# Demand Response Mechanisms and Network Support Services

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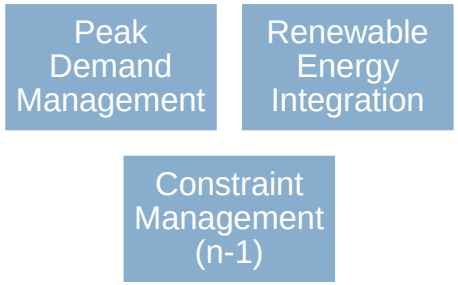
# Demand Response Mechanisms

- **Demand Side Management (DSM) – Direct Load Control**:
  - Demand that can be *directly* controlled either remotely from the control room, or locally when installed in appliances (*deterministic* quantity)
- **Demand Side Response (DSR) – Indirect Load Control**:
  - *Incentive based DSR (Interruptible Contracts):* activated in times of system stress when load shedding is required ('*near deterministic*' quantity)
  - *DSR in response to peak-, real-time- and time-of-day pricing*: economic reasons (*probabilistic* quantity)

- In this presentation we will be using term *DSR* for both DSM and DSR

# Overview of DSR

- Study done by 'Work Stream 6 (WS6)' of the 'Smart Grid Forum'-2015
  - WS6 chaired by 'Ofgem', experts from all DNOs, suppliers, etc.
  - WS6 in charge of 'Commercial and Regulatory Issues'
  - Full report on: https://www.ofgem.gov.uk/publications-and-updates/working-documents-work-srex
- Study done for WS7 of the 'Smart Grid Forum' – 2016
  - WS7 in charge of technical studies of future distribution networks
  - Study 'Distribution Systems 2030': https://www.ofgem.gov.uk/electricity/distribution-networks/forums-seminars-and-working-groups/decc-ofgem-smart-grid-forum/workstream-seven-ws7-2030-distribution-system
- **Drivers for DSR**:



# DSR Drivers

1. **Peak Demand Management:**

   - DSR can be an alternative to traditional generation reserve
   - DNOs find DSR an option to postpone reinforcements
   - DSR in DNOs' business planning:
     - ENWL: asking customers to shift the peak away from peak periods
     - SSE: need for aggregated DSR from buildings (lighting & motor/pump loads)
     - UK Power Networks: storage and direct load control (fridges, heating, cooling systems)
     - Commercial arrangements to engage domestic and I&C customers at times of high load and network emergencies
     - SPEN: DSR as a short-term alternative to asset replacement

# DSR Drivers

**2. Constraints Management**:

- Every distribution network needs to comply with national planning standards ‘ER P2/6’ (ENA)

- When network emergencies occur, there may be cases when DSR is very effective in managing constrained networks

- DSR can also be used to help DNOs meet the Quality-of-Supply targets

- It is expected that DSR provider certainly delivers an agreed service over a defined period of time

- National Grid has recognized constraint management services as an ancillary service contracted through a commercial service contract

- **Conclusion:**

*Pre-contracted DSR provides occasional constraint management opportunities for DNOs at times of reduced network capacity*

# DSR Drivers

**3. Renewable Energy Integration**:

- ‘A lot of’ wind and solar generation connected to distribution networks to meet emission targets

- Supply-side *flexibility* significantly reduced due to uncontrollability of wind & solar sources

- Increased *flexibility* on demand side required

- DSR is a potential solution to ensure demand-supply balance in networks with a higher amount of intermittent generation

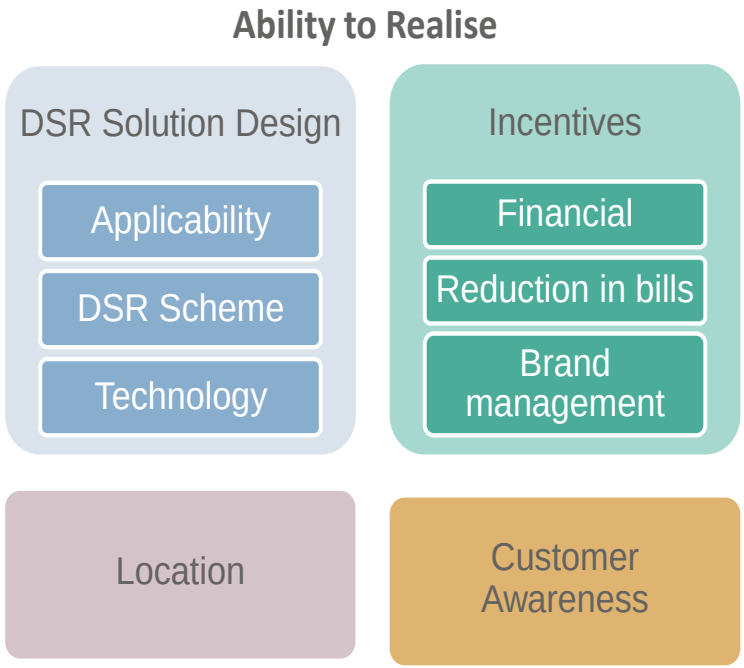
- DSR could increase load in times of higher output from wind or solar generators and lower loads when renewable generation is not available

- **Conclusion**:

*Intermittent generation has reduced supply-side flexibility and increased the need for demand-side flexibility*

# Ability to Realize

- Ability to realize the DSR potential is dependent on 4 factors:
  - (a) Design of DSR solution
  - (b) Incentives offered to participants
  - (c) Availability of right solution at right location
  - (d) Customer awareness



# Ability to Realize

1. **Design of DSR Solution**:

- Domestic, commercial, SME and large businesses should be involved

- Motivation to participate in DSR *varies significantly* among customer groups and even within the same group

- The DSR solution will need to include technical, commercial and user-appeal aspects

- Participation of customers in several schemes may be appropriate

- Schemes that require *manual response* are expected to be less effective than the ones which are equipped with *automated systems*

- Enabling technologies (reliable, secure communications, smart controllers-intelligent loads) will play an important role

**Conclusion:**

*DSR should be attractively designed to gain effective participation from customers*

# Ability to Realize

**2. Incentives:**

- Financial incentives are the primary reason for customer participation in DSR schemes

- C&I customers can also be motivated by some other factors, such as reduction of electricity consumption and bills

- Some commercial companies wanted to participate in a DSR scheme to reduce carbon footprint and improve *company brand image*

- Customer survey seems to be good starting point; questions need to address technical and commercial aspects

**Conclusion:**

*Schemes with higher incentives are expected to get higher participation*

# Ability to Realize

**3. Location:**

- The extent to which DSR resource could be utilised depends upon its location on the network

- DSR implementation will only be successful if peak demand reduction, demand shifting and addition of generation occurs on the sections of the network where it is actually needed

- Planners need to understand DSR requirements, system requirements and interactions with other system interventions

- System requirements are likely to be *dynamic in time* so this will become a new aspect

- Account must be taken of a TSO using DSR for *national* demand balancing or constraint balancing

- Awareness is needed of both *local* and *national* requirements as there may be times when they conflict each other

# Ability to Realize

4. **Awareness:**

- Many customers will not be aware of the opportunities in the electricity network and how they could contribute and benefit

- All DSR initiatives would have to communicate the benefits to the target customers effectively

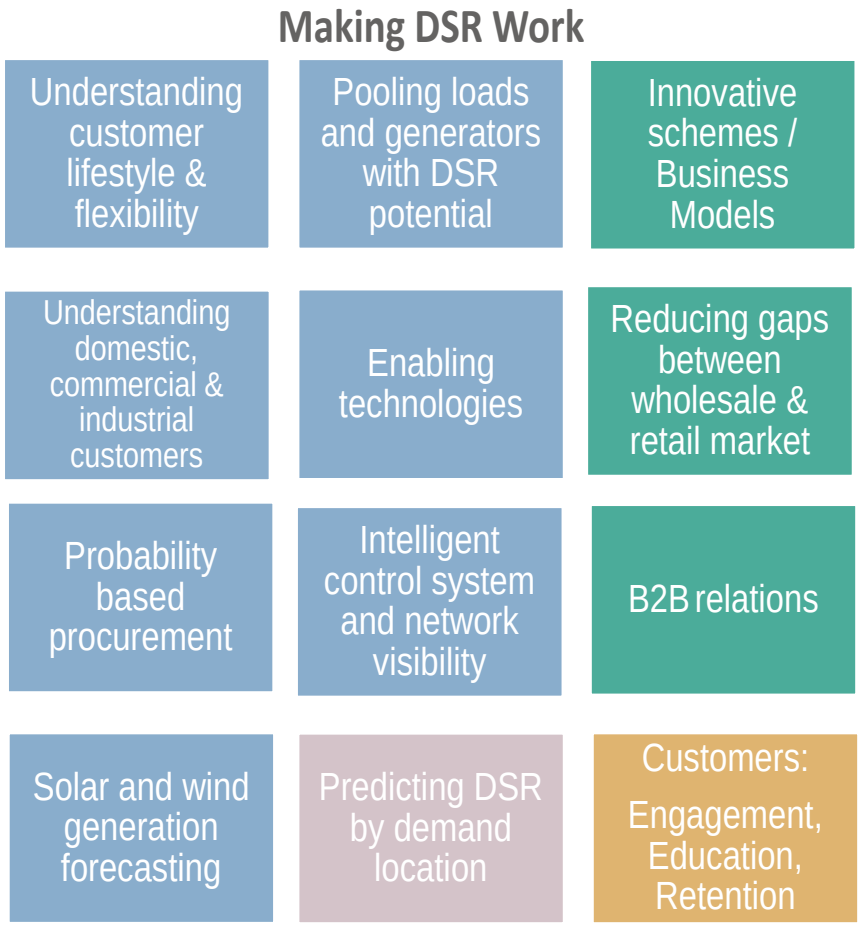
- It is necessary to recognise the party that will be the most appropriate to communicate with the customers

**Conclusion:**

*Customer engagement is essential and continuously required*

# Making DSR Work

- The studies have indicated the following factors are most important:



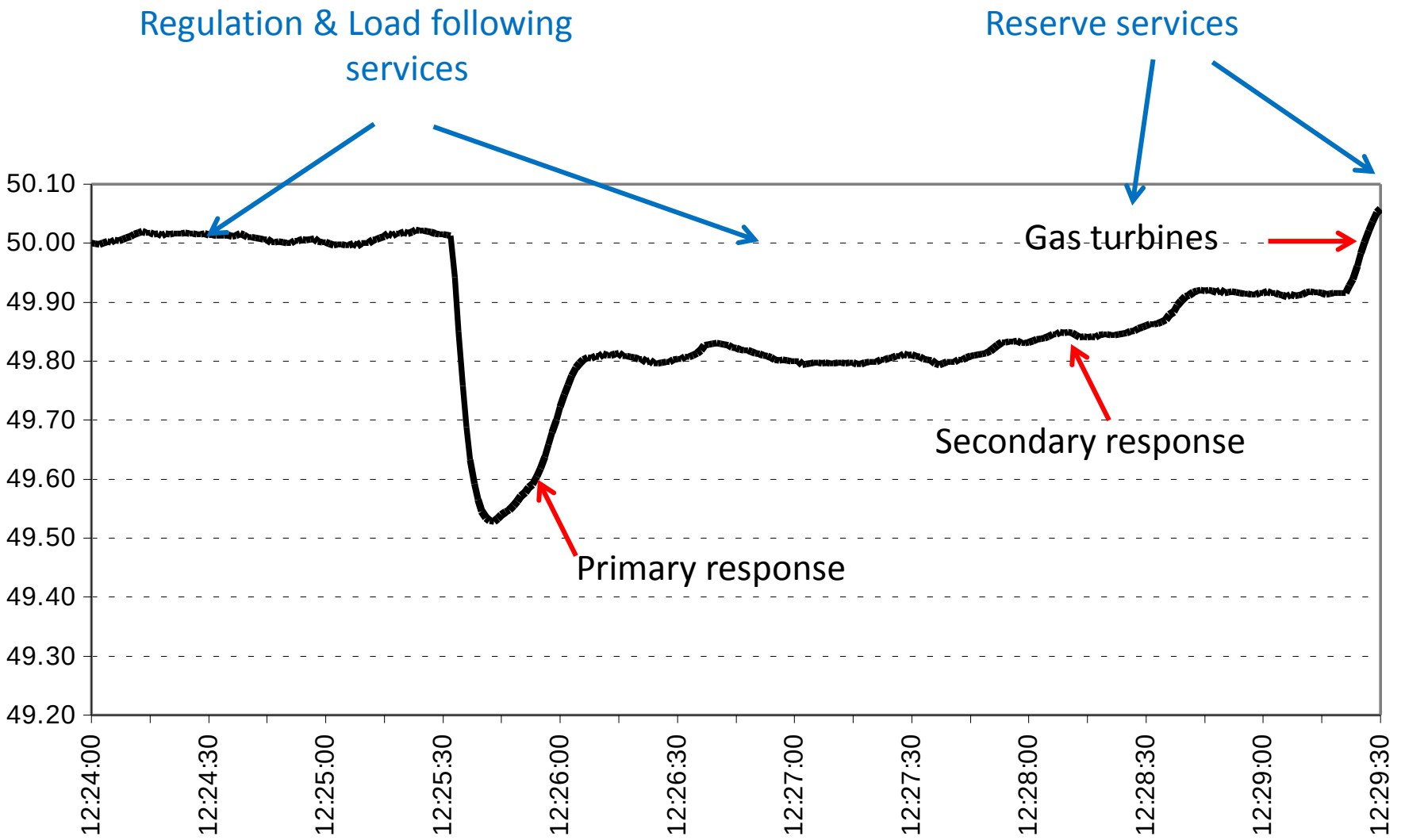
# Making DSR Work

- *Customer interventions could be better designed by studying customer lifestyle (link between household income & electricity use)*
- *I&C DSR should be considered to avoid primary network reinforcement*
- *Recognising and aggregating similar loads is essential to get meaningful response*
- *Incentive schemes: Time of Use Tariff is the most popular option but implementation typically requires AMI and commercial settlement*
- *Enabling technologies: Automated DSR helps ensure that customers respond predictably and persistently over long periods*
- *DNOs would need to maintain new Business to Business relationships (e.g. aggregators, bulk consumers and smart device manufactures)*
- *Over-procurement of DSR using a probability based approach is necessary to ensure a reliable response*
- *Dynamic wholesale prices to be made visible to retail customers DSR*
- *Active Network Management can be a facilitator of DSR schemes*
- *DNOs need to provide location based information for Non-discriminatory access to DSR*
- *Finding right customers at the right location is difficult, and so is keeping them involved*

# Network Support Services
# or
# Ancillary – Balancing Services

# Fundamentals of Ancillary – Balancing Services

## Example: Outage of a large generating unit



# Fundamentals of Ancillary – Balancing Services
# How much ancillary services should be bought?

- (**Independent**) **System Operator** purchases the balancing services
  - Works on behalf of the users of the system
- Balancing services are most important for contingencies
  - ***Availability*** is often more important than actual usage
  - Actual usage is often remunerated through ***utilization*** tariffs
- Not enough services
  - Can't ensure the security of the system
  - Can't maintain the quality of the supply
- Too much services
  - Life of the operator is easy
  - Cost passed on to system users
  - Operator needs the right incentives to perform economically
- Complicated **probabilistic Benefit – Cost (B/C) Analysis**

# Fundamentals of Ancillary – Balancing Services

## How should ancillary – balancing services be obtained?

- Two approaches:
  - **Compulsory provision**
  - **"Market"** for ancillary – balancing services
  - The latter is often realized through **tenders** and **auctions**
  - **Tender** is an open Request for Proposals when a company wants to buy something; potential 'suppliers' provide **bids**
  - **Auction** is a (public) event where goods or services are sold to the highest bidder(s)
- Both approaches have advantages and disadvantages:
  - Choice influenced by:
    - Type of service
    - Nature of the power system
    - History of the power system

# Fundamentals of Ancillary – Balancing Services

## Market for ancillary – balancing services

- Different “markets” for different services;
- Different “markets” in different countries/pools
- **Long(er) term contracts**
  - For services where quantity needed does not change rapidly and availability depends on equipment characteristics
  - Example: *blackstart capability, intertrip schemes, frequency regulation, power system stabilization*,
- **Spot market(s)**
  - Needs change over the course of a day
  - Price changes because of interactions with energy market
  - Example: *reserve*
- System operator may reduce its risk by using a combination of long term contracts and spot market(s)

# Fundamentals of Ancillary – Balancing Services

## Who should pay for ancillary - balancing services?

- Not all users value security and quality of supply equally:
  - Producers vs. consumers
  - Semi-conductor manufacturing vs. irrigation load
- Ideally, users who value security more should get more security and pay for it
- With the current technology, this is not possible:
  - System operator provides an average level of security to all users
  - The cost of ancillary services is shared by all users on the basis of their consumption
- Some participants increase the cost of reserve more than others (e.g. intermittent generation)
  - They should pay more to encourage to change behaviour

# Fundamentals of Ancillary – Balancing Services

## Selling ancillary - balancing services

- Ancillary – balancing services are another business opportunity for generators
- Limitations:
  - Technical characteristics of the generating units
    - Maximum ramp rate
    - Reactive capability curve
  - *Opportunity cost*
    - Can't sell as much energy when selling reserve
    - Need to **optimize jointly the sale of energy and reserve**
- Can demand "sell" ancillary services?
  - We'll consider this shortly!

# Ancillary – Balancing Services in GB

## Introduction

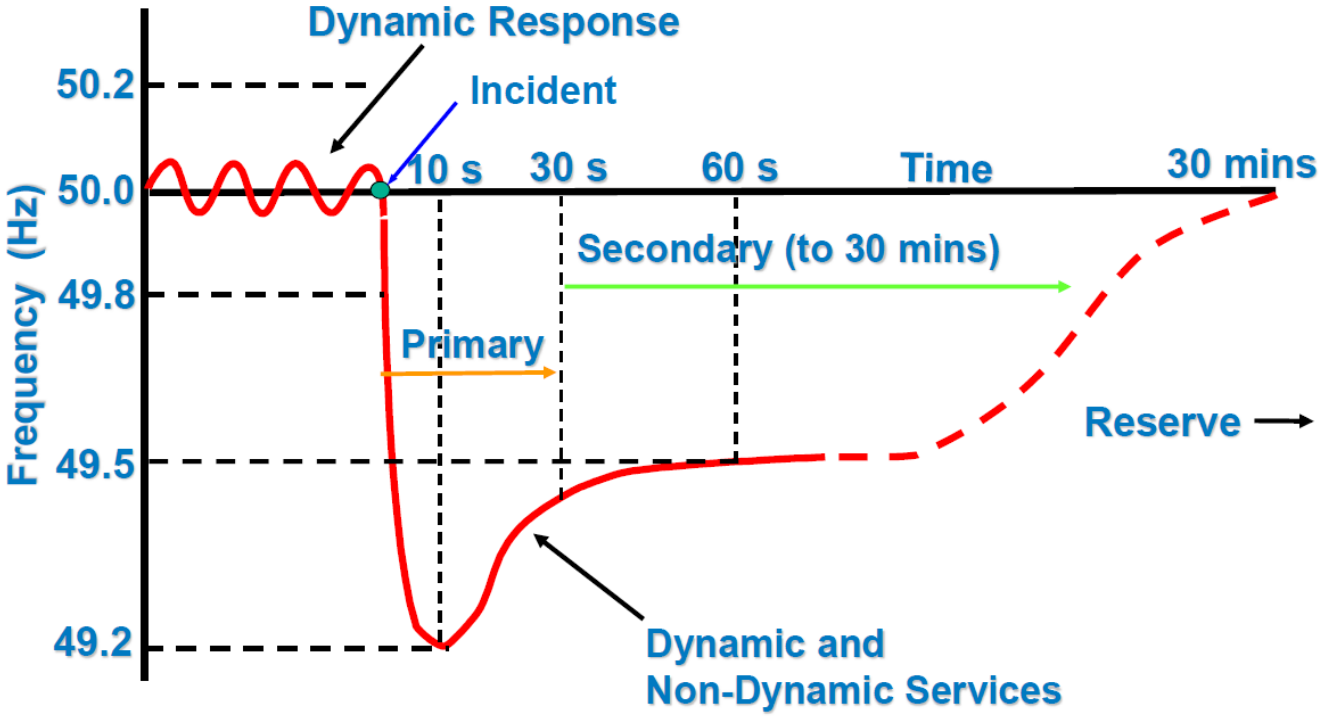
- In GB, there are three **Transmission Operators** (**TO**s) permitted to develop, operate and maintain a high voltage system:
  - 'National Grid Electricity Transmission' (NGET) for England and Wales,
  - 'Scottish Power Transmission Limited' for southern Scotland, and
  - 'Scottish Hydro Electric Transmission' for northern Scotland and the Scottish islands groups.
- A single **System Operator** (**SO**) is responsible for ensuring the stable and secure operation of the whole transmission system:
  - This is 'National Grid Electricity Transmission' (NGET) – a company separated from the **TO**
- NGET – **SO** procures **ancillary – balancing services**
- Some other services are procured by both the **SO** and **TOs**

# Ancillary – Balancing Services in GB
# GB balancing services

- **Classification of balancing services**:
  - 1. **Frequency Response:** System frequency is controlled by the real time (sec-to-sec) balance between system demand and total generation
  - 2. **Reserve:** NGET needs extra power in the form of either generation or demand reduction, to deal with unforeseen demand increase and/or generation outages
  - 3. **Reactive Power:** voltages must be within prescribed voltage limits
  - 4. **Demand side response:** reduction/increase of demand can contribute to the system security
  - 5. **System Security:** NGET has the obligation of ensuring the security and quality of electricity supply across the GB Transmission System
  - **{**6. **Trading:** In meeting forecast energy requirements at minimum cost NGET trade energy related products forward in time (i.e. in advance of the Balancing Mechanism)**}**

# Ancillary – Balancing Services in GB
# Frequency responses/services

- Two types of frequency response:
  - 1. **Dynamic** response
  - 2. **Non-Dynamic** Response.
- **Dynamic Frequency Response** is a continuously provided service used to manage the normal second by second changes on the system.
- **Non-Dynamic Frequency Response** is *usually* a discrete service triggered at a defined frequency deviation.



# Ancillary – Balancing Services in GB
# Frequency responses/services

- **Dynamic frequency response** (pre-fault):
  - Only a service that operates continuously around 50Hz can provide the pre-fault control needed
  - The remaining requirements can be met by a **full range dynamic** service or a **set point triggered** service

- **Full range dynamic frequency response** (pre- and post-fault):
  - Continuously provided response in proportion to frequency :
    - 1. **Primary Response** (Full delivery up to 10sec, sustained 30sec)
    - 2. **Secondary Response** (Full delivery up to 30sec, sustained 30min)
    - 3. **High Response** (Full delivery up to 10sec, sustained indefinitely)

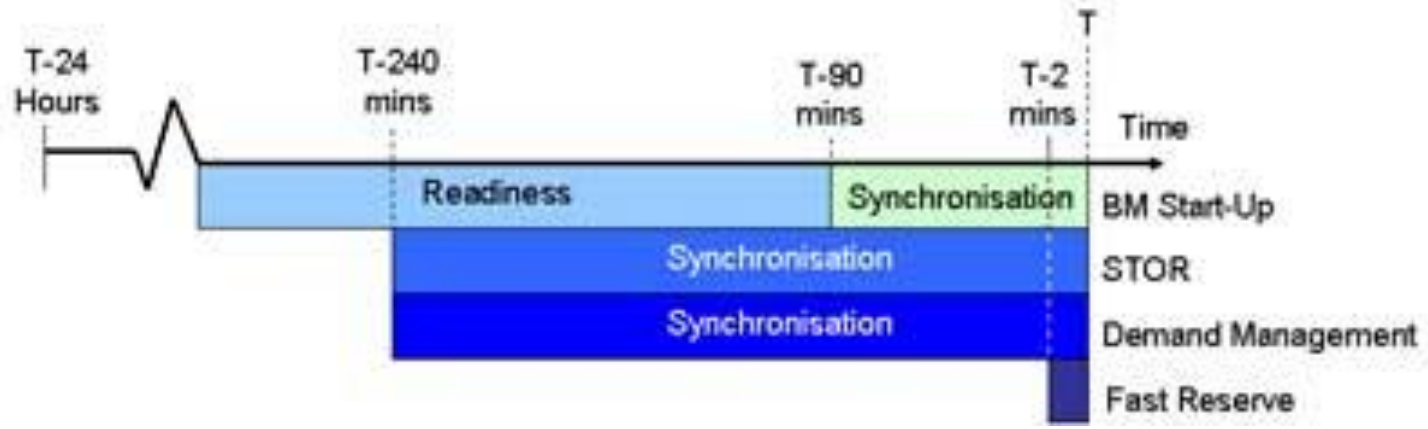
- **Set point triggered response** (mostly post-fault):
    - 1. Primary / Secondary / High Response
    - 2. Low-frequency-**LF** and high-frequency-**HF** relays (ie **load shedding**)

# Ancillary – Balancing Services in GB Frequency responses/services

- **Dynamic** and **non-dynamic** (or '**static**') frequency responses:
  - The above classification is based on engineering designs and technical requirements
- However, ***commercial*** classification is different:
  - 1. Mandatory Frequency Response: Mandatory Frequency Response (**MFR**) is an automatic change in active power output in response to a frequency change and is a Grid Code requirement.
  - 2. Firm Frequency Response (FFR): Firm Frequency Response (**FFR**) is the firm provision of Dynamic or Non-Dynamic Response to changes in Frequency.
  - 3. Frequency Control by Demand Management: **FCDM** provides frequency response through interruption of demand customers.
  - 4. Enhanced Frequency Response: A new service aimed predominantly at storage assets to provide frequency response in 1 second or less.

# Ancillary – Balancing Services in GB
# Reserve services

- Unforeseen demand increase and/or generation unavailability dealt with sources of extra power in the form of either generation or demand reduction
- These additional power sources provide **Reserve Service** and comprise synchronised and non-synchronised units
- Different units require different timescales in order to be ready to deliver the services, as illustrated in the figure below
- Classification of Reserve shown in the next slide:



# Ancillary – Balancing Services in GB
# Reserve service

- 1. **Fast Reserve (FR)**:Fast Reserve provides the rapid and reliable delivery of active power through an increased output from generation or a reduction in consumption from demand sources
- 2. **Short Term Operating Reserve (STOR)**: STOR is a service for the provision of additional active power from generation and/or demand reduction
- 3. **Balancing Mechanism (BM) Start-up**: The BM Start-up Service gives NGET on-the-day access to additional generation BMUs that would not otherwise have run, and which could not be made available in Balancing Mechanism timescales.
- 4. **STOR runway**: STOR Runway is a contracting opportunity for **Demand Side Providers** to support the growth of new volume into the STOR market
- 5. **Demand Turn-Up**: The service has been developed to allow demand side providers to increase demand (either through shifting consumption or reducing embedded generation) as an economic solution to managing excess renewable generation when demand is low

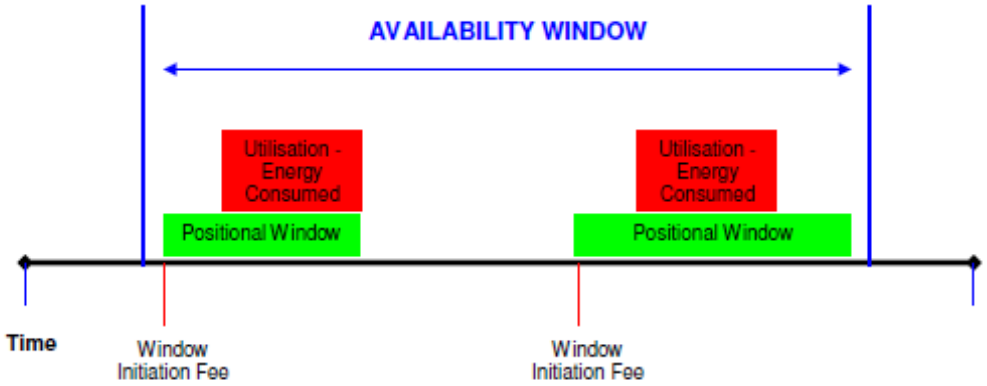
# Ancillary – Balancing Services in GB
# Fast reserve service

- Payments that can be made with regard to each of the potential options

| Payments | Firm Service (BMU) | Optional Service (BMU) | Firm Service (Non-BMU) | Optional Service (Non-BMU) |
|---|---|---|---|---|
| **Availability Payment (£ / hour)** | Firm Availability | Enhanced Rate Fee | Firm Availability | Optional Availability |
| **Positional Payment (£ / hour)** | Yes | N/A | Yes | N/A |
| **Window Initiation (£ / per Firm Window)** | Yes | N/A | Yes | N/A |
| **Utilisation Payment** | Capped Bid-Offer Price (£/MWH) | Capped Bid-Offer Price (£/MWH) | Firm Fast Reserve Energy Fee (£/MWH) | Optional Energy Payment (£/MWH) |

- These payments are triggered at different times during Fast Reserve availability, notification and utilisation. The below graph illustrates when these payments may be earned by the Fast Reserve Providers

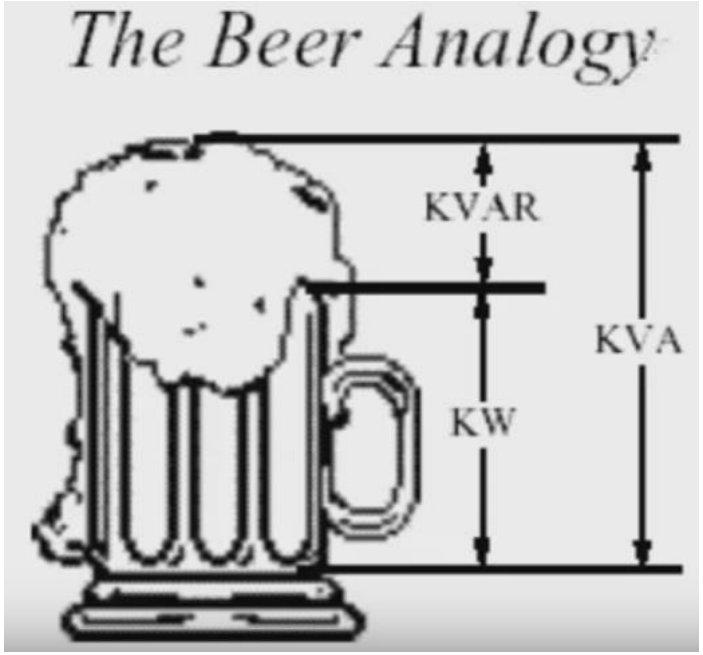
# Ancillary – Balancing Services in GB
# Fast Reserve service




- **Availability Payment**:
  - The Availability window is bided/tendered by the FR Provider and NGET will make this payment throughout the period of the window
- **Positional Payment**:
  - The FR Provider, having been informed of the required Windows, will maintain the dynamic parameters of the Unit in a position to provide Firm Fast Reserve
- **Window Initiation Fee**:
  - NGET will notify the FR Provider of any windows during which the Firm Fast Reserve service is required and for this the Window Initiation Fee is paid
- **Utilisation Payment**:
  - Utilisation payments are paid in relation to the energy used in providing the FR service

# Reactive Power Services in GB

- NGET utilises the below services in order to manage voltage levels
  - 1. **Obligatory Reactive Power Service** (ORPS)
    - The Obligatory Reactive Power Service is the provision of mandatory varying Reactive Power output.
  - 2. **Enhanced Reactive Power Service** (ERPS)
    - The Enhanced Reactive Power Service is the provision of voltage support that exceeds the minimum technical requirement of the Obligatory Reactive Power Service.
    - The Enhanced Reactive Power Service is procured via a Market Tender



# Reactive Power Services in GB

- **Obligatory Reactive Power Service** (**ORPS**):
  - Generally, all transmission connected generators over **50MW** are required to have the capability to provide this service
  - The ORPS is paid for Utilisation in ***£/MVArh***

- **Enhanced Reactive Power Service** (**ERPS**):
  - The ERPS is procured via a Market Tender
  - The tender allows the Generator to request:
    - An Available Capability Price (£/MVar/hr), and/or
    - A Synchronised Capability Price (£/MVar/hr), and/or
    - A Utilisation Price (£/MVarh)

# Demand Side Response in GB

- **Demand side response** (**DSR**) are services that enable consumers to turn-up, turn-down or shift demand in real-time
- Opportunities for large electricity users:
  - Balancing Services: Frequency Response
    - Firm Frequency Response (**FFR**) and Enhanced Frequency Response (**EFR**)
  - Balancing Services: Reserve
    - Short Term Operating Reserve (**STOR**); STOR Runway; Fast Reserve; Demand Turn Up
  - **Capacity Mechanism** (we'll discuss it in more detail)
    - The capacity mechanism is a catch-all term for the auctions for the Capacity Market that NGET runs to guarantee capacity for any year
  - **Peak Avoidance**
    - **'Triad' Avoidance –** Reducing consumption at periods where national winter peak demand is forecast
    - **Red Zone Management –** Shifting consumption to avoid periods of highest *distribution network* cost, often referred to as "red-zones"

# System Security Services in GB

- There are two types of balancing actions
  - **Energy imbalance** actions address mismatches between generation & demand
  - **System imbalance** actions tackle constraints in the *capacity of the network*
- **System imbalance** actions:
  - **1. Transmission Constraint Management**: The system is unable to transmit power supplied to the demand due to network congestion
  - **2. Contingency Balancing Reserve**:
    - Demand Side Balancing Reserve (**DSBR**) is targeted at large energy users who volunteer to reduce their demand
    - Supplemental Balancing Reserve (**SBR**) is targeted at keeping power stations in reserve that would otherwise be closed or mothballed
  - **3. Maximum Generation**: This service allows access to capacity which is outside of the Generator's normal operating range in emergencies
  - **4. Intertrips**: The services are an *automatic* control arrangement where generation may be reduced or disconnected following a system fault event
  - **5. Black Start**: Black Start is the procedure to recover from a total or partial shutdown of the GB Transmission System
  - **6. SO to SO**: SO to SO services are provided mutually with other TSOs System Operators connected to the GB Transmission System via interconnectors

# Demand Response Mechanisms
# and
# Network Support Services

## Q & A

**Victor Levi**

**30 April 2018**