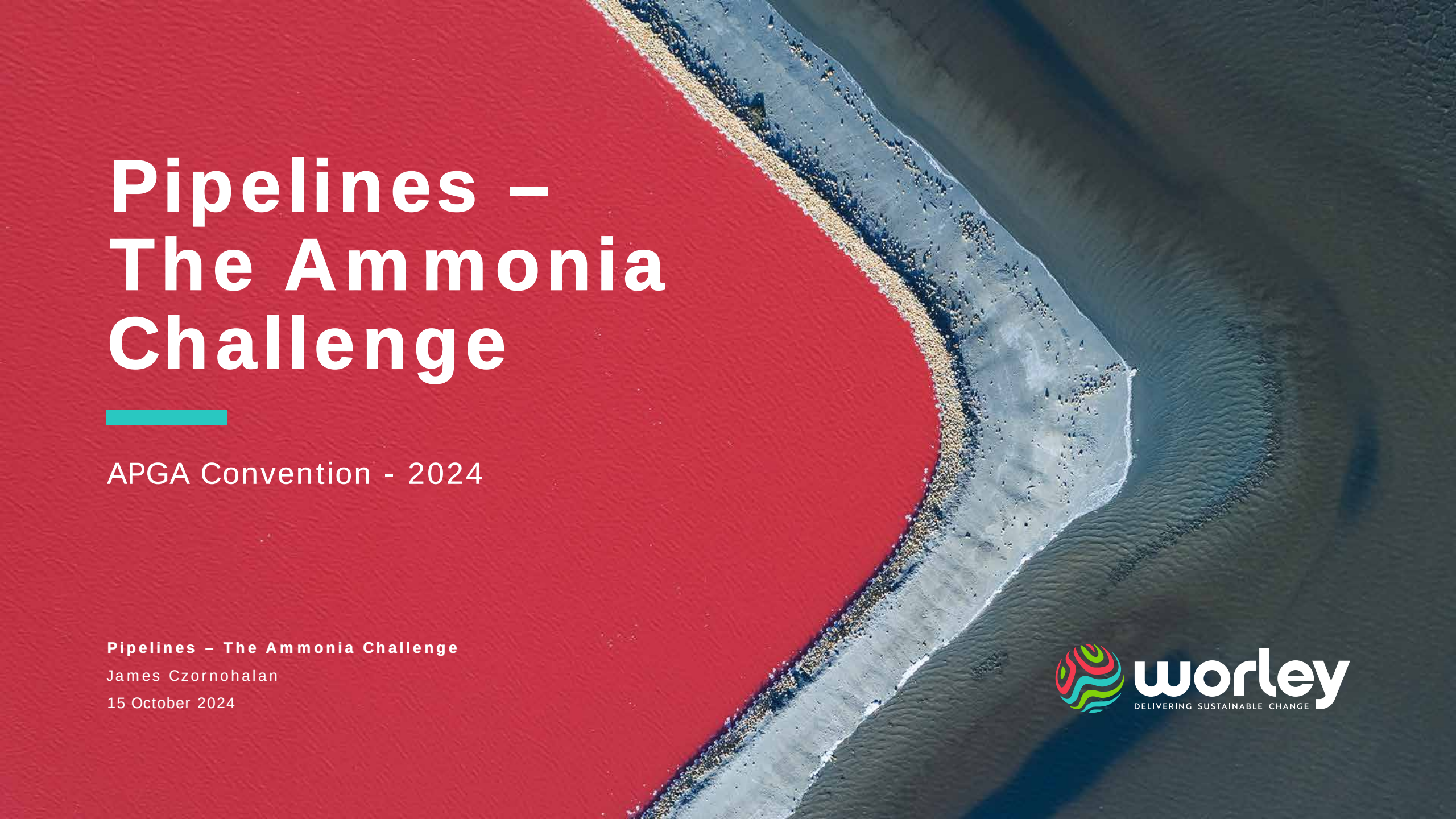
Pipelines – The Ammonia Challenge

APGA Convention - 2024



Pipelines – The Ammonia Challenge
James Czornohalan
15 October 2024

worley
DELIVERING SUSTAINABLE CHANGE

Wait a minute, Ammonia? Weren’t we all talking about Hydrogen?

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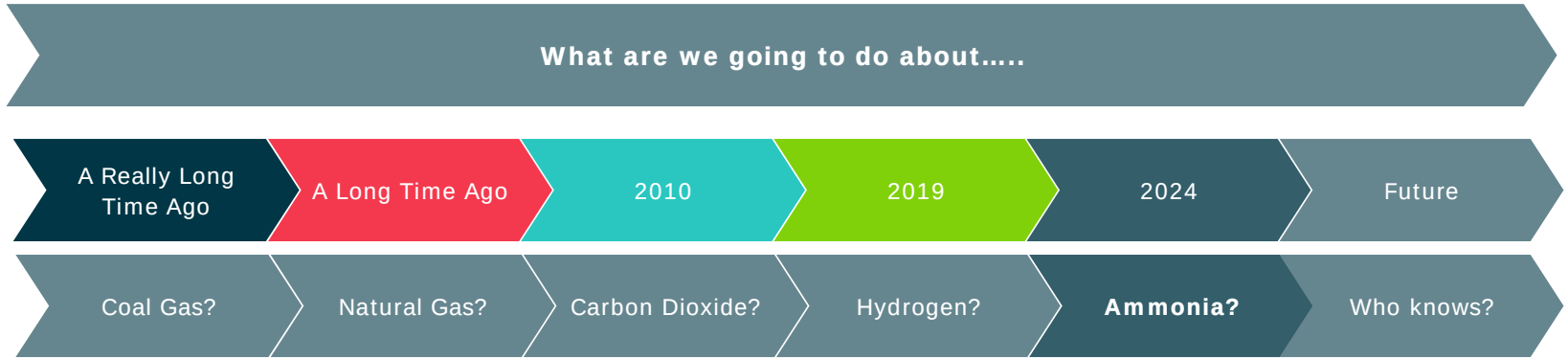
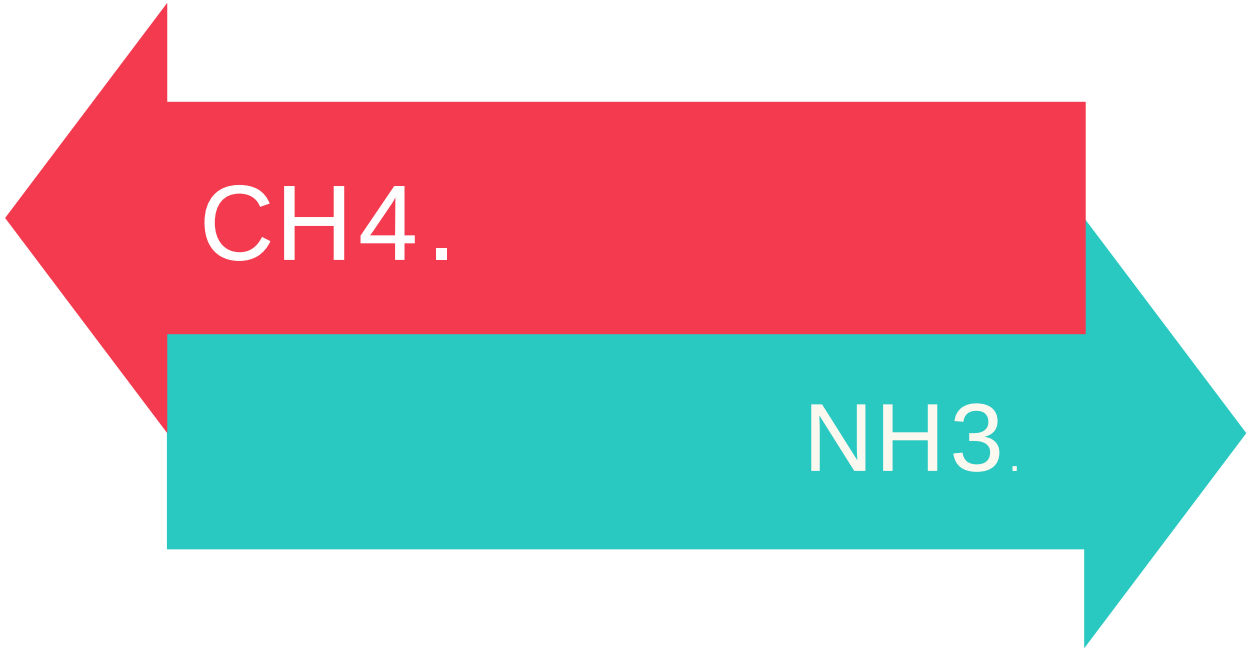
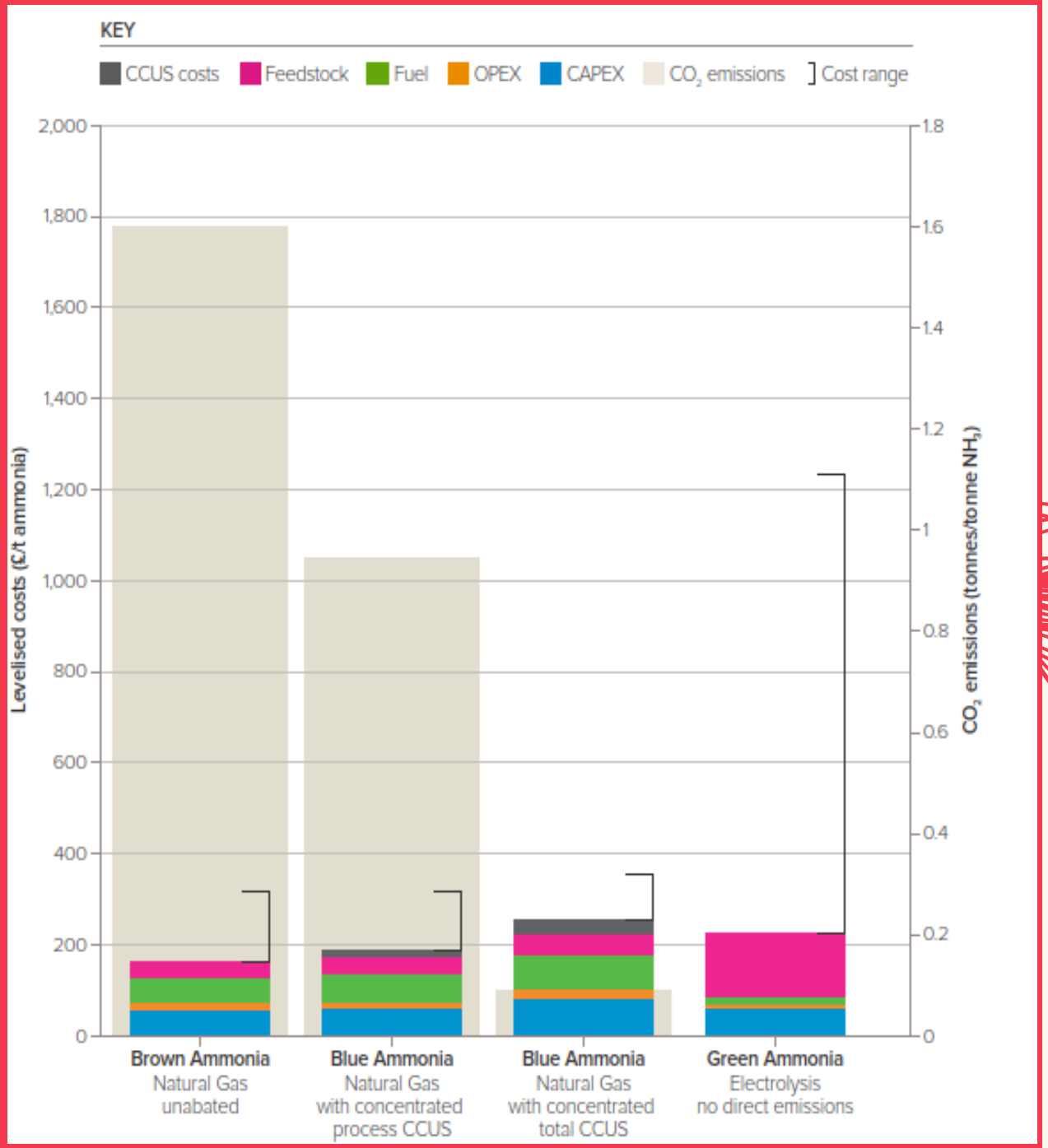
Pipeline Engineers be like

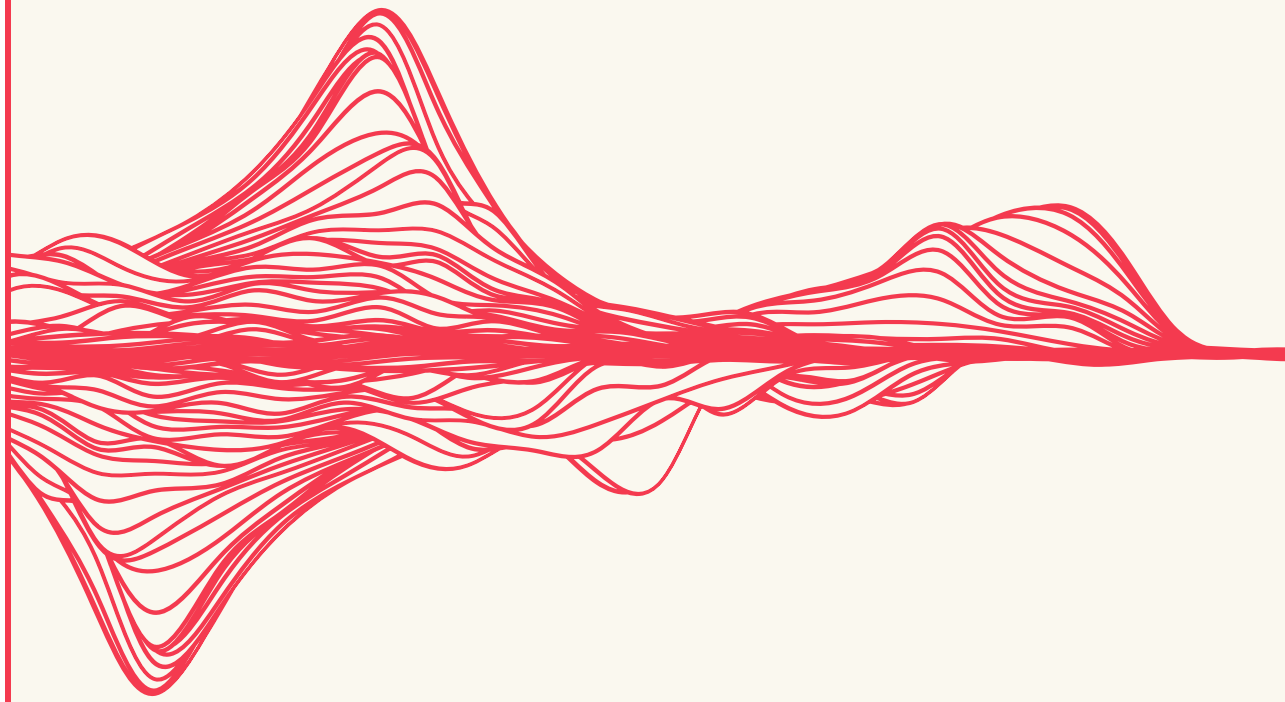


Why Ammonia?

Out with the Carbon, in with the Nitrogen




KEY
CCUS costs
Feedstock
Fuel
OPEX
CAPEX
CO_2 emissions
Cost range
Levelised costs (£/t ammonia)
CO_2 emissions (tonnes/tonne NH_3)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Brown Ammonia
Natural Gas
unabated
Blue Ammonia
Natural Gas
with concentrated
process CCUS
Blue Ammonia
Natural Gas
with concentrated
total CCUS
Green Ammonia
Electrolysis
no direct emissions

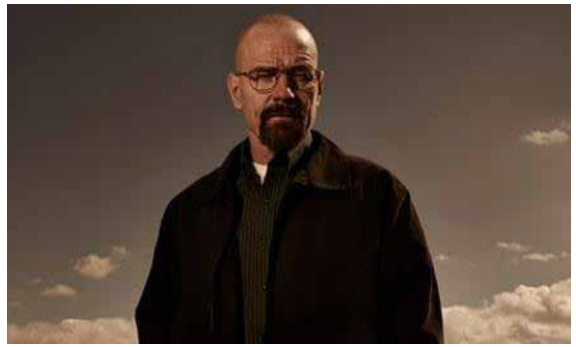


Project name	Proponents	State/Territory	City/Region	Status	Production method
Allied Green Ammonia	Allied Green Ammonia	NT	Gove	Under development	Electrolysis
Boolathana Project	Gascoyne Green Energy	WA	Gascoyne region	Under development	Electrolysis
Central Queensland Hydrogen (CQ-H2) Project	Stanwell Corporation, Iwatani Corporation, Marubeni Corporation, Kansai Electric Power Company, Keppel Infrastructure	QLD	Gladstone	Under development - FEED	Electrolysis
East Kimberley Clean Hydrogen Project	Aboriginal Clean Energy Partnership (Balanggarra Ventures Limited, MG Corporation, Kimberley Land Council, Pollination)	WA	East Kimberley	Under development	Electrolysis
Eyre Peninsula Gateway Project - Demonstrator Stage	The Hydrogen Utility (H2U)	SA	Eyre Peninsula	Under development - FEED	Electrolysis
Geraldton Export-Scale Renewables Investment	bp Australia Pty Ltd	WA	Geraldton/Oakajee	Under development	Electrolysis
Gibson Island Green Hydrogen and Ammonia Project	Fortescue, Incitec Pivot Ltd	QLD	Brisbane	Under development - FEED	Electrolysis
Good Earth Green Hydrogen and Ammonia Project	Hiringa Energy (Operator), Sundown Pastoral Company	NSW	Moree	Under development - FEED	Electrolysis
H2-Hub™ Gladstone	The Hydrogen Utility (H2U)	QLD	Gladstone	Under development	Electrolysis
Han-Ho H2 Hub - Feasibility Study	Ark Energy Corporation Pty Ltd	QLD	Collinsville	Under development	Electrolysis
HyEnergy Project	Province Resources Ltd	WA	Gascoyne	Under development	Electrolysis
Joint Feasibility Study for Creation of a Supply Chain of Low Carbon Ammonia in Western Australia	Mitsui E&P Australia Pty Ltd	WA	Mid-west WA	Under development	Fossil fuel conversion with CCS
Mid West Clean Energy Project	Pilot Energy	WA	Mid-west WA	Under development	CO2 convective reforming with integrated CO2 storage and Electrolysis
Murchison Hydrogen Renewables Project	Murchison Hydrogen Renewables Pty Ltd (parent company is Copenhagen Infrastructure Partners)	WA	Murchison	Under development	Electrolysis
North Queensland Clean Energy Project (HyNQ)	Energy Estate, CS Energy, Idemitsu Renewable Developments Australia, IHI Engineering Australia	QLD	Abbot Point	Under development	Electrolysis
Oakajee Energy Green Hydrogen and Ammonia Export Project - Stage 1	Oakajee Energy	WA	Oakajee region	Under development	Electrolysis
ScaleH2	ATCO Australia Pty Ltd	NSW	Port Kembla	Under development	Electrolysis
Yuri Renewable Hydrogen to Ammonia Project	Yuri SPV (ENGIE Lead Proponent), Mitsui	WA	Pilbara	Under construction	Electrolysis

It’s about the economics

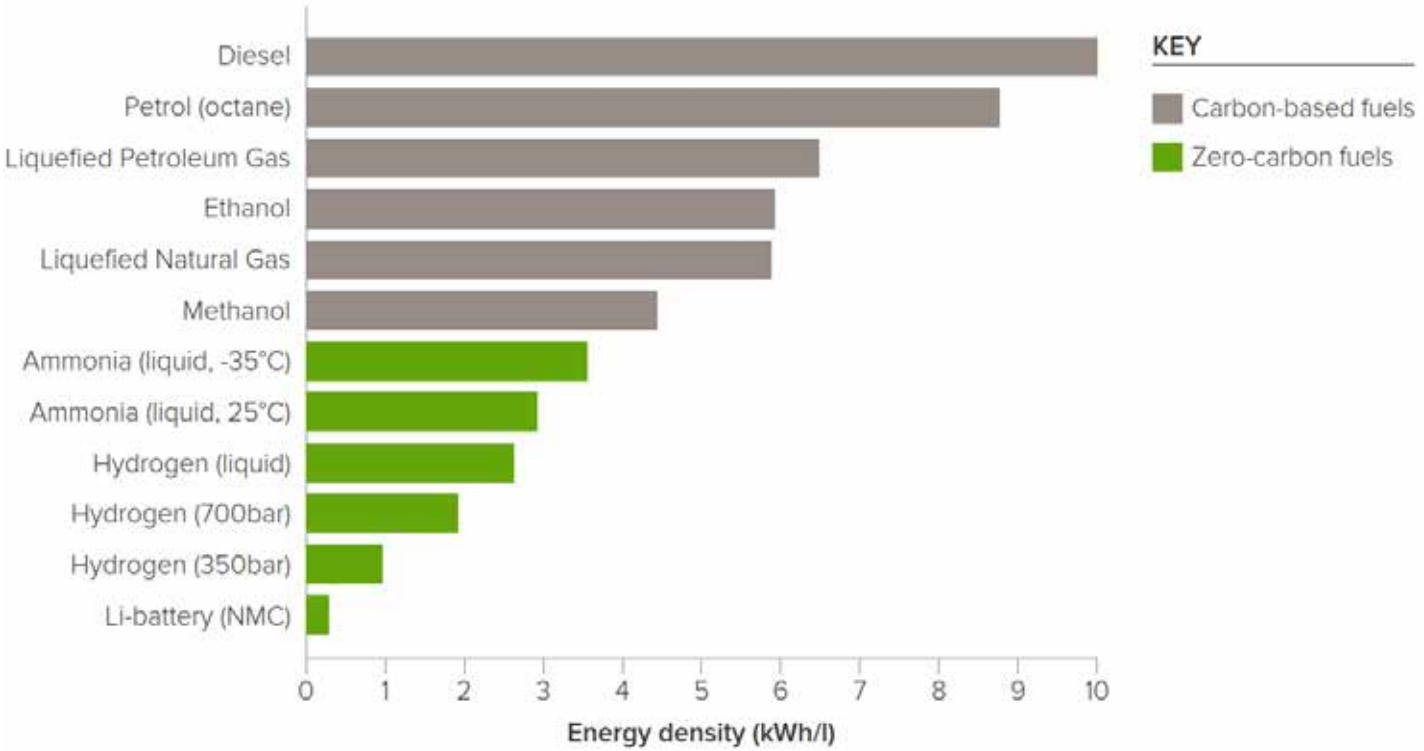
Existing markets for Ammonia include:-

- Fertilizers, some 45% of the world’s food production relies on ammonia based fertilizers.
- Explosives – Ammonium Nitrate is used in mining worldwide.
- Refrigerant.
- Cleaner.
- NOx control in catalytic reduction systems
- Pharmaceuticals

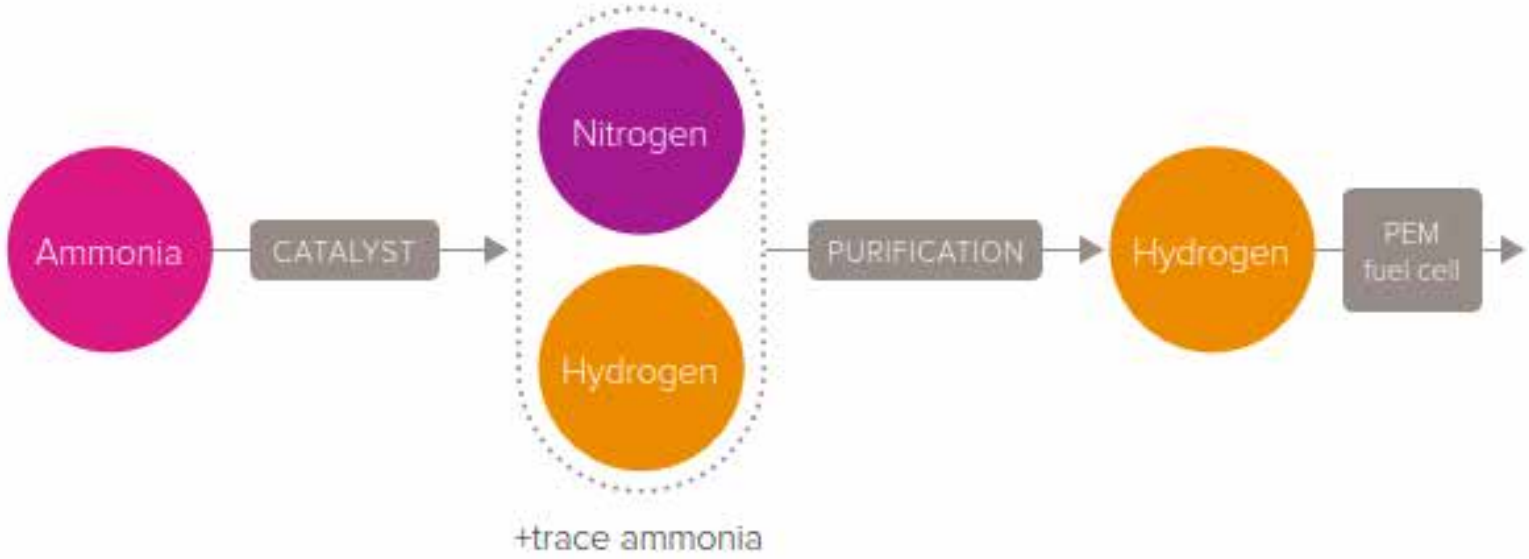


This lets us make it while we develop Ammonia as fuel

The volumetric energy density of a range of fuel options.



And crack it to get the H2 back out of it.



Not without its problems though…

It’s toxic!

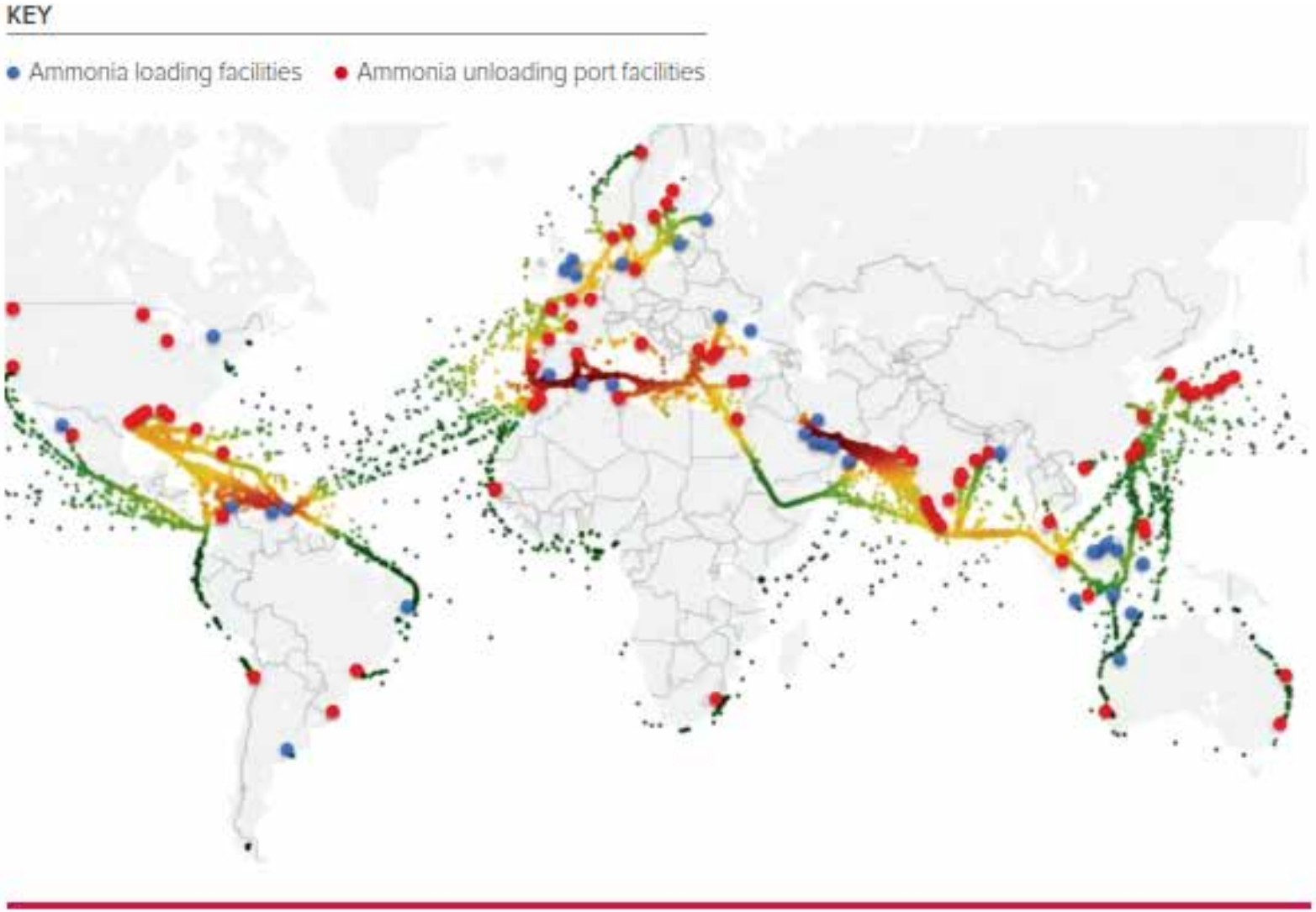
This presents us with some pipeline design challenges.

- How do we decide on measurement lengths? Ammonia is a HVPL, and exposure is time based.
- Various international guidelines, including by FFCRC, but numbers range from 150 to 1500pm for one hour.
- Ammonia industry uses AEGL (Acute Exposure Guideline Levels), which are broadly analogous to our 4.7 and 12.6.

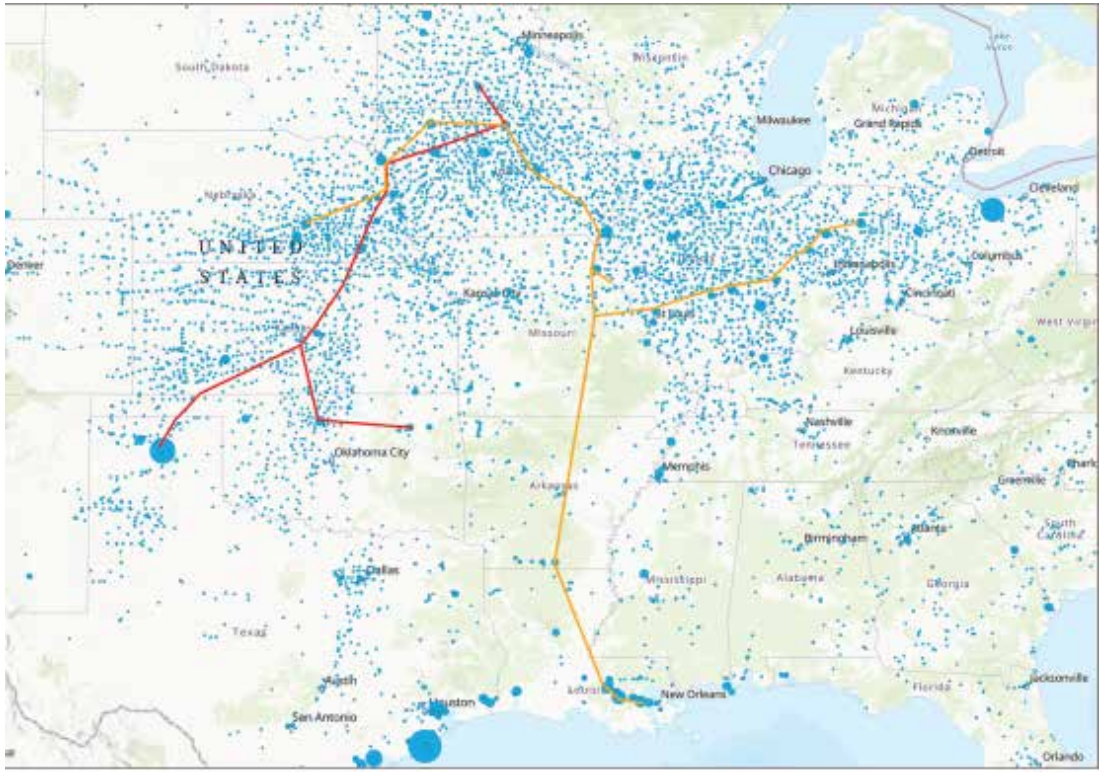
HOWEVER!

These distances are measured in km!

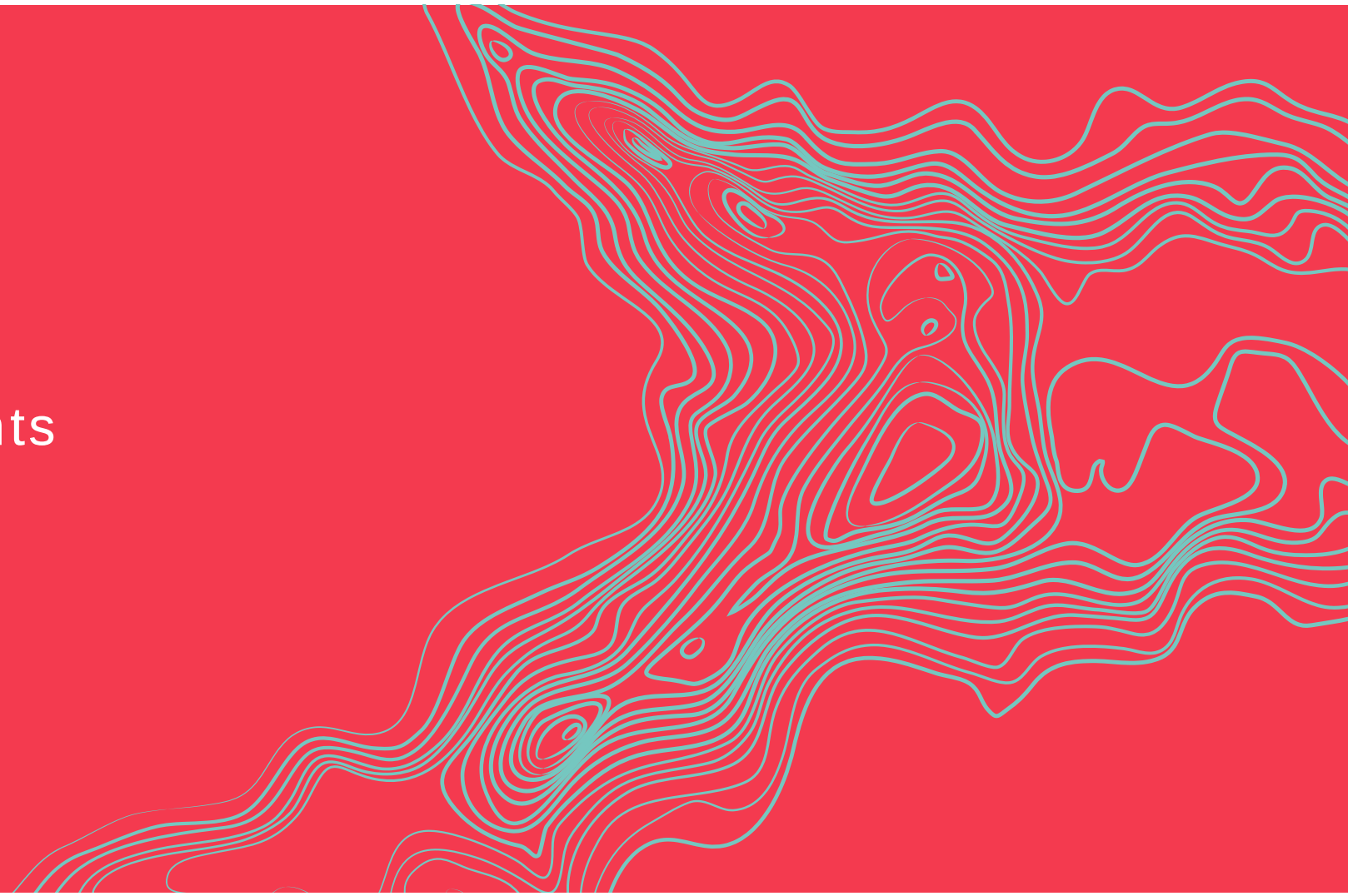
Ammonia Transportation

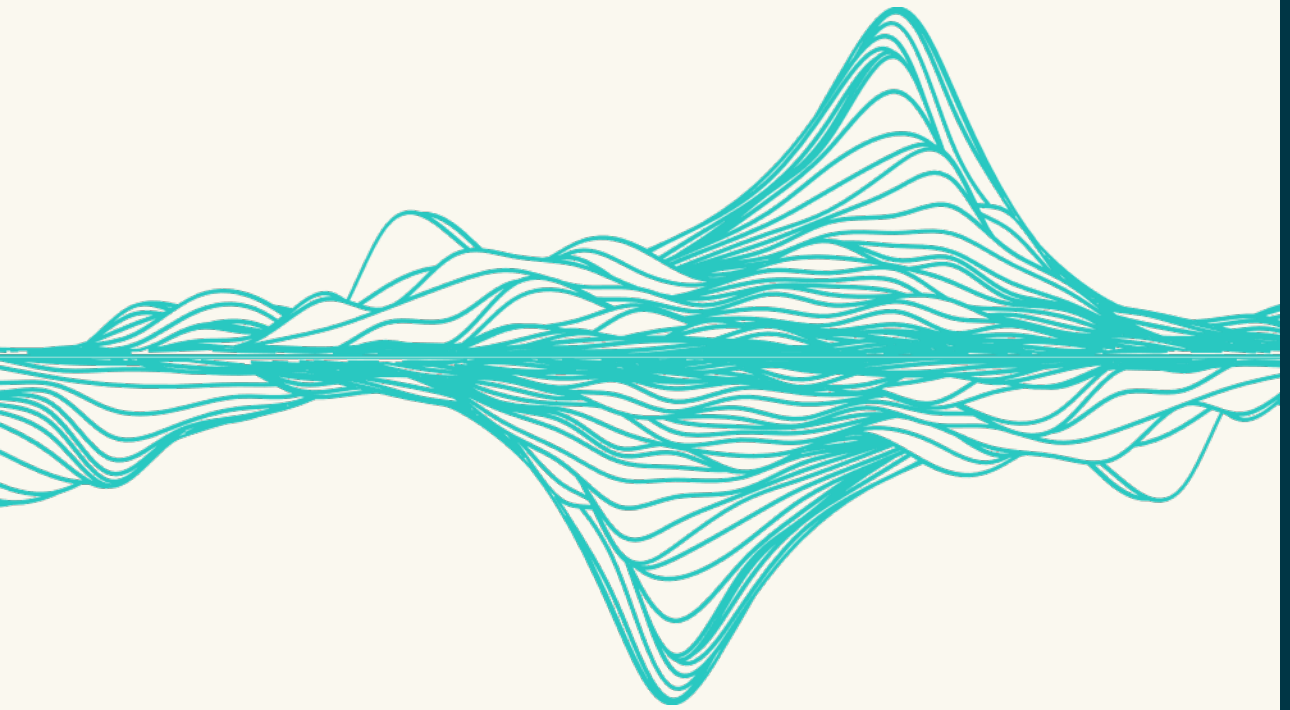


Where	Length	Under/above ground	Remarks
USA	5000 Km of pipelines	Mainly underground	• Gulf Central. The 3057 km Gulf Central pipeline is the longest system and connects the major producers along the Texas and Louisiana Gulf coast with terminals in Arkansas, Iowa, Illinois, Indiana, Nebraska and Missouri. • MAPCO. The MidAmerica Pipeline System (MAPCO) extends from Northern Texas, across Oklahoma, Kansas, Nebraska and Iowa, and ends in Minnesota, all intensive agricultural areas. The total length is 1754 km. • Tampa. Another shorter system (132 km) is the Tampa Bay pipeline in Florida. • Texas: Yara is currently building a 20 km pipeline and many other projects under construction
Russia Ukraine	2424 Km (1 pipeline)	Unknown	The longest Ammonia pipeline in the world has been in operation since 1983 in Russia/Ukraine. It connects the large production facilities Togliatti/Gordlovska in Russia with the Black Sea port of Odessa in the Ukraine.
European Union	201 Km of pipeline	Aboveground and underground	25 small pipelines varying from 1.5 to 74 km (Italy) • Belgium: 2 pipelines • Germany: 3 pipelines • Italy 1 pipeline • Netherlands: 2 pipelines • France: at least 3 pipelines • Portugal: 1 pipeline • UK: 7 pipelines • Spain: 4 pipelines • Poland: 5 pipelines
Australia (Yara)	5.3 Km	Aboveground	A new pipeline less than 1 km long between Ammonia plant and TAN in 2016



Has there been incidents we can learn from?

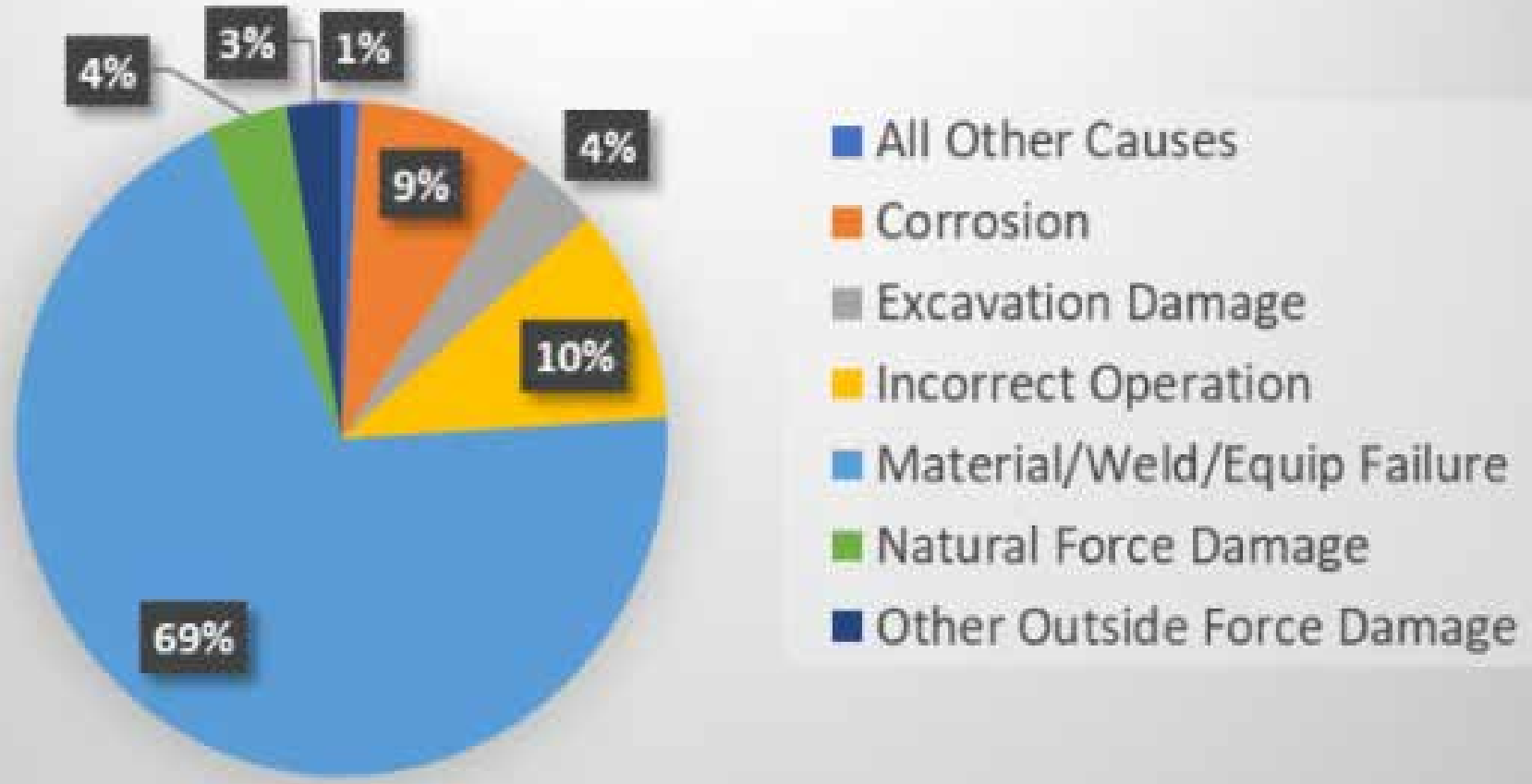




Where	What happened and Cause	Barrier
Texas City, Texas, 1969	Freeze-thaw cycle in the water containing annular space of a double walled ammonia pipe	Not double wall design
McPherson, Kansas, 1973	Overpressure on a previously mechanically damaged pipe part.	Relief devices
Texas City, Texas, 1975	External corrosion as a result of mechanical damage to the pipe coating and interference in the cathodic protection in an underground pipeline	No cathodic protection as the line is not buried Regular external inspections
Ince, England, 1981	Leak developed from a small branch of a liquid ammonia pipeline that was not in continuous operation. Root cause was external corrosion due to unforeseen (rain) water entry to the pipe surface	Recirculation prevents external corrosion
Algona, Iowa, 2001	A large ammonia leak developed in a liquid ammonia pipeline as a result of maintenance work on a valve in that pipeline	Unclear
Grand Parish Louisiana, 2001	Ammonia thief drilled into a valve of the pipeline, probably to obtain Ammonia to make the drug methamphetamine	No access given to general public Pipeline fenced and located in a remote area
Kingman, Kansas, 2004	A huge leak developed after a rupture liquid ammonia pipeline. Probable cause was metal fatigue cracking in combination with previous mechanical pipe damage.	Recirculation prevents thermal fatigue
Clay County, Kansas, 2006	A 200 mm diameter liquid ammonia pipeline failed. As far as we know, the cause has not been determined yet, but seam failure is suspected	Recirculation decreasing the stresses to the welds
Mulberry, Florida, 2007	The Tampa Bay liquid ammonia pipeline near Mulberry, possibly with a diameter of 100 mm or 150 mm there, developed a leak. A boy drilled a hole in the pipeline out of curiosity.	No access given to general public Pipeline fenced and located in a remote area
Togliatti-Odessa pipeline, 2015	The leak occurred in the Ternovo district of the Voronezh region of Russia on June 21th, causing an unprecedented environmental and health disaster that has gone underreported in both Russian and international media. The leak is still under investigation	Waiting for cause
Masyutivka-Kharkiv, 2023	The 2.500km long pipeline ran through the conflict zone in the war in Ukraine, during which the pipeline had already been taken out of commission. A explosion has caused a leakage. The effects are still being researched.	Waiting for cause

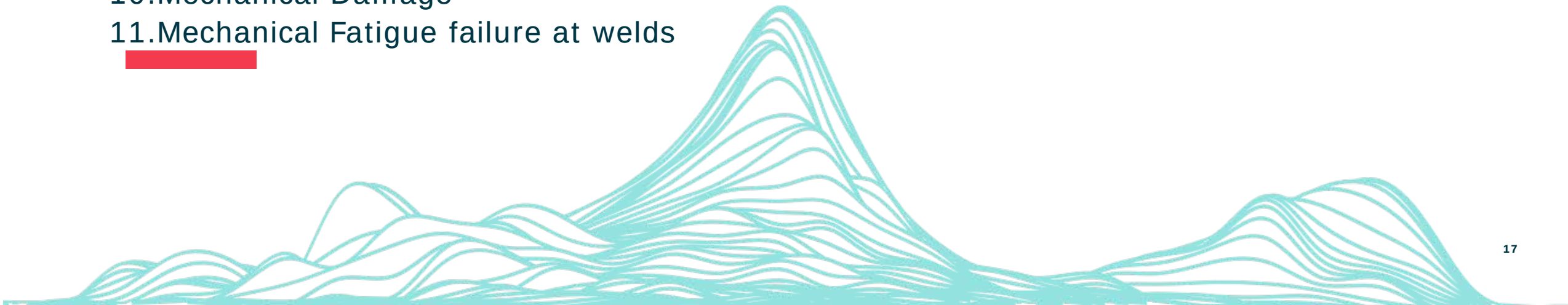
PHMSA Pipeline Incidents from 2017-2021

Hazardous Liquid - HVL Flamm Toxic



Ammonia pipeline historic failure mechanisms

1. Ammonia Stress Corrosion Cracking
2. External Corrosion
3. Brittle fracture
4. External SCC
5. Corrosion Fatigue Cracking
6. Corrosion Under Insulation
7. Crevice Corrosion
8. Fabrication or Metal Defects
9. Freeze damage/Frost Heave
10. Mechanical Damage
11. Mechanical Fatigue failure at welds



Teklemah Incident

DN 200 pipe, constructed in 1968 failed from external corrosion that occurred in a split in the coal tar epoxy wrap.

Release of ~500t of Ammonia resulting in one fatality.

Pipe failed at its normal operating pressure of 5.5MPa.

Pipeline had been subject to an ILI, but this defect was not detected.

Pipeline has had 12 loss of containment events, with releases ranging from 285kg to 8.2t.

A campaign of hydrotesting in 2008 failed 5 joints of pipe in one 50km section all with SCC.

Learnings

Poor coating means you have to really manage the CP.

Failures should be investigated thoroughly (words straight from the NTSB report)

It.s not enough to do an ILI, you have to select the right tool, and do your calibration digs.

What can we learn?

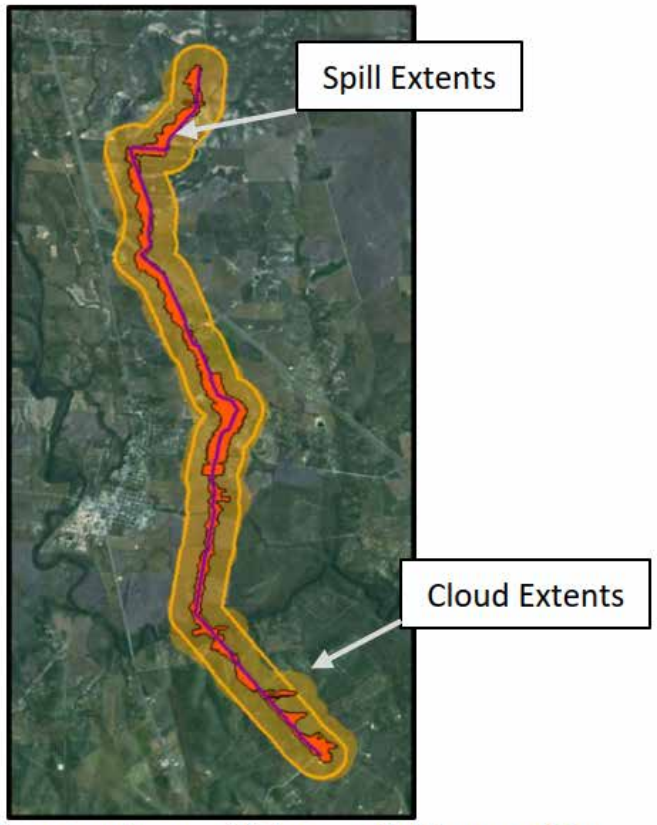
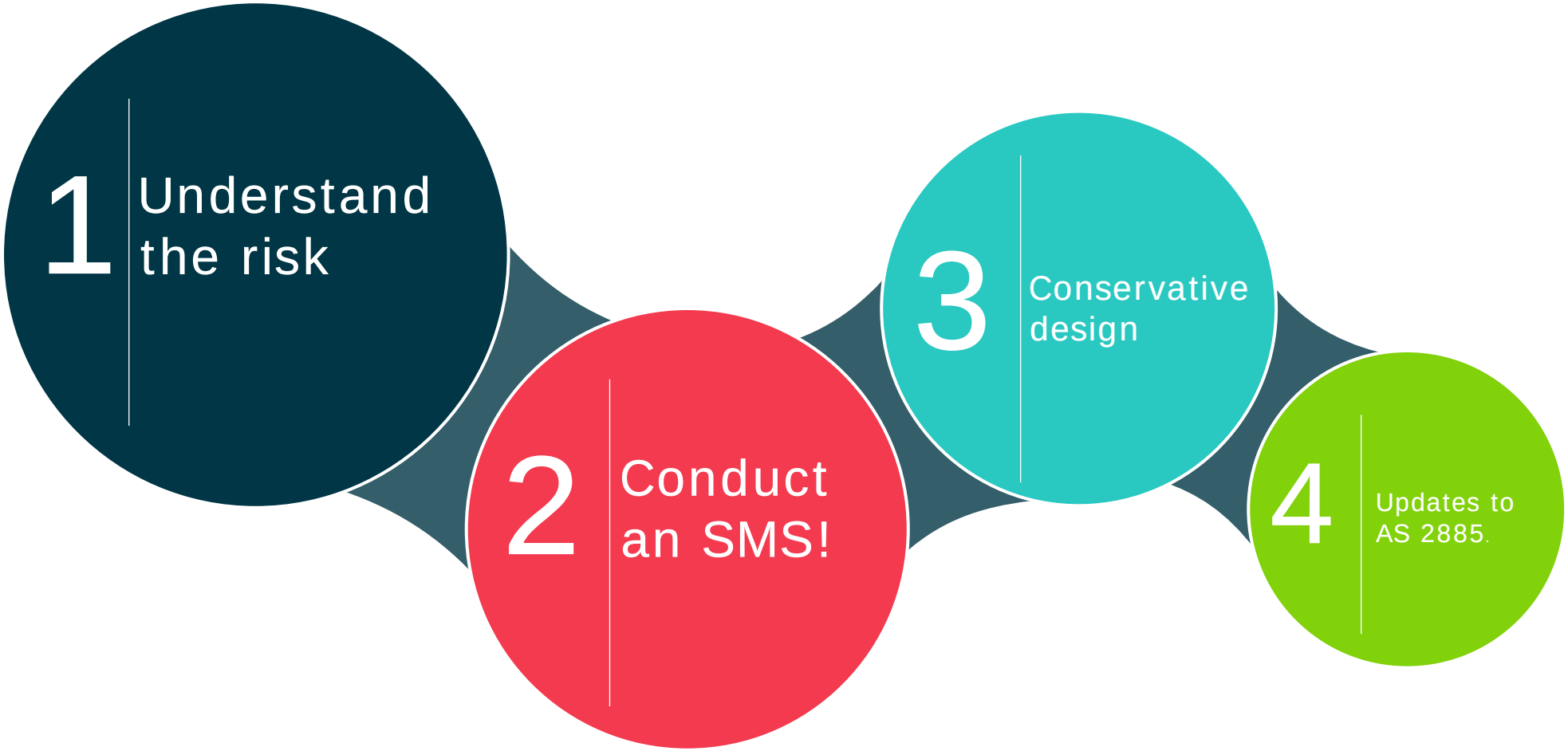


Figure 5. Comparison of Flat and Uneven Terrain Model, Spill and Cloud Dispersion Extents

What are we going to do?



Setting of Performance Standards

1.5.41
measurement length
radius of the 4.7 kW/m^2 radiation contour for an ignited RUPTURE, calculated in accordance with AS/NZS AS 2885.6, applied at all locations along the pipeline

Note 1 to entry: MEASUREMENT LENGTH is used in the determination of LOCATION CLASS regardless of whether RUPTURE is a credible failure mode.

BECOMES

"the distance at which an able-bodied person can escape and avoid serious injury. For natural gas, this equates to a radiation intensity of 4.7kW/m^2 "


Q&A

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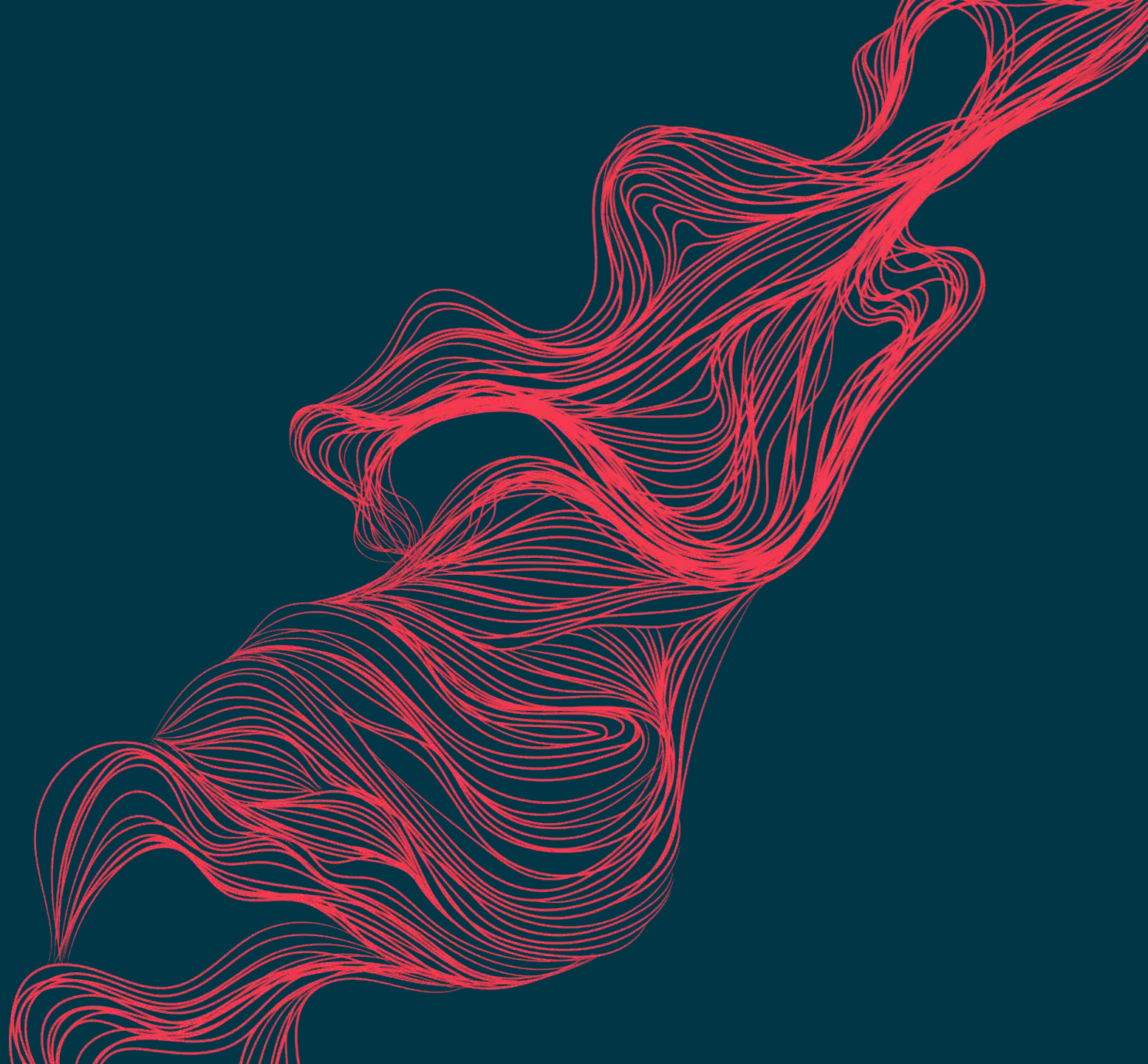
Contact Us:
N: James Czornohalan – Senior Associate
T: +438 550 737
E: james.czornohalan@worley.com

worley.com



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