THE OXFORD INSTITUTE FOR ENERGY STUDIES

The Future of Natural Gas and LNG: are methane emissions a big problem?

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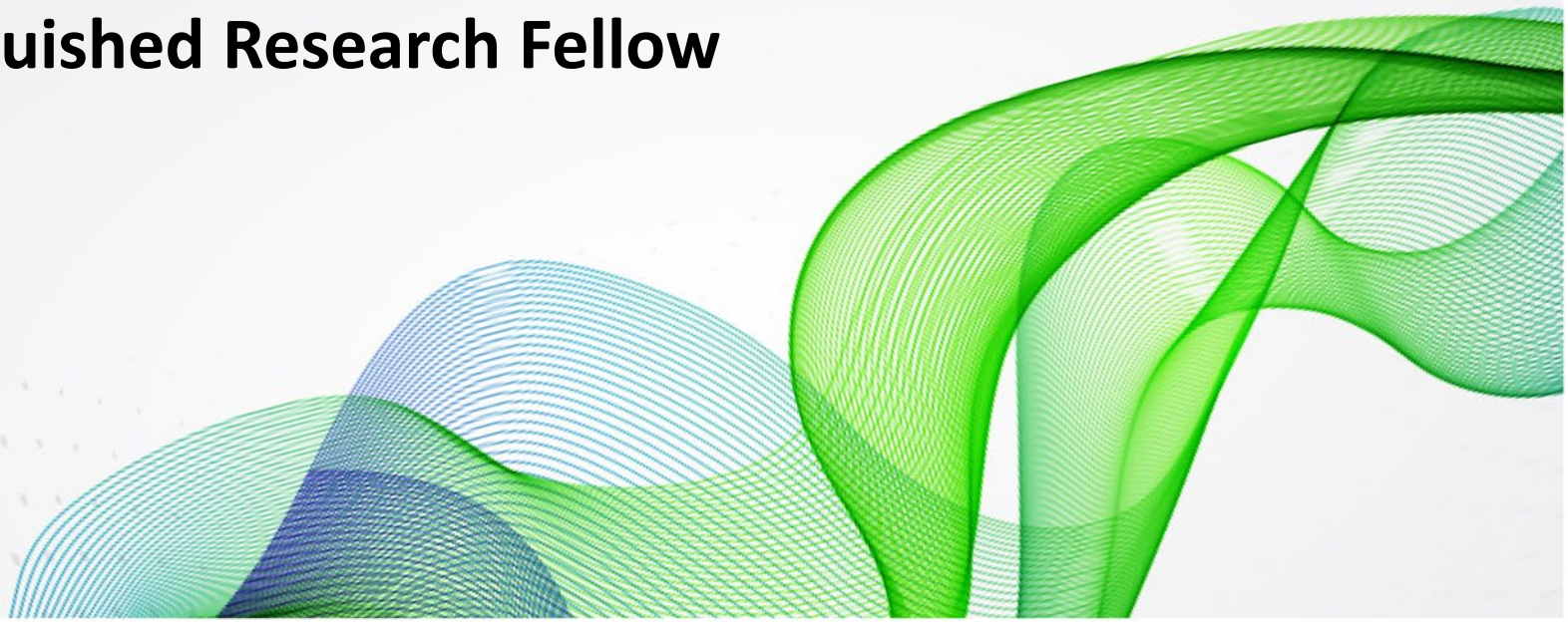
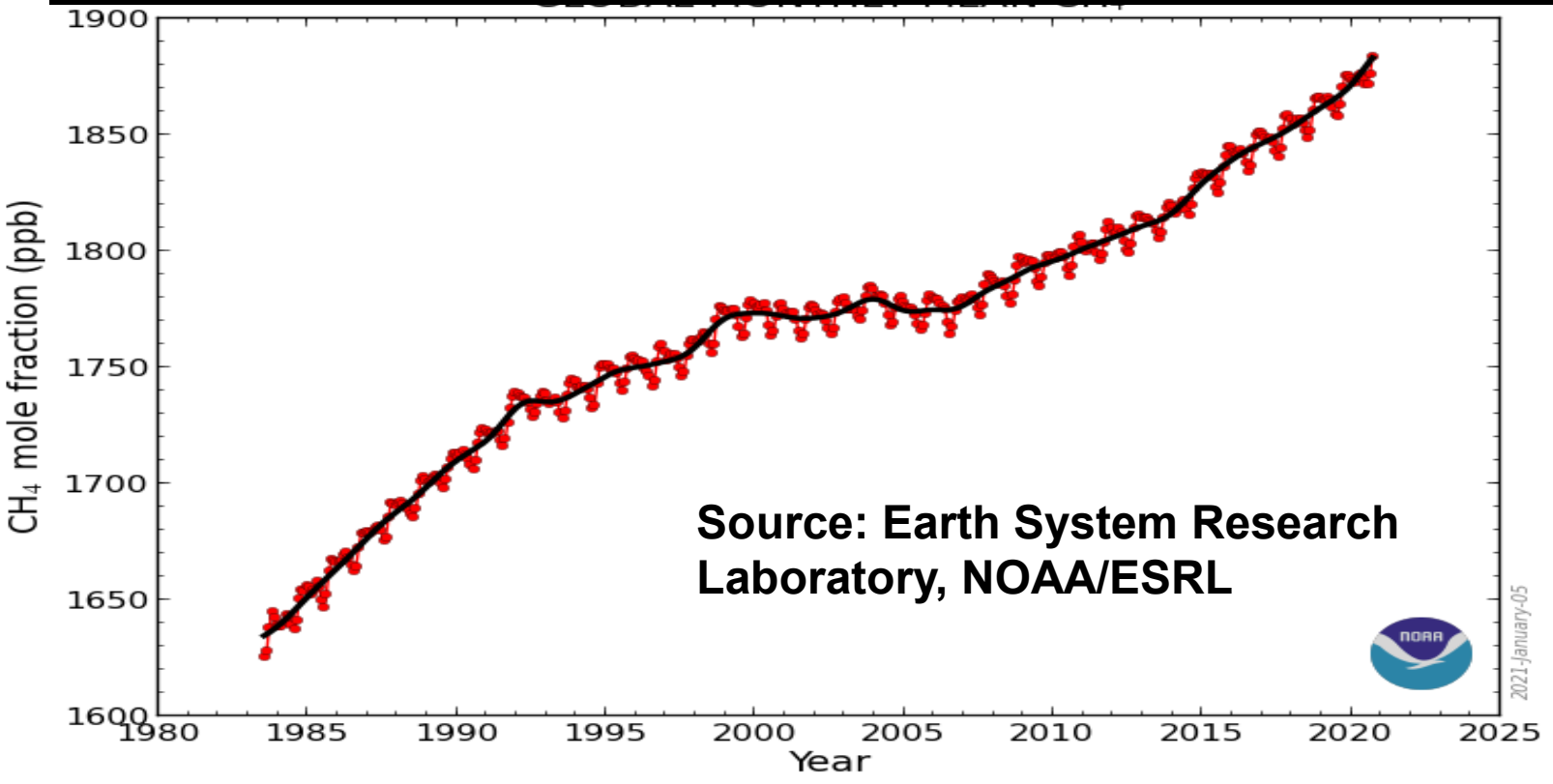


AGENDA

- Importance of methane emissions
- The future of natural gas under net zero targets
- Difficulties and complexities of data; measurement reporting and verification
- The EU Methane Strategy
- Emissions from LNG value chains: carbon neutral LNG and the Pavilion initiative
- Conclusions

Methane Emissions: steadily increasing since 2005

Global Monthly Mean Atmospheric Methane Concentrations 1983-2020



Methane emissions have been rising rapidly over the past decade, data for 2008-17 show an increase in anthropogenic methane 60% of which is agriculture and 40% fossil fuels, of which 57% oil and gas

Especially important for substitution of coal by imported natural gas and LNG

- Combustion of natural gas emits 45% less CO2 than coal and 25% less CO2 than oil BUT..adding methane emissions (to gas and coal) will impact these figures. Taking methane emissions into account the IEA says that <u>on average</u>:
  - coal-to-gas switching reduces emissions by 50% when producing electricity and by 33% when providing heat;
  - electricity produced from gas that has been transported as LNG results on average in 45% lower GHG emissions than coal.

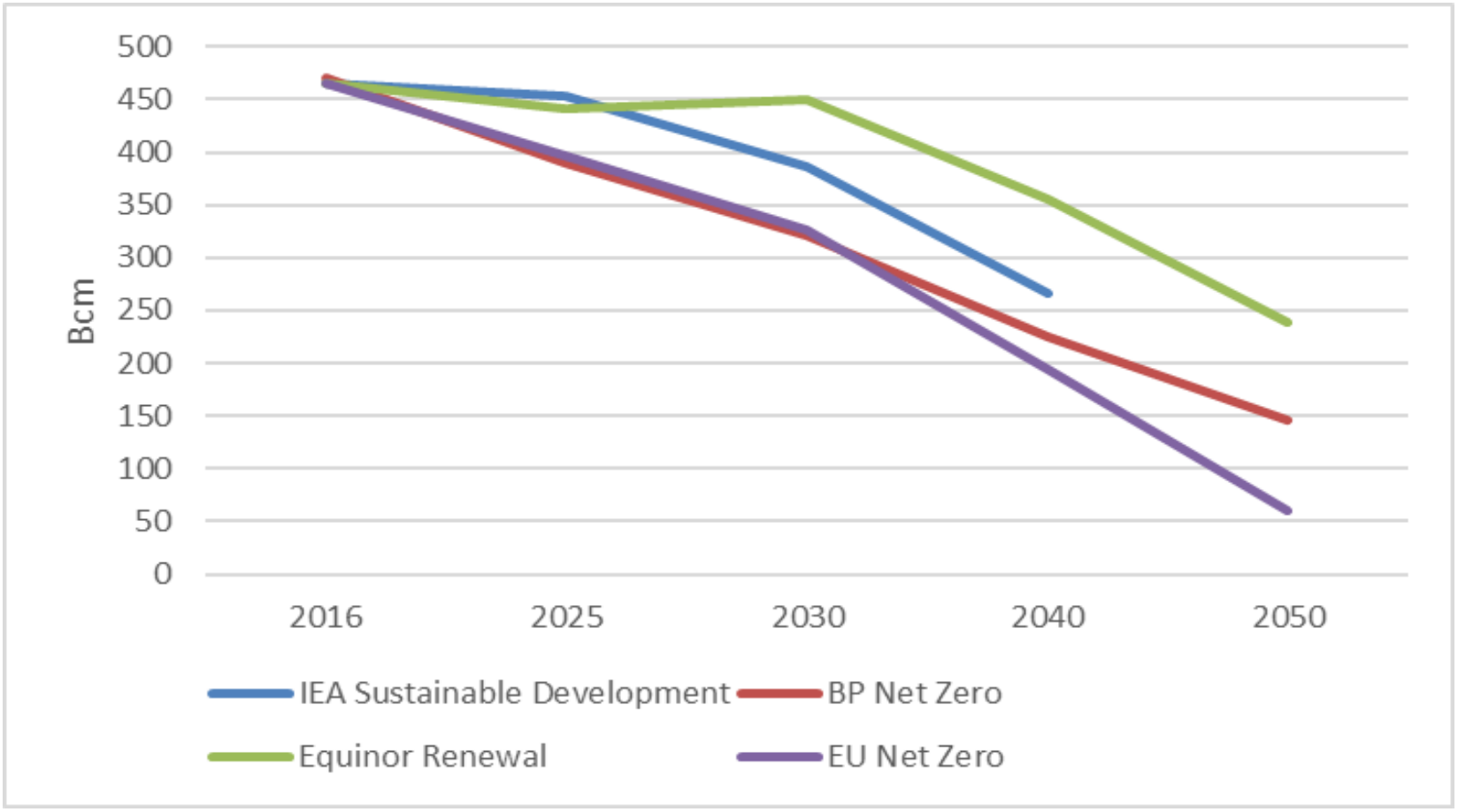
But `average' is not useful, what importers need to know is:

- What is the GHG content of the coal (or oil) that they are currently using compared with..
- the GHG content of the natural gas or LNG imports which will be replacing the coal (or oil)

Policy and regulation needs to be based on accurate measurement not averages

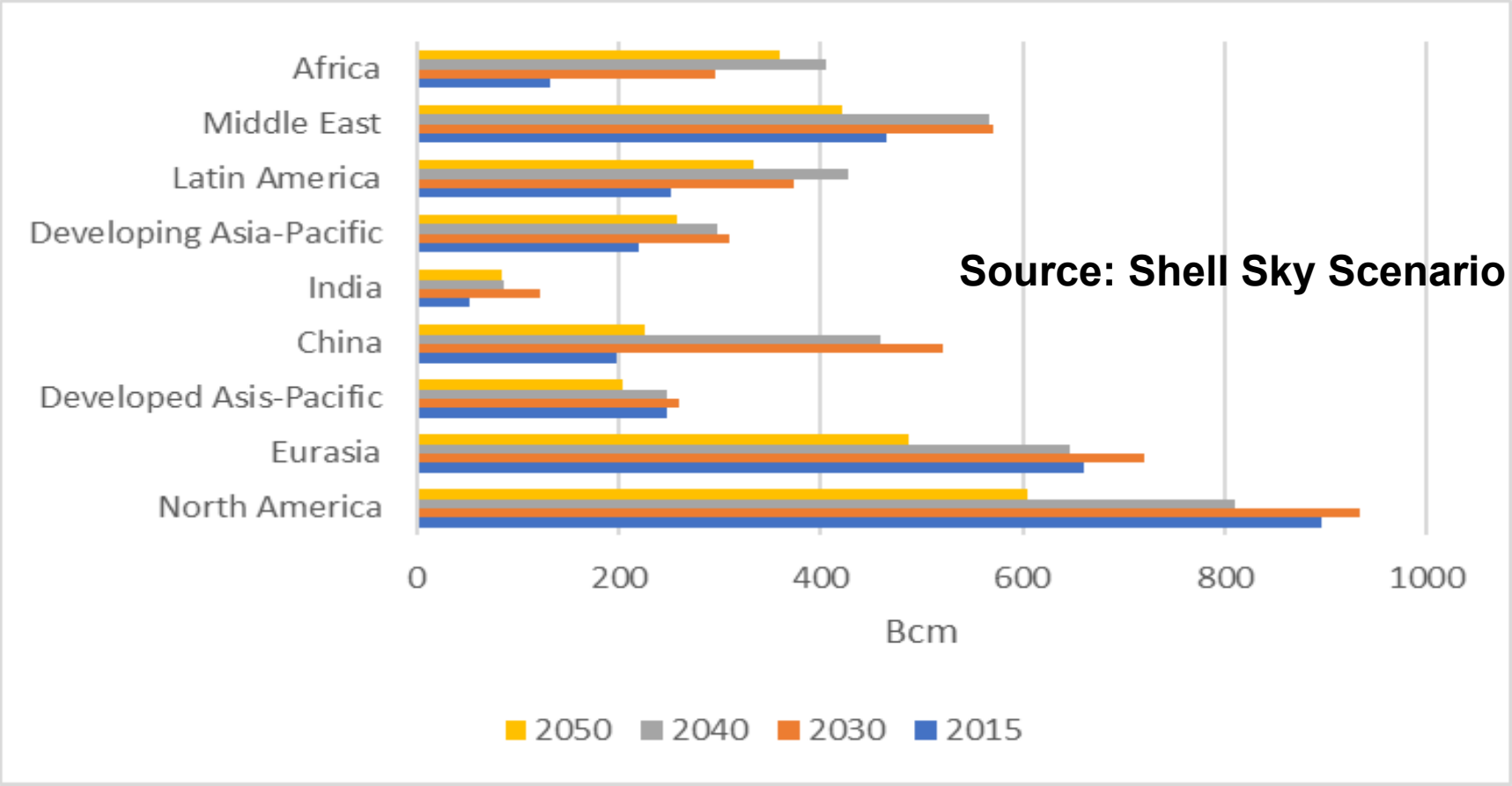
The Future of Natural Gas and LNG under Net Zero Targets

EU Gas Demand to 2050 Under COP21 and Net Zero Scenarios



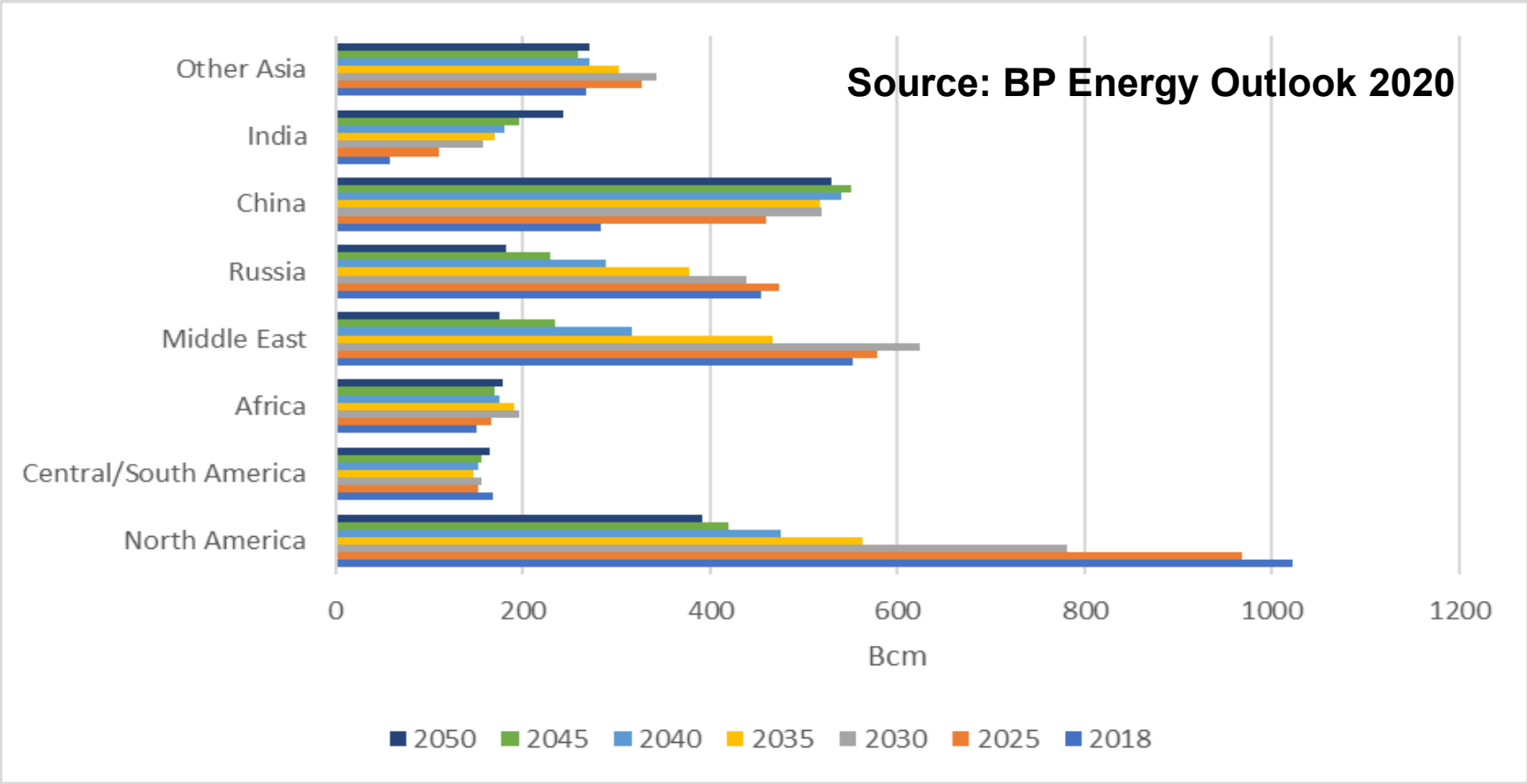
COP21+ means stable demand up to 2025-2030 then sharp decline; Net Zero means decline of 25% by 2030 accelerating thereafter

Shell Sky Scenario for non-European Gas Demand



Note that Indian demand never rises above 100 bcm and Chinese demand collapses post-2040, Middle East over 400 Bcm in 2050; Latin America over 400 bcm in 2040

BP Net Zero Scenario for Non-European Gas Demand

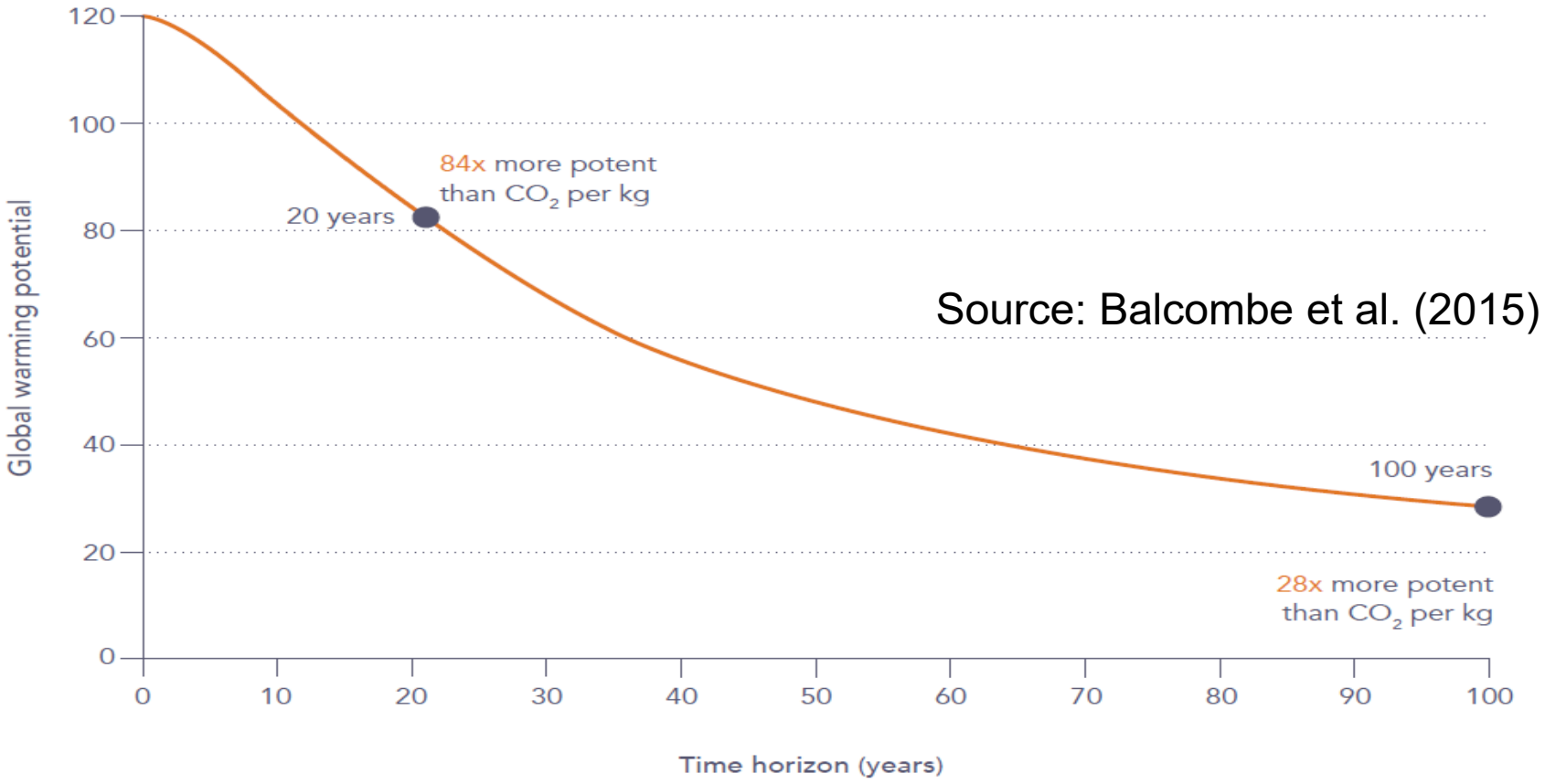


Note Indian demand is 250 bcm by 2050, China steady at >500 Bcm; Middle East below 200 Bcm; North America and Russia much lower by 2040 than in other scenarios

CONCLUSION: net zero global energy models can result in very different outcomes for regional gas demand in 2050. The GHG footprint of natural gas and LNG will determine its future in different countries

Difficulties and Complexities of Data and Measurement

Greenhouse Gas Emissions: the global warming potential (GWP) of methane relative to CO2



Source: Balcombe et al. (2015)

IPCC AR5 (and most of the fossil fuel literature) uses a 100 year time horizon ie 28 x CO2 For a 20 year time horizon the GWP would be 84 times that of CO2

Major Sources of Methane Emissions from Fossil Fuels: data availability

- **VENTING**: from oil and gas production and processing (tends to be deliberate)
- **FLARING**: particularly from gas associated with oil production, mainly CO2 but can include methane and other uncombusted gases
- **FUGITIVE**: emissions (usually unintended) from gas pipelines and LNG (liquefaction, shipping and regasification)

TWO MAIN SOURCES OF DATA:

- **UNFCCC**: 30-year time series and full chain, but inconsistent and with countries (mostly) limited to Annex 1
- **IEA Methane Tracker**: short time series, upstream only, but consistent and includes many more countries

Methodologies for Measuring Methane: bottom-up (ground level) and top-down (aerial)

- **Bottom-up** (ground level) measurement:
  - Advantages: low cost, highly location-specific (not contaminated by other sources of methane) and can be 24/7 so will capture occasional but potentially very strong emission episodes
  - Disadvantages: may not be capturing all emissions eg venting and uncombusted flares, offshore limits
- **Top-down** (remote) – aeroplane overflights, satellites, drones:
  - Advantages: identifies emissions which need explanation not registered at ground level
  - Disadvantages: insufficiently location-specific, low reporting frequency may not capture key episodes

Verification requires reconciliation of bottom-up and top-down measurements

Reporting and Verification

REPORTING:

- Impossible to separately report oil and gas emissions for associated gas production; some countries report all methane emissions as oil- (not gas-) related
- Coal emissions hardly reported, very important for claims of GHG reduction from coal to gas/LNG switching

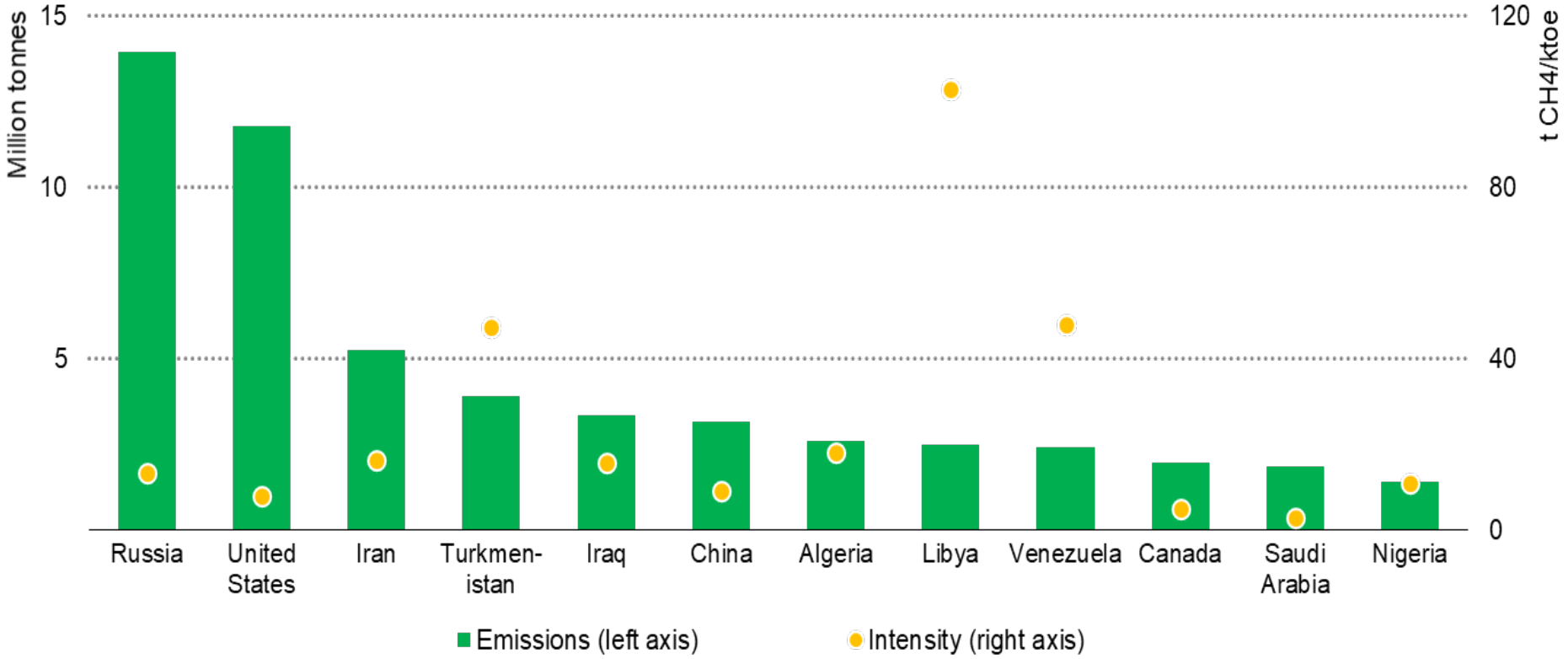
VERIFICATION:

- Current verification is mostly accountancy-based ie checking data collected by companies
- Future verification needs to be based on replication of emission measurements based on sample testing by accredited independent organisations

The IEA Methane Tracker (January 2021): "data are poor, incomplete and contradictory"

Average Upstream Methane Intensity of Major Gas and LNG Exporters to EU Countries (2020)

Source: IEA Methane Tracker (2021)



This is national intensity from oil and gas exploration and production only; not intensity from gas and LNG exports

THE EU METHANE STRATEGY (October 2020) is principally concerned with Measurement, Reporting and Verification (MRV)

EU domestic gas production is falling rapidly hence the focus on methane emissions from imports (upstream+transportation), said to be 3-8 times those of domestic emissions

Elements of the EU Methane Strategy (2020)

- The Strategy covers energy, agriculture and waste
- Energy: all sources – oil, fossil gas, coal, pipeline gas, LNG, storage
- Biogas must be based on waste/residues, not food or feed crops
- **Make Tier 3 the `benchmark standard'**– satellite data sharing (using Copernicus) can identify and eliminate super-emitters
- Voluntary initiatives: **Oil and Gas Methane Partnership (OGMP)** is the best existing framework – extend through the value chain
- Create a global **Methane Observatory** to establishment an `independent and qualified international methane emissions mechanism' (UNEP based on OGMP principles) within the CCAC
- **Legislation will require: obligations to report, repair (LDAR improvement)**, transparency of methodology and data; **`routine' venting and flaring to be banned by 2025**, transportation and coal mines to be addressed later
- **Proposes a coalition of importing countries (China, Japan, South Korea) to `coordinate energy sector methane emissions'**

Likely timeline: publication of draft legislation end-2021, agreement by Council end 2022, transposed into national legislation 2024-25

The EU Methane Strategy: persuasion versus compulsion

EXPORTERS:

Persuasion: "The EU will lead a diplomatic outreach campaign to fossil fuel producer countries and companies… technical assistance.."

Compulsion: "the Commission will propose to use **a default value** for volumes that do not have adequate MRV systems in place..[it] will be applied where necessary until a compulsory MRV framework for all energy-related methane emissions..is implemented…In the absence of significant [MRV] commitments from international partners, the Commission will consider proposing **legislation on targets, standards or other incentives** for fossil energy consumed and imported in the EU."

Persuasion is likely to work better (and faster!) than compulsion; compulsion means there is potential for years to be spent on extra-territoriality/WTO discrimination legal arguments

Strategy needs to focus on different emissions profiles from different export supply chains

- Russia Pipeline: Nord Stream, Yamal-Europe, Ukraine
- Russia LNG: Yamal LNG, Sakhalin LNG
- US LNG: different supply sources (Permian, Gulf of Mexico, other) arriving through different pipelines to individual liquefaction terminals (Sabine Pass, Cameron, Freeport)
- Algeria: pipeline and LNG deliveries from Hassi R'Mel and Hassi Mesaoud via different pipelines (trans-Mediterranean and GME) and/or different LNG terminals (Arzew, Skikda)

Estimating emissions from gas and LNG delivered via specific export supply chains will be complex, but much easier than trying to agree a `national' emission standard defined by a global body

Countries and Companies which delivered significant pipeline gas and LNG to the EU (2019)

COUNTRY	COMPANIES WHICH DELIVERED SIGNIFICANT VOLUMES OF PIPELINE GAS AND LNG TO EUROPEAN CUSTOMERS IN 2019
	MEDIUM AND LONG TERM CONTRACTS
Russia	Gazprom, Novatek
Norway	Equinor
Algeria	Sonatrach
Qatar	Qatargas
Nigeria	Nigeria LNG
United States	Cameron LNG, Total, Cheniere
Azerbaijan	Socar
Trinidad	Atlantic LNG
Libya	Libyan National Oil Company
PORTFOLIO LNG SELLERS	
Shell, Total, Centrica, ENI, Equinor, Iberdrola, Naturgy	

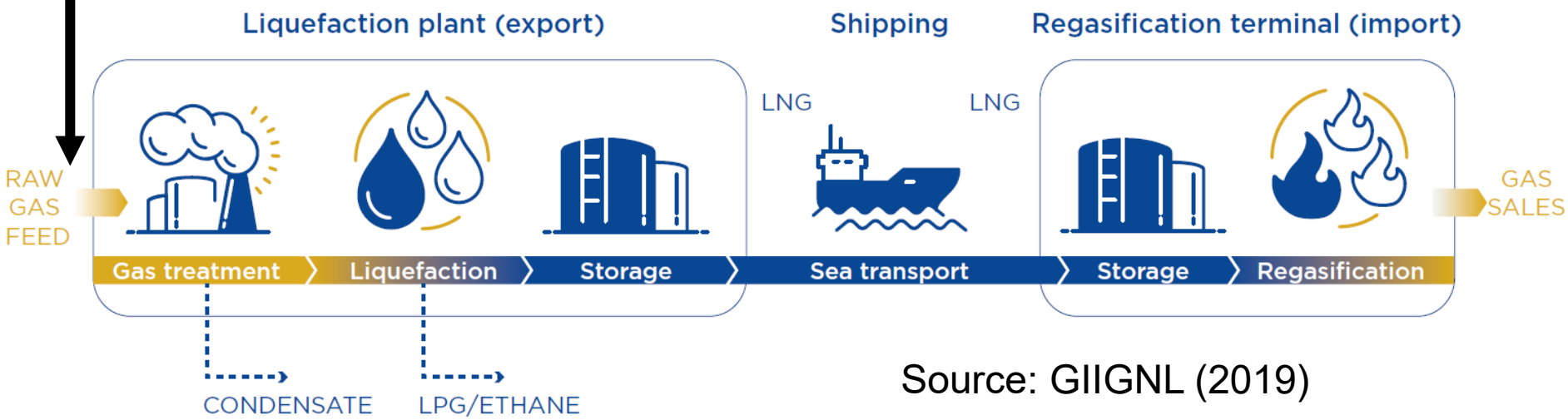
The top six countries account for >90% of EU Imports; urgency is agreement with those governments/companies

Emissions from LNG value chains

LNG: the Value Chain

Exploration and Production

Pipeline from field to Liquefaction plant



Source: GIIGNL (2019)

Emissions from the whole value chain need to be measured:

- **From exploration and production to the delivery point (regas terminal or DES – Scope 1 and 2 emissions) are the most important for the industry to measure**
- **Data are often confidential/unavailable**

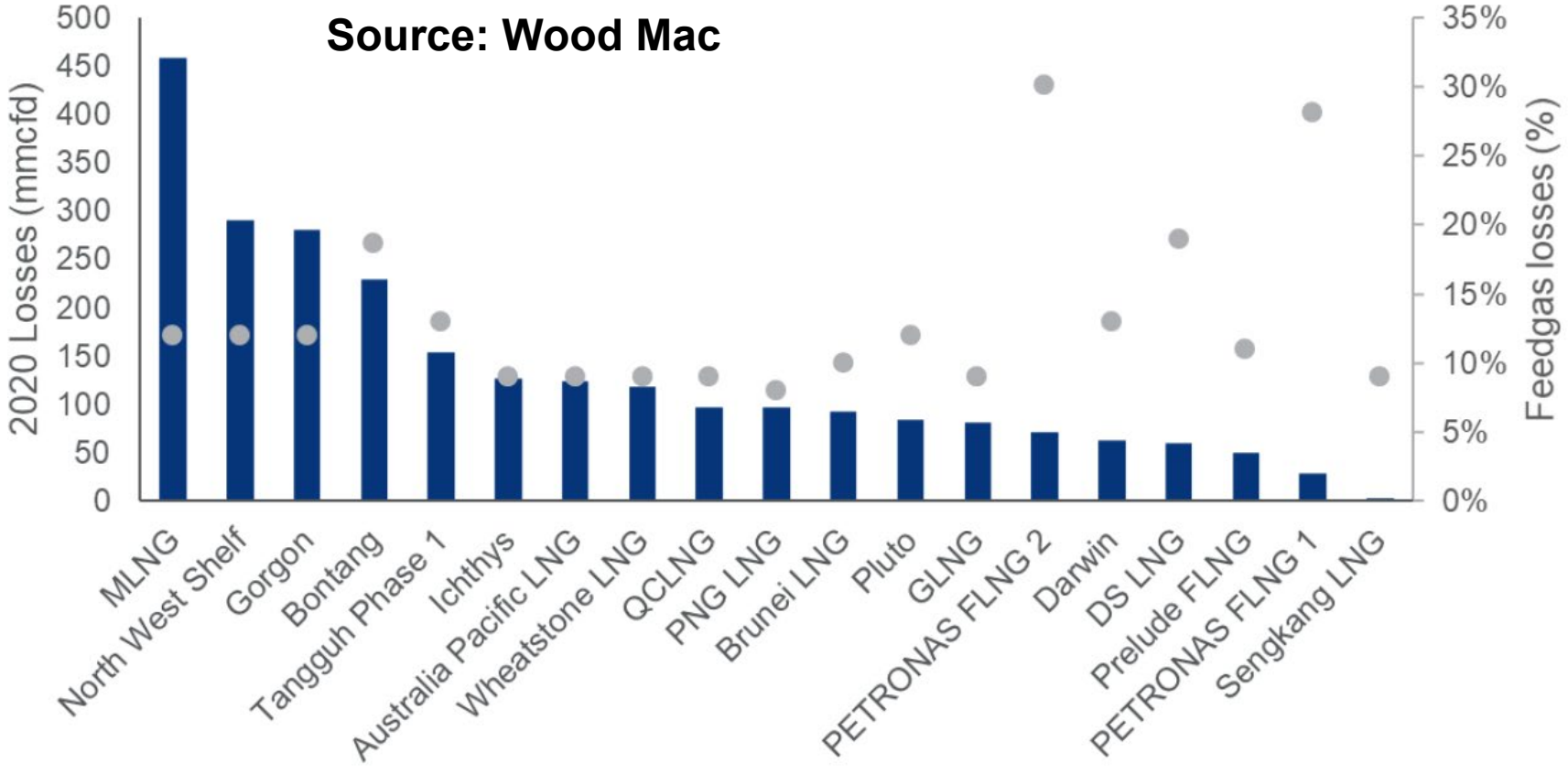
Why have emissions from LNG trade become important in the context of decarbonisation?

- Increasing share of LNG in total natural gas trade
- Increasing concern from importers about upstream emissions in exporting countries – where data may not be available (and very high emissions may be suspected)
- Because of the energy needed for liquefaction, around 8-12% of gas produced at the wellhead (significantly higher than pipeline gas) and can be much higher for FLNG

Methane emissions from the LNG value chain can significantly increase the total GHG footprint

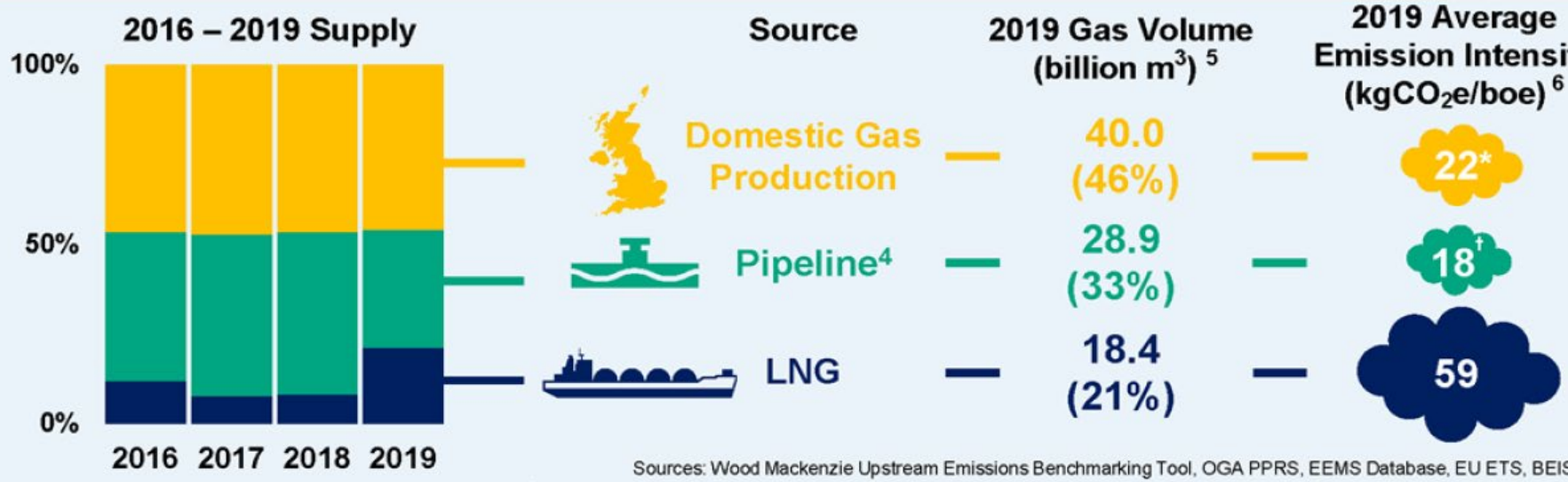
Feedgas Use in Asian LNG Projects*

*** Energy needed to generate electricity to run the plant and fuel the liquefaction process.**



Big variations in percentage losses for different projects, up to 30% for some FLNG projects

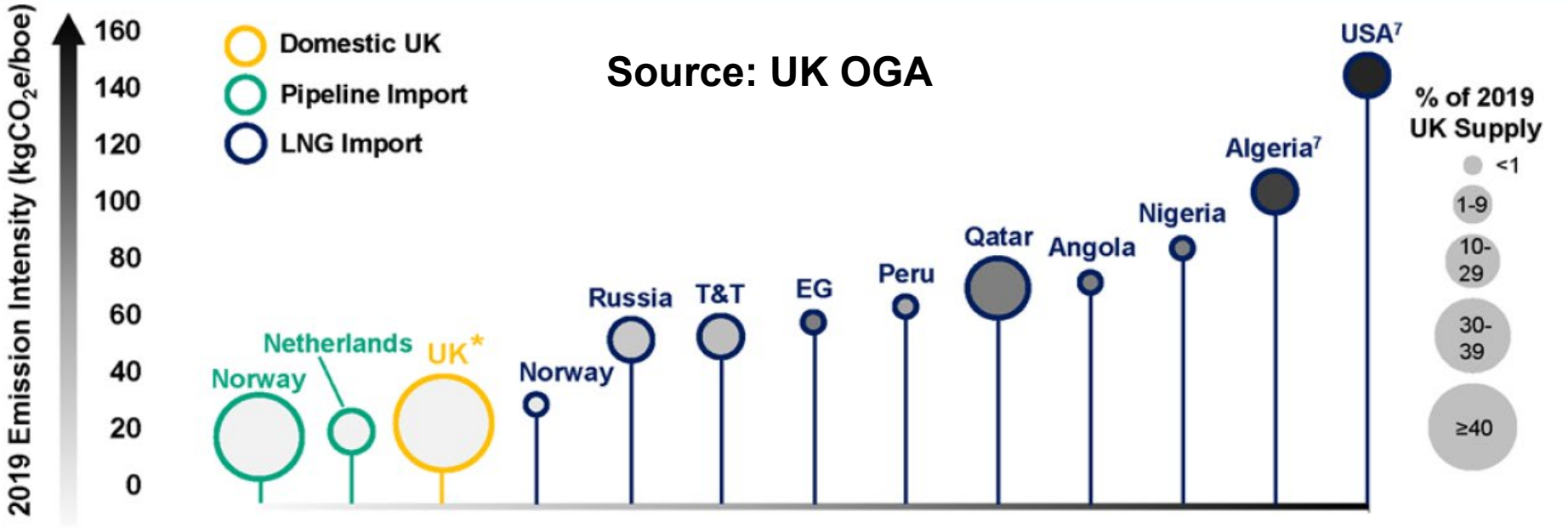
UK Gas Supply by Origin



Sources: Wood Mackenzie Upstream Emissions Benchmarking Tool, OGA PPRS, EEMS Database, EU ETS, BEIS, NPD

† Gas imported via the Belgian and Dutch interconnectors cannot be traced to the point of origin therefore the intensity could be higher.

Emission Intensities of UK Gas Sources



T&T: Trinidad and Tobago, EG: Equatorial Guinea

Sources: Wood Mackenzie Upstream Emissions Benchmarking Tool, OGA PPRS, EEMS Database, EU ETS, BEIS, NPD, Thinkstep

Seven `Carbon-Neutral' LNG cargos via (mainly) forest offsets all in Asia, 2019-20*

- Shell-Tokyo Gas (June 2019) delivery in Japan (1)
- Shell-GS Energy (June 2019) delivery in South Korea (1)
- Jera Global Markets - Adnoc (June 2019) delivery in India
- Shell-CPC (March 2020) delivery in Taiwan (1)
- Shell-CNOOC (June 2020) delivery in China (2)
- Total-CNOOC (October 2020) delivery in China (1)**

*The Shell and Total cargoes offset emissions from extraction to regasification; the Jera cargo only offset emissions from the regas terminal downstream **part forest/part wind power offset

- **Were these cargos carbon-neutral or GHG-neutral?**
- **No details of: measurement methodologies, emissions per cargo, volume/value of offsets, verification of data**
- **Additional cost per cargo estimated at $2.4m = $0.7-0.8/Mmbtu**
- **Are offsets realistic on a large scale for LNG contracts?**

Pavilion LNG (Singapore) tender for 2mt of LNG with defined GHG content to commence 2023

- Long term contract tender – 25 offers of supply
- Not `carbon neutral' but cargos with defined GHG content from wellhead to delivery point
- First contract won by Qatar Petroleum Trading 1.8mt/year for 10 years – each cargo will have a statement of GHG emissions from wellhead (additional contracts anticipated)
- Standardised measurement and verification methodology to be published

Potential to become a standard methodology for GHG emissions from LNG cargos

CONCLUSIONS

Different Approaches to Methane Emissions Reduction

- **GLOBAL – UN Observatory will collect, collate and publish national emissions data**
- **EU Regulatory Approach:**
  - **EU Methane Strategy will require MRV for EU imports of (all fossil fuels but focussed on) natural gas and LNG; this may be completely different to national data**
- **Corporate (per cargo) Approach (Asia):**
  - **Carbon-neutral LNG cargos**
  - **Long(er) term LNG contracts with defined MRV methodology for each cargo (could become a multilateral standard)**

Transparent Measurement, Reporting and Verification of Methane Emissions: questions for companies

MEASUREMENT:

- **How were emissions measured: with what instruments, were bottom up and top down measurements carried out and reconciled?**

REPORTING:

- **How have emissions been reported: by field (production), network (transmission and distribution), export/import (pipeline and LNG value chain)?**
- **Are they reported by fuel – oil, gas and coal?**
- **How are they attributed between oil and gas production?**

VERIFICATION:

- **Which organisation has verified the emissions; was this an accounting exercise or did it include sampling of emissions?**

Confidentiality is the enemy of credibility

Are Methane Emissions from Natural Gas and LNG a Big Problem?

- In some respects – NO – methane emissions from agriculture (and in some countries waste) are a bigger problem BUT..
- methane emissions from natural gas and LNG can be reduced much more quickly and at much lower cost than from agriculture
- If natural gas and LNG companies fail to respond to calls to reduce methane emissions then the fuel may be phased out faster, certainly in Europe and possibly in Asia

Methane emissions are considered a `big problem' by governments and environmental groups, therefore they are a big problem for natural gas and LNG companies, and net zero targets mean this problem will get bigger

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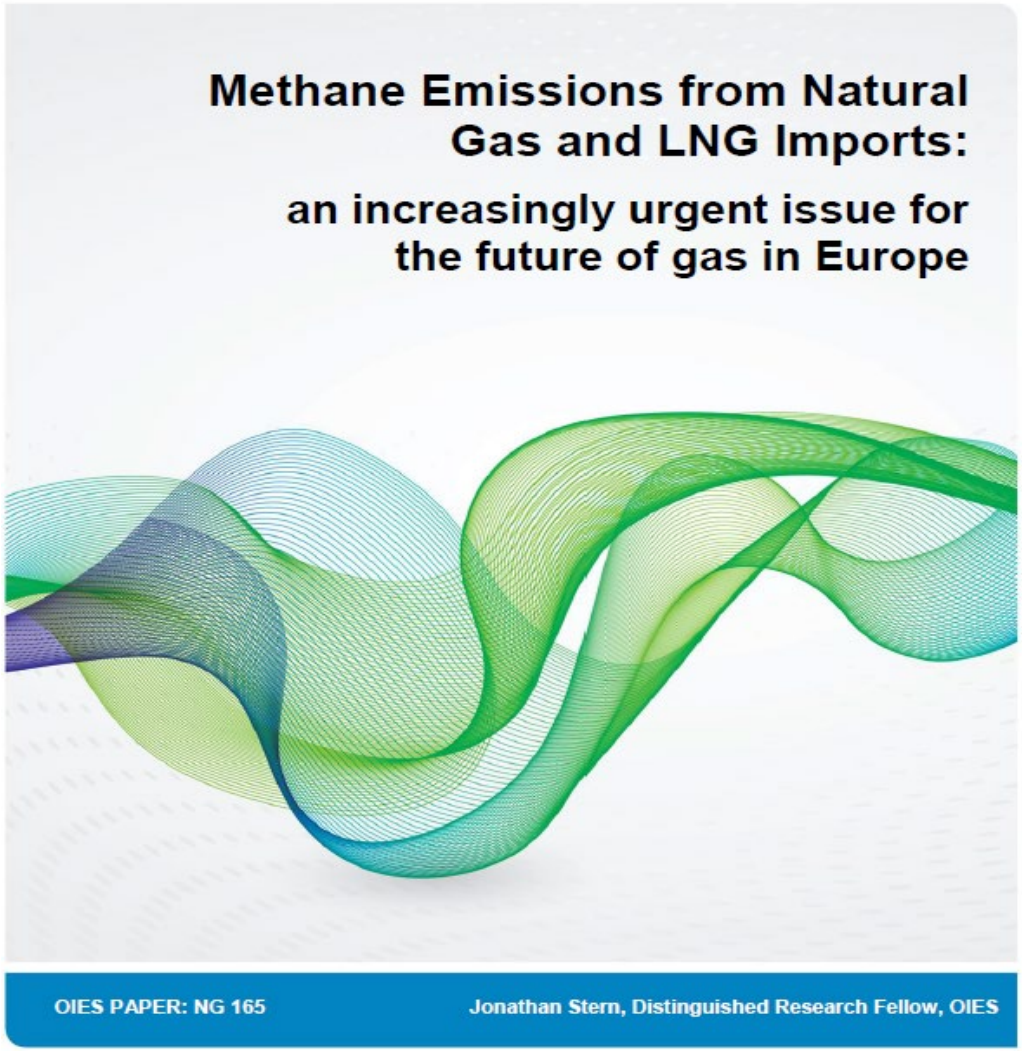

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