Operating the network

We will start at 10.02 to allow participants to finish previous meetings and join the call

While you are waiting, please access Sli.do which we will be using for Q&A

Event Code:

#GTX10

Sli.do Instructions:

You can access Sli.do at www.sli.do or by downloading the Sli.do app.

Once you've logged on, enter the code above when prompted.

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Welcome and Opening

Thank you for joining us today

Please feedback via SLIDO

Slido.com
#GTX10

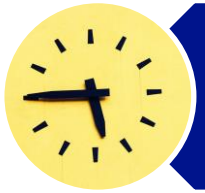
Who will be speaking today?

Glenn Bryn-Jacobsen
Head of National Control

Richard Pickup
Control Room Manager

Nera Lenden
Stakeholder Experience Team

Logistics



Should last for approximately about 60 min

Questions and polling via slido.com #GTX10

All callers will be placed on mute

We will circulate the slides and a recording of this webinar

Agenda

Basics of Gas System Operation: A focus on linepack

Linepack in Action: Operating the Network on a high line pack swing day

Energy vs Volume

Hydrogen in the Mix

Questions

Gas
Transmission

Basics of Gas System Operation: A focus on Linepack

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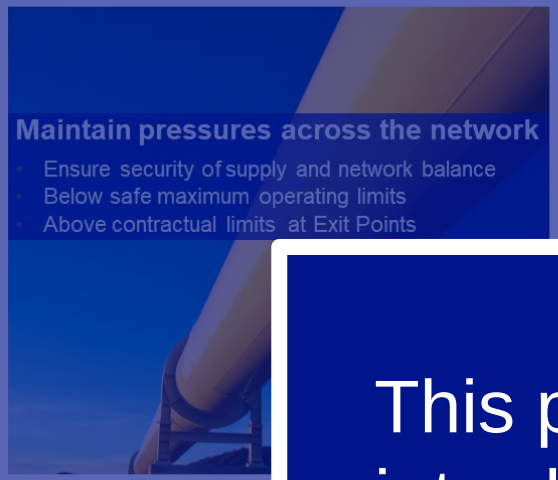
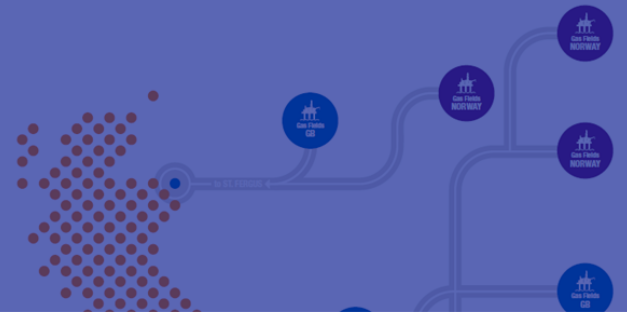
Role of the GSO: Safe, efficient and economic real-time operation of the National Transmission System in Great Britain



Maintain pressures across the network

- Ensure security of supply and network balance
- Below safe maximum operating limits
- Above contractual limits at Exit Points

Managing System Balance, Procuring Reserve



UK Entry Points

- UKCS & Norwegian Sea Terminals (6)
- 2 LNG Importation Terminals (2)
- 3 Interconnectors (3)
- Storage sites (10)

UK Exit Points

- Distribution Offtakes (121)
- (48)
- (21)

- 60 km)
- stations (23)
- trol Centre (1)
- d installations (530+)

This presentation builds on the more generic introduction to Gas Transmission and the overall role of Gas System Operation. Available here

Balancing the

The NTS transports ga
(supply) to exit points

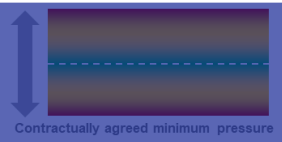
The daily profiles of su
differ significantly.

As a result of the imbalance between supply and demand, the volume of gas in the NTS varies during the day.

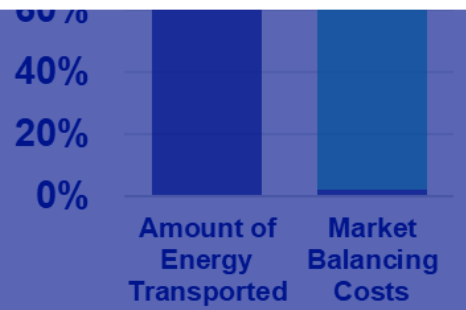
Typical daily balance

The NTS is able to operate within a range of pressure limits.

This allows for some flexibility to manage the daily imbalances and protect customers from short-term asset failures.



Note that the NTS was built to transport gas efficiently based on flat daily supply and demand profiles.



acilitates the
alancing regime
t for the use of

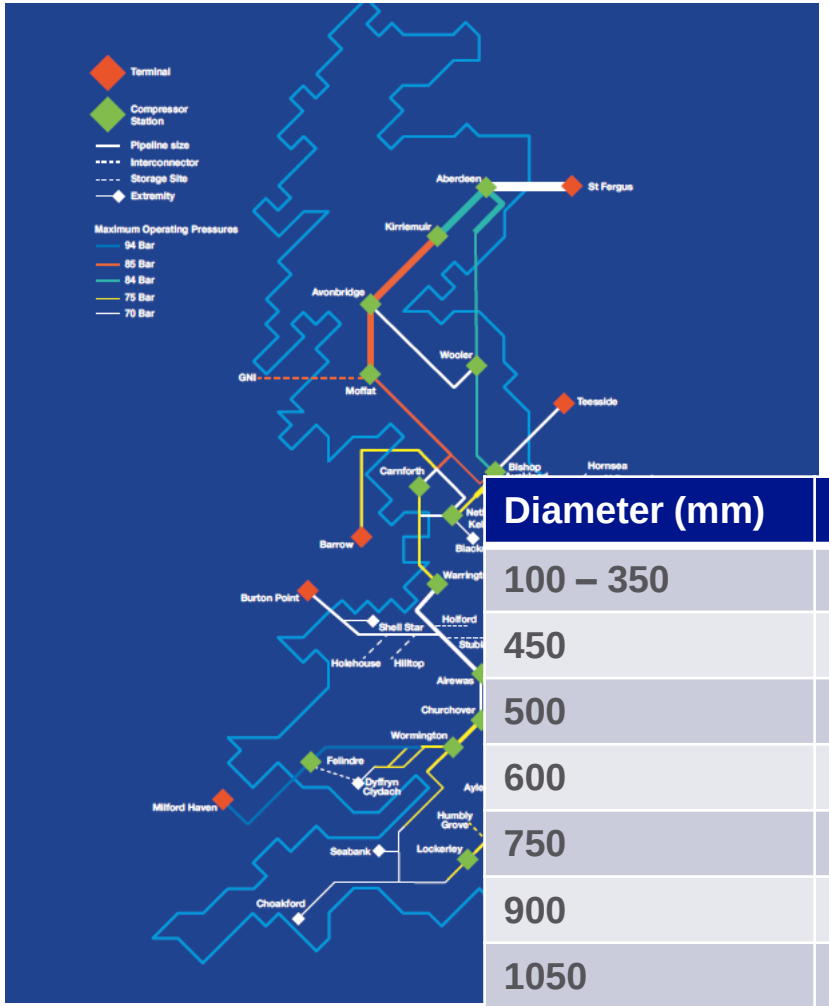
Compressors are complex rotating machinery which require close co-ordination with field operations and asset management to ensure availability and reliability.

GSO Total £29M ESO Total £1268M (All Figures 19/20)

National Grid

Linepack – What is it?

- Linepack is **volume** of gas held under pressure in the NTS
- Gas volume or flow is stated in **mcm** or **mcm/d** at standard atmospheric conditions (1.01325bar & 15 ºC)
- **Methodology** for calculating linepack is in accordance with Special Condition 28B of GT Licence
- Volume of NTS pipes **~5mcm** but typical linepack ranges from **320mcm to 380mcm**



Diameter (mm)	Length (km)
100 – 350	109
450	195
500	64
600	1006
750	507
900	3649
1050	1261
1200	863
TOTAL	7654

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Linepack – What is it?

- A typical linepack level for the NTS is 350mcm and the volume of the NTS pipes are ~5mcm
- If you compress 350mcm of natural gas into a 5mcm volume like the NTS what would be the average pressure?

A 70bar

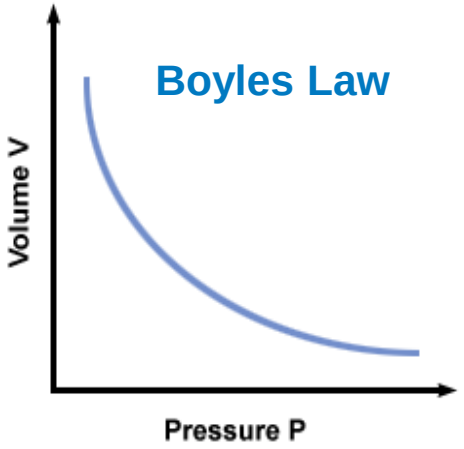
B 68bar

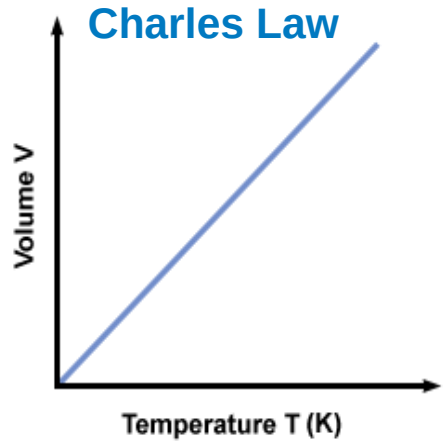
C 58bar

D 57bar

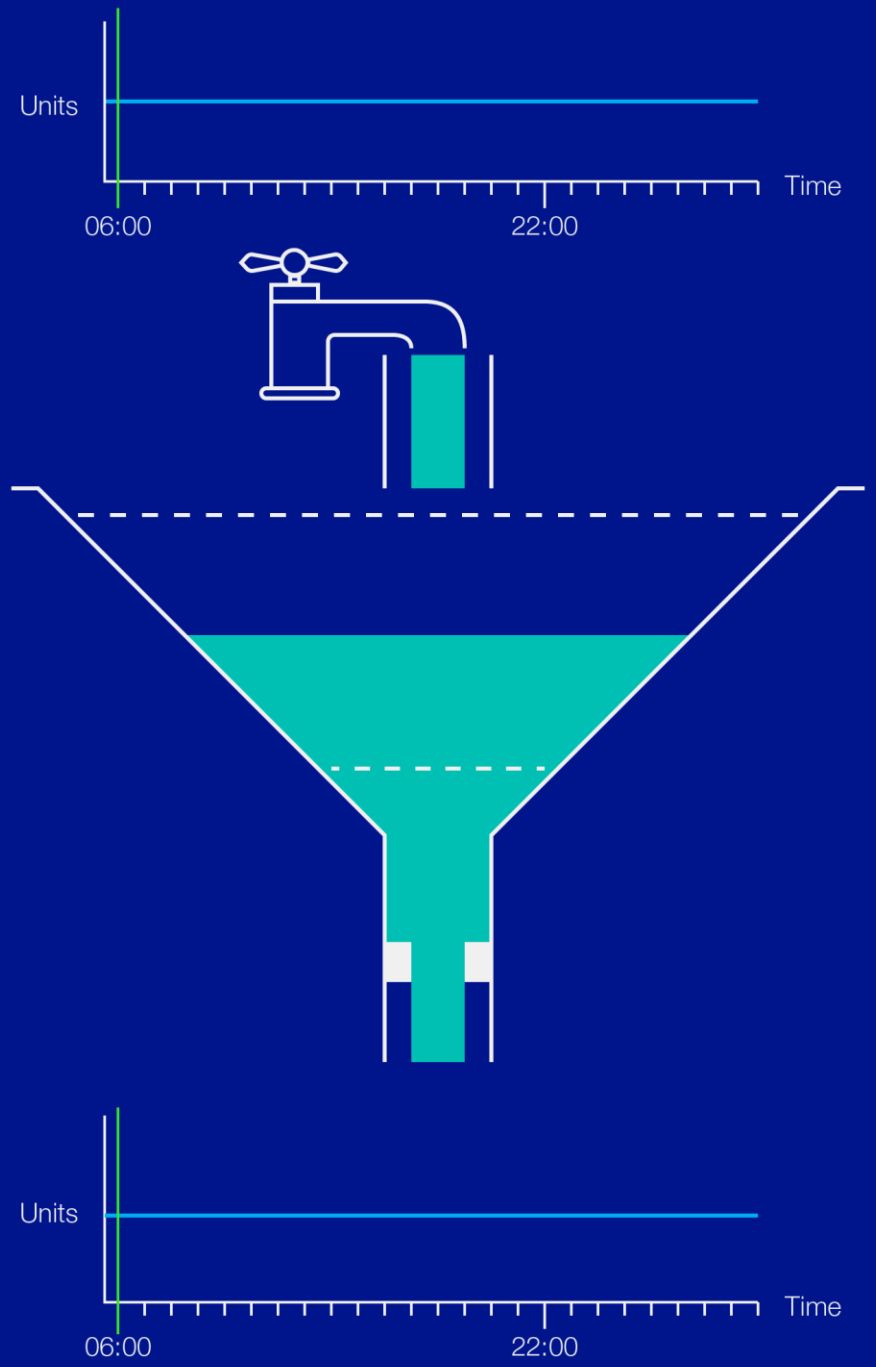
Linepack - A bit of physics

- 350mcm of linepack in a 5mcm NTS volume what would be the average pressure 70bar, 68bar, 58bar or 57bar?
  - Boyles Law – Pressure and Volume inversely proportional – 70bar
  - Charles Law – Volume proportional to Temperature – 68bar
  - Compressibility – Z factor for real gases – 58bar
  - Gauge pressure vs absolute pressure – 57barg
- This is what the pressure would level out at if you shut all entry and exit valves
- Gas in the NTS is always on the move



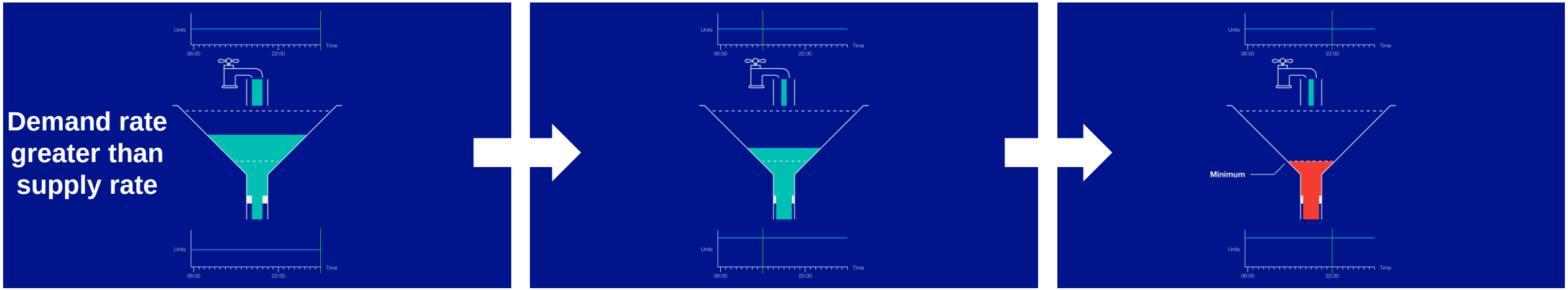


$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

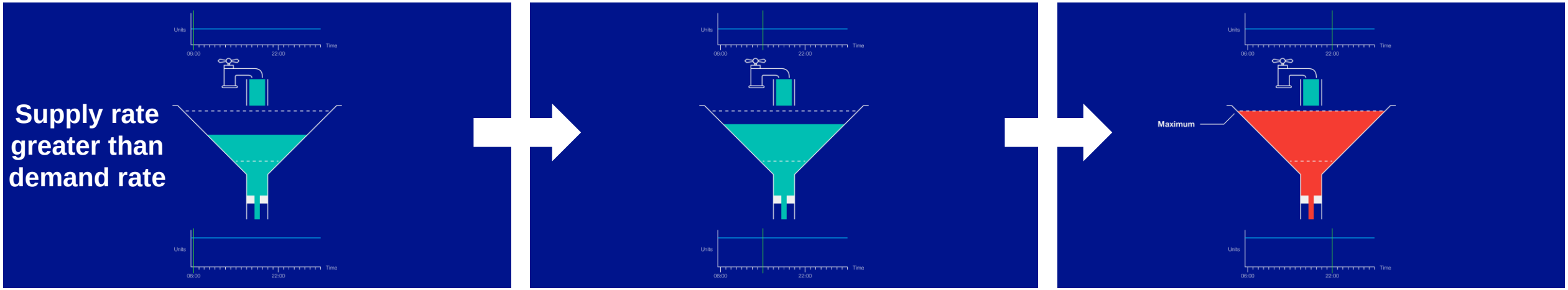

Units
Time
06:00
22:00
Units
Time
06:00
22:00

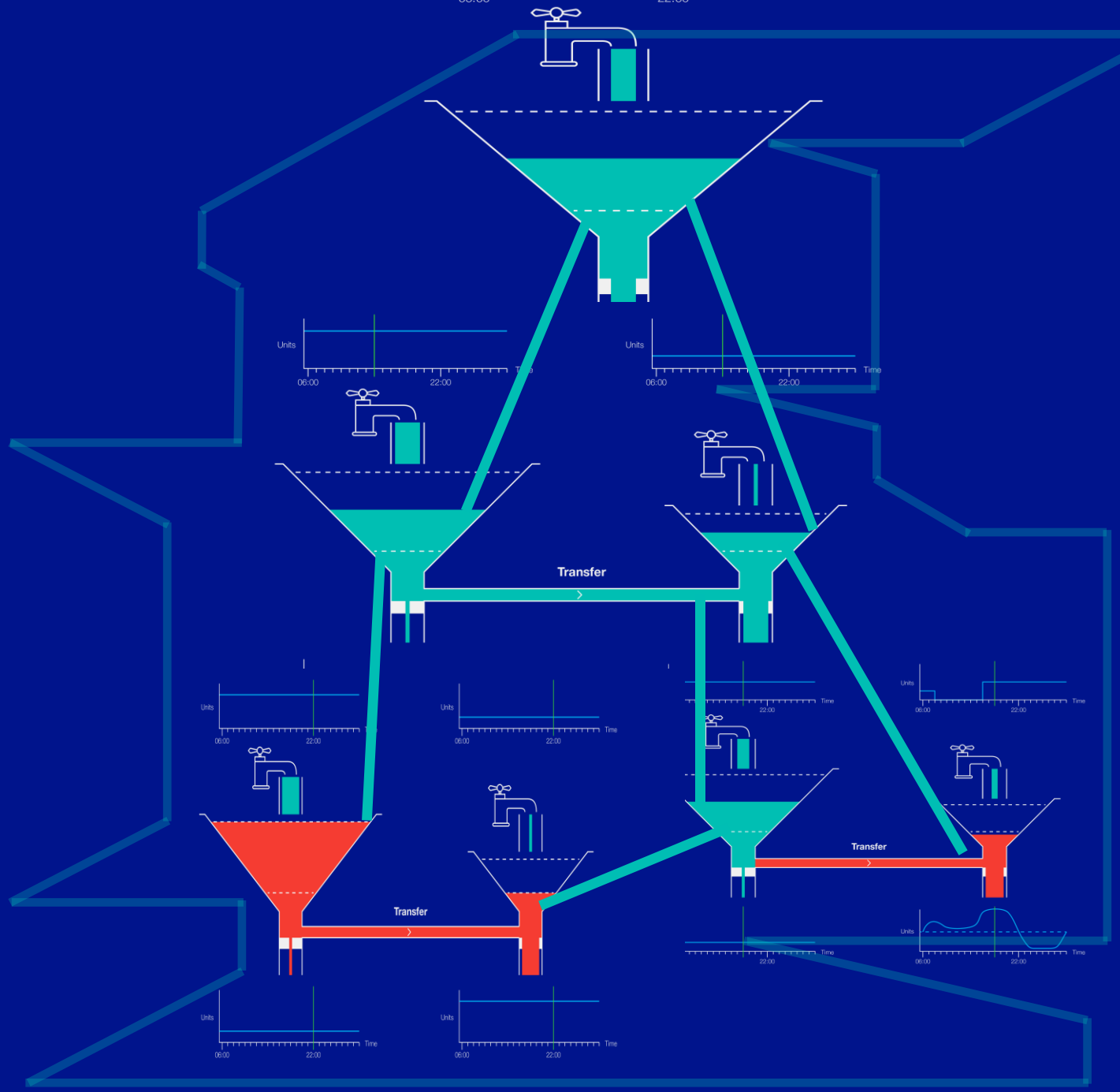
Linepack – Why does the level change?

Demand rate greater than supply rate



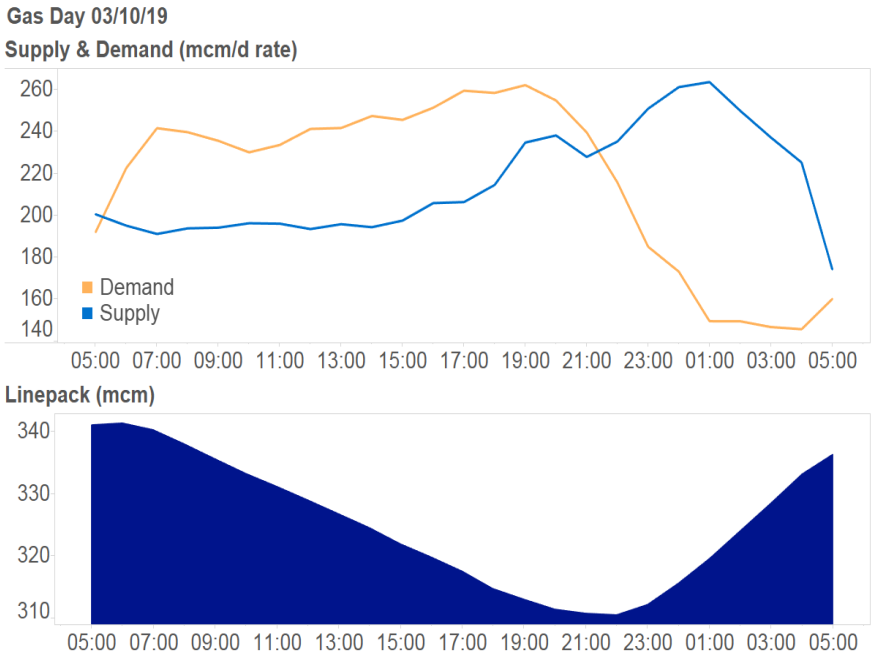
Supply rate greater than demand rate




Units
Time
06:00
22:00
Transfer
Transfer
Transfer

What is linepack swing?

- Supply and demand on the NTS is **not steady**
- This variation affects the **volume** of gas in the system (linepack) and therefore the **pressures**
- Pressures must be safely **below maximum** design pressure and **above minimum** pressures
- **Linepack swing** typically between 06:00 & 22:00
  - DN load –diurnal profile
  - CCGTs – changes depending on generation mix
  - Supplies – generally flatter profile but can backload
  - Other – market imbalances, forecast errors etc.



Gas
Transmission

Linepack in Action

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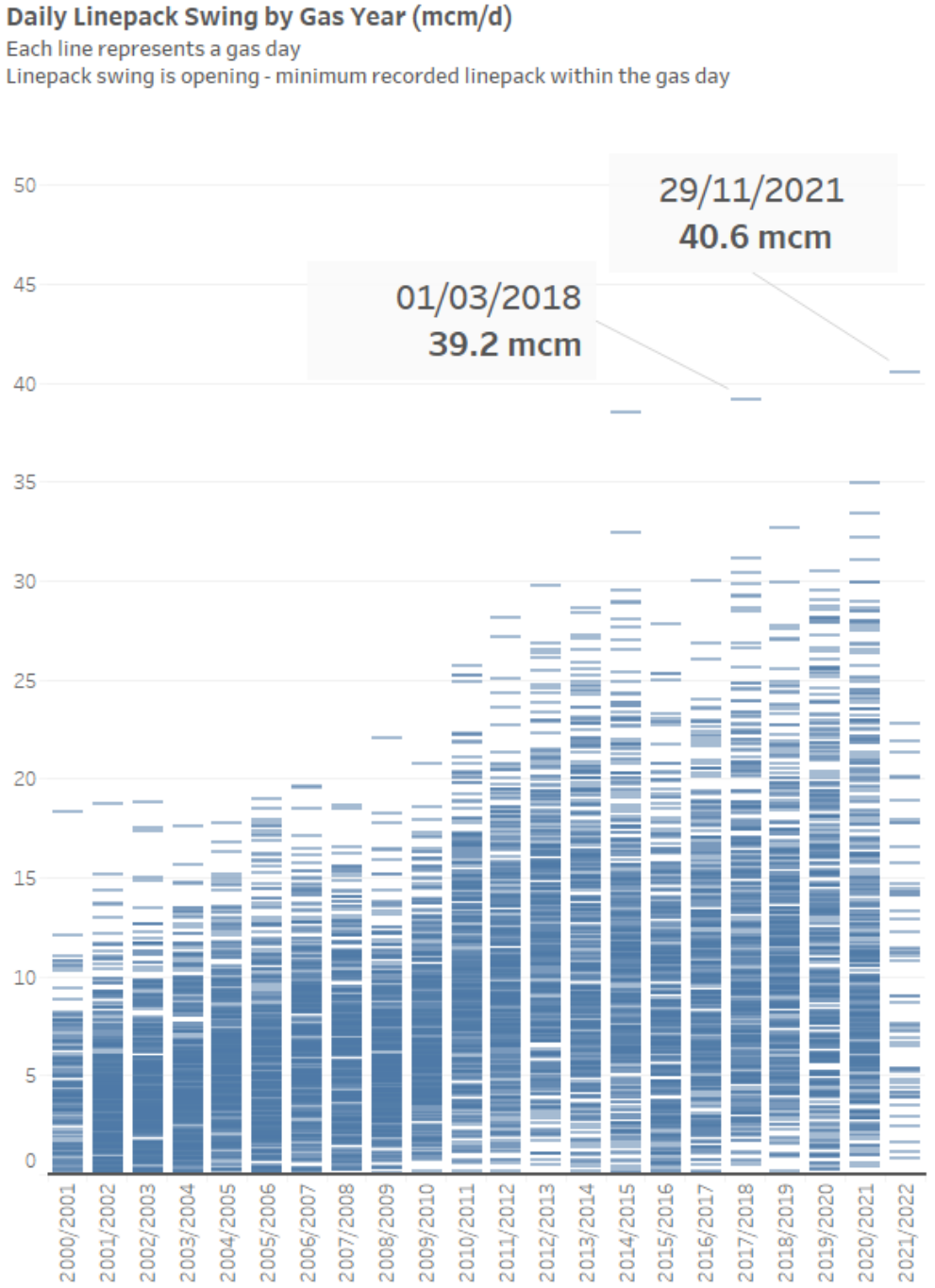
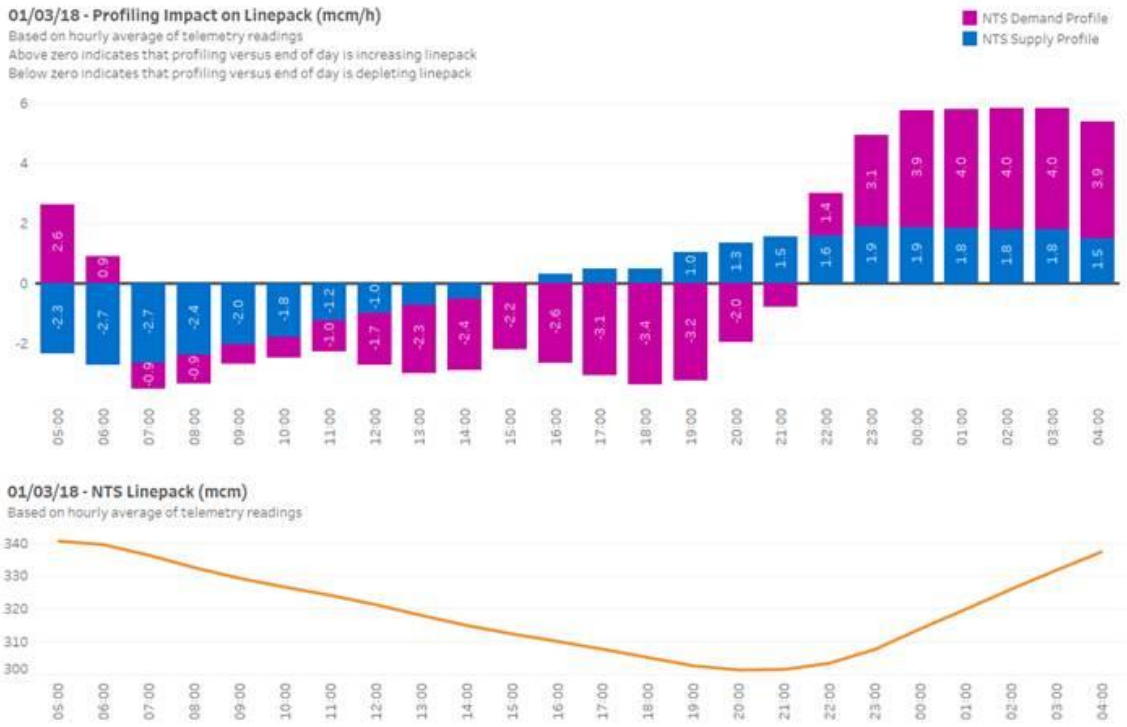
Linepack Swing: 29th Nov 2021

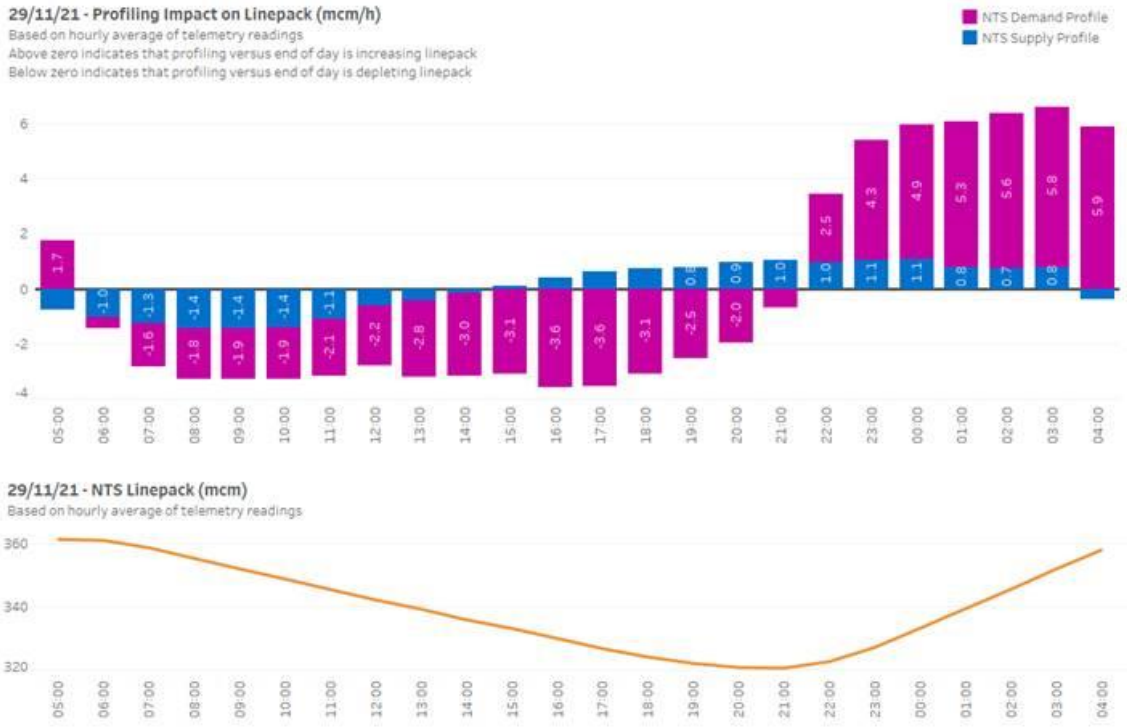
- Largest ever within-day swing seen on the NTS (comparing opening stock to minimum recorded)
- 2nd Largest ‘Beast From the East’ weather front: 1st March 2018



Supply or Demand Driven – A comparison



1st Mar supply driven: Early supply losses



29th Nov 21 demand driven: DN & Power Profiles

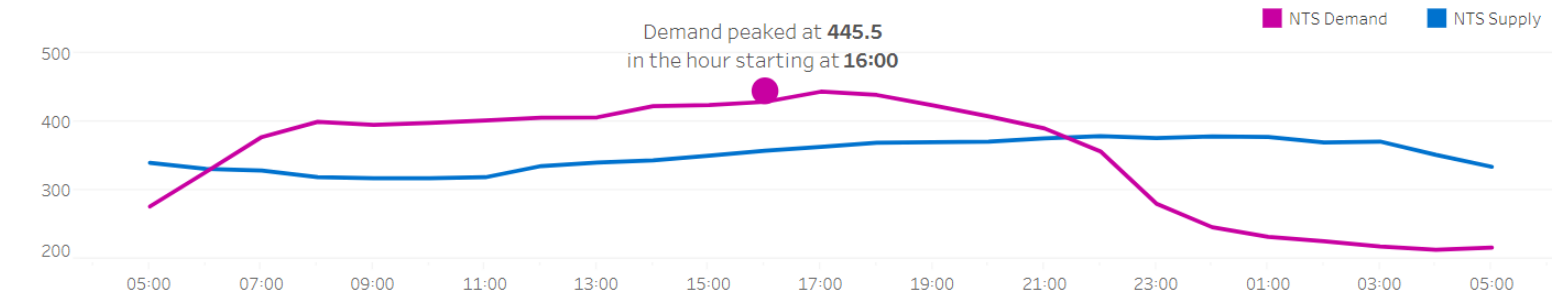
29th November: Key Statistics

Opening Linepack
361.0 mcm

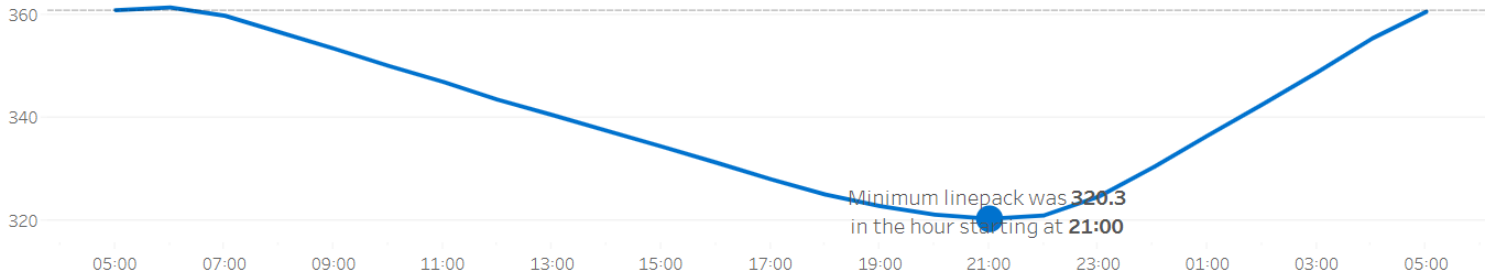
Linepack Change
-0.3 mcm

Linepack Swing
40.7 mcm

Supply and Demand (mcm/d)



Linepack (mcm)



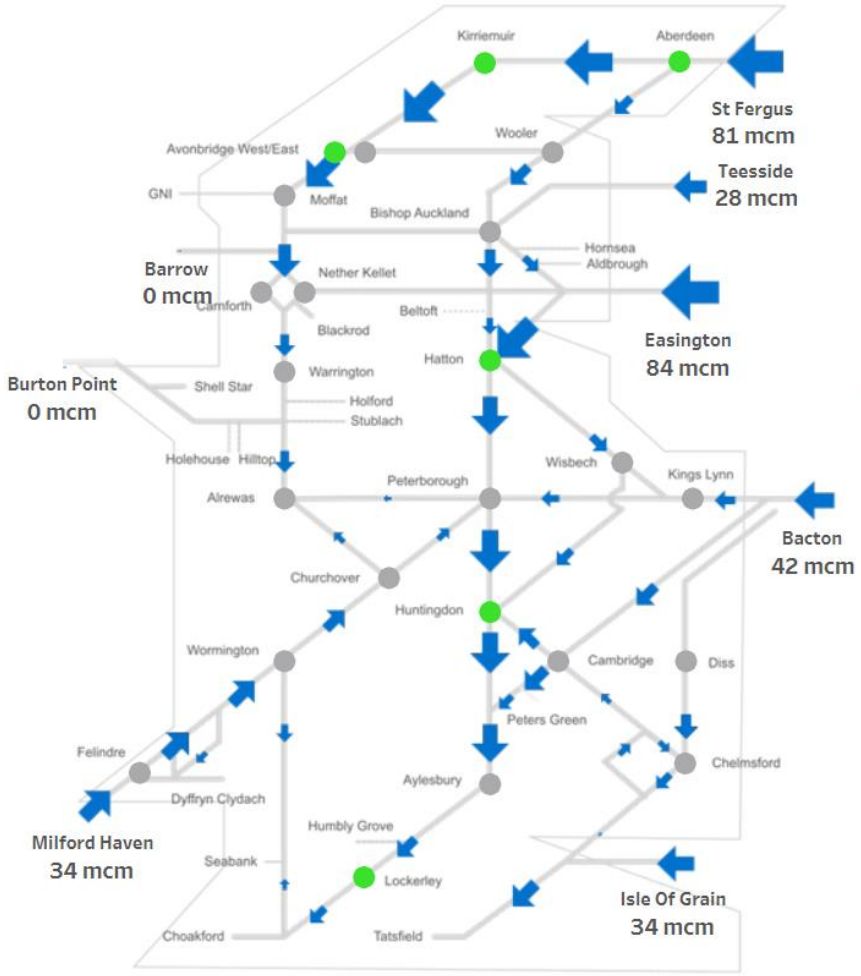
Note that the trend charts above show the value on each hour. Values will vary within each hour.

Electricity Comparators

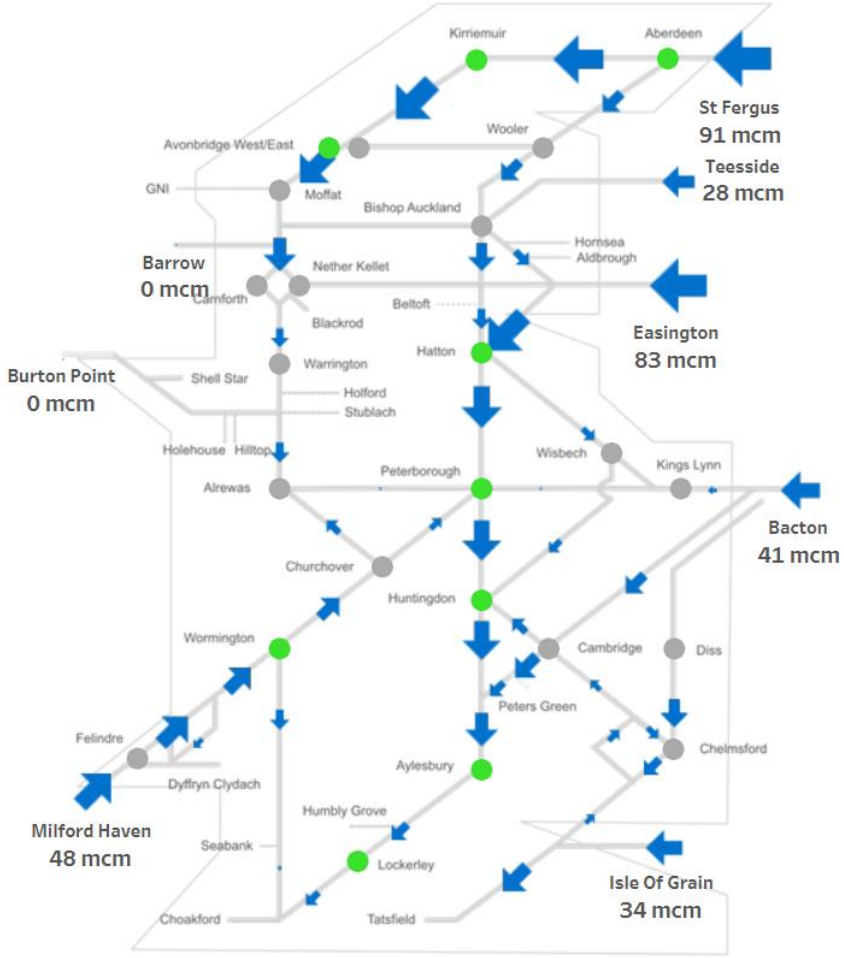
- 40.7mcm = 448GWh
- Over 16hr period this is 28GW
- Approx. total UK installed wind turbine capacity is 24GW
- Typically less than 9GW
- Approx. UK CCGT generating capacity 32GW
- Largest battery in the world (California) 230MW
- Dinorwig 1,728MW
- 254,500 Nissan Leafs
- 36.4M horses

Physical Management

14:00



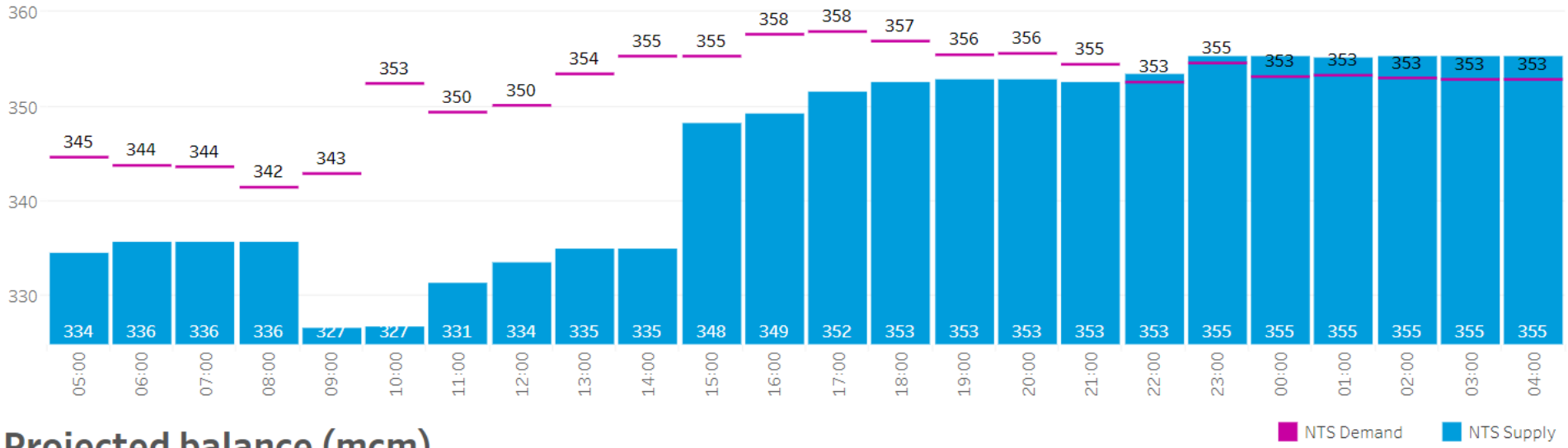
19:00



Commercial Management

Projected end of day demand and supply (mcm)

Projected end of day NTS demand and supply based on latest notifications at each hour of the gas day.



Projected balance (mcm)

-10.3	-8.1	-7.9	-5.8	-16.4	-25.9	-18.1	-16.7	-18.6	-20.5	-7.1	-8.5	-6.5	-4.4	-2.8	-2.8	-2.1	0.7	0.6	1.9	1.7	2.1	2.3	2.3

Market Information:

Real-time on actual line pack levels, supply & demand available on prevailing view

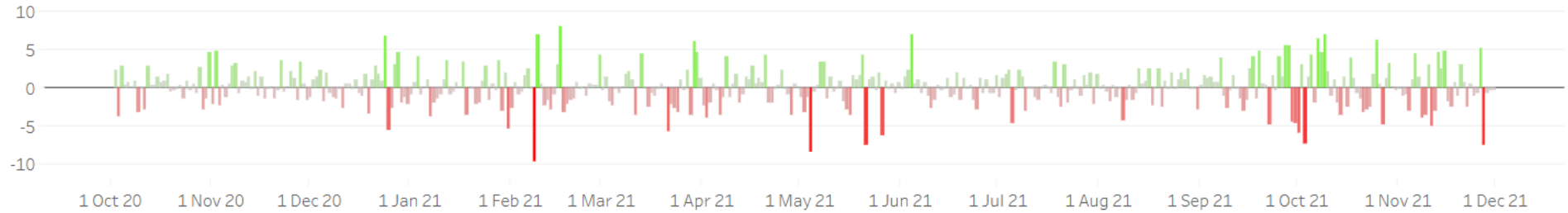
N.B. All external information provided on the day is from the market

Managing variation – Inter and Intra-day

Opening Linepack (mcm)

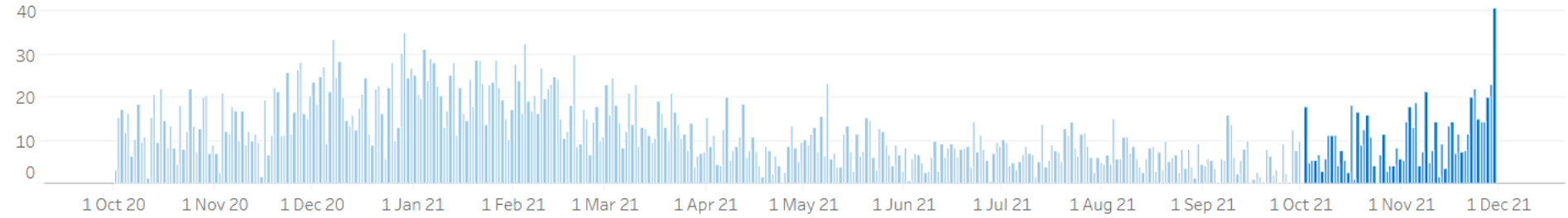
Linepack Gain/Loss (mcm)

The difference between the opening and closing linepack



Linepack Swing (mcm)

Linepack swing is calculated as the difference between the maximum the minimum linepack recorded for each gas day.



Gas
Transmission

Energy vs Volume

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Energy v’s Volume

- GNCC responsible for **moving physical volumes** of gas
- Gas market and industry **operate in energy** not physical volume
- Gas not uniform and composition, characteristics and **energy content vary**
- The **lower** the **calorific value** (energy content) the **greater** the **physical volume** that has to be delivered

Ten Year Statement – Gas Quality Specifications

Parameter	Quality requirement
Hydrogen sulphide	Not more than 5 mg/m³
Total sulphur	Not more than 50 mg/m³
Hydrogen	Not more than 0.1% (molar)
*Oxygen	Not more than 0.001% (molar)
Hydrocarbon dewpoint	Not more than -2°C at any pressure up to 85 barg
Water dewpoint	Not more than -10°C at 85 barg
Wobbe number (real gross dry)	The Wobbe number shall be in the range 47.20 to 51.41 MJ/m³
Incomplete combustion factor (ICF)	Not more than 0.48
Soot index (SI)	Not more than 0.60
Carbon dioxide*	Not more than 2.5% (molar)
Contaminants	The gas shall not contain solid, liquid or gaseous material that might interfere with the integrity or operation of pipes or any gas appliance, within the meaning of regulation 2(1) of the Gas Safety (Installation and Use) Regulations 1998, that a consumer could reasonably be expected to operate.
Organo halides	Not more than 1.5 mg/m³
Radioactivity	Not more than 5 becquerels/g
Odour	Gas delivered shall have no odour that might contravene any statutory obligation. The odourisation requirements in GS(M)R do not apply where the gas is at a pressure above 7 barg.
Pressure	The delivery pressure shall be the pressure required to deliver natural gas at the delivery point into our entry facility at any time, taking into account the back pressure of our system at the delivery point, which will vary from time to time. The entry pressure shall not exceed the maximum operating pressure at the delivery point.
Delivery temperature	Between 1°C and 38°C
Mercury	No more than 10 µg/m³
*Requests for higher limits will be considered	

Gas
Transmission

Hydrogen in the Mix

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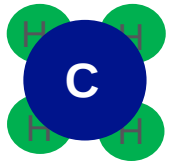
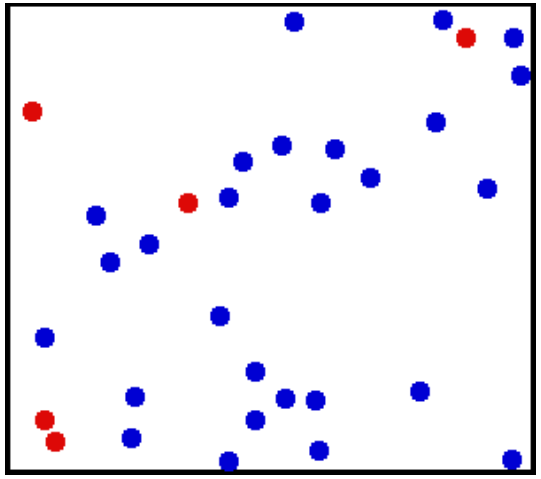
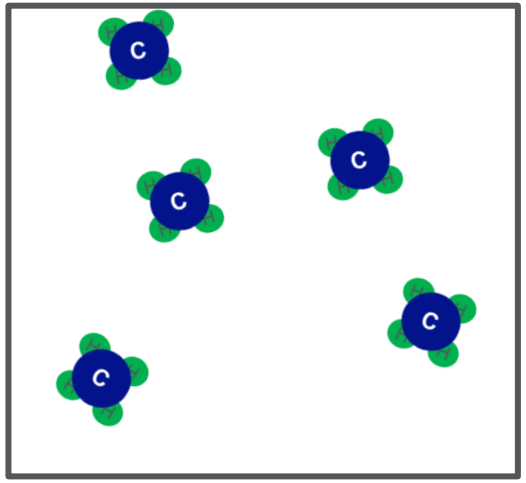
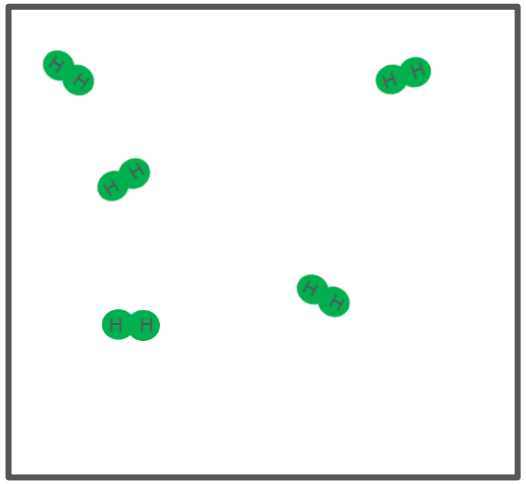
Future Operation – A Hydrogen Blend?



	Methane	Ratio	Hydrogen
Molecular Weight (g/mole)	16	8 : 1	2
Mass Density (kg/m^3)	0.68	7.6 : 1	0.09
Energy (MJ/kg)	50	1 : 2.4	120
Energy Density (MJ/m3)	34	3.2 : 1	10.8

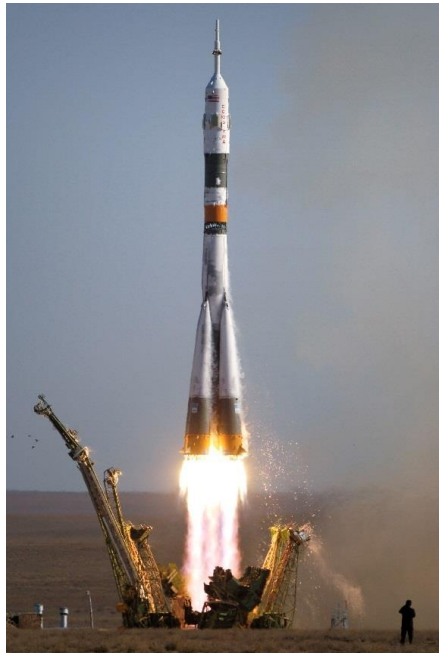






A bit of Rocket Science…






- Rocket design is a **trade off** between weight (spacecraft, payload, fuel etc) and aerodynamics (speed, size, drag etc.)
- Hydrogen is **lightest** of elements and has the **highest energy per weight** but is **not energy dense** in terms of volume

Downstream Impacts:

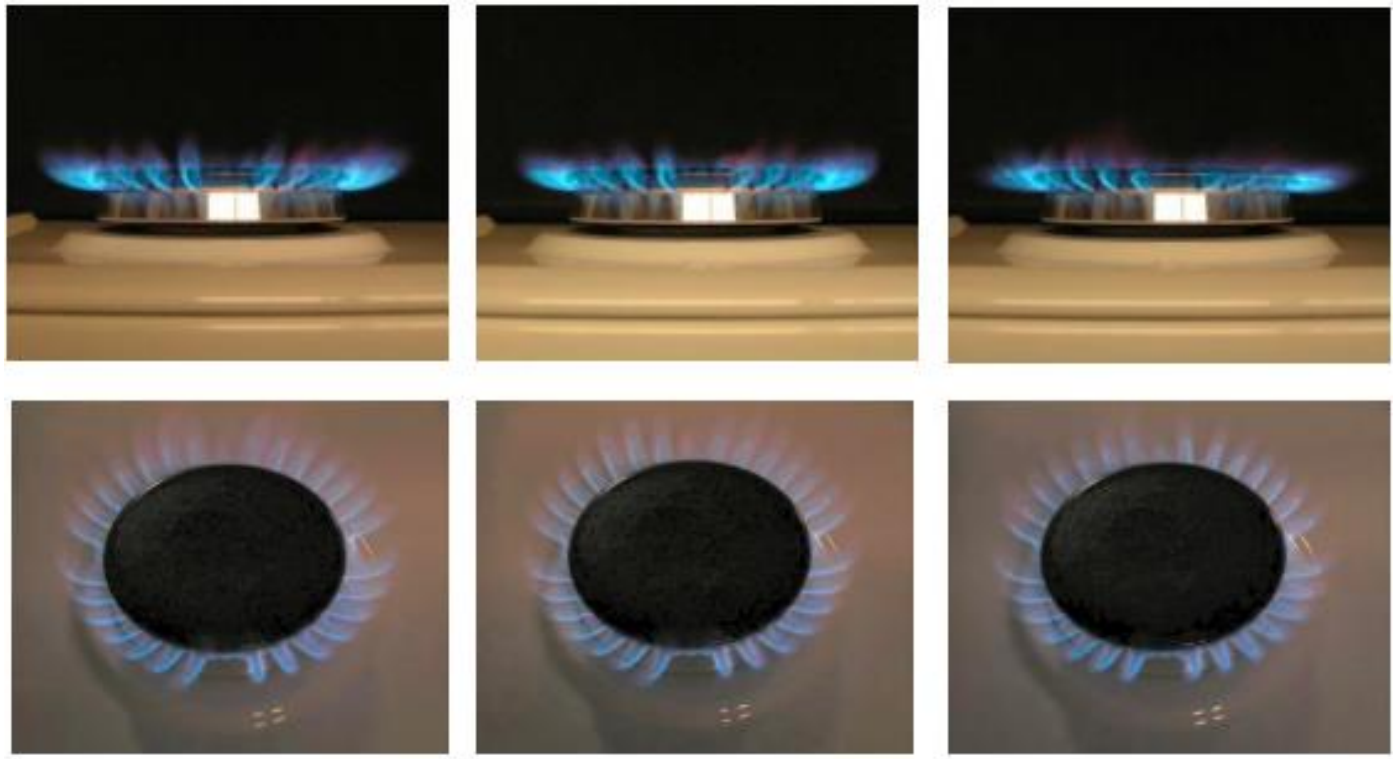


Figure 6 Gas ring fuelled by hydrogen enriched natural gas (62), hydrogen content of gas increasing from left to right

HSE

Health and Safety Executive

Injecting hydrogen into the gas network – a literature search

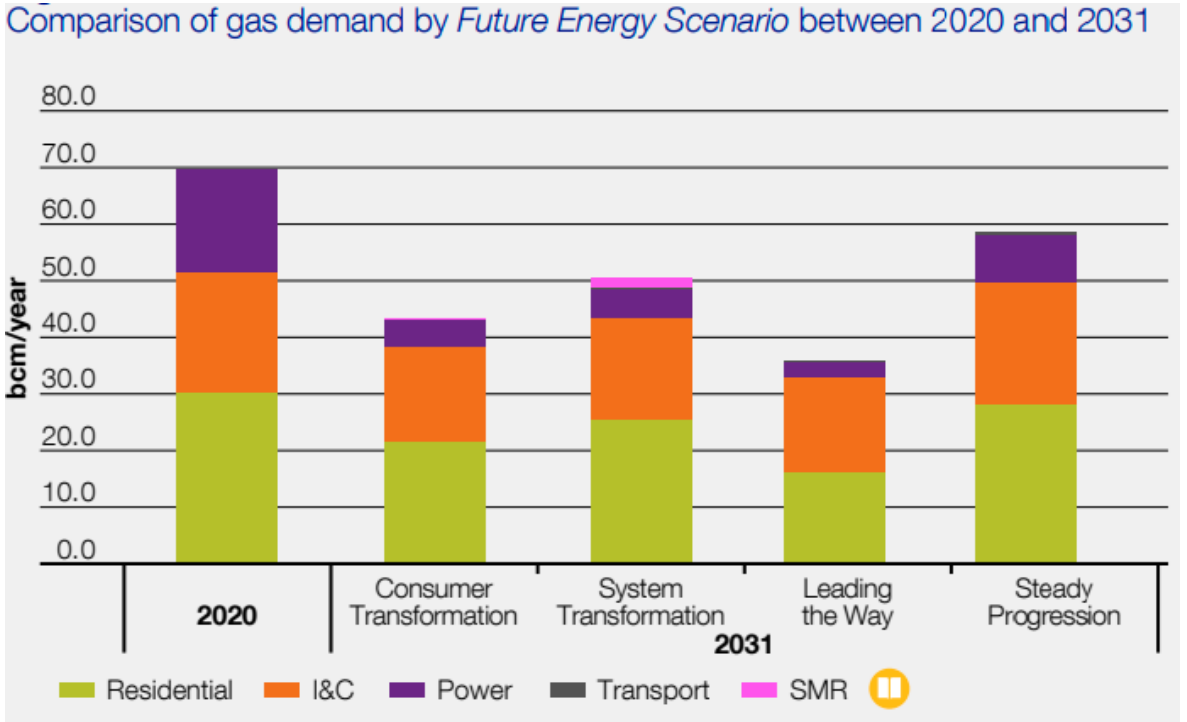
Prepared by the **Health and Safety Laboratory** for the Health and Safety Executive 2015

"The report concludes that concentrations of hydrogen in methane of up to 20% by volume are unlikely to increase risk from within the gas network for from gas appliances to consumers or members of the public"

RR1047
Research Report

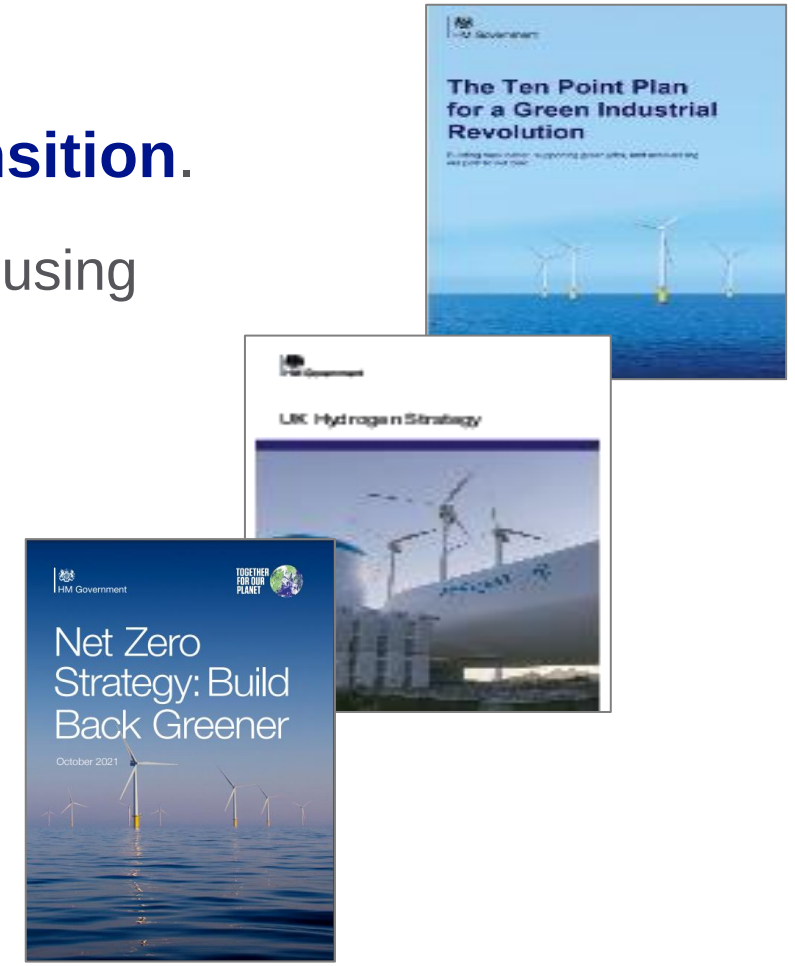
Future Operation – A 20% Hydrogen Blend

- HSE indicated up to 20% blend with **no increased risk** on consumers and public
- Energy – per volume will **reduce with need to transport** ~16% more volume/flow
- Other factors such as **compressibility**, managing **blends/gas quality**, **gas speeds** being looked at but anticipated **within margins** as we move to a decarbonised future.



Future Operation – A 20% Hydrogen Blend

- Initial view is there is that there are **no significant barriers** from a System Operator perspective
- Significant amount of work underway - **trials and transition**.
  - Future Grid (NTS) – construction of test facility underway using existing assets, blending. Entry and exit assets 2023 and compression in 2024
  - Government 10 point plan
  - Market Models
  - De-blending



Future Operation – A 20% Hydrogen Blend?

- No significant barriers from a System Operator perspective
- This is what we do

Q&A

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Thank you for joining us today

Keynote speech	Complete	Watch again
Future of Gas	Complete	Watch again
Innovation – broadening the horizon	Complete	Watch again
Gas Market Plan	Complete	Watch again
Transitioning to a hydrogen backbone	Complete	Watch again
Managing methane emissions	Complete	Watch again
Supporting regional hydrogen transitions	Complete	Watch again
Understanding the skills needed for a net zero world	Complete	Watch again
Digital Strategy and Information Provision	Complete	Watch again
Operating the network	Complete	
Gas Emergency Frameworks Overview	Thu 09th Dec 14.00 – 15.30	Register here
FutureGrid 2021 Progress report	Tue 14th Dec 10.00 – 11.00	Register here
Annual Network Capability Assessment Report	Wed 15nd Dec 10.00 – 11.00	Register here

What next?

You will receive the recording and material from today’s session

If you have any further questions or would like to discuss anything specific please get in touch with Jennifer.Pemberton@nationalgrid.com

Feedback is important to us, therefore if you have not already taken part, we would like to put you forward for a survey

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