THE OXFORD INSTITUTE FOR ENERGY STUDIES

OIES Energy Transition Scenarios: Impact on Natural Gas

Alternative scenarios to 2050

Mike Fulwood

Senior Research Fellow

OIES GAS PROGRAMME

Acknowledgements

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Preface

These medium-term gas demand scenarios build on the net zero modelling work that the OIES Gas Programme commenced in early 2022. These scenarios aim to establish what the role for gas is in the most realistic scenarios and what the conditions for that would be.

The key takeaways are that, leaving aside our reference/control DPS scenario, sustained gas use in both FRAG and NZwthCCS will require huge investments in carbon management/CCS. In both of these scenarios, gas demand will peak around 2030, with the major difference thereafter being the pace of decline and the location of that decline.

The main losses in gas demand (compared to 2022) are in OECD economies and China, while the demand difference between the two core scenarios show up in North America, Middle East, Europe and China. There is a lot to digest on price, carbon, supply and trading in these scenarios. We welcome all feedback from sponsors and other stakeholders.

Bill Farren-Price, Head of Gas Research

Highlights

- All three of our energy transition scenarios suggest global gas demand will not peak at less than 4,300 bcm or earlier than 2030. The most bullish Declared Policies Scenario (DPS) sees gas demand peaking around 2040 at some 4,700 bcm, before declining slightly through 2050.
- Under the Net Zero with CCS (NZwthCCS) scenario, global gas demand peaks at just over 4,300 bcm in 2030, while in the Fragmented (FRAG) scenario, where different countries move at varied paces along the decarbonization path, demand peaks just under 4,400 bcm.
- By 2050 global demand in NZwthCCS is down to 2,280 bcm; in FRAG just under 3,000 bcm. NZwthCCS gas demand is significantly higher than IEA NZE, which could be accounted for by more gas demand in power and less bioenergy, hydro and nuclear, with significantly more CCS required.
- In all three scenarios LNG trade peaks around 2030. In DPS, LNG trade declines gradually in the 2030s and 2040s, principally due to China peaking and declining.
- By 2050, LNG trade in NZwthCCS is 60% lower than DPS and FRAG is 50% lower.
- The LNG exporting regions most impacted by much lower demand in NZwthCCS and FRAG are North America, ASEAN and Oceania (Australia). The model indicates that Qatar exports the same volume whatever the scenario.
- In NZwthCCS and FRAG, Japan, Korea and Taiwan and ASEAN are the two key LNG importing regions, with Europe third, albeit with much lower levels than in DPS.
- Green hydrogen remains a niche product in NZwthCCS where blue hydrogen predominates (except in China and India where brown hydrogen is more prominent).
- In FRAG, some regions see green hydrogen develop more rapidly post-2040, limiting the growth in blue hydrogen.
- A key conclusion is that if gas is to remain a major fuel in a rapidly decarbonising world, then the industry needs to invest in an enormous amount of CCS. The alternative is rapid decline, as in IEA NZE.

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Introduction

Scenario Development

The refinement of scenarios is a long process since there are many pathways that lead to plausible energy futures. The scenarios developed here by the OIES Gas Programme focus very much on the role of natural gas and the impact the different scenarios have on natural gas.

The Intergovernmental Panel on Climate Change (IPCC) gather and review over 400 scenarios, of which some 85 or so are consistent with limiting the global temperature rise to 1.5° C. Even the 85 or so scenarios which limit the temperature rise to 1.5° C, have a very wide range of outcomes for natural gas demand by 2050. The IEA's net zero scenario (NZE) sees a rapid decline in global natural gas demand to very low levels, which is at odds with many other scenarios in the IPCC data set. The IEA NZE is wrongly, in our view, seen by many commentators, NGOs and politicians as the pathway to follow, implying any other route is by definition not consistent with limiting the rise in greenhouse gas emissions – although the IEA itself never makes this claim. The IEA NZE is in fact one of many scenarios to achieve net zero by 2050.

The scenarios developed here are the first in the Gas Programme's consideration of how the natural gas market may develop over the next 25 years or so, and comments from readers are always welcome. The number of scenarios has initially been limited to just three. There is what might loosely be called a "business as usual" scenario consistent with various policies around the world. There is also a net zero by 2050 scenario but with a much higher level of gas demand globally by 2050 than in the IEA NZE. A third scenario looks at a three or four speed world but does not achieve the necessary reduction in emissions under a net zero scenario. Gas demand at the global level still declines in the OIES net zero scenario and in the third scenario but natural gas remains much more relevant for longer.

The scenarios have been developed using NexantECA's World Gas Model, where gas demand by country is an exogenous input and the model solves for the optimal trade solution. The gas demand inputs are developed by making assumptions on fuel shares in the different consuming sectors.

Three Scenarios

Three scenarios are considered in this paper, covering the period to 2050. None of these are forecasts, nor are they expectations of the most likely path to net zero, or some other decarbonization route. In that respect they are similar in construct to the IEA scenarios, which are also not a most likely pathway to any predetermined outcome. The three scenarios are:

- **Declared Policies Scenario (DPS):** broadly similar in concept to the IEA's Stated Policies Scenario (STEPS)
- **Net Zero with CCS (NZwthCCS):** Net zero achieved by 2050 but does not limit temperature rise to 1.5° C
- **Fragmented (FRAG):** Net zero by 2050 not achieved but global emissions on a steep downward trajectory from 2030 onwards

Total energy demand in DPS is assumed to be the same as IEA STEPS, while for NZwthCCS and FRAG, energy demand assumed to be as in IEA APS (Announced Pledges). Different gas demand scenarios are generated by changing the fuel shares by sector.

Declared Policies Scenario (DPS)

While broadly similar in concept to IEA STEPS, DPS differs in that it is not assumed that all policies necessarily get successfully implemented. This is particularly true in Europe. As a consequence, there are more fossil fuels in the mix and generally higher gas demand than in STEPS. This is particularly the case in Europe, China and other Asian countries, such as Japan.

While coal does decline over time in most markets, it is not completely phased out and natural gas remains with significant shares in buildings, industry and power in key markets.

Renewables continue to grow significantly and CO2 emissions do peak and there is a gradual decline post-2030. However, the global temperature rise is well over 2° C by 2050.

The roll out of green and blue hydrogen is limited and there is little development of carbon capture and storage.

Net Zero with CCS (NZwthCCS)

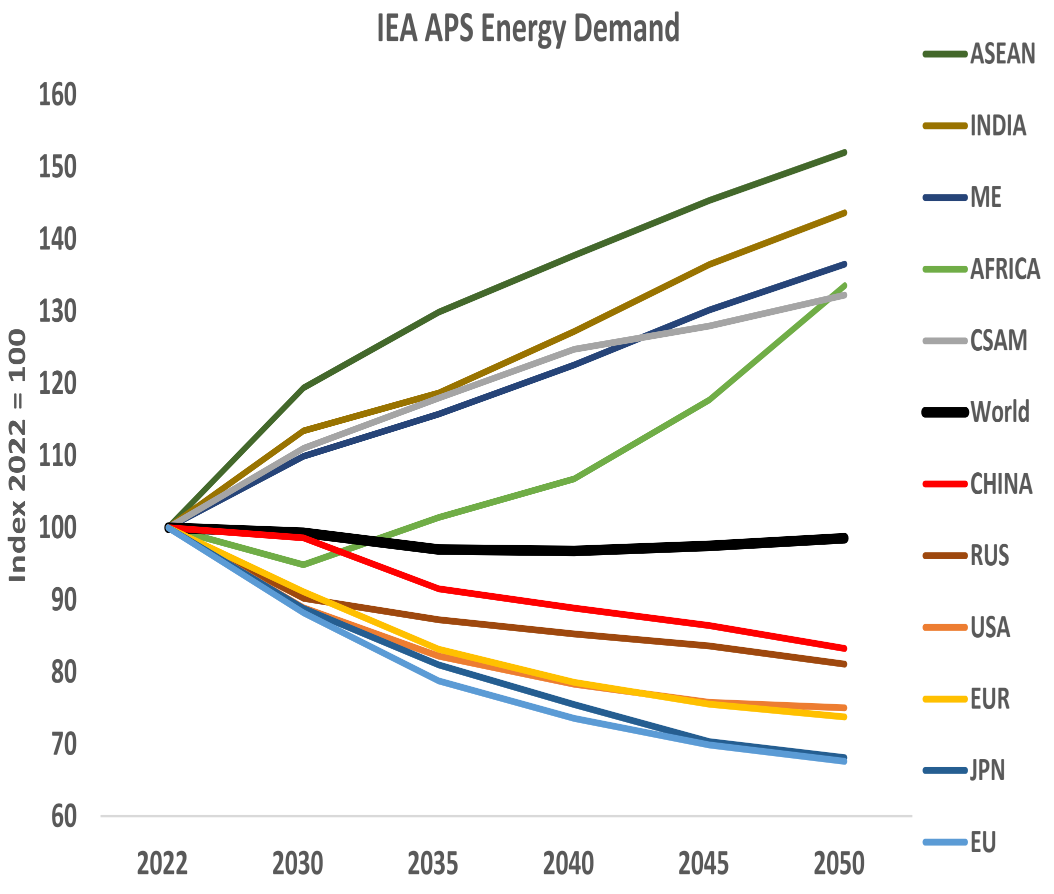
NZwthCCS does not limit temperature rise to 1.5° C by 2050 but overshoots, with negative emissions post 2050 to get back to 1.5° C by 2100. The driver is to electrify as much as possible, but intermittency of renewables remains a major issue – batteries are not the solution so abated fossil fuel, especially gas, remains a material proportion of the power generation mix. CCS is widespread. Energy intensive industries – especially high temperature ones – require combustion of a gas. In large industries this can be abated inside the industrial complex and CO_2 captured with CCS. In smaller industries a hydrogen grid can be developed but predominantly using blue hydrogen with CCS. Hydrogen has an important role as a "clean" fuel but largely in industry and transport. It is localised and will not be transported over long distances due to cost. Blue hydrogen outweighs green hydrogen, except in China, where brown hydrogen dominates. All countries make steady progress towards net zero in a co-ordinated manner. Oil's share declines less than coal as it still plays a role in petrochemicals.

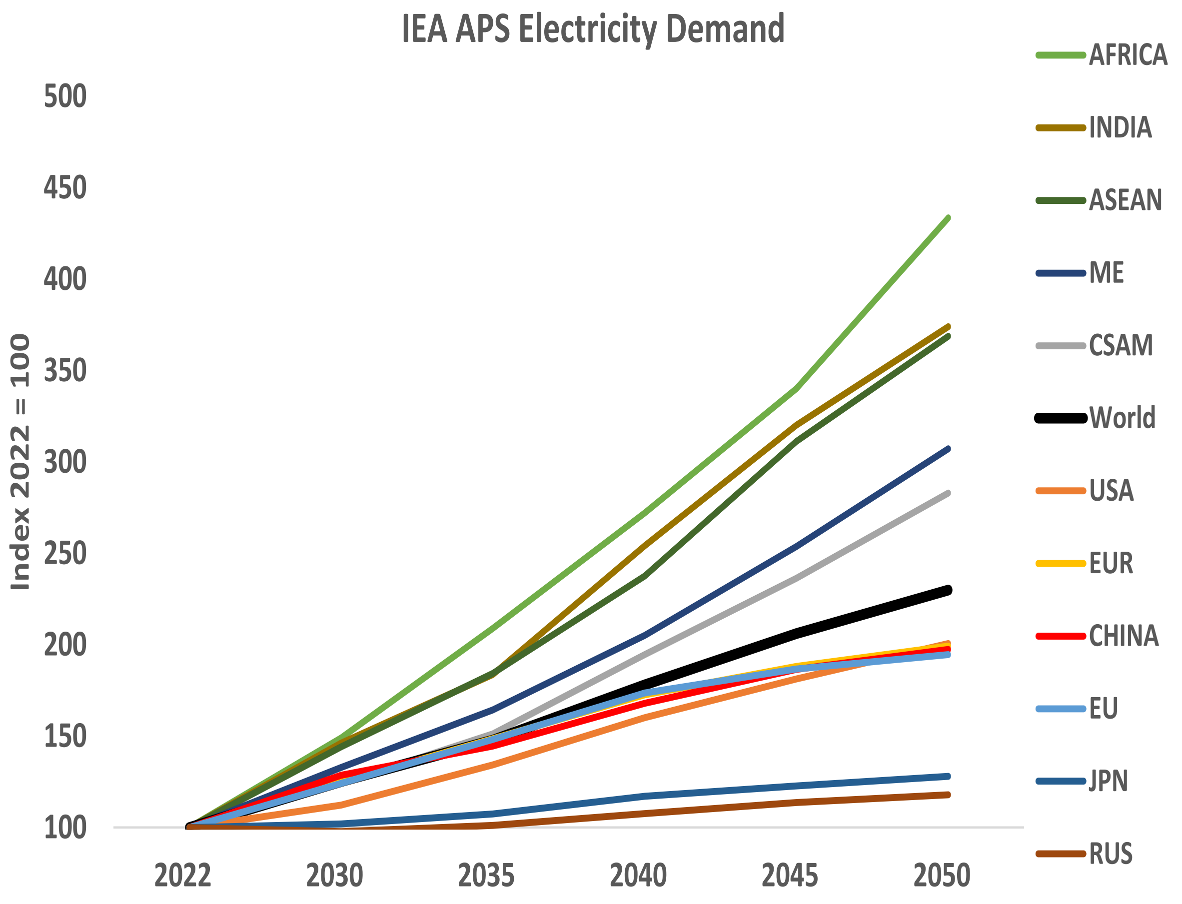
Fragmented (FRAG)

FRAG relaxes the assumption that net zero is achieved by 2050. This scenario acknowledges that NZwthCCS is not seen as that realistic across the board. FRAG has a higher temperature target due to higher CO_2 emissions by 2050. In a more fragmented world, different countries and regions move at different paces and with different methods of decarbonising. Commitment to decarbonization is strongest in the OECD economies, followed closely by China. On the low commitment end are Russia and Africa with C&S America, ASEAN and Middle East partially committed with India just behind. The adjustments between FRAG and NZwthCCS is essentially higher share of gas and less renewables and electricity. Other fuel shares remain similar, including coal. If coal was higher in FRAG, gas would be lower, but emissions a lot higher.

While FRAG is not a predicted outcome or forecast, it can be seen as a more realistic scenario than NZwthCCS and the IEA's NZE scenario, albeit one which is a long way away from a scenario which is likely to limit the temperature rise to 1.5° C.

Different demand trajectories for developed and emerging markets in IEA APS





IEA APS Energy and Power Demand

IEA Announced Pledges Scenario (APS) energy demand is used in NZwthCCS and FRAG scenarios. Energy demand in the IEA APS track is broadly flat from 2022 to 2050 – but combines very different trajectories for developing markets compared to developed markets (including China), where energy demand declines. Electricity demand in contrast grows much more rapidly and grows across the board, with the same developing markets showing the fastest growth. This does not necessarily imply that primary energy demand in end-use sectors declines, since the number of PJ required to generate a TWh declines over time.

The volume of PJ required to generate electricity rises by just under 50% between 2022 and 2050, while the amount of electricity generated in TWh rises by 130% - the “assumed” PJ required to generate a TWh for renewables is less than half the PJ required from fossil fuels. This is often referred to as “energy efficiency” but it is not true efficiency but rather a decline in measured energy intensity.

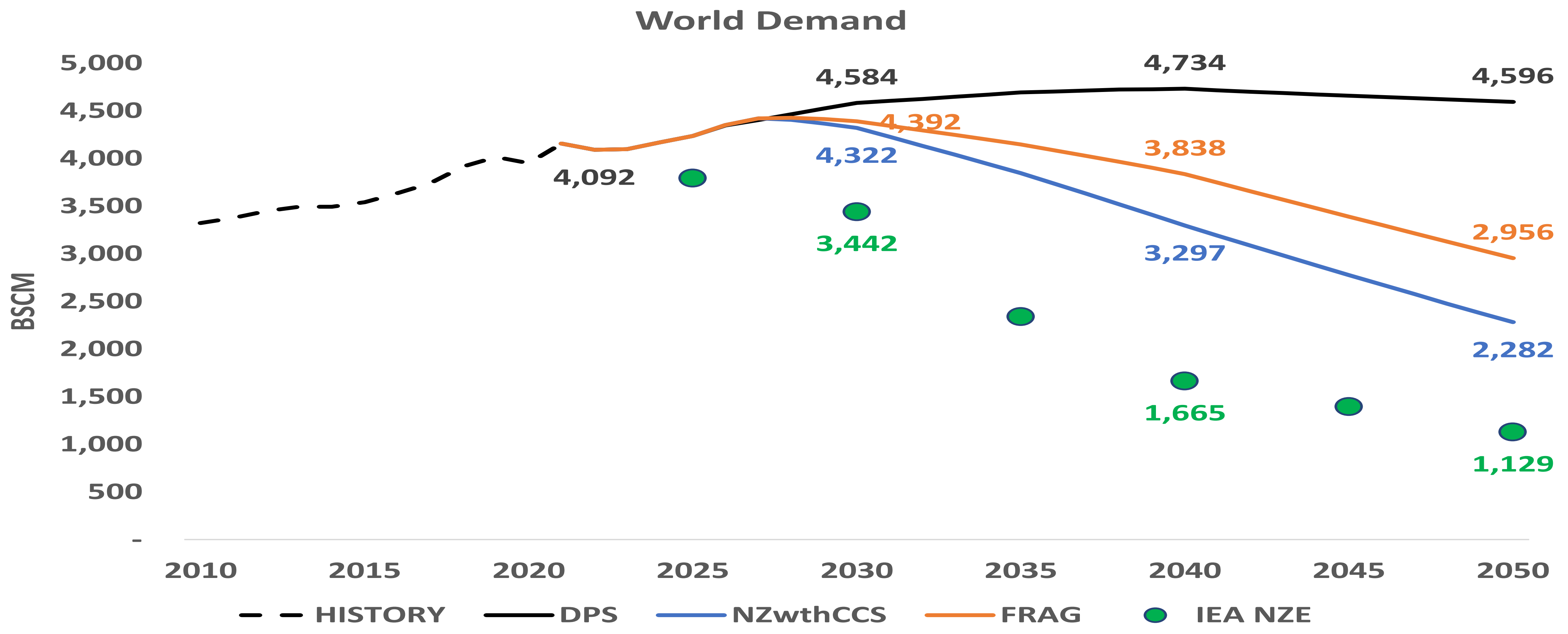
Energy demand per capita rises strongly in India and ASEAN and declines in more advanced economies. It remains flat in China, Russia and somewhat surprisingly in Africa – the APS is clearly not a just and sustainable energy transition for Africa. Electricity demand per capita grows across the board but growth in Africa is weaker than most of the rest of the world, aside from Russia, Japan and the US.

PJ per Million	APS Energy Demand Per Capita					
	2022	2030	2035	2040	2045	2050
World	79	78	77	76	75	75
USA	279	249	231	221	215	213
CSAM	55	58	62	64	66	68
EUR	112	107	102	99	98	98
EU	125	116	109	105	102	101
AFRICA	26	24	23	23	23	23
ME	138	142	144	145	148	150
RUS	238	228	232	236	239	240
CHINA	112	119	118	118	120	120
INDIA	30	35	38	40	42	44
JPN	133	127	123	119	118	119
ASEAN	45	52	56	60	63	66

OIES Regional Definitions

Demand and Supply

Gas demand peaks in late 2020s/2030 in FRAG and NZwthCCS – 2040 in DPS



Global Demand

Global gas demand rises in all three scenarios between 2022 and 2030. From a level of just under 4,100 bcm in 2022, demand reaches some 4,584 bcm by 2030 in DPS (12% growth), 4,392 bcm in FRAG (7% growth) and 4,322 bcm in NZwthCCS (6% growth). This is in marked contrast to IEA NZE where demand is down to 3,442 bcm by 2030 (16% decline).

In the DPS scenario, gas demand peaks around 2040 and declines slowly after that. In FRAG and NZwthCCS, gas demand peaks around 2030 in both. The decline thereafter is more rapid in NZwthCCS with gas demand falling below 3,000 bcm in the early 2040s, whereas in FRAG it doesn't fall below that level until the later 2040s. By 2050, gas demand is 2,596 bcm in FRAG and 2,282 bcm in NZwthCCS. IEA NZE drops below 2,000 bcm in late 2030s and reaches 1,129 bcm by 2050.

Note: IEA NZE figures in the chart are different from the published 2023WEO, as biomethane has been added to the WEO numbers. IEA treats biomethane as an alternative to natural gas demand, while in the OIES scenarios, biomethane is a source of supply to meet demand.

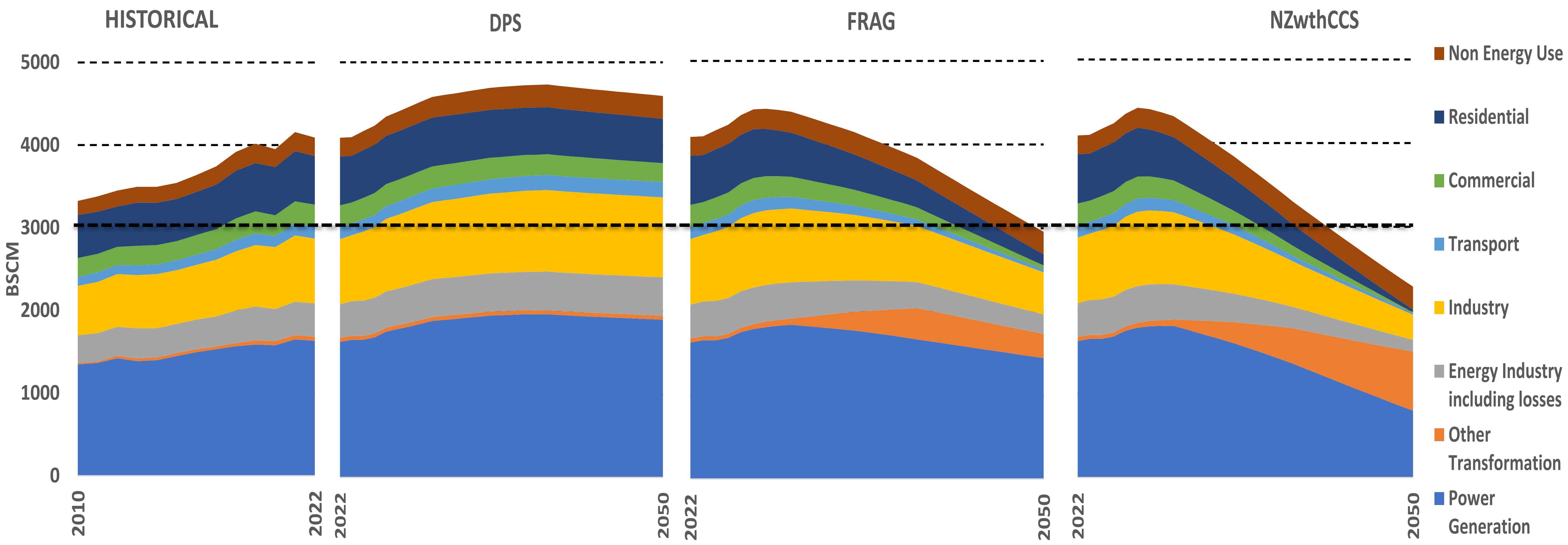
Power generation accounted for some 40% of global gas demand in 2022, with industry (including non-energy use) at some 25%. Residential and commercial are at 21% and transport at 4%.

As electrification proceeds rapidly in NZwthCCS and, to a lesser extent in FRAG, the residential and commercial share (essentially buildings) falls to 2% in NZwthCCS and 6% in FRAG.

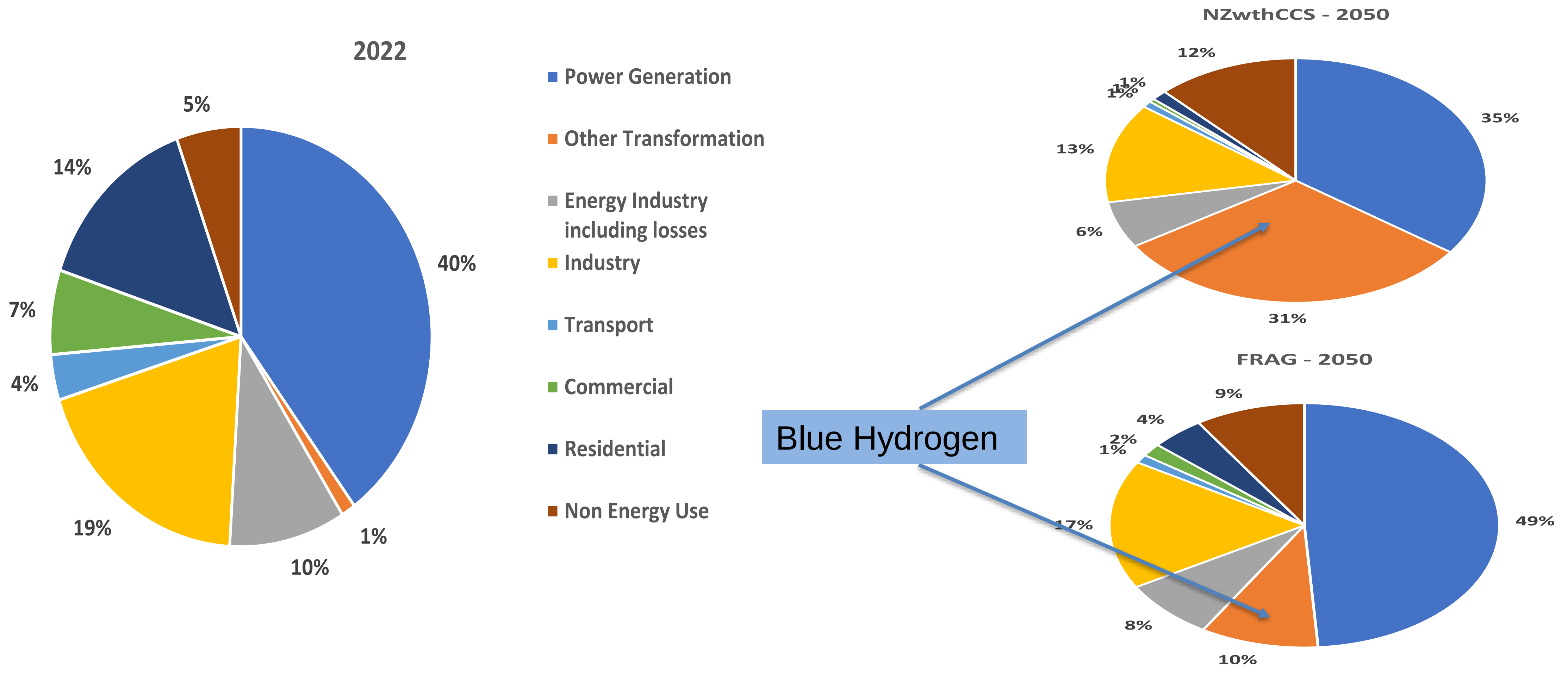
The power generation share rises in FRAG to almost half global gas demand by 2050 and declines a little in NZwthCCS to 35%. Industry share (including non-energy use) is maintained in both FRAG and NZwthCCS. However, the volume of gas demand in both industry and power generation is lower in 2050 than in 2022 since total gas demand is much lower.

The key change is in other transformation, which is essentially blue hydrogen, with a share of over 30% in NZwthCCS – with little competition from green hydrogen – and 10% in FRAG, where green hydrogen is relatively more important. Hydrogen use is predominantly in the high temperature "hard-to-abate" sectors and is focused around large industrial sites.

Sectoral global gas demand



Changing composition of gas demand – large decline in buildings



Regional Demand and Supply

In DPS, demand is flat or weak in North America, Europe and JKT, as well as the Former Soviet Union countries. Demand is stronger in other regions, notably China, especially before the mid-2030s, together with the Middle East and Africa. There is also growth in ASEAN, South Asia and Central and South America.

In FRAG and NZwthCCS, gas demand falls sharply in North America, Europe, JKT and the Former Soviet Union countries, but also in the Middle East. In other regions, after growth to 2030 – and in FRAG to 2040 – declines do set in. However, in ASEAN, South Asia, Africa and Central and South America, gas demand in FRAG is higher or at a similar level in 2050 as in 2022. For Africa, even in NZwthCCS, gas demand is higher in 2050 than in 2022.

In respect of supply, the key drivers are the demand in the region and the export requirements. In DPS therefore, North America supply remains at a high level, with rising LNG exports offsetting weak domestic demand. Middle East and Africa supply rises even more strongly than demand, driven by LNG exports. China supply also grows in line with demand.

In FRAG and NZwthCCS, the supply picture is somewhat different. North America and Russia supply fall sharply – a combination of declining demand and exports. Supply holds up better in the Middle East – because of stronger exports – and Africa, with stronger demand. China supply declines sharply in both FRAG and NZwthCCS following the falling demand profile.

Demand

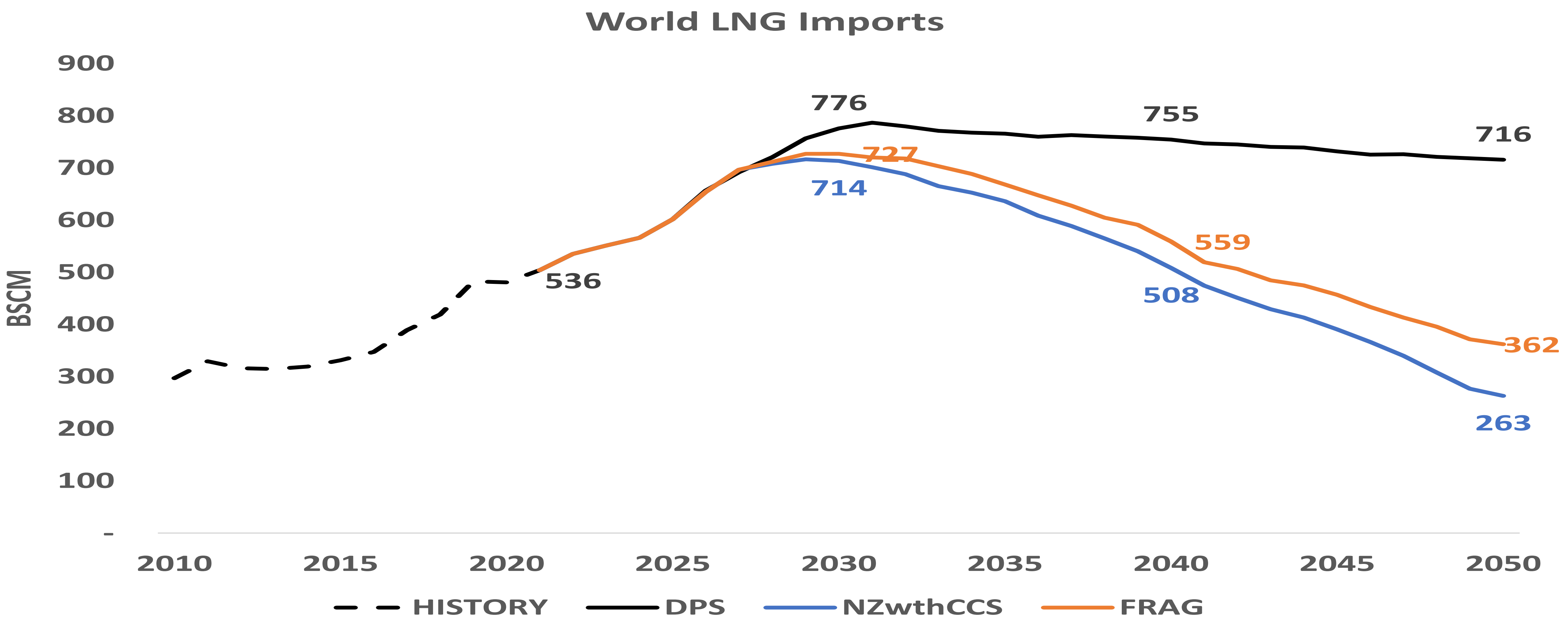
BCM			DPS			NZwthCCS			FRAG		
	2021	2022	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	1,083	1,131	1,138	1,119	1,064	1,078	758	424	1,122	898	586
Europe	570	493	471	425	393	446	304	175	458	340	216
Central & South America	157	146	176	189	175	165	146	110	170	177	141
Russia	527	512	512	507	496	483	376	275	480	433	398
Caspian	117	114	115	118	115	108	83	57	107	99	89
China	374	367	541	564	523	499	315	194	502	404	290
South Asia	142	134	171	191	190	158	155	130	158	168	147
Japan, Korea, Taiwan	188	191	188	183	173	170	137	108	175	157	121
ASEAN	161	158	220	240	234	211	191	130	211	209	181
Oceania	44	44	54	52	49	49	33	21	49	42	33
Middle East	577	590	724	807	836	698	534	427	698	615	487
North Africa	126	122	157	170	170	148	137	124	150	151	135
Sub Saharan Africa	38	40	65	100	101	63	83	77	64	92	88
Ukraine, Belarus, Moldova	52	47	44	49	50	41	35	26	41	41	39
LNG Bunker Fuel	-	-	9	19	29	8	8	3	7	11	5
Total	4,157	4,092	4,584	4,734	4,596	4,322	3,297	2,282	4,392	3,838	2,956

Supply

BCM			DPS			NZwthCCS			FRAG		
	2021	2022	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	1,209	1,275	1,380	1,378	1,328	1,321	932	441	1,360	1,075	636
Europe	207	217	196	170	132	199	147	106	197	162	113
Central & South America	152	153	173	180	167	151	129	100	157	160	127
Russia	794	700	659	715	714	611	481	335	614	559	498
Caspian	197	202	189	192	175	169	118	74	170	136	103
China	217	230	293	333	338	275	202	149	278	288	241
South Asia	95	96	91	97	102	92	108	116	90	104	115
Japan, Korea, Taiwan	2	2	2	1	1	2	1	1	2	1	1
ASEAN	193	192	193	123	110	179	103	81	180	116	99
Oceania	172	181	157	134	118	140	51	21	141	74	43
Middle East	702	728	948	1,040	1,062	916	744	626	922	849	721
North Africa	188	181	168	166	160	154	140	127	160	152	136
Sub Saharan Africa	72	70	124	187	183	106	130	99	110	149	116
Ukraine, Belarus, Moldova	19	19	16	13	11	15	13	7	15	13	11
Total	4,219	4,248	4,589	4,728	4,602	4,330	3,300	2,283	4,395	3,837	2,958

Trade and Prices

LNG trade peaks in early 2030s in all scenarios



LNG Trade

LNG trade rises through 2030 in all three scenarios but also peaks in all scenarios around that time. DPS LNG trade then plateaus to 2040 with a small decline thereafter. In contrast, sharp declines in trade set in in both FRAG and NZwthCCS post-2030, driven by the falling gas demand in key importing regions.

Europe is the largest importing region in DPS, with JKT, South Asia and ASEAN also remaining key importers. China is one of the largest importers in 2030 but LNG imports decline in the 2030s and 2040s as stable, then declining, demand is met with rising pipeline imports from Russia – Power of Siberia 2 comes on in the early 2030s – and flat domestic production.

In FRAG and NZwthCCS, all regions see declining LNG imports from 2030 on. The decline in Europe is especially sharp, but imports into JKT and ASEAN hold up somewhat better.

In respect of LNG exports, in DPS North America is the largest exporting region, followed by the Middle East (mainly Qatar). Russia LNG exports grow through 2030 as Arctic 2 eventually comes on, and Sub-Saharan Africa also grows volumes. Oceania and ASEAN see much reducing LNG exports as older plants close and contracts expire.

The outlook in FRAG and NZwthCCS is very different. North American LNG exports fall away sharply, being a relatively high-cost producer in an oversupplied world. LNG export volumes elsewhere also decline and in NZwthCCS, Oceania and ASEAN completely cease exports by 2050 with plants closing.

The only region not to follow this trend is the Middle East, essentially Qatar, where there is little or no difference in LNG exports in all three scenarios. As the lowest cost LNG exporter, Qatar always produces, whatever the scenario.

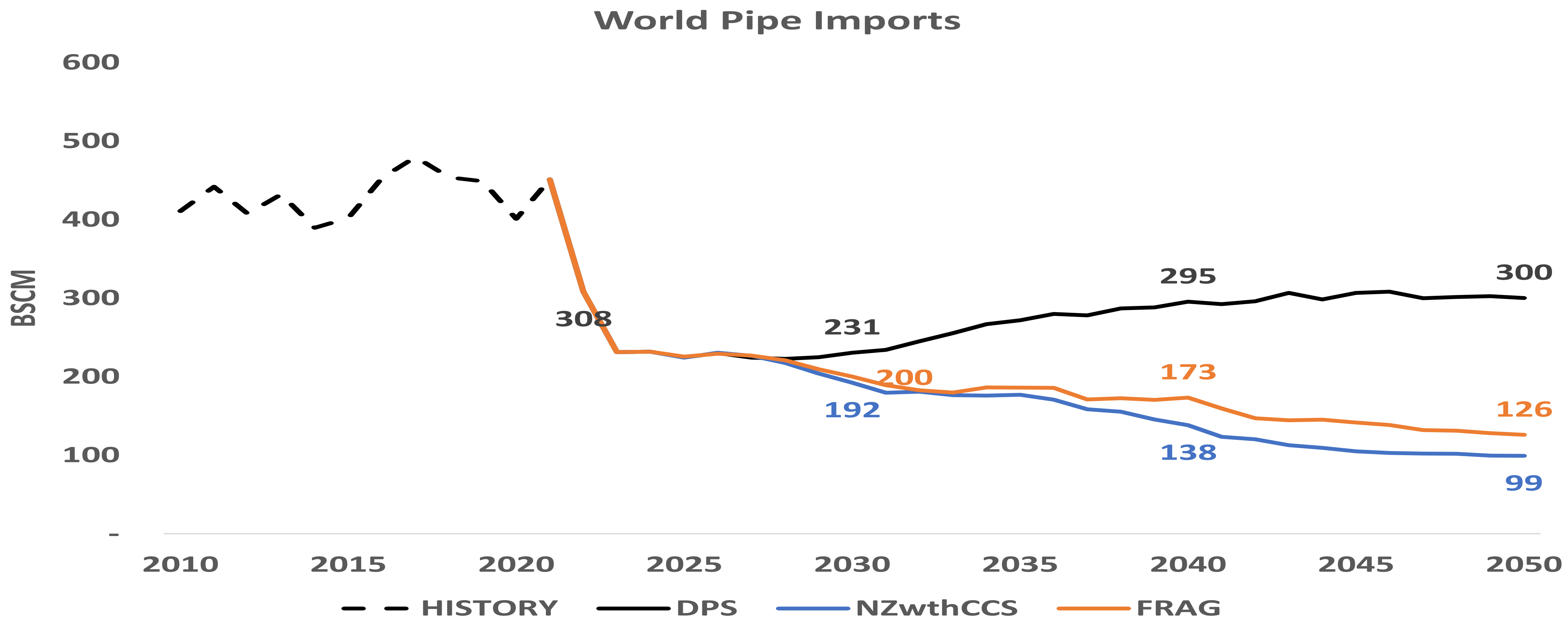
LNG Imports

BCM			DPS			NZwthCCS			FRAG		
	2021	2022	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	2	2	1	-	-	1	-	-	1	-	-
Europe	102	168	215	193	209	204	121	36	213	132	76
Central & South America	24	15	20	20	16	19	17	10	19	20	14
China	106	89	143	88	41	132	49	13	131	49	13
South Asia	51	42	80	95	87	66	47	15	67	64	33
Japan, Korea, Taiwan	187	185	187	182	173	168	136	108	174	156	120
ASEAN	21	26	105	141	136	98	100	49	98	114	90
Middle East	10	10	14	13	15	14	16	15	14	9	9
North Africa	0	0	2	2	9	2	13	13	2	2	2
Sub Saharan Africa	-	-	1	1	-	1	1	2	1	1	-
Total	**504**	**536**	**776**	**755**	**716**	**714**	**508**	**263**	**727**	**559**	**362**

LNG Exports

BCM			DPS			NZwthCCS			FRAG		
	2021	2022	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	89	104	237	266	259	238	174	18	238	177	50
Europe	0	5	0	-	-	0	-	-	0	-	-
Central & South America	12	14	17	11	8	5	-	-	6	3	-
Russia	40	44	62	67	70	60	47	18	60	55	51
ASEAN	60	64	73	20	7	62	7	-	63	17	5
Oceania	117	117	105	82	69	93	17	-	93	32	10
Middle East	127	130	210	215	215	203	215	203	210	215	215
North Africa	24	26	12	6	5	8	-	-	10	4	3
Sub Saharan Africa	36	33	60	87	82	44	48	24	47	58	28
Total	**504**	**536**	**776**	**755**	**716**	**714**	**508**	**263**	**727**	**559**	**362**

Pipeline trade declines gradually in FRAG and NZwthCCS



Pipeline Trade

Having fallen sharply following the Russian invasion of Ukraine, pipeline trade plateaus into the 2030s in DPS before Power of Siberia 2 starts up and trade rises.

This is reflected in rising China pipe imports, while flows into Europe stabilize at the lower 2030 level, following further reductions in imports from Russia and also North Africa. North Africa pipe imports are largely to Egypt from Israel and Cyprus.

Caspian exports are to Europe and China while Middle East pipe exports are from Iran to Turkey plus Israel to Egypt.

In FRAG and NZwthCCS, there is no Power of Siberia 2, so China pipe imports are lower as are Russia pipe exports. China's generally lower demand profile also impacts pipe imports on existing pipelines from Russia and Caspian (Central Asia).

Europe reduces pipe imports in FRAG and NZwthCCS hitting both flows from Russia (including into Turkey), Azerbaijan and, in NZwthCCS, Middle East exports to Turkey.

Pipe Imports

BCM			DPS			NZwthCCS			FRAG		
	2021	2022	2030	2040	2050	2030	2040	2050	2030	2040	2050
Europe	231	143	70	82	76	52	47	45	58	56	41
Russia	11	9	7	3	2	3	3	1	4	3	2
Caspian	12	13	5	7	18	2	2	2	2	3	2
China	50	51	105	143	143	92	64	32	94	67	36
North Africa	4	7	17	24	21	17	-	-	16	16	17
Ukraine, Belarus, Moldova	143	85	28	37	40	26	23	19	26	28	29
Total	**451**	**308**	**231**	**295**	**300**	**192**	**138**	**99**	**200**	**173**	**126**

Pipe Exports

BCM			DPS			NZwthCCS			FRAG		
	2021	2022	2030	2040	2050	2030	2040	2050	2030	2040	2050
Europe	3	3	8	20	25	7	8	10	7	10	11
Russia	245	157	94	144	151	71	61	43	78	75	51
Caspian	66	65	79	81	78	63	37	19	65	40	16
ASEAN	5	4	5	5	5	5	4	-	5	5	4
Middle East	14	16	28	30	25	28	11	11	27	27	28
North Africa	38	35	18	15	15	18	17	17	18	16	16
Ukraine, Belarus, Moldova	80	27	-	1	1	-	-	-	-	1	-
Total	**451**	**308**	**231**	**295**	**300**	**192**	**138**	**99**	**200**	**173**	**126**

Prices

NexantECA World Gas Model can be run in long run or short run marginal cost pricing mode. The model ensures prices clear and balance the market.

In long run mode, TTF is at $8 per MMBtu plus in the 2030s, rising to $9 plus in 2040s in DPS – in FRAG $6 per MMBtu or so from 2030s on, with NZwthCCS down to $5 and less. Japan at just under $10 per MMBtu in the 2030s rising above $10 in the 2040s in DPS – in FRAG at $7 plus in 2030s and 2040s and NZwthCCS below $7. Henry Hub at $4 per MMBtu in DPS long run - $1 to $2 in FRAG and $1 or below in NZwthCCS.

For all prices, there is not too much difference between NZwthCCS and FRAG prices – similar long run cost profiles.

In short run mode, prices are some $2 to $3 per MMBtu less than long run prices, except for Henry Hub where long run and short run prices are much closer.

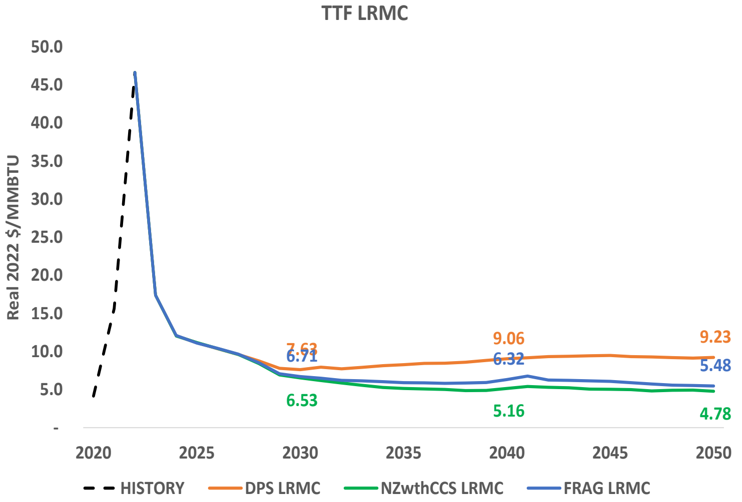
Looking at the longer term context for prices, going back to the 1970s or 1980s, projections for TTF, as a proxy for European prices, are in DPS similar to the 2005 to 2020 average. FRAG and NZwthCCS are at lower levels similar to 1990s or 2019/2020 levels.

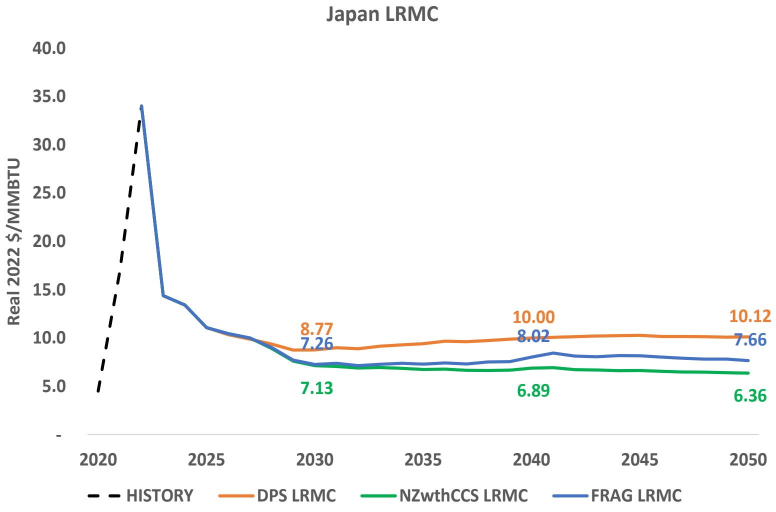
Japan spot prices (as a proxy for historic Japan prices) are in DPS similar to the 2000s – pre-Fukushima – or 2015 to 2019. In FRAG and NZwthCCS, prices are back to 1990s levels or 2019/2020 levels.

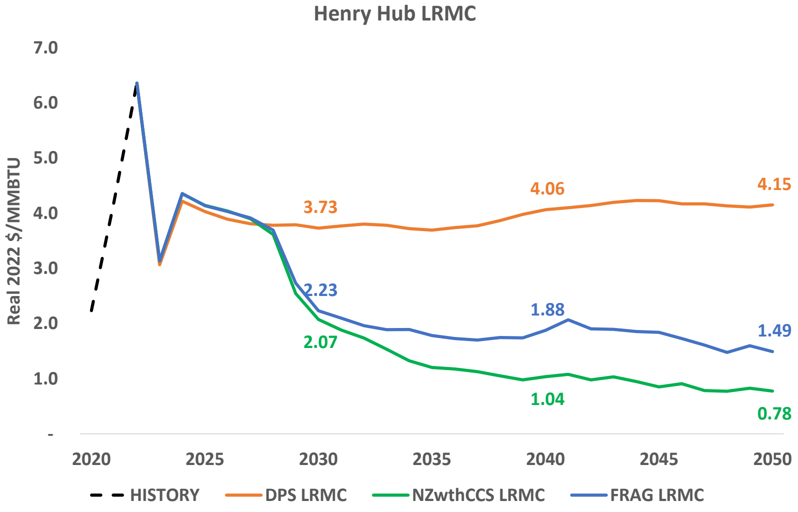
US prices, as represented by Henry Hub from 1989 and wellhead prices before that, are in DPS similar to the 2010s or the 1990s. FRAG and NzwthCCS fall sharply in the 2030s to historically low levels.

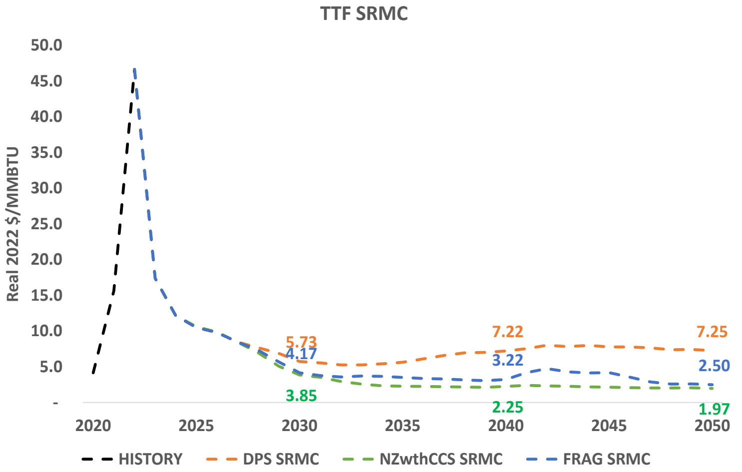
Overall, the price projections for all three scenarios can be seen as similar to past periods historically in real terms, at least for long run pricing calculations. Short run pricing, however, would see prices at relatively low levels historically, at least in FRAG and NZwthCCS.

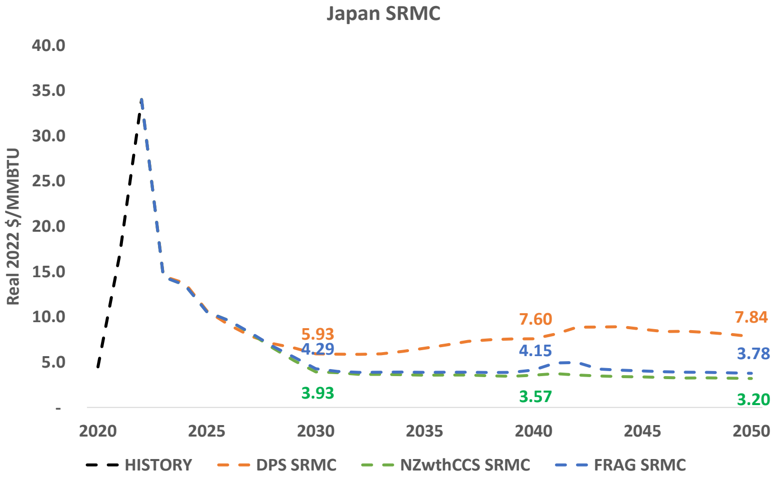
Spot Prices – LRMC and SRMC

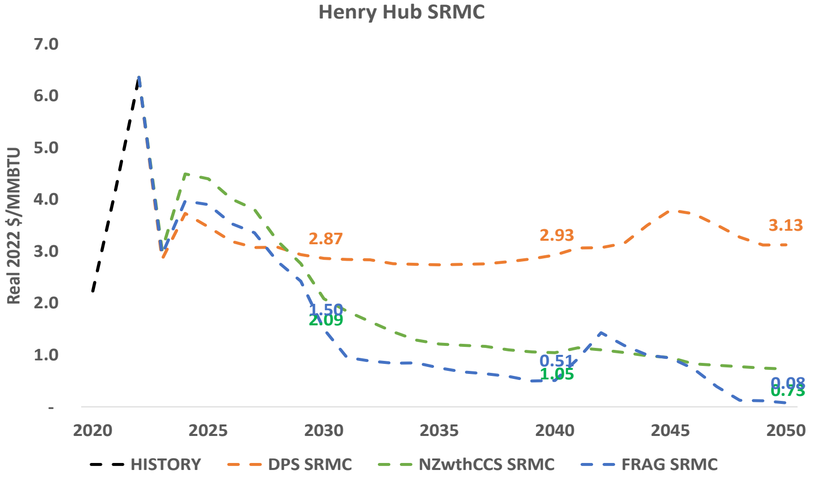




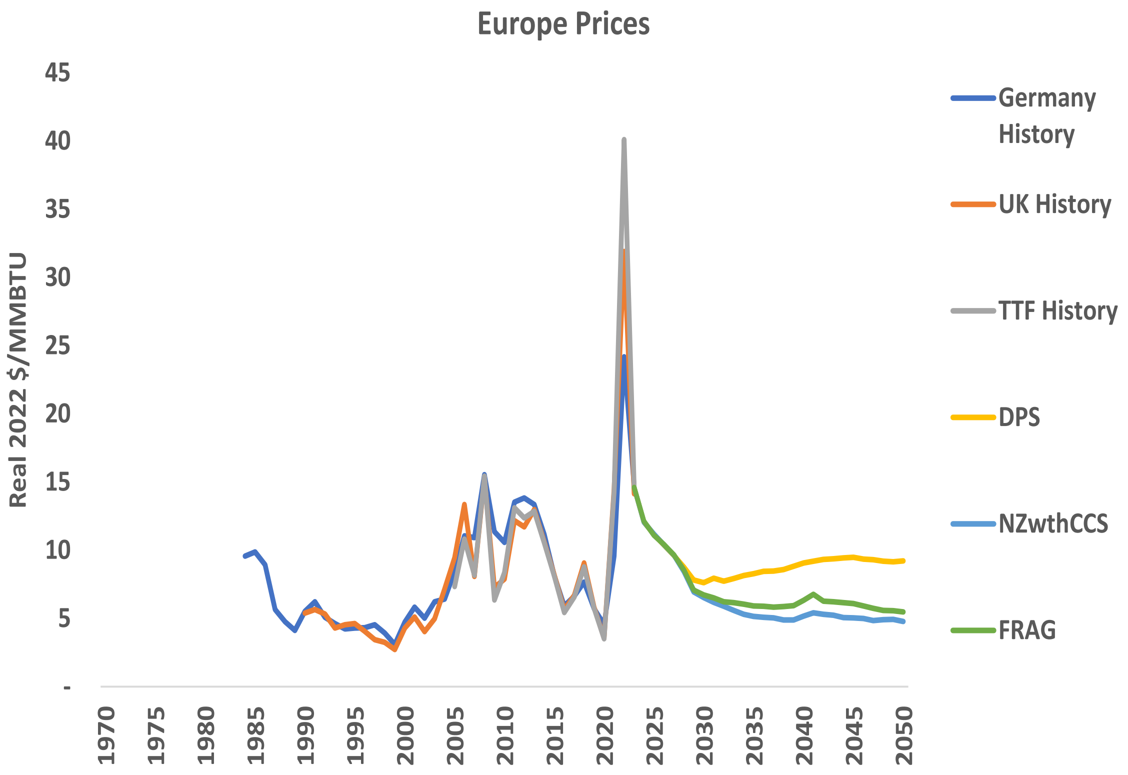


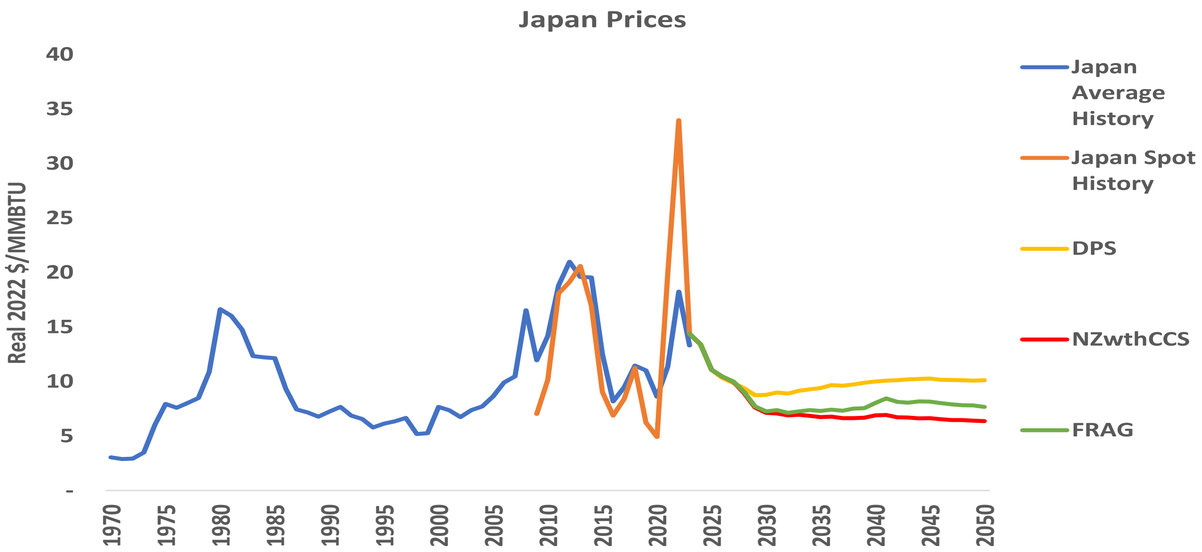


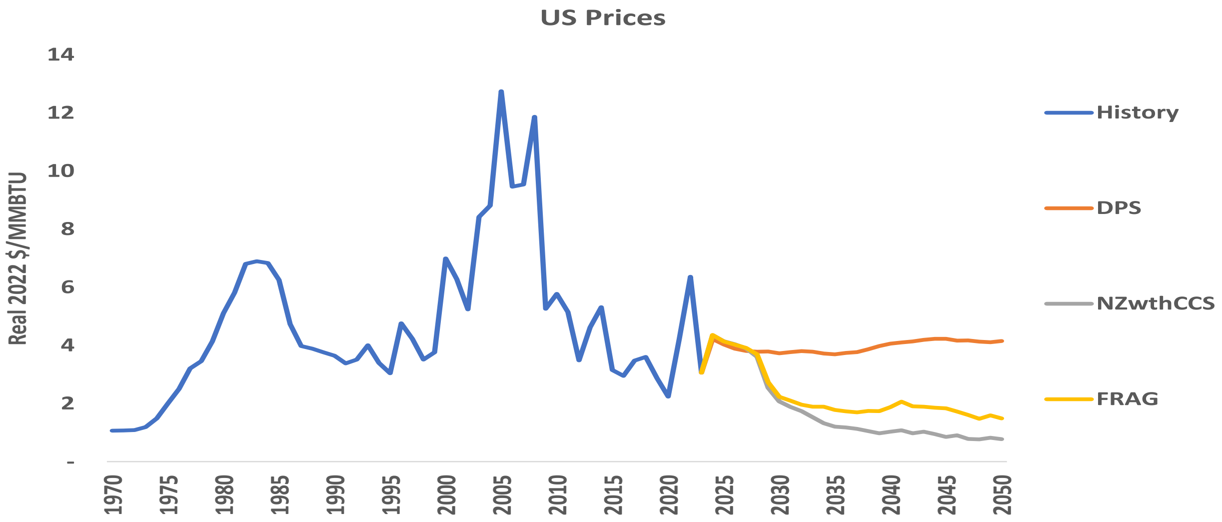




Longer Term Price Context

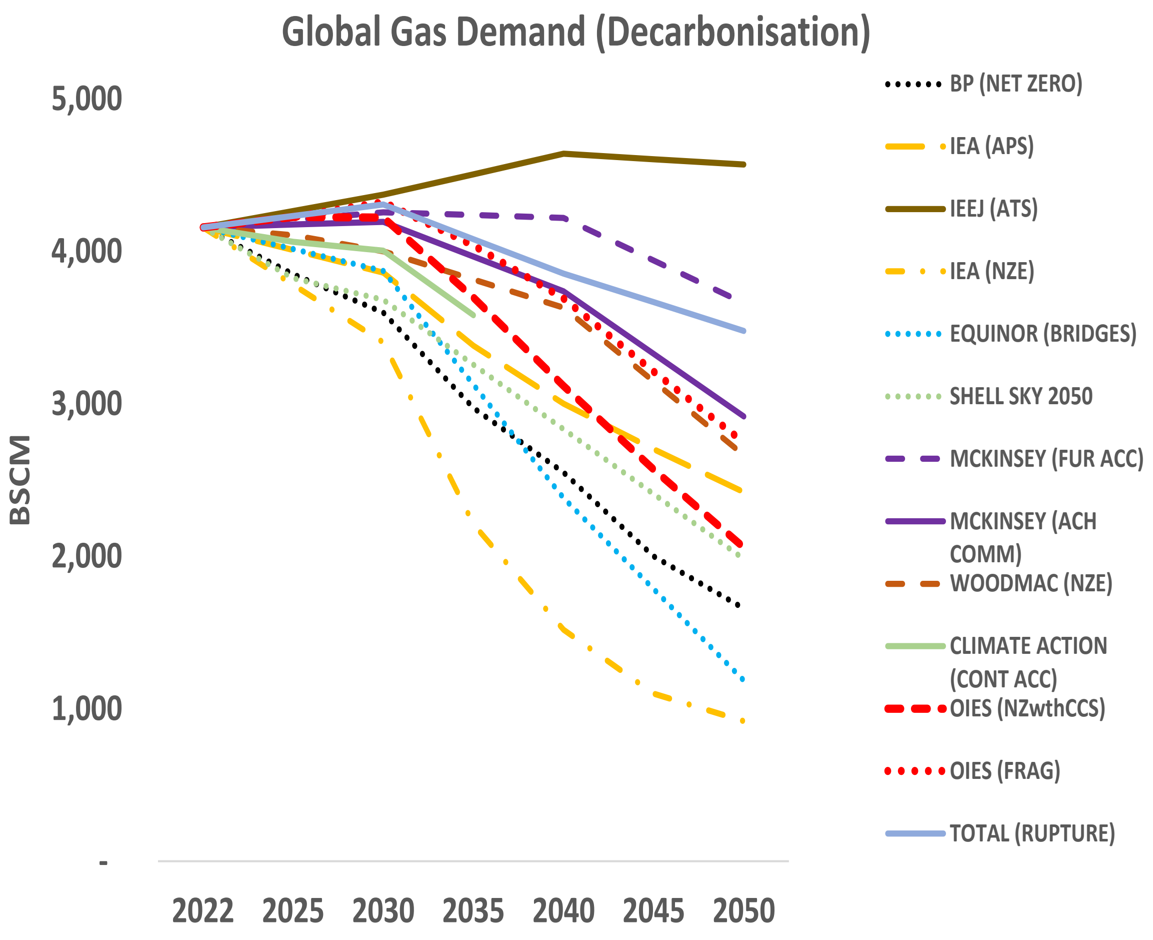


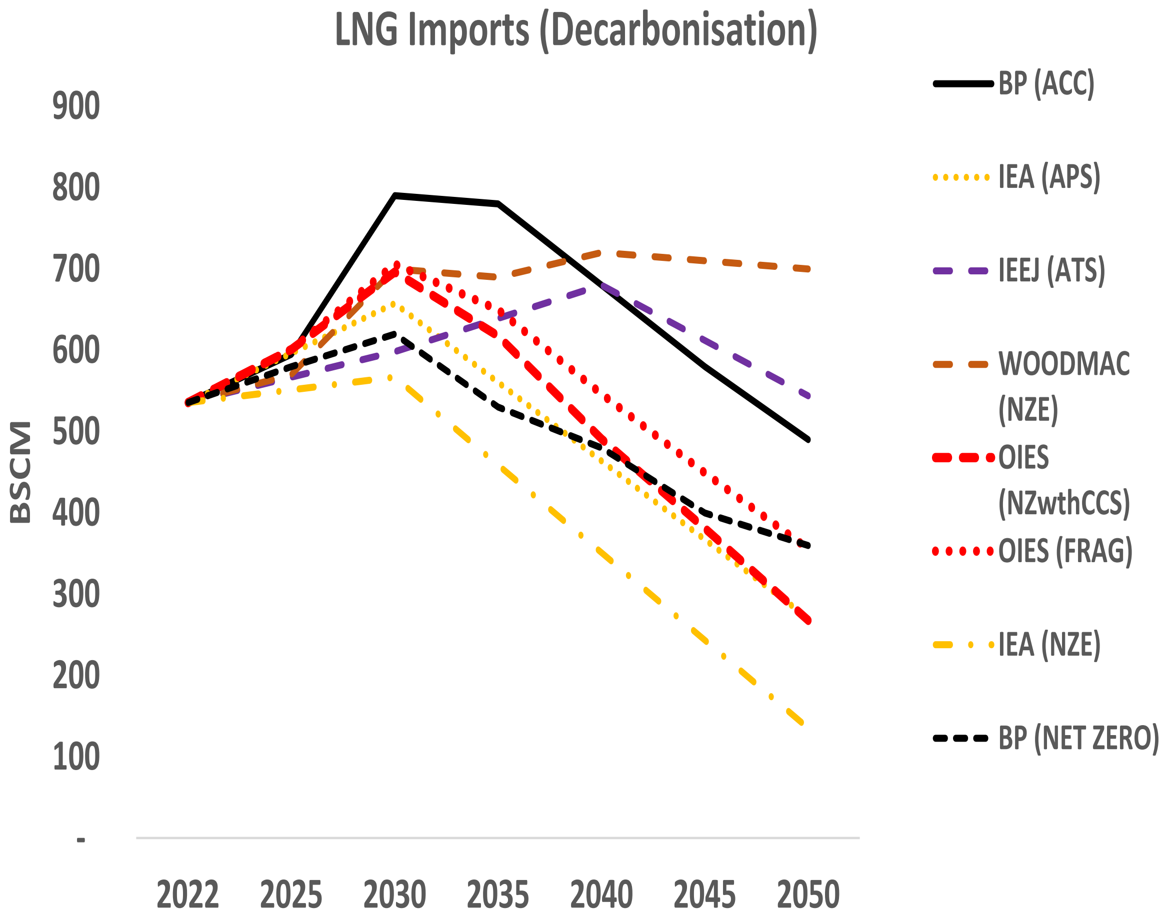




Comparisons

Wide range of decarbonisation scenarios





IEA NZE – Key Trends

					Net Zero Emissions by 2050 Scenario (EJ)					Shares (%)			CAAGR (%) 2022 to:	
	2010	2015	2021	2022	2030	2035	2040	2045	2050	2022	2030	2050	2030	2050
Total energy supply	541	574	624	632	573	535	528	533	541	100	100	100	-1.2	-0.6
Renewables	43	54	71	75	166	241	306	353	385	12	29	71	10	6.0
Solar	1	2	5	7	35	66	97	120	138	1	6	26	23	11
Wind	1	3	7	8	25	43	61	74	84	1	4	16	16	9.0
Hydro	12	14	15	16	20	24	27	29	30	2	3	5	2.9	2.3
Modern solid bioenergy	23	27	33	35	55	65	71	74	73	6	10	13	5.8	2.6
Modern liquid bioenergy	2	3	4	4	11	13	13	12	11	1	2	2	13	3.3
Modern gaseous bioenergy	1	1	1	1	7	9	11	13	15	0	1	3	22	9.0
Traditional use of biomass	25	24	24	24	-	-	-	-	-	4	-	-	n.a.	n.a.
Nuclear	30	28	31	29	43	55	63	65	67	5	8	12	5.0	3.0
Unabated natural gas	115	123	146	144	113	68	40	22	14	23	20	3	-3.0	-8.1
Natural gas with CCUS	0	0	1	1	6	9	13	16	18	0	1	3	35	13
Oil	173	182	182	187	148	110	79	56	42	30	26	8	-2.8	-5.2
Non-energy use	25	27	31	32	35	34	33	32	30	5	6	6	1.3	-0.1
Unabated coal	153	161	167	170	93	43	16	8	3	27	16	1	-7.3	-14
Coal with CCUS	-	0	0	0	2	7	10	11	12	0	0	2	87	27

Comparisons

All the comparisons are for decarbonization scenarios, not what are loosely called "business as usual" scenarios or those which see little or no attempt at decarbonization.

Net zero scenarios – except for OIES, WoodMac and McKinsey (ACH COMM which is a 1.6° C rise) – generally have much lower gas demand than those with a slower decarbonisation track.

The IEA is generally at the lower end of the range for both gas demand and LNG imports.

NZwthCCS is broadly similar to Shell Sky scenario for global gas demand. FRAG is closer to the Woodmac NZE scenario.

There are fewer scenarios to compare with for LNG imports and the range is very wide. Woodmac NZE sees LNG imports plateauing at 700 bcm or so. Declines in LNG imports generally set in in the 2030s or 2040s, apart from Woodmac NZE.

NZwthCCS is broadly similar to IEA APS, while FRAG, by 2050, is at same level as BP Net Zero.

IEA NZE has gas demand (abated and unabated) down by some 70% by 2050 compared to 2022 – 18% down by 2030 and 65% down by 2040.

FRAG has gas demand down by 30% by 2050 – higher in 2030 than 2022 and only marginally lower in 2040.

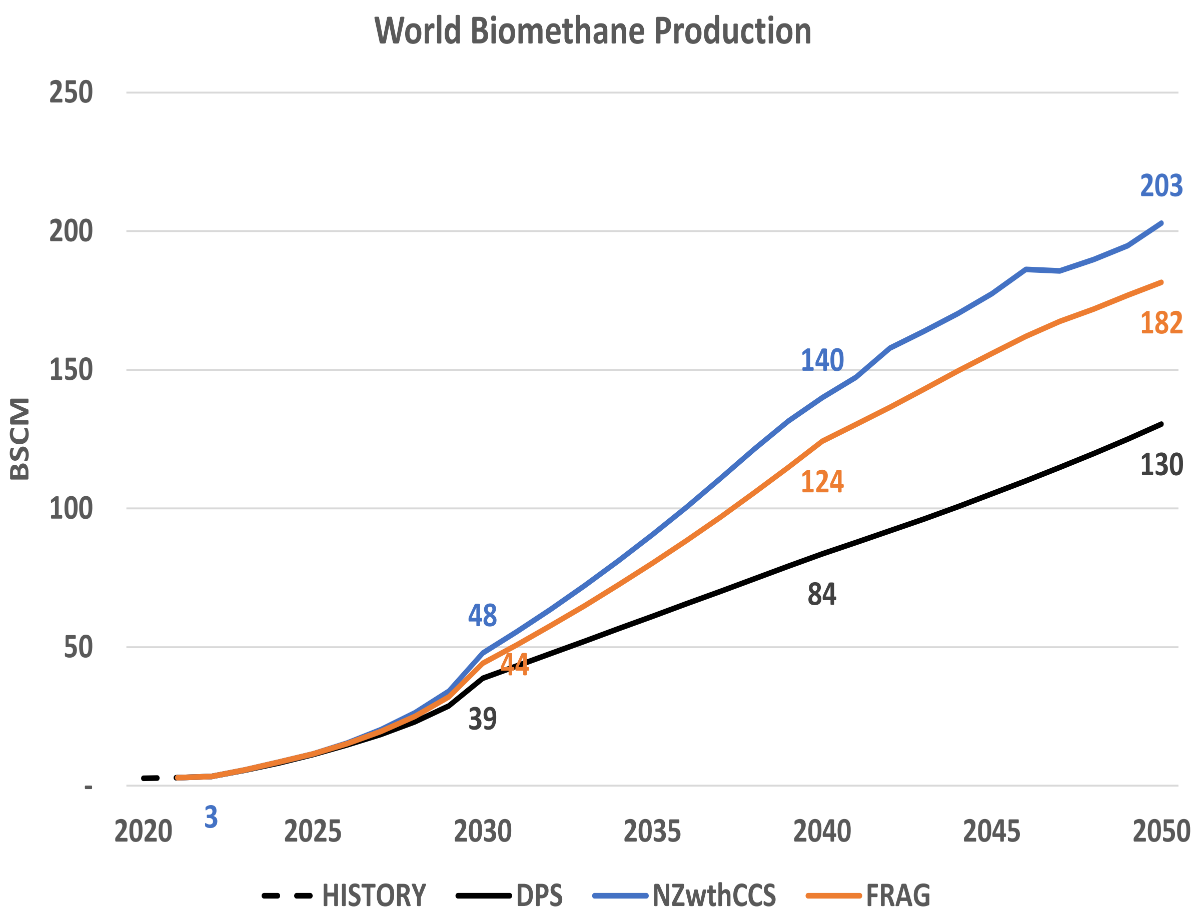
NZwthCCS has gas demand down by 45% by 2050 – higher in 2030 than 2022 and 20% lower in 2040.

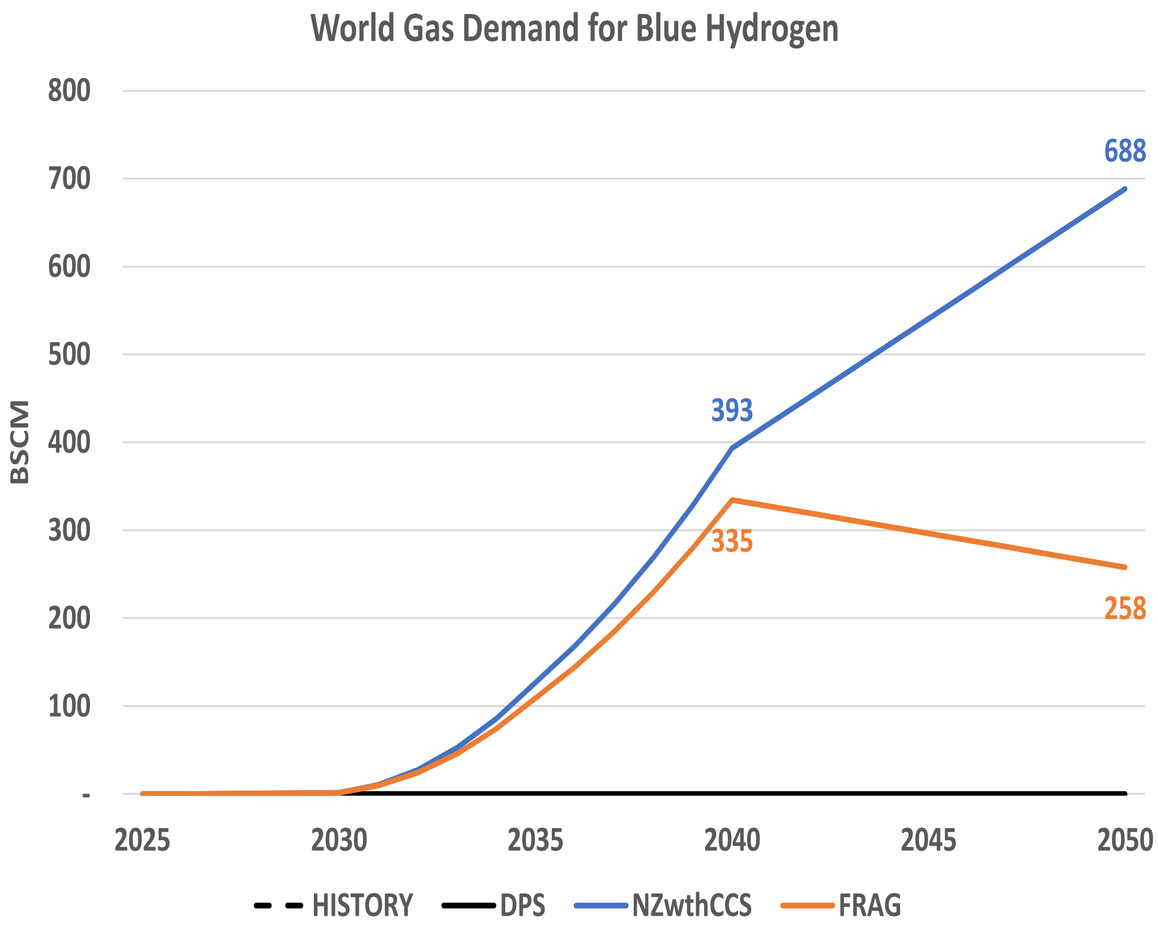
IEA NZE basically has more renewables than in FRAG and NZwthCCS. In particular, there is significant growth in modern bioenergy, hydro and nuclear, apart from the growth in solar and wind. In NZE, abated and unabated natural gas is some 42 EJ in 2050 – in FRAG it is 109 EJ and NZwth CCS it is 85 EJ. NZwthCCS has much the same gas demand as the IEA APS.

Slower growth in modern bioenergy, hydro and nuclear and much higher natural gas with CCS could easily account for the 40 plus EJ difference between IEA NZE and NZwthCCS.

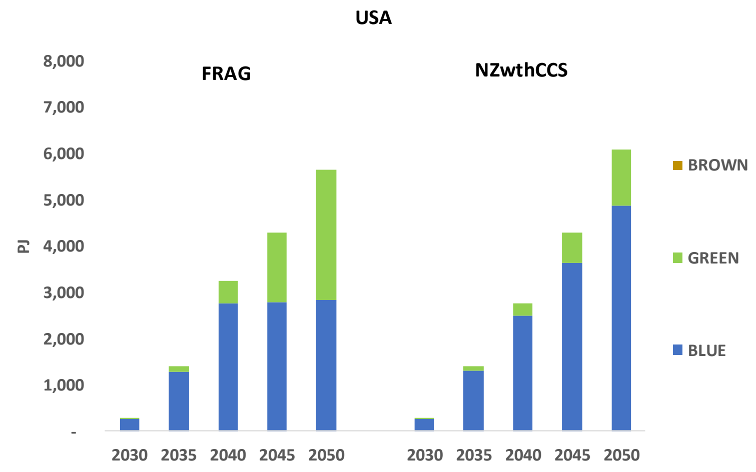
Renewable Gases

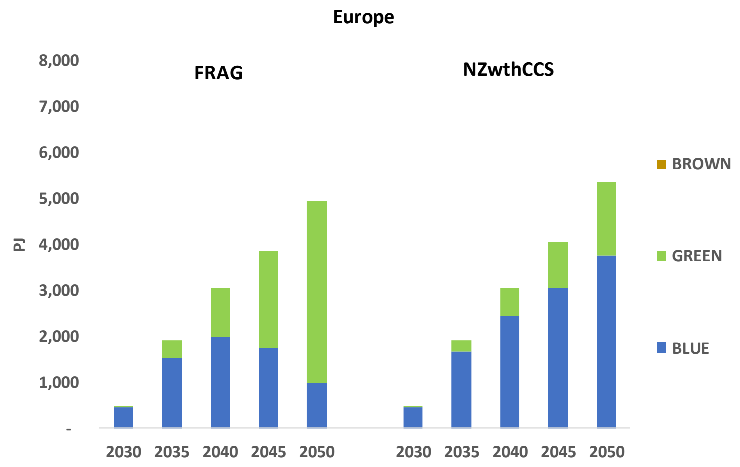
Biomethane and Blue Hydrogen

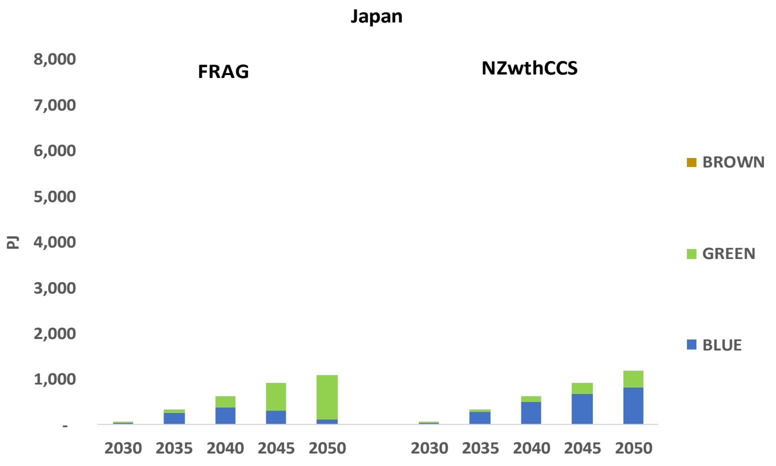


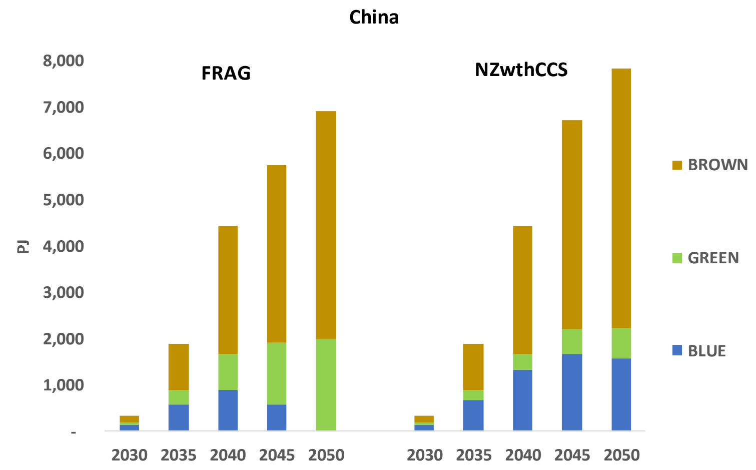


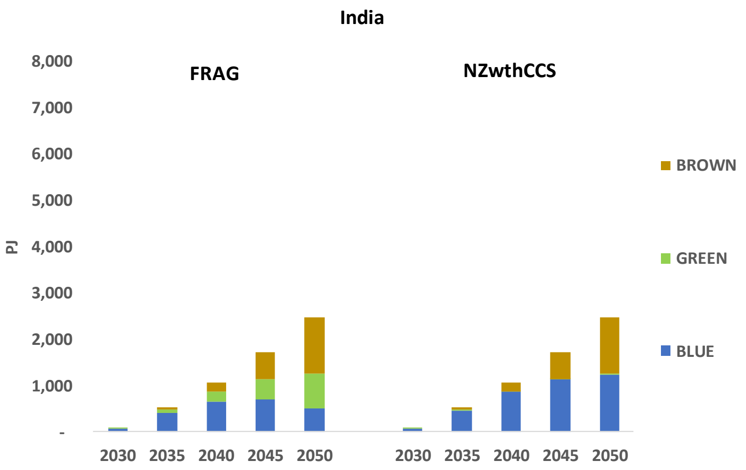
Hydrogen Production - Selected

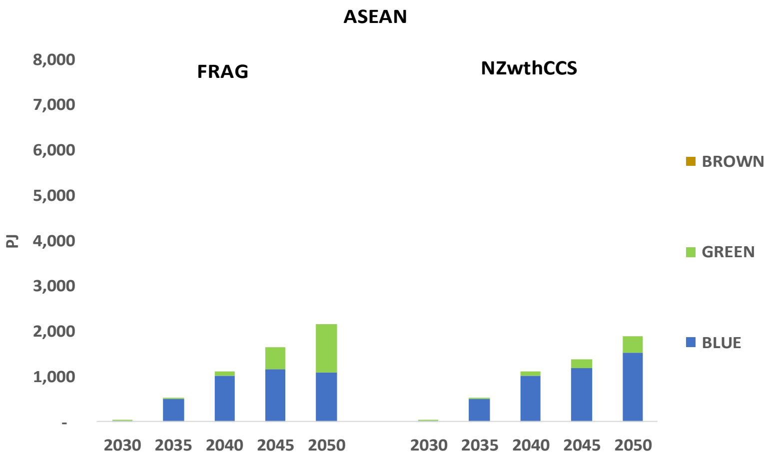












Renewable Gases

Biomethane growth in China and India is strong post-2030, while low carbon hydrogen is predominantly blue at least until 2040 in all scenarios.

In NZwthCCS, there is strong growth in blue hydrogen, combined with a slower roll out of green hydrogen, which is almost totally locally produced. In FRAG, blue hydrogen is initially the primary low-carbon hydrogen, but then is gradually displaced by green hydrogen, which becomes more important from 2040 on, but still localised.

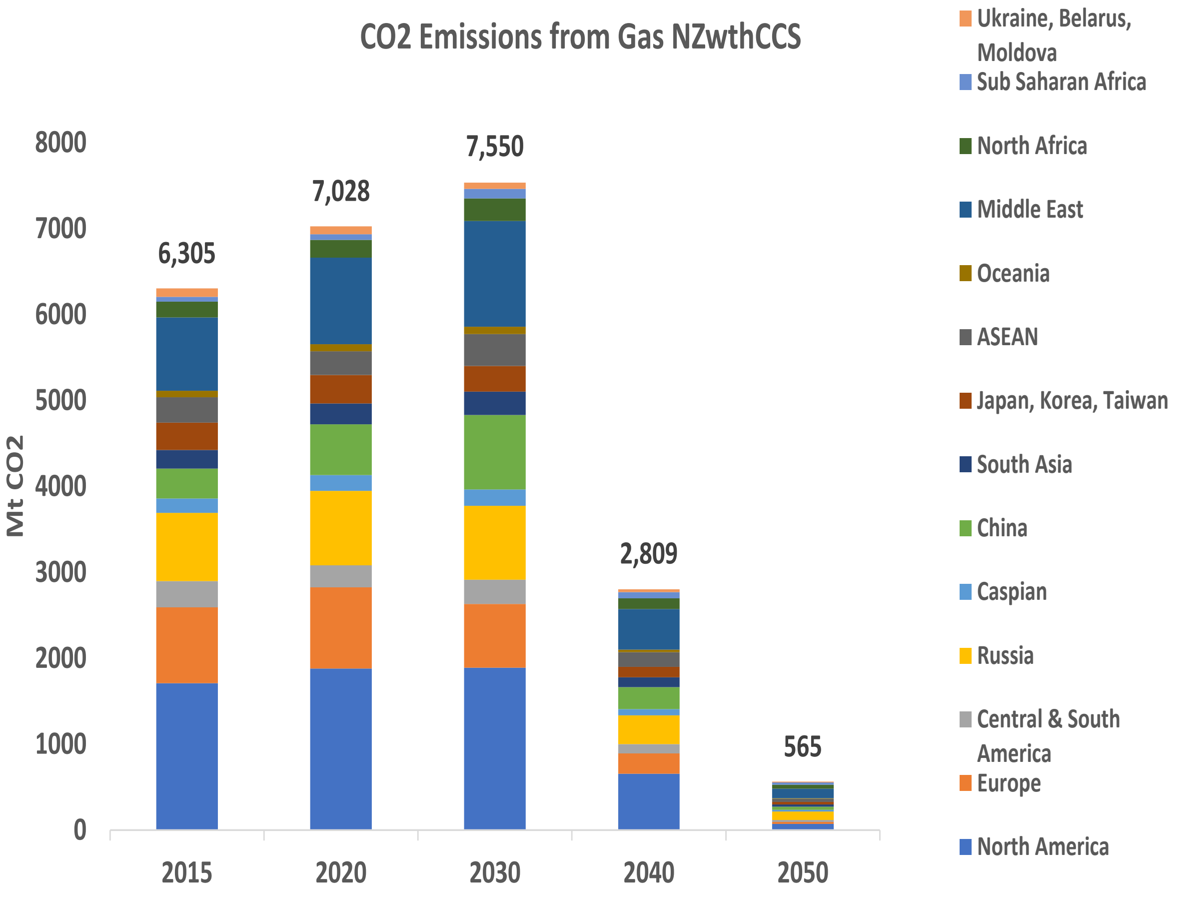
Blue hydrogen is strong in North America, Europe and Middle East up to 2040, in both NZwthCCS and FRAG. Post-2040, blue hydrogen is expected to predominate in regions with ample CCS storage capacity.

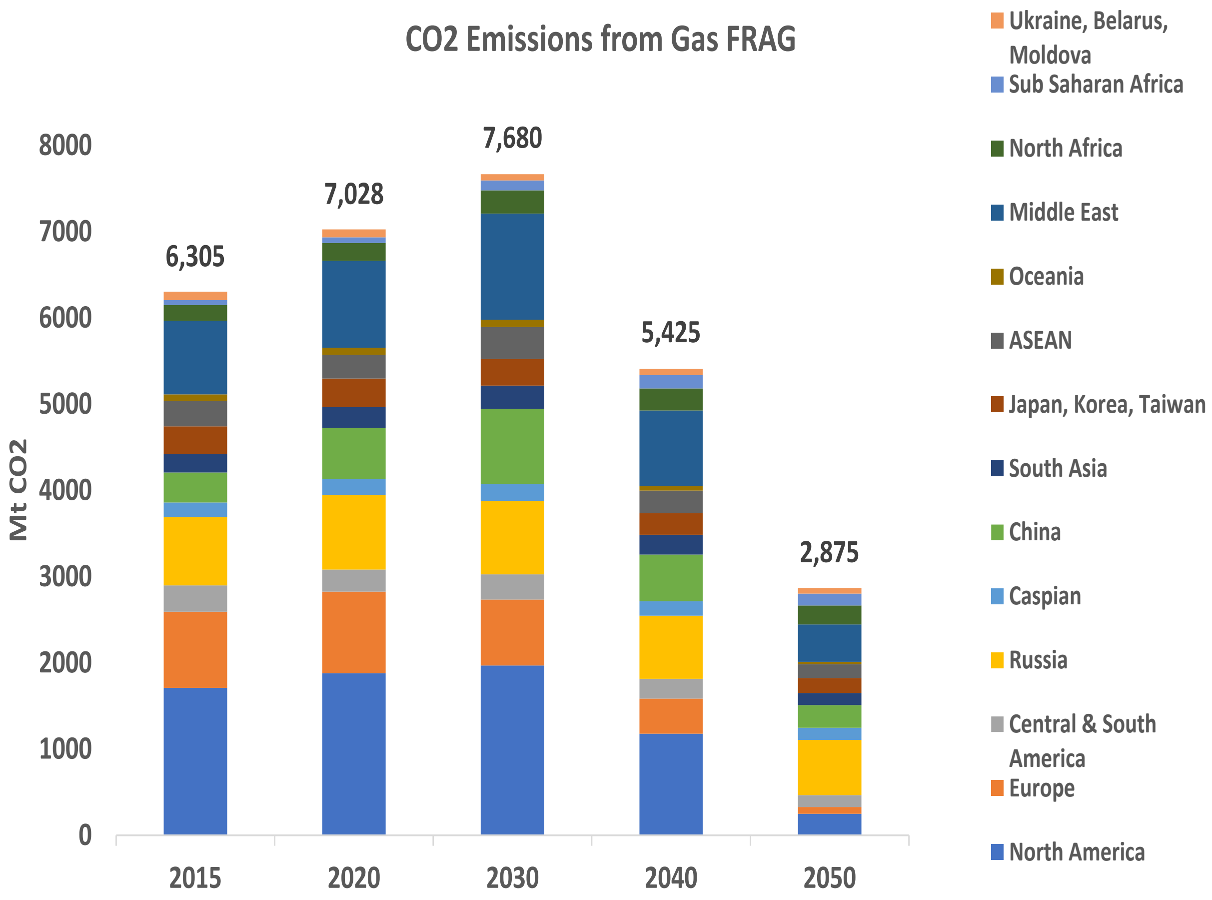
Outside China and India, the gas share (blue) of hydrogen is largely between 70% and 90% by 2050 in NZwthCCS. Brown hydrogen from coal is set to be more important in China and India.

The gas share (blue) of hydrogen in FRAG begins to reduce from 2040 onwards, as green hydrogen becomes more prominent. However, it still remains at up to 75% in 2050 in North America and Europe, 50% in Middle East and ASEAN, albeit somewhat lower elsewhere.

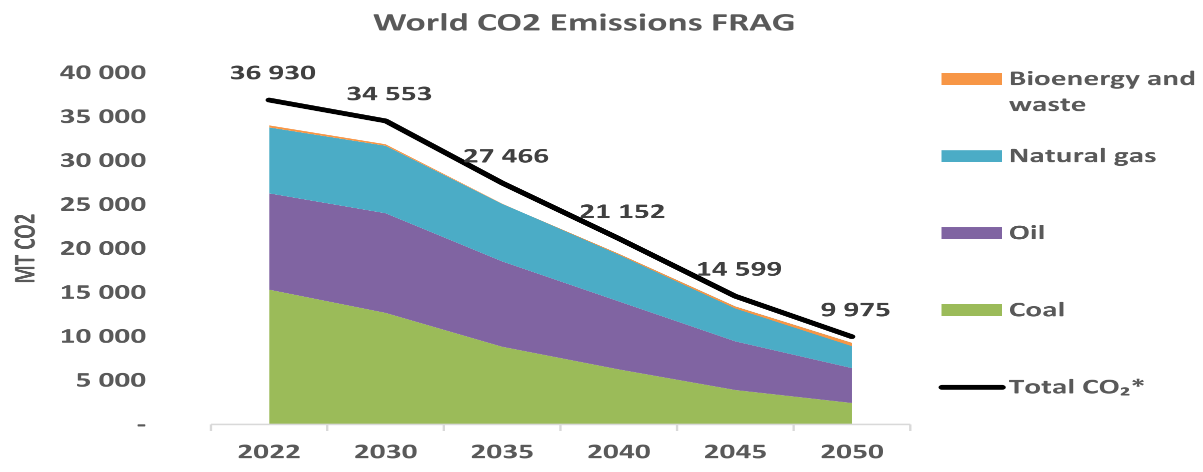
Emissions

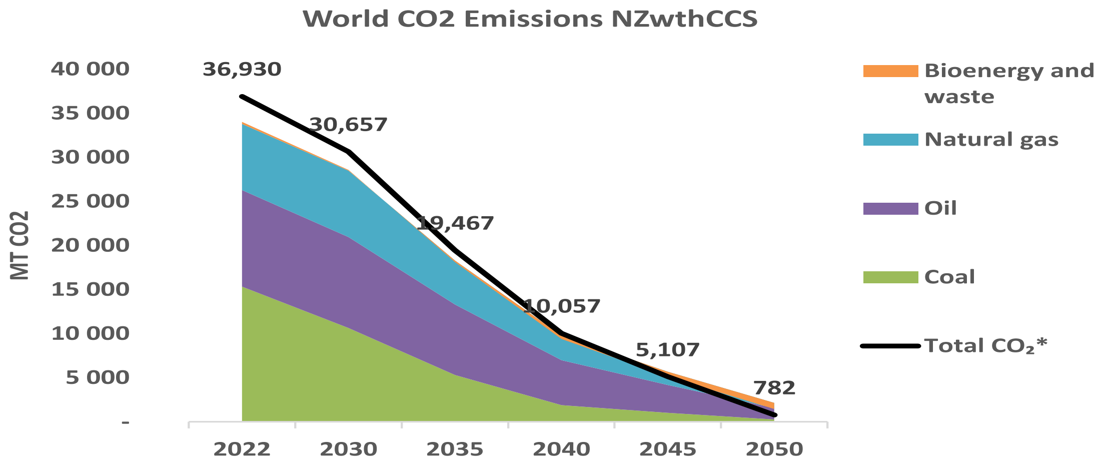
CO2 emissions from natural gas

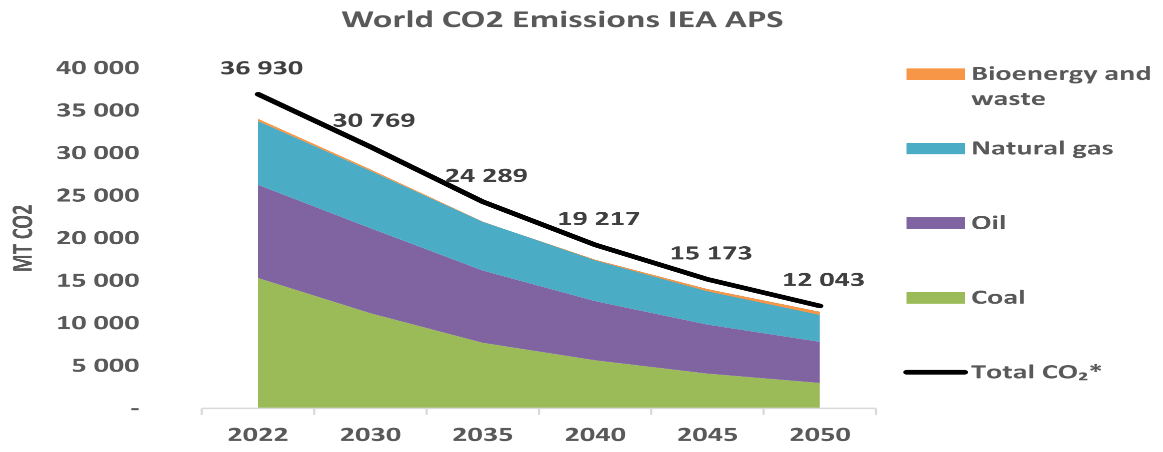


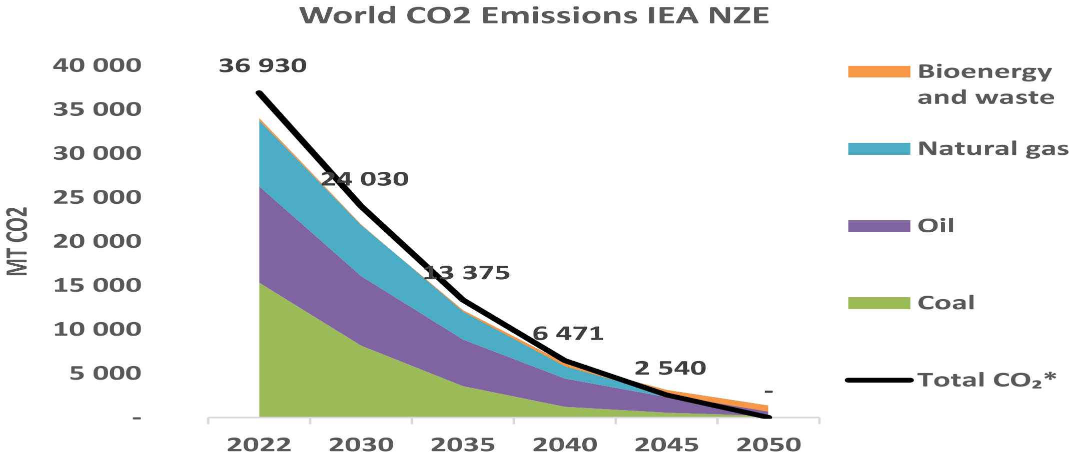


Total CO2 emissions comparison









Emissions

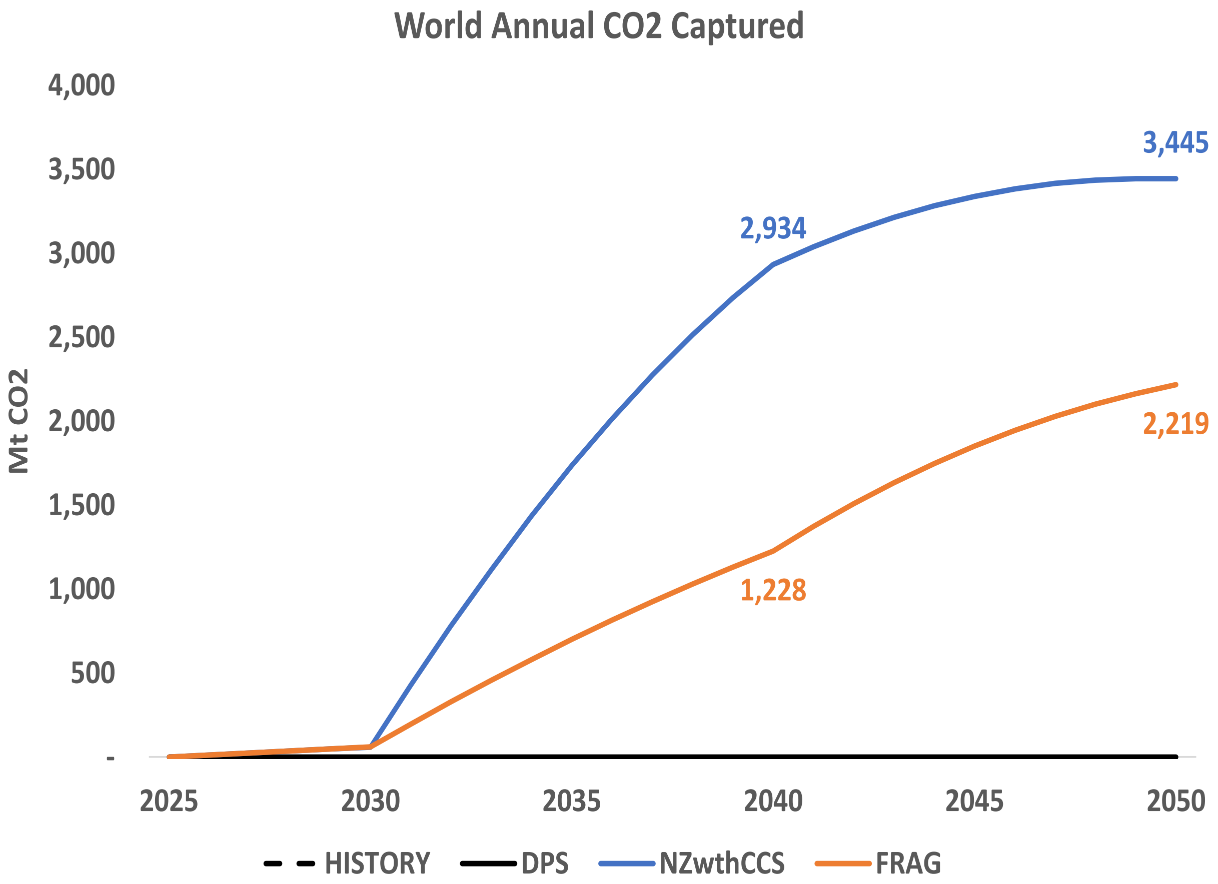
The fall of CO_2 emissions from gas in NZwthCCS by 2050 is consistent with net zero (gross emissions offset by negative emissions elsewhere), with carbon capture from gas taking off in the 2030s.

Total CO_2 emissions are generally higher over time than IEA NZE but come together by 2050 (IEA NZE is a net emissions measurement).

In FRAG, the fall in CO_2 emissions from gas is at a much slower rate and does not lead to almost complete decarbonisation as in NZwthCCS, with carbon capture developed more slowly. However, it leads to lower total CO_2 emissions each year than IEA APS.

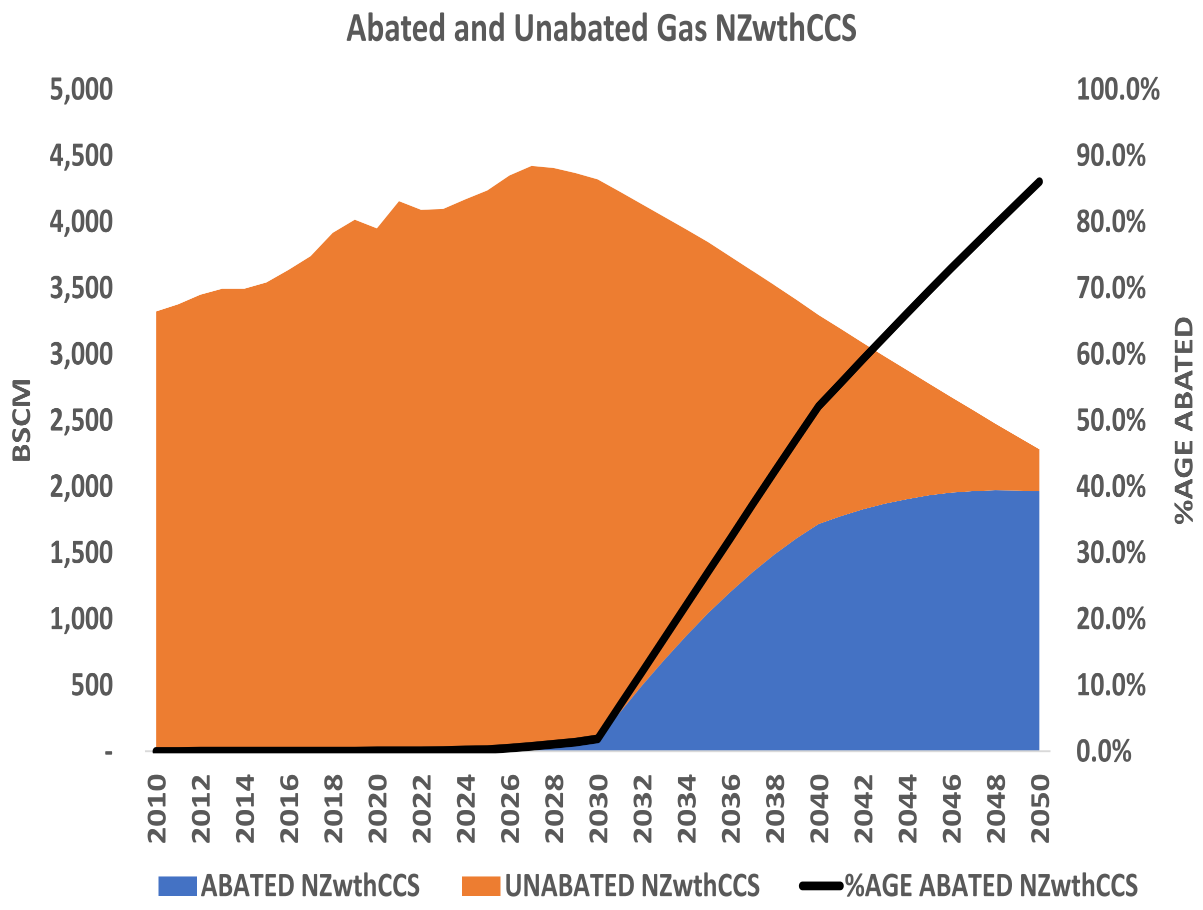
Appendix C on fuel shares and emissions includes regional and country detail. In the US and to a lesser extent Europe, the difference in total CO_2 emissions between NZwthCCS and FRAG are much less significant. In other countries and regions, the differences are more marked.

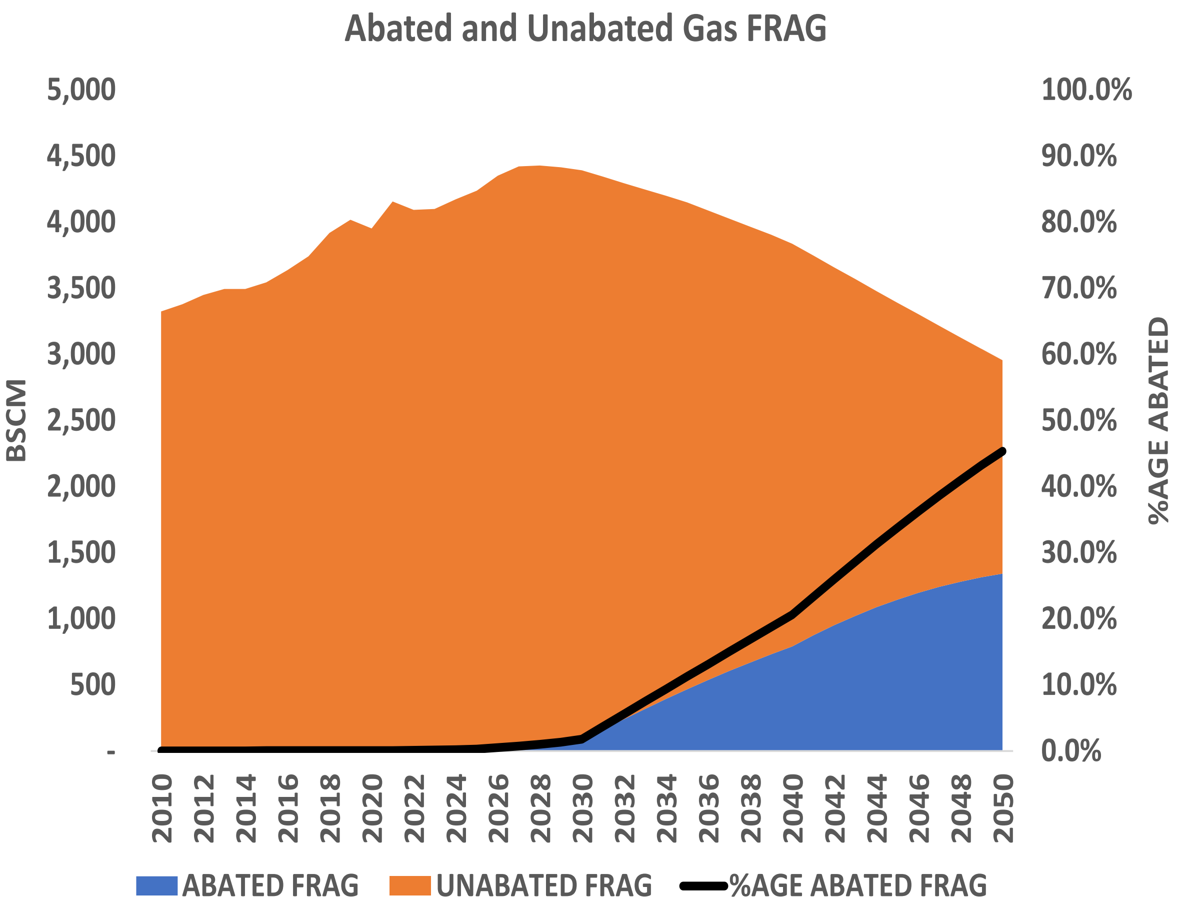
Carbon capture from natural gas



Mt CO2	NZwthCCS			FRAG		
	2030	2040	2050	2030	2040	2050
North America	19	675	679	20	400	782
Europe	8	271	281	8	151	288
Central & South America	-	130	167	-	47	75
Russia	-	335	392	-	39	71
Caspian	-	74	81	-	9	16
China	9	280	293	9	144	207
South Asia	3	138	186	3	30	65
Japan, Korea, Taiwan	3	122	164	3	28	43
ASEAN	4	170	197	4	111	161
Oceania	1	30	32	1	22	29
Middle East	12	476	646	12	219	434
North Africa	-	122	176	-	13	24
Sub Saharan Africa	-	74	110	-	8	16
Ukraine, Belarus, Moldova	-	31	37	-	4	7
Total	**59**	**2,934**	**3,445**	**60**	**1,228**	**2,219**

Abated gas


Abated and Unabated Gas NZwthCCS
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
BSCM
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
%AGE ABATED
2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040 2042 2044 2046 2048 2050
ABATED NZwthCCS
UNABATED NZwthCCS
%AGE ABATED NZwthCCS


Abated and Unabated Gas FRAG
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
BSCM
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
%AGE ABATED
2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040 2042 2044 2046 2048 2050
ABATED FRAG
UNABATED FRAG
%AGE ABATED FRAG

Carbon Capture and Abatement

Some 3.4Gt of CO2 is captured from gas in 2050 in NZwthCCS, with some 2.2Gt captured in FRAG in 2050.

There is generally a slower roll out of CCS in FRAG than in NZ50. However, there is still strong carbon capture in North America and Middle East to some extent in FRAG. In Russia there is minimal carbon capture in FRAG and also materially lower in C&S America, JKT, Africa and South Asia.

The IEA's new Net Zero Pathway has total CO2 capture in 2050 of 6Gt, of which 3.7Gt is from fossil fuels and industrial processes – balance is bioenergy and direct air capture. OIES NZwthCCS has somewhat more CO2 capture from gas than IEA NZE but in FRAG the CO2 capture rate is likely lower than in IEA NZE – but FRAG is not a net zero scenario.

IEA also note that the level of deployment of carbon capture in NZE is much lower than in other comparable 1.5° C scenarios, which are in the range of 3.5Gt to 16Gt in 2050.

In NZwthCCS abated gas – direct at burner tip, blue hydrogen, biomethane – is 85% by 2050. There is significant abatement in North America, Russia, China and Middle East, but abatement is across the board in all regions.

In FRAG, 45% of gas is abated by 2050, with much less abatement in Africa, JKT, Russia, Caspian and South Asia, but still strong in USA and Europe.

Conclusions

Conclusions

Our NZwthCCS scenario achieves net zero across the board everywhere but with a significant volume of CCS required in all countries/regions. The realism of this scenario can therefore be questioned.

The FRAG scenario reflects a multi-paced world with some countries/regions more committed to decarbonization than others. There is still significant CCS which is required to maintain a reasonable level of gas demand. At COP28, the prospect of the use of fossil fuels as transitional fuels was recognised. In that respect, it could be argued that the FRAG scenario is much closer to the COP28 outcome, with natural gas a transitional fuel.

Global energy demand remains flat between 2022 and 2050 with developing markets growing and developed markets declining. Displacement of fossil fuels by renewables in power significantly reduces “energy intensity”.

Gas demand peaks around 2030 in NZwthCCS and FRAG and declines gradually. By 2050, gas demand in NZwthCCS is more than 20% below FRAG and 45% below the 2022 level. FRAG is 30% below the 2022 level in 2050.

The main losses in gas demand (compared to 2022) are in OECD economies and China. The main differences in demand between DPS and NZwthCCS or FRAG are in North America, Middle East, Europe and China.

The main differences in supply scenarios are in North America, Middle East and China.

LNG and pipeline trade are significantly lower in NZwthCCS and FRAG than in DPS. LNG trade peaks around 2030 in all three scenarios. NZwthCCS is lower than DPS by 60% in 2050, while FRAG is 50% lower.

NZwthCCS and FRAG demand are higher than IEA NZE and IEA APS. NZwthCCS is similar to other decarbonising scenarios e.g Shell Sky 2050. FRAG is very similar to WoodMac NZE and McKinsey.

Europe and Asia spot prices are around $9 to $10 per MMBTU in DPS and some $4 or so lower in NZwthCCS and FRAG. Henry Hub is in a $4-5 range in all scenarios. Longer term prices are consistent with historical averages going back to 1990s – lower prices – and 2000s – higher prices.

NZwthCCS CO2 emissions from gas fall by 2050 consistent with net zero (gross emissions offset by negative elsewhere), with carbon capture taking off in the 2030s.

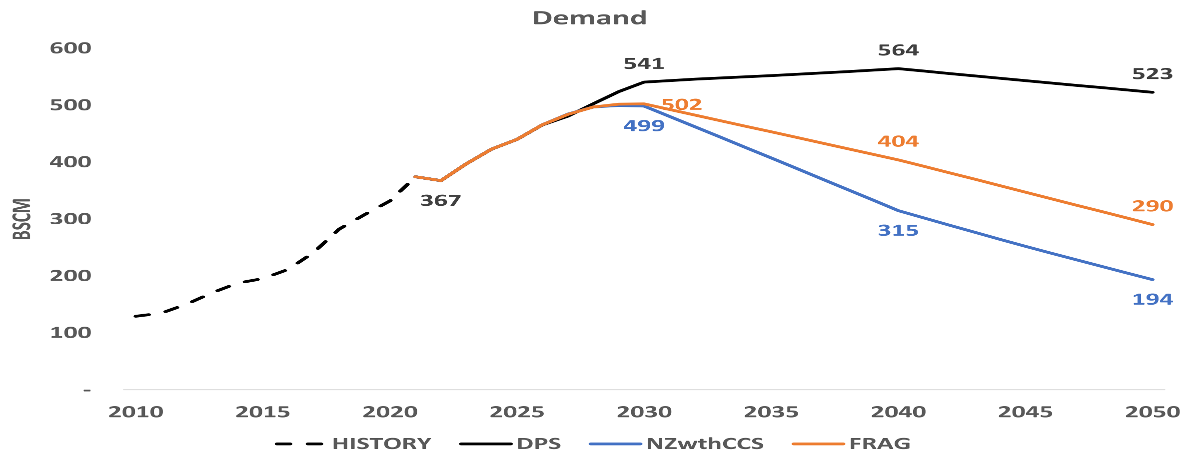
In FRAG, the fall in CO2 emissions from gas is at a much slower rate and does not lead to near complete decarbonisation as in NZwthCCS, with carbon capture rolling out more slowly.

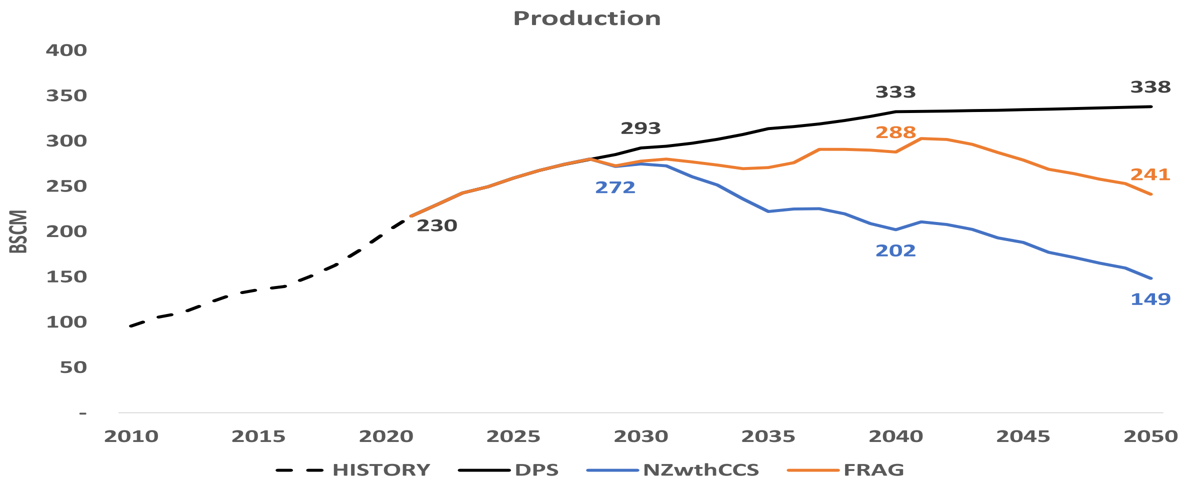
CCS from gas is some 3.4Gt in NZwthCCS and 2.2Gt in FRAG – latter more consistent with IEA NZE but other IPCC scenarios have more CCS than NZE. By 2050, 45% of gas demand is abated in FRAG and 85% in NZwthCCS.

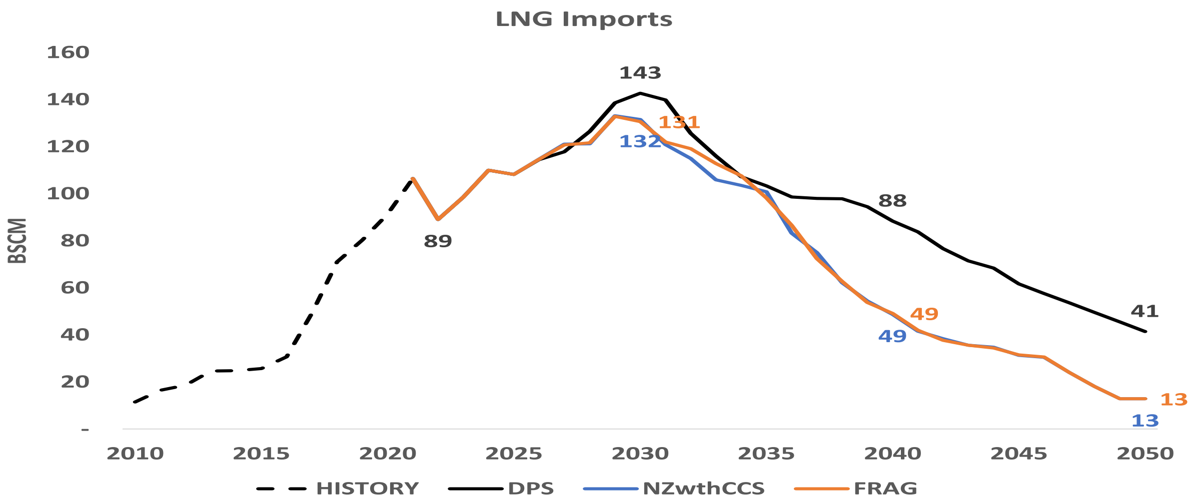
The key conclusion is that if gas is to remain a significant fuel in a rapidly decarbonising world, then the industry needs to invest in an enormous amount of CCS. The alternative is rapid decline, as is shown in the IEA NZE scenario.

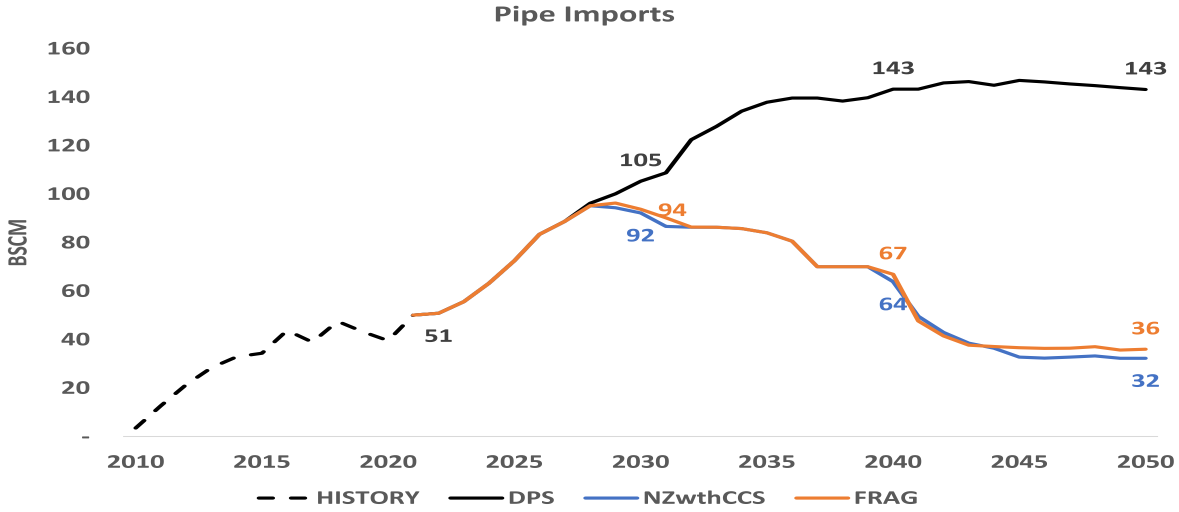
Appendix A – Selected Regional Data

China - Lower production accounts for most of the difference in demand between NZwthCCS and FRAG

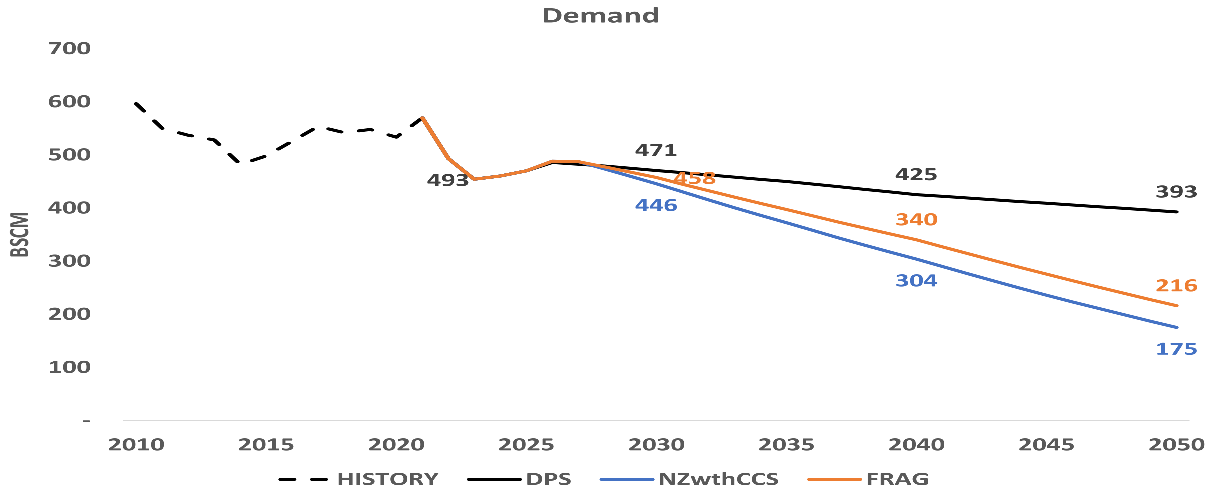


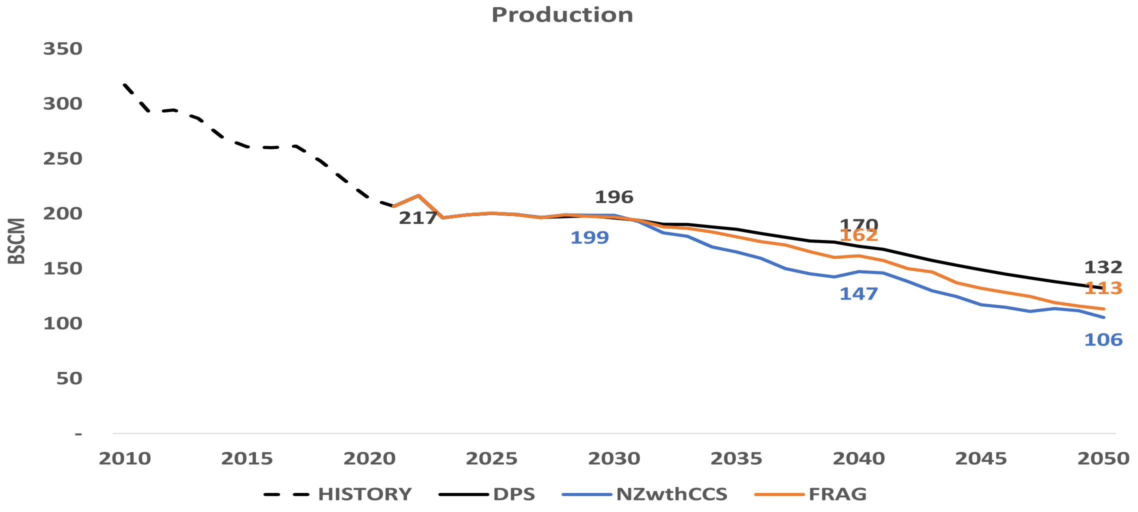


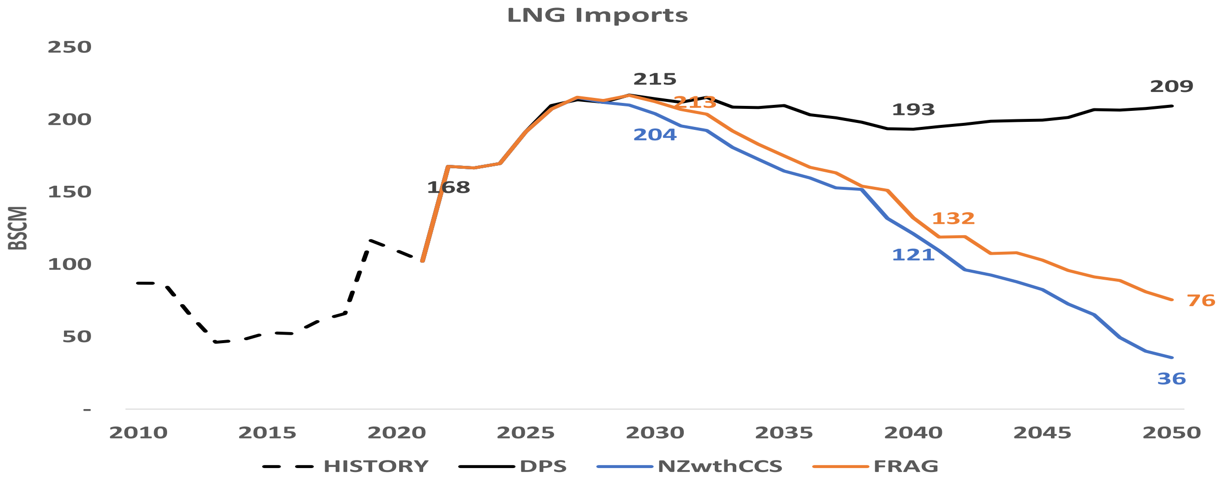


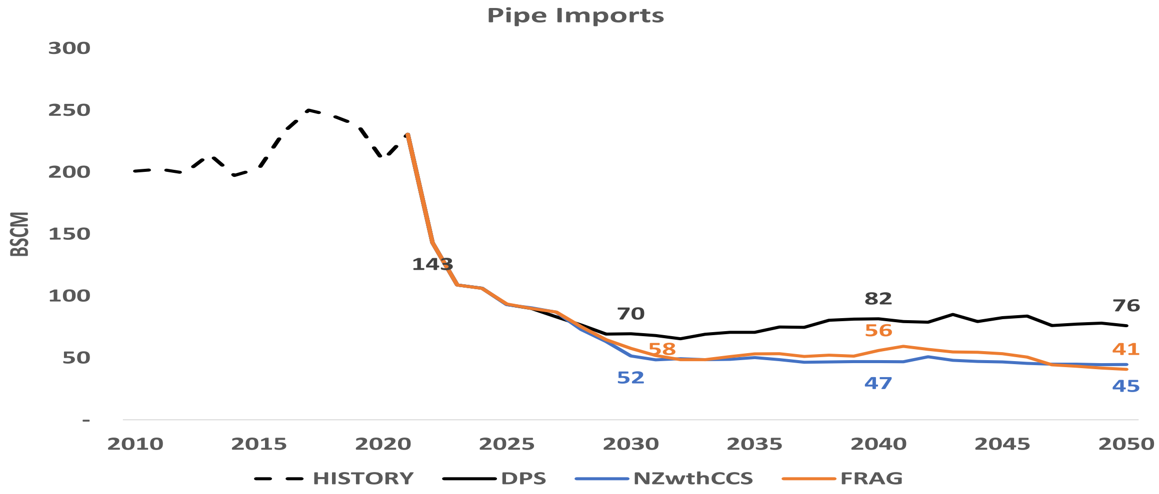


Europe - Lower demand between DPS and NZwthCCS and FRAG reduces imports., especially of LNG

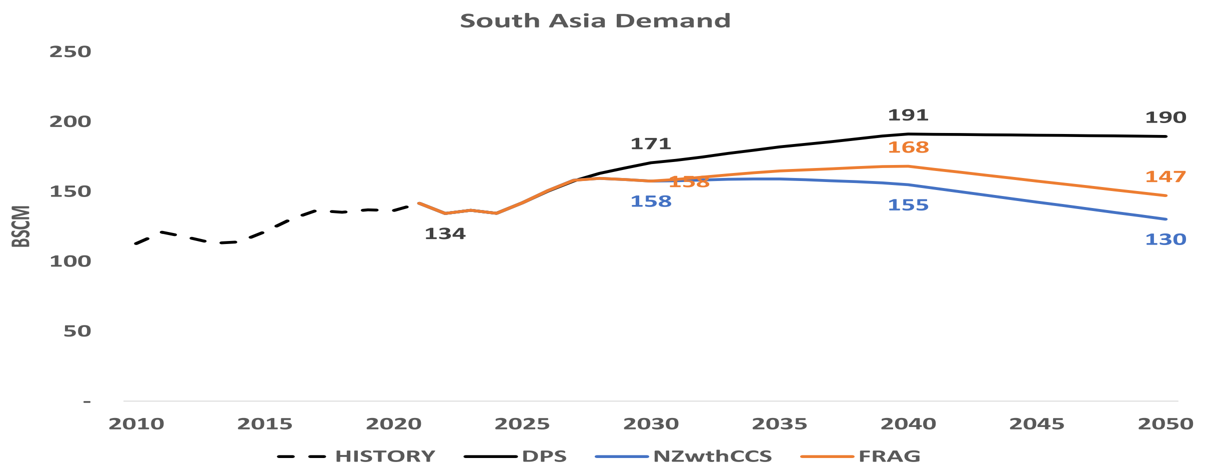


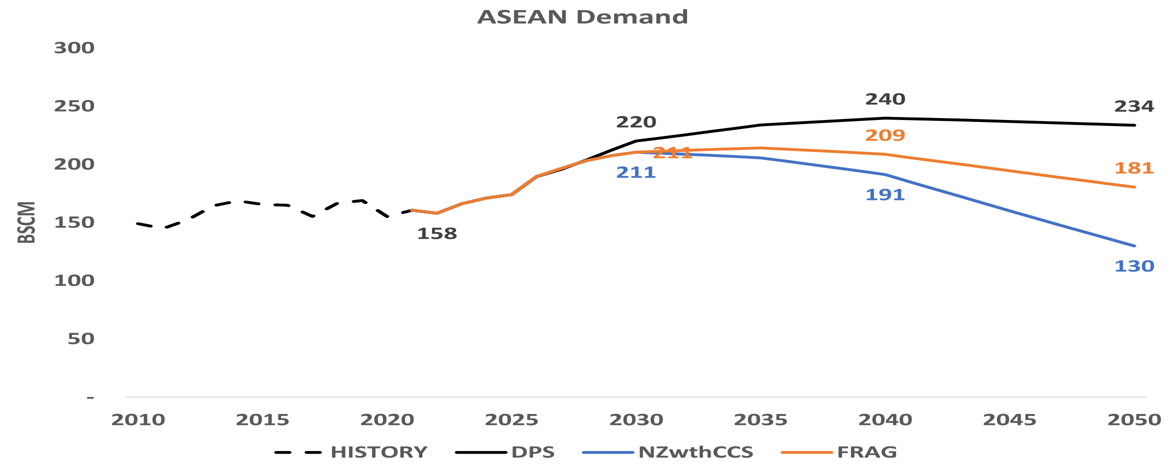


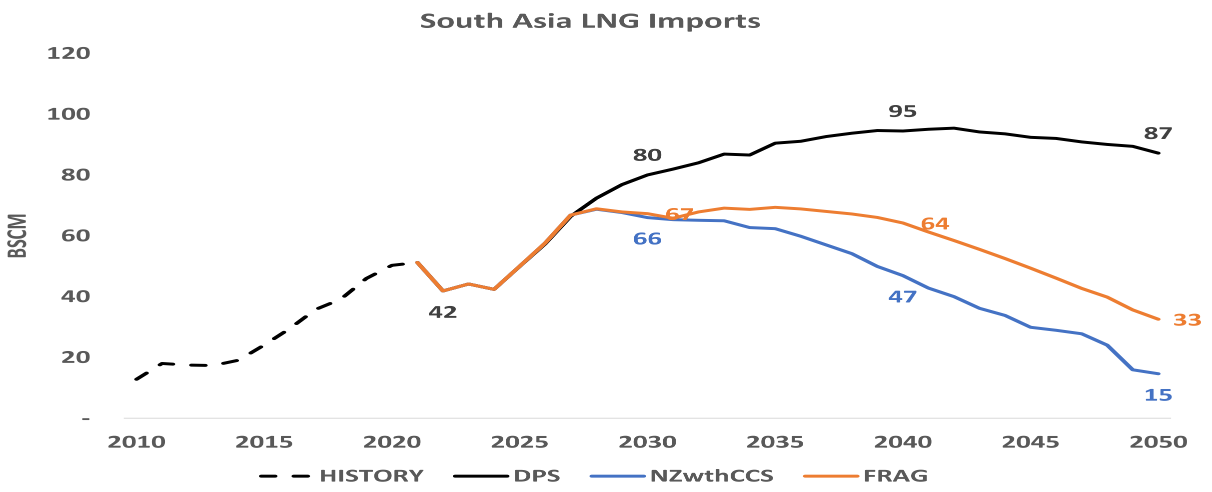


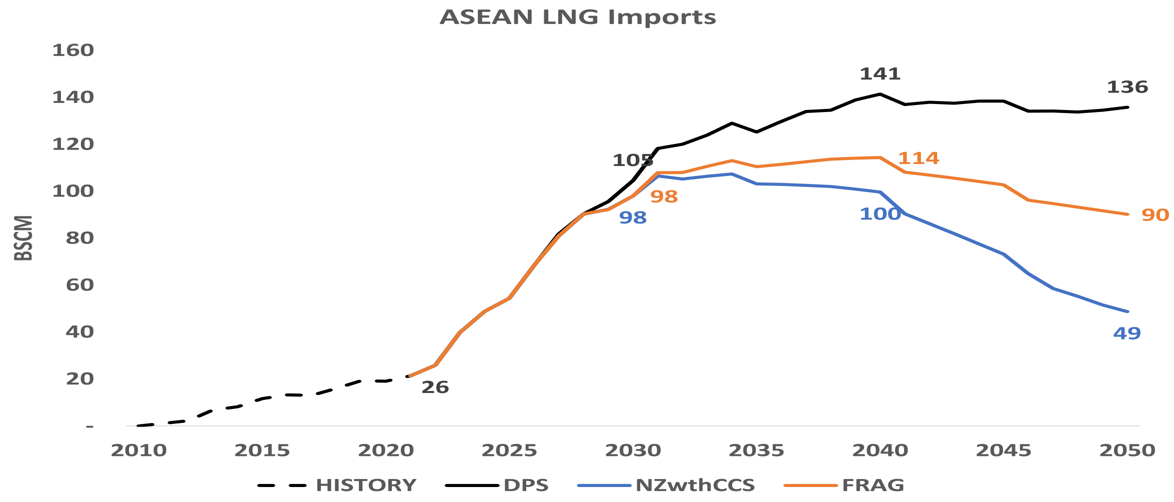


Asia - Lower South Asia demand impacts LNG imports. ASEAN demand relatively stable

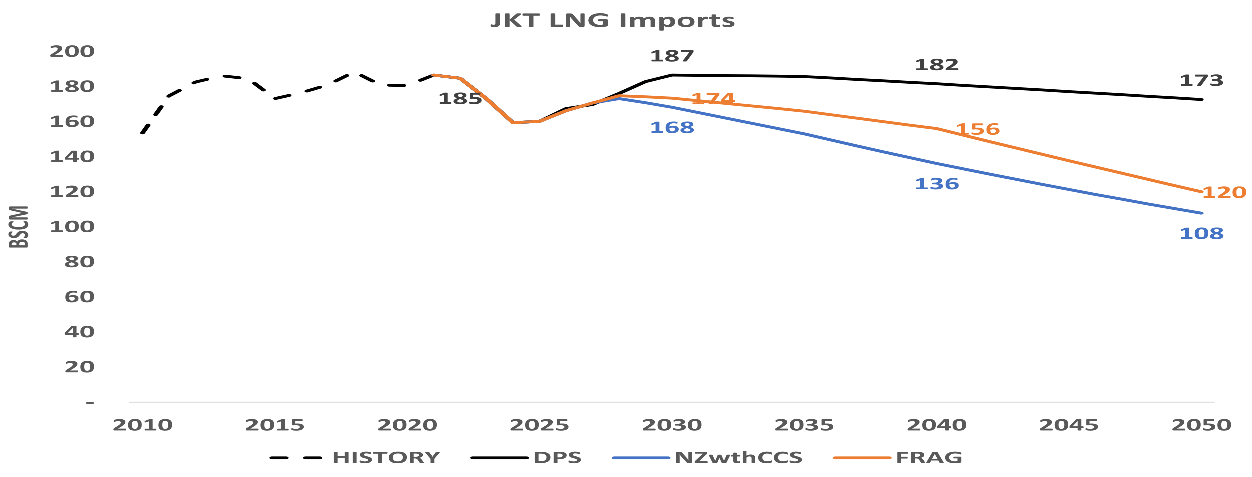


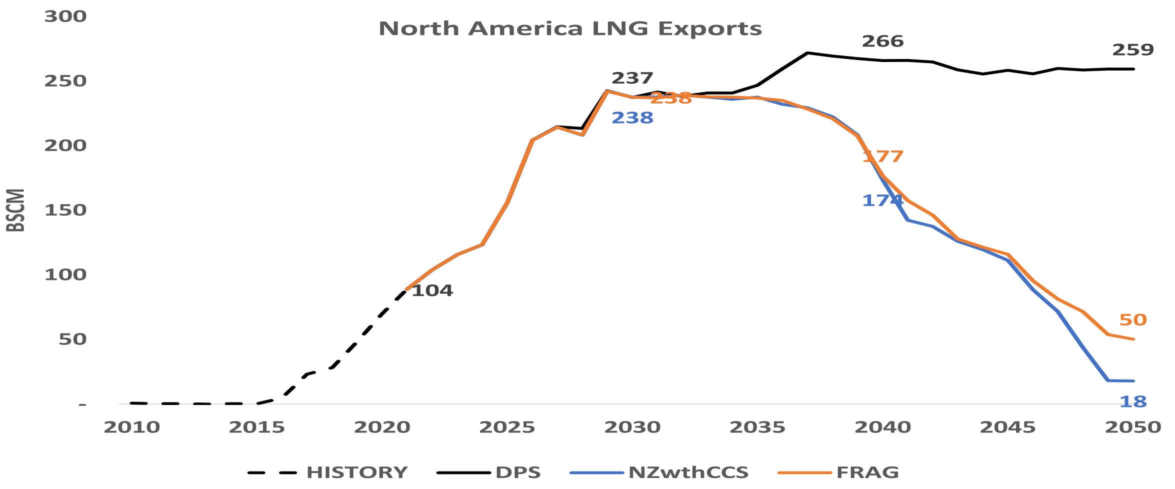


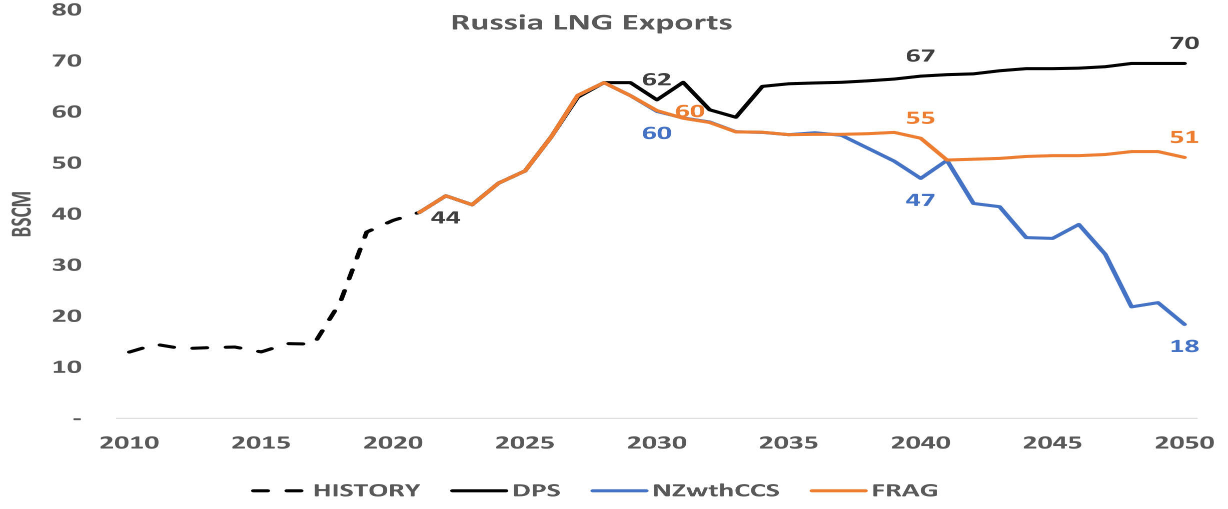


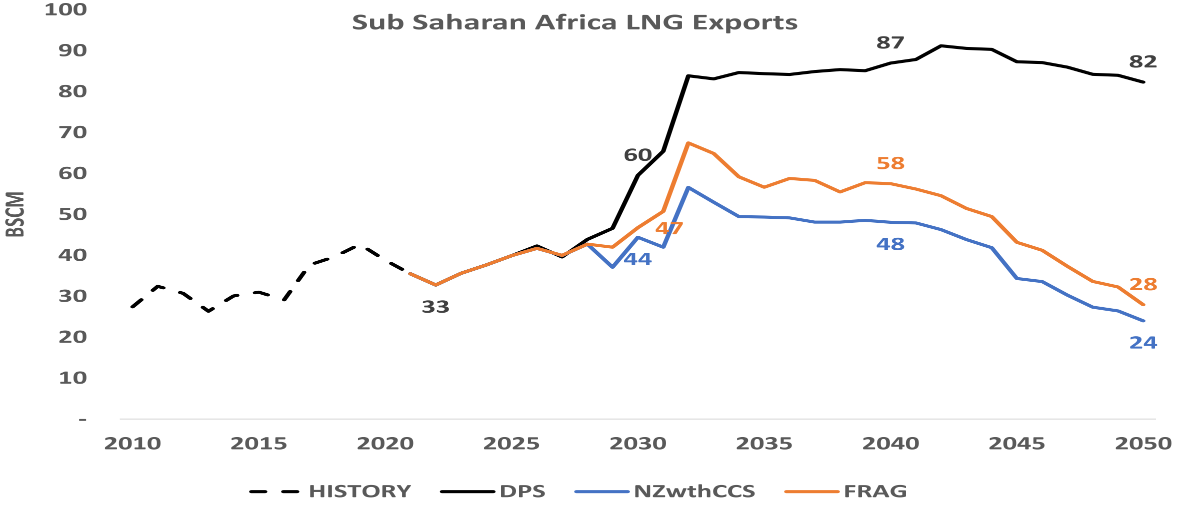


Selected LNG Imports and Exports









Appendix B – Scenario Differences

DEMAND

BCM	NZwthCCS less DPS			FRAG less DPS			NZwthCCS less FRAG		
	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	-61	-361	-640	-17	-221	-478	-44	-140	-162
Europe	-25	-121	-217	-13	-85	-177	-12	-36	-41
Central & South America	-12	-43	-64	-6	-12	-34	-5	-32	-31
Russia	-28	-131	-221	-32	-74	-98	3	-57	-123
Caspian	-7	-35	-58	-7	-19	-26	1	-16	-33
China	-42	-249	-329	-38	-160	-233	-4	-89	-97
South Asia	-13	-36	-59	-13	-23	-42	-	-13	-17
Japan, Korea, Taiwan	-18	-45	-65	-13	-26	-53	-5	-20	-12
ASEAN	-10	-49	-104	-10	-31	-53	-0	-17	-51
Oceania	-5	-19	-27	-5	-10	-16	-0	-9	-11
Middle East	-26	-273	-409	-26	-192	-349	-0	-81	-60
North Africa	-9	-33	-46	-6	-19	-34	-3	-14	-11
Sub Saharan Africa	-2	-17	-24	-1	-8	-13	-1	-9	-11
Ukraine, Belarus, Moldova	-3	-13	-23	-3	-8	-10	0	-6	-13
LNG Bunker Fuel	-1	-11	-26	-2	-8	-24	0	-2	-2
Total	**-261**	**-1,437**	**-2,314**	**-192**	**-896**	**-1,640**	**-70**	**-541**	**-674**

PRODUCTION

BCM	NZwthCCS less DPS			FRAG less DPS			NZwthCCS less FRAG		
	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	-59	-447	-887	-21	-303	-692	-38	-143	-194
Europe	2	-23	-27	1	-9	-19	2	-14	-8
Central & South America	-23	-51	-66	-17	-20	-40	-6	-31	-27
Russia	-48	-234	-379	-45	-156	-216	-3	-78	-163
Caspian	-19	-73	-101	-19	-55	-72	-1	-18	-29
China	-18	-130	-190	-15	-45	-97	-3	-86	-93
South Asia	1	11	13	-0	7	12	1	4	1
Japan, Korea, Taiwan	-	-	-	-	-	-	-	-	-
ASEAN	-14	-20	-29	-13	-8	-12	-1	-12	-17
Oceania	-17	-84	-96	-17	-60	-75	-0	-23	-21
Middle East	-31	-296	-436	-26	-191	-341	-5	-105	-94
North Africa	-14	-25	-33	-8	-14	-24	-6	-11	-8
Sub Saharan Africa	-18	-56	-84	-14	-37	-67	-4	-19	-17
Ukraine, Belarus, Moldova	-1	-1	-4	-1	-	-	0	-1	-4
Total	**-259**	**-1,428**	**-2,319**	**-193**	**-891**	**-1,643**	**-65**	**-537**	**-675**

LNG EXPORTS

BCM	NZwthCCS less DPS			FRAG less DPS			NZwthCCS less FRAG		
	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	0	-92	-242	0	-89	-209	0	-3	-32
Europe	-	-	-	-	-	-	-	-	-
Central & South America	-12	-11	-8	-10	-8	-8	-2	-3	-
Russia	-2	-20	-51	-2	-12	-18	-0	-8	-33
Caspian	-	-	-	-	-	-	-	-	-
China	-	-	-	-	-	-	-	-	-
South Asia	-	-	-	-	-	-	-	-	-
Japan, Korea, Taiwan	-	-	-	-	-	-	-	-	-
ASEAN	-11	-13	-7	-10	-3	-3	-1	-9	-5
Oceania	-12	-65	-69	-12	-50	-59	0	-15	-10
Middle East	-6	-0	-12	-0	-0	-0	-6	-0	-12
North Africa	-4	-6	-5	-2	-3	-2	-3	-4	-3
Sub Saharan Africa	-15	-39	-58	-13	-29	-54	-2	-9	-4
Ukraine, Belarus, Moldov	-	-	-	-	-	-	-	-	-
Total	**-62**	**-246**	**-453**	**-49**	**-195**	**-354**	**-14**	**-51**	**-99**

LNG IMPORTS

BCM	NZwthCCS less DPS			FRAG less DPS			NZwthCCS less FRAG		
	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	-	-	-	-	-	-	-	-	-
Europe	-10	-72	-174	-2	-61	-134	-8	-11	-40
Central & South America	-1	-3	-6	-0	0	-2	-1	-3	-4
Russia	-0	-0	-0	-0	-0	-	-	-	-0
Caspian	-	-	-	-	-	-	-	-	-
China	-11	-40	-29	-12	-39	-29	1	-0	-
South Asia	-14	-48	-73	-13	-30	-55	-1	-17	-18
Japan, Korea, Taiwan	-18	-45	-65	-13	-26	-53	-5	-20	-12
ASEAN	-7	-42	-87	-7	-27	-46	-	-15	-41
Oceania	-	-	-	-	-	-	-	-	-
Middle East	0	3	-0	0	-4	-6	-	7	5
North Africa	0	11	5	0	-0	-7	-0	11	11
Sub Saharan Africa	0	1	2	-0	-	-	0	1	2
Ukraine, Belarus, Moldov	-	-	-	-	-	-	-	-	-
Total	**-62**	**-246**	**-453**	**-49**	**-195**	**-354**	**-14**	**-51**	**-99**

PIPE EXPORTS

BCM	NZwthCCS less DPS			FRAG less DPS			NZwthCCS less FRAG		
	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	-	-	-	-	-	-	-	-	-
Europe	-0	-12	-15	-0	-10	-13	0	-2	-1
Central & South America	-	-	-	-	-	-	-	-	-
Russia	-23	-83	-108	-16	-69	-100	-7	-14	-8
Caspian	-16	-44	-59	-14	-41	-62	-2	-3	3
China	-	-	-	-	-	-	-	-	-
South Asia	-	-	-	-	-	-	-	-	-
Japan, Korea, Taiwan	-	-	-	-	-	-	-	-	-
ASEAN	-	-1	-5	-	-0	-1	-	-0	-4
Oceania	-	-	-	-	-	-	-	-	-
Middle East	1	-19	-15	-0	-3	2	1	-16	-17
North Africa	0	1	2	0	1	1	0	1	1
Sub Saharan Africa	-	-	-	-	-	-	-	-	-
Ukraine, Belarus, Moldov	-	-1	-1	-	-1	-1	-	-1	-
Total	**-38**	**-157**	**-201**	**-31**	**-122**	**-174**	**-8**	**-35**	**-27**

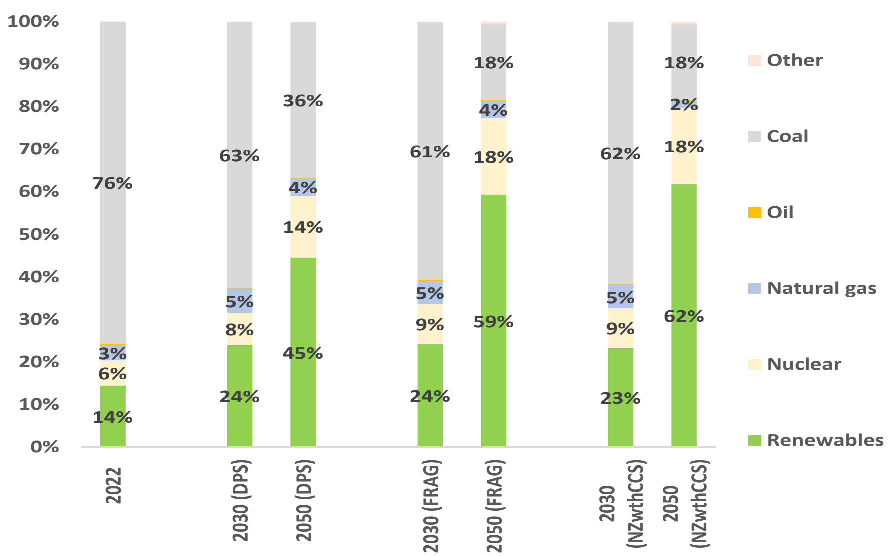
PIPE IMPORTS

BCM	NZwthCCS less DPS			FRAG less DPS			NZwthCCS less FRAG		
	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	-	-	-	-	-	-	-	-	-
Europe	-18	-35	-31	-12	-26	-35	-6	-9	4
Central & South America	-	-	-	-	-	-	-	-	-
Russia	-3	-0	-1	-2	-0	-0	-1	-0	-0
Caspian	-3	-5	-16	-3	-4	-16	-	-1	-0
China	-13	-79	-111	-12	-76	-107	-2	-3	-4
South Asia	-	-	-	-	-	-	-	-	-
Japan, Korea, Taiwan	-	-	-	-	-	-	-	-	-
ASEAN	-	-	-	-	-	-	-	-	-
Oceania	-	-	-	-	-	-	-	-	-
Middle East	-	-0	-	-	-0	-	-	0	-
North Africa	1	-24	-21	-0	-7	-4	1	-16	-17
Sub Saharan Africa	-	-	-	-	-	-	-	-	-
Ukraine, Belarus, Moldov	-2	-14	-21	-2	-8	-12	0	-6	-9
Total	**-38**	**-157**	**-201**	**-31**	**-122**	**-174**	**-8**	**-35**	**-27**

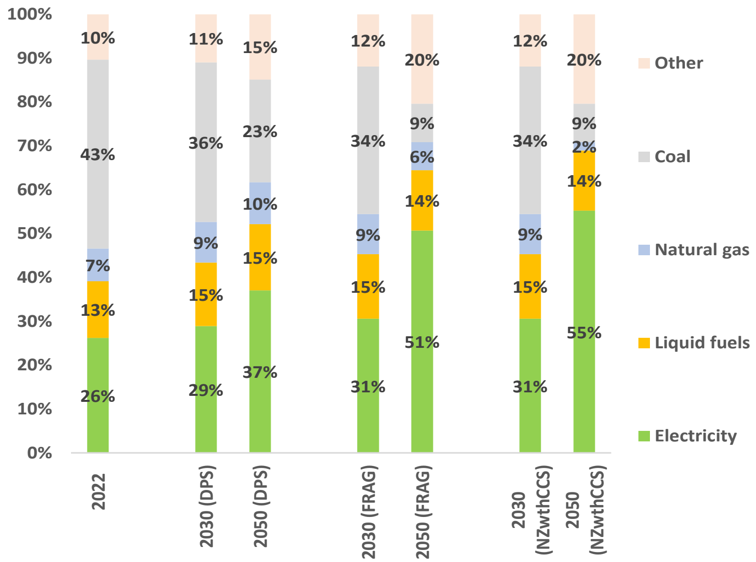
Appendix C – Fuel Share and CO2 Emissions

CHINA

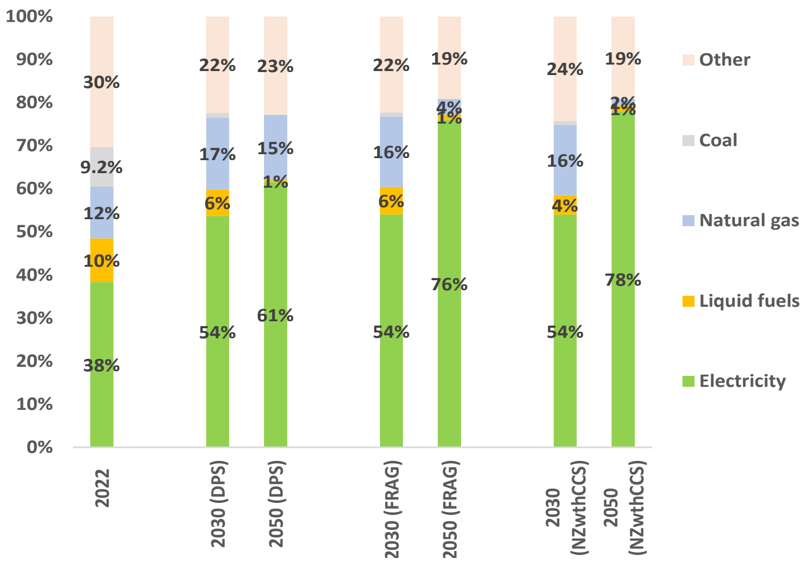
Power Shares



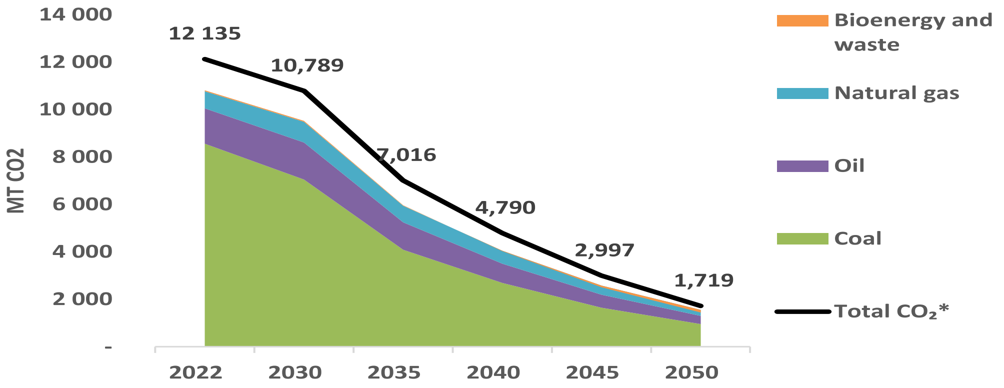
Industry Shares



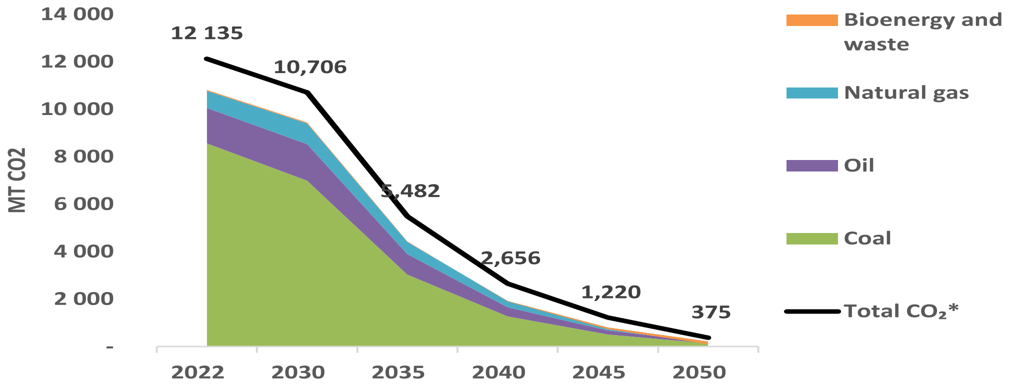
Buildings Shares



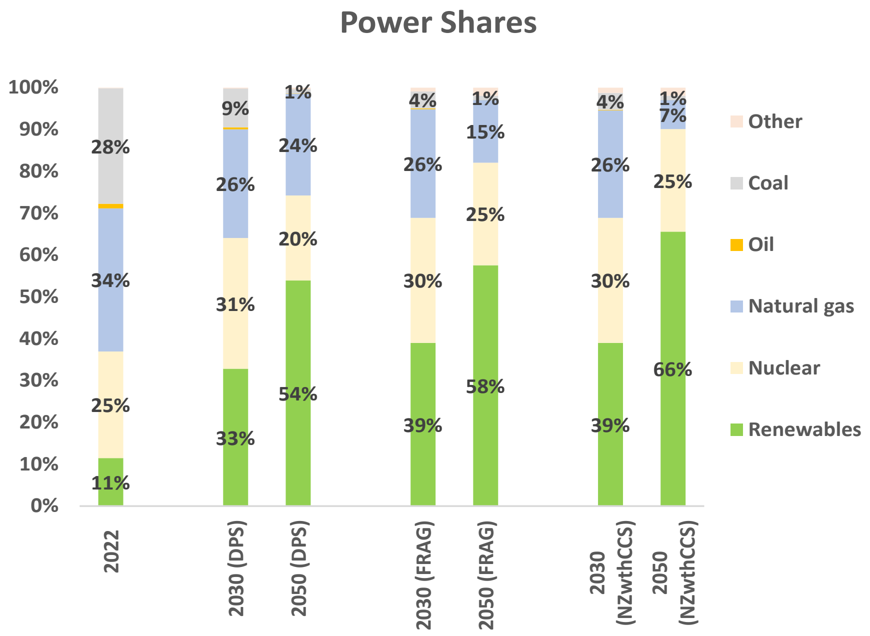
China CO2 Emissions FRAG

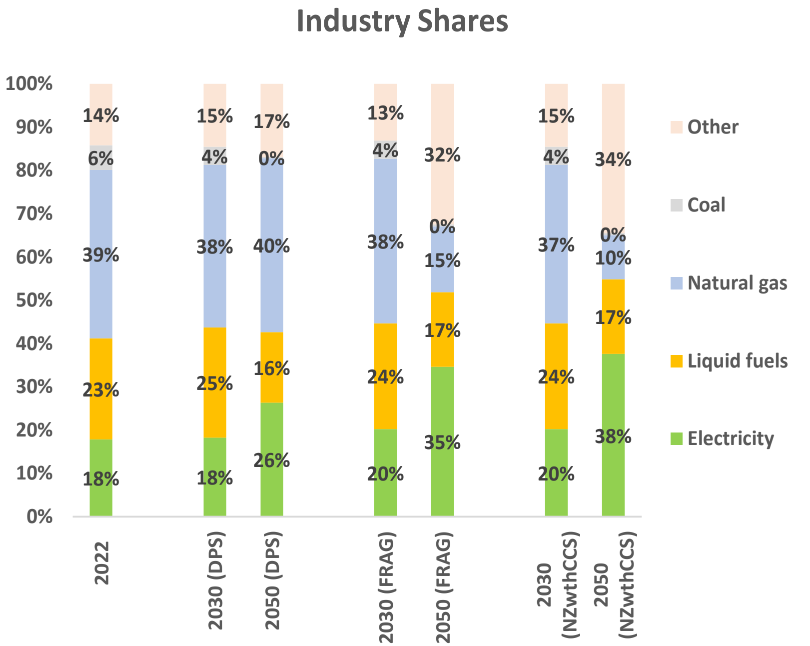


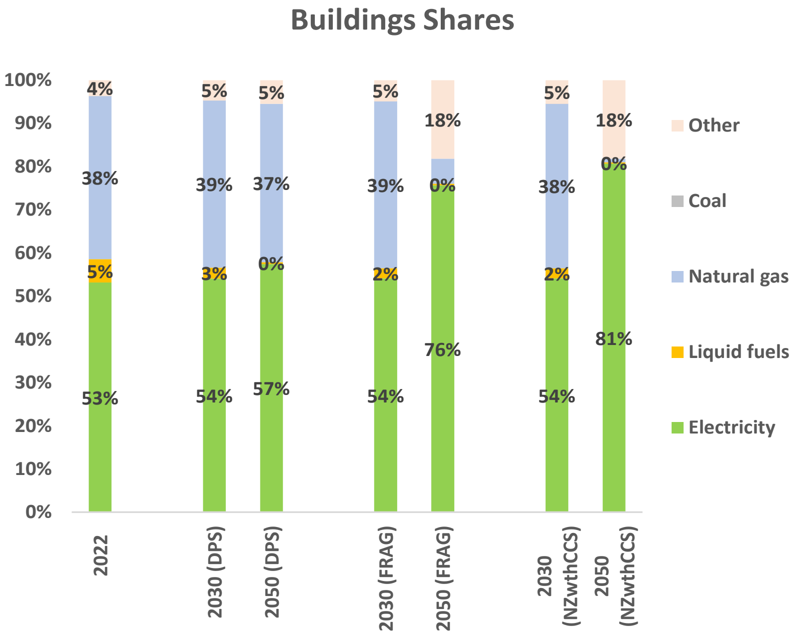
China CO2 Emissions NZwthCCS

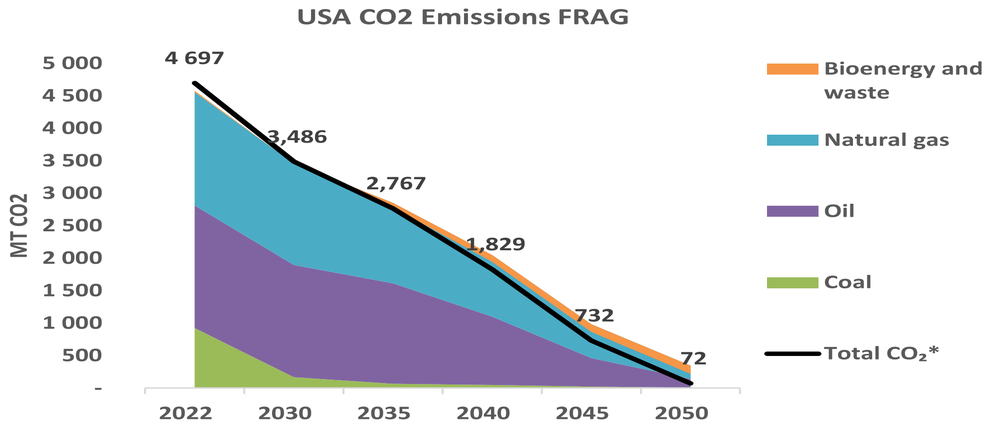


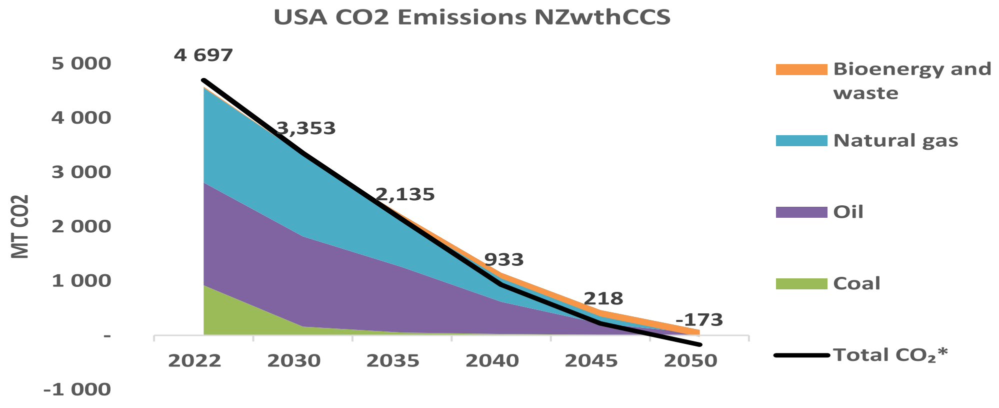
USA


Power Shares
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2022
2030 (DPS)
2050 (DPS)
2030 (FRAG)
2050 (FRAG)
2030 (NZwthCCS)
2050 (NZwthCCS)
Other
Coal
Oil
Natural gas
Nuclear
Renewables
11%
25%
34%
28%
33%
31%
26%
9%
54%
20%
24%
1%
39%
30%
26%
4%
58%
25%
15%
1%
39%
30%
26%
4%
66%
25%
7%
1%


Industry Shares
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2022
2030 (DPS)
2050 (DPS)
2030 (FRAG)
2050 (FRAG)
2030 (NZwthCCS)
2050 (NZwthCCS)
Other
Coal
Natural gas
Liquid fuels
Electricity
18%
23%
39%
6%
14%
18%
25%
38%
4%
15%
26%
16%
40%
0%
17%
20%
24%
38%
4%
13%
35%
17%
15%
0%
32%
20%
24%
37%
4%
15%
38%
17%
10%
0%
34%

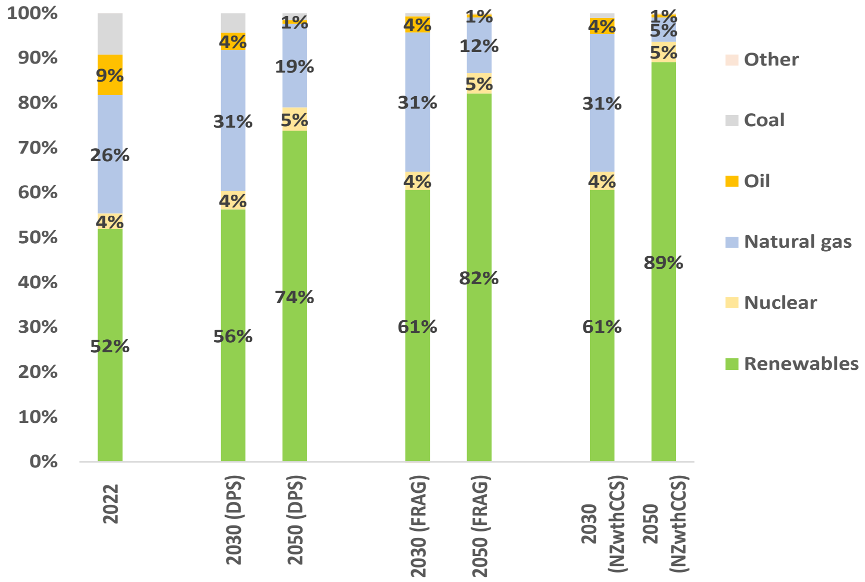

Buildings Shares
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2022
2030 (DPS)
2050 (DPS)
2030 (FRAG)
2050 (FRAG)
2030 (NZwthCCS)
2050 (NZwthCCS)
Other
Coal
Natural gas
Liquid fuels
Electricity
53%
5%
38%
4%
54%
3%
39%
5%
57%
0%
37%
5%
54%
2%
39%
5%
76%
0%
18%
54%
2%
38%
5%
81%
0%
18%


USA CO2 Emissions FRAG
MT CO2
5 000
4 500
4 000
3 500
3 000
2 500
2 000
1 500
1 000
500
-
2022
2030
2035
2040
2045
2050
4 697
3,486
2,767
1,829
732
72
Bioenergy and waste
Natural gas
Oil
Coal
Total CO₂*

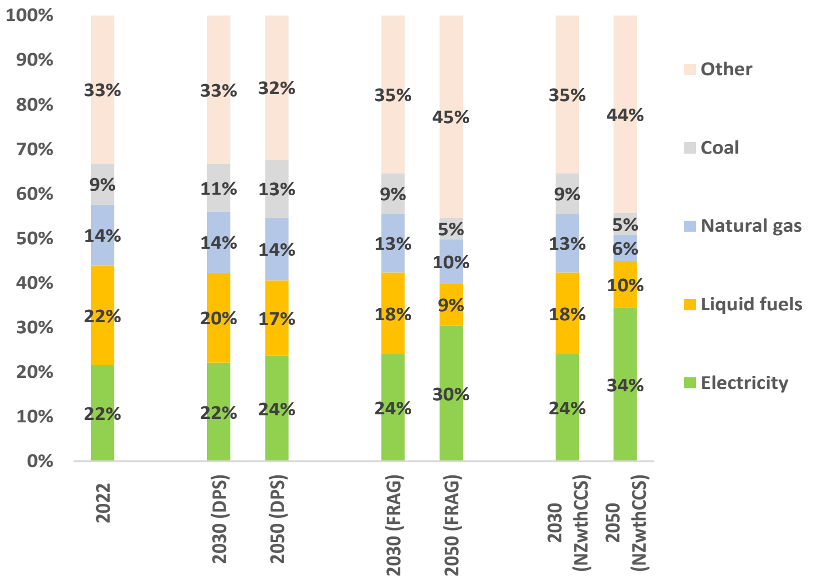

USA CO2 Emissions NZwthCCS
MT CO2
5 000
4 000
3 000
2 000
1 000
-
-1 000
2022
2030
2035
2040
2045
2050
4 697
3,353
2,135
933
218
-173
Bioenergy and waste
Natural gas
Oil
Coal
Total CO₂*

C&S AMERICA

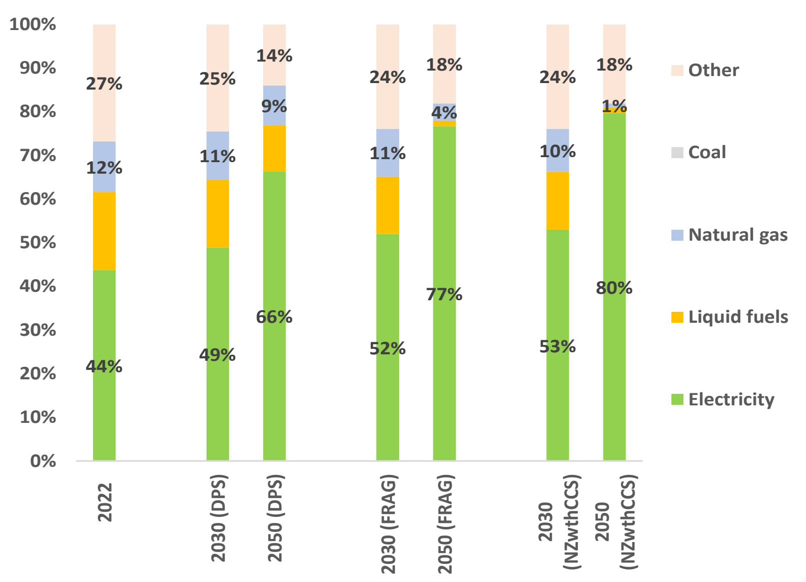
Power Shares



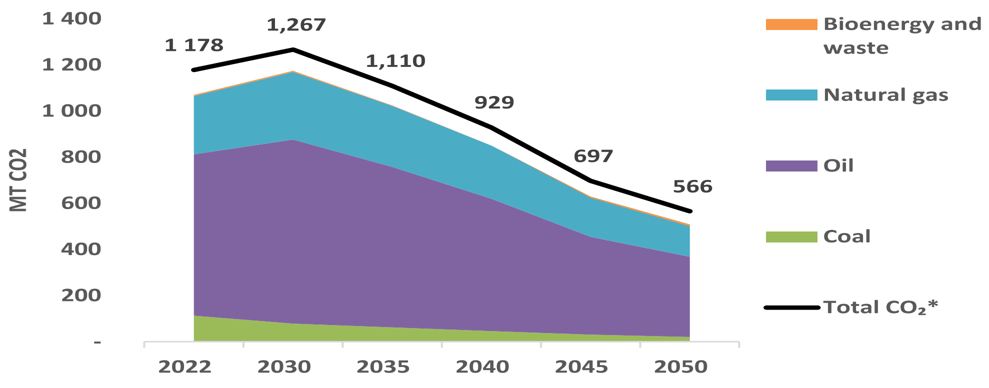
Industry Shares



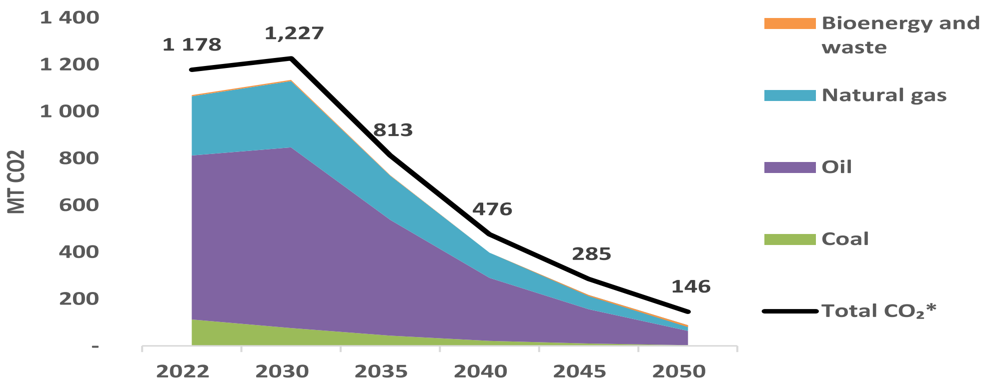
Buildings Shares



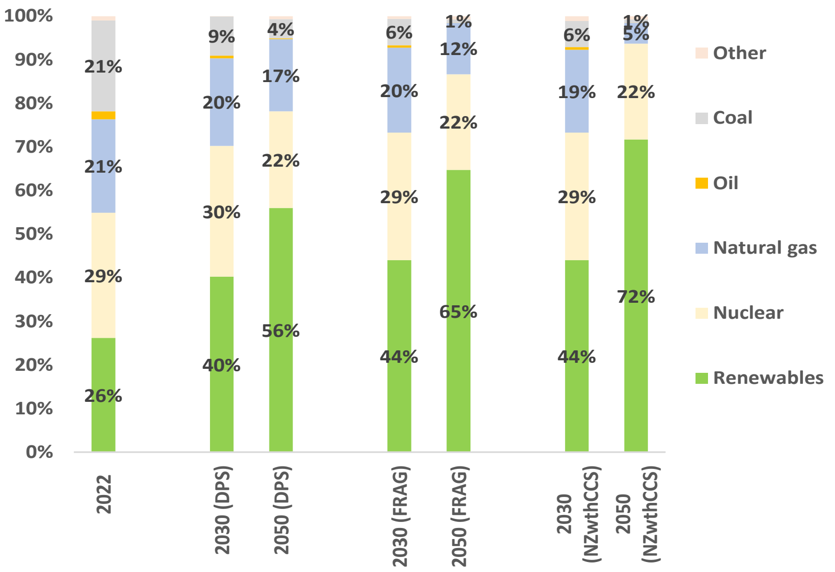
C&S America CO2 Emissions FRAG



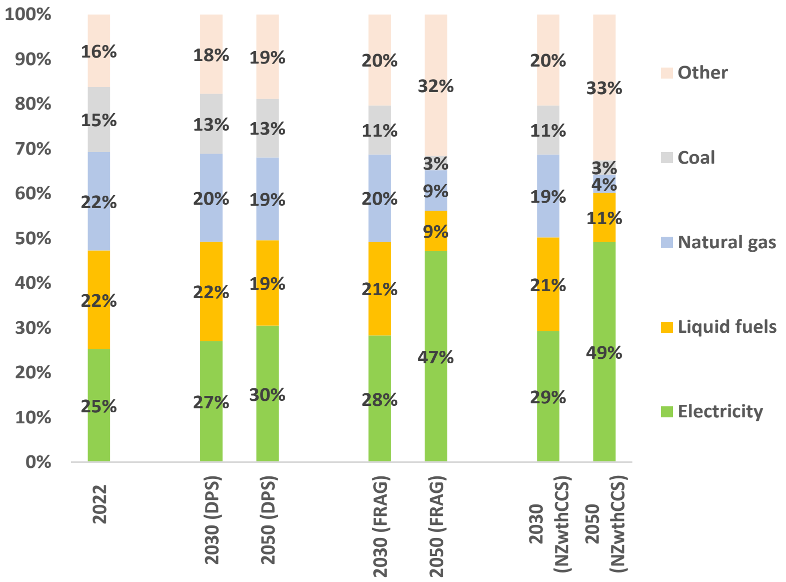
C&S America CO2 Emissions NZwthCCS



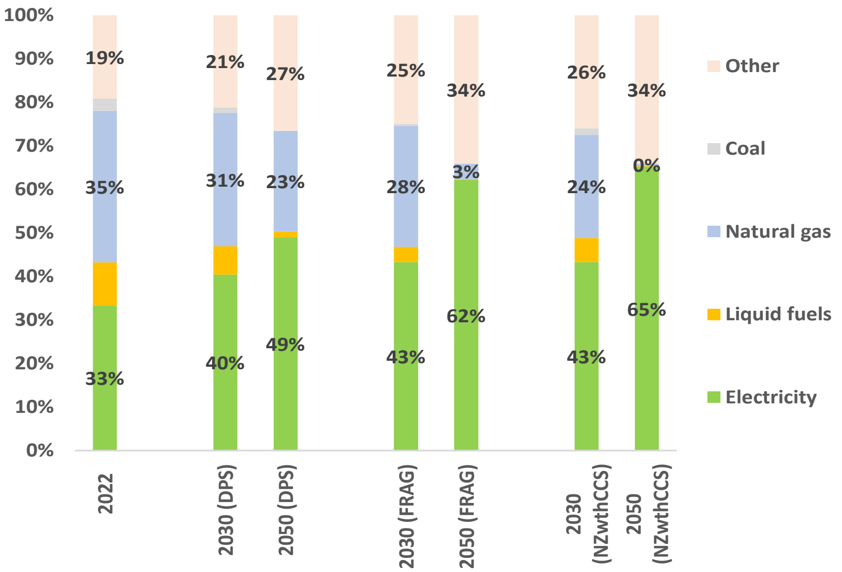
Power Shares



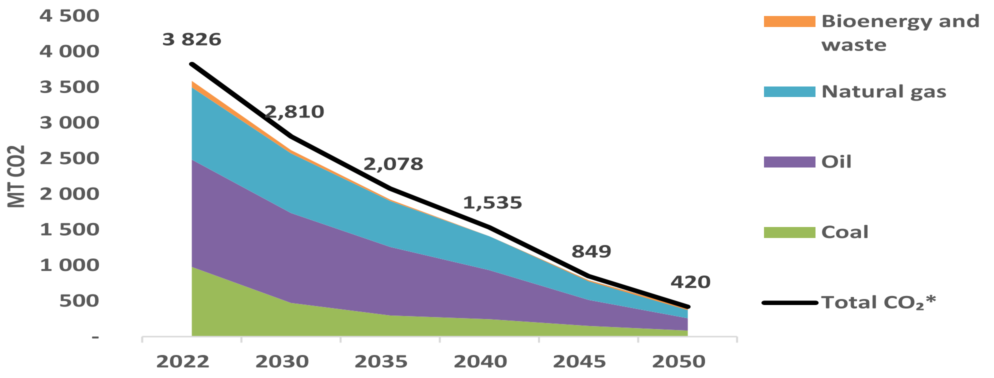
Industry Shares



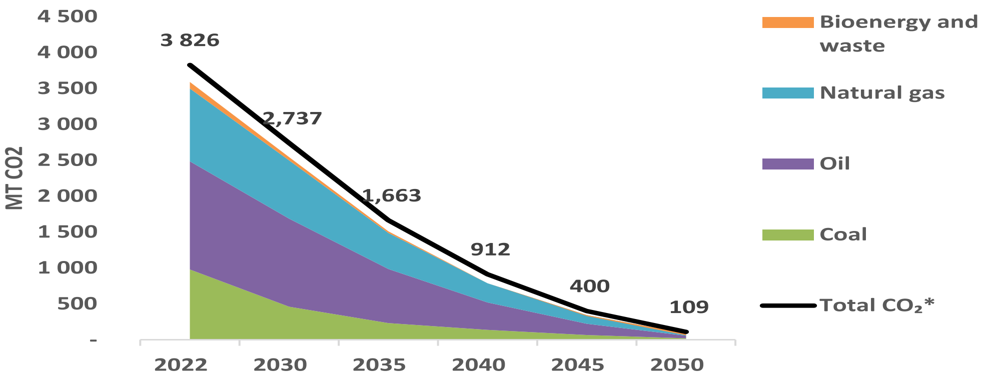
Buildings Shares



Europe CO2 Emissions FRAG

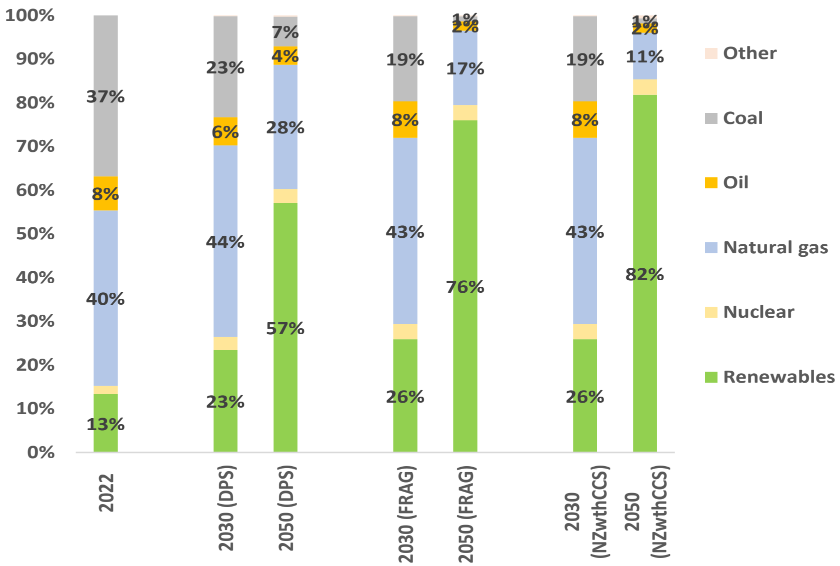


Europe CO2 Emissions NZwthCCS

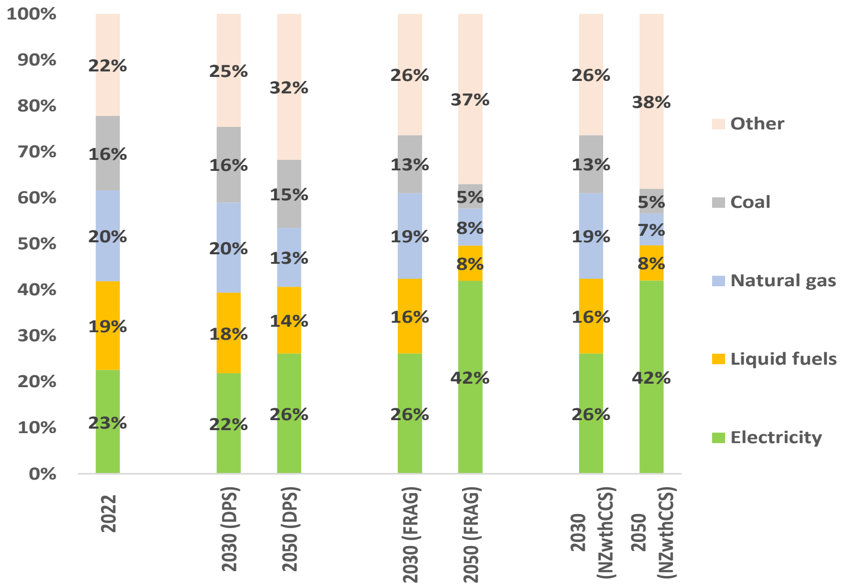


AFRICA

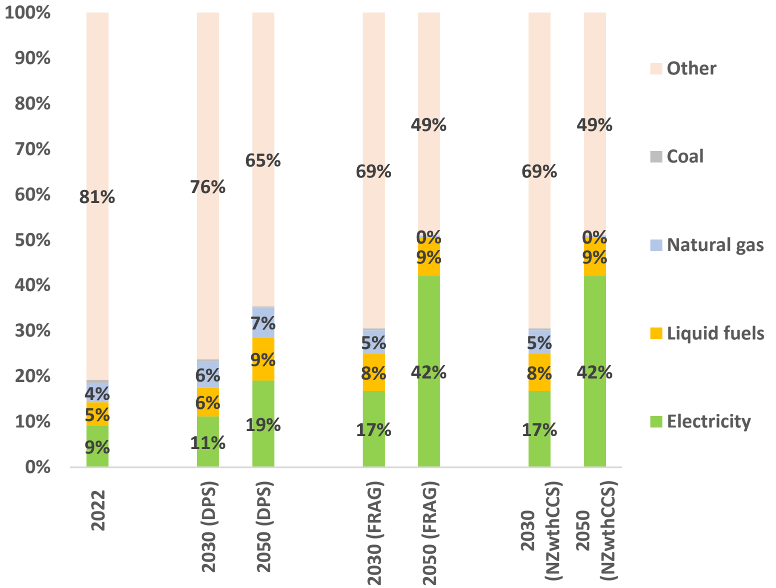
Power Shares



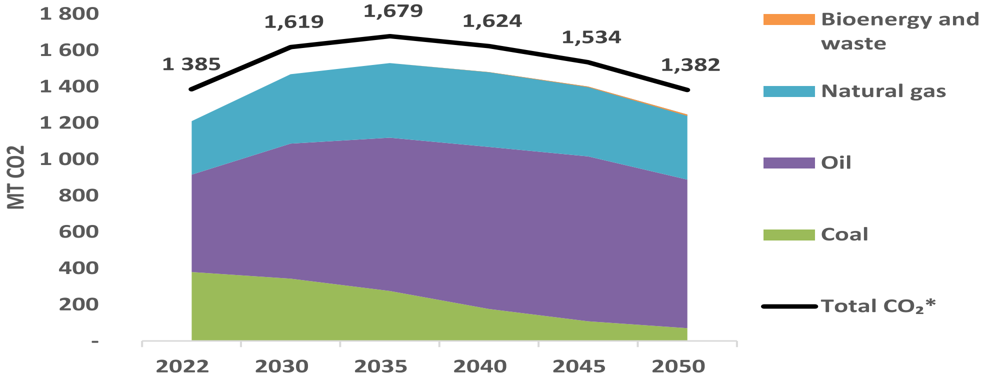
Industry Shares



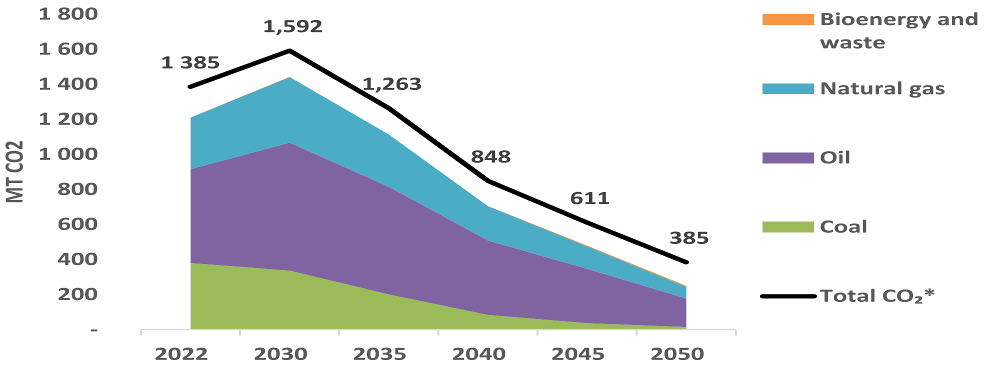
Buildings Shares



Africa CO2 Emissions FRAG

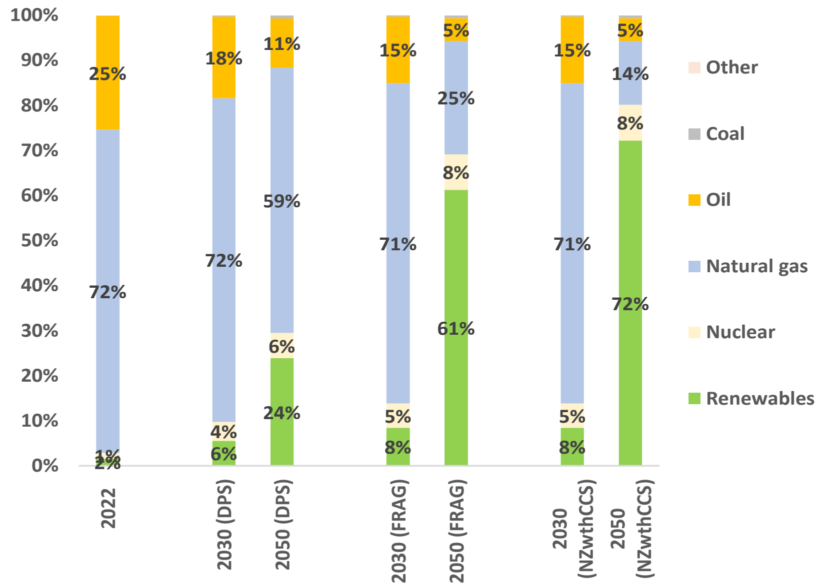


Africa CO2 Emissions NZwthCCS

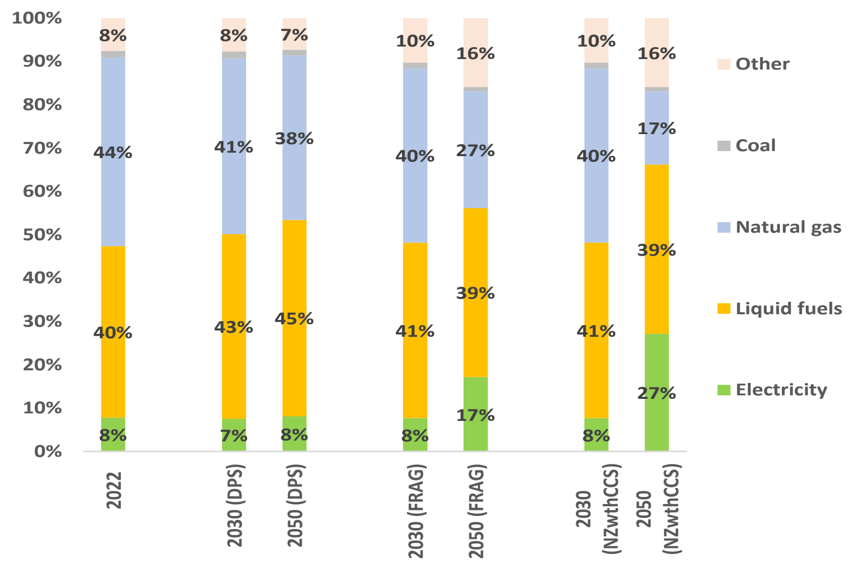


MIDDLE EAST

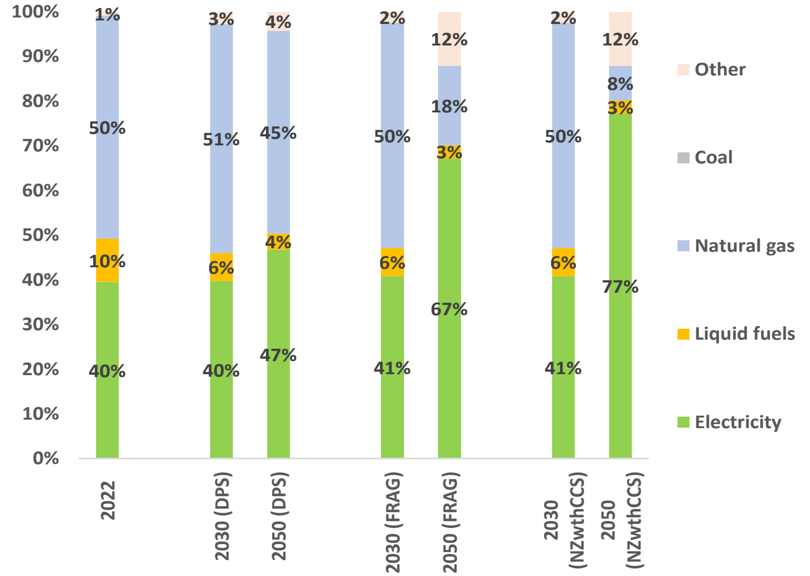
Power Shares



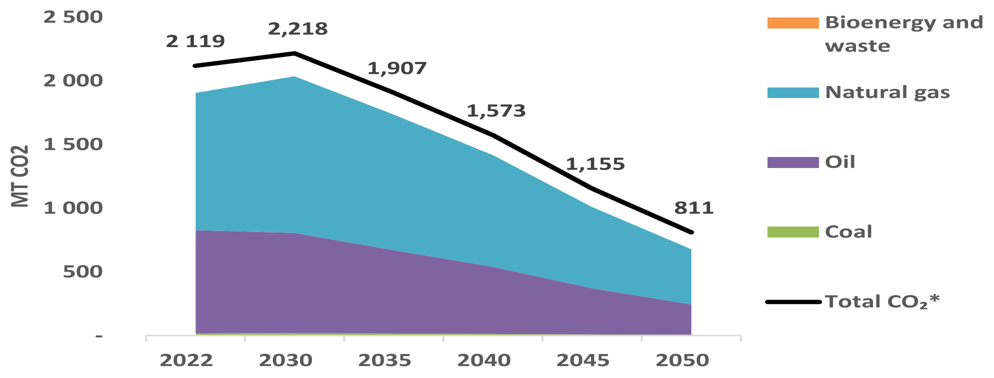
Industry Shares



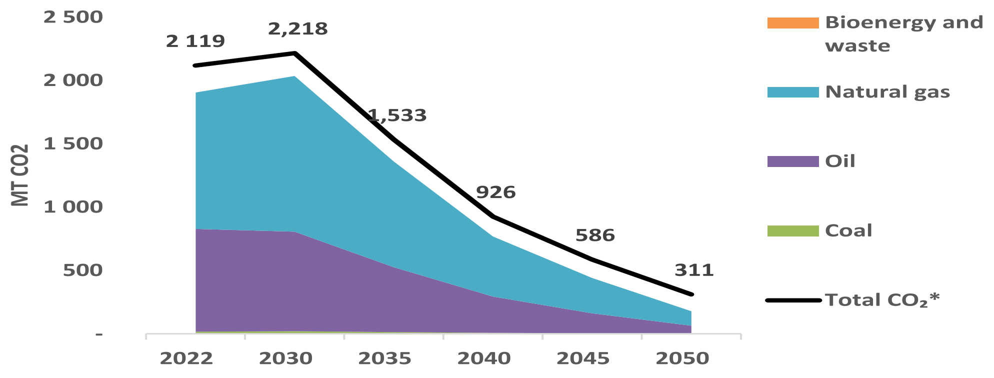
Buildings Shares



Middle East CO2 Emissions FRAG

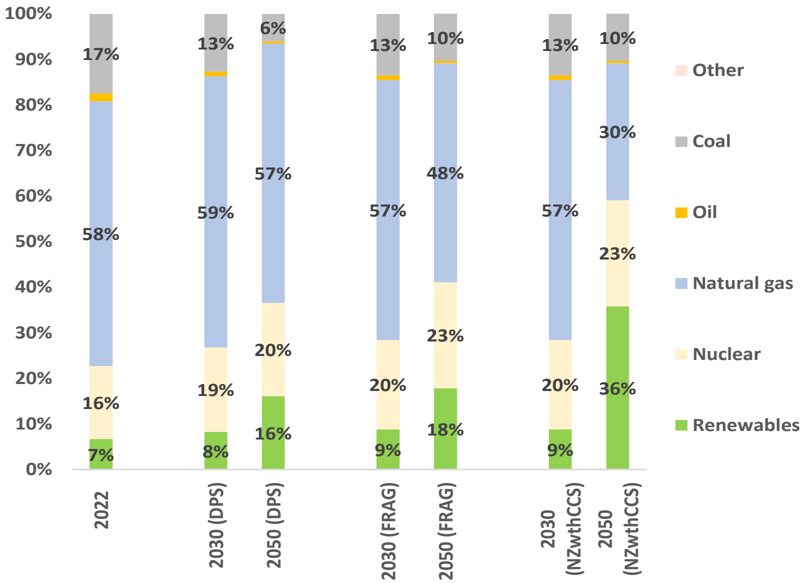


Middle East CO2 Emissions NZwthCCS

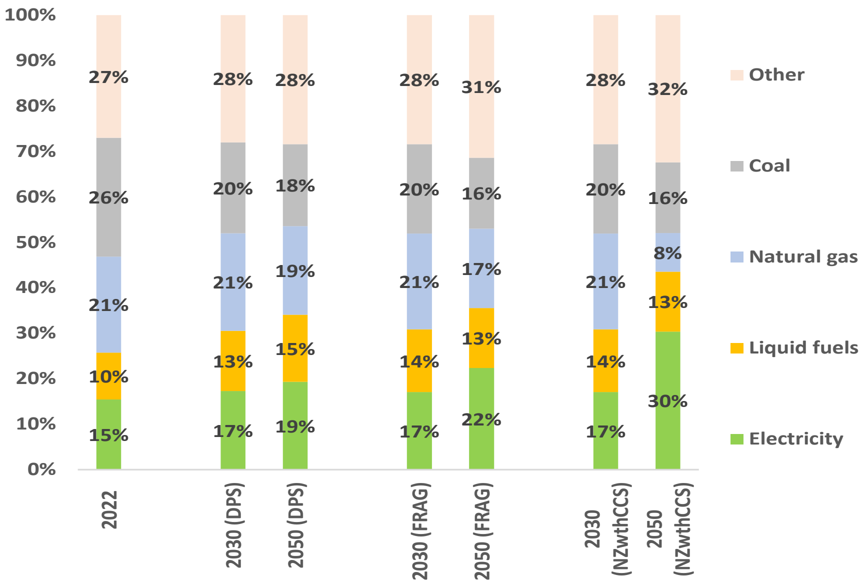


RUSSIA

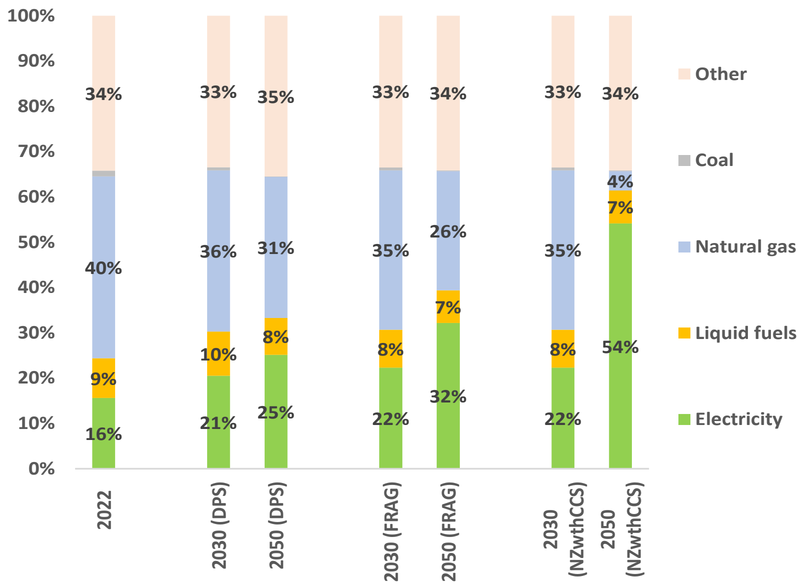
Power Shares



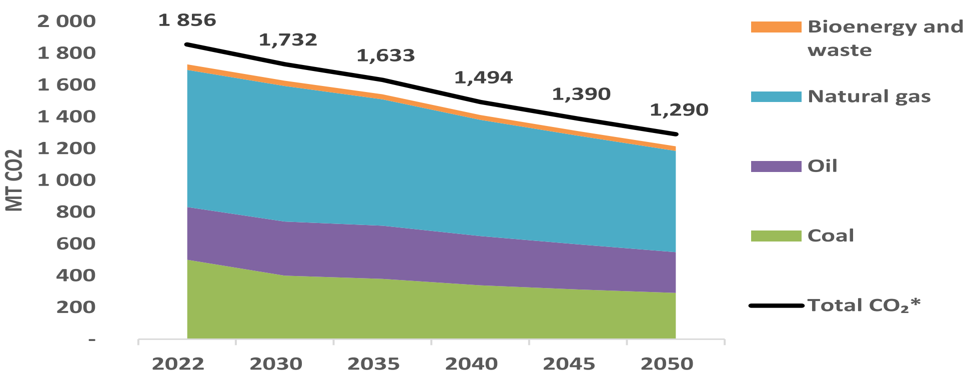
Industry Shares



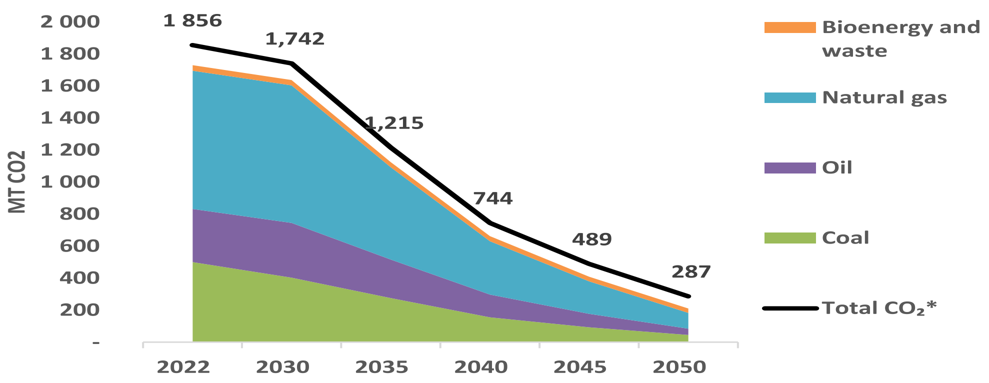
Buildings Shares



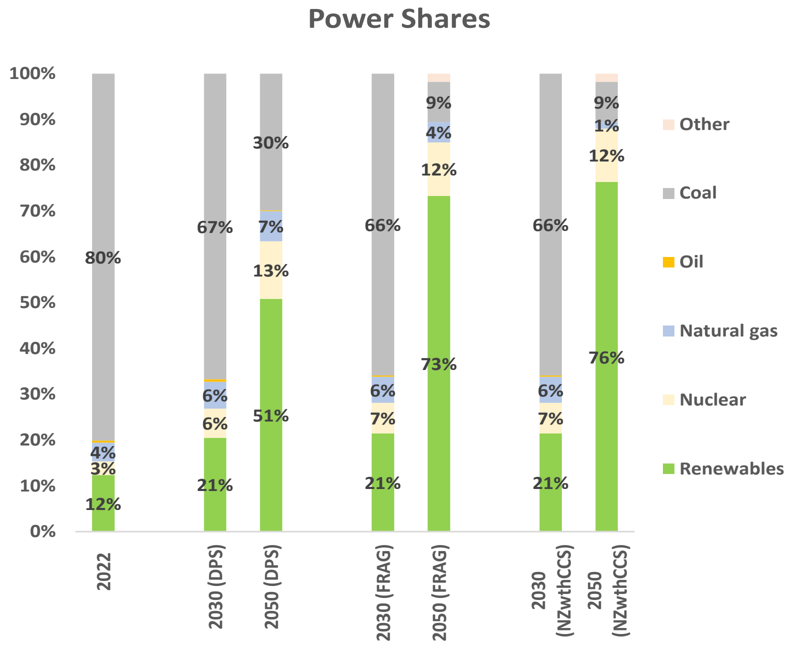
Russia CO2 Emissions FRAG

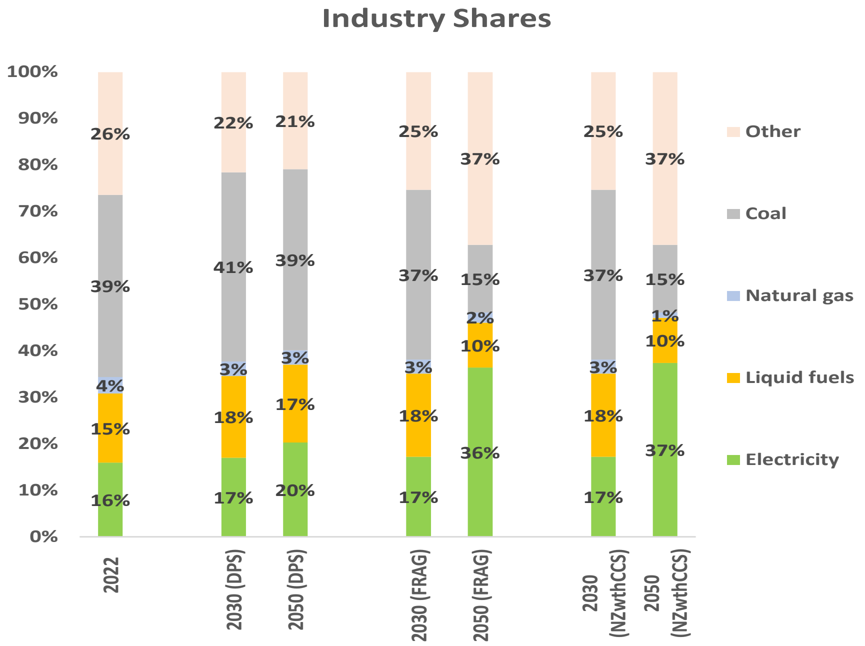


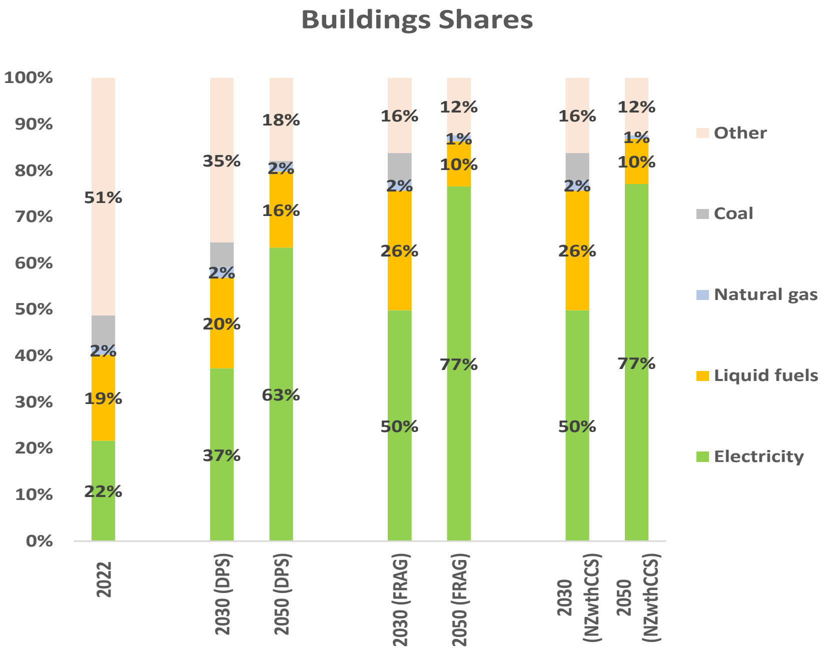
Russia CO2 Emissions NZwthCCS

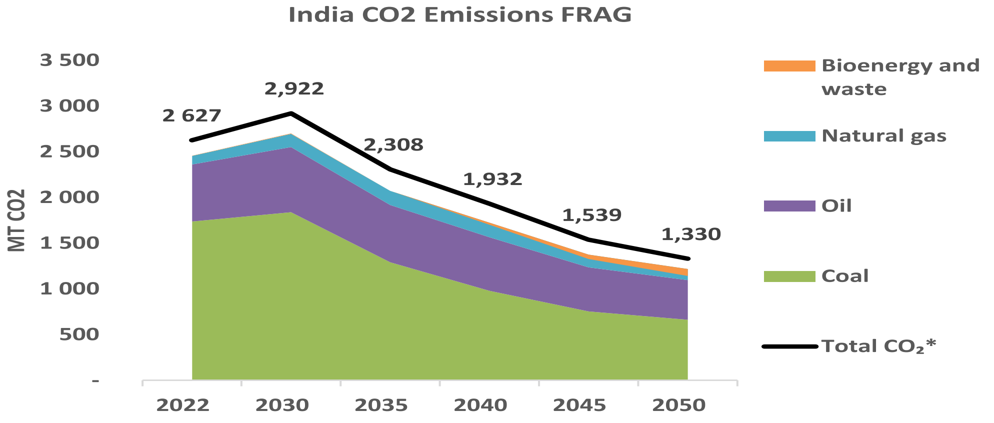


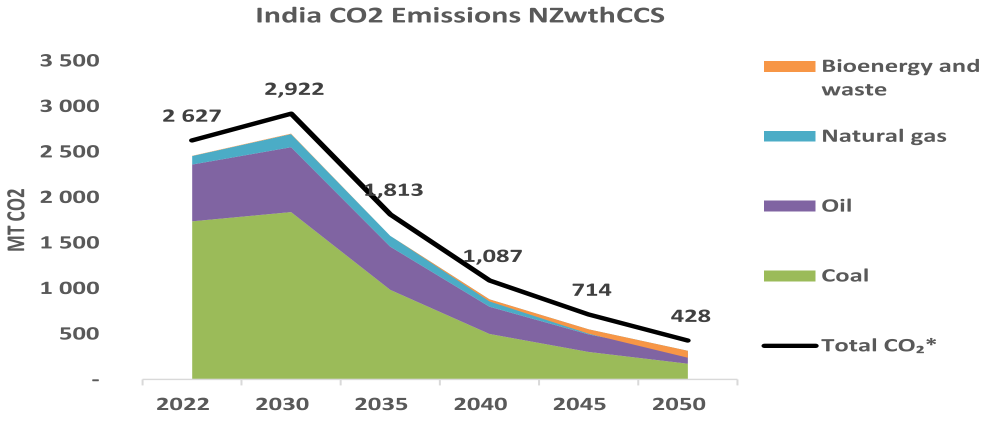
INDIA


Power Shares
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2022
2030 (DPS)
2050 (DPS)
2030 (FRAG)
2050 (FRAG)
2030 (NZwthCCS)
2050 (NZwthCCS)
80%
4%
3%
12%
67%
6%
6%
21%
30%
7%
13%
51%
66%
6%
7%
21%
9%
4%
12%
73%
66%
6%
7%
21%
9%
1%
12%
76%
Other
Coal
Oil
Natural gas
Nuclear
Renewables


Industry Shares
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2022
2030 (DPS)
2050 (DPS)
2030 (FRAG)
2050 (FRAG)
2030 (NZwthCCS)
2050 (NZwthCCS)
26%
39%
4%
15%
16%
22%
41%
3%
18%
17%
21%
39%
3%
17%
20%
25%
37%
3%
18%
17%
37%
15%
2%
10%
36%
25%
37%
3%
18%
17%
37%
15%
1%
10%
37%
Other
Coal
Natural gas
Liquid fuels
Electricity

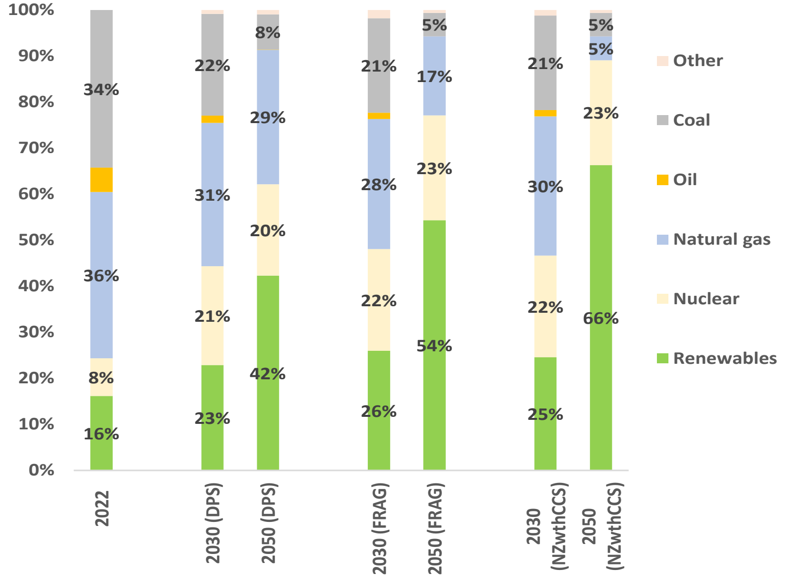

Buildings Shares
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2022
2030 (DPS)
2050 (DPS)
2030 (FRAG)
2050 (FRAG)
2030 (NZwthCCS)
2050 (NZwthCCS)
51%
2%
19%
22%
35%
2%
20%
37%
18%
2%
16%
63%
16%
2%
26%
50%
12%
1%
10%
77%
16%
2%
26%
50%
12%
1%
10%
77%
Other
Coal
Natural gas
Liquid fuels
Electricity


India CO2 Emissions FRAG
MT CO2
3 500
3 000
2 500
2 000
1 500
1 000
500
-
2022
2030
2035
2040
2045
2050
2 627
2,922
2,308
1,932
1,539
1,330
Bioenergy and waste
Natural gas
Oil
Coal
Total CO_2*

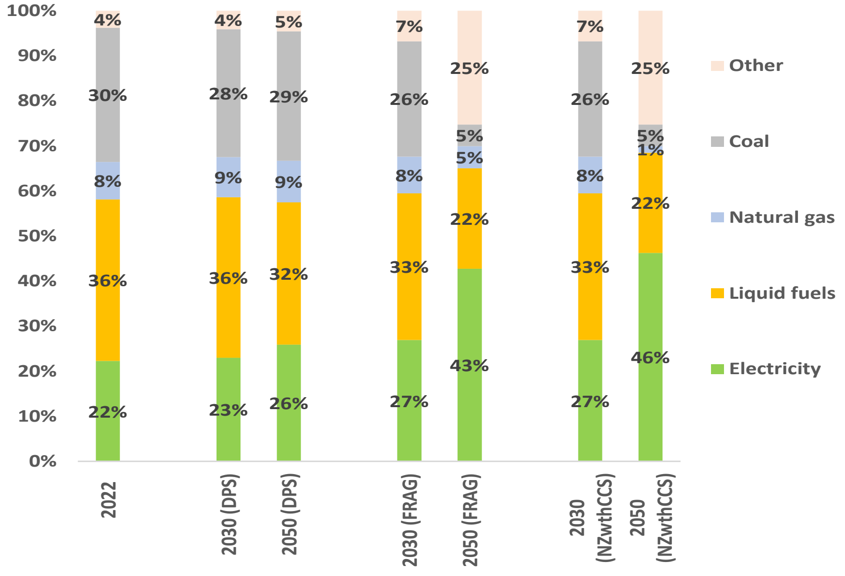

India CO2 Emissions NZwthCCS
MT CO2
3 500
3 000
2 500
2 000
1 500
1 000
500
-
2022
2030
2035
2040
2045
2050
2 627
2,922
1,813
1,087
714
428
Bioenergy and waste
Natural gas
Oil
Coal
Total CO_2*

JAPAN

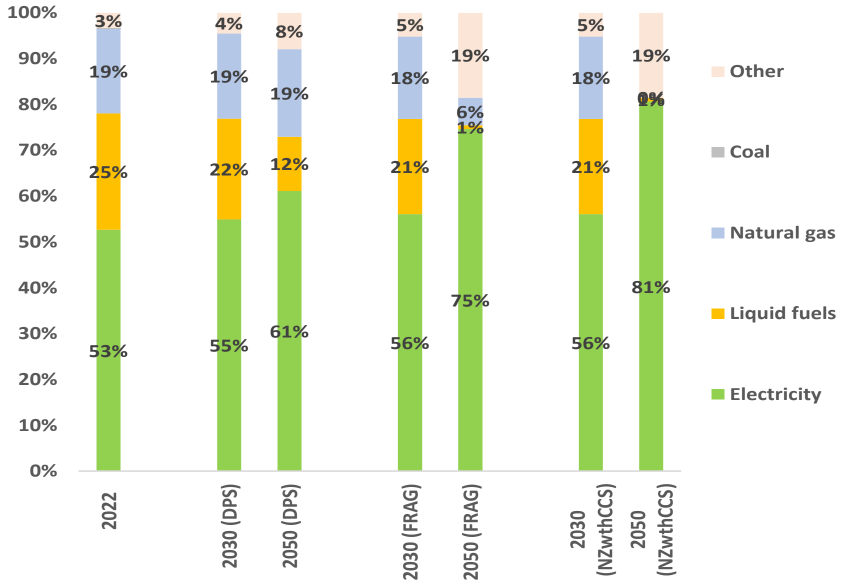
Power Shares



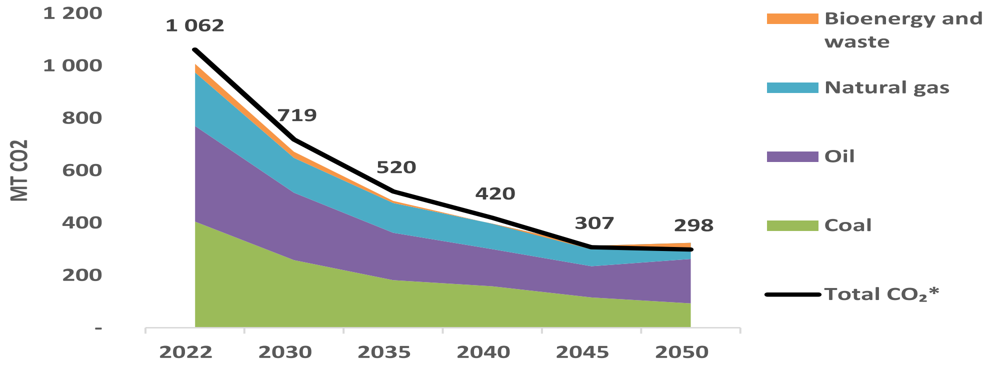
Industry Shares



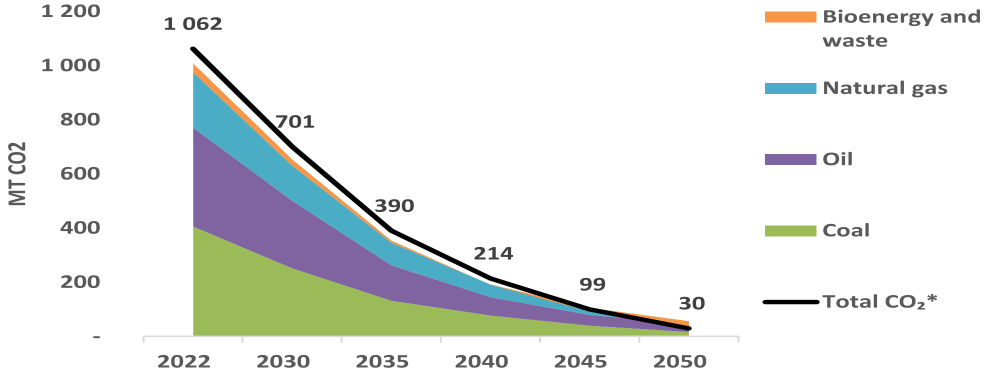
Buildings Shares



Japan CO2 Emissions FRAG

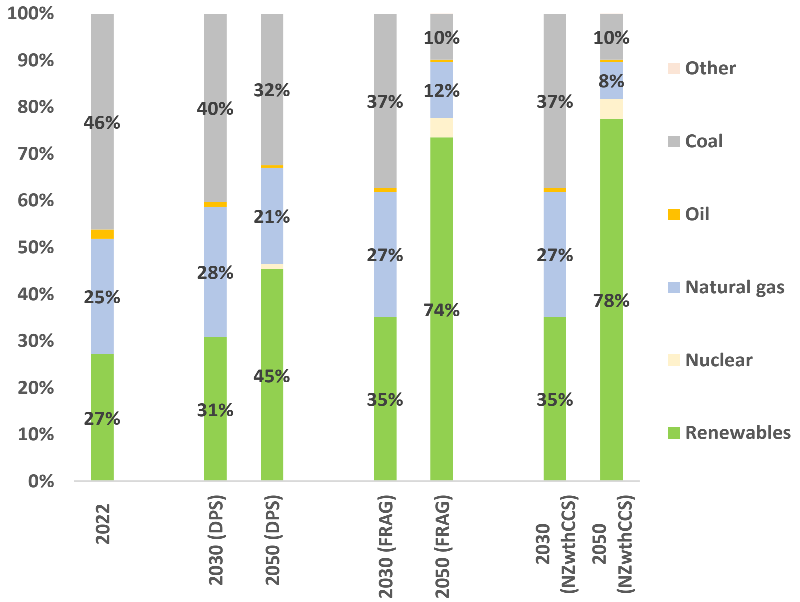


Japan CO2 Emissions NZwthCCS

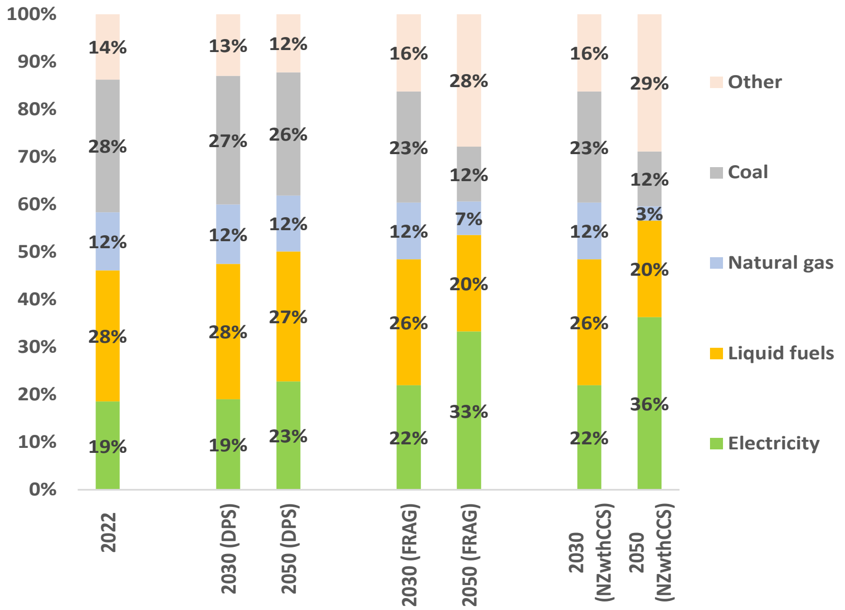


ASEAN

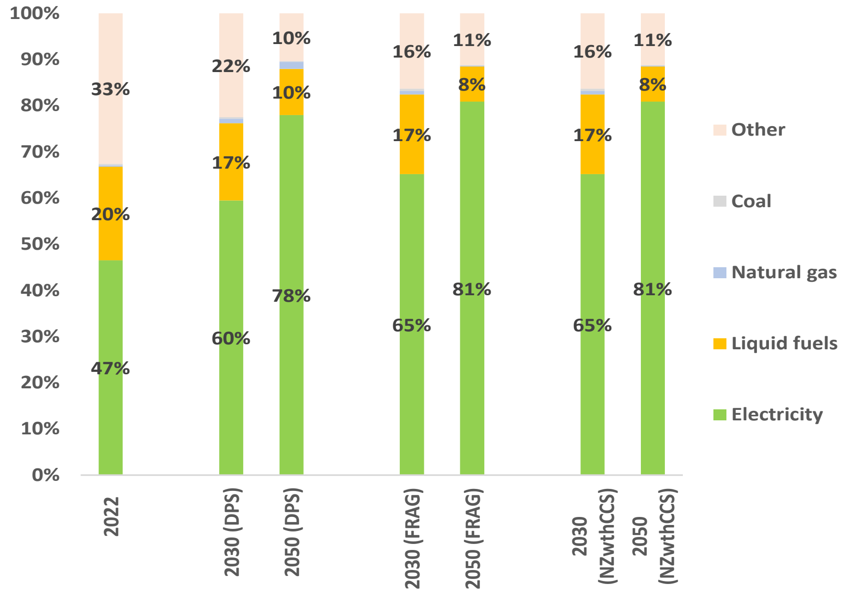
Power Shares



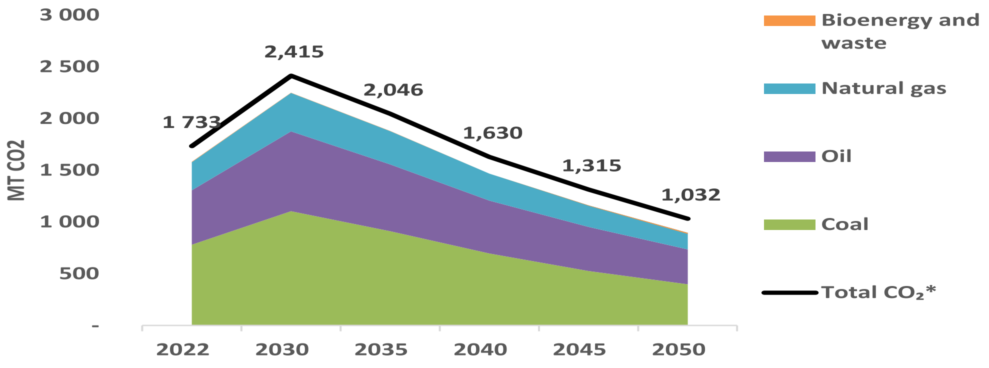
Industry Shares



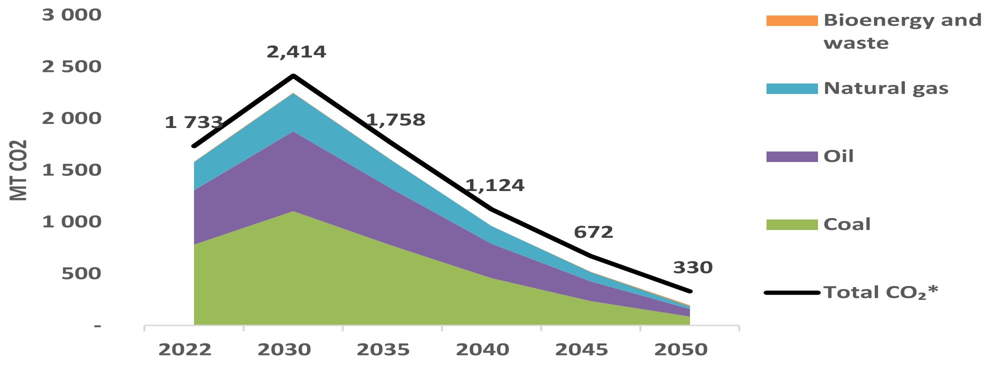
Buildings Shares



ASEAN CO2 Emissions FRAG



ASEAN CO2 Emissions NZwthCCS



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