reduce the volumes and due to the low volumes the impact would be very small
- 132kV/EHV – Auto Close Scheme
  - The volumes are low and in most cases customers will experience a 3 minute interrupted
  - Volume can be reduced, but require expensive capital investment and due to the low volumes the impact would be very small
- HV – Remote Control & Automation
  - The volumes are high, however, the DNO have used this technology to reduce the impact permanent faults have on customer
  - IIS incentive have been used to fund this investment

What elements are controllable (UKPN)

- EHV – Auto Reclose
  - Depending on network running conditions will depend on whether customer see 3 minute interruption
- HV – Auto Reclose
  - Auto-reclose operates for both source circuit breakers and inline pole mounted circuit breakers
  - Non-affected customer may see a dip in their supply
  - Limits the impact of severe weather events, wind and lightning
  - High volumes
  - May be an area where improvements can be achieved
- LV – Auto Reclose
  - This is a new area where DNOs are looking to reduce the impact of permanent fault by using automatic reclosers to restore customers in under 3 minutes
  - While introduces more short interruption it will reduce the impact of repeat fuse operation where a fault cannot be located

What elements are controllable (UKPN)

- Summary
  - Auto-reclose is a cost affective way of protecting the network against transient fault
  - While it may be possible to reduce some transient fault, the number would be limited, as most are due to the characteristic of the way overhead line operate/work
  - Due to the limited time available for protection devices to operate, means additional protection zones cannot be added
  - The attenuation of fault current down overhead line networks needs to be understood, when considering opportunities as it is a limiting factor
  - Cost of reducing fault volumes is very prohibitively high
- Of the types of short ints discussed, what do people believe are ones where there are opportunities for the volumes of them to be reduced?
- In thinking about the above question we should be mindful of what might be high costs to prevent a short int, but it may be practical to reduce the volumes of customers affected by them

What is reported on short ints in ED1 (UKPN)

- In the Interruptions pack the data is broken down as follows:

Short interruptions by "causes" (including LV)	INPUT	OUTPUT
	Sum of number of customers interrupted	Calculation of number of short interruptions
Automatic operation and restored by automatic switching	1853552	80.42
Automatic operation and restored by manual or remote switching	207122	8.99
Manual or remote operation	126132	5.47
Operation of switchgear on other connected systems	0	0.00
Total	2186806	94.87692889

- In the ONI pack the data is broken down as follows:

1914

Incident Reference	Voltage	Start date & time of incident
FREP-139687-G	11	07/04/2018 09:17:02
FREP-139768-G	11	08/04/2018 09:49:32
FREP-140177-G	LV	11/04/2018 23:25:00
FREP-141183-G	11	20/04/2018 23:03:00
FREP-141393-G	11	24/04/2018 02:43:06
FREP-141835-G	LV	27/04/2018 22:23:00
FREP-142130-G	11	30/04/2018 22:49:08
FREP-142241-G	11	01/05/2018 14:56:32
FREP-142429-G	11	02/05/2018 18:56:00
FREP-142470-G	11	03/05/2018 14:25:00
FREP-142718-G	11	06/05/2018 08:48:56

What is reported on short ints in ED1 (SPEN)

- Now we know what is reported in ED1, how has performance up to and including ED1 been tracking?

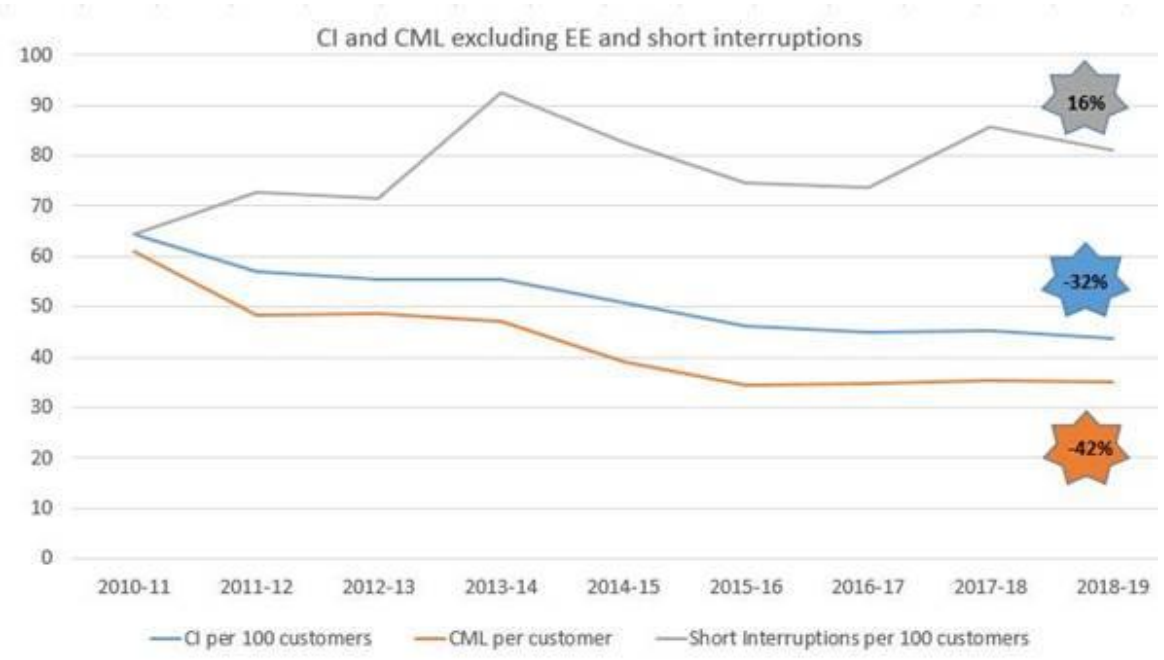
ED1 performance to date, compared to D5:

1. **Reportable** fault interruptions (duration >3 minutes, including Exceptional Events) have reduced by **21%**.
2. **Total** fault interruptions (including Short Interruptions and Exceptional Events) have reduced by **7%.**

Reportable interruptions - all data taken from Interruptions workbooks (includes EEs)	D5 to ED1 % Reduction (-is an increase)	All Interruptions (reportable fault CI, including EEs and SIs)	D5 to ED1 % Reduction (-is an increase)
CIs		All Interruptions (S	
ENWL	15%	ENWL	0%
NPGN	13%	NPGN	7%
NPGY	26%	NPGY	17%
WMID	25%	WMID	3%
EMID	15%	EMID	12%
SWALES	23%	SWALES	22%
SWEST	5%	SWEST	4%
LPN	32%	LPN	10%
SPN	21%	SPN	-8%
EPN	25%	EPN	3%
SPD	17%	SPD	16%
SPMW	10%	SPMW	0%
SSEH	27%	SSEH	11%
SSES	25%	SSES	10%
GB Ave	21%	GB Ave	7%

Figures sourced from 2019 11 27 SRR WG Interruption Figures File.
D5 is the average performance across the 5 years.
ED1 is the average across the first 4 years of ED1.

Short ints compared to CIs (SPEN)



What data we capture on short ints and could report relatively quickly in ED1 (UKPN)

- There are a small number of relatively simple changes to reporting which could be made to give greater visibility of short ints in the ONI pack
  - Add the type of short int (based on either the existing options from the interruptions pack or those talked through earlier in this slide deck)
  - Add the duration (or end time) of the short int
  - Add the number of customers affected
- What do other DNOs believe they can easily report on before the end of ED1?
- If these would be of use to Ofgem and other stakeholders then all DNOs would need to formally assess whether they capture and can report on this data before proceeding

What are the impacts of short ints? (SPEN)

- The cost and inconvenience to customers of interruptions can be considered in two components; fixed and variable.

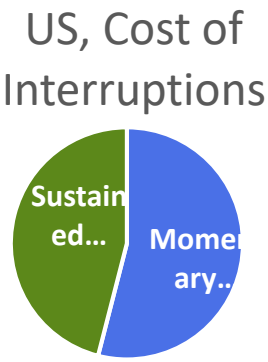
- **Fixed Customer Cost** – occurs from being interrupted at all.

- **Variable Customer Cost** – increases over time.

Research from Lawrence Berkeley National Laboratories found the total cost to the US economy of short interruptions to be greater than sustained interruptions.

This cannot be directly translated to GB due to differences in reporting, network types and customer expectations/willingness to pay, but is illustrative of impact.

A 2008 Accent survey for Ofgem showed a WTP for improvements in short ints – is now the time to run a similar survey?



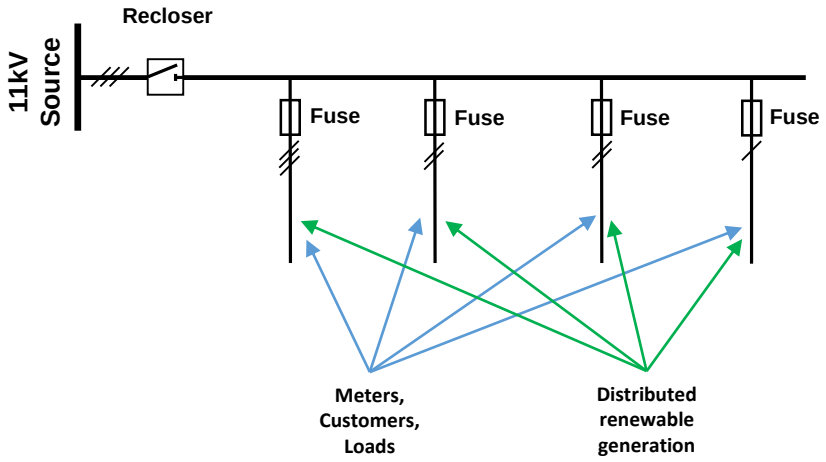
Is it appropriate to incentivise a reduction in *duration* OR in *occurrence* of SIs

What technologies are out there to help with short ints (S&C)

Type of Measurement	Reported if	Solutions		Measures will reduce
CML	Over 3 mins (Customer x affected by time)	More repair engineers		CML
		SCADA - manual remote control		
		SCADA - Automation sequences		
		SCADA (fast peer-to-peer)		
		FPI (communicating)		
		Reclosers		
		Increased protection stages	Instanteous, IDMT, Fuses	
		Mesh Networks		
		Local Battery storage		
CI	Over 3 mins (Customer numbers affected)	Reclosers, **spur reclosing**		CI, CML
		SCADA - Automation sequences		
		SCADA (fast peer-to-peer)		
		Increased protection stages	Instanteous, IDMT	
		Mesh Networks		
		Local Battery storage		
SI	Under 3 minutes (Customer numbers affected)	Reclosers, **spur reclosing**		SI, CI, CML
		SCADA (fast peer-to-peer)		
		Increased protection stages	IDMT	
		Mesh Networks		
		Local Battery storage		

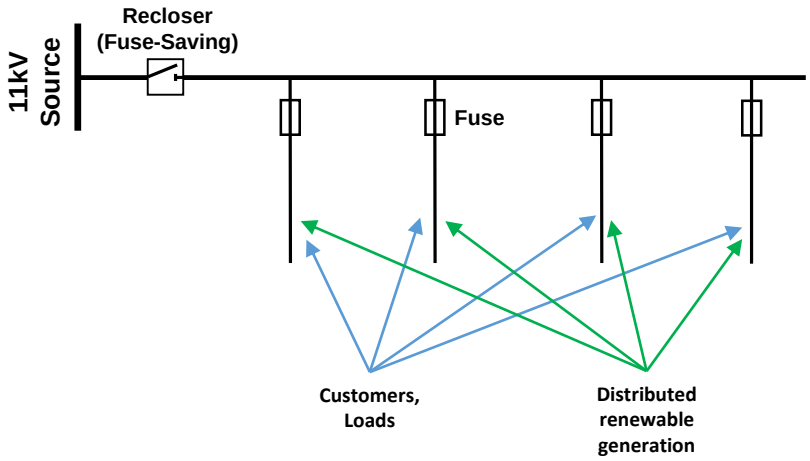
Eliminating faults isn't the only way of reducing short interruptions

Impact of transient faults on spurs under different scenarios

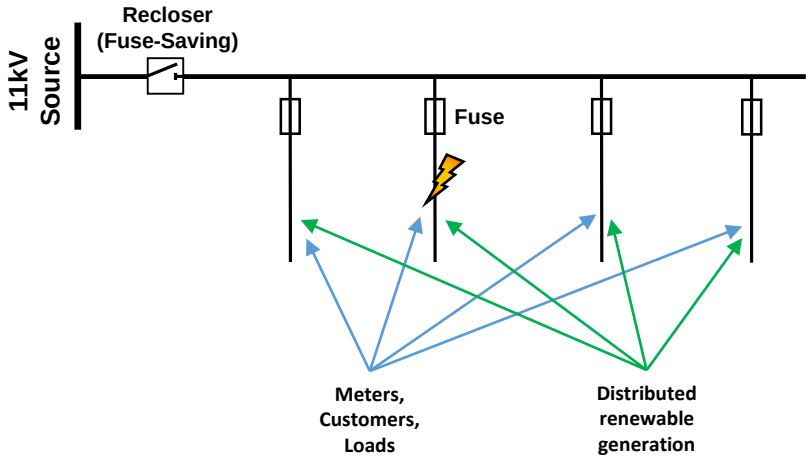


1

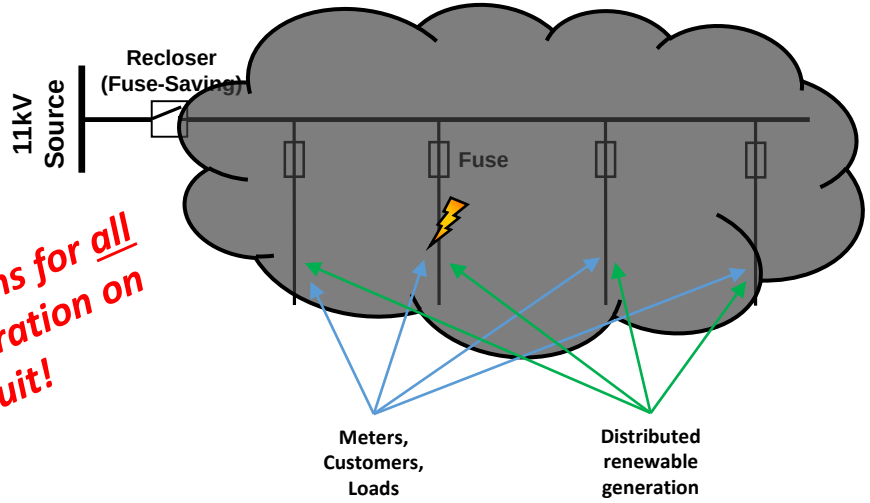
System response to transient faults…
…using Fuses and “Fuse-Saving” settings



System response to transient faults…
…using Fuses and “Fuse-Saving” settings



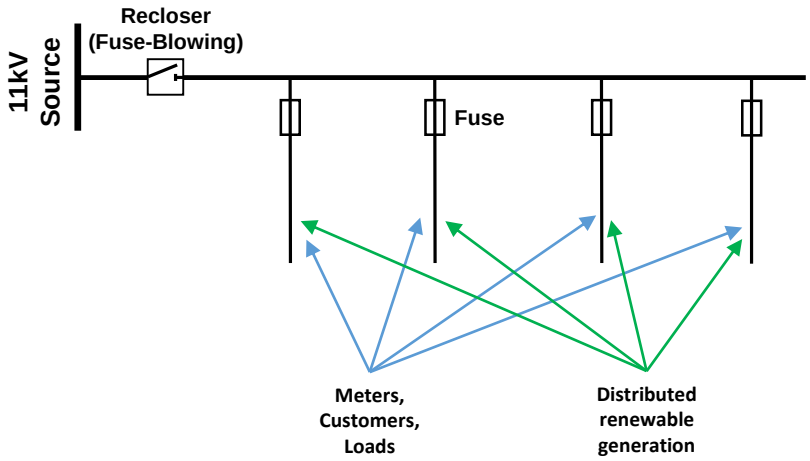
System response to transient faults…
…using Fuses and "Fuse-Saving" settings



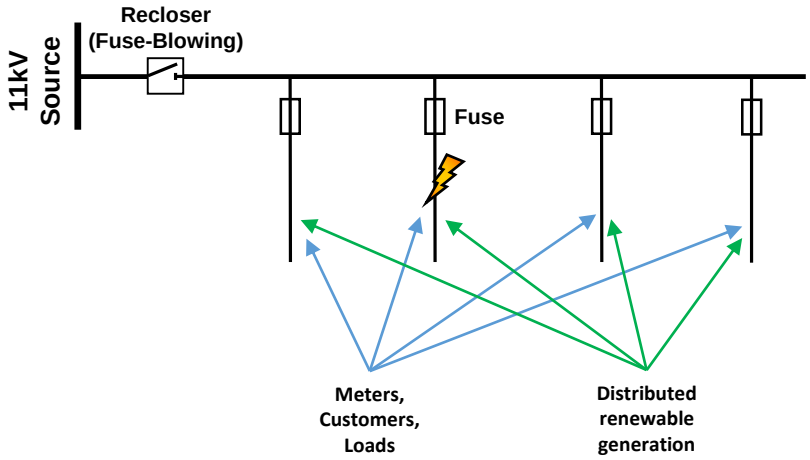
Short Interruptions for all loads and generation on the circuit!

2

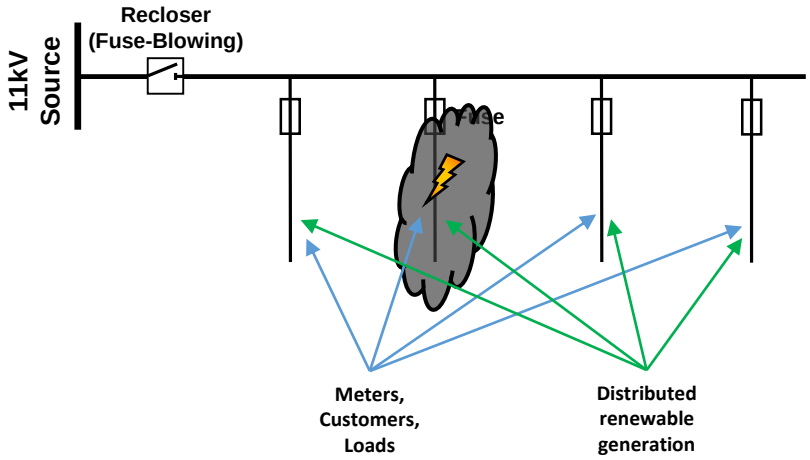
System response to transient faults…
…using Fuses and “Fuse-Blowing” settings



System response to transient faults…
…using Fuses and “Fuse-Blowing” settings



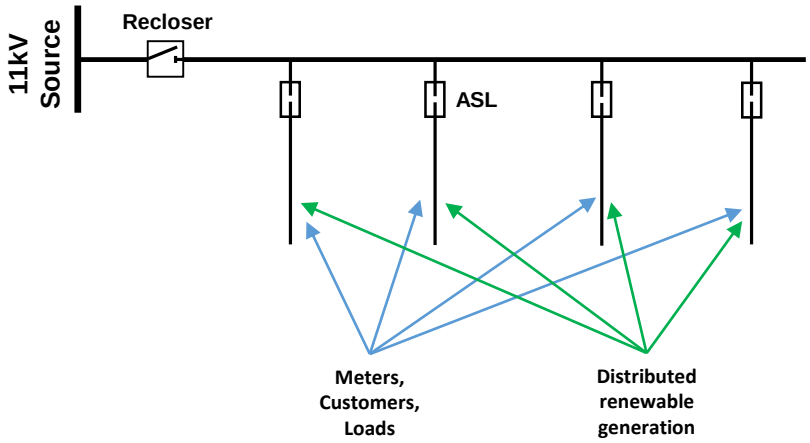
System response to transient faults…
…using Fuses and “Fuse-Blowing” settings



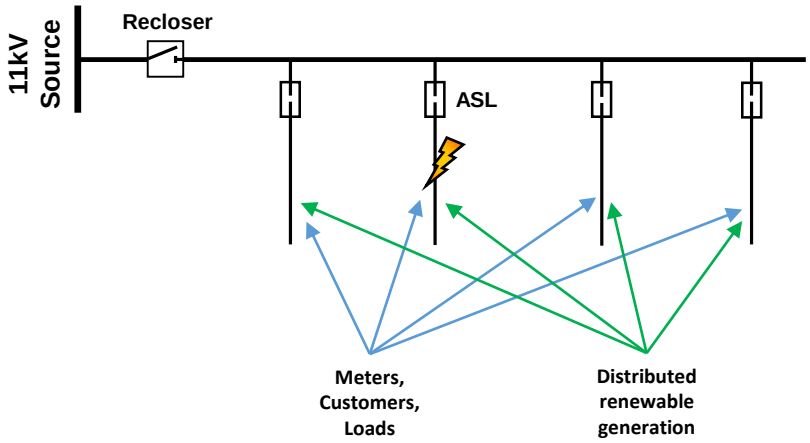
Longer Sustained Outages for loads and generation on the spur!

3

System response to transient faults…
…using Automatic Sectionalising Links

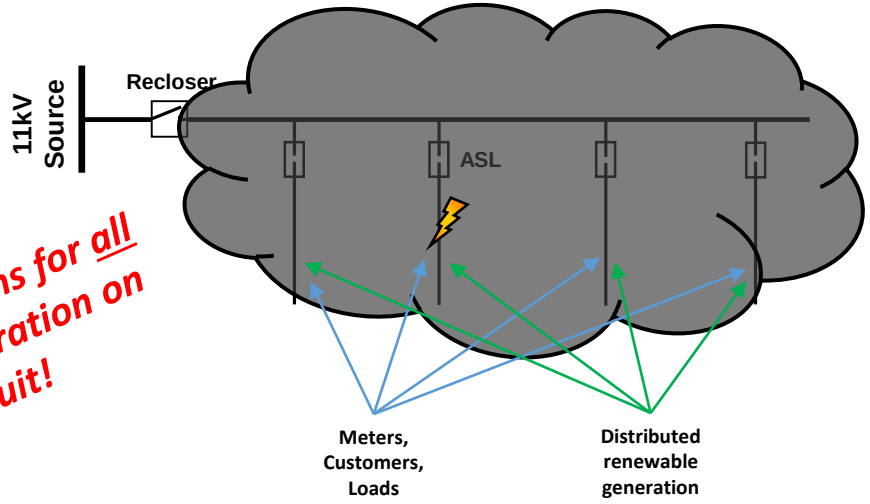


System response to transient faults…
…using Automatic Sectionalising Links



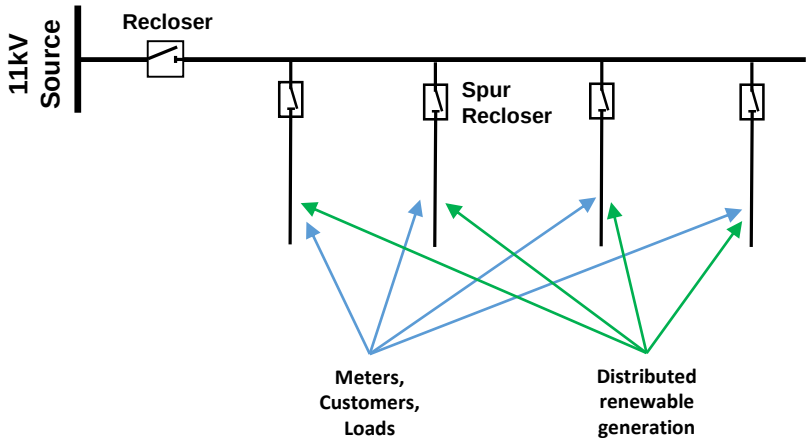
System response to transient faults…

…using Automatic Sectionalising Links

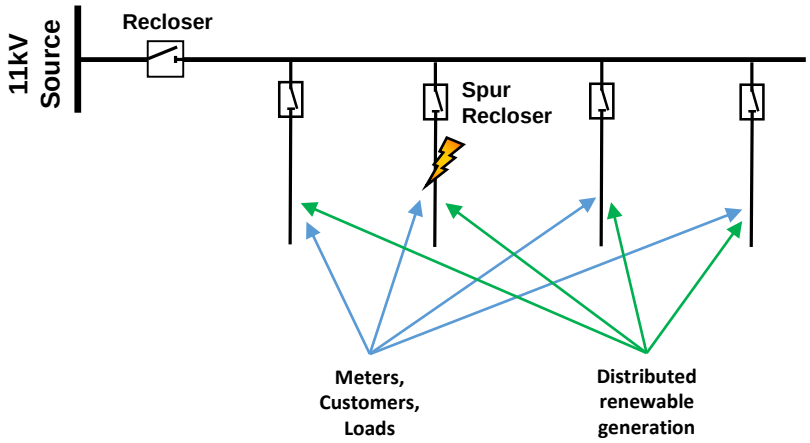


Short Interruptions for all loads and generation on the circuit!

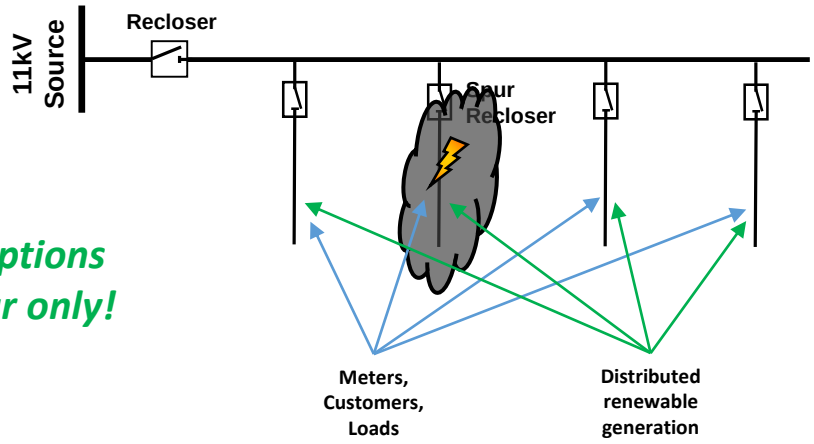
System response to transient faults…
…using Spur Reclosing



System response to transient faults…
…using Spur Reclosing

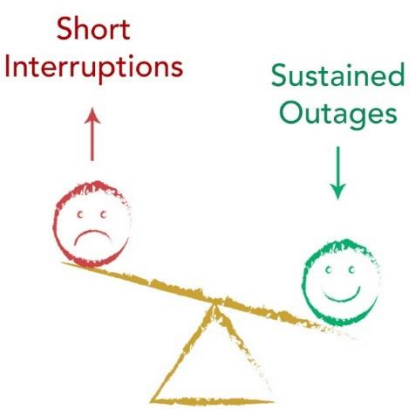


System response to transient faults…
…using Spur Reclosing

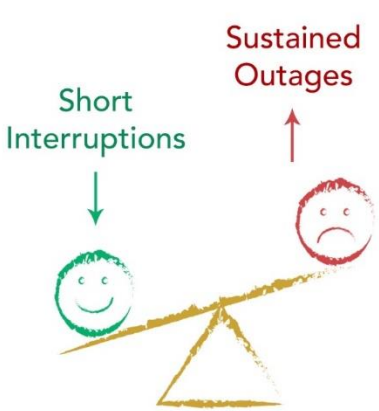


Short Interruptions limited to spur only!

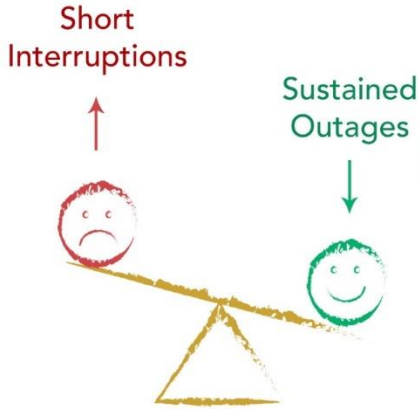
Fuse Saving



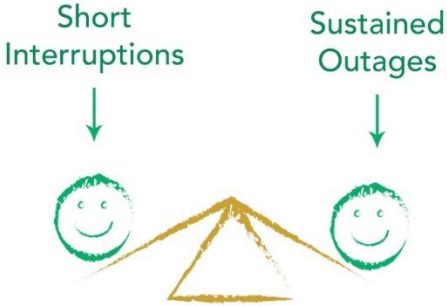
Fuse Blowing



Auto Sectionalising Link



Spur Reclosing



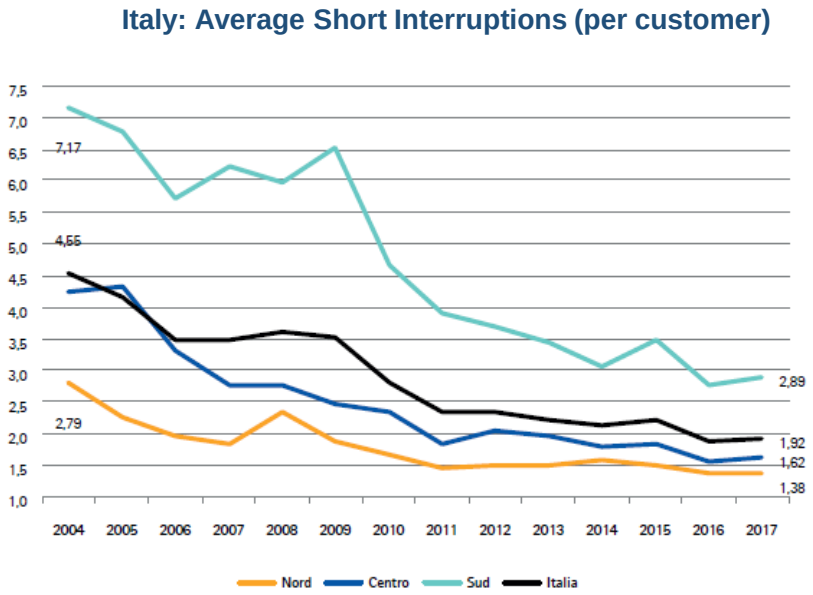
What are people's thoughts on these slides in terms of benefits and its implementability?

What is the rest of the world doing (S&C)

- Many state Public Utility Commissions are using the % of Customers Experiencing more than x Multiple Interruptions (CEMI-X) for worst-served performance
- Some US utilities have now starting monitoring and reporting the % of Customers Experiencing more than x Multiple Momentaries as another key measure (CEMM-X)
  - Driver for investment, measure use in regulatory filings (price control submissions)

Examples from the rest of the world

- Incentives are already in place for reduction short interruptions in Victoria (Australia), Norway, Finland and Italy
- Since financial incentives were introduced on short interruptions in Italy in 2008 there has been a 46% reduction in the average number of short interruptions each year



So what are the options for ED2? (SPEN)

- In RIIO-ED1, restoring supplies quickly following an interruption has been prioritised.
- In RIIO-ED2, networks could also pursue improvements in underlying network resilience to prevent the absolute occurrence of interruptions.
- **Resilience Metric Development**
  - Overall interruption performance (including SIs) could provide a measure of underlying network resilience.
  - Short Interruptions (SIs) should remain a separately reported metric, with improved reporting and/or a separate incentive/accountability.
  - The existing CI/CML framework can be maintained.

The existing CI measure has improved QoS. Further benefits can be achieved through improving asset resilience.

So what are the options for ED2?

Resilience – Multiple Short Interruptions

- Two sub-3 minutes faults may be of greater customer cost than a 6 minute interruption.
- Preventing multiple short interruptions may be of greater materiality to customers than tightening the 3-minute threshold.
- Incentivising underlying resilience guards against automation being deployed where other solutions e.g. undergrounding, modernisation, tree-cutting is of greater customer benefit.

MSI Metric Development

- An additional metric could be used to track MSIs without polluting existing metrics.
- This could be introduced as a reputational measure in RIIO-ED2, without an incentive, to ensure DNOs accurately capture data and avoid unintended incentive consequences.
- Alternatively it could be introduced as a standard of performance or an incentive following baselining of data for the remainder of ED1

A reputational MSI measure enables tracking of underlying network resilience without unintended consequences.

So what are the options for ED2?

- **3 Minute SI Threshold**
  - The 3 minute threshold was introduced to allow transient faults to clear, and for automation switching cycles, and control room switching to be completed safely.
  - **Potential Effects of Reducing Threshold**
    - ✓ Average duration of customers short interruptions would reduce.
    - Reduction in overall number of interruptions is not incentivised.
    - National protection setting adjustments would increase short-term costs.
    - Automation not adopted where sub-3 minutes in not possible.
    - Consistency with historic performance is corrupted.
  - Customer supply is impacted irrespective of a 2 minute or 3 minute boundary, avoiding interruptions may be more meaningful than tweaking the threshold.

Is it appropriate to incentivise a reduction in *duration* OR in *occurrence* of SIs

So what are the options for ED2?

- **Changes should only be made to deliver what customers value.**
  Do customers value increased network resilience, fewer interruptions, shorter duration 'SIs'?
- Any measure should take account of:
  - **Consistency:** A new mechanism must ensure that reporting is consistent.
  - **Absolute Performance**: Ability to make deep improvements is diminished year-on-year.
  - **Network Topography:** OHL networks have more interruptions than mixed & cable networks, and greater ability to make improvements.
  - **Customer Inconvenience:** Consider customers who frequently experience poor performance e.g. multiple short interruptions similar to Worst Served Customer metric.
- Now is the time to conduct WTP for ED2

Important that any measure has a consistently defined set of rules before baselining and target setting.

Lunch

Worst Served Customers

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Evaluation of Interruptions Incentive Scheme – initial findings

Description

Martin Campbell and Augustin Lorne
18 February 2020

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Contents

- Objectives, Theory of Change and method
- Initial findings – data, econometric and qualitative analysis
- Lessons learned for ED2

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Aims of the evaluation

1. How have DNOs performed against unplanned interruptions targets and to what extent has performance varied across DNOs?
2. To what extent have improvement factors driven performance improvements?
3. To what extent did the use of the value of VoLL from RIIO-T1's 'energy-not-supplied' incentive drive performance improvements in IIS? To what extent can it explain DNOs' rewards obtained in RIIO-ED1?
4. How have DNOs achieved performance against target?
5. What would have happened to number and length of interruptions without IIS? (counterfactual)

Summary of our findings

1. Overall IIS has successfully reduced CIs and CMLs - improving overall network reliability
2. No evidence that DNOs with comparatively stringent targets have responded more than those with less stringent targets
3. Customers have been generally well served by IIS – but some are not
4. Marginal cost of improvement possibly becoming too high – improvements seem to be bottoming out

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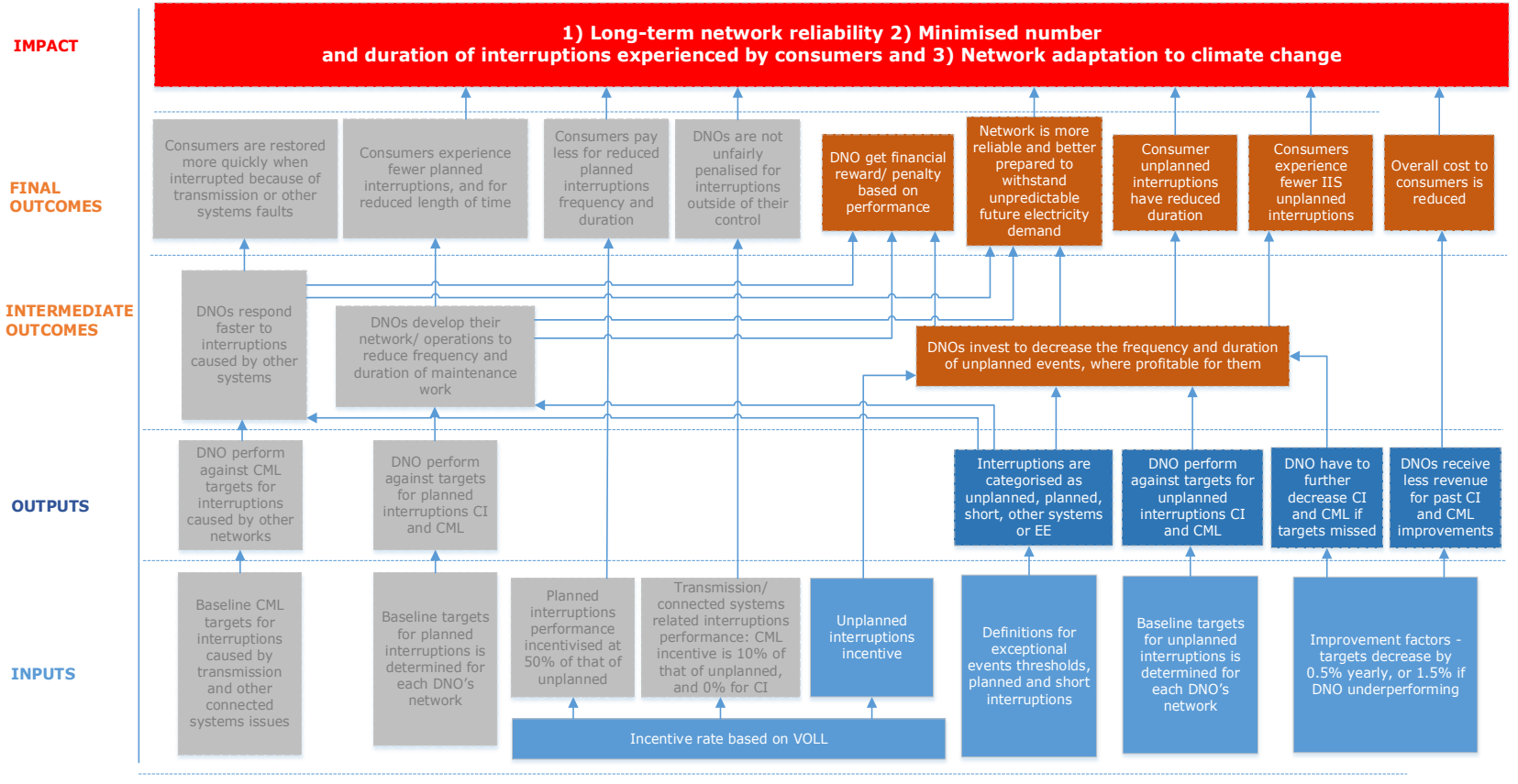
Our Theory of Change



Assumptions

- The VOLL used for the scheme accurately reflects GB consumers' valuation of continuity of supply
- DNOs can't predict unplanned interruptions 48h in advance
- RIIO ED1 allowed revenue does not cover investments with expected improvements in interruptions performance greater than the set baseline targets
- The exceptional events definition and threshold capture events which are outside of DNOs' control
- DNOs do not refrain from making performance improvements to benefit from easier targets in ED2
- It is not cost-efficient for consumers for Ofgem to incentivise reduction in frequency of interruptions below 3min

ISSUE IIS ADDRESSES: DNOs have the incentive to reduce costs at the expense of quality of service in the price control

KEY:
EE = Exceptional Events
DNO = Distribution Network Operator
CI = Customer Interruption
CML = Customer Minutes Lost
WTP = Willingness To Pay
VOLL = Value Of Lost Load

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Method

Econometric modelling and database development

- **Main model** – has increase in incentive rate and decrease in target levels led to CI and CML performance improvements in ED1? We use the differences in how these incentive and target levels have changed across DNOs between DPCR5 and the IIS to distinguish between the effect of incentives and targets on performance separately.

- **Second model** – has IIS led to 1) a sudden improvement in performance upon introduction of the new ED1 scheme and/or 2) continuous performance improvements thorough the scheme – compared to DPCR5.

Consultations

- **DNOs**: ENWL, NPg, SPEN, SSEN, UKPN, WPD, Centrica
- **Academics/stakeholders:** Keith Bell, Professor of Electrical Engineering and Caroline Farquar, Senior Policy Researcher, Citizens Advice
- **Ofgem:** Steve McMahon, Jack Ambler, Mark Hogan

Peer review

Tooraj Jamasb, CBS Endowed Professor of Energy Economics at Copenhagen School of Energy Infrastructure – reviewed econometric modelling

Target and baseline process

Theory of Change - inputs

- Target setting process and targets themselves were good based on knowledge at the time. Advanced notice gave DNOs investment certainty and allowed them to plan.
- Some suggestions that DNOs' position was not as well reflected as it might have been. Past historical performance over 4 years used for HV and LV, longer for EHV and 132kV (10 years), and longer timeframe for all may have been more appropriate to reflect the different positions of the DNOs
- Also a sense that targets could have been more bespoke to each DNO rather than an average – could have tried to make targets more varied depending on historical performance and future trajectory of each DNO – some had challenging targets whilst others did not - important lesson for ED2 about moving to targets that change every year.

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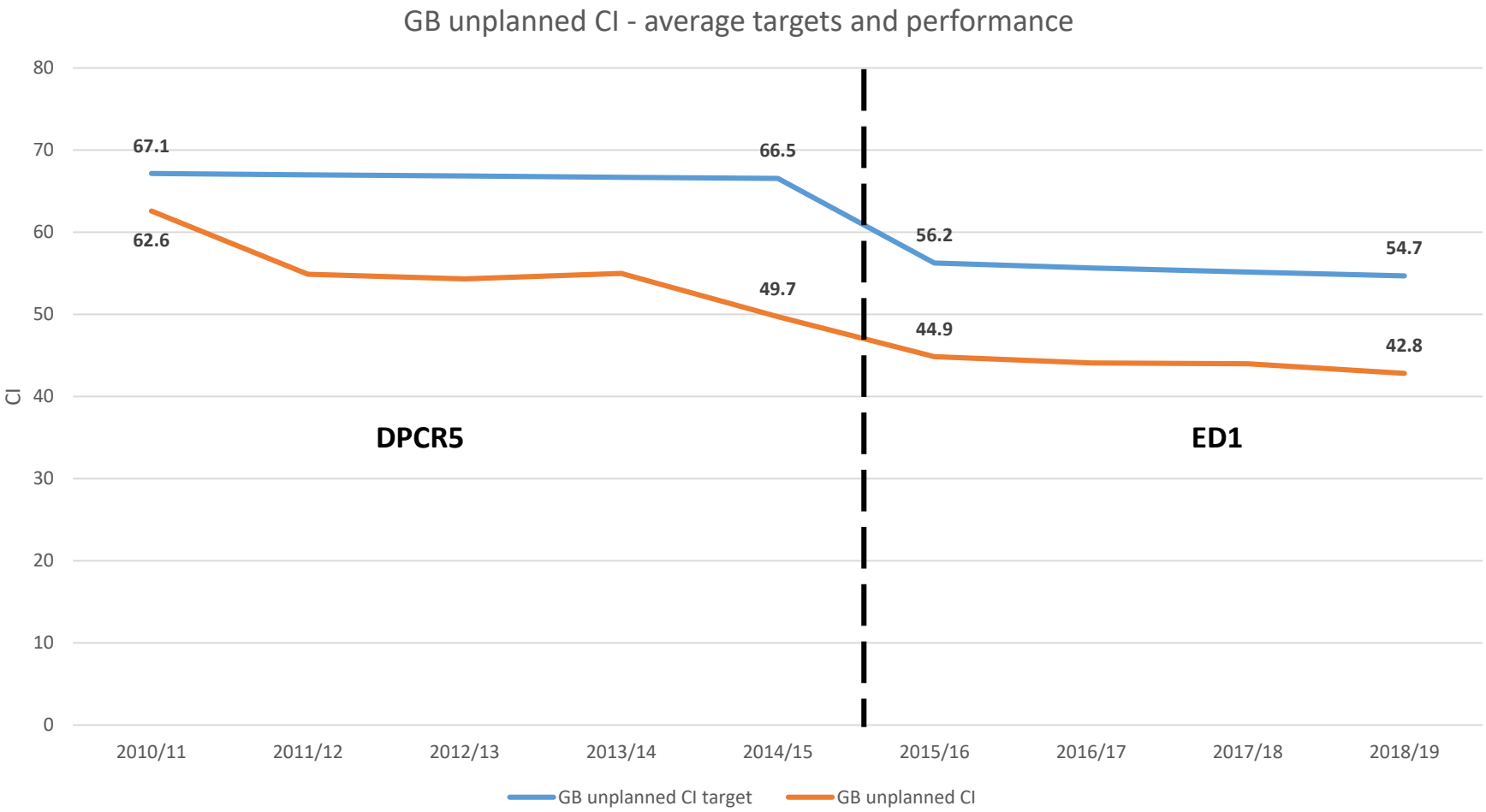
Performance against targets

Theory of Change – final outcomes – customers experience fewer unplanned interruptions & are of reduced duration

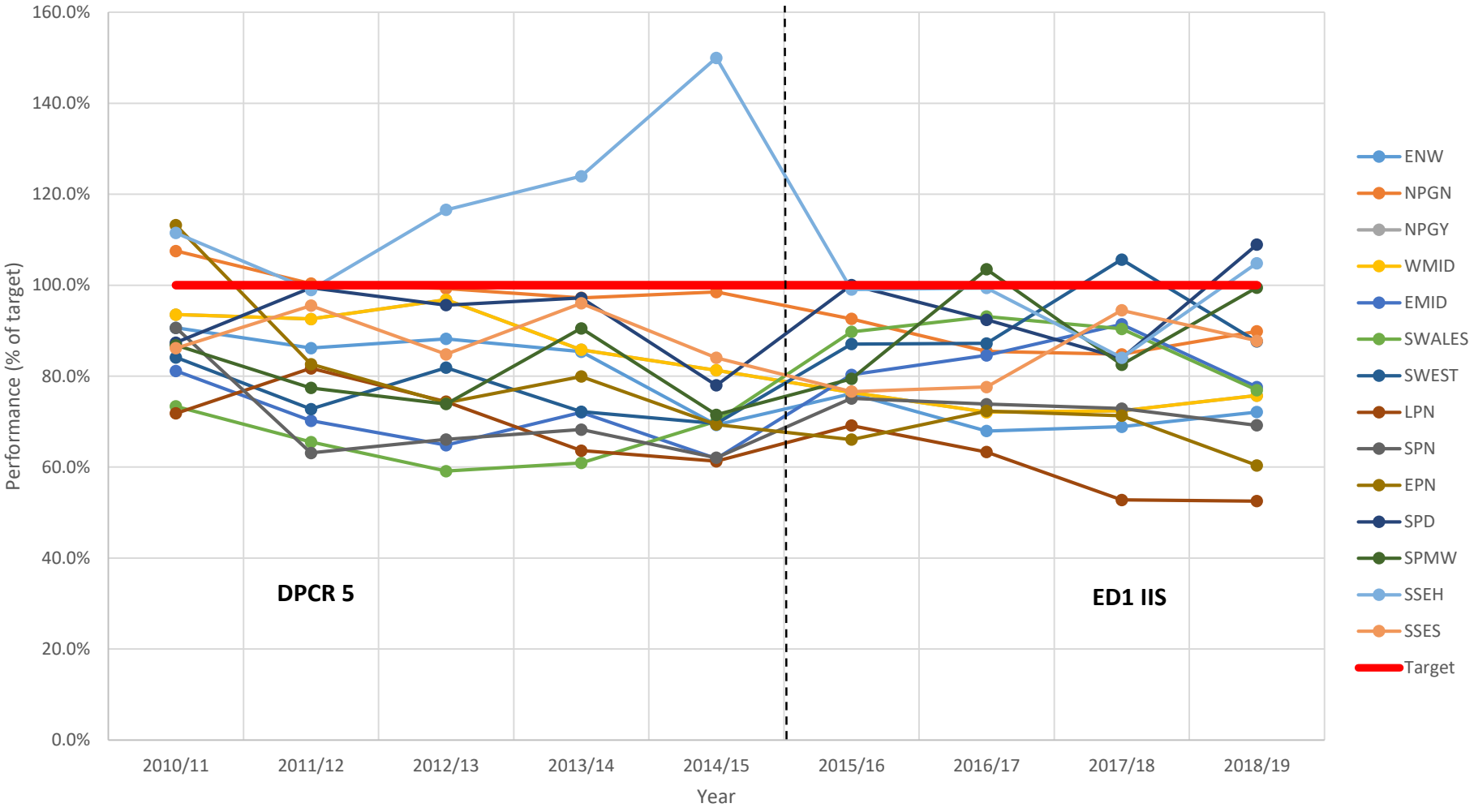
Big improvement between DPCR5 and RIIO-ED1 on both CI and CML – however rate of improvement has slowed markedly in ED1

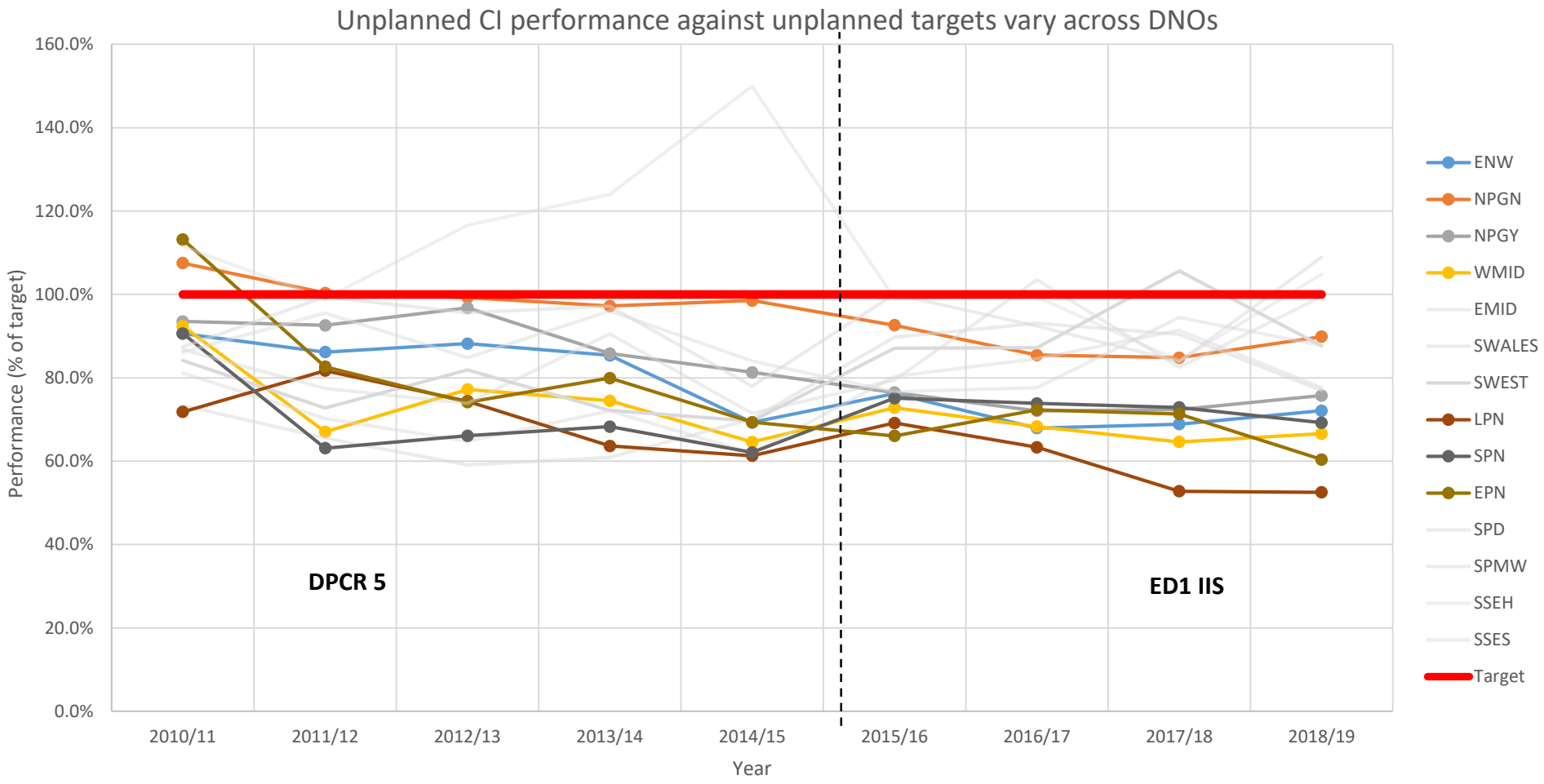
Some variation amongst DNOs – though majority of them have performed much better than targets

Data shows extent of change

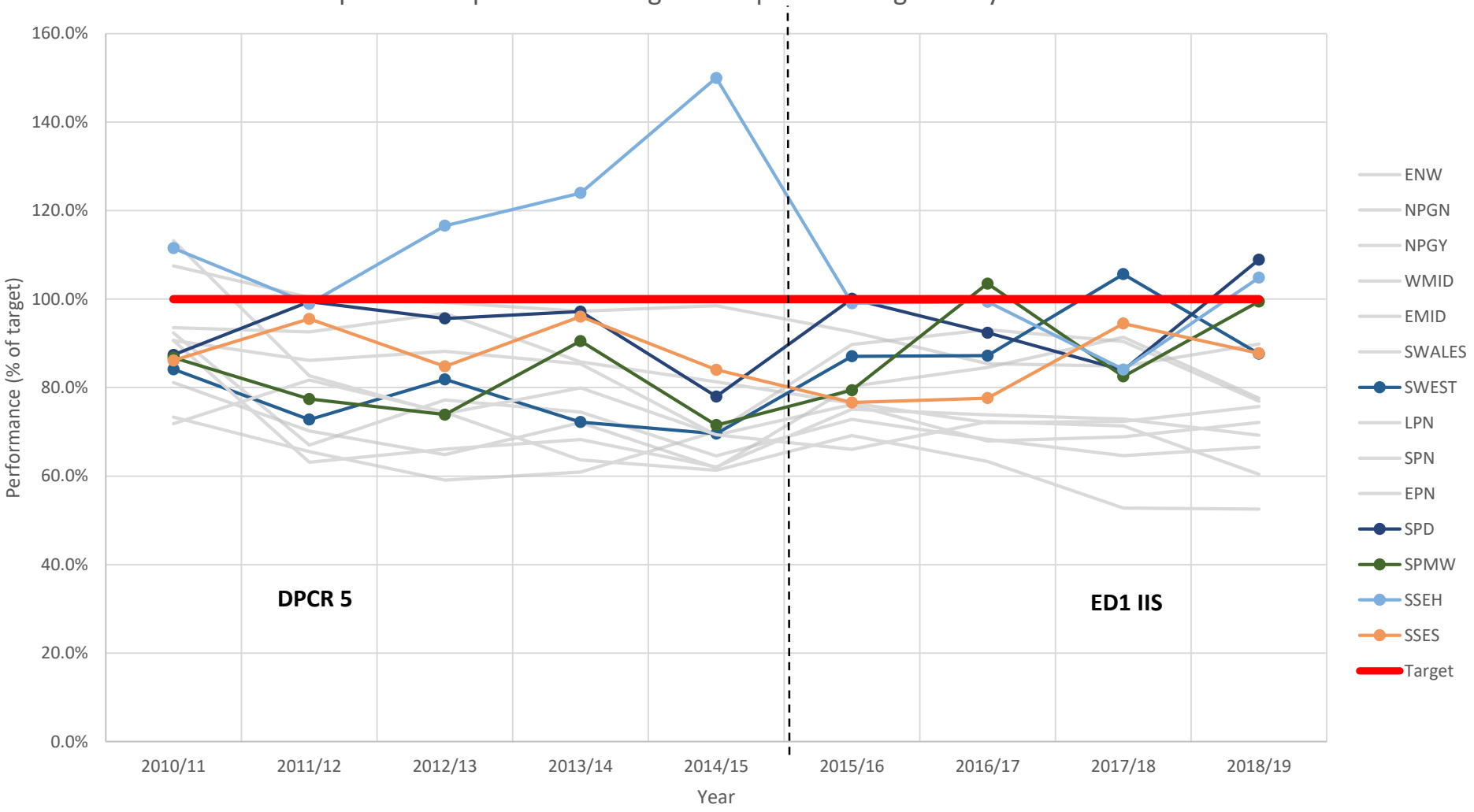

GB unplanned CI - average targets and performance
80
70
60
50
40
30
20
10
0
CI
67.1
66.5
56.2
54.7
62.6
49.7
44.9
42.8
DPCR5
ED1
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18
2018/19
GB unplanned CI target
GB unplanned CI

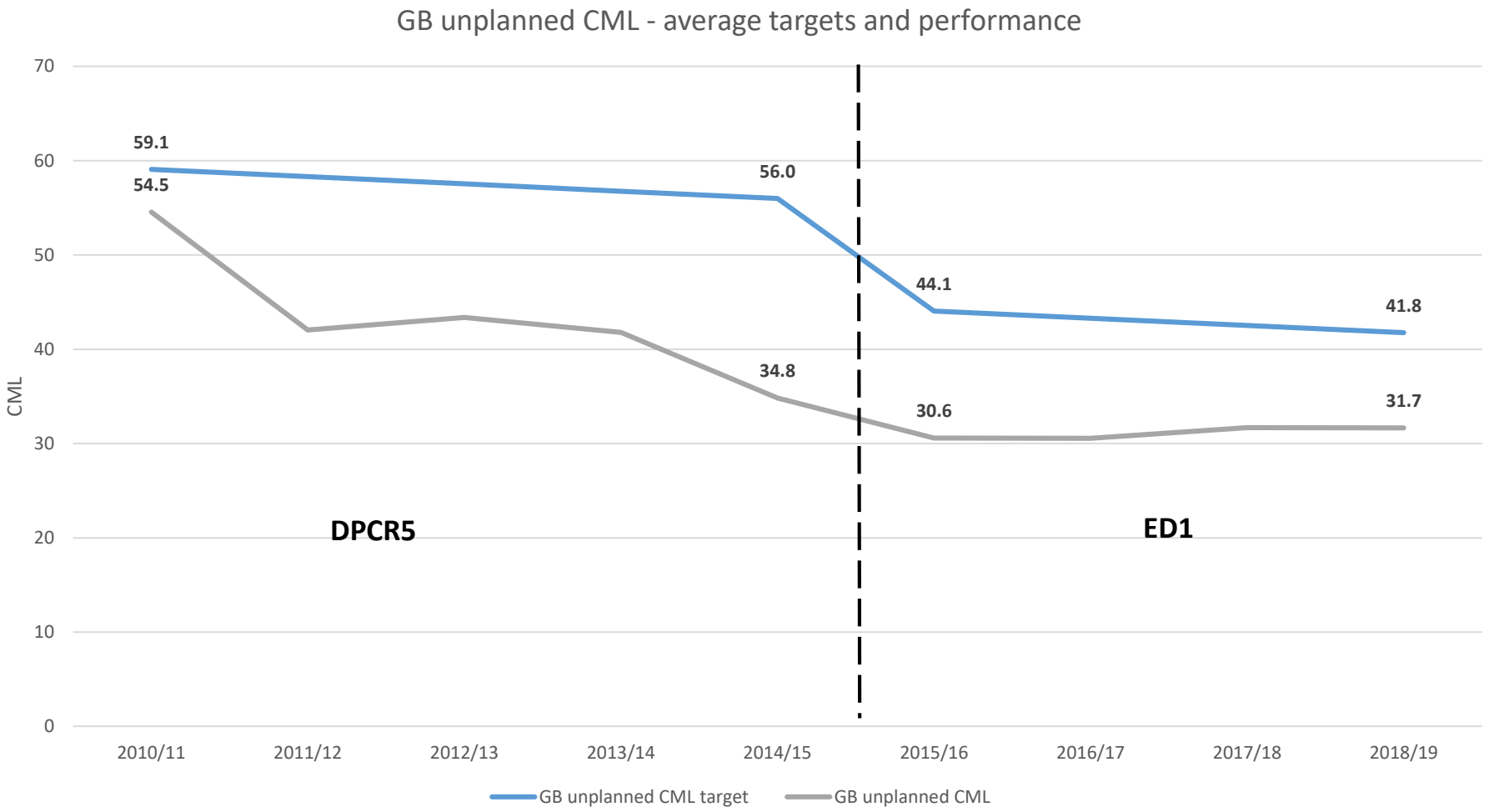
Unplanned CI performance against unplanned targets vary across DNOs



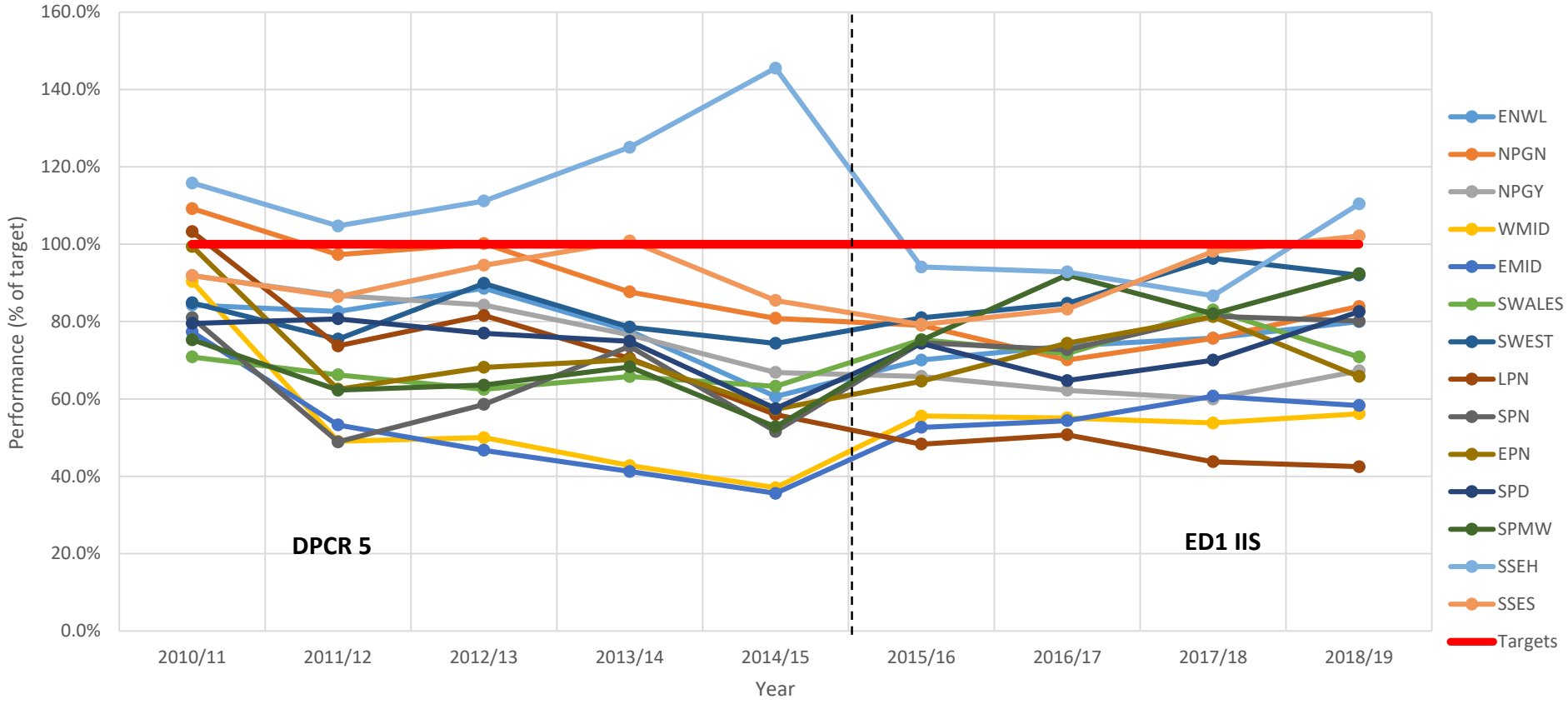

Unplanned CI performance against unplanned targets vary across DNOs
160.0%
140.0%
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Performance (% of target)
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18
2018/19
Year
DPCR 5
ED1 IIS
ENW
NPGN
NPGY
WMID
EMID
SWALES
SWEST
LPN
SPN
EPN
SPD
SPMW
SSEH
SSES
Target

Unplanned CI performance against unplanned targets vary across DNOs

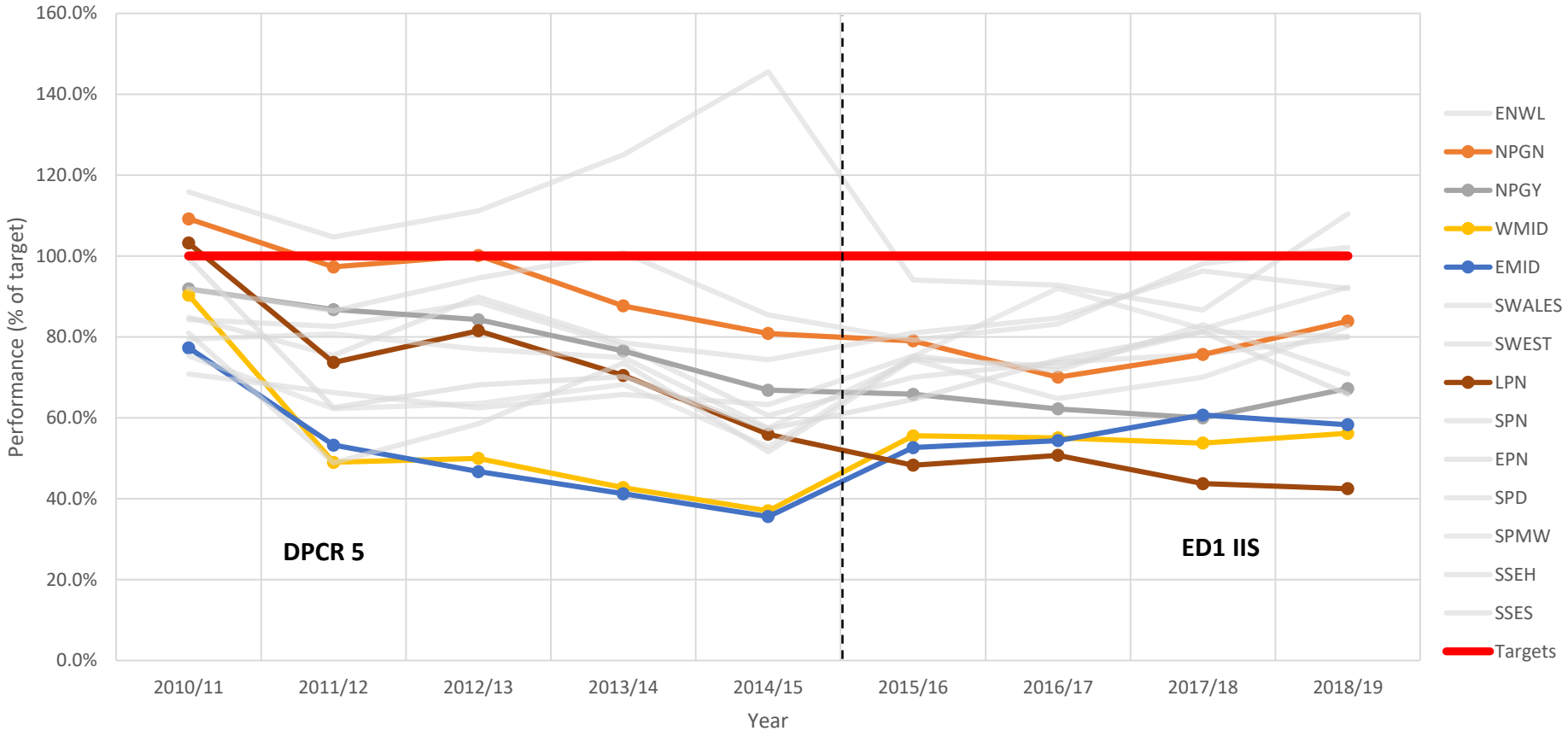



GB unplanned CML - average targets and performance
CML
70
60
50
40
30
20
10
0
59.1
54.5
56.0
44.1
41.8
34.8
30.6
31.7
DPCR5
ED1
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18
2018/19
GB unplanned CML target
GB unplanned CML

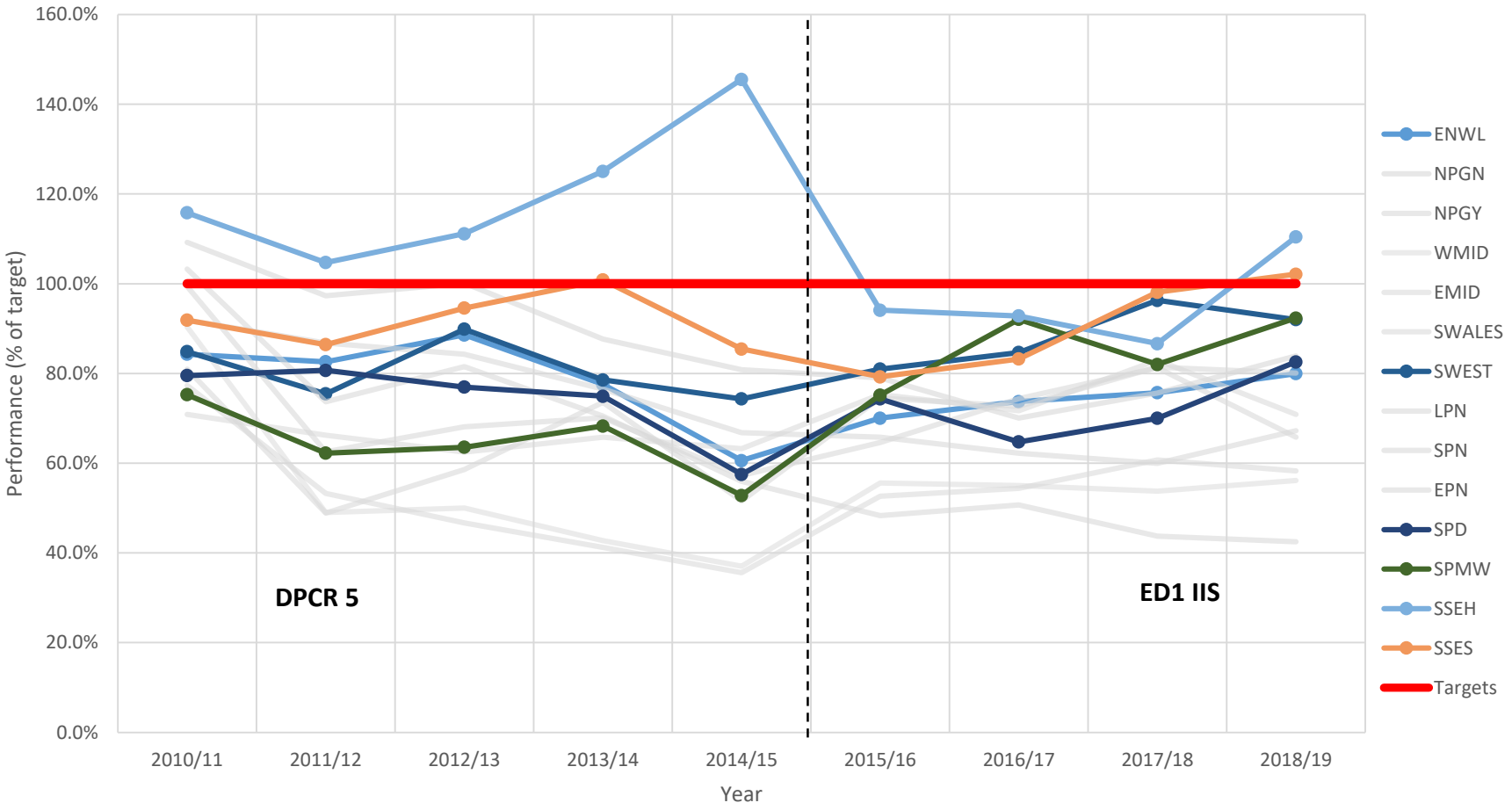
Unplanned CML performance against unplanned targets vary across DNOs



Unplanned CML performance against unplanned targets vary across DNOs



Unplanned CML performance against unplanned targets vary across DNOs



Econometric analysis - aims

The aims of the econometric analysis were to find out:

1. if, and to what extent, the ED1 IIS successfully reduced frequency and duration of unplanned interruptions; and
2. the effect of adjusting target levels on reducing the frequency and duration of unplanned interruptions.

Why use econometrics?

- To add robustness to the insights found in the graphs
  - We have controlled performance improvements by factors which impact all DNOs on a given year, and DNO inherent characteristics which remain constant over time
- To single out the effect of targets on performance separately

Econometric analysis – Results

What are our main results?

1. **The IIS has caused sudden improvements in CI and CML at the start of ED1**

2. **The ED1 IIS has not caused the same degree of continuous improvements in either CI or CM**L across the scheme, while it was the case for DPCR5 IIS
   - This could be explained by the investment strategies of DNOs to deliver the bulk of improvements in performance at the start of the scheme, or marginal cost of improvements increasing

3. **We do not find evidence that more stringent target adjustments in ED1 for some DNOs compared to others has led to them delivering greater comparative improvements in performance.**

4. **Year-on-year improvements have been slowing down since 2010, for CI more than for CML**.

Drivers of performance – DNO response strategies

Theory of Change – intermediate outcomes – DNOs invest to decrease frequency and duration of unplanned interruptions where profitable for them

Some investment in fault prevention – checking strength and weaknesses of lines and prioritising those that may fail first

Heavy investment in automation – for example switchgear and auto reclosers - resectioning network and remote control

Operational changes – recruiting more engineers to fix faults, and positioning them closer to areas of likely faults to reduce response times

Important to remember that networks are very different and solutions are not always completely transferrable eg rural networks more likely to need operational response, urban can use more automation to resolve faults (more parts of the network to switch to).

Exceptional events

Theory of Change Assumption – exc. events definition & threshold capture events outwith DNOs' control

Important to have an exceptional events process - however criticisms of length and transparency of process – one comment that there should be 'peer review' of process to see if improvements could be made

Threshold can be frustrating – if DNOs are just under the threshold for an EE – where to draw the line

Unintended consequence – in EE DNOs with additional resources send them to DNO experiencing the EE. The EE DNO may get an EE exemption, preserving their revenue, but DNO that provides the resources gets no recompense. Disincentives DNOs from providing these resources

What have customers experienced?

Theory of Change - final outcomes – consumers experience fewer and shorter unplanned interruptions

No doubt that rural customers are affected most by interruptions, though overall satisfaction remains high - feature of IIS – DNOs "chase the average"

Worst Served Customer mechanism exists but does not work well. Requirements are too onerous (customers can drop in and out of eligibility depending) and process is inflexible (cap on £ per customer than can be invested). DNOs do not want to commit money to make these improvements if:

- Eligibility is not guaranteed from one year to the next
- Same £ could be spent on another part of the network that would benefit more consumers
- But some sense that DNOs could be pushed harder to spend this money

Can IIS deliver further improvements?

Theory of Change – Assumptions
1) VoLL used accurately reflects GB consumers valuation of continuity of supply
2) not cost effective for consumers for Ofgem to incentivise reduction in interruptions below 3 min

Overall consensus is that there is no real room for further improvement on CIs. Investment required would not stack up under current regime – however investments made at the start of price control

Some think customers would value reduction in 3 minute restoration time – though acknowledgement it is an evidence gap. Possibly bigger question is should we be striving to eliminate interruptions altogether given increased future electrification of economy & society

Possibly further to go on CMLs – average time to get back on supply could probably go down more

However costs may reduce in future, particularly on tech and if further innovations come through

Conclusions

Theory of Change – impact

- IIS has met its aims – network reliability is improved
- There is rightly a focus on revenue earned and target setting should be reviewed (costs to consumers) but needs to be balanced by societal and economic benefit of having fewer long interruptions on the network
- Investments made at start of price control maximise benefit over price control period – improvement bottomed out quickly
- Conflicting views as to whether there are further improvements to be made – some sense that IIS has further to go on CML, others feel improvements are bottoming out given current incentive rates.
- Is not incentivising getting to zero interruptions – but is any benefit worth the investment

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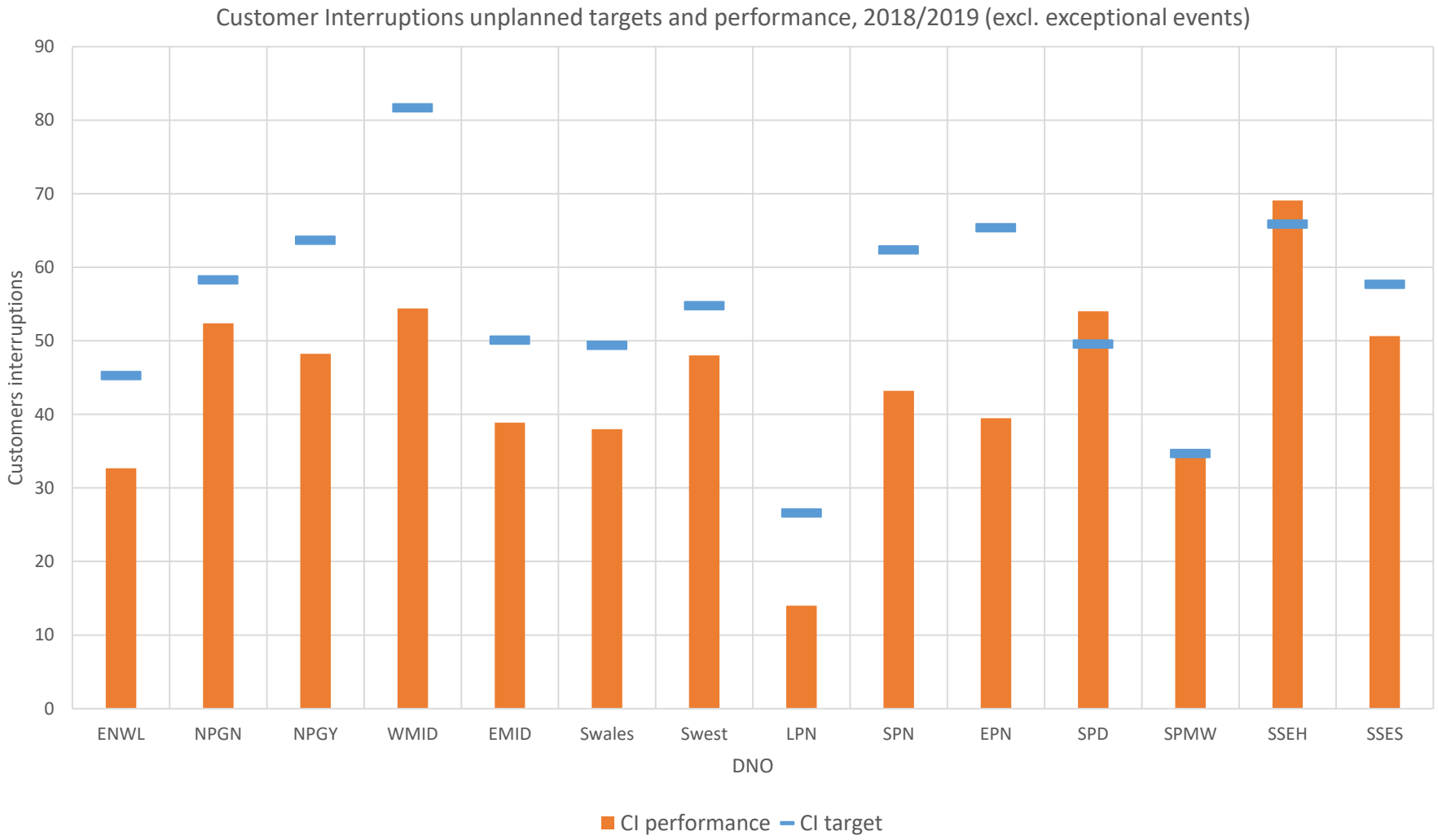
Lessons learned

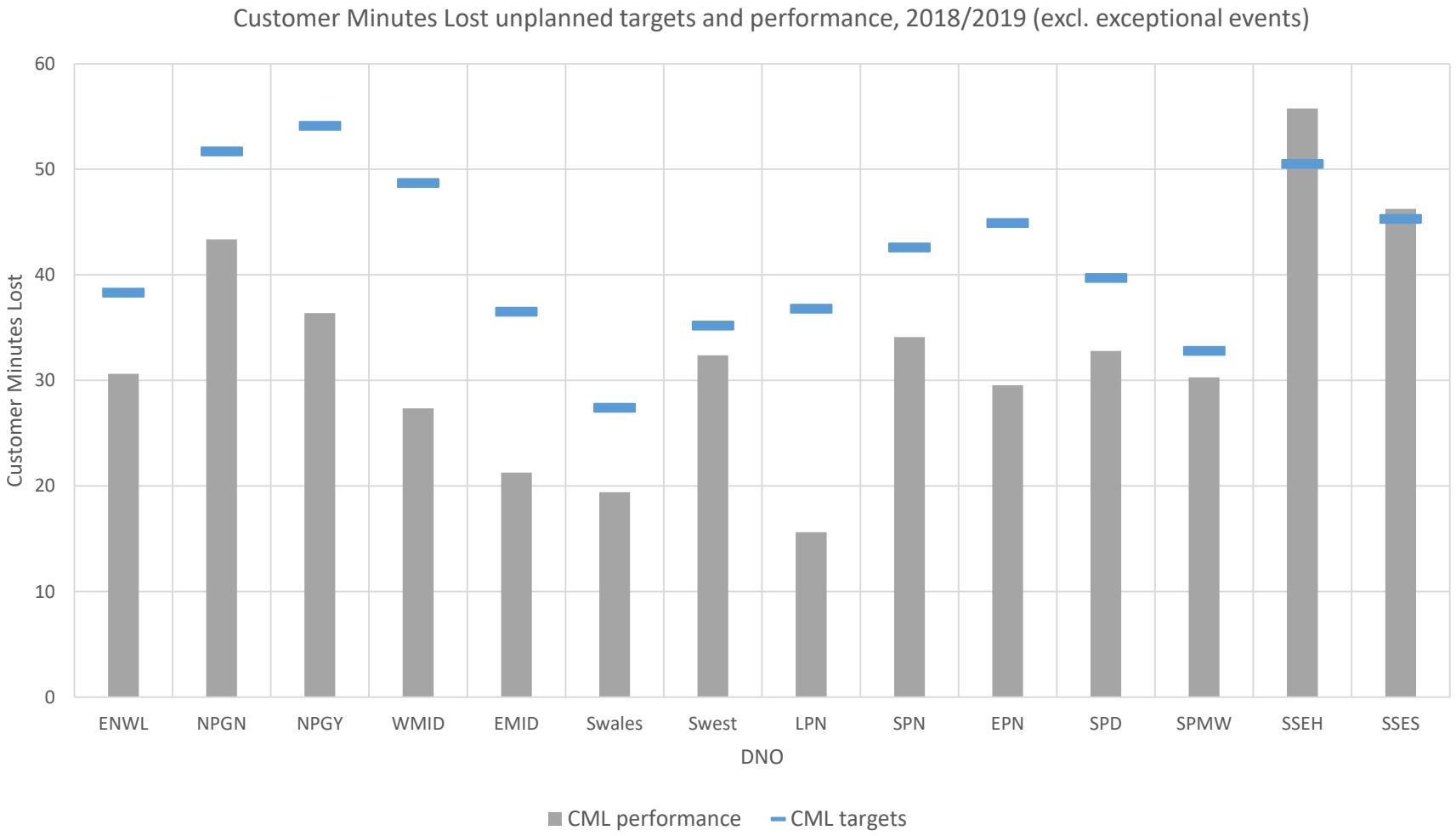
1. Targets based on historical performance can drive future performance but at the expense of flexibility – specific targets taking into account the starting position of those being set the target could help drive further improvements

2. Consider incentivising DNOs to eliminate interruptions – no sense that cost to reduce below 3 mins would deliver extra consumer value

3. Data quality is important to identify unintended consequences – length of short interruptions and DNOs' response – clustering around 2 mins 59 secs?

Annex


Customer Interruptions unplanned targets and performance, 2018/2019 (excl. exceptional events)
Customers interruptions
90
80
70
60
50
40
30
20
10
0
ENWL
NPGN
NPGY
WMID
EMID
Swales
Swest
LPN
SPN
EPN
SPD
SPMW
SSEH
SSES
DNO
CI performance
CI target


Customer Minutes Lost unplanned targets and performance, 2018/2019 (excl. exceptional events)
Customer Minutes Lost
60
50
40
30
20
10
0
ENWL
NPGN
NPGY
WMID
EMID
Swales
Swest
LPN
SPN
EPN
SPD
SPMW
SSEH
SSES
DNO
CML performance
CML targets

Econometric analysis - methodology

What did we do?

- We ran **fixed-effect regressions** to better isolate the effect of the IIS, with 2 econometric models:
  - One trying to **assess the overall effect of the IIS** on performance
    - We tested whether we saw a significant **'step change'** in CI and CML performance when the IIS was introduced
    - We also tested to see if significant **continuous improvements** were seen during the IIS compared to DPCR5
  - One trying to **single out the effect of target levels** on performance
    - For this, we used the difference in how DNOs were treated in the IIS
      - Targets changed to a different degree for DNOs
        - So we used the difference of target levels across DNOs in the difference across time as the source of variability for our analysis
      - This allowed to see if DNOs which had a bigger adjustment in targets compared to DPCR5 had improved their performance significantly
- For more robustness we used 2 datasets:
  - **Yearly data** from the ED1 team
  - We constructed a **weekly-interruptions performance database** to have a more granular account of performance (from stage data)

Econometric analysis - methodology

What were our model specifications?

$$Interruption\ performance_{i,t} = \beta_0 + \beta_1 Target_{i,t} + \beta_2 Incentive_{i,t} + \beta_{(3,\dots,11)} DummyYears_{i,t} + \beta_{(12,\dots,25)} Dummy\ DNOs_{i,t} + \beta_{(25,\dots,36)} Dummy\ MONTHS_{i,t} + u_{i,t}$$

$$In\ terruption\ Performance_{i,t} = \beta_0 + \beta_1 DummyIIS_{i,t} + \beta_2 DPCR5TREND_{i,t} + \beta_3 IISTREND_{i,t} + \beta_{(4,\dots,17)} DummyDNOs_{i,t} + \beta_{(18,\dots,29)} Dummy\ MONTHS_{i,t} + u_{i,t}$$

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Results – year-on-year improvements

Model 2 - CI performance

	(1) ci_w	(2) ci_w	(3) ci_y
	FE	FE	FE
iis_dummy	-16.19*** (0.000)	-16.33*** (0.000)	-20.07*** (0.000)
dpcr5trend	-0.0429*** (0.002)	-0.0421*** (0.002)	-0.0615*** (0.000)
iistrend	0.0275** (0.013)	0.0296** (0.011)	0.00777 (0.304)
Monthly dummies	No	Yes	No
DNO FE	Yes	Yes	Yes
Year FE	No	No	No
Constant	57.01*** (0.000)	60.11*** (0.000)	45.93*** (0.000)
Observations	6422	6422	126
R^2	0.163	0.184	0.819

Model 2 - CML performance

	(1) cml_w	(2) cml_w	(3) cml_y
	FE	FE	FE
iis_dummy	-22.88*** (0.000)	-23.01*** (0.000)	-13.77*** (0.000)
dpcr5trend	-0.0643*** (0.000)	-0.0683*** (0.000)	-0.0408*** (0.003)
iistrend	0.0441*** (0.000)	0.0403*** (0.000)	-0.0131 (0.138)
Monthly dummies	No	Yes	No
DNO FE	Yes	Yes	Yes
Year FE	No	No	No
Constant	40.36*** (0.000)	41.16*** (0.000)	57.42*** (0.000)
Observations	6422	6422	126
R^2	0.180	0.208	0.872

Results – incentives and target effects

CML log model - updated with unplanned targets

	(1) lncml_y	(2) lncml_y	(3) lncml_y	(4) lncml_y
lncml_unpltarget	**0.855*** **	**0.549*** **	**-0.00472**	**0.00505**
	(0.000)	**(0.000)**	**(0.983)**	**(0.984)**
DNO FE	No	Yes	Yes	Yes
Years FE	No	No	Yes	Yes
lncml_incentive				0.0447
				(0.852)
Constant	0.466	1.673***	4.028***	4.026***
	(0.191)	(0.001)	(0.001)	(0.001)
Observations	126	126	126	126
R^2	0.418	0.893	0.927	0.927

p-values in parentheses
Notes
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

CI log model - updated with unplanned targets

	(1) lnci_y	(2) lnci_y	(3) lnci_y	(4) lnci_y
lnci_unpltarget	**0.533*** **	**1.157*** **	**-0.105**	**-0.140**
	(0.000)	**(0.001)**	**(0.636)**	**(0.522)**
DNO FE	No	Yes	Yes	Yes
Years FE	No	No	Yes	Yes
lnci_incentive				0.201***
				(0.000)
Constant	1.227***	-1.621	3.969***	4.539***
	(0.003)	(0.190)	(0.001)	(0.000)
Observations	126	126	126	126
R^2	0.187	0.756	0.885	0.891

p-values in parentheses
Notes
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results – year-on-year improvements

CML model - difference model years

	(1) cml_y_yeardiff	(2) cml_y_yeardiff	(3) cml_y_yeardiff	(4) cml_y_yeardiff
cml_y_2010diff	**0.198*** (0.000)**	**0.289** (0.035)**	**0.759*** (0.000)**	**0.900*** (0.000)**
DNO FE	No	Yes	Yes	Yes
Years FE	No	No	Yes	Yes
cml_unpltarget				-0.255** (0.044)
cml_incentive				14.72*** (0.005)
Constant	0.292 (0.713)	1.221 (0.426)	-1.546 (0.614)	7.038 (0.323)
Observations	112	112	112	112
R^2	0.126	0.138	0.441	0.525

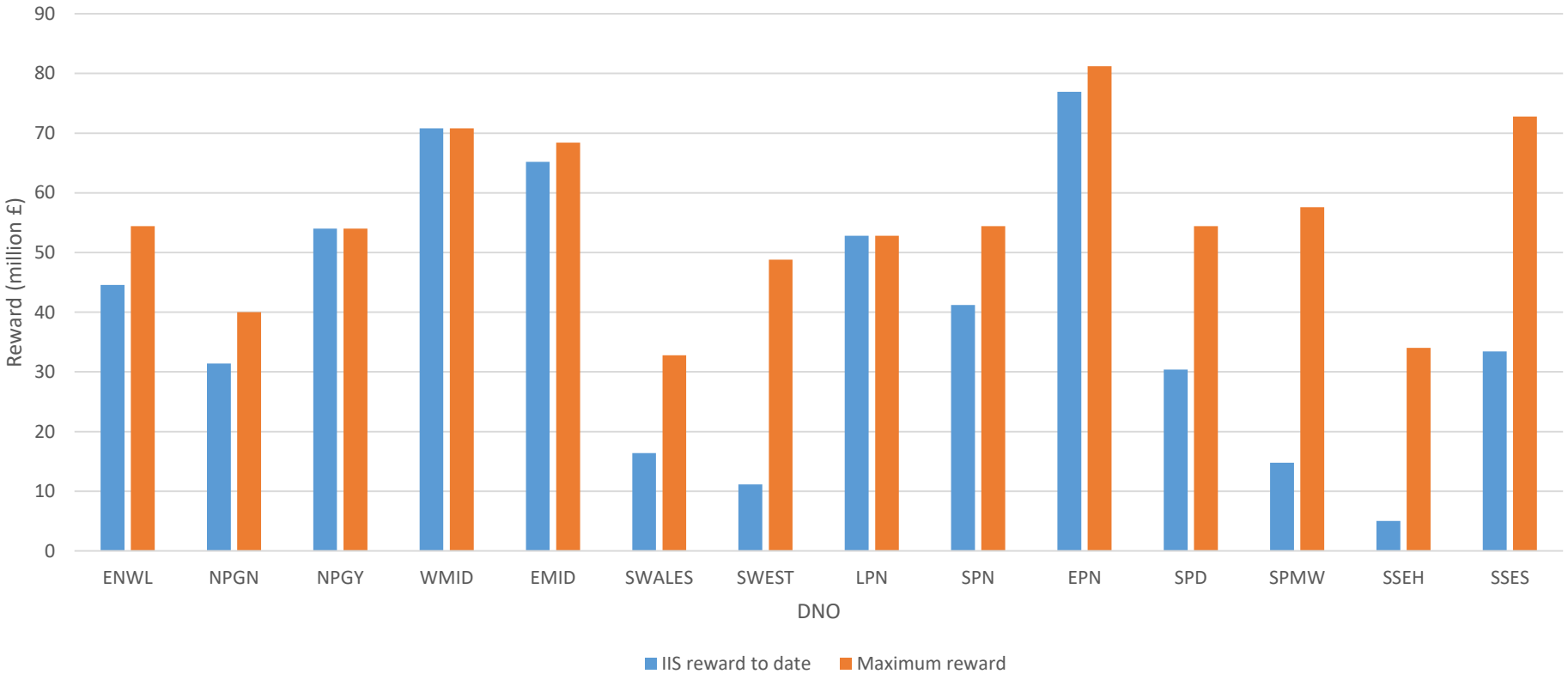
p-values in parentheses
Notes
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

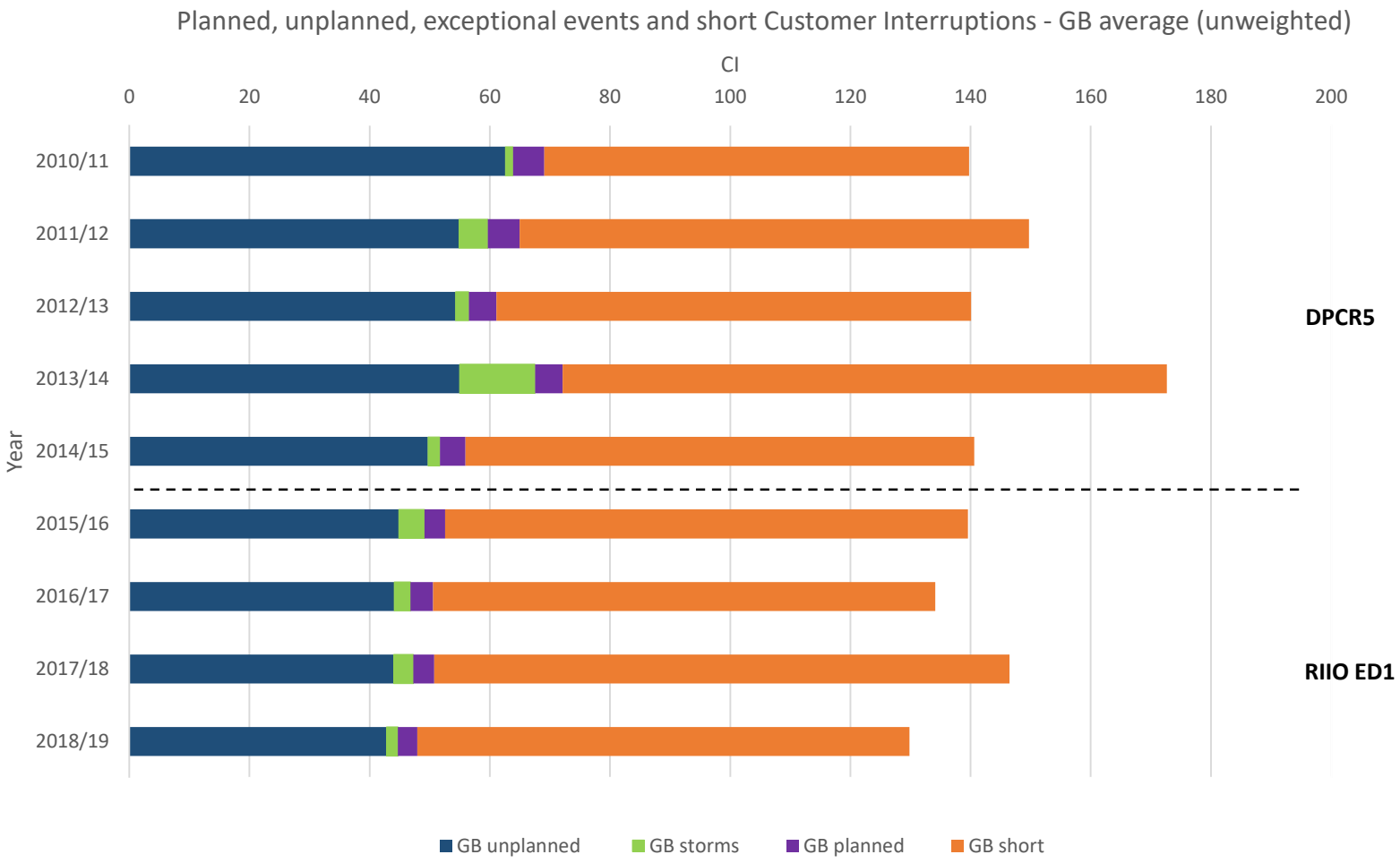
CI model - difference model years

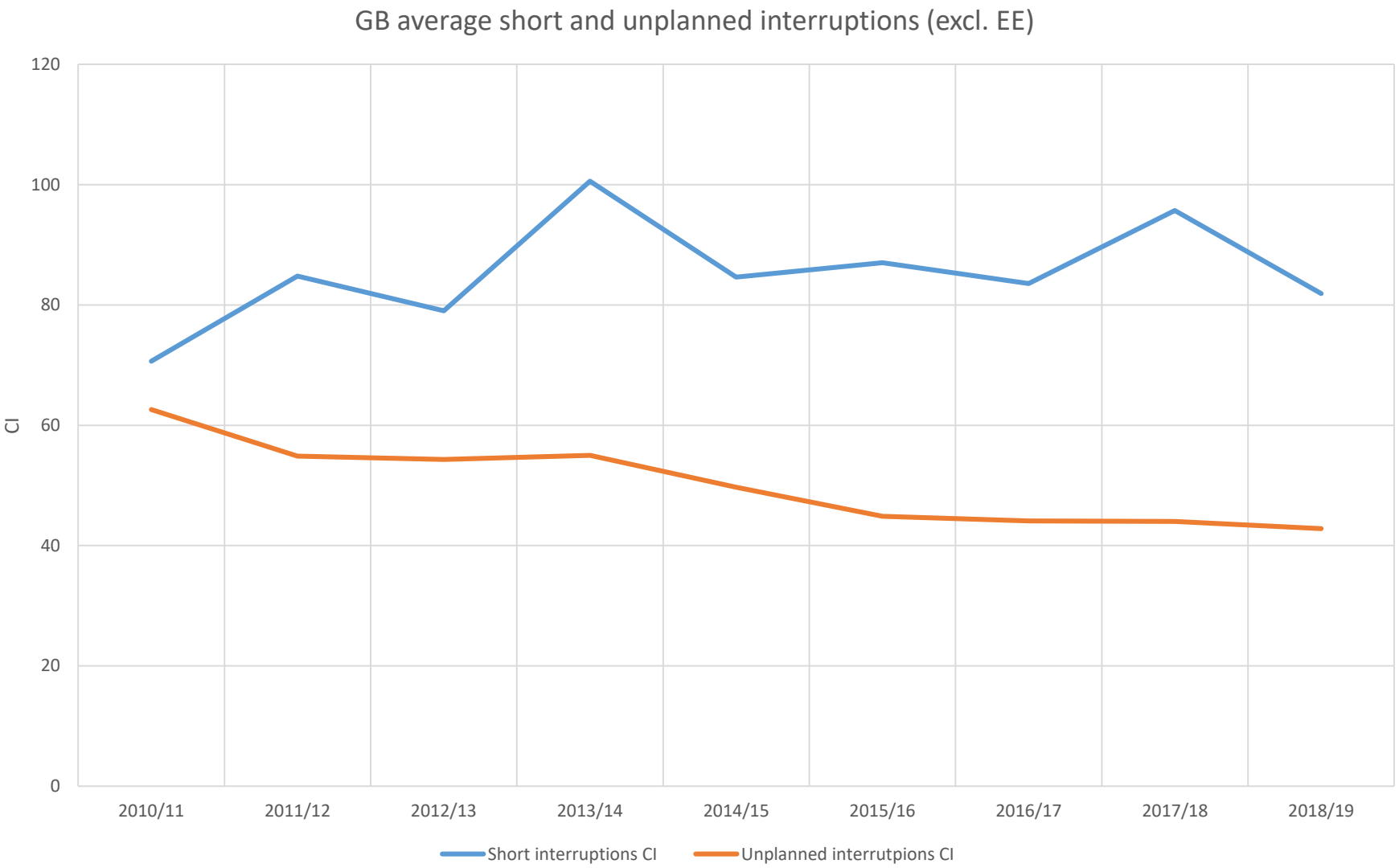
	(1) ci_y_yeardiff	(2) ci_y_yeardiff	(3) ci_y_yeardiff	(4) ci_y_yeardiff
ci_y_2010diff	**0.152*** (0.009)**	**0.155 (0.239)**	**0.578*** (0.002)**	**0.591*** (0.001)**
DNO FE	No	Yes	Yes	Yes
Years FE	No	No	Yes	Yes
ci_unpltarget				**0.0505 (0.760)**
ci_incentive				18.19 (0.116)
Constant	0.0896 (0.933)	0.264 (0.913)	9.007*** (0.002)	2.977 (0.800)
Observations	112	112	112	112
R^2	0.061	0.063	0.562	0.577

p-values in parentheses
Notes
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To date, some DNOs have reached their maximum reward available with the first 4 years of the IIS




Planned, unplanned, exceptional events and short Customer Interruptions - GB average (unweighted)
CI
0
20
40
60
80
100
120
140
160
180
200
Year
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18
2018/19
DPCR5
RIIO ED1
GB unplanned
GB storms
GB planned
GB short


GB average short and unplanned interruptions (excl. EE)
120
100
80
60
40
20
0
CI
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18
2018/19
Short interruptions CI
Unplanned interrutpions CI

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WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

<u>Potential</u> refinements to the Interruption Incentive Scheme Target Setting Methodology

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Inconsistent averages

Multi year sum/multi-year sum vs Average of individual years

Customers interrupted	Customer minutes lost	Duration
1,000,000	30,000,000	30.0
1,100,000	29,000,000	26.4
1,200,000	28,000,000	23.3
1,300,000	27,000,000	20.8
1,400,000	26,000,000	18.6
1,500,000	25,000,000	16.7
1,600,000	24,000,000	15.0
1,700,000	23,000,000	13.5
1,800,000	22,000,000	12.2
1,900,000	21,000,000	11.1
14,500,000	**255,000,000**	**18.8**
	17.59	

Average of individual years
- LV actual CI (own 4 year average)
- EHV actual CI (own 10 year average)
- EHV industry duration
- 132kV actual CI (own 10 year average)
- 132kV industry duration

Multi-year sum/Multi-year sum
- LV industry duration
- HV factors (fault rate, customers per fault, upper quartile duration, etc)

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Inconsistent treatment for establishing benchmarks (duration)

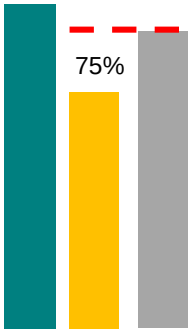
LV better than average

HV better than upper quartile

EHV better than average

132kV better than average

LV worse than average



HV worse than upper quartile

EHV worse than average

132kV worse than average

Key

- Actual
- Average / Quartile
- Benchmark

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WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

Improvement transitions

ED1 approach

- CI targets
  - Progressive improvement from actual
  - Different rate for (above/below benchmark)
- CML targets
  - Immediate move to benchmark

ED2 change options

- Introduce transitional arrangements for CMLs
- Remove transitional arrangement for CIs
  - Consider - Is it reasonable to expect an immediate transition to benchmark performance?

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Improvement factors

ED1 approach

- CI targets
  - 1.5% per annum improvement from actual (above benchmark)
  - 0.5% per annum improvement from actual (below benchmark)
- CML targets
  - 1% pa improvement (LV, EHV,132kV),
  - 3% pa improvement (HV)

ED2 options

- Review improvement rates
  - Align to revealed improvement rates
  - Consider diminishing opportunity
- Replace improvement rates with rolling recalculation of benchmarks/targets
  - Consider visibility of targets for price control package
  - Consider cost benefit certainty during price control
  - Consider whether rolling recalculation is necessary in a shorter price control

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LV

CIs

- ED1 – own 4 year average
- ED2 options/considerations
  - Introduce industry CI benchmark
  - Have targets based upon a blend of industry / DNO performance (as per CML)
  - Consider if LV CI can be improved cost effectively

CMLs

- ED1
  - BM (based on industry 4 year average duration) where better than BM
  - 25% towards BM where worse than BM
- ED2 options/considerations
  - Revise blend of BM and own performance

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LV

Disaggregation (processes would need to be established)

- Existing reporting is subdivided into the following categories

LV non-damage
LV Overhead Mains - damage
LV Underground Mains - damage
LV All Other Switchgear, Plant & Equipment - damage
LV P&E link boxes only
LV Services overhead (excl cut-outs) - damage
LV Services underground (excl cut-outs) - damage

- Can exceptional event exclusions be applied to disaggregated data?
- What benchmarking approach could apply at each disaggregation level?

HV

CIs

- ED1 approach
  - 22 element disaggregation
  - average industry performance used in most factors
- ED2 options/considerations
  - Is it correct to use industry values in some factors? (e.g. customers/circuit)
  - Are all three levels of sub-division still relevant? (i.e. type of circuit, length, customer numbers)
  - Review of fault rate proportions (opportunities for cost effective improvements)

CMLs

- ED1 approach
  - as per CI
  - Plus upper quartile duration
- ED2 options/considerations
  - Consider if using upper quartile in each disagg band is ‘cherry picking’

EHV/132kV

CIs

- ED1 approach - own 10 year average
- ED2 options/considerations
  - Introduce an industry BM
  - Consider inherited network architecture, low volumes of incidents, ‘lumpiness’ of incidents
  - No 132kV in SPD and SSEH

CMLs

- ED1 approach – lower of own 10 year average or industry 10 year average
- ED2 options/considerations
  - Higher of own ave vs BM (alignment with LV/HV)
  - Consider ability to change response to meet BM

The overall incentive package

Improvements (Costs)

- Response arrangements
  - Staff availability
  - Contractor response
- Impact reductions
  - Remote control
  - Automation
  - Sectionalisation
- Preventative actions
  - R&M
  - Tree clearance
  - Reconfiguration
  - Asset replacement

V

Incentive value (Benefits)

- Improvement opportunity (diminishing scale)
- Outperformance opportunity (rewards from targets)
- Incentive value

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