The Enhanced Frequency Control Capability (EFCC) Network Innovation Competition Project

Cost Benefit Analysis – Initial Results

25th September 2018

box.EFCC@nationalgrid.com

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Contents

Project Overview

EFCC – the future of frequency control

The EFCC project

- Three year, £8.5 million project network innovation competition project which started in 2015
- Working alongside eight industry and academic partners

Project background

- Changes to energy landscape have identified potential future system operability challenges.
- Project focus on one of these challenges; reduction in system inertia, which results in more volatile system frequency.

The solution

- Provision of rapid frequency response from a diverse range of technologies, to assist with frequency management.
- Underpinned by a monitoring and control system (MCS) that facilitates the coordination of, and maximises the contribution from resource providers.
- Project has focused on the development and testing of the MCS and commercial trials of fast frequency response (target 500ms).

The energy landscape is changing

Great Britain goes without Coal Generation for 24 hours

Friday 21st April 2017 was the first 24-hour period since the 1880s where Great Britain went without coal-fired power stations.

National Grid Control Room @NGControlRoom · 25 Dec 2017

On Sunday #wind generated 35.1% of British electricity, more than gas 26.7%, nuclear 23.4%, imports 8.1%, biomass 2.4%, hydro 1.8%, storage 1.0%, coal 0.6%, solar 0.5%

UK runs without coal power for three days in a row

Demand lower following recent warm weather, making it easier for gas, renewables and nuclear to cover UK's needs

theguardian.com

24th April 2018

National Grid Control Room @NGControlRoom · Mar 18

Yesterday #wind generated 35.7% of British electricity, more than gas 20.3%, nuclear 17.6%, coal 12.9%, imports 6.0%, biomass 4.1%, solar 1.8%, storage 0.8%, hydro 0.6%, other 0.2%, national demand 858 GWh

How can EFCC resolve the system operability challenges?

Reduction in system inertia, making system frequency more volatile

- System inertia is the aggregated inertia of all rotating machines that are coupled to the system
- Frequency is more volatile when system inertia is low

Rate of Change of Frequency (RoCoF) is increasing, faster response capability is required

- RoCoF depends on the total amount of energy stored in the rotating masses which are synchronised to the system
- Reducing system inertia requires faster delivery of response

Regional vs National Frequency: frequency differs across the system immediately after an event

- Requires proportional response to frequency events

EFCC Project: what are the potential system benefits from accessing and instructing faster response to frequency disturbances in a proportional manner?

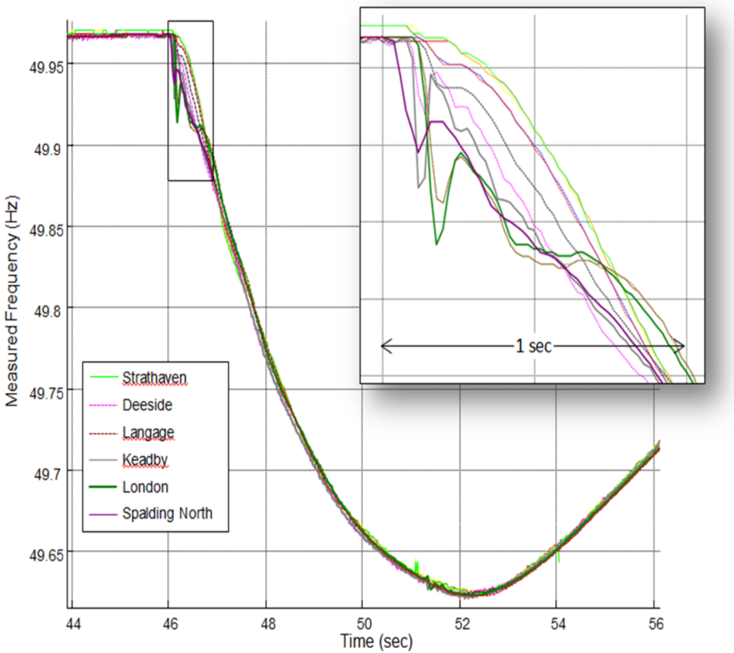
Falling system inertia results in faster Rate of Change of Frequency (RoCoF)

Operating with low system inertia: RoCoF relay changes and predicted reduction in synchronous generation resulting in reduced levels of system inertia *(unconstrained system)*

Frequency Containment: will become more challenging as RoCoF increases with the ability to respond faster required in the next 3-5 years

Regional vs National Frequency: when responding faster to an event (1-2 secs), system frequency differs across the network, requiring proportional response

with divergence & increased unpredictability in system frequency movement across the network



Event detection: ability to accurately identify events within faster timescales

Verification of Event: faster event detection requires accurate measurement

Faster Response: required to 'catch' frequency immediately after the event

Targeted and Proportional: accurate deployment required to avoid unintentional system consequences

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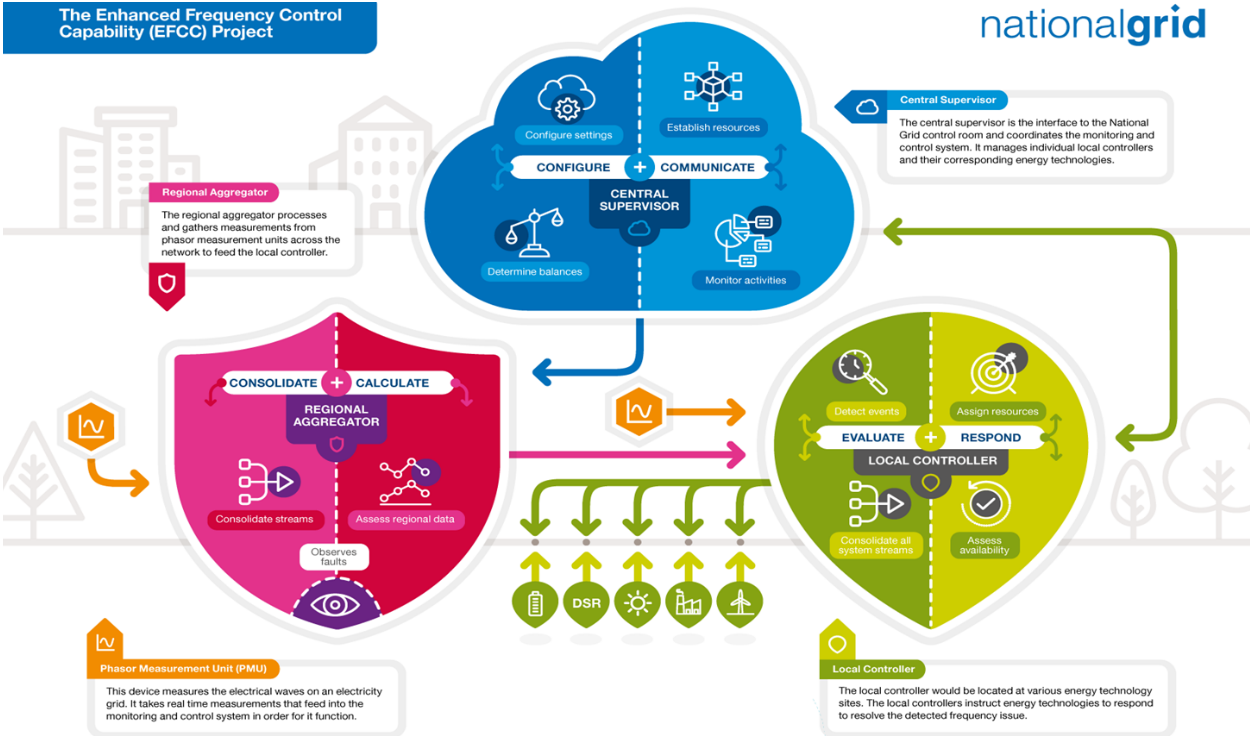
The MCS detects and verifies frequency events, providing a targeted, proportional response



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What is the system benefit of faster frequency response when coupled with the MCS?

Ability to run the electricity system with increasing volumes of non-synchronous generation

Managing the system to faster RoCoF which has regional variation

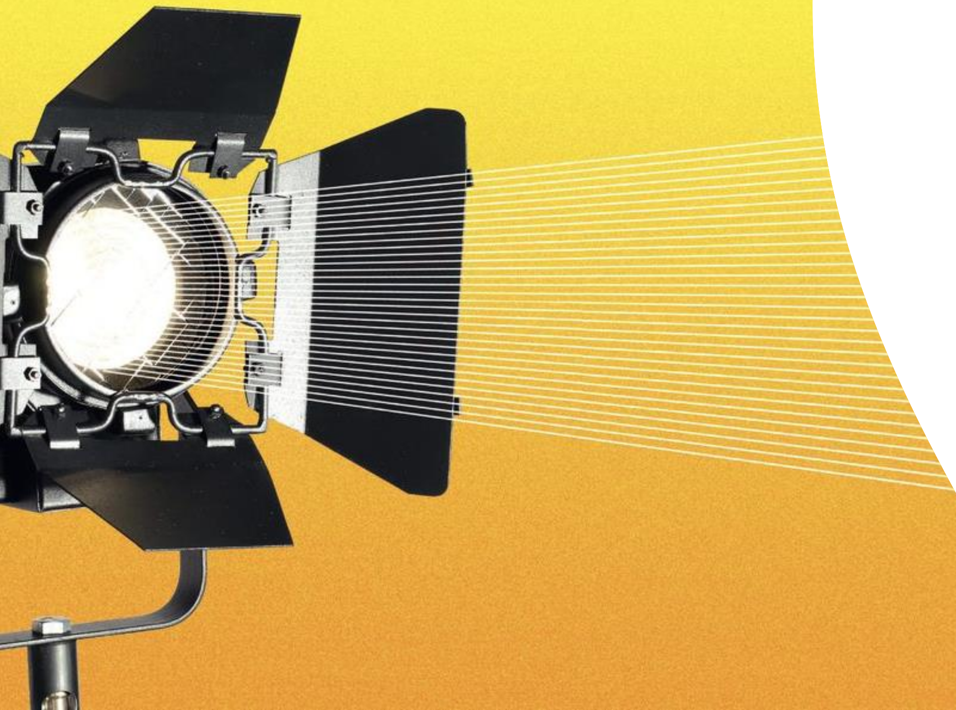
The MCS is a delivery mechanism for managing faster frequency response

Utilising full capability from resource providers, coordinating the output to meet the response profile

What is the system value of faster frequency response coupled with MCS?

The ability to access and coordinate within quicker timeframes

Cost Benefit Analysis



EFCC project CBA

CBA results – progress update

EFCC webinar

25 September 2018

Agenda

	Description
Analysis overview	What are we trying to achieve, what it our approach and what are the key elements of the CBA?
Modelling assumptions	How have we modelled inertia constraints, RoCoF and generator groupings? How have we used Plexos to model EFCC?
Worked example of EFCC response	How will EFCC work in theory and in practice? What's the interaction with traditional response services and timeframes?
Roll-out profile assumptions	What have we assumed about the EFCC roll-out assumptions for each technology?
High level CBA results	What are the high level benefits of EFCC? How are the benefits generated? What are the costs and the total NPV and breakeven date for EFCC?
Further results and analysis	How does inertia distribution change between each scenario and model run?

Summary

Baringa

Baringa are developing cost and benefits analysis (CBA) of the EFCC innovation project. This slide pack provides an overview of the Baringa's approach, our CBA design, work to date and next steps.

What are the expected benefits of EFCC?

- EFCC will give National Grid the tools to accommodate a faster RoCoF, reducing system re-dispatch costs and reducing the overall reserve provision required to manage the system.
- Wider benefits may also expected from a possible reduction in carbon intensity of the GB system.

How are Baringa helping and how will the CBA be used?

- Baringa has developed an economic model to calculate the economic benefits of the EFCC project.
- The CBA will identify the distribution of potential benefits from domestic and cross-border re-dispatch, changes to curtailment, and changes to carbon intensity of the generation mix in GB
- The CBA will be used by:
  - National Grid to consider the potential costs/savings for future response strategy
  - EFCC Project Partners and wider industry to show the value of EFCC capabilities as the system evolves

What have we done so far?

- Used National Grid's FES assumptions (Steady State and Consumer Power) to build a model of the GB market in Baringa's Plexos model
- Developed a set of results to show the impact of a move to faster RoCoF, and the impact on system dispatch costs
- Taken simplified response assumptions from Project Partners to understand the response from the EFCC technologies
- Developed an approach to model the impact of EFCC on response holding volumes for primary, secondary and high, as well as a 0.5 second stylised EFCC response

High level costs and benefits of EFCC

There are a range of possible benefits and costs from EFCC. These costs and benefits will be distributed amongst new and existing market participants, and consumers.

EFCC expected benefits
1. Faster RoCoF = Reduction in **system actions** & **costs** 2. Higher EFCC response potential = **potential impact in holding volumes and costs** **3. Carbon savings** from constraining on thermal plant less as a result of enabling faster RoCoF

EFCC expected costs
1. EFCC **investment costs** (i.e. the cost of innovation to develop the project) **2. Estimated costs of investment** needed in existing GB generation fleet to accommodate faster RoCoF (i.e. RoCoF based relays) 3. Ongoing opex 4. Response holding costs

EFCC distributional impacts
▲ Some redistribution of revenue from the provision of response services from 'traditional' to 'EFCC' providers ▲ Impact on consumers – net benefit/cost feeds through to BSUoS (for example)

Overview of Baringa's CBA approach

Baringa

The CBA includes a counterfactual model run and a 'test case' to show the impact of a change in RoCoF limits and the introduction of EFCC

1. Replicate FES Steady State and Consumers Power in Baringa's in-house dispatch model 2019-2028

Traditional MFR and FFR providers of Primary, Secondary and High response

Move to 0.2 Hz/s in 2021

Counterfactual

2. Run Baringa model with existing RoCoF constraint and traditional response providers
3. Calculate cost of system actions required to meet the current RoCoF constraint
4. Calculate response holding requirements

Δ in total system costs = market impact of EFCC

EFCC impact "test case"

5. Re-run the analysis allowing faster RoCoF
6. Calculate change in system actions required to meet faster RoCoF
7. Calculate the response holding requirements with EFCC capabilities

Move to 1 Hz/s in 2021

+

Sunk Costs

8. Costs of installing and maintaining EFCC (for NG and industry)

Subtracted from benefit to reveal total net effect

Modelling assumptions

RoCoF and inertia modelling

Baringa

The RoCoF and inertia modelling optimises largest infeed re-dispatch actions to manage the system within the required RoCoF limit

RoCoF assumptions

- The fast response from EFCC is a system enabler, allowing the system to operate at a faster RoCoF.
- The main EFCC benefit in the CBA is derived from enabling this RoCoF limit change, and the resulting benefit from reduced system actions. The RoCoF limits used in the modeling are shown in the table below.

Without EFCC, we assume the system can manage a 0.2Hz/s RoCoF

With EFCC, we assume the system can manage a 1Hz/s RoCoF

RoCoF limit (Hz/s)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Counterfactual	0.125	0.125	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Factual-EFCC case	0.125	0.125	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Interconnector assumptions

- Interconnectors are commonly the largest infeed on the system, and therefore constraining down flows on interconnectors is a key tool for managing RoCoF.
- To simulate this, we first model an unconstrained market to calculate the cross-border flows for each hour (i.e. based on economic dispatch). Then, we use these unconstrained market results to set the interconnector flows for the constrained market run (i.e. applying the RoCoF constraints).
- We limit the re-dispatch of interconnectors for RoCoF management to 50 % of interconnector capacity. We also assume a fixed cost of interconnector re-dispatch of £25/MWh.

Generator groupings

- The RoCoF modelling takes into account the impact of generator transmission connection groupings and the impact this has on the largest infeed (i.e. the extent to which a credible loss on the transmission system could result in a RoCoF event exceeding the RoCoF limit).
- The Baringa model takes into account the local RoCoF groups identified by National Grid in 'The Statement of the Constraint Cost Target Modelling Methodology' (Immingham, Saltend, Seabank and South Humber Bank).

Response modelling – response volumes

The response modelling sets the demand for each response service using regression analysis of the relationship between demand, inertia, infeed and static response.

Primary, Secondary, High

- **Counterfactual**: Within the counterfactual, our model is procuring the traditional frequency services:
  - Primary (Max delivery by 10s after the event).
  - Secondary (Max delivery by 30s after the event).
  - High (Max delivery by 10s after the event).
- **Regression analysis**: To calculate response holding volumes we derived a relationships between demand, inertia, largest loss and static volume
- This regression analysis provided coefficients for each variable which we have used in our model to calculate the required response holding requirements for each hour

Response = Demand + Inertia + In-feed/ex-feed loss

Response modelling – response volumes

The response modelling sets the demand for each response service using regression analysis of the relationship between demand, inertia, infeed and static response.

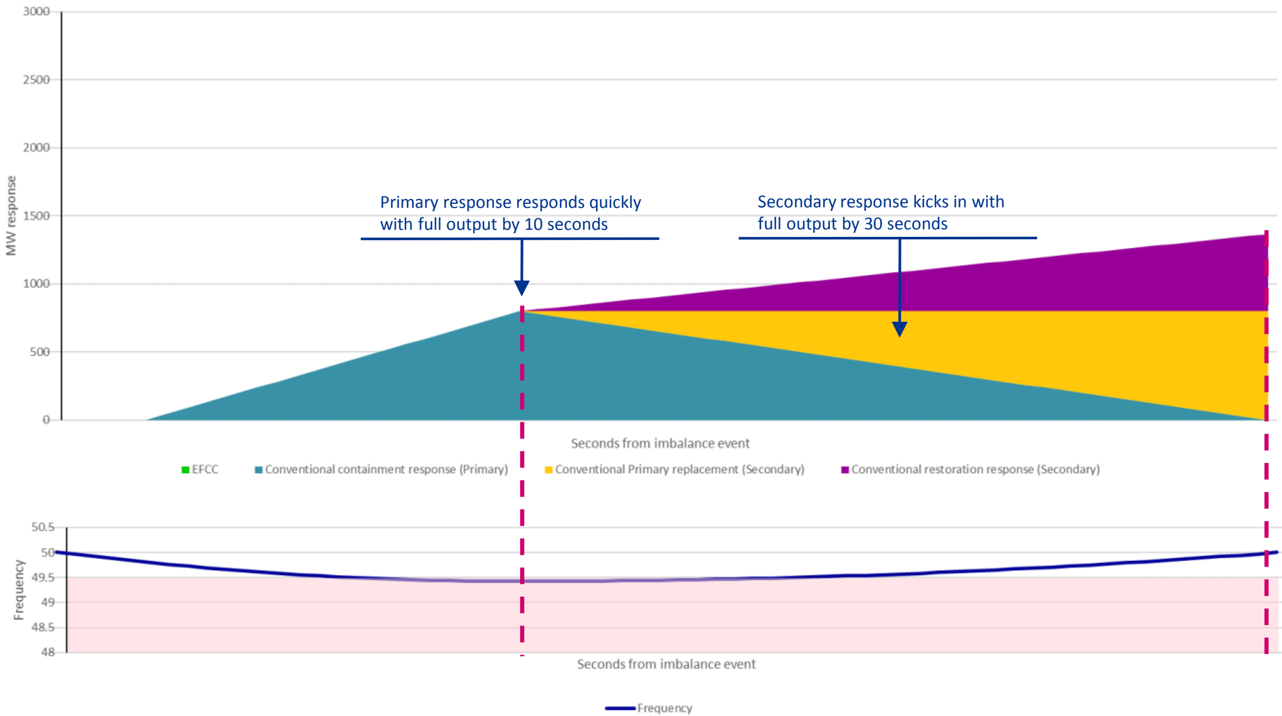
Modelled EFCC response

- We conducted this CBA on the understanding that a faster-acting form of frequency containment is required to manage a system with a faster RoCoF.
- For modelling purposes, we assume that this faster acting form of frequency containment is provided within 0.5 seconds. This is a modelling simplification. We understand alternative services can also deliver valuable response and forms part of the scope of the EFCC analysis. The team at National Grid are considering all these options.
- **EFCC 'factual' modelling**:
  - The modelled EFCC technology response is based on max delivery by 0.5s after the event.
  - The EFCC response requirement is a function of the largest infeed, with our current assumptions that EFCC volume will equal 1 x LIFL
- **Economic choice**: If it is more economic to sustain an EFCC response into the traditional frequency service timeframes, then the model will choose to hold EFCC over current 'traditional' providers.
- Plexos calculates the response holding provisions from each of the technologies included in the EFCC analysis, taking into account:
  - The **economic market** dispatch (where applicable)
  - **Availability** of response in each hour (accounting for wind speed, solar irradiation profiles, system inertia constraints, outages).
- **Low and high response**: In the low response service, Plexos will either use available headroom to count towards response or deload generation where required to ensure response holding requirements are met each half-hour. The opposite is true for high response.

Modelled EFCC Response = In-feed/ex-feed loss

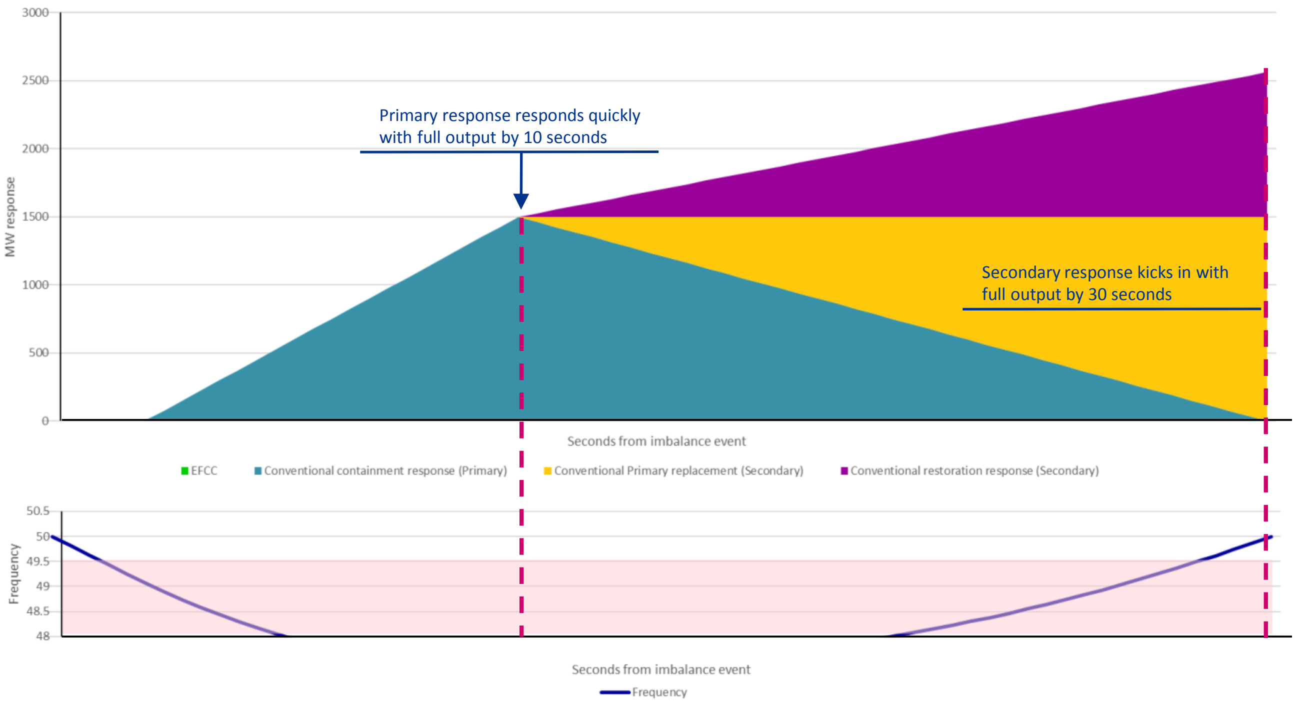
Worked example #1 – Normal conditions

Under normal conditions, and with high levels of inertia, a frequency is contained from dipping past 49.5Hz with traditional Primary and Secondary response



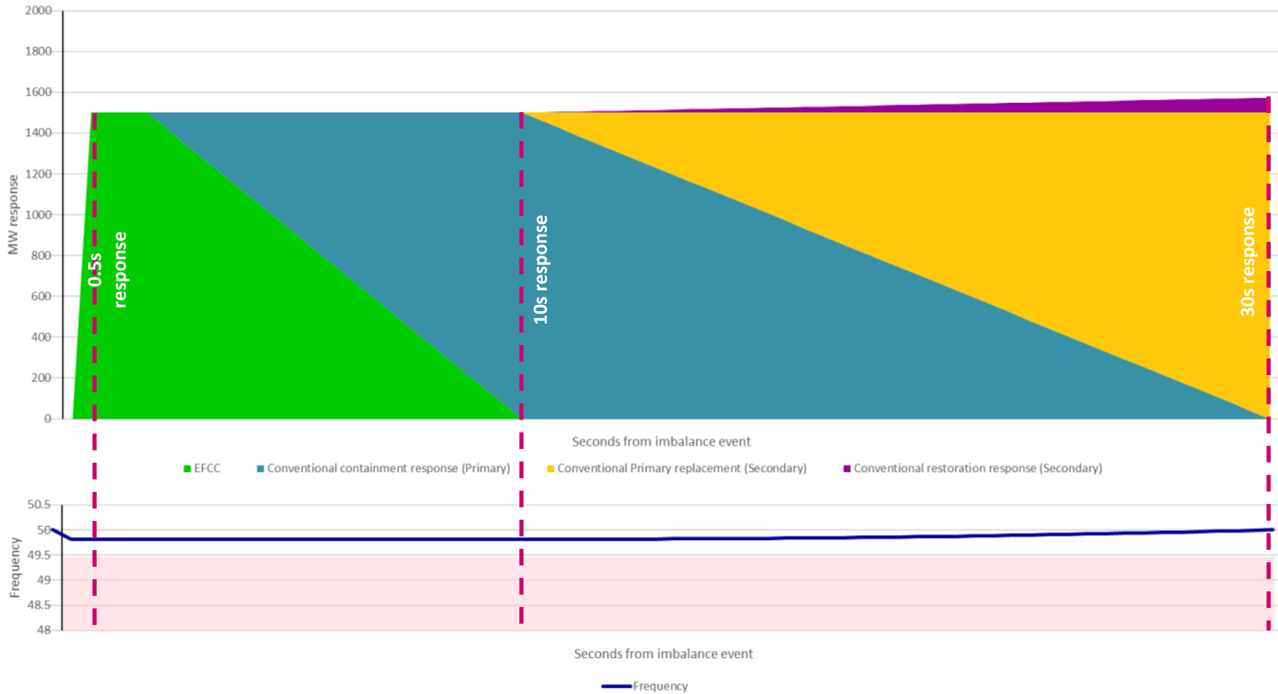
Worked example #2 – Low inertia

With low inertia, the frequency drop cannot be contained by the traditional services as response times are not fast enough. Frequency falls below 49.5Hz in the 2s window before services kick in



Worked example #3 – With EFCC

With EFCC, the very fast response is able to contain the frequency change in the 0.5 second timeframe, even with low inertia, buying time for the traditional Primary and Secondary services to kick-in.



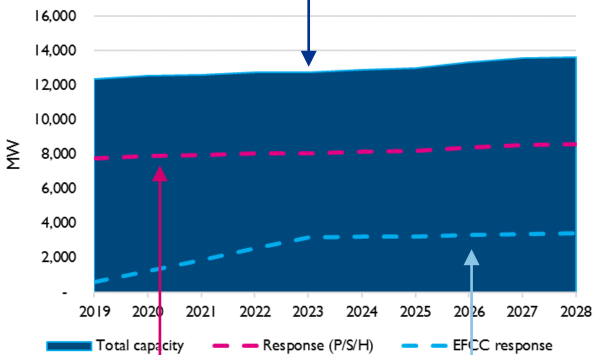
Roll-out assumptions

Roll-out profile – explanatory slide

This slide provides an example of the response and EFCC assumptions presented in the remainder of this section. All of the assumptions are based on 2017 data.

Example roll-out – to explain the assumptions slides

Total capacity taken from the FES for all technologies



Response capability is the MW of total capacity assumed to be able to offer traditional response (primary, secondary and high)

The actual response provided by each technology will be a function of the response capability, and the assumed service response (shown in the pink table)

The EFCC response capability is the MW of total capacity that can offer EFCC capability (i.e. some response at 0.5s)

The actual EFCC response will be a function of this assumption and the assumed EFCC response (shown in the blue table)

De-load: maximum volume the generator can reduce output to offer response service (no change over time)

Counterfactual	De-load	Response
Low response	45%	100%
High response	0%	100%

EFCC	De-load	Response
EFCC boost (low)	0%	1.5%
EFCC (low)	45%	10%
EFCC (high)	0%	10%

Response: Proportion of de-load that counts towards response provision at each timeframe (i.e. 10 and 30s)

We assume an EFCC boost for onshore and offshore wind only, with a small response at 0.5s

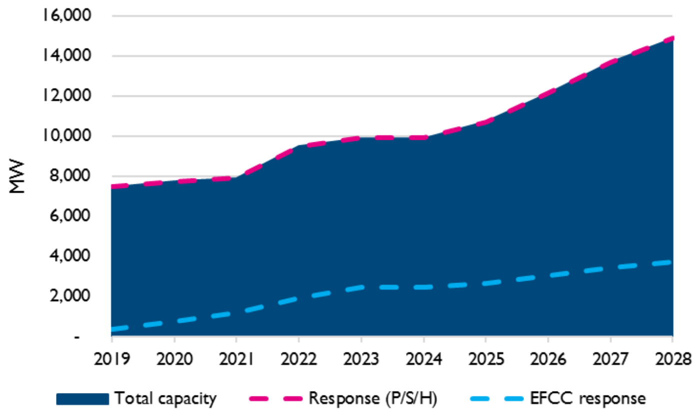
The de-load and potential response approach is the same for traditional response and EFCC. For EFCC we show the assumed response from each technology at 0.5s

The EFCC assumptions are combined with the counterfactual/traditional response assumptions in the EFCC case (i.e. EFCC is additional to traditional response)

Response and EFCC roll-out profiles: Offshore wind

The roll-out profiles are technology specific and show the volume of capacity assumed to be able to provide P/S/H and EFCC response from 2019-2028

Offshore wind



Counterfactual	De-load	Response
Low response	45%	100%
High response	0%	100%

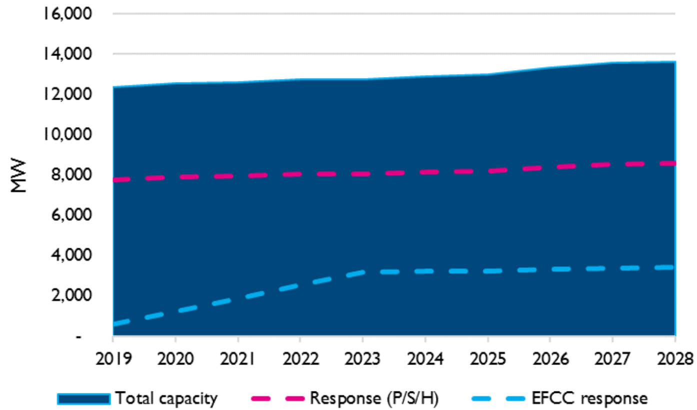
EFCC	De-load	Response
EFCC boost (low	0%	1.5%
EFCC (low)	45%	10%
EFCC (high)	0%	10%

- In the counterfactual we assume that 100% of offshore wind will provide response (Primary, Secondary and High) as part of mandatory service from 2019. To replicate current commercial arrangements, we assume that onshore and offshore wind can only provide high response if the generator is de-loaded to provide Primary and Secondary response.
- This assumption is maintained for new offshore wind investment throughout the time horizon.
- The EFCC deployment assumptions are based on a steady roll-out of 5% of installed capacity per year between 2019 and 2023, then maintained at 25% thereafter
- EFCC response capability is set at 10% at 0.5 seconds, with additional value assumed from EFCC boost capability (1.5% at 0.5 seconds)

Response and EFCC roll-out profiles: Onshore wind

The roll-out profiles are technology specific and show the volume of capacity assumed to be able to provide P/S/H and EFCC response from 2019-2028

Onshore wind



Counterfactual	De-load	Response
Low response	45%	100%
High response	0%	100%

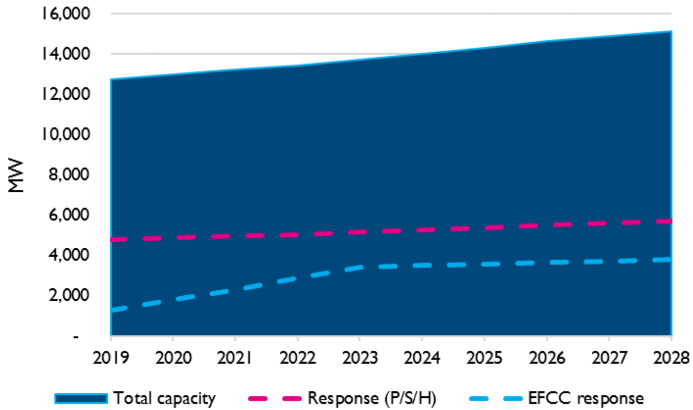
EFCC	De-load	Response
EFCC boost (low	0%	1.5%
EFCC (low)	45%	10%
EFCC (high)	0%	10%

- In the counterfactual, onshore wind greater than 10MW is required to offer mandatory response under the grid code
- We have applied the ratio of wind capacity >10MW/total capacity in 2017 to each modelled year to show the counterfactual onshore wind response capacity (equal to 63% of total capacity)
- We assume that for EFCC, onshore wind can provide the same response as offshore wind
- Onshore and offshore roll-out profiles are aligned, with 5% conversion per year from 2019 to 2023, then maintained at 25% of total capacity each year thereafter

Response and EFCC roll-out profiles: Solar

The roll-out profiles are technology specific and show the volume of capacity assumed to be able to provide P/S/H and EFCC response from 2019-2028

Solar



Counterfactual	De-load	Response
Low response	100%	100%
High response	0%	100%

EFCC	De-load	Response
EFCC (low)	100%	12%
EFCC (high)	0%	12%

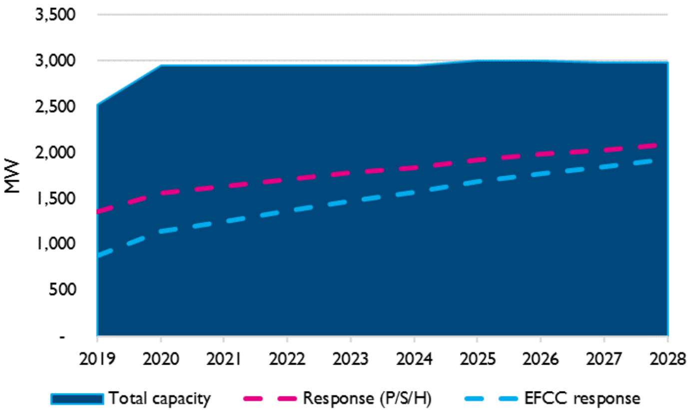
- In the counterfactual, solar generators greater than 10MW are required to offer mandatory response under the grid code
- We have applied the ratio of solar capacity >10MW/total capacity in 2017 to each modelled year to show the counterfactual solar response capacity (equal to 37.5% of total capacity)
- We use the assumption that solar deployment could start at 10% of installed capacity, rising to 25% by 2023 then remaining flat through to 2028

Response and EFCC roll-out profiles: Batteries

Baringa

The roll-out profiles are technology specific and show the volume of capacity assumed to be able to provide P/S/H and EFCC response from 2019-2028

Batteries



Counterfactual	De-load	Response
Low response	100%	100%
High response	0%	100%

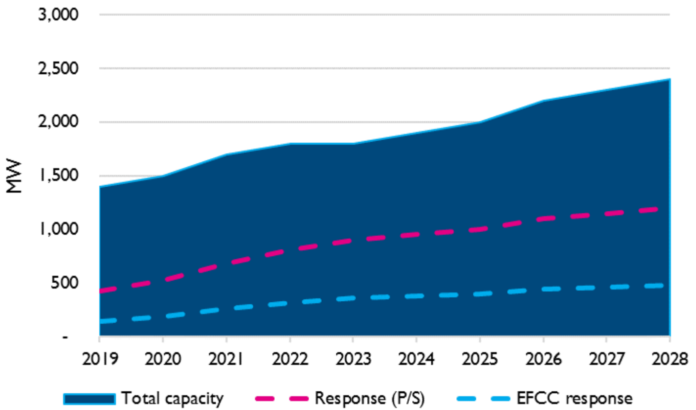
EFCC	De-load	Response
EFCC (low)	100%	100%
EFCC (high)	0%	100%

- We assume that the battery capacity providing response in 2019 is the current FFR market size (600MW) plus 30% of the total market in 2019 is retrofitted to providing response
- This reflects the fact that not all batteries will be operating in response mode in 2019 (also taking arbitrage strategies)
- Between 2020 and 2028, we assume that the volume of new batteries providing response will rise from 30-50%
- In total, combining the existing 600MW and new batter assumptions, we assume that 54% of total battery capacity in 2019 provides response services, rising to 70% by 2028
- We assume that most, but not all of the batteries providing response will also provide EFCC. Battery capacity providing EFCC start at 35% of total installed capacity in 2019 rising to 65% in 2028.

Response and EFCC roll-out profiles: DSR

The roll-out profiles are technology specific and show the volume of capacity assumed to be able to provide P/S/H and EFCC response from 2019-2028

DSR



Counterfactual	De-load	Response
Low response	100%	100%
High response	-	-

EFCC	De-load	Response
EFCC (low)	100%	25%
EFCC (high)	-	-

- We assume 30% of installed DSR provides response in 2019, rising to 50% by 2023 and plateauing at this level
- We have applied a simplified approach to DSR EFCC provision (although noting that three separate products were investigated – static, dynamic and inertial)
- We assume 25% response as 0.5 seconds for DSR with deployment set at 10% of installed capacity in 2019 rising to 20% by 2023 and plateauing at this level through to 2028
- We note that DSR may, in some situations, provide high response at the 0.5s timeframe and will consider how to incorporate this into further analysis

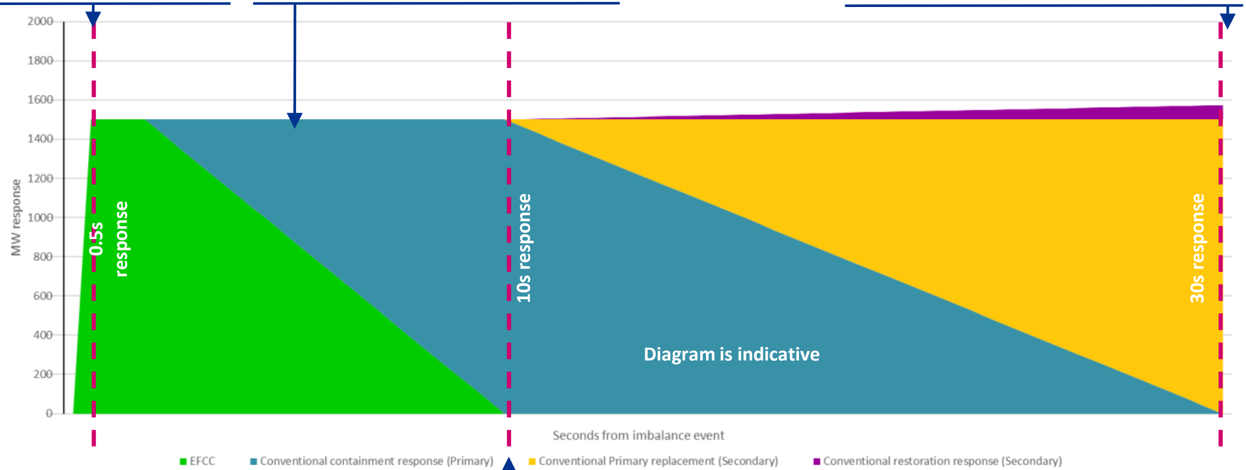
EFCC provision by technology

Different technologies can meet the immediate EFCC requirement (assumed at 0.5s in our modelling) and the transition to Primary and Secondary timeframes.

EFCC 0.5s response:
Mainly provided by **batteries** and **interconnection**, with some provision from **DSR**, **wind** (**wind-boost)** and **solar**

EFCC transitional response:
Between 0.5s and the primary timeframe, **CCGTs** may provide transitional response reducing reliance on 0.5s responders

Traditional secondary response:
In the secondary timeframe, batteries may continue to provide response, alongside traditional providers



Traditional primary response:
Batteries may continue through the EFCC timeframe into primary response (instead of contracting additional/traditional primary providers).

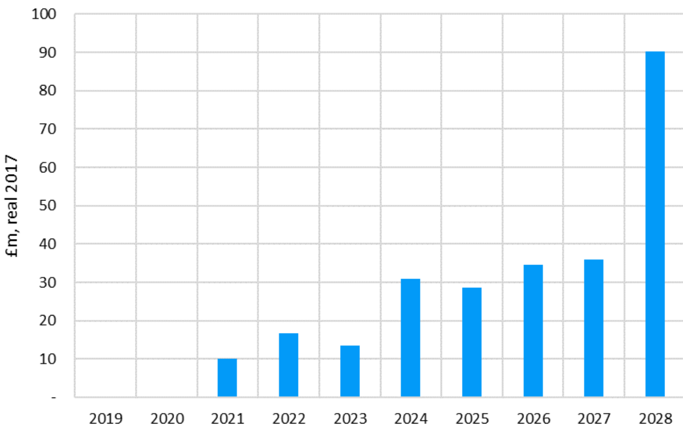
Modelling and results

High level benefits summary – Steady State (1)

Baringa

The benefits in Steady State are driven by renewables and interconnectors, with the step up in 2024 and 2028 driven by new interconnectors setting a higher LIFL

Steady State – total benefit



Key messages

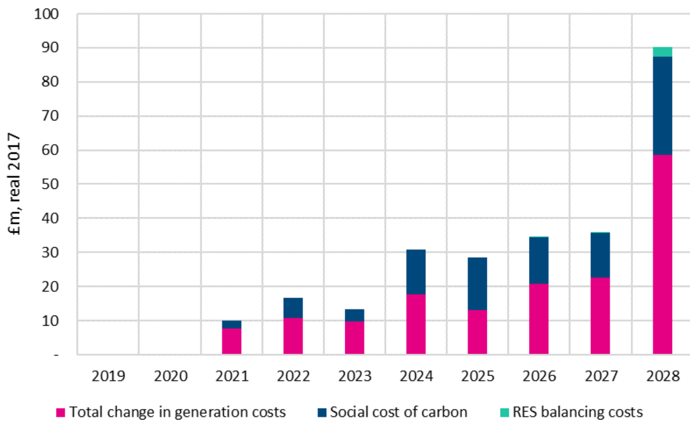
Steady State

- This chart shows the total aggregate benefits from EFCC (we consider costs later in this pack)
- In this modeling set-up, EFCC enables faster RoCoF from 2021
- In early years, we apply an EFCC-choice whereby faster RoCoF is enables in periods (months) where there an expected benefit can be realised
- This limits the benefit in early years as in some periods, the model takes actions to reduce the largest infeed in order to reduce the EFCC requirement (as we model EFCC as a function of LIFL)
- The EFCC requirement is met in all later years due to increasing volume of batteries and renewables
- There is a higher benefit from 2024 onwards with two 2.4 GW new interconnectors coming online
- As a result, LIFL increases. Managing this LIFL is costly in the low RoCoF run, which leads to a larger benefit with EFCC (i.e. high RoCoF) from 2024 onwards
- In 2028, another 1.4 GW interconnection comes online, leading to further jump in benefit

High level benefits comparison – Steady State (2)

Around two-thirds of the EFCC benefits result from a change in generation cost (re-dispatch and LIFL actions) the remainder is largely from the reduction in carbon intensive generation

Steady State– breakdown of benefits



GB generation costs — Total 'European' generation costs (+ NL, SEM, FR, BE, NO, DK) + IC re-dispatch costs = Total generation cost

Key messages

Total change in generation costs

- The change in generation costs reflects the total system cost change with a move to faster RoCoF
- This include GB and connecting market generation costs (including fuel, VOM, emission and start and shut down costs), plus an assumed cost of interconnector re-dispatch as shown below (at an assumed cost of 25 £/MWh)

Social cost of carbon

- Our modelled generation costs takes into account the cost of carbon for each generator. Here we add in the social cost of carbon, from the Treasury green book to account for wider benefits to society
- This only reflects the GB portion of carbon savings (i.e. does not take into account the change in carbon in connecting markets)

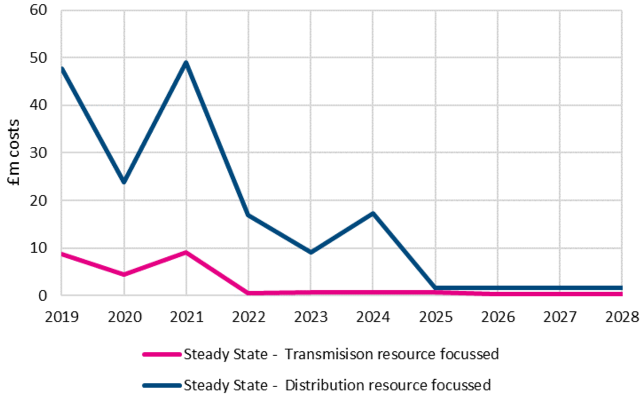
Renewable curtailment costs

- At a faster RoCoF, the system can accommodate a greater volume of renewables. This reduces the cost or renewables curtailment, represented by a benefit in the CBA
- We calculate this using the change in wind and solar generation multiplied by an assumed balancing bid cost (£50/MWh onshore wind, £100/MWh offshore wind & solar)

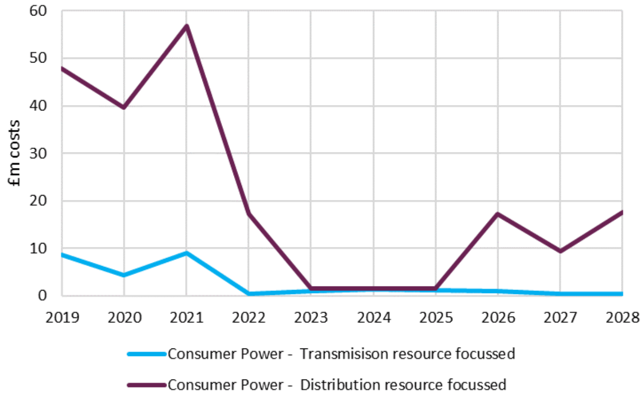
High level results summary – Cost assumption

The current cost assumptions are based on NG's assessment of EFCC costs (MCS capex and opex along with provider costs) between 2019 and 2028

Steady State



Consumer Power



Cost variant description

Transmission resource focussed scenario:

- The required volume is satisfied via fast response technologies available in the FES scenarios.
- Cost assumptions are based on the expected volumes of upside response (down side not being a major issue) and the number of fast response providers that satisfy the volume. Each provider has a local controller
- Wider National Grid MCS hardware, system monitoring equipment, estimated redundancy plus maintenance and support costs have been included

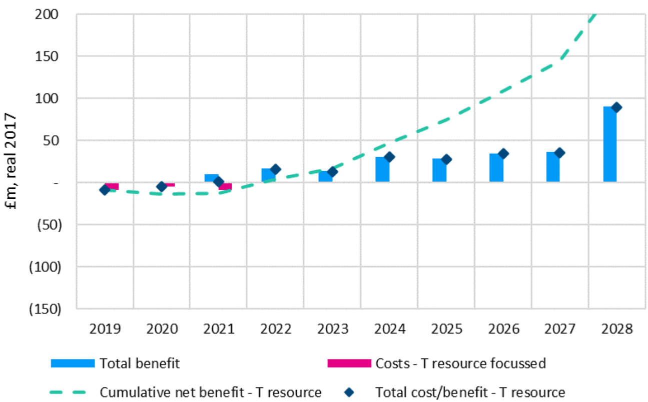
Distribution resource focussed scenario:

- For ease of illustration, based on battery provision (5MW units) managing output at 50% state of charge. In practice could represent a broader range of providers.
- Cost assumptions and volume requirement as per Transmission focused scenario.
- Larger number of more remote located resources to meet same volume of procured capability, and estimates for a dedicated communications link to each provider are included.

High level results summary – Steady State

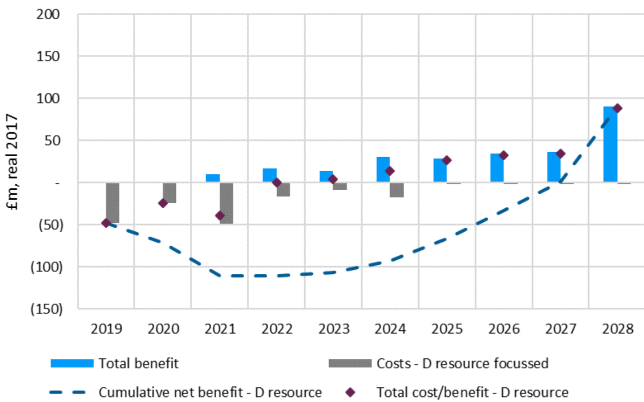
The Steady State results show positive NPVs under both cost variants, with only a small positive NPV under the more costly distribution-focussed as a result of battery volume costs

Steady State – Transmission resourced



Results metrics – SS, T	
NPV (costs and benefits)	£175m
Breakeven	2022

Steady State – Distribution resourced

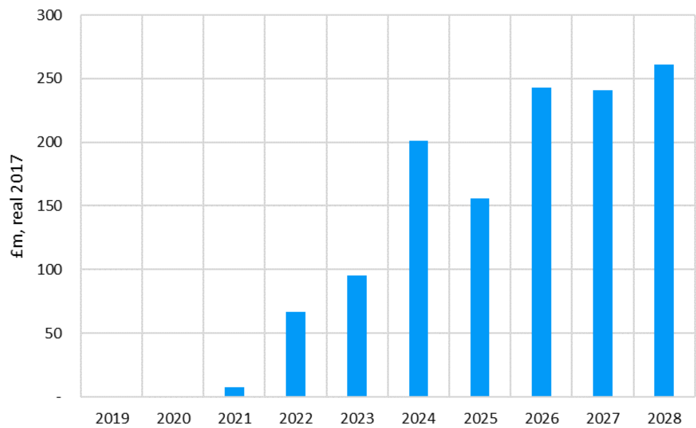


Results metrics – SS, D	
NPV (costs and benefits)	£45m
Breakeven	2027

High level benefits summary – Consumer Power (1)

Benefits in the Consumer Power scenario are driven by large volumes of interconnection and renewables – reductions in re-dispatch and LIFL actions drives a large benefits with higher RoCoF

Consumer Power – total benefits



Key messages

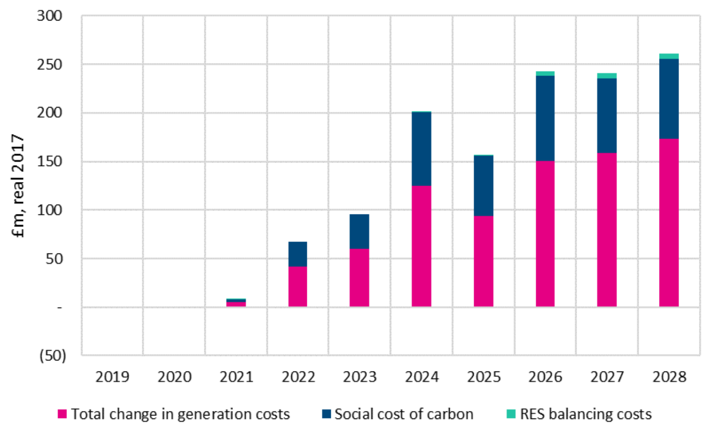
Consumer Power

- 10-year NPV (benefits only) = £978m (at 3.5%)
- EFCC enables faster RoCoF from 2021
- EFCC requirement met in all years due to significant volume of batteries and renewables in this scenario
- Significant interconnector investment in this scenario delivers a large, and increasing benefit from EFCC, as the higher RoCoF significantly reduces the cost of re-dispatch
- Similarly, the large volume of renewables in this scenario increases the impact of the move to faster RoCoF
- In particular, we see:
  - 2022: 2.4GW
  - 2023: 2GW
  - 2024: 2.8GW
  - 2026: >3GW
- The 1.4GW interconnectors set LIFL in both scenarios, with a more significant impact in Consumer Power due to the large number of large projects

High level benefits comparison – Consumer Power (2)

The ratio of benefits is similar between Steady State and Consumer Power, with more benefit from a reduction renewable curtailment costs in this scenario, given renewable investment

Consumer Power – breakdown of benefits



GB generation costs

Total 'European' generation costs (GB, NL, SEM, FR, BE, NO, DK)

+

IC re-dispatch costs

=

Total generatio n cost

Key messages

Total change in generation costs

- The change in generation costs reflects the total system cost change with a move to faster RoCoF.
- This include GB and connecting market generation costs, plus an assumed cost of interconnector re-dispatch (as shown below)

Social cost of carbon

- Our modelled generation costs takes into account the cost of carbon for each generator. Here we add in the social cost of carbon, from the Treasury green book to account for wider benefits to society
- This only reflects the GB portion of carbon savings (i.e. does not take into account the change in carbon in connecting markets)

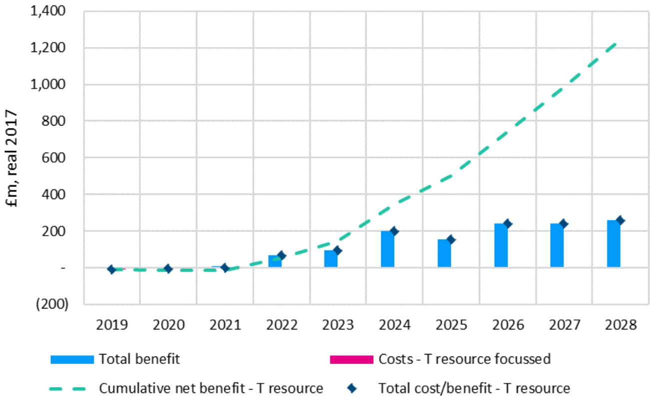
Renewable curtailment costs

- At a faster RoCoF, the system can accommodate a greater volume of renewables. This reduces the cost or renewables curtailment, represented by a benefit in the CBA.
- We calculate this using the change in wind and solar generation multiplied by an assumed balancing bid cost (£50/MWh onshore wind, £100/MWh offshore wind & solar)

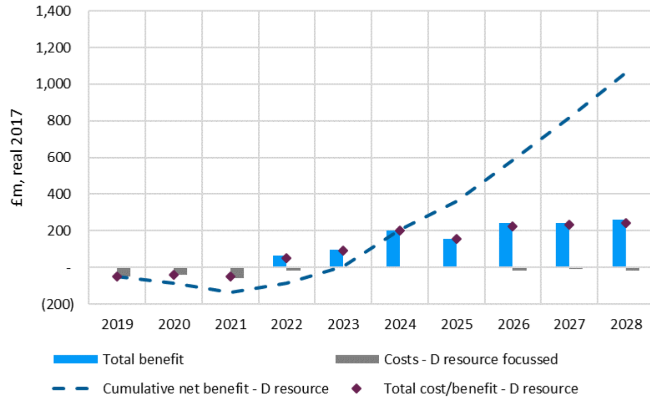
High level results summary – Consumer Power

The higher benefits under Consumer Power, driven by renewable and interconnector assumptions, results in a large positive NPV under both cost variants

Consumer Power – Transmission resourced



Consumer Power – Distribution resourced



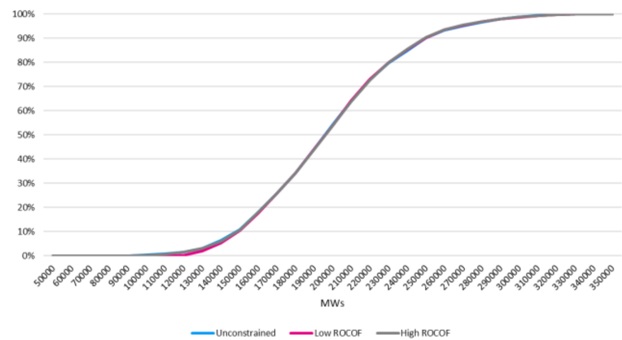
Results metrics – CP, T	
NPV (costs and benefits)	£953m
Breakeven	2021

Results metrics – CP, D	
NPV (costs and benefits)	£792m
Breakeven	2023

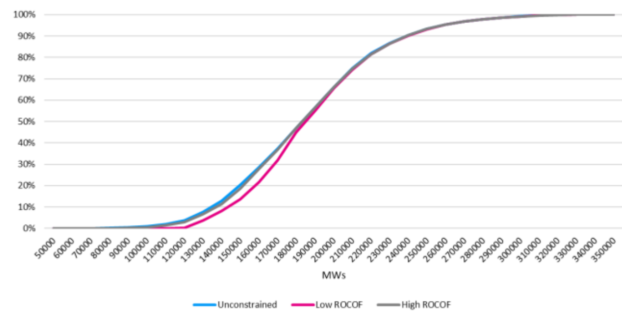
Inertia distribution – Steady State

These charts show how system inertia changes over the modelling horizon in Steady State.

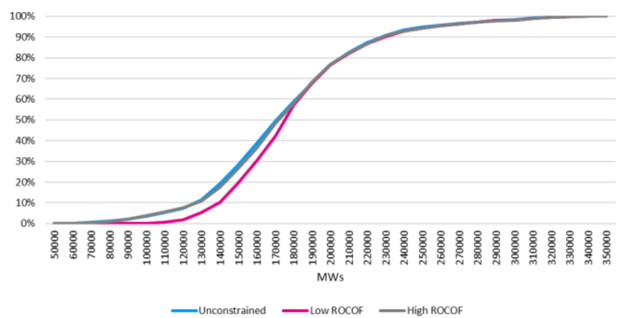
2021



2024



2028

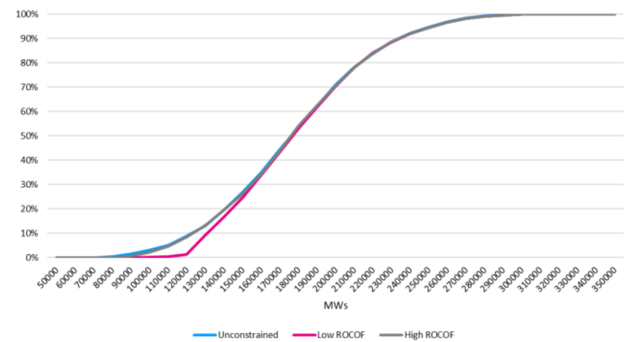


- The charts compare inertia in the unconstrained market run (blue), with the Low RoCoF run (pink) and High RoCoF run (grey)
- In 2021, there is very little difference between the low and high RoCoF runs, but this does show a small increase in inertia in the Low RoCoF run (pink line to the right)
- Later on in the scenario, we see higher inertia in the Low RoCoF run as plant is brought on for inertia to manage the low RoCoF limit
- Moving to High RoCoF moves inertia back to levels closer to the unconstrained run, as fewer actions are needed to manage system frequency compared to the Low RoCof run

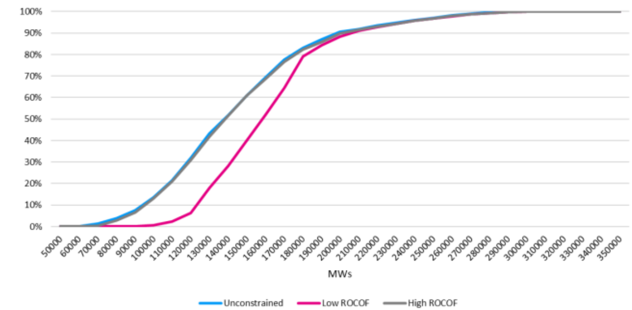
Inertia distribution – Consumer Power

These charts show how system inertia changes over the modelling horizon in Consumer Power.

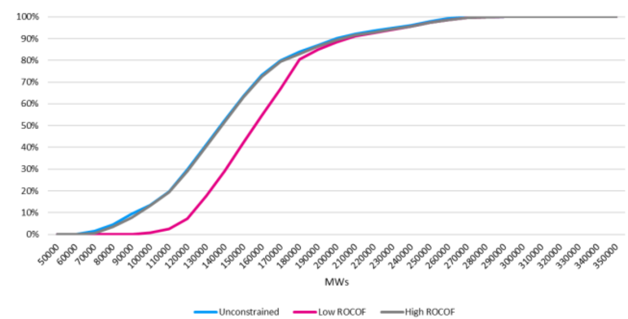
2021



2024



2028



- In the Consumer Power scenario, the significant volume of renewables results in a larger difference in inertia distribution between the unconstrained run and the Low RoCoF run (i.e. the system needs more re-dispatch actions to meet the RoCoF constraint)
- The modelling shows this as a greater move in the inertia distribution curve between the unconstrained run and Low RoCoF run (compared to Steady State)
- As a result, moving to Higher RoCoF delivers a greater benefit than in the Steady State scenario

Next Steps

Next steps for EFCC Project

Completion of commercial trials

Completion of cost benefit analysis including sensitivities

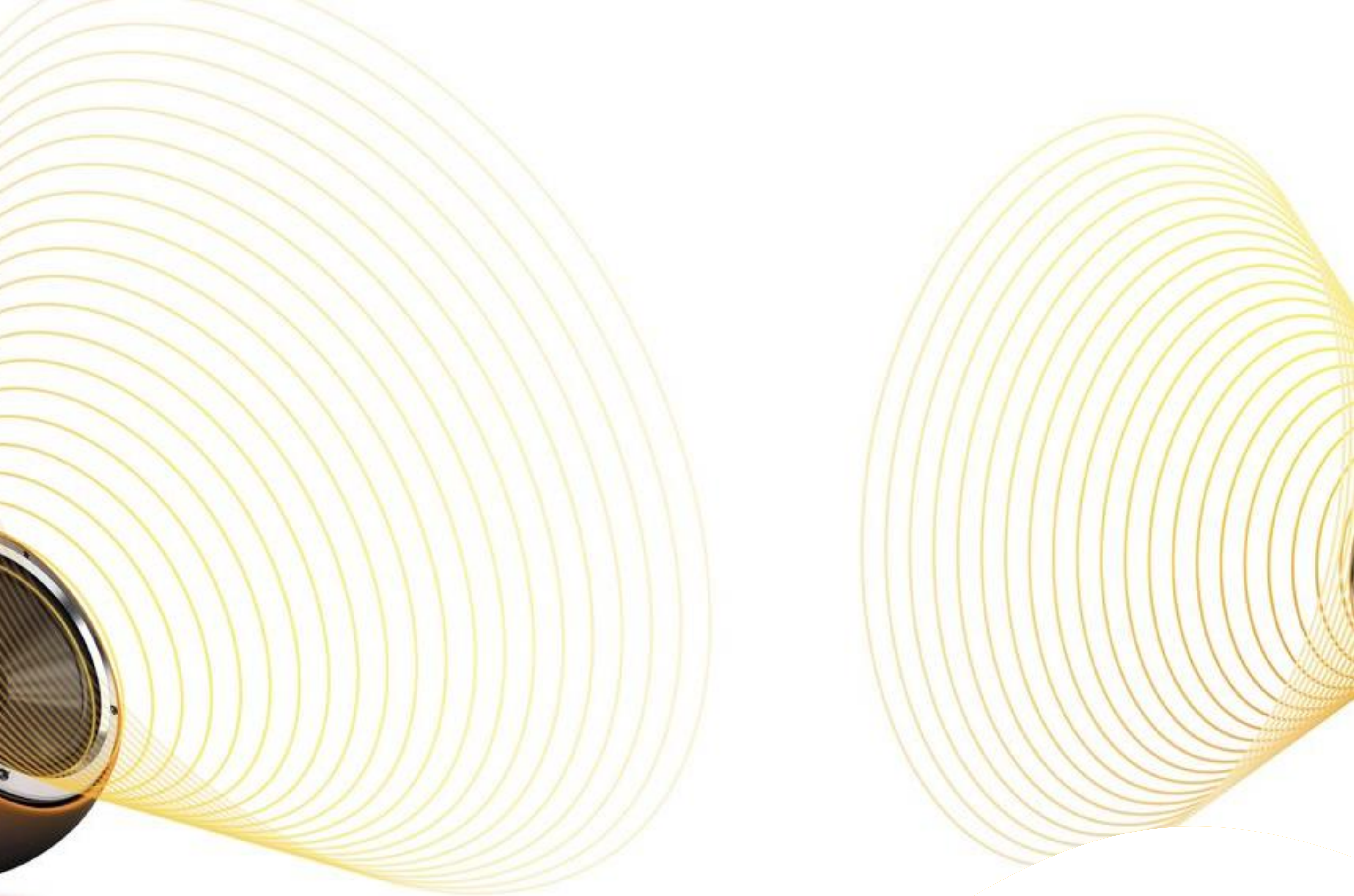
Installation of MCS on the system – testing communications network

Project learning into business as usual activities

Continue to share our findings and learnings with the industry

Thank you for listening

- Please send any questions to box.EFCC@nationalgrid.com
- Feedback on webinar welcome, please complete survey
- Presentation will be available on EFCC website: www.nationalgrid.com/EFCC



nationalgrideso.com

National Grid ESO, Faraday House, Warwick Technology Park,
Gallows Hill, Warwick, CV346DA