Presentation to IET M&WC Retired Professionals Group

CLASS

Customer Load Active System Services

Thursday 11 May 2017

electricity north west

Bringing energy to your door

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electricity north west

Bringing energy to your door

Agenda

CLASS
Customer Load Active System Services

- Background & original project
- How does CLASS work?
- Market Analysis
- Deployment
- Q & A

Background and CLASS project outline

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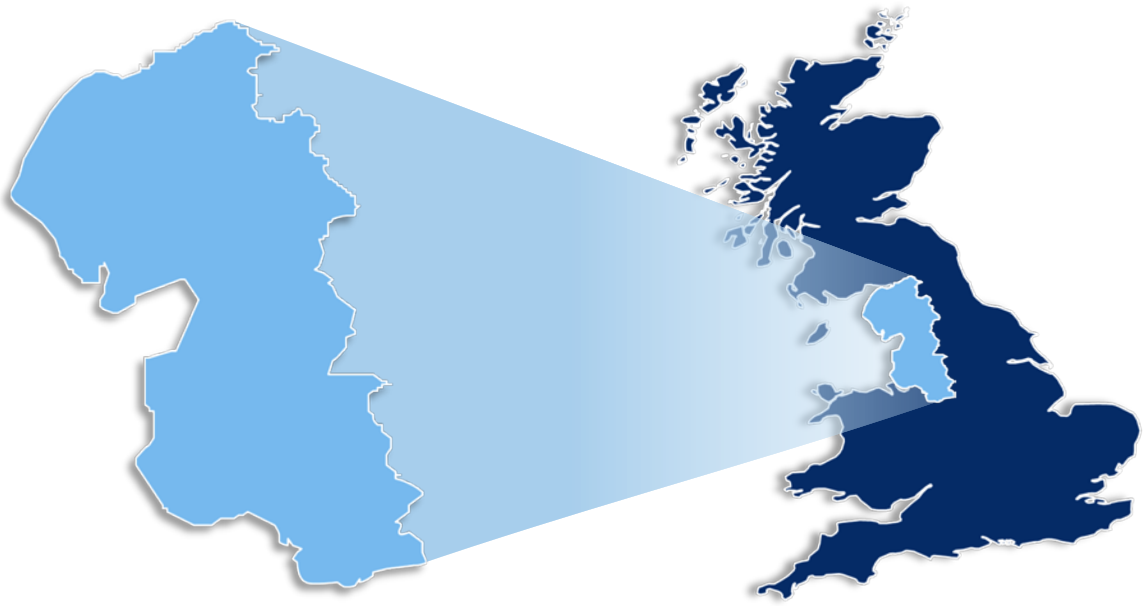
Introducing Electricity North West

4.9 million

2.4 million

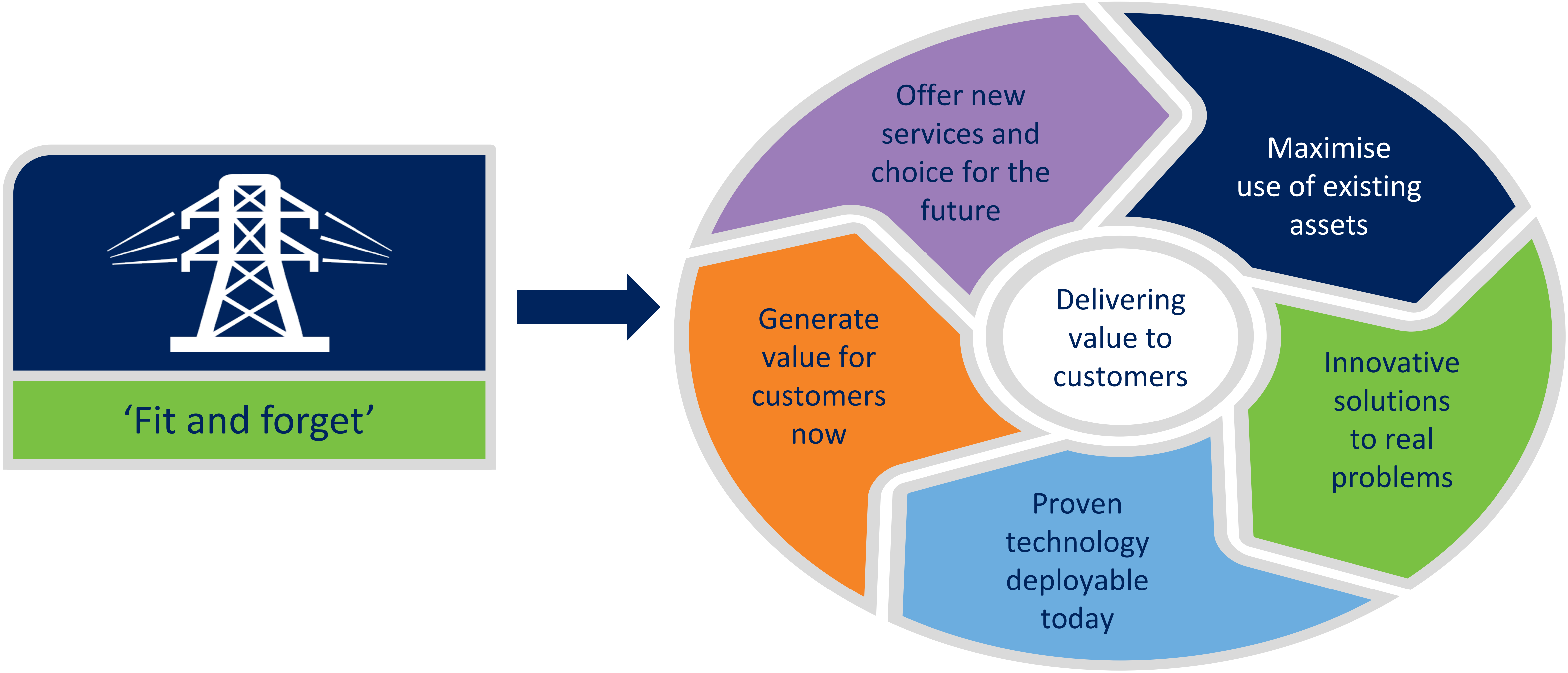
25 terawatt hours



£12 billion of network assets

56 000 km of network ● 96 bulk supply substations
363 primary substations ● 33 000 transformers

Our innovation strategy



Our smart grid development

Leading work on developing smart solutions

Deliver value from existing assets

Customer choice

LCN Fund Low Carbon Networks

Five flagship products (second tier/NIC)

£42 million

C2C

SMART STREET

Celsius

CLASS

RESPOND

Background and recap

Sought to demonstrate that electricity demand can be managed by controlling voltage…

…without any discernible impacts on customers

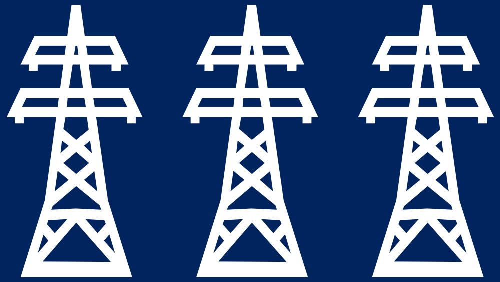
Customer Load Active Systems Services

CLASS project overview

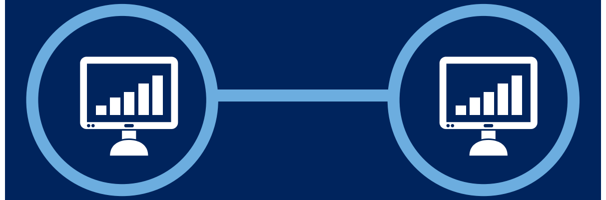
Objectives	Reduction of peak demand; Frequency response and voltage support; Voltage and demand relationship; No effect on customers
What?	Baseline measure: Spring 2014 Monitoring waves: Summer 2014 to Spring 2015 All **485 000** customers in test area received letter **696** customers recruited at **baseline** **1,357 monitoring** interviews
Customer hypothesis	**“CLASS will be indiscernible to customers”** Customers will not see / observe / notice an impact on their supply quality when these innovative techniques are applied

Results summary

Statistical findings are that domestic customers did not notice the CLASS functions



Lessons have been learned during the installation phase, that can be integrated into any future ‘rollout’



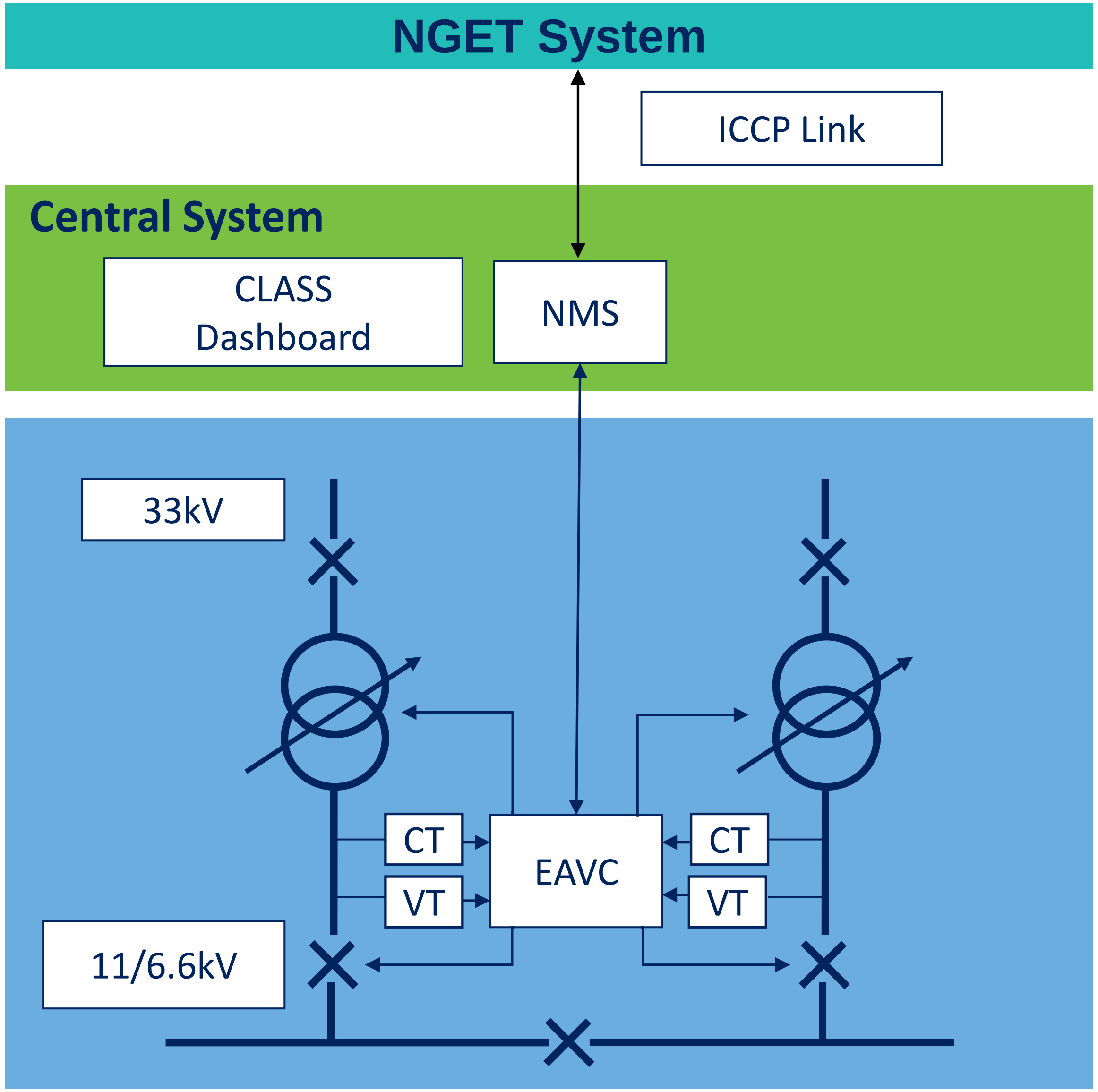
CLASS has provided National Grid with the ability to use an ICCP link which provides them with a demand response during a system frequency event

CLASS has shown an approximately linear relationship between voltage and demand

High level benefits

- Low cost high speed frequency support
- 3GW demand reduction or boost
- 2GVAr National Grid voltage control
- Reinforcement deferral
- 24/7 voltage/demand relationship matrix

CLASS system overview



NGET System	ICCP link will provide future capability for National Grid to access the CLASS functionality directly for flexible whole system response
Central System (Dashboard)	Facility to specify service requirements Monitors the status of each CLASS substation and which should be armed or disarmed Monitor performance
Enhanced Automatic Voltage Controller	Measure performance. voltage, current, power, frequency etc Hold arm/ disarm flags for each of the CLASS services Trip or close circuit breakers or operate tap changers to implement CLASS services

CLASS extension objectives

Assess the market for each CLASS service

Market structure, entry qualifications and price

Size of market in 2015 and potential size to 2027

Current and potential future competitors – no, type and size of players

Assess the impact for each CLASS service

Market structure and service price

Competitors – number, type and size of players

Determine benefits for GB customers

Costs and benefits for GB customers

Potential winners and losers in each market

Whole market impact

Sharing of DNO revenues with customers

Regulatory treatment clarified

Revenue and costs classified as Value Added Services (DRS8)

Services described generically as:
‘distribution network voltage control and network management services procured from the licensee by National Grid for the purposes of its system operator residual balancing activity’.

The reasons for this decision:

These services utilise DNO assets

Licensees incentivised to provide services to National Grid: should benefit consumers by more efficient procurement of system balancing requirements;

Consumers should benefit by sharing any net revenue received by the licensee

How does CLASS work?

Bringing energy to your door

Reducing voltage reduces demand

Mainly domestic	Mainly industrial/ commercial	Mixed
1% change in voltage ~ 1.3% change in demand	1% change in voltage ~ 1.48% change in demand	1% change in voltage ~ 1.22% change in demand

Reducing voltage means it will take slightly longer for a kettle to boil.

00:03:00	2% ↑	00:00:08	↓ 2%

The cost £ to make your cup of tea is always the same!

“A problem shared is a problem halved...”

20,000 homes in a town

200,000 homes in a city

26 million across the GB

CLASS uses small changes over many customers to give a big response

Did customers notice CLASS?

No differences by customer type, trial type, region, vulnerable customers, survey season

No complaints from customers about power quality that could be attributed to CLASS

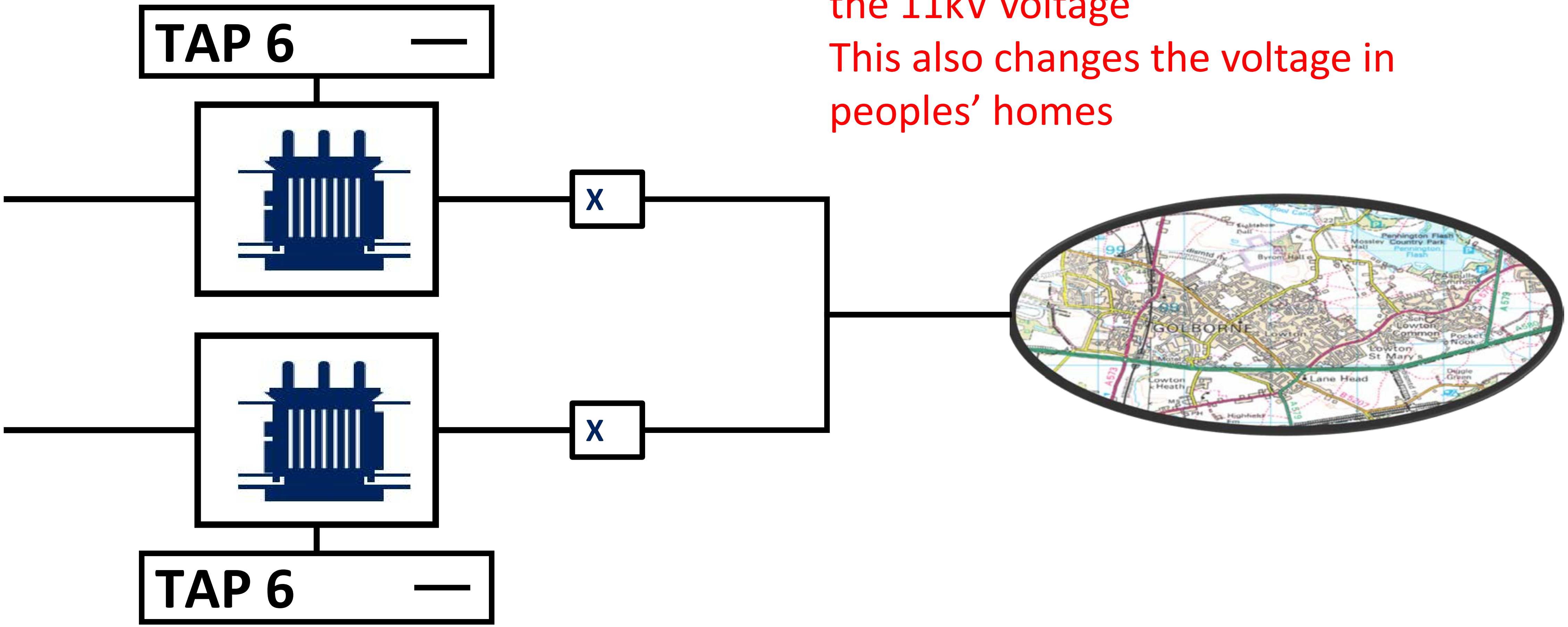
485,000 customers

Customers did ***not*** notice the CLASS tests

Using our Primary (33kV/ 11KV) substations

33kV **11kV**

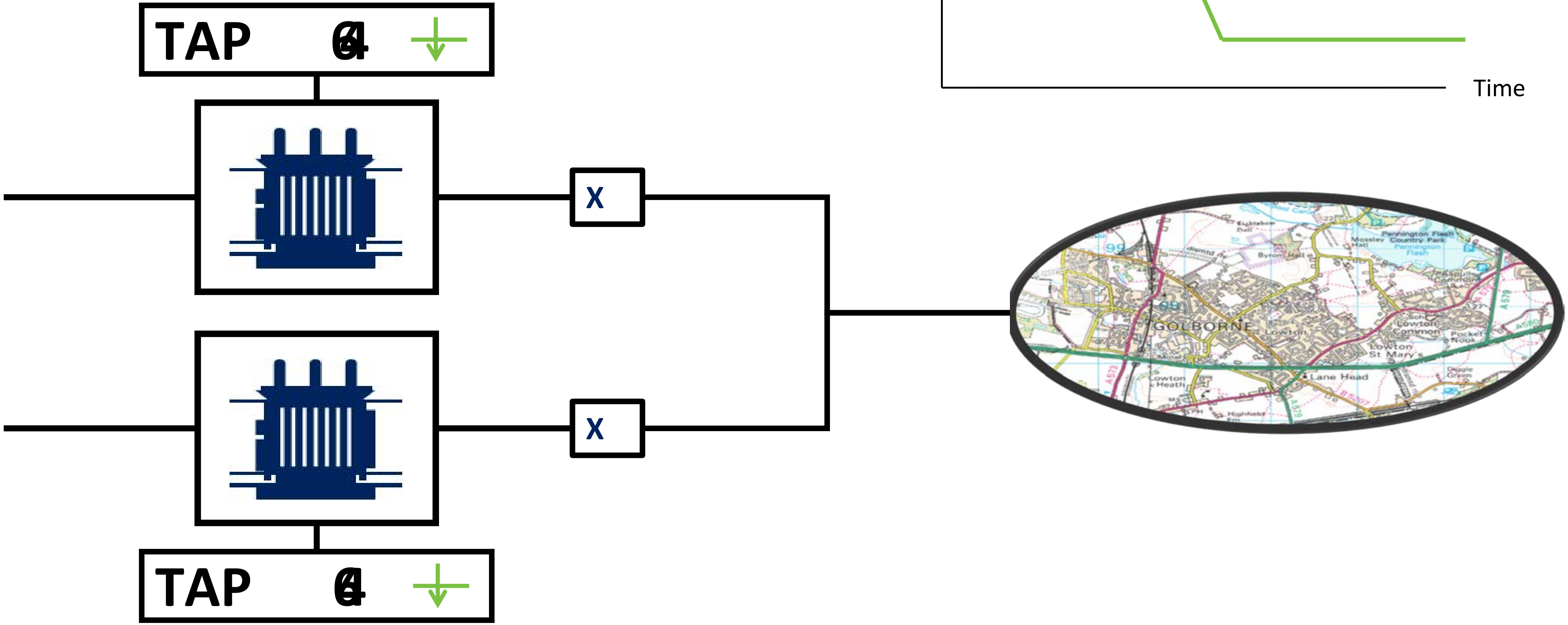
Our Primary Substations have 'tapchangers' which allow us to change the 11kV voltage
This also changes the voltage in peoples' homes

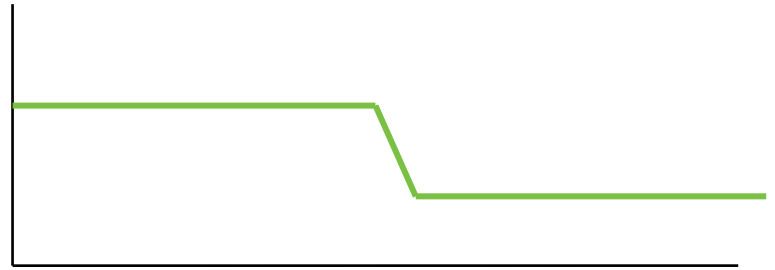


Primary transformer

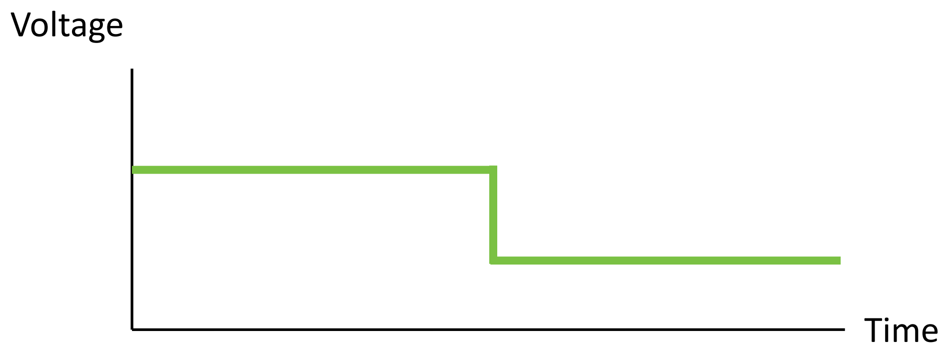
Demand reduction using tapchangers

33kV

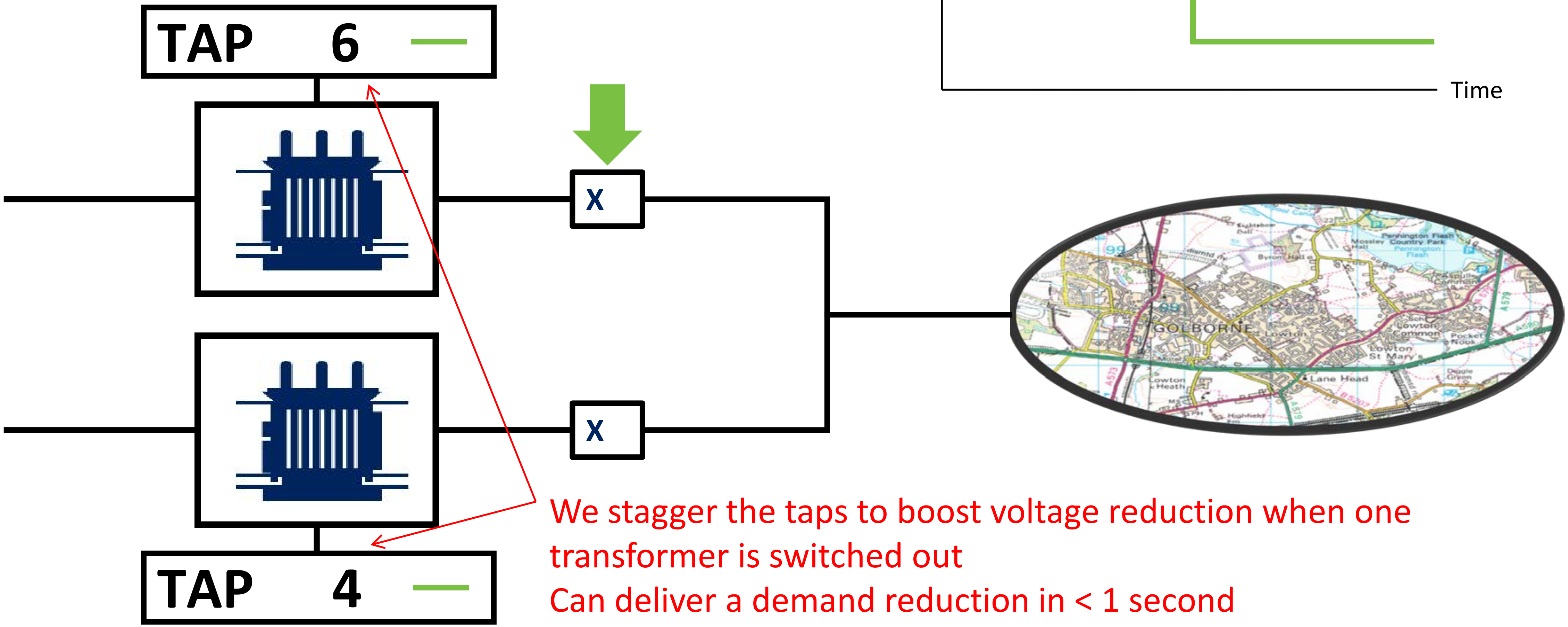




Demand reduction by switching out a transformer



33kV

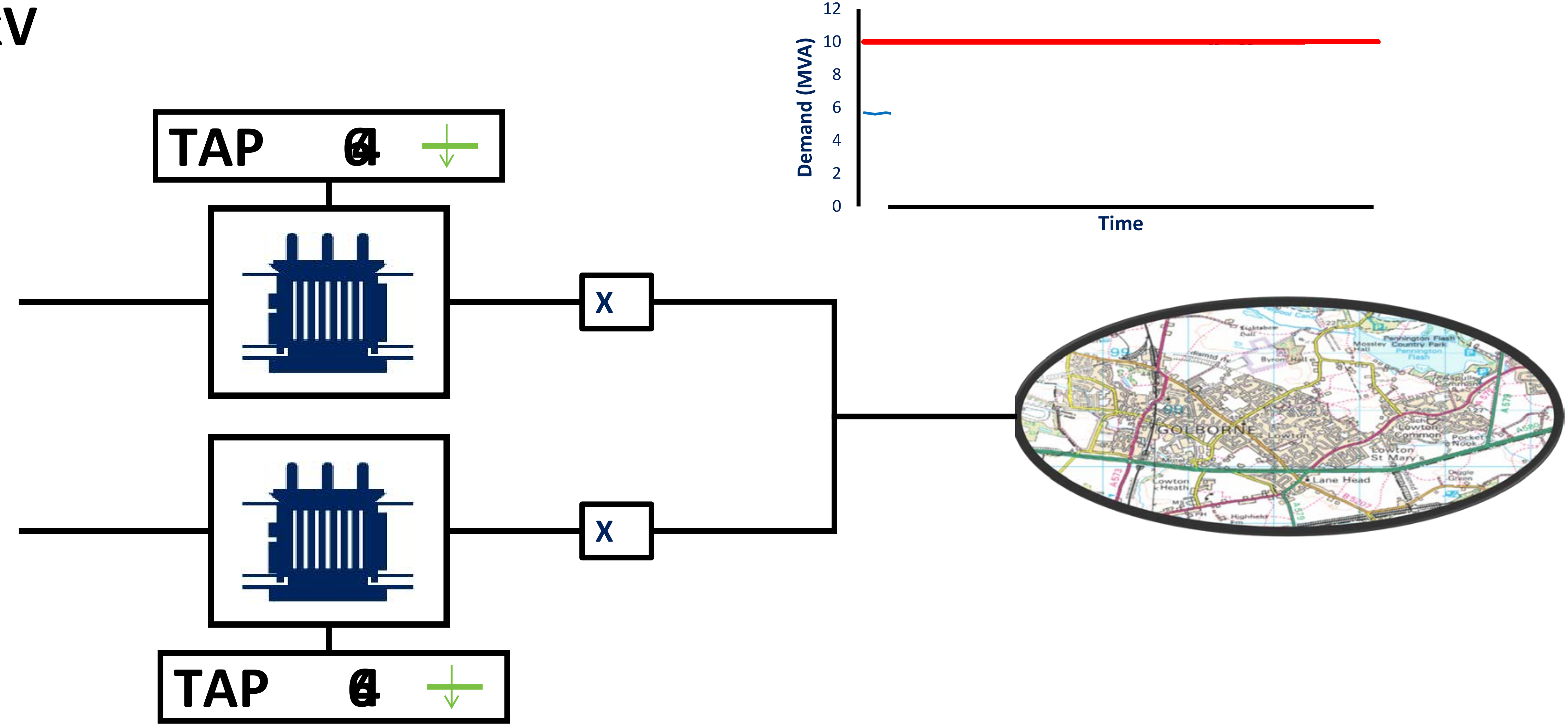


We stagger the taps to boost voltage reduction when one transformer is switched out

Can deliver a demand reduction in < 1 second

CLASS can also be used to defer reinforcement of our network

33kV



CLASS can also be used to defer reinforcement of our network

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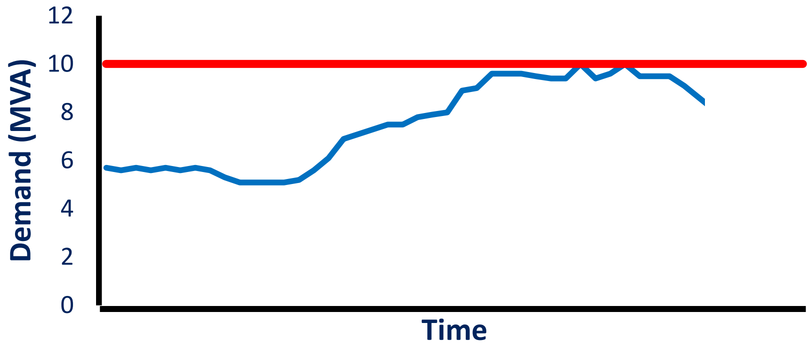
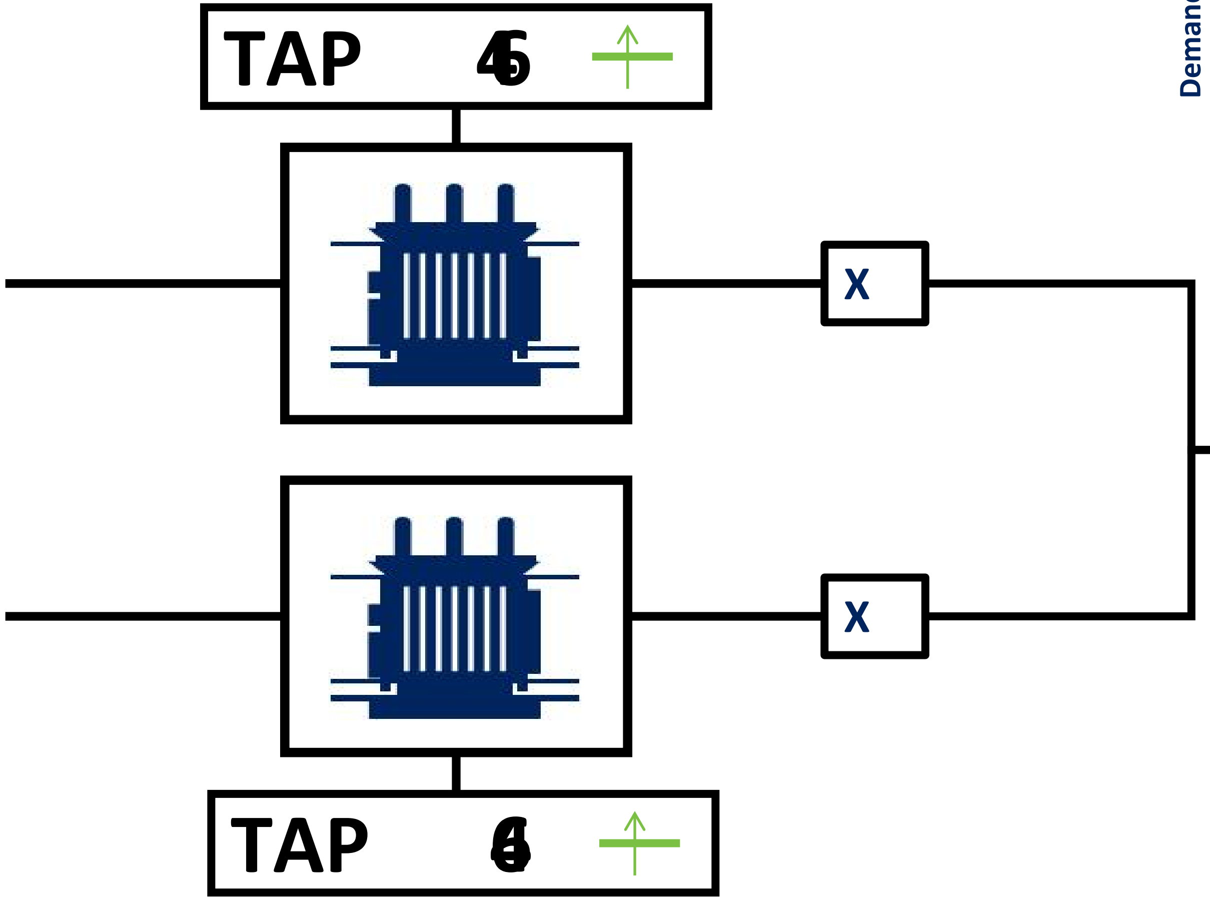
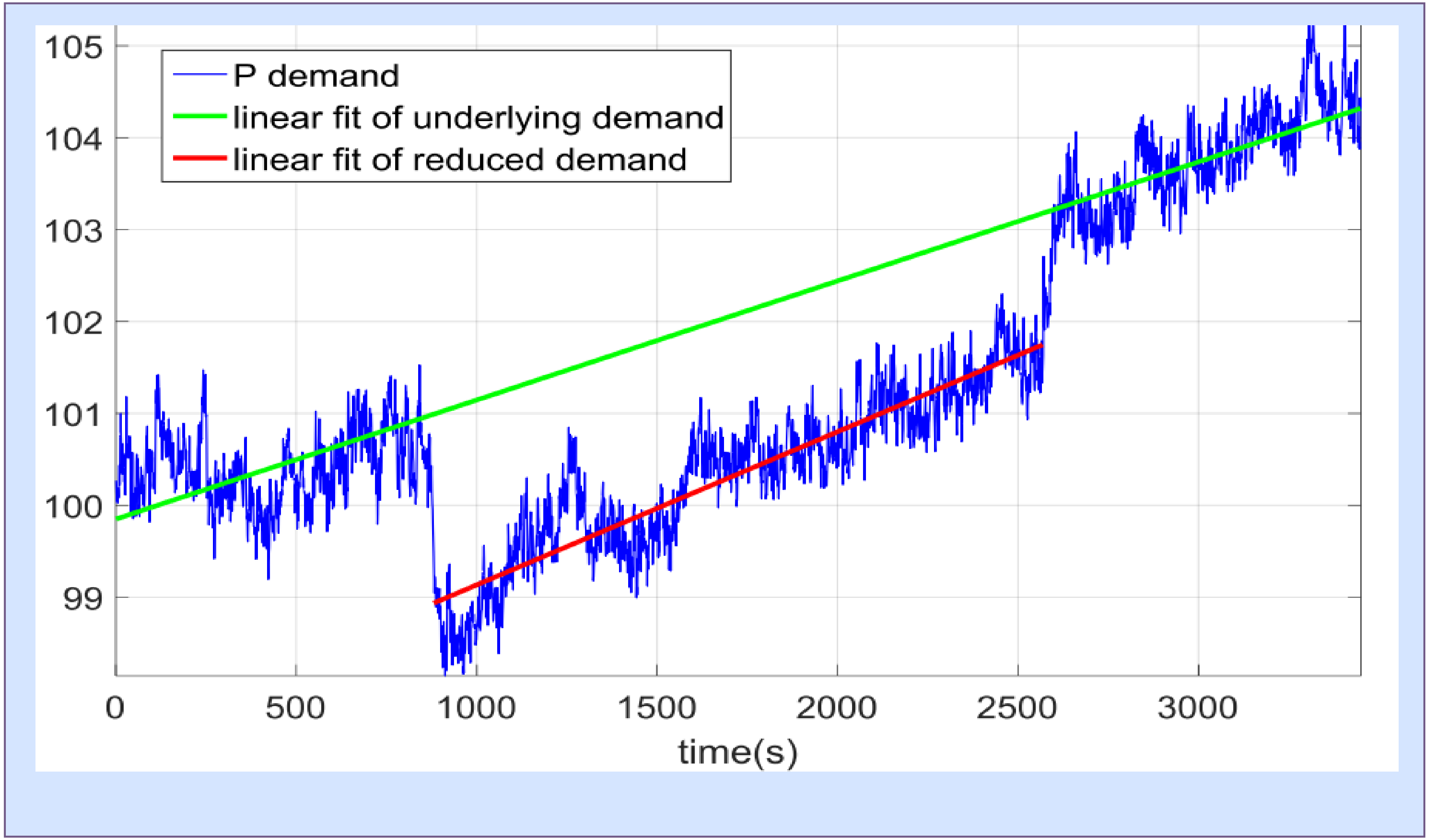




Measured CLASS response



Market Analysis

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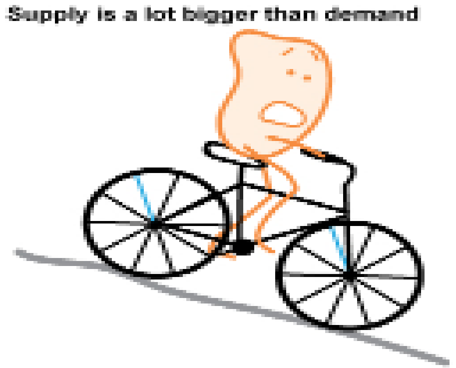
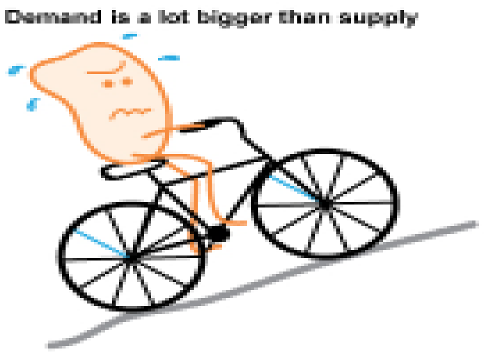
What is frequency?

- Alternating current (AC) is what it sounds like – it flips back and forth: Electrons move first in one direction, then back in the opposite direction, 50 times a second, or 50 Hz. That's what we mean when we talk about 'frequency' .
- The grid, and everything connected to it are designed to work at 50Hz.
- Frequency fluctuates depending on how much energy is being used (demand) and how much energy is being generated (supply).
- Typically, it stays within a safe range, but when the system deviates too far from 50 Hz, things can go haywire, leading to massive blackouts.

Balancing Supply and Demand



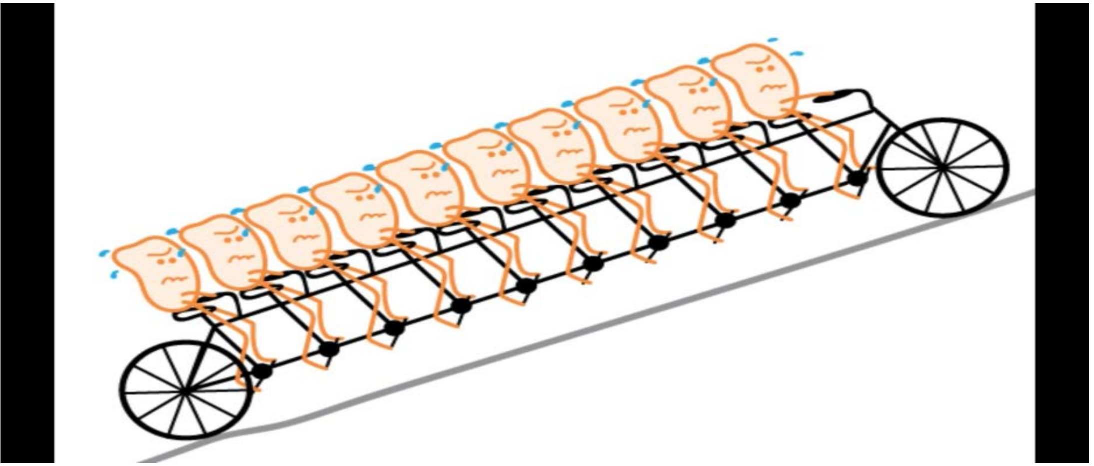


The grid is a giant balancing act between supply and demand, If there's more demand than supply, the frequency drops; if there's more supply than demand, frequency goes up

The role of frequency can be compared to riding a bike.

- Rider is the power plant and the bike represents things like power lines
- The speed of pedalling is the frequency and has to stay close to 50 Hz no matter what
- The slope represents demand: higher demand the hill gets steeper. Pedalling can't slow down, so must pedal a lot harder to keep going up the hill
- On the electric grid, this means that grid operators need to bring more power online
- And vice versa if demand falls

What happens if it goes wrong?

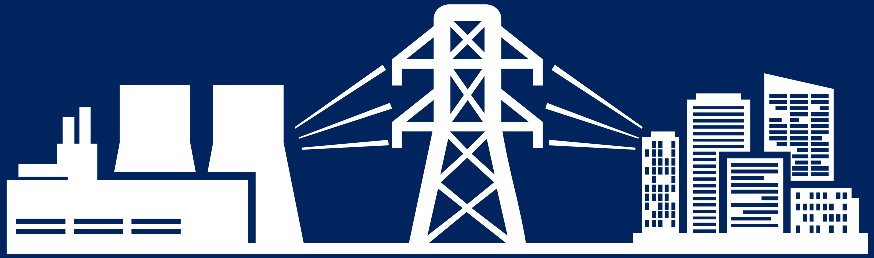


It has happened in the US and Italy resulting in power cuts over a wider area affecting millions of people

- Going back to the bike analogy, but this time make it a tandem with 10 riders
  - Each rider is a power plant, and they all have to pedal at the same rate.
  - As the hill gets steeper and steeper, eventually, the weakest rider will get fatigued and will stop pedalling.
  - Those left have to pedal harder to make up for the slacker until the next weakest rider stops too.
  - Each time a rider fails, it gets harder for everyone else to keep going.
  - Soon, the whole bike will fall down.

Potential markets identified

What are Balancing Services?	Who provides Balancing Services?
Range of energy and capacity products designed by National Grid – the System Operator Used to maintain the balance of supply and demand after gate closure, to maintain stability, and ultimately ensure security of supply	Balancing Mechanism (BM) providers – large, often transmission-connected generators Non-BM (distributed resources) Demand side response Other TSOs (via interconnectors)

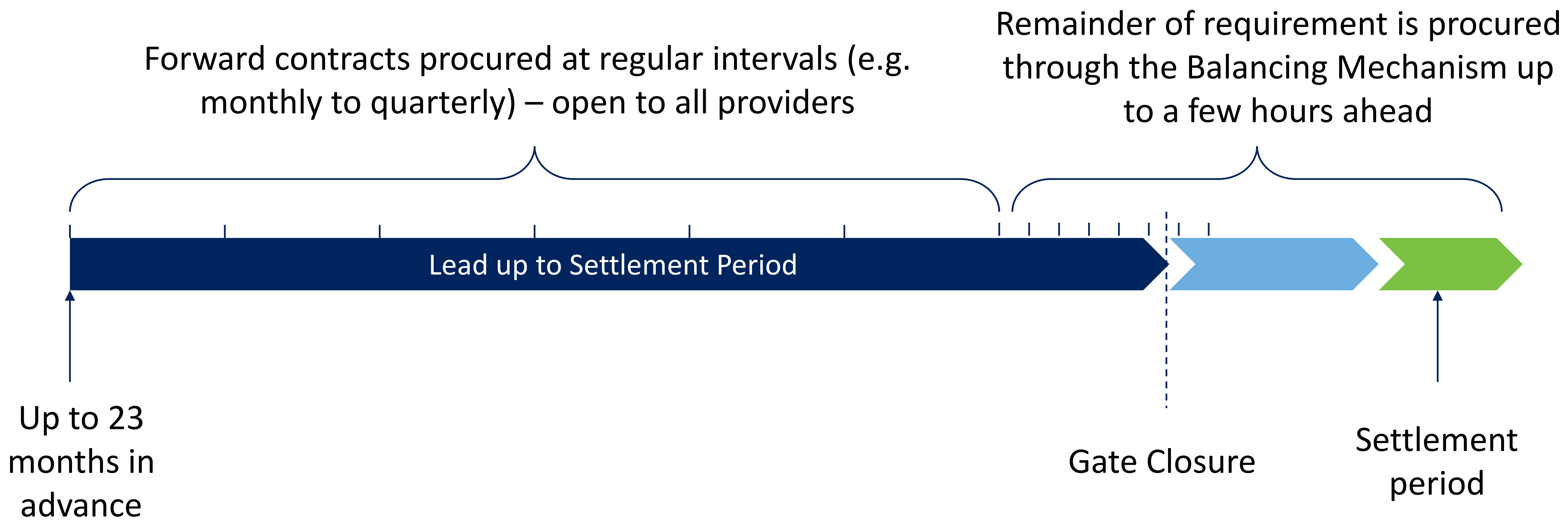


What Services do we plan to provide to National Grid?

Product	Notes
Primary Frequency Response	• Activates automatically when frequency drops below a set level • Delivered through switching out a single transformer • **Must respond in within 10s and maintain service for 30s** • **Minimum requirement currently 10MW**
Secondary Frequency Response	• Activates automatically when frequency drops below a set level • Delivered through tap changes • **Must respond in 30s and maintain service for 30m** • **Minimum requirement currently 10MW**
Fast Reserve	• Activates by an instruction from National Grid • Delivered through tap changes • Through tap changes • **Must respond in 2m and maintain service for 15m** • **Minimum requirement currently 50MW**

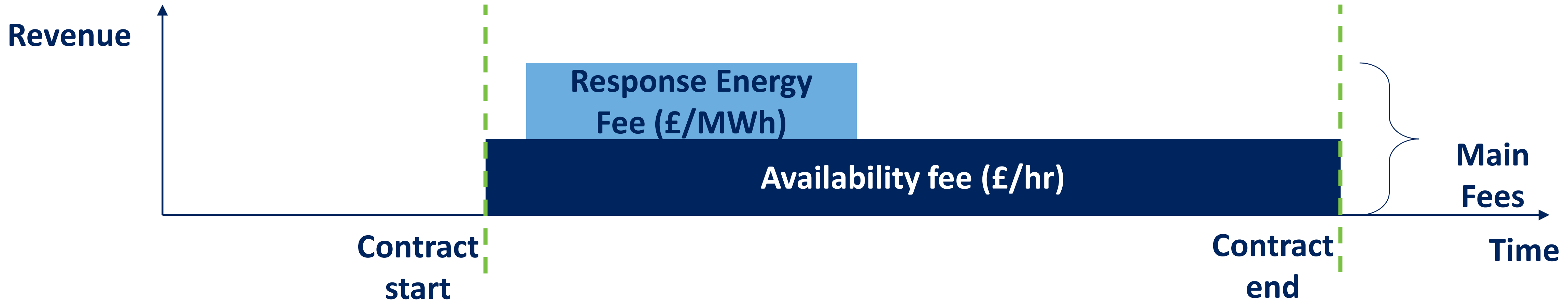
How are Services procured?

When does National Grid buy Balancing Services, and how long for?



How does payment work?

How are providers paid for Balancing Services?

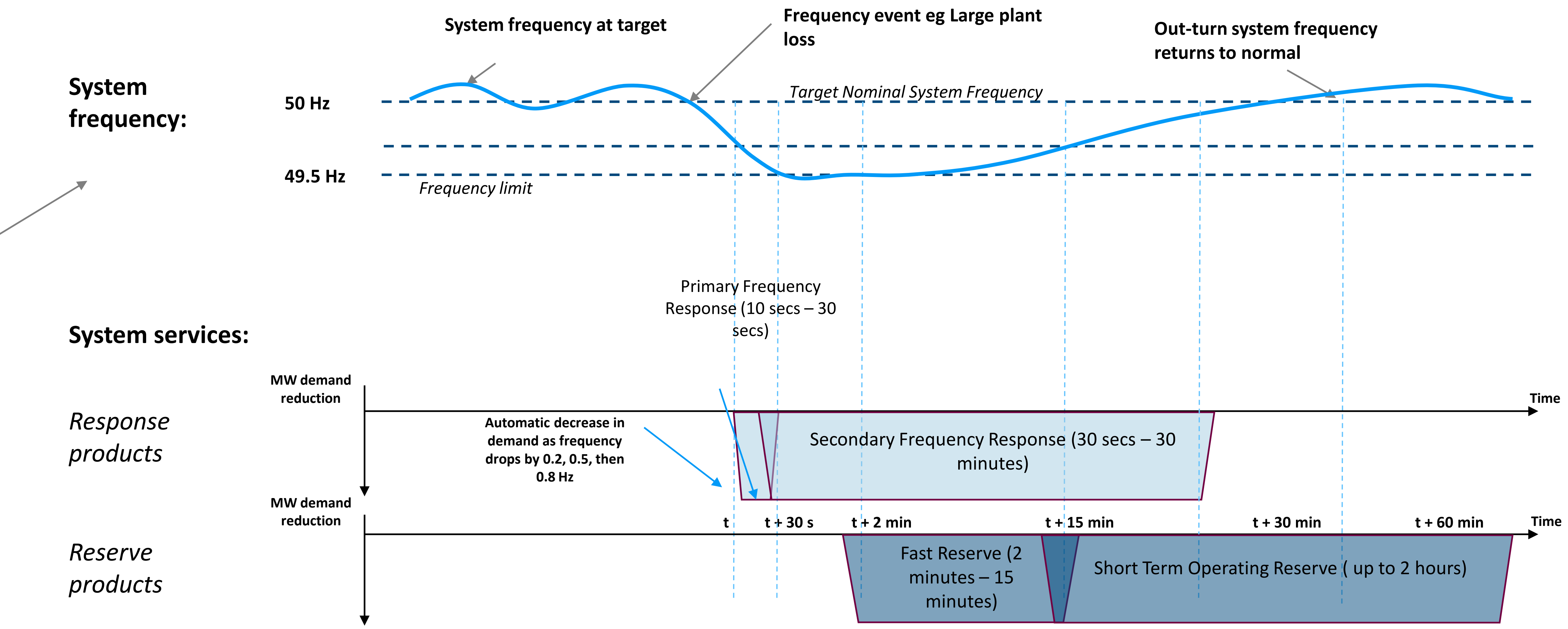


Forward-procured Balancing Services are structured as availability fees and energy fees

Successful providers are paid the availability fee for their 'window' and energy fee for any utilisation

Balancing Services procured in the Balancing Mechanism are paid according to bids and offers for energy utilised

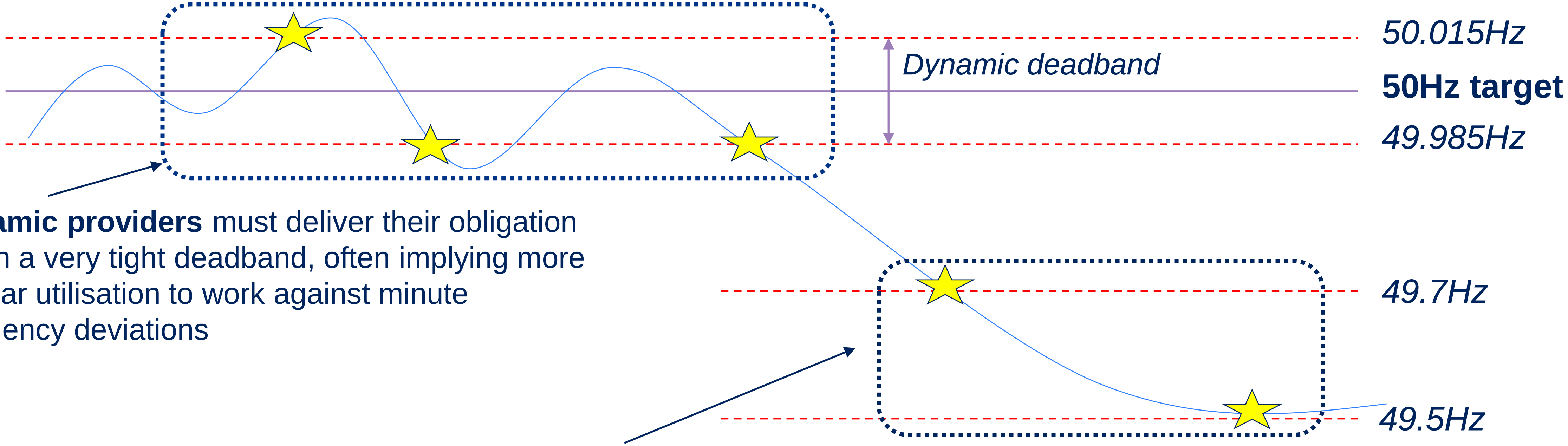
How are the products used together?



Dynamic vs static Frequency Response

NGET needs to maintain a proportion of dynamic response at all times

- CLASS’ treatment as either static or dynamic will determine the size of its Frequency Response market, and have knock-on effects into other markets



Dynamic providers must deliver their obligation within a very tight deadband, often implying more regular utilisation to work against minute frequency deviations

Static providers must deliver their obligation where the frequency hits a certain trigger point, potentially increasing response as the size of the deviation increases

Current market (2014/15)

Note that "Current" in this context refers to FY 2014/15 (one of the focus years for the impact assessment, for which we have a full year's worth of data)

Significant contribution from BM providers

Significant contribution from Pumped Storage

Signs of stronger engagement from DSR participants

Highly competitive STOR market

- Note – recent changes in the markets – (since September 2015):
  - New entry of Non-BM participants (DSR, Diesel) in Frequency Response
  - New entry of Non-BM participants in Fast Reserve (Gas Engines)

Future market (2027) context

Why 2027? To account for changes in Balancing Services requirements resulting from an increase in largest infeed loss, and to allow for sufficient deployment of new technologies into balancing services markets.

Increased market size (driven by increased infeed loss)

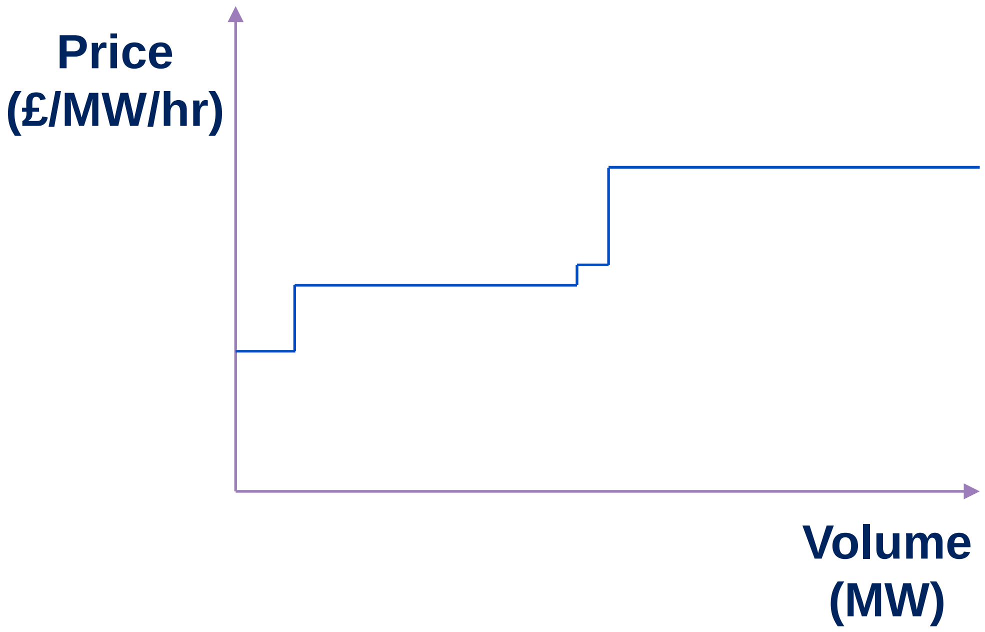
Reduced reliance on BM providers of reserve

Increased participation of small scale new entrant technologies

Resources used:

- Lazard capital cost assumptions for generating technologies and storage technologies
- DECC Electricity Generation Costs (2016 Commissioning used to represent existing installations), and Parsons Brinkerhoff update (also 2013)
- DECC UEP 2015 (Electricity and Carbon Prices)

Building baseline market supply stacks



2014/15: Actual participant data and corresponding bids used as baseline stack, as reported by NGET

2027: New entry assumptions derived from CM results, and through deployment rates

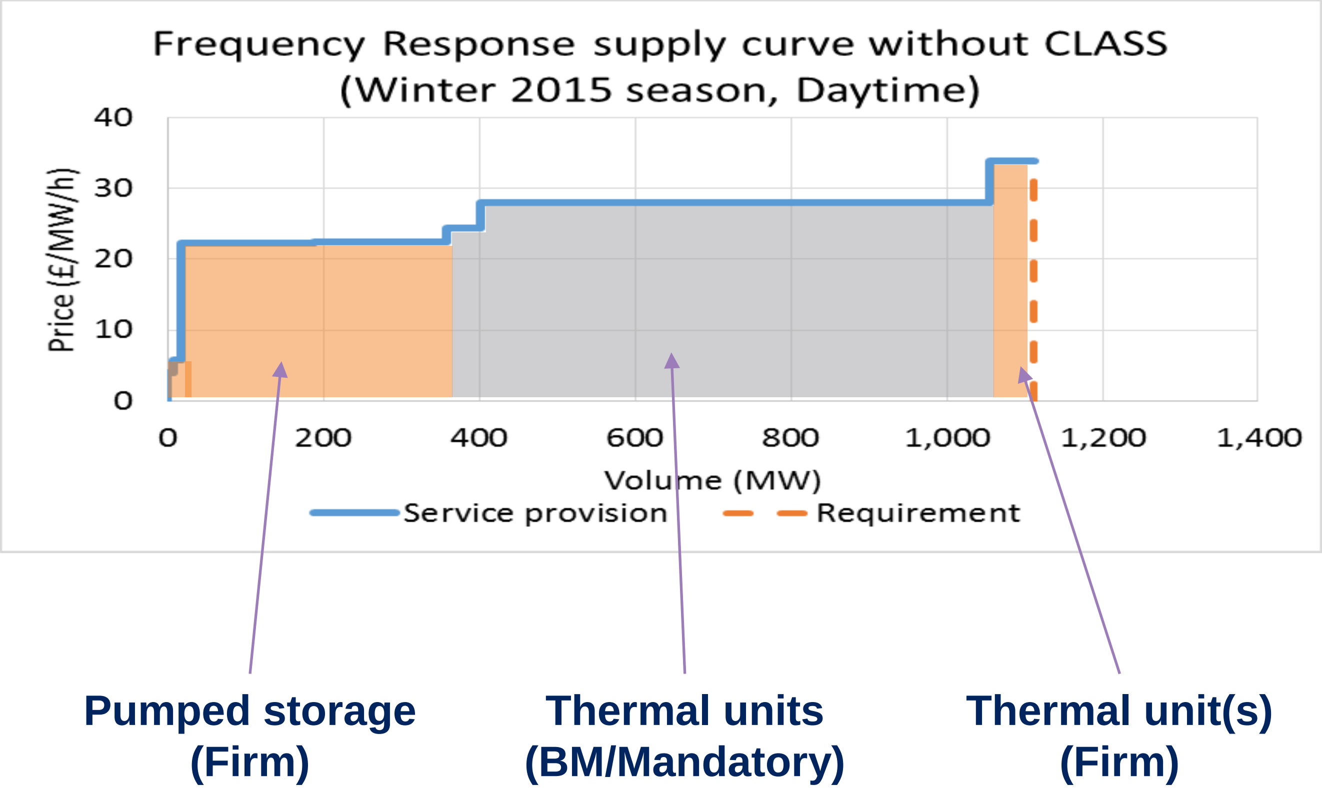
Baseline bids calculated from one of two methodologies:

- Opportunity cost
- Long run marginal cost (less other fixed revenues)

Frequency Response baseline 2014/15

Supply of Frequency Response in 2014/15

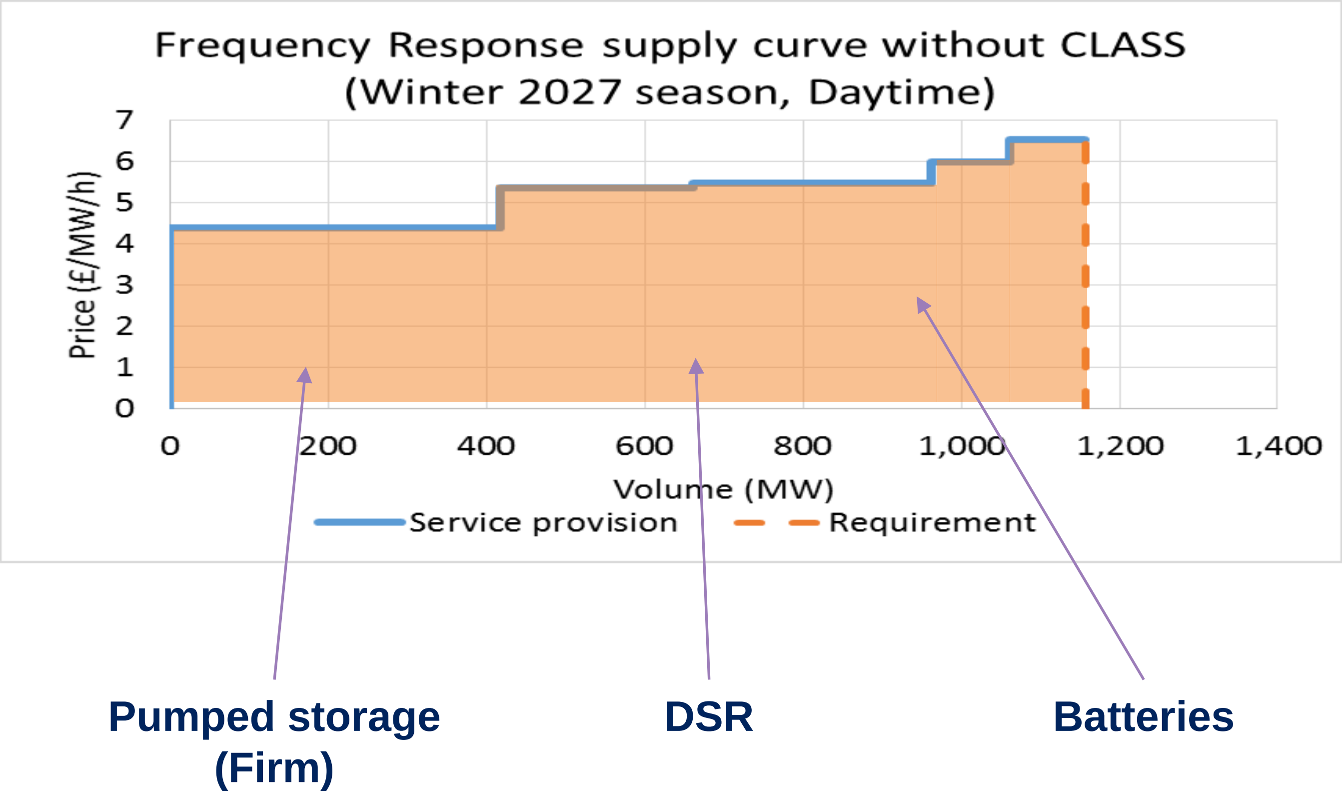
- Sized for NGET's Secondary requirement, meaning surplus Primary and High was procured
- Minimum dynamic level of 450MW
- Firm providers (red areas) were predominantly pumped storage and thermals
- Other firm providers included small diesel generators
- BM (or "Mandatory" Frequency Response) regularly accounted for between 40-60% of total requirements



Frequency Response baseline 2027

Supply of Frequency Response in 2027

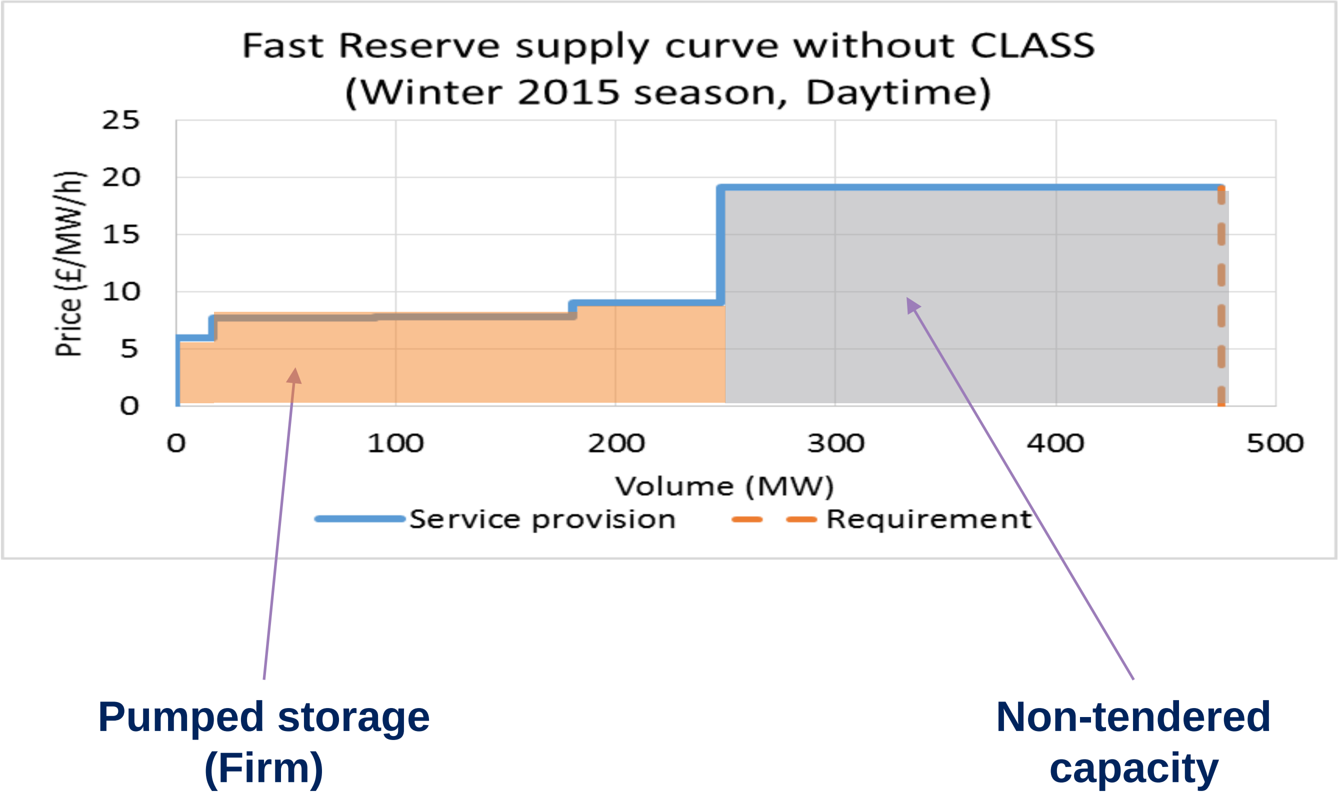
- Secondary requirement is assumed to be binding
- 450 MW dynamic constraint
- All provision met by Firm providers
- Bottom-up cost-based bidding produces lower fees than in 2014/15 – reflects greater competition from increased diversity of new entrants
- New entrants are assumed to have a 20 year life, and to benefit from forecast CM revenues



Fast Reserve baseline 2014/15

Supply of Fast Reserve in 2014/15

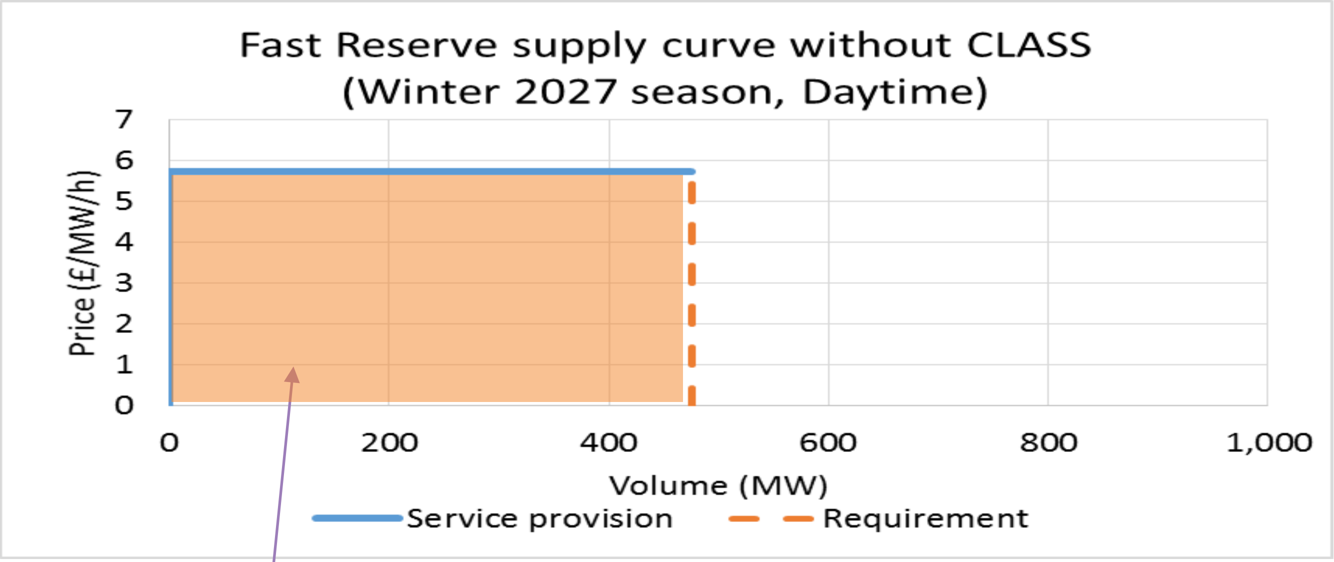
- The market is split into Firm (tendered) contracts, and Non-tendered contracts
- The 2014/15 Firm market was fully supplied by two pumped storage providers
- Non-tendered contracts are understood to also be mainly supplied by pumped storage, for a few hours per day



Fast Reserve baseline 2027

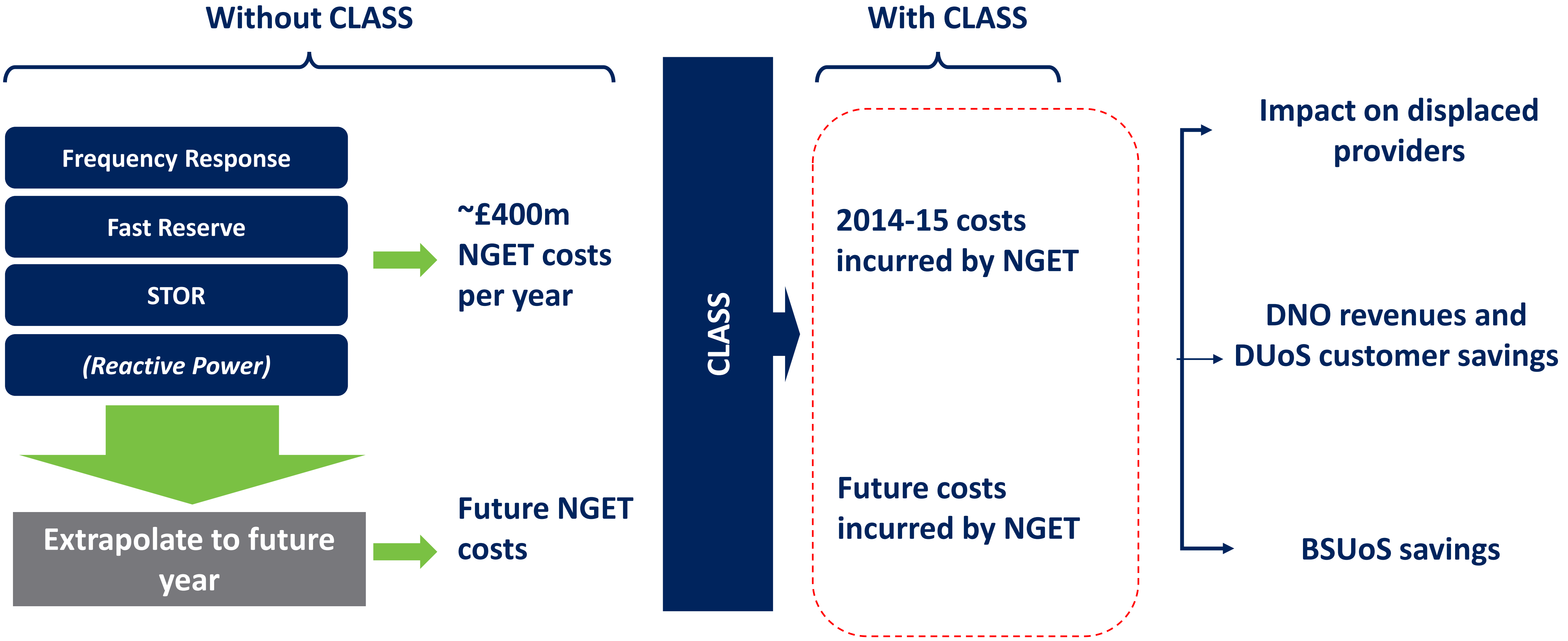
Supply of Fast Reserve in 2027

- Assumed that pumped storage is still competitive to provide Fast Reserve in 2027 by bidding down to opportunity cost
- Gas engines are out-of-merit owing to their LRMC-based bids being uncompetitive – though are assumed to provide any “shoulder” hours where pumped storage could otherwise be unavailable



Pumped storage (Firm)

Impact assessment methodology



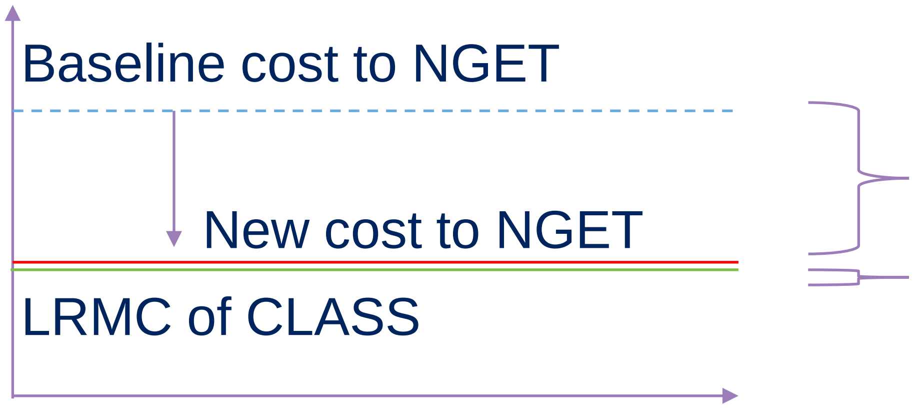
Consumer bill benefits

- BSUoS (Balancing Services Use of System) charges
  - Cost of NGET balancing actions are passed to consumers via BSUoS charges
  - If those costs can be reduced, majority of benefit passes to customers

- DUoS (Distribution Use of System) charges
  - All DNOs to treat CLASS costs and revenues as DRS8 as Directly Remunerated Service 8 DRS8, Valued Added Services
  - Net CLASS costs/revenues will be treated as Totex, being split between “fast” and “slow” money
  - Costs and revenues subject to each DNO’s sharing factor

CLASS pricing options

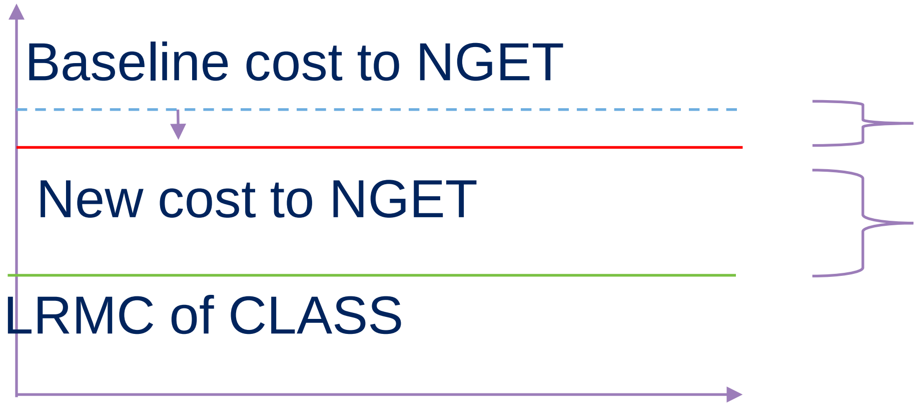
LRMC pricing



Customer benefit from BSUoS reduction

No net DUoS reduction

Shadow marginal pricing



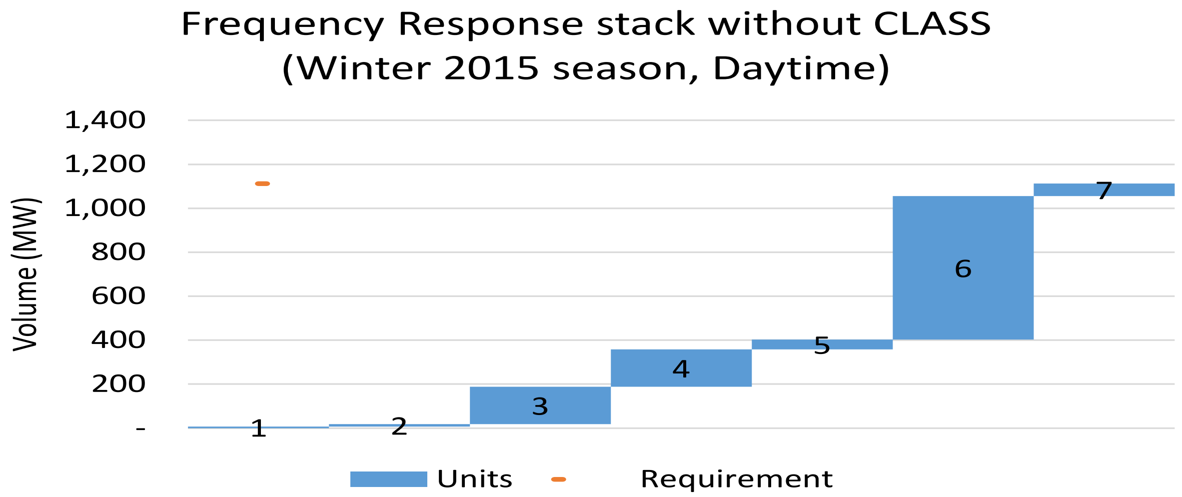
Minimal savings in BSUoS

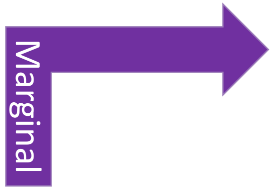
Net benefit above LRMC passed to consumers via DUoS under Totex treatment and sharing factors

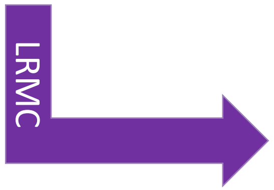
Non-bill benefits

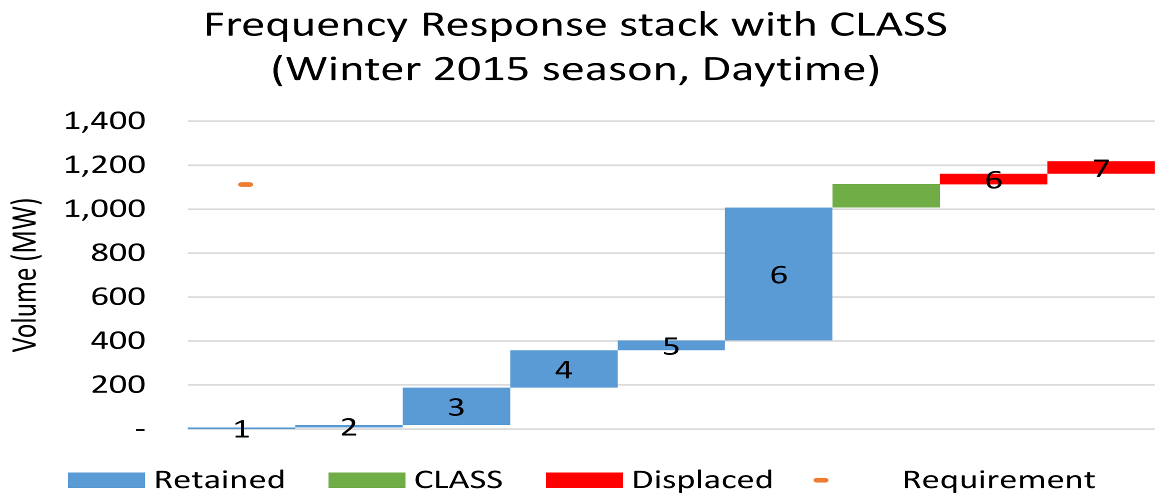
- Carbon emissions
  - Reduction in carbon emissions expected
    - Reduced part-loading of thermal generators
    - Reduced utilisation of more carbon-intensive providers
  - Depends on behaviour of displaced providers
- Security of Supply
  - Direct but small increase in risk of Customer Interruptions and Customer Minutes Lost (likely to be below regulatory threshold)
  - Less certain impact of displacing existing providers from balancing services
  - Uncertain interaction with OC6 requirement but likely to be neutral or possibly a positive impact

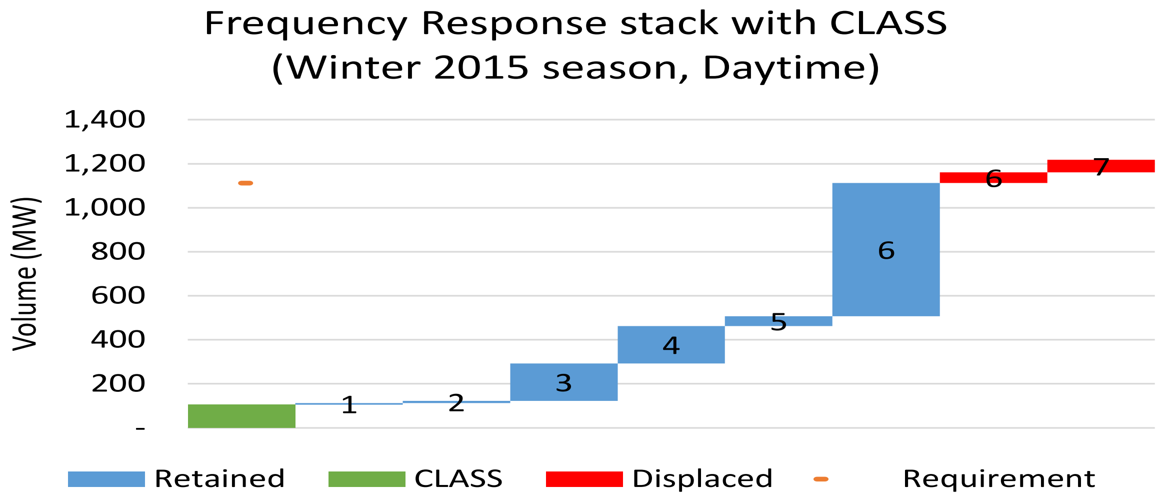
2014-15 CLASS impact – stack









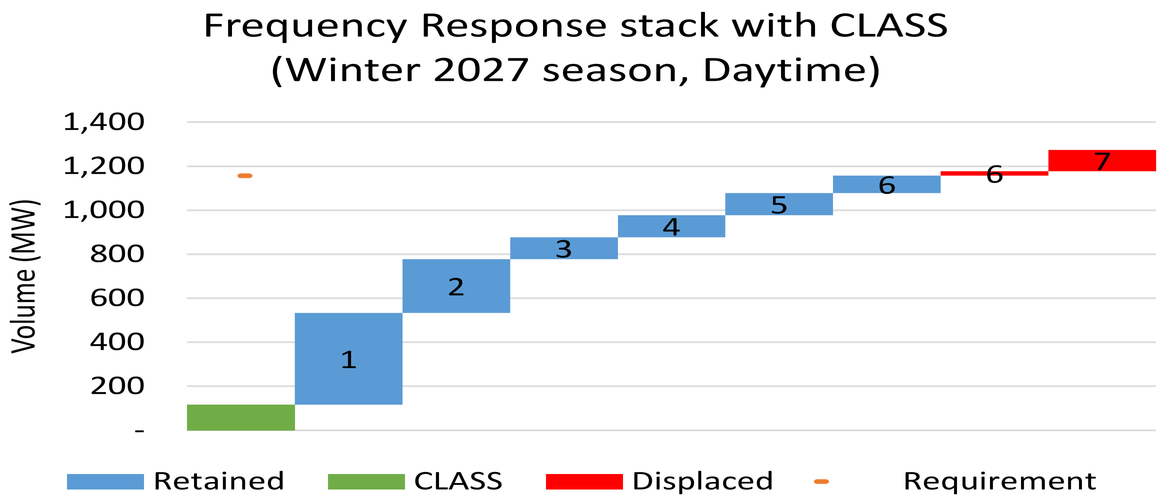


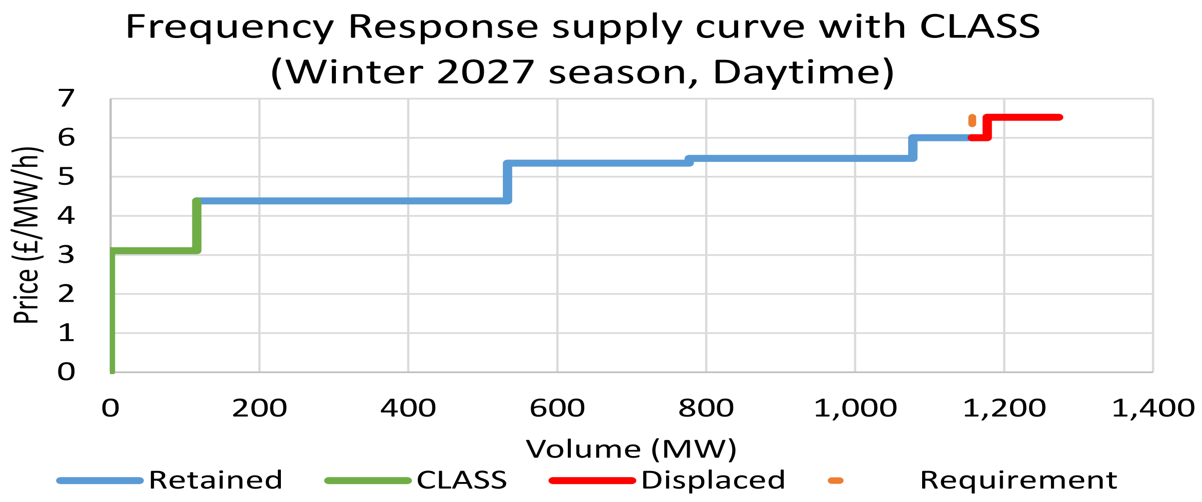
2014-15 impact

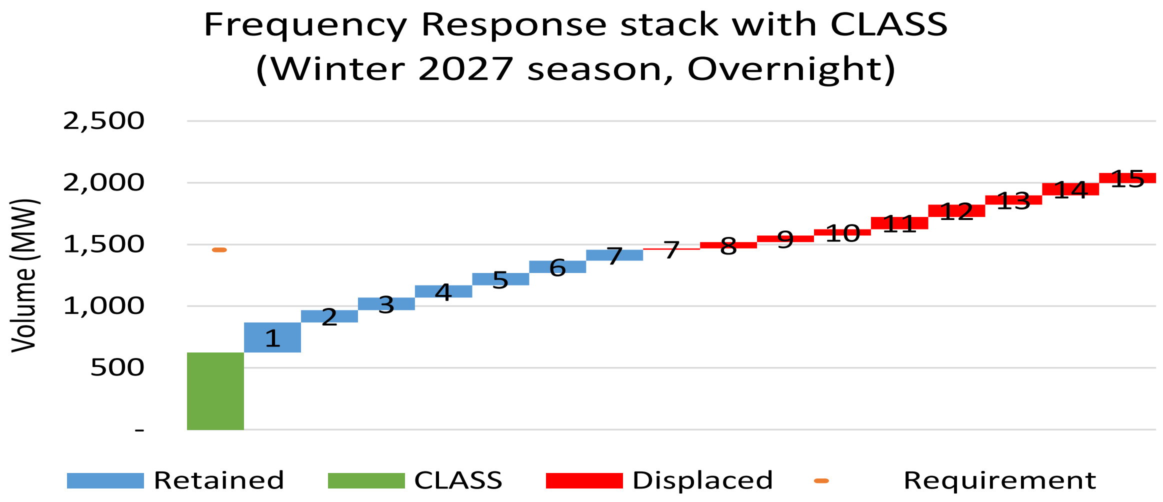
2015 (~180MW CLASS)	LRMC pricing £m (real 2015)	Marginal pricing £m (real 2015)
Cost to DNO of providing CLASS	2.4	2.4
Cost to NGET of CLASS	2.4	29.9
Displaced cost to NGET	32.2	32.2
Net NGET cost reduction	**29.8**	**2.3**

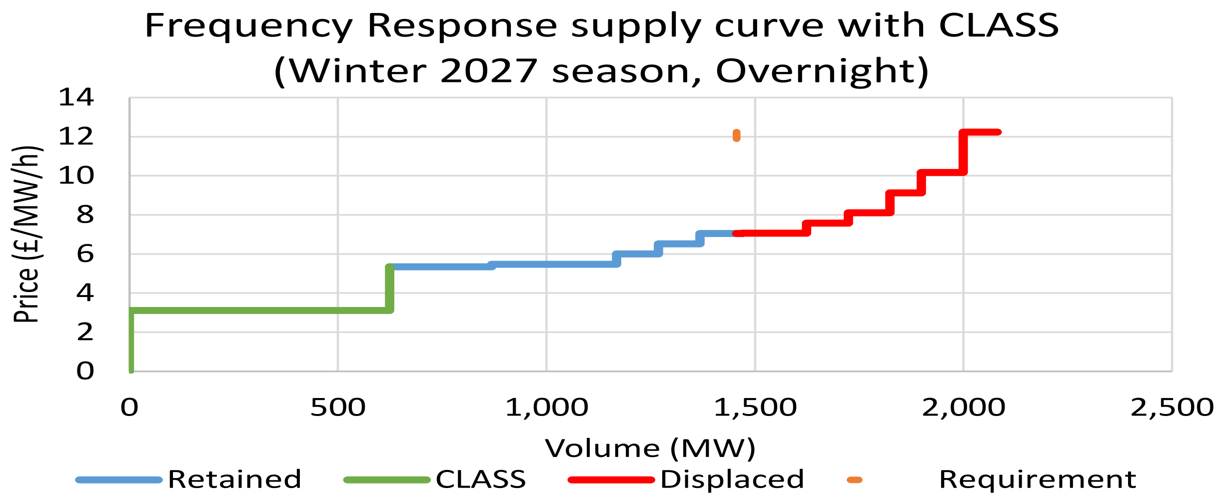
- Other quantified benefits:
  - Carbon: £82k benefit based on reduced part loading of thermals
  - CI/CML: Negligible cost (£82) since risk of fault and time to recover post-fault are both low

2027 CLASS impact – Frequency Response (restricted case)

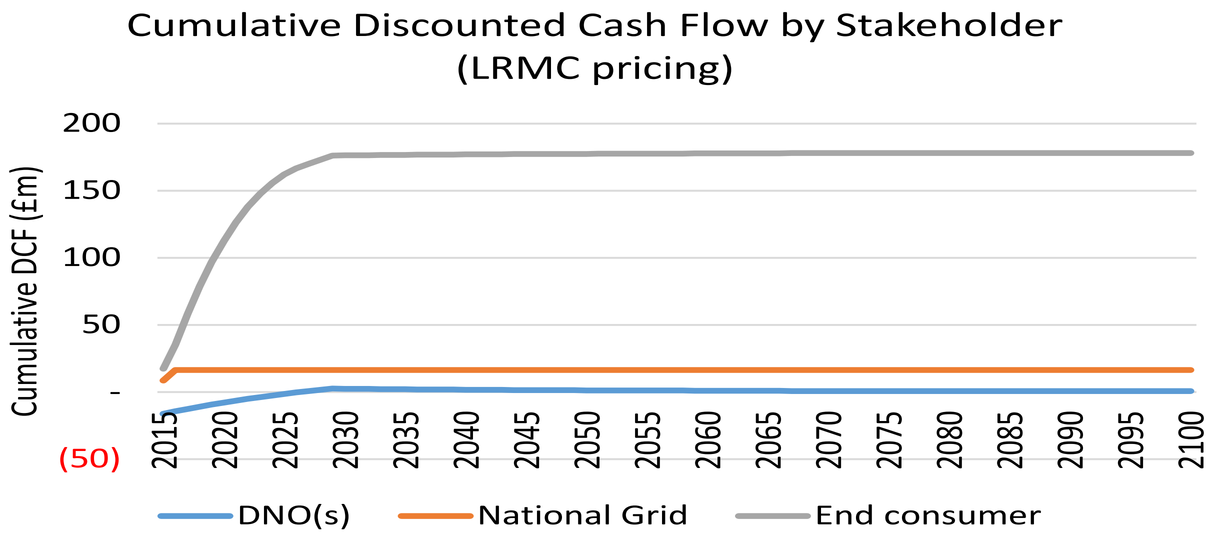


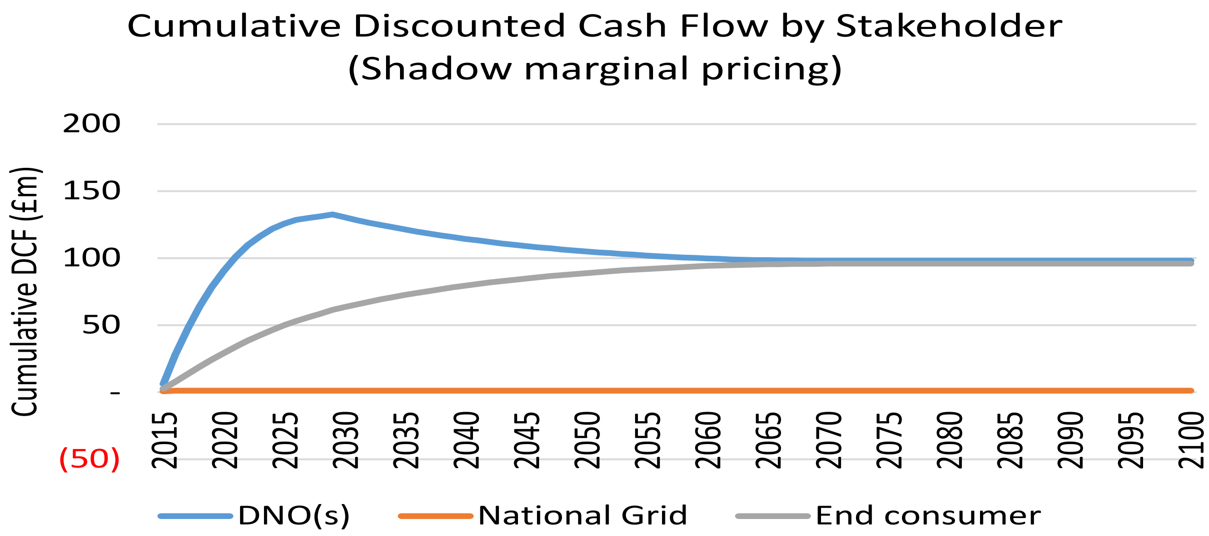






CLASS CBA – initial capex tranche

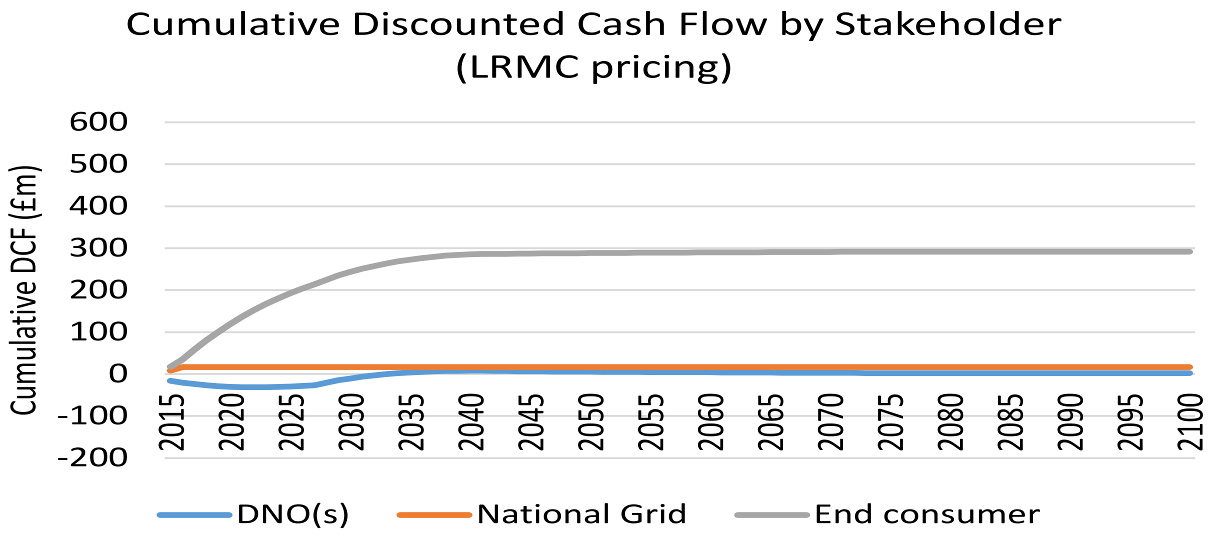


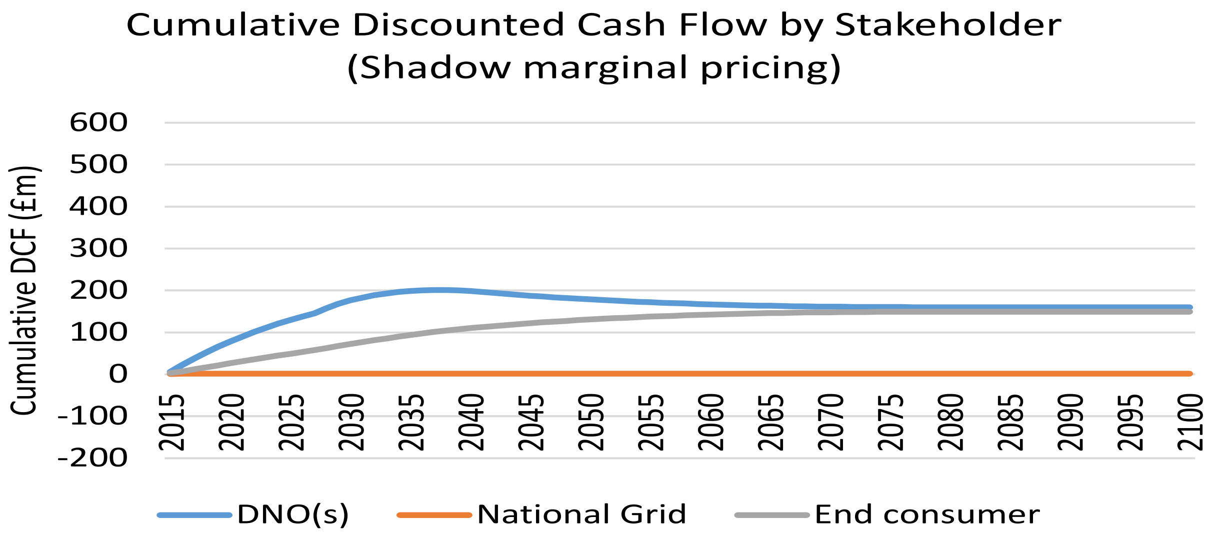


- Initial tranche only
- Cost Benefit Analysis expressed as Discounted Cash Flow
  - 3.5% discount rate
- Relative benefits depend on CLASS pricing strategy
  - Long Run Marginal Cost: DNO breaks even
  - Shadow marginal pricing has minimum BSUoS benefit but customers benefit through DUoS

Stakeholder	LRMC NPV	Marginal NPV
DNO(s)	£0.7m	£98.0m
NGET	£16.4m	£1.3m
Consumers	£178.0m	£95.8m
Total	**£195.1m**	**£195.1m**

CLASS CBA – projected deployment (restricted response provision)



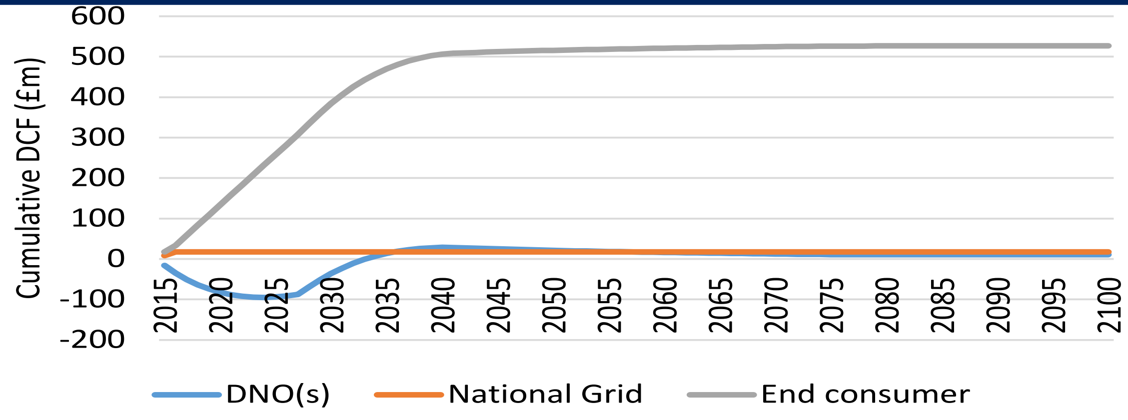


- If CLASS cannot provide dynamic and “high” response the potential market is severely restricted
- No value in deploying at more than 2,000 substations (1GW) (vs 5,900 projected) including initial 354

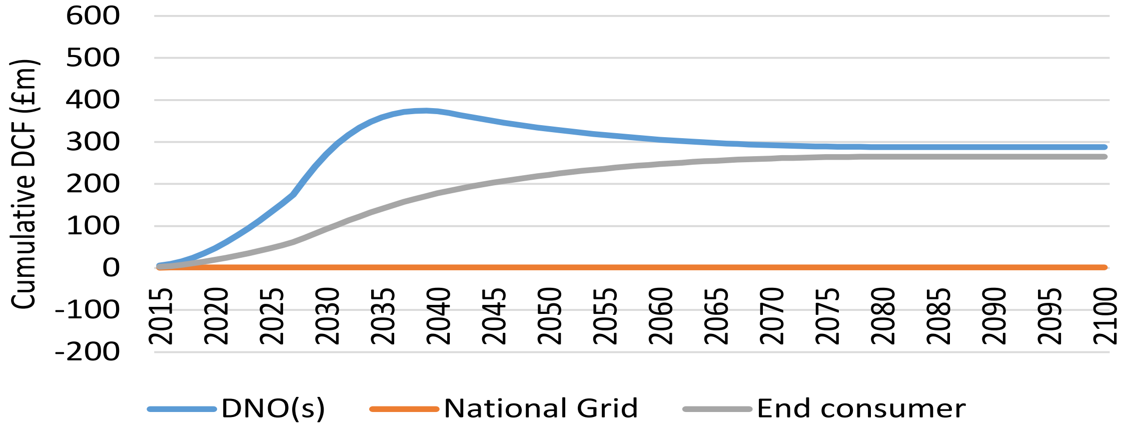
Stakeholder	LRMC NPV	Marginal NPV
DNO(s)	£2.3m	£160.0m
NGET	£16.6m	£1.3m
Consumers	£291.8m	£149.5m
Total	**£310.8m**	**£310.8m**

Potential benefits

Cumulative discounted cash flow by stakeholder (LRMC pricing)



Cumulative discounted cash flow by stakeholder (Shadow marginal pricing)



CLASS deployment
354 substations (180MW) 2014-15
5,900 substations (3GW) 2027
Linear growth between

DNOs incurring capex until 2027

Totex capitalisation means net revenues are shared over 45 years

DNOs under LRMC break even in long run but not until 2035

Stakeholder	LRMC NPV	Marginal NPV
DNO(s)	£10.3m	£287.8m
National Grid	£17.2m	£1.3m
Consumers	£526.8m	£265.2m
Total	**£554.3m**	**£554.3m**

Conclusions

There is significant scope for CLASS to reduce consumer costs

Most valuable if CLASS treated as capable of providing dynamic and high response

If not, deployment of CLASS will be constrained by 2027, reducing its potential to benefit consumers

The DUoS sharing factor allows consumers to benefit under a range of pricing strategies

More consumer benefit if CLASS is priced at cost, manifesting as reduced BSUoS

Under shadow marginal price, all revenues, costs and risks shared between DNO and consumers

Note that CLASS deployment levels could vary as a function of pricing rules

Future benefits and revenues from CLASS less certain

NPV horizon does not necessarily reflect DNO business decision-making

Competitive technologies expected to drive prices down

Growth in market requirement not enough to offset this

Deployment

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Securing the benefits

A key aspect for most projects is to ensure that the forecast benefits are delivered

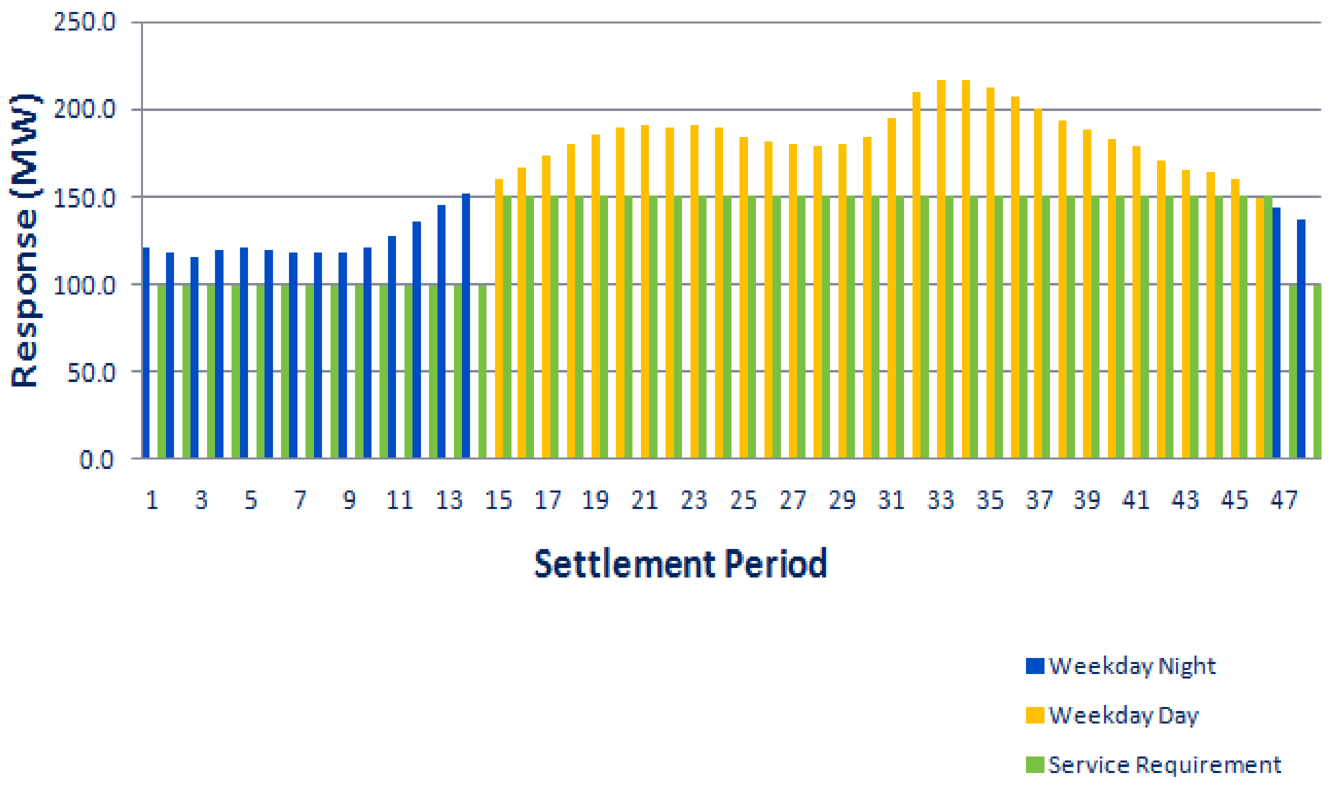
For CLASS, the main benefits to support the investment are revenues for Balancing Services

Revenues are not guaranteed. Contracts must be won in the established markets for balancing services

Service requirements are specified by National Grid

The CLASS services must be configured to deliver these services

CLASS Response – daily profile: winter



Considerations for delivery strategy

Installation work: safety and system risk priorities

Not all required functionality in trial system

New NMS system to incorporate smart meter benefits: need to integrate CLASS functionality

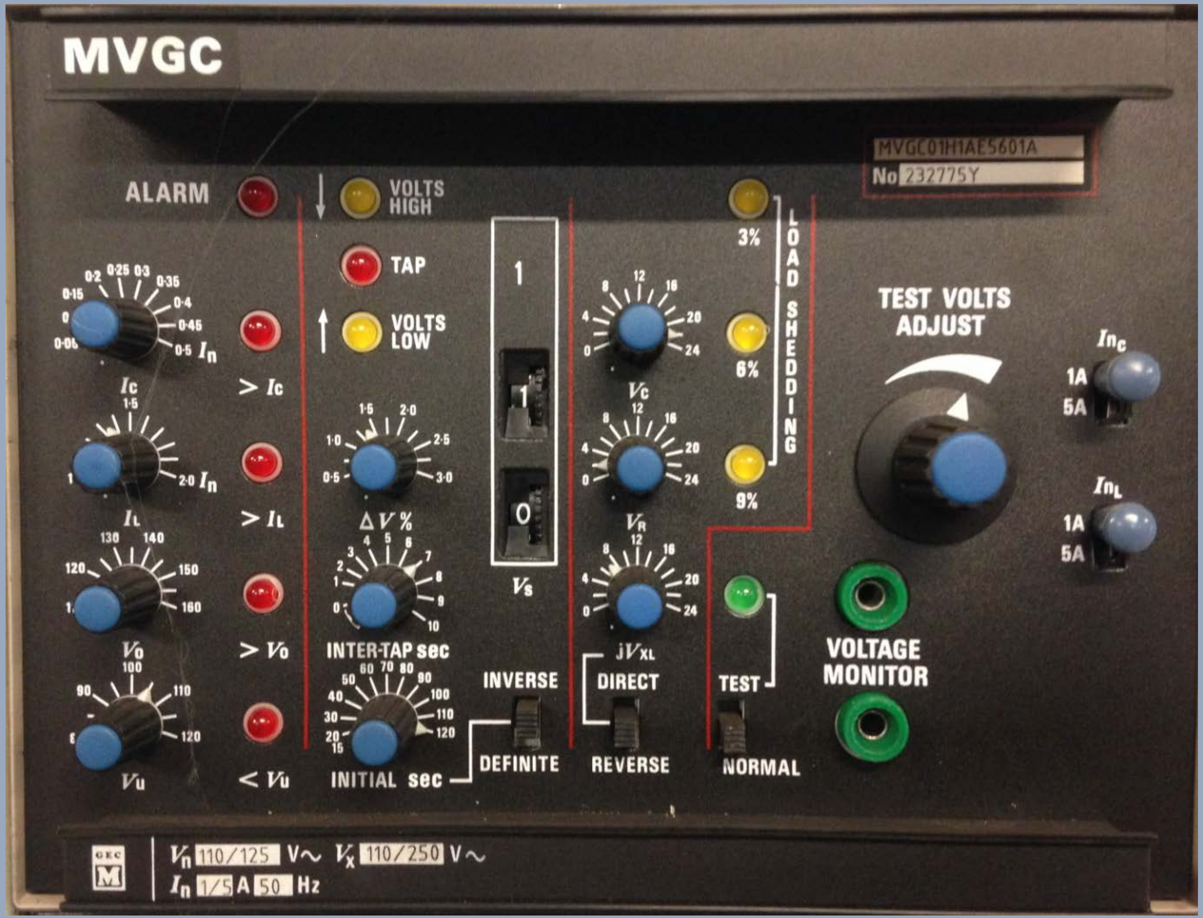
Maintain Grid Code OC6 compliance

Considered using trial equipment and extending trial sites for quicker deployment ● Adds significant risk and cost for minimal benefits

CLASS trial equipment

Existing AVC equipment

Existing AVC equipment



New CLASS trial EAVC

Next Steps

• Initial Site Installations	July – September 2017
• Dashboard development	
• Test Dashboard (Internal)	July 2017
• Full Dashboard (Schneider as part of NMS)	September 2017
• Phase 1 installation at scale	October 2017
• Internal Testing	July – October 2017
• National Grid Testing - Response	November 2017
• First Response Tender submission (monthly process)	December 2017
• National Grid Testing – Fast Reserve	January 2018
• First Reserve Tender submission (monthly process)	February 2018

QUESTIONS

&

ANSWERS

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