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Energy Transition: Modelling the Impact on Natural Gas

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Acknowledgements

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My thanks are also owed to the International Energy Agency (IEA) for their extensive work and analysis on energy transition scenarios, with their willingness to publish detailed data and analysis on which other organization and institutions can build on. Also, to NexantECA for allowing the Institute to use their World Gas Model to assess in detail the impact of the energy transition scenarios on the natural gas market.

Finally, thanks to James Henderson and Jonathan Stern for their comments on the various drafts and to John Elkins and Kate Teasdale for their editorial and administrative support. All opinions, errors and omissions are, of course, my own.

Preface

In the debate about the impact of the Energy Transition on the current global energy system it is becoming increasingly clear that there are multiple pathways, technologies and outcomes that can help the world to decarbonize. There is no doubt that radical steps need to be taken and that zero-carbon sources of energy will play an increasing role over the next decades, but at OIES we also believe that it is important to consider the contributions that can be made by the incumbent fuels, albeit in an abated form. With this in mind, Mike Fulwood has used the NexantECA World Gas Model to create three scenarios for gas demand to 2050 which can help us to explore the impact on supply, demand, trade and prices in a world that must restrain emissions to meet global temperature targets. One of the scenarios shows a Business-as-Usual outcome, in which decarbonization policies are implemented too slowly and emissions are not reduced fast enough. We show this purely as a reference case and are certainly not advocating it as a preferred outcome. We all have children and grandchildren whom we want to live in an environment that has not been destroyed by human activity.

The important scenarios provide outcomes that do meet the goal of limiting the increase in global temperatures rise to 1.5^{o} by 2100, although they differ in their outcomes for gas. One is favourable, one unfavourable, driven largely by policy decisions and government regulation, and we use them to provide some form of boundary for future gas demand. Clearly, there are multiple other scenarios that we could have modelled, and we invite debate and conversation on possible alternative assumptions and outcomes. We do not want to pretend that our modelling has produced a definitive answer. We simply believe that in the discussion of multiple scenarios the most logical balance of future energy transition strategies can be found. Please do contact us with your thoughts and we would be delighted to continue the debate.

James Henderson
Director, Gas Programme, OIES

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Summary

OIES has prepared two scenarios considering the impact of the energy transition on natural gas. Both scenarios were developed to be consistent with the IEA's Sustainable Development Scenario (SDS) which is fully aligned with the Paris Agreement to hold the rise in global average temperature to "well below 2 °C … and pursuing efforts to limit [it] to 1.5 °C". One of the scenarios (FAV1.5) is more favourable to gas, with gas gaining significantly against coal and oil, together with a slower roll out of renewables. The other scenario (UNFAV1.5) has gas gaining share more slowly against coal and oil and a faster roll out of renewables. Both scenarios are compared with a business-as-usual (BAU) scenario. The scenarios are not based on economics but more on how different policies might impact gas in the energy transition, while balancing energy supply and demand and meeting the emissions targets.

Total primary energy supply (TPES) is constrained to be broadly the same in both scenarios and declines rather than increasing through 2040 before stabilizing. CO_2 emissions are also similar across both scenarios and are slightly below the emissions levels in the IEA SDS.

In BAU, gas demand continues to increase, peaking at over 5,000 bcm in 2040. In FAV1.5 gas demand continues to grow in the 2020s, peaking at just under 4,600 bcm in the early 2030s. In contrast, in UNFAV1.5 gas demand is expected to peak within the next few years at around 4,250 bcm. By 2050, the differences between the three scenarios are significant, with BAU at just under 5,000 bcm, FAV1.5 at 4,200 bcm and UNFAV1.5 at 2,550 bcm. The pattern of demand, however, does change over time, with growth mainly in the Asian economies, in all scenarios, while gas demand declines sharply in Europe and North America and, in UNFAV1.5, in the Middle East as renewables rapidly replace gas.

The regions with the largest differences in supply between the scenarios are mainly those which are the big exporters, including North America, Russia, Middle East and Sub Saharan Africa. Despite the fact that demand levels in FAV1.5 and UNFAV1.5 are below BAU and show a decline from the mid-2030s and 2020s respectively, the impact on trade (both pipe and LNG) is significantly different, at least in the early years. Trade in FAV1.5 is actually more buoyant than in BAU and even in UNFAV1.5 it is little different until post 2030.

A substantial part of the rise in interregional trade comes from a rise in LNG trade, with the key Asian LNG importers requiring large volumes in FAV1.5. Growth is especially rapid in the 2020s with global LNG imports rising from around 480 bcm in 2020 to 860 bcm in 2030. UNFAV1.5 is not much below BAU until the early 2030s but tails off significantly thereafter.

The additional demand in the 2020s in FAV1.5 compared to BAU is met by increased volumes from North America and Russia plus some from Oceania (Australia and PNG). Middle East volume growth is unchanged, since Qatar's cost

advantages ensure largely maximum production, whatever the scenario.

Interregional pipeline trade is dominated by exports from Russia to Europe and increasingly China. Exports from the Caspian region and North Africa and the Middle East into Europe, but the latter two routes are becoming less important. Russia pipe exports are only marginally different in BAU and FAV1.5 until the late 2030s, with the growth largely occurring in China exports. Pipe imports are generally the low-cost supply so are impacted less by declining demand than LNG but do decline sharply in UNFAV1.5.

By 2050 hydrogen accounts for some 10% of final energy consumption in both FAV1.5 and UNFAV1.5. In FAV1.5 blue hydrogen is just under 50% of total hydrogen production in 2050 – grey hydrogen is phased out in the 2030s – with 40% green hydrogen and the balance from coal, mostly in China, with some in India. Almost 2,000 GW of dedicated solar and wind generation capacity would be required to produce the green hydrogen. In UNFAV1.5 two-thirds of total hydrogen production is green, requiring some 3,250 GW of dedicated solar and wind generation, with 28% being blue hydrogen.

In respect of the volume of natural gas required to produce the blue hydrogen, this grows gradually over time reaching 500 bcm by 2040 in FAV1.5 and over 800 bcm by 2050 – this represents some 20% of total global gas demand. In UNFAV1.5 the volume plateaus at some 400 bcm as the world turns more to green hydrogen. In 2050 this represents some 17% of total global gas demand.

Carbon captured from natural gas reaches 4.3 Gt by 2050 in FAV1.5 and 2.5 Gt in UNFAV1.5. Cumulatively the volume of carbon captured by 2050 is 51.5 Gt in FAV1.5 and 35.7 Gt in UNFAV1.5. Regionally the largest volumes captured are in North America, Middle East, Russia and China but it is assumed that all regions have the ability to capture and store CO2. Carbon amounting to 2.5 Gt in FAV1.5 and 2 Gt in UNFAV1.5 is also captured from coal, especially in China and India. Total carbon captured in 2050, therefore, is some 6.8 Gt in FAV1.5 and 4.5 Gt in UNFAV1.5, which compares with 5.2 Gt captured from fossil fuels in the IEA's Net Zero scenario.

We have compared our scenarios with a wide range of energy transition scenarios, which have been published recently. In the more business as usual scenarios, global demand by 2050 is at 5,000 bcm or at least at 4,500 bcm. Our FAV1.5 scenario is just over 4,000 bcm in 2050, similar to BP RAPID1. A number of more radical scenarios have demand around 3,000 bcm by 2050, while our UNFAV1.5 is below 3,000 bcm, just above BP Net Zero, with the 2021 IEA NZE scenario below 2,000 bcm.

The IEA Net Zero scenario (NZE) sets out a pathway to achieving net zero emissions in 2050. Some of the reporting, which did not always accurately represent what the IEA were saying, focused on the statement that there is no need for investment in new fossil fuel supply in the net zero pathway.

[1] https://www.bp.com/en/global/corporate/energy-economics/energy-outlook/introduction/overview.html

This was the logical outcome following on from the pathway which suggested that peak oil and peak coal demand have already been reached and peak natural gas demand is expected in the mid-2020s at some 4,300 bcm.

Apart from the large projected rise in solar and wind, the IEA NZE also assumes a doubling of hydro and nuclear by 2050 and a six-fold increase in other renewables (essentially geothermal and marine i.e. tidal power). Modern bioenergy also increases rapidly, but this is a common feature of many energy transition scenarios and the IEA is much more bearish on this than almost all the IPCC scenarios of pathways to get to net zero by 2050.

Compared to FAV1.5, IEA NZE has more renewables but this may well reflect the rapid growth in geothermal and marine, plus more nuclear, hydro and biofuels (modern bioenergy), while the projections of solar and wind look to be similar. The 58 EJ higher natural gas in FAV1.5, than in IEA NZE in 2050, is exactly matched by the higher renewables, nuclear, hydro and biofuels for IEA NZE, with the renewables difference likely to be in geothermal and marine. UNFAV1.5 is much closer to IEA NZE, with the difference being largely accounted for by more biofuels (modern bioenergy), in IEA NZE.

Just as the IEA NZE scenario depicted a pathway to limiting temperature increases in line with COP21, we have painted two different possible pathways for an energy transition which could achieve the Paris COP21 emissions targets, while involving gas to a much greater degree, especially in FAV1.5. We do not suggest that this is “the” answer, but it does offer an alternative view of the future which may be considered more achievable given current infrastructure in place and the important role that gas can clearly play in many regions as an agent of decarbonisation.

Introduction

The OIES presented the results of its modelling of energy transition scenarios at its Sponsors meeting at the end of March 2021. The initial modelling aimed to broadly replicate the IEA's Sustainable Development Scenario (SDS) as outlined in the 2019 and 2020 World Energy Outlooks[2]. The SDS is designed to meet the energy-related United Nations Sustainable Development Goals to achieve: universal access to affordable, reliable and modern energy services by 2030; a substantial reduction in air pollution, and effective action to combat climate change. The SDS is fully aligned with the Paris Agreement to hold the rise in global average temperature to "well below 2 °C … and pursuing efforts to limit [it] to 1.5 °C".

Using the SDS as a starting point, two additional scenarios were developed – one which was "favourable" for natural gas and one which was "unfavourable" for natural gas. The assumptions behind these scenarios were developed by OIES research fellows and designed to reflect different political and policy outcomes that might occur in different countries and regions, with the favourable scenario seen to be more policy friendly to abated gas and the unfavourable scenario less policy friendly to abated and unabated gas. The scenarios presented in this report are as follows:

FAV1.5 – natural gas gains significantly relative to coal and oil and there is a slower pace of roll out of renewables, compared to the IEA SDS.

Unless otherwise stated sources for all the figures and tables are IEA, OIES and NexantECA World Gas Model

UNFAV1.5 – natural gas gains more slowly relative to coal and oil and the renewables roll out is much faster than in the IEA SDS**.**

The results of these scenarios are compared to a "business-as-usual" scenario (BAU), which is broadly similar to the IEA's Stated Policies Scenario (STEPS) in terms of the level of overall global gas demand. The May 2021 IEA Net Zero Emissions pathway[3] is also discussed in a separate section and comparisons made.

[2] IEA World Energy Outlooks 2019 and 2020, Paris, International Energy Agency

[3] Net Zero by 2050, Paris, international Energy Agency

Key Assumptions

Total primary energy supply (TPES) is constrained to be broadly the same across the FAV1.5 and UNFAV1.5 scenarios. The TPES is shown in Figure 1 for the FAV1.5 scenario – the TPES for the UNFAV1.5 scenario is within 1% of the FAV1.5 TPES numbers.

The TPES by 2050 is some 20% lower than in the BAU scenario, based on energy efficiency improvements, as well as falling energy intensity and greater electrification. The natural gas share will differ between FAV 1.5 and UNFAV 1.5.

The level of CO_2 emissions from fossil fuels is also similar across the FAV1.5 and UNFAV1.5 scenarios. A key assumption is that both coal and natural gas are significantly abated over time, with 80% abatement of both in 2050, in addition to the capture of CO_2 from natural gas, when it is used for the production of blue hydrogen.

The CO_2 emissions in FAV1.5 are higher than in UNFAV1.5, largely reflecting the higher level of renewables in the latter. The CO_2 emissions do not include bioenergy offsets or direct air capture.

The FAV1.5 CO_2 emissions in 2050 at just under 8Gt are below the 10Gt in the IEA's SDS.

Figure 1: Total Primary Energy Supply

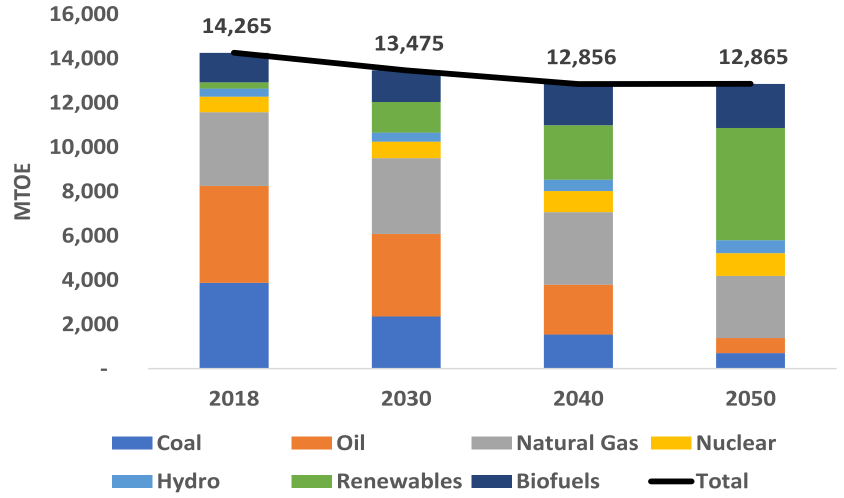
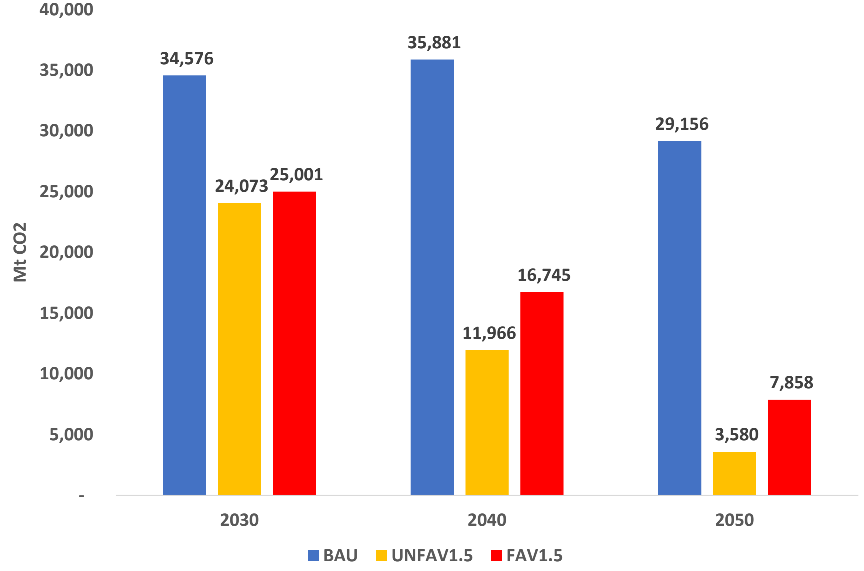


Figure 2: Energy-Related CO_2 Emissions



Natural Gas Share

The natural gas share in TPES, at the World level, is relatively stable in BAU, but declines gradually over time in both FAV1.5 and UNFAV1.5. There is minimal change in the share by 2030, although there is a 2% fall in UNFAV1.5. In the 2030s the decline accelerates in UNFAV1.5 and begins in FAV1.5. In the 2040s, the share declines accelerate further in both scenarios.

Gas gains relative share against coal in both scenarios but more in FAV1.5, and loses against renewables (including bioenergy).

Figure 3: Natural Gas World Share of TPES

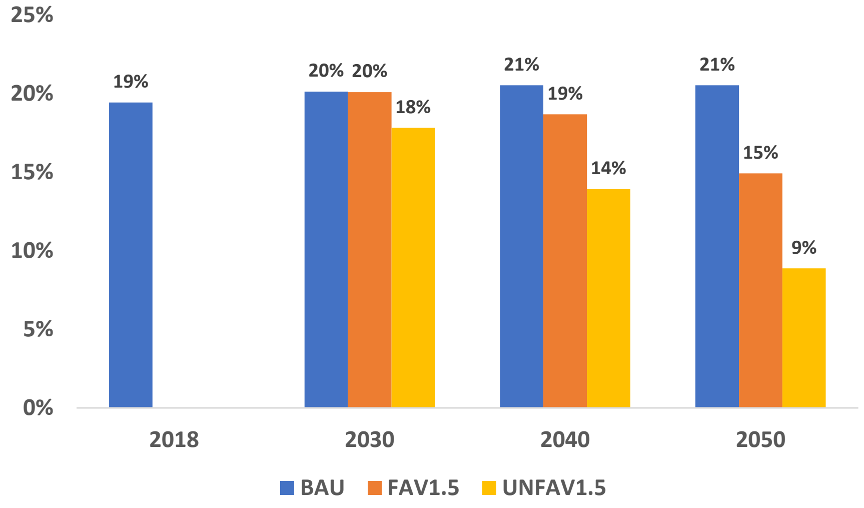


Figure 4: Change in Natural Gas Share Relative to Coal

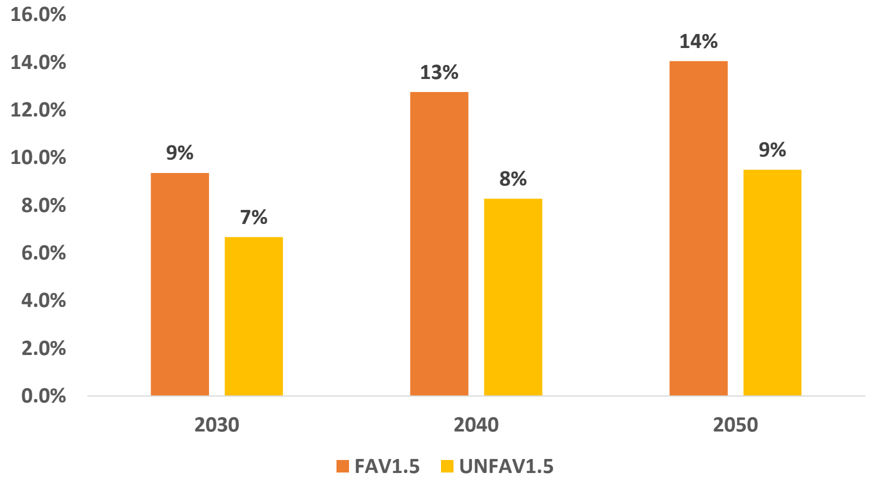
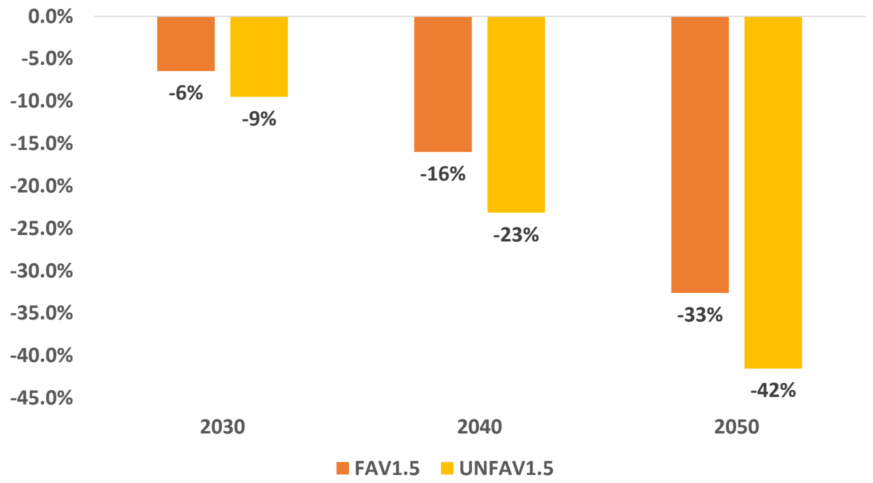


Figure 5: Change in Natural Gas Share Relative to Renewables



Gas Demand

Global natural gas demand reached around 4,000 bcm in 2019 before declining in 2020, as a result of the impact of COVID-19, albeit recording much less of a fall than had initially been expected.

In BAU gas demand continues to increase, peaking at over 5,000 bcm in 2040. In FAV1.5 gas demand continues to grow in the 2020s, peaking at just under 4,600 bcm in the early 2030s. In contrast, in UNFAV1.5 gas demand is expected to peak within the next few years at around 4,250 bcm.

By 2050, the differences between the three scenarios are significant, with BAU at just under 5,000 bcm, FAV1.5 at 4,200 bcm and UNFAV1.5 at 2,550 bcm.

There are distinct differences between regions, however, with the largely more developed gas economies in North America, Europe and North East Asia, registering large declines in demand, even in FAV1.5. In contrast, in the less developed gas markets, especially in Asia, gas demand is higher in 2050 than in 2020 even in UNFAV1.5 in some cases.

It is notable that in the gas rich Middle East demand actually declines in FAV1.5 from 2030 onwards and in UNFAV1.5 from the late 2020s with the switch to more renewables.

Figure 6: Global Gas Demand

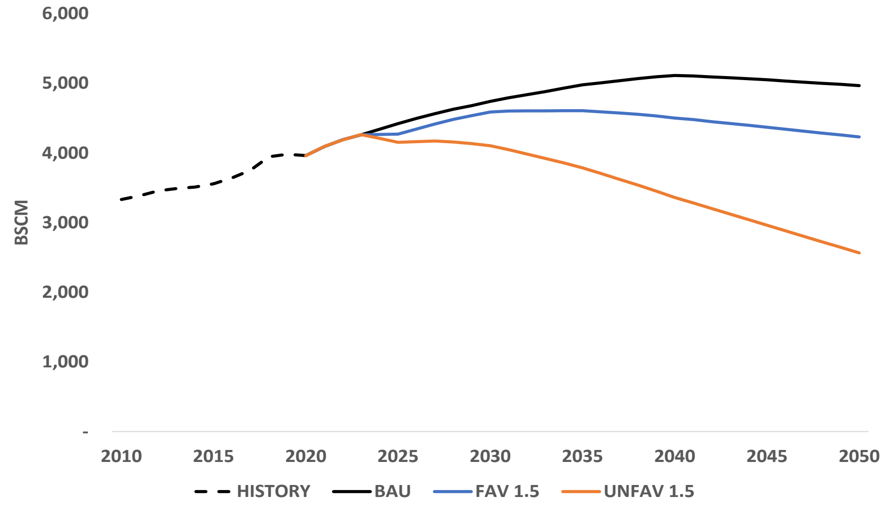


Table 1: Change in Gas Demand 2020 to 2050

BCM	Change in Demand		
	BAU	FAV 1.5	UNFAV 1.5
North America	4	-321	-679
Europe	-69	-194	-339
Central & South America	92	37	-44
Russia	-22	63	-93
Caspian	17	44	-7
China	380	372	85
South Asia	62	175	33
Japan, Korea, Taiwan	21	-17	-51
ASEAN	108	34	-26
Oceania	1	-21	-31
Middle East	258	-52	-258
North Africa	65	43	-16
Sub Saharan Africa	80	82	29
Other Eurasia	6	24	3
Total	**1005**	**269**	**-1395**

Gas Supply

The differences between regions on the supply side are much less than the differences in demand. In those regions where production is a relatively small proportion of demand there may be little difference in the change in supply between 2020 and 2050. This includes South Asia and, until the 2040s, China.

The regions with the largest differences in supply between the scenarios are mainly in those regions which are the big exporters, including North America, Russia, Middle East and Sub Saharan Africa.

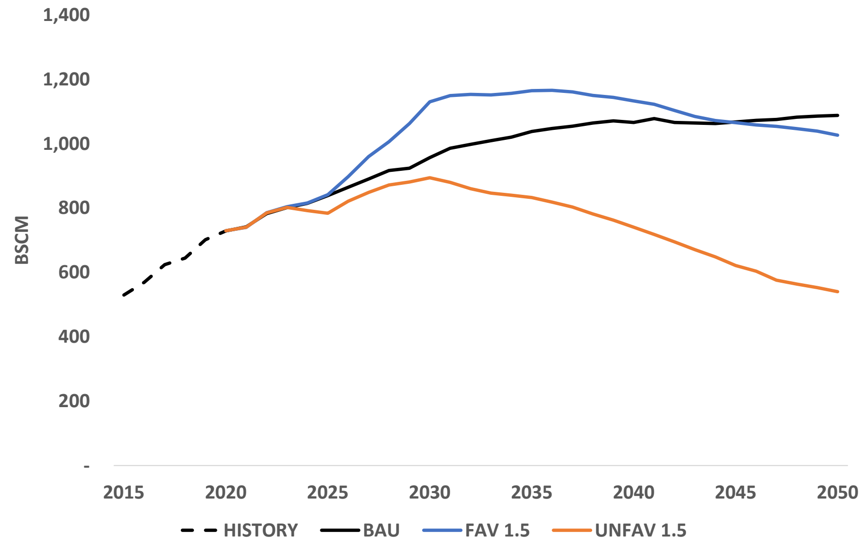
Table 2: Change in Gas Supply 2020 to 2050

BCM	Change in Supply		
	BAU	FAV 1.5	UNFAV 1.5
North America	98	-193	-712
Europe	-81	-100	-165
Central & South America	80	40	-53
Russia	172	180	-154
Caspian	41	63	-3
China	171	171	95
South Asia	32	32	32
Japan, Korea, Taiwan	-1	-1	-1
ASEAN	-27	-62	-121
Oceania	-1	-19	-86
Middle East	324	55	-168
North Africa	25	9	-46
Sub Saharan Africa	167	100	-8
Other Eurasia	-10	-10	-10
Total	**990**	**264**	**-1400**

Gas Trade

Despite demand levels in FAV1.5 and UNFAV1.5 being below BAU and declines from the mid-2030s and 2020s respectively, the impact on trade (both pipe and LNG) is significantly different, at least in the early years. Gas demand in FAV1.5 remains strong in some regions in the 2020s, notably in the Asian markets. This reflects the need to reduce CO_2 emissions rapidly and consequently the switch away from coal to gas, especially in power. Trade in FAV1.5 is actually more buoyant than in BAU and even in UNFAV1.5, it is little different until the post 2030 period.

Figure 7: Interregional Trade



LNG

Demand

A substantial part of the rise in interregional trade comes from a rise in LNG trade, with the key Asian LNG importers requiring large volumes in FAV1.5. Growth is especially rapid in the 2020s, with global LNG imports rising from around 480 bcm in 2020 to 860 bcm in 2030, where it levels off, although remaining above BAU until the mid-2040s. UNFAV1.5 is not much below BAU until the early 2030s but tails off significantly thereafter.

In FAV1.5, the period to 2030 is the most dramatic with LNG imports growing by 370 bcm, compared to 230 bcm in BAU and just under 200 bcm in UNFAV1.5. As shown in Table 3 – *note this is to 2030 only unlike previous tables* – the big difference is in Asia with China, South Asia (India, Pakistan and Bangladesh) and even JKT all growing very rapidly, driven by the accelerated switching from coal to gas, mostly in power but in industry and buildings as well in China. Only in the ASEAN countries in that broader region do LNG imports grow at a slower rate than in FAV1.5 and UNFAV1.5 than BAU, although the growth remains strong. In the mid to late 2020s, Europe is still absorbing the LNG supply surge in BAU but some of this is diverted to Asia in FAV1.5 and, in UNFAV1.5, declining demand reduces the need for LNG.

Figure 8: LNG Imports

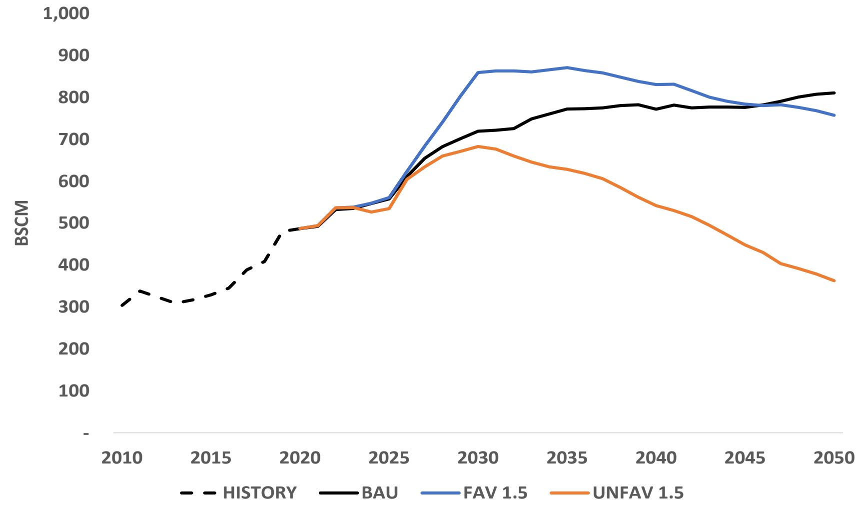


Table 3: Change in LNG Imports 2020 to 2030

BCM	Change in LNG Imports		
	BAU	FAV 1.5	UNFAV 1.5
North America	1	1	5
Europe	26	10	-13
Central & South America	5	3	2
China	43	94	31
South Asia	35	105	67
Japan, Korea, Taiwan	14	50	38
ASEAN	80	73	56
Middle East	14	8	2
North Africa	5	5	1
Sub Saharan Africa	7	7	4
Total	**232**	**358**	**196**

Supply

The additional LNG demand in the 2020s in FAV1.5 compared to BAU is met by increased volumes from North America, Russia plus some from Oceania (Australia and PNG). Middle East volume growth is unchanged, since Qatar's cost advantages ensure largely maximum production, whatever the scenario.

In UNFAV1.5 by 2030, overall demand is only slightly below BAU and the reduced supply largely impacts Sub Saharan Africa and Central and South America, where there are lower levels of contracted volumes.

The longer-term picture to 2050 looks very different. FAV1.5 is not too far below BAU but Sub Saharan Africa is worst affected, while North America and Middle East fare much better. In UNFAV1.5, the dramatic decline in demand would seem likely to lead to significant early contract termination from the buyers' side and a free-for-all in the plummeting market. The only winner – or more correctly non-loser – would be likely to be Qatar because of its low-cost position.

Table 4: Change in LNG Exports 2020 to 2030

BCM	Change in LNG Exports		
	BAU	FAV 1.5	UNFAV 1.5
North America	77	148	74
Central & South America	2	2	-10
Russia	25	45	24
ASEAN	11	11	11
Oceania	-8	23	-12
Middle East	72	72	72
North Africa	-2	-1	-2
Sub Saharan Africa	56	58	37
Total	**232**	**358**	**195**

Table 5: Change in LNG Exports 2020 to 2050

BCM	Change in LNG Exports		
	BAU	FAV 1.5	UNFAV 1.5
North America	96	131	-36
Central & South America	0	0	-14
Russia	63	52	-14
ASEAN	18	4	-35
Oceania	-1	2	-54
Middle East	67	66	66
North Africa	-9	-9	-9
Sub Saharan Africa	91	20	-37
Total	**324**	**266**	**-134**

Pipeline Trade

Interregional pipeline trade is dominated by exports from Russia to Europe and increasingly China, plus exports from the Caspian region – largely Turkmenistan, Kazakhstan and Uzbekistan to China and much smaller volumes from Azerbaijan into Europe – and North Africa and the Middle East into Europe, but the Caspian, North Africa and Middle East volumes are becoming less important[4]. Russia pipe exports are only marginally different in BAU and FAV1.5 until the late 2030s, with the growth largely occurring in exports to China. Pipe imports are generally lower cost supply so are impacted less by declining demand than LNG but do decline sharply in UNFAV1.5.

Figure 9: Russia Pipe Exports

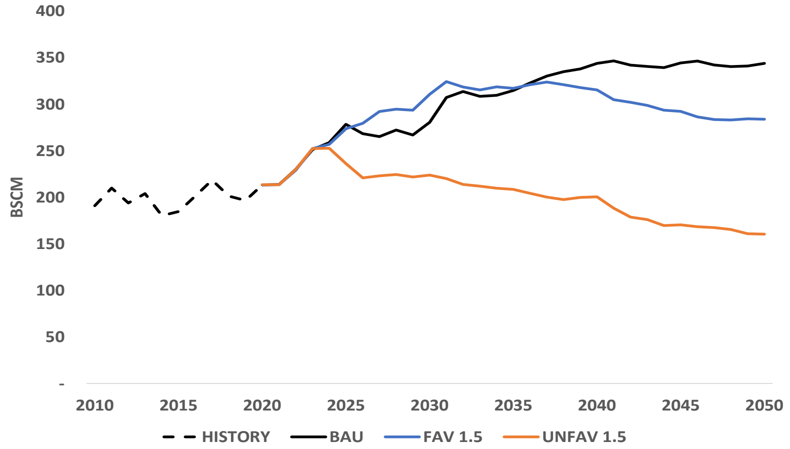


Figure 10: Europe Pipe Imports

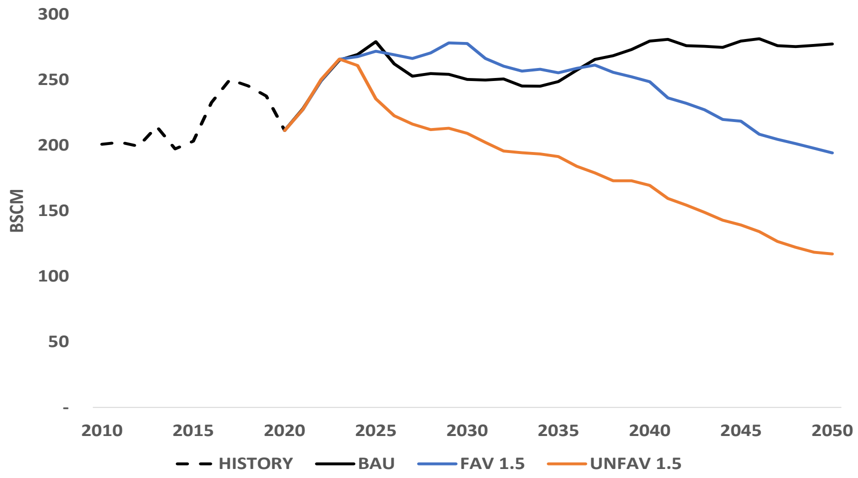
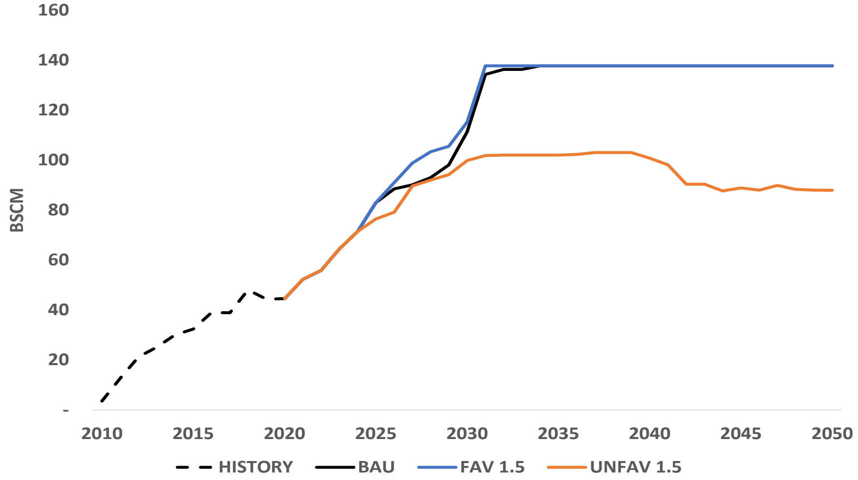


Figure 11: China Pipe Imports

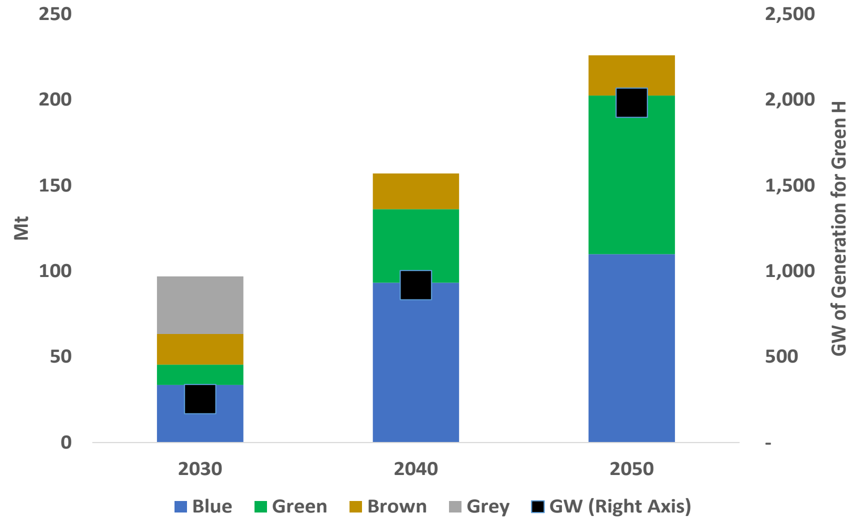


[4] It should be noted that some of the more speculative pipeline projects such as TAPI, Iran-Pakistan-India and East Med are not built.

Hydrogen

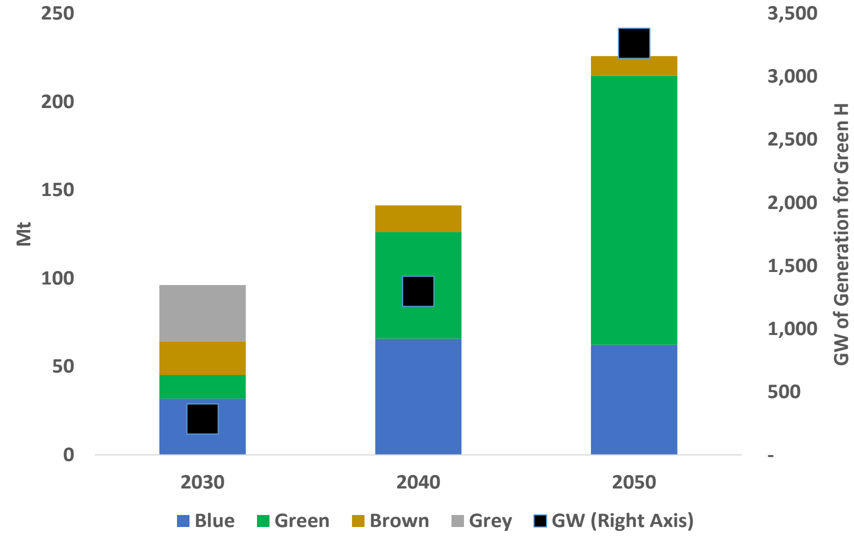
Currently around 70% of hydrogen is thought to be produced using natural gas, with most of the rest coming from coal, and a very small amount from oil and electrolysis[5]. Total production in 2018 was 115 Mt and 60% (67 Mt) came from dedicated production, with the balance being "by-product" hydrogen, meaning that it comes from facilities and processes designed primarily to produce something else. Apart from the tiny amount of electrolysis and minimal use of CCS, all the production emits CO_2. The figures on hydrogen production in Figure 12 are for dedicated production.

Figure 12: Hydrogen Production FAV1.5



In FAV1.5 blue hydrogen is just under 50% of total hydrogen production in 2050 – grey hydrogen is phased out in the 2030s – with 40% green hydrogen and the balance from coal, mostly in China, with some in India. Almost 2,000 GW of dedicated solar and wind generation capacity would be required to produce the green hydrogen[6]. In UNFAV1.5 two-thirds of total hydrogen production is green, requiring some 3,250 GW of dedicated solar and wind generation, with 28% being blue hydrogen. Total hydrogen production is similar in both scenarios and accounts for some 10% of final energy consumption in 2050.

Figure 13: Hydrogen Production UNFAV1.5



[5] The Future of Hydrogen, Paris, international Energy Agency

[6] In 2019 total global renewables generating capacity was around 1,200 GW (BP)

The volume of natural gas required to produce the blue hydrogen grows gradually over time reaching 500 bcm by 2040 in FAV1.5 and over 800 bcm by 2050 – this represents some 20% of total global gas demand. In UNFAV1.5 the volume plateaus at some 400 bcm as the world turns more to green hydrogen. In 2050 this represents some 17% of total global gas demand. In energy terms gas is assumed to be 70% efficient in producing blue hydrogen.

The main regions where blue hydrogen is expected to be produced are North America, the Middle East, followed by Russia and China, and other Asia regions. Blue hydrogen growth slows in the 2040s in UNFAV1.5, as there is a switch away from blue to green hydrogen.

All regions have scope for blue hydrogen production, but not necessarily all countries, as the ability to store the CO_2 extracted depends on the geology, plus government policy and attitudes to storing carbon. In Europe for example, by far the largest production of blue hydrogen is in the UK, then other Northwest Europe countries where the captured CO_2 can easily be transported and stored in the North Sea.

Figure 14: Gas Demand for Blue Hydrogen

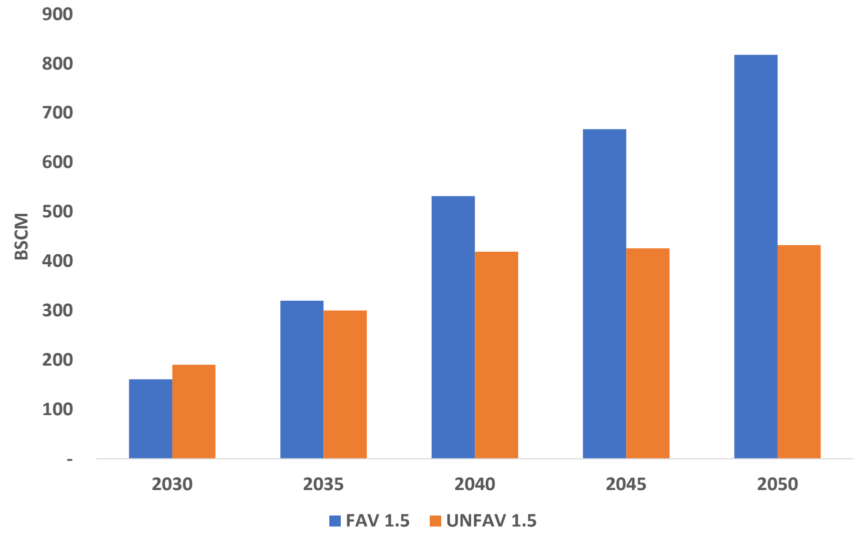


Table 6: Gas Demand for Blue Hydrogen by Region

BCM	FAV1.5			UNFAV1.5		
	2030	2040	2050	2030	2040	2050
North America	24	153	262	33	91	129
Europe	25	42	41	29	39	16
Central & South America	4	15	27	5	12	17
Russia	7	66	89	9	39	53
Caspian	2	19	29	2	11	17
China	32	57	80	31	50	38
South Asia	17	37	46	20	36	23
Japan, Korea, Taiwan	7	14	27	9	17	14
ASEAN	5	14	38	5	11	11
Oceania	1	3	7	1	3	2
Middle East	32	90	123	40	95	84
North Africa	2	8	23	3	7	14
Sub Saharan Africa	1	5	14	1	4	8
Other Eurasia	1	7	11	1	4	7
Total	**161**	**532**	**818**	**190**	**419**	**433**

Carbon Capture

Carbon is captured from natural gas either as part of the process of transformation into blue hydrogen or directly in the process of combustion at power plants and/or large industrial complexes – the process of abatement. In both FAV1.5 and UNFAV1.5 it is assumed that 10% of natural gas is abated by 2030, 50% by 2040 and 80% by 2050, but this is only in the Power and Industry sectors – inside the boundaries of the facilities – and not in the buildings and transport sectors. Blue hydrogen is used in the latter sectors but is produced and then transported.

Carbon captured from natural gas reaches 4.3 Gt by 2050 in FAV1.5 and 2.5 Gt in UNFAV1.5. Cumulatively the volume of carbon captured by 2050 is 51.5 Gt in FAV1.5 and 35.7 Gt in UNFAV1.5. Regionally the largest volumes captured are in North America, Middle East, Russia and China but it is assumed that all regions have the ability to capture and store CO_2[7].

Carbon is also captured from coal, especially in China and India. This amounts to 2.5 Gt in FAV1.5 and 2 Gt in UNFAV1.5.

Figure 15: CO_2 Captured from Natural Gas

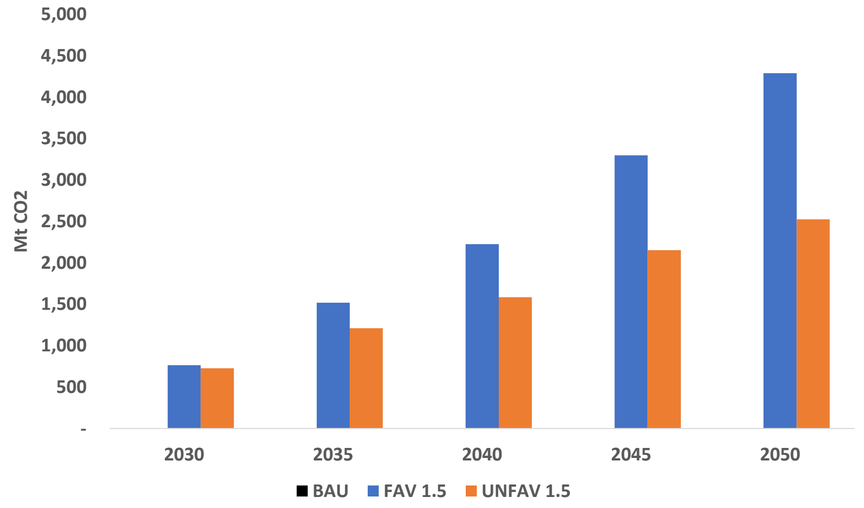


Table 7: CO_2 Captured from Natural Gas by Region

Mt CO2	FAV1.5			UNFAV1.5		
	2030	2040	2050	2030	2040	2050
North America	125	514	779	127	265	402
Europe	111	209	370	106	154	199
Central & South America	19	62	176	18	48	101
Russia	51	279	593	48	209	394
Caspian	13	76	166	12	55	110
China	133	272	591	108	194	346
South Asia	67	147	297	72	108	163
Japan, Korea, Taiwan	30	44	74	30	40	52
ASEAN	27	100	211	22	77	130
Oceania	7	21	37	5	16	22
Middle East	150	379	655	148	330	391
North Africa	15	52	154	15	39	102
Sub Saharan Africa	12	39	110	10	27	62
Other Eurasia	5	30	77	4	23	52
Total	**764**	**2,224**	**4,290**	**727**	**1,584**	**2,526**

[7] CCUS in Clean Energy Transitions, Paris, international Energy Agency

Abatement

Abatement of gas can take place either at the burner tip (pre or post combustion), through the production of blue hydrogen or through the use of biomethane. In FAV1.5 abatement reaches 60% by 2050 and slightly under 60% in UNFAV1.5. Abated gas totals some 2,560 bcm in FAV1.5 and 1,510 bcm in UNFAV1.5. These abatement levels directly link with the amount of CO_2 captured from gas using CCS.

Figure 16: Abatement of Gas FAV1.5

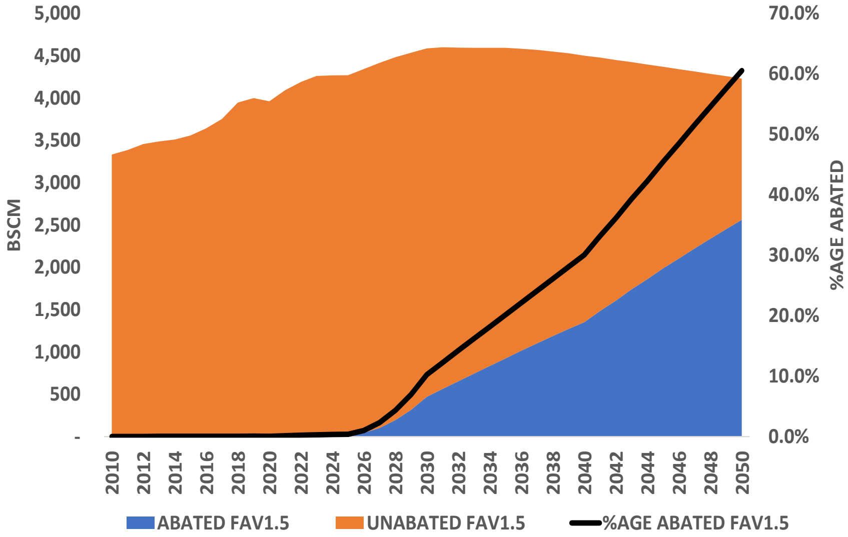
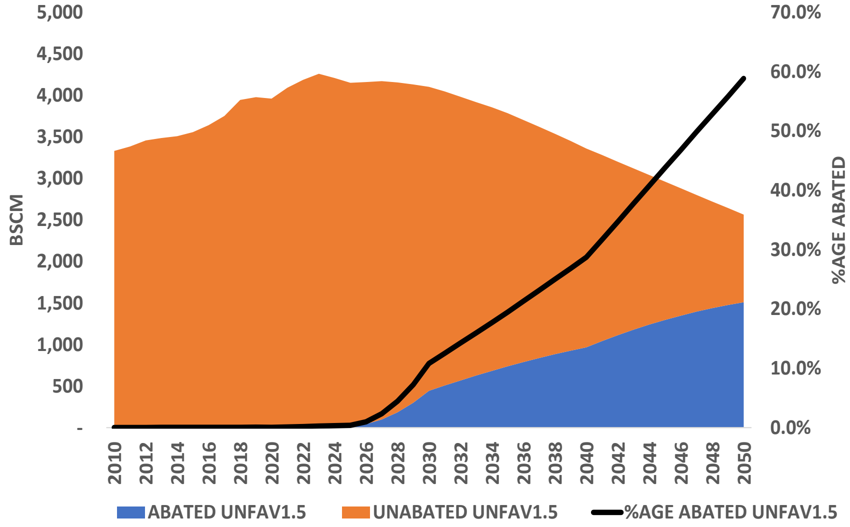


Figure 17: Abatement of Gas UNFAV1.5



Energy Prices

The assumptions on oil, coal and carbon prices are the same as in the IEA's SDS and applied to FAV1.5 and UNFAV1.5. The BAU is OIES assumptions. Oil prices are some $10 lower in the long run in FAV1.5 and UNFAV1.5, with coal prices lower by a similar amount.

There are no carbon prices outside Europe and Asia in BAU but they are extended to the rest of the world, including North America in FAV1.5 and UNFAV1.5. with price well over $100/tonne in the 2040s.

Figure 18: Brent Oil Prices

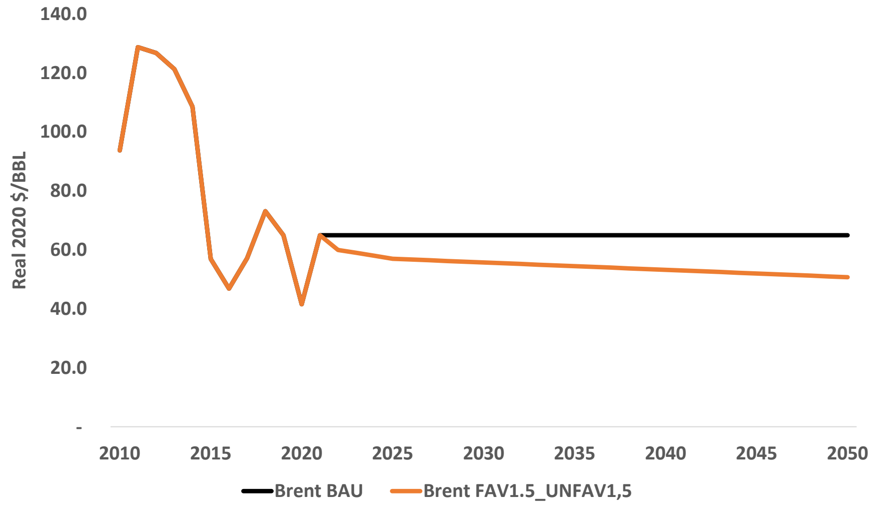


Figure 19: Coal Prices

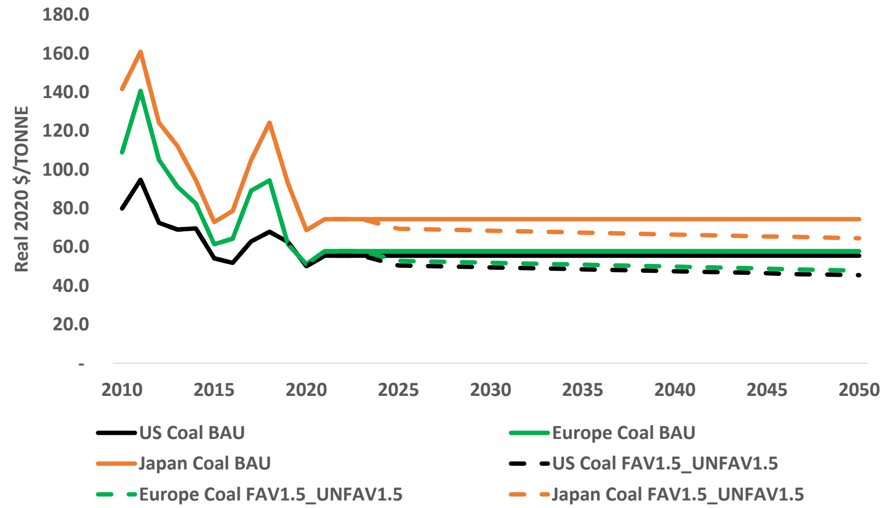
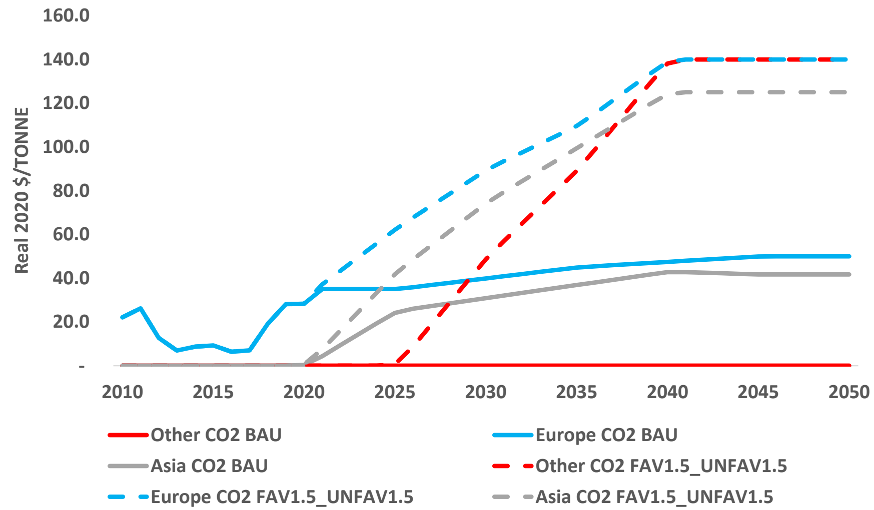


Figure 20: Carbon Prices



Sources: IEA and OIES

Natural Gas Prices[8]

Henry Hub prices in BAU are projected to be in the $3 to $4/MMBtu in the longer term. In FAV1.5 prices may be slightly higher because of the pull on US LNG exports at the margin, but in UNFAV1.5 prices are in the $2 to $3 range. TTF prices are higher in FAV1.5 than in BAU as the tightening market for imports raises prices until global demand starts to fall away significantly. In UNFAV1.5 prices are generally much lower as the impact of declining demand bites, with Japan spot prices and TTF falling to below $4.

Figure 21: Henry Hub Prices

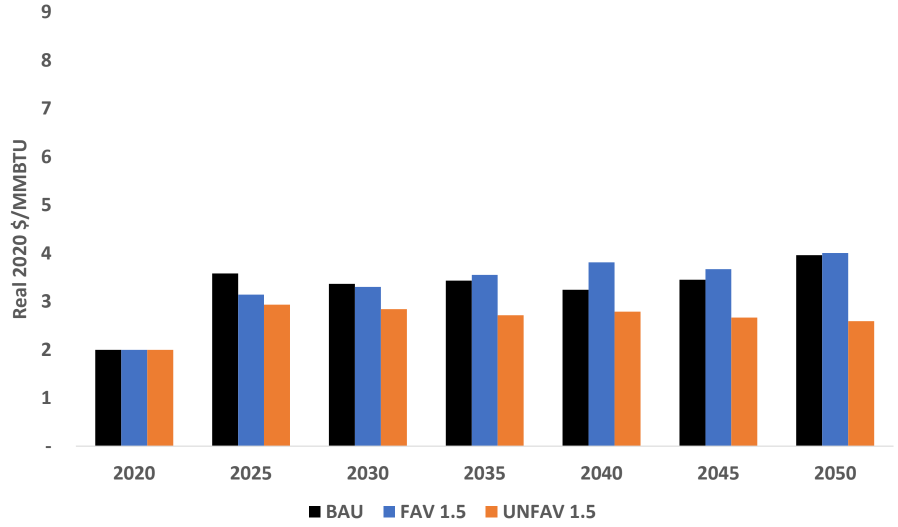


Figure 22: TTF Prices

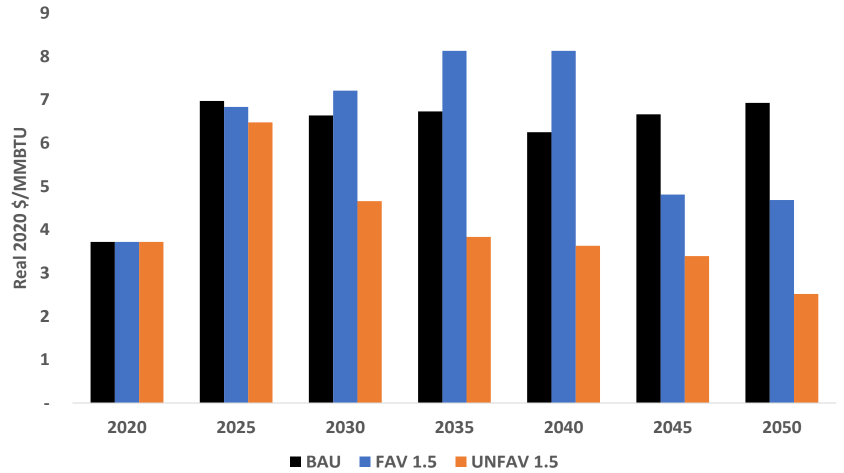
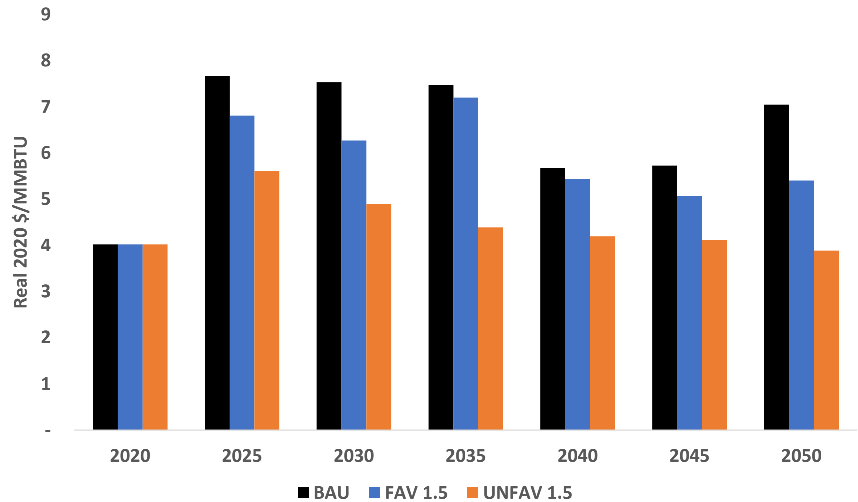


Figure 23: Japan Spot Prices



[8] Gas prices are an output from the model not an assumption

Comparisons with Other Scenarios

There is a wide range of energy transition scenarios, although not all of them extend out to 2050. In the more business as usual scenarios, global demand by 2050 is at 4.5 to 5 tcm. Our FAV1.5 scenario is just over 4 tcm in 2050, similar to BP RAPID. A number of scenarios have demand above 3 tcm by 2050, while our UNFAV1.5 is below 3 tcm, just above BP Net Zero, with the IEA NZE below 2 tcm[9].

There are fewer scenarios to compare for LNG trade, especially ones which are consistent with the Paris agreement. FAV1.5 is close to the more business as usual scenarios, rather than more radical energy transition scenarios. BP RAPID has very strong growth in LNG trade as Asia switches away from coal to gas. There is a strong consensus on LNG trade growth through to 2030, even for those scenarios which are consistent with the energy transition. This is apart from the IEA Net Zero scenario[10], which will be discussed in more detail in the next section. UNFAV1.5 sees LNG trade at below 400 bcm by 2050 as discussed above, while IEA NZE has total LNG trade at less than 200 bcm.

Figure 24: Selected Global Gas Demand Comparisons

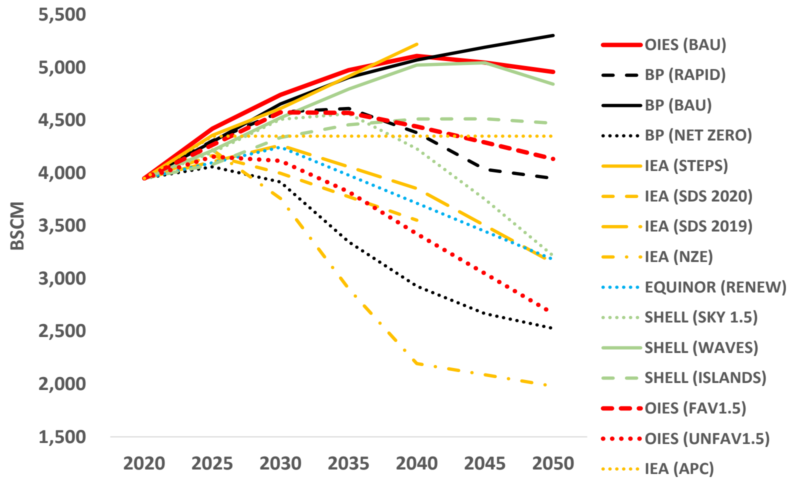
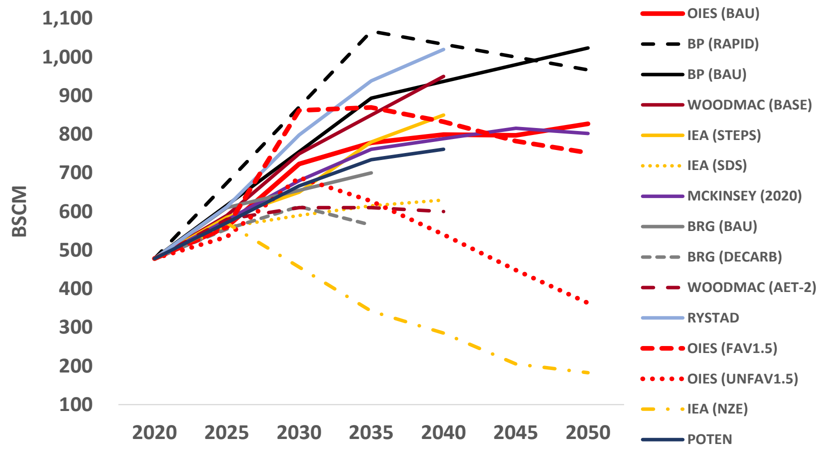


Figure 25: Selected LNG Trade Comparisons



[9] IEA NZE demand has been adjusted to add on biomethane which is included in the OIES scenarios as supply to meet demand.

[10] IEA NZE figures have been adjusted from those published in Net Zero by 2050, since it appeared that the latter only covered interregional trade and not total LNG trade.

IEA Net Zero Scenario[11]

The IEA Net Zero scenario (NZE) set out a pathway to achieving net zero emissions in 2050. Some of the reporting, which did not always accurately represent what the IEA were saying, focused on the statement that there is no need for investment in new fossil fuel supply in the net zero pathway. However, this was not an instruction but was the logical outcome following on from, what the IEA itself described as “a” pathway which suggested that peak oil and peak coal demand have already been reached and peak natural gas demand is expected in the mid-2020s at some 4,300 bcm, and certainly not a prediction. The LNG projects already under development and the pipelines coming on stream shortly are more than enough to meet this peak demand, in this particular pathway. By 2030 natural gas demand is already some 300 bcm below the 2019 level of around 4,000 bcm, with very rapid declines thereafter.

It should also be noted that, apart from an expected large projected rise in solar and wind, the IEA NZE also assumes a doubling of hydro and nuclear by 2050 and a six-fold increase in other renewables (essentially geothermal and marine i.e tidal power). Modern bioenergy also increases rapidly, but this is a common feature of many energy transition scenarios and the IEA is much more bearish on this than almost all the IPCC scenarios of pathways to get to net zero by 2050.

Table 8: IEA Net Zero Pathway (TPES)[12]

	Energy supply (EJ)				
	2019	2020	2030	2040	2050
Total energy supply	612	587	547	535	543
Renewables	67	69	167	295	362
Solar	4	5	32	78	109
Wind	5	6	29	67	89
Hydro	15	16	21	27	30
Modern solid bioenergy	31	32	54	73	73
Modern liquid bioenergy	4	3	12	14	15
Modern gaseous bioenergy	2	2	5	10	14
Other renewables	4	5	13	24	32
Traditional use of biomass	25	25	-	-	-
Nuclear	30	29	41	54	61
Unabated natural gas	139	136	116	44	17
Natural gas with CCUS	-	1	13	31	43
Oil	190	173	137	79	42
of which non-energy use	28	27	32	31	29
Unabated coal	160	154	68	16	3
Coal with CCUS	0	0	4	16	14

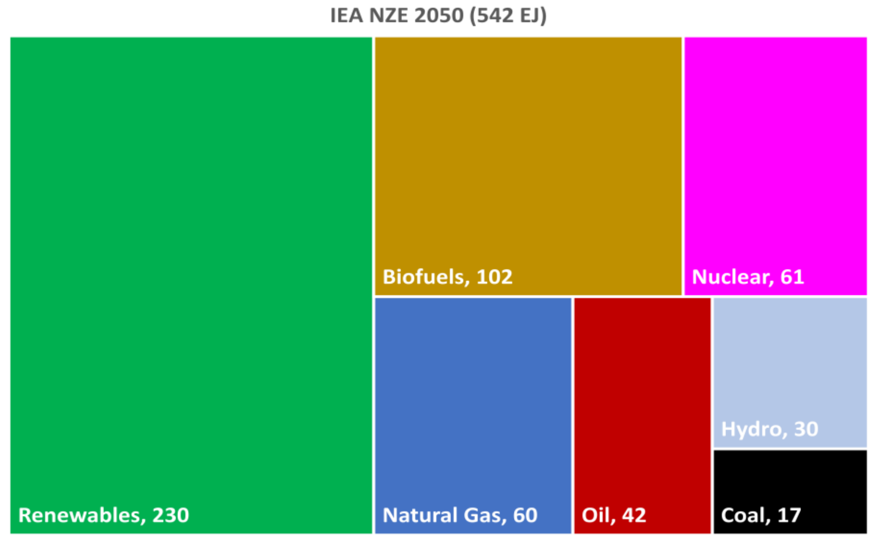
Source: International Energy Agency (2021), Net Zero by 2050, IEA, Paris

In figures 26 to 28 the IEA NZE is compared with FAV1.5 and UNFAV1.5 for total primary energy supply (TPES) in 2050. There is little difference between the three scenarios in terms of TPES, so the differences are in the shares by fuels.

[11] Net Zero by 2050, Paris, international Energy Agency

[12] 1 EJ is approximately 24 MTOE or 26.5 BCM

Figure 26: IEA NZE TPES in 2050



Renewables in these figures means solar, wind and geothermal and marine, as the OIES analysis had aggregated these. Geothermal and marine (tidal power) accounts for some 32 EJ out of the 230 EJ in total renewables, which has grown from 16 EJ in 2020 – an increase of 214 EJ (27 EJ of this increase comes from geothermal and marine).

IEA NZE has more oil than FAV1.5 and UNFAV1.5, which appears to be industry, including use as a feedstock, and gains share in this sector compared to natural gas, which reverses the long run trend. IEA NZE also has slightly less coal but that is consistent with achieving net zero emissions.

Figure 27: OIES FAV1.5 TPES in 2050

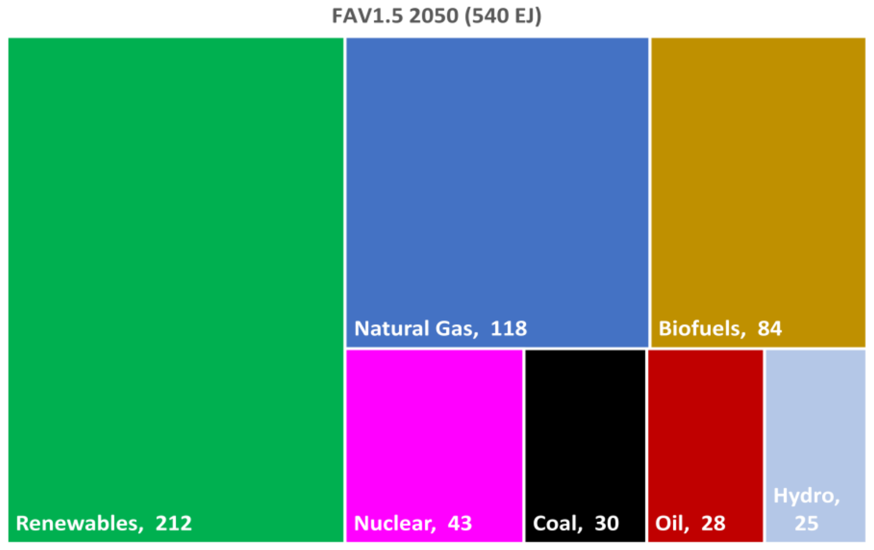
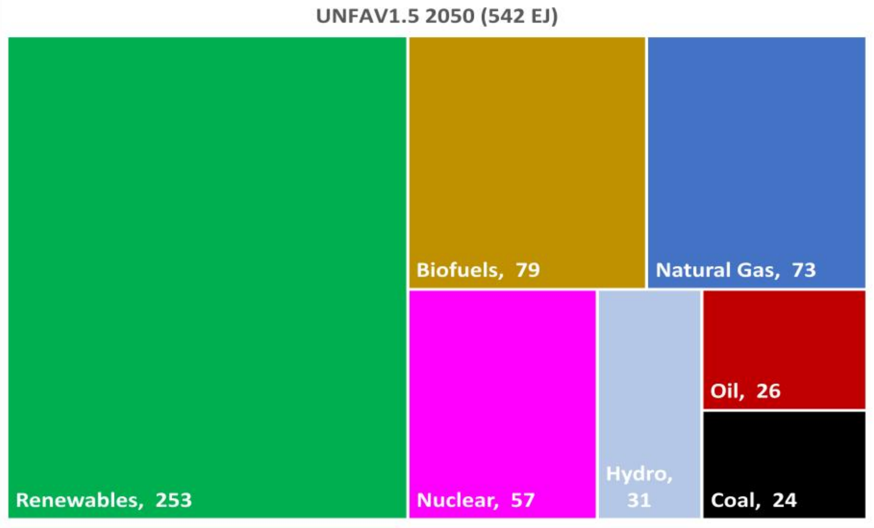


Figure 28: OIES UNFAV1.5 TPES in 2050



Compared to FAV1.5, IEA NZE has more renewables but that seems to reflect the rapid growth in geothermal and marine, plus more nuclear, hydro and biofuels (modern bioenergy). The 58 EJ higher natural gas in FAV1.5 than in IEA NZE in 2050, is exactly matched by the higher renewables, nuclear, hydro and biofuels for IEA NZE, with the renewables difference likely to be in geothermal and marine. Fundamentally, FAV1.5 differs little from IEA NZE in terms of solar and wind but there is more gas (abated) instead of more nuclear, hydro, bioenergy and geothermal and marine, as in IEA NZE. UNFAV1.5 is much closer to IEA NZE, with the difference being largely accounted for by more biofuels (modern bioenergy), in IEA NZE.

In terms of carbon emissions, FAV1.5 and UNFAV1.5 have higher gross emissions than IEA NZE, but lower than IEA SDS, where emissions are some 30 Gt in 2030, 20 Gt in 2040 and 10 Gt in 2050, but our scenarios still achieve the COP21 Paris agreement temperature limits. IEA NZE achieves net zero in 2050 through bioenergy offsets and direct air capture, which are not assumed in our scenarios.

Generating capacity for renewables (solar, wind and geothermal and marine) in 2050 is some 23,500 GW in IEA NZE, 22,500 GW in FAV1.5 and 28,000 GW in UNFAV1.5.

Total carbon capture in IEA NZE is some 7.6 Gt in 2050, of which 5.4 Gt comes from fossil fuels. This compares to 6.8 Gt from fossil fuels in FAV1.5 and 4.5 Gt in UNFAV1.5.

Figure 29: Gross CO_2 Emissions by Scenario

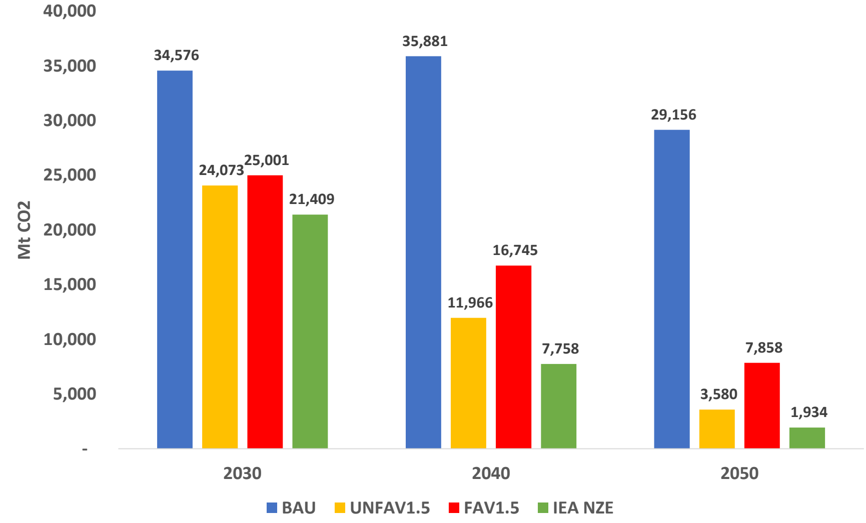
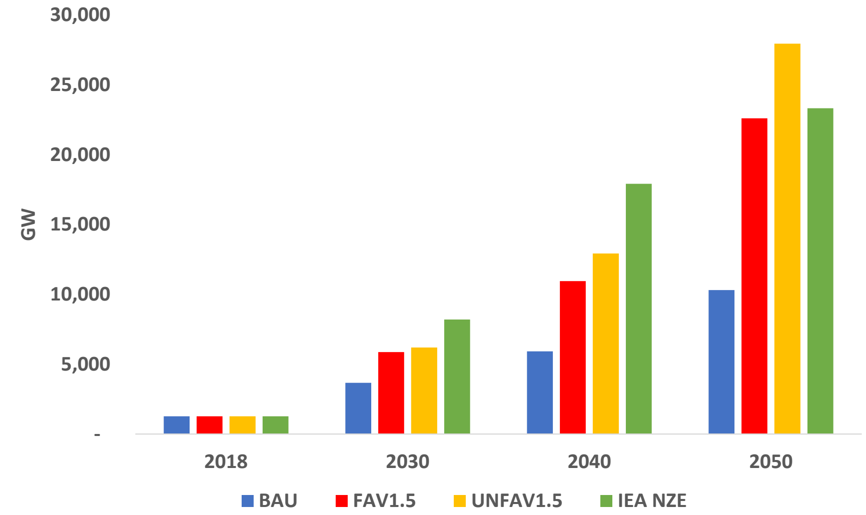


Figure 30: Renewables Generating Capacity



Key Regions

The outlook for natural gas demand is far from consistent across the regions in the energy transition scenarios. It has already been noted that the rising Asia demand, especially in FAV1.5, has significant consequences for trade, especially for LNG. In UNFAV1.5, the decline in Asia demand from the mid-2030s also has significant consequences for all gas trade.

On the other hand, a significant decline in demand is anticipated in North America and Europe in any energy transition scenario. In FAV1.5 demand may hold up well in Russia, Caspian, Central and South America and Africa, while all regions (outside Asia) might be expected to see significant demand declines in UNFAV1.5, especially in the Middle East.

China

China demand grows more rapidly in FAV1.5 than in BAU, initiated by a more rapid switch away from coal to reduce carbon emissions more quickly. This begins in the next few years and, as noted above, has important consequences for global LNG demand. By the end of the period there is little difference between BAU and FAV1.5. In UNFAV1.5, demand peaks in the early 2030s, having grown more slowly up until then. The different demand outlooks are exaggerated in terms of the impact on LNG imports.

Figure 31: China Demand

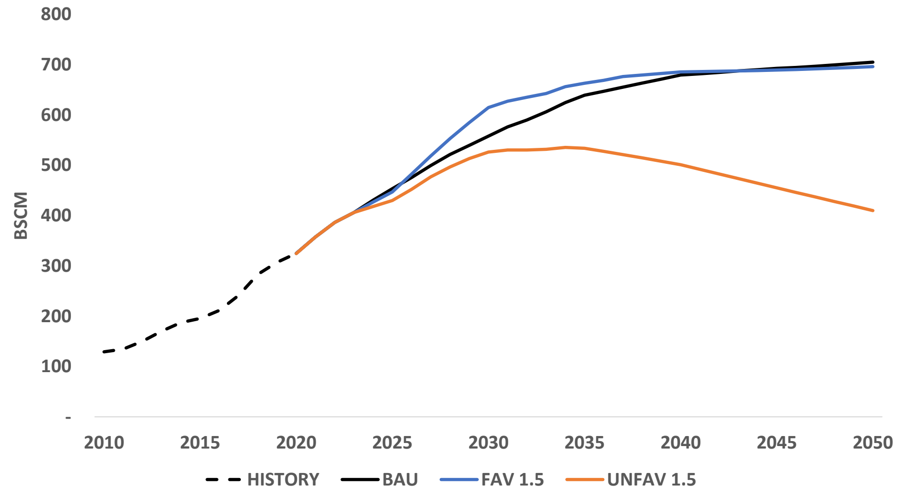
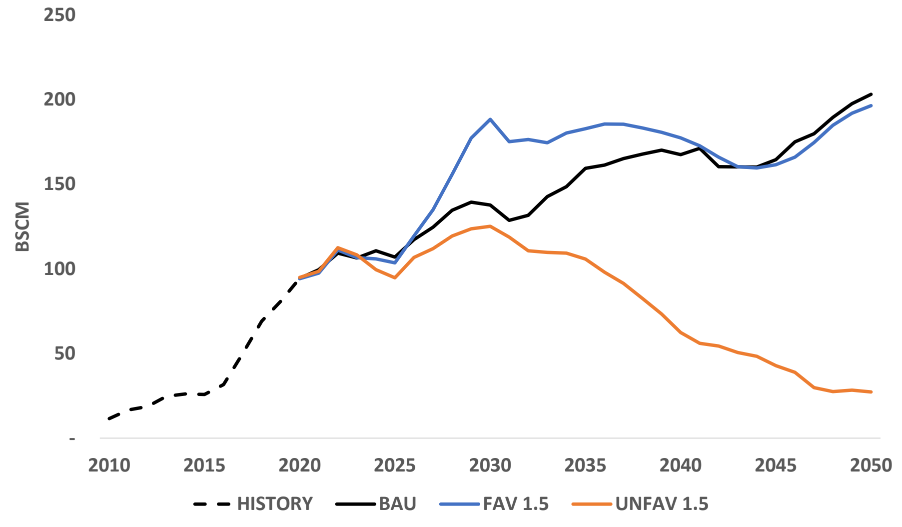


Figure 32: China LNG Imports



South Asia

The profile in India, Pakistan and Bangladesh is similar to China, with strong demand growth in FAV1.5 driven by the coal to gas switching in India. The differences from BAU, however, are even more marked, and even in UNFAV1.5, gas demand growth is stronger than in BAU because it is required to meet emissions targets through rapid switching away from coal. While there is some production growth, the main impact of differing demand is again reflected in LNG imports. It should be noted, however, that even in FAV1.5, natural gas does not achieve the government target of a 15% share of energy supply by 2030. The infrastructure build-out required to achieve that would be enormous and would almost certainly require both Turkmenistan-Afghanistan-Pakistan-India (TAPI) and the Iran-Pakistan-India (IPI) pipelines to be built by the mid to late-2020s. Even in UNFAV1.5 the infrastructure build-out is challenging.

Figure 33: South Asia Demand

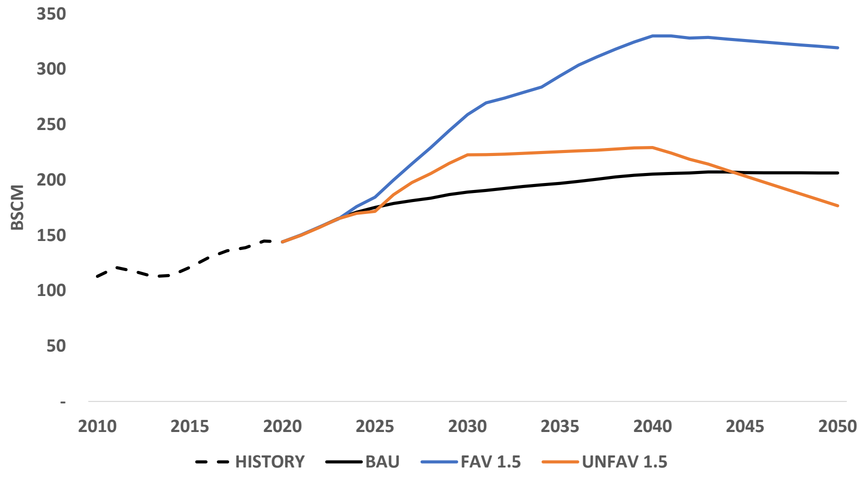
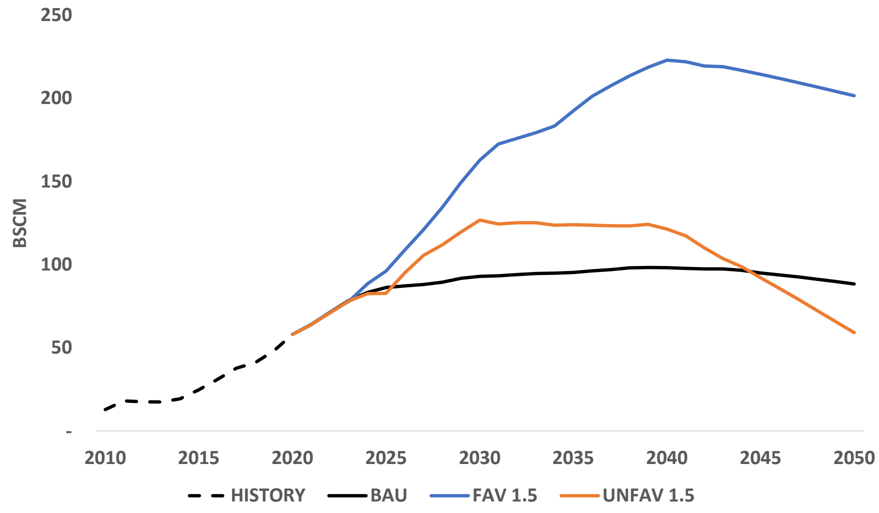


Figure 34: South Asia LNG Imports



ASEAN

Demand in the ASEAN countries in BAU was expected to grow at a steady rate as gas was displacing coal in some countries. In FAV1.5 growth is more sluggish as the already gas-rich countries tend towards renewables and in UNFAV1.5 this trend is exacerbated. LNG import growth is projected to be very rapid in BAU as a result of some coal to gas switching but also as domestic production declines in countries such as Thailand, together with a move away from pipeline imports in Thailand and Singapore. These trends are mitigated somewhat in FAV1.5 and UNFAV1.5 as there is more emphasis on renewables.

Figure 35: ASEAN Demand

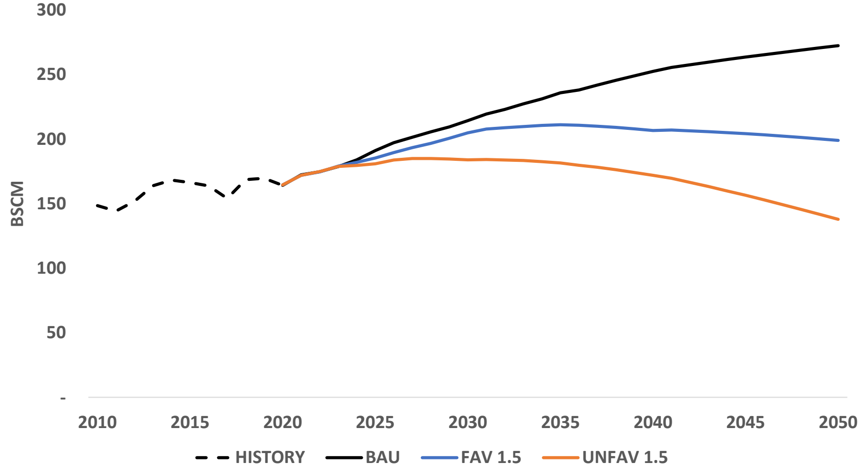
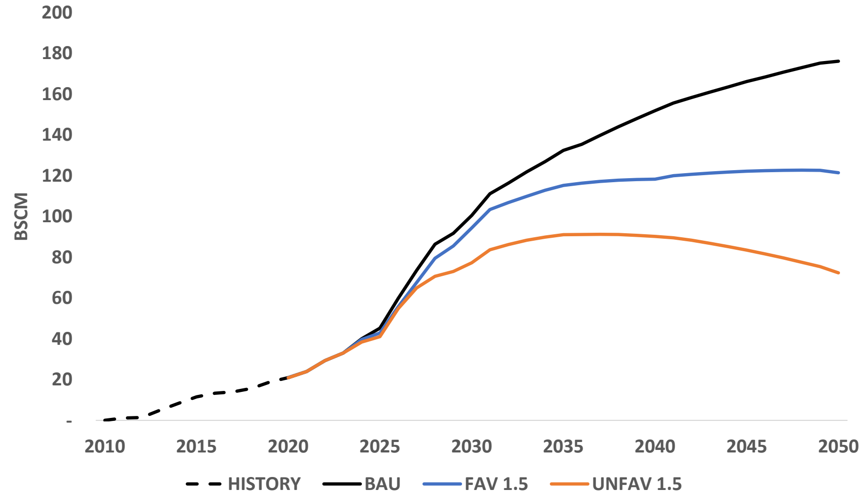


Figure 36: ASEAN LNG Imports



Europe

Demand in Europe has reached a plateau and in the buildings sector it has been declining. In BAU and FAV1.5 the switching from coal to gas supports demand through 2030 but decline sets in thereafter as renewables growth takes precedence. The impact on pipeline imports was discussed earlier and this is particularly severe in UNFAV1.5. LNG imports are very much the balancing item, and in BAU as well as FAV1.5 the LNG supply surge in the late 2020s leads to a new peak in LNG imports before declining demand leads to lower LNG imports in all three cases.

Figure 38: Europe LNG Imports

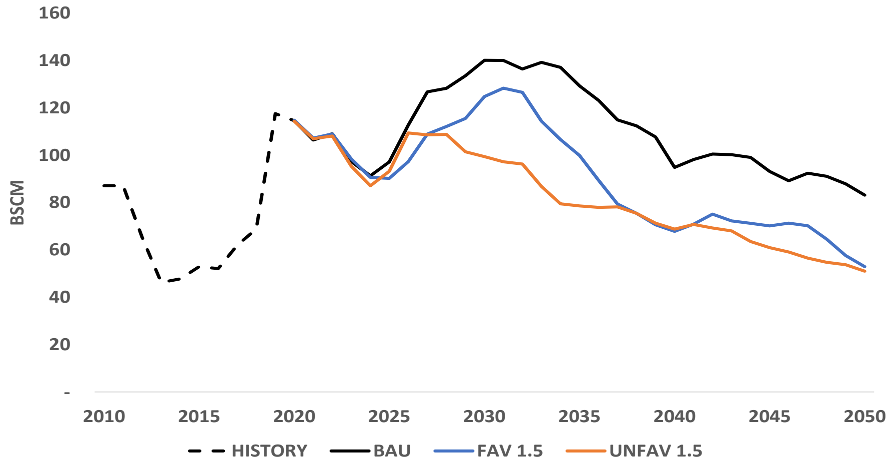
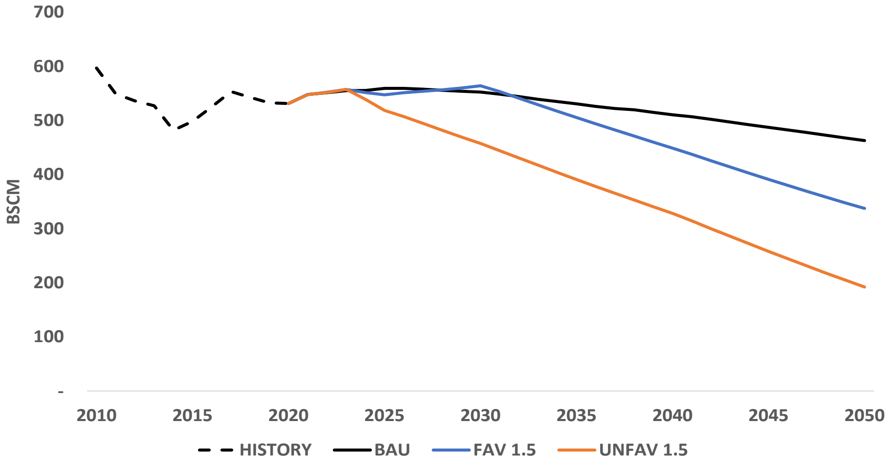


Figure 37: Europe Demand



North America

North America is the other region where demand is expected to decline in FAV1.5 and UNFAV1.5, compared to growth in BAU through the mid-2030s. Natural gas use in power and as feedstock for blue hydrogen supports demand but unabated gas loses share rapidly in buildings and industry. Demand remains somewhat supported through CCS to abate natural gas and develop blue hydrogen. North America is very sensitive to the LNG export market. In FAV1.5 the dash to gas to replace coal in the 2020s leads to a number of US projects being built and with LNG trade remaining buoyant through much of the period the high level of exports is maintained. In UNFAV1.5, the vulnerability of the region to rapidly declining demand in the late 2030s is exposed.

Figure 39: North America Demand

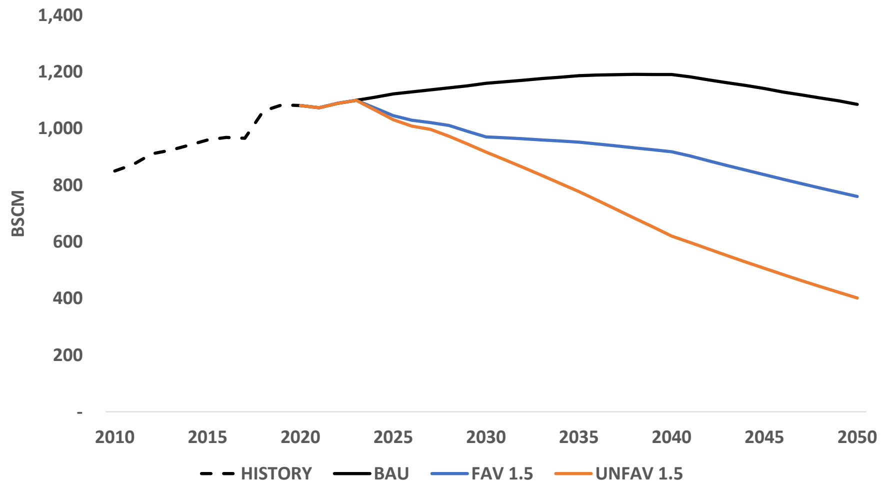
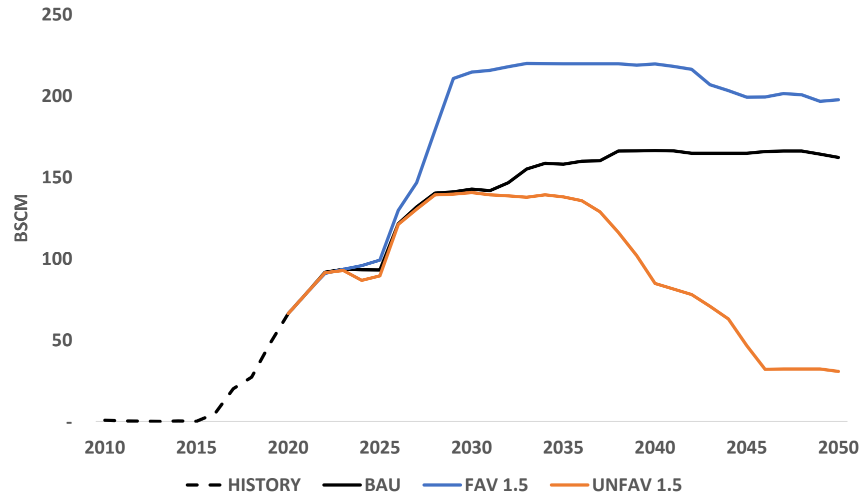


Figure 40: North America LNG Exports



Middle East

In BAU demand in the Middle East is expected to grow rapidly, largely supplied from its own production, but BAU does not meet the COP21 emissions targets. In FAV1.5 and UNFAV1.5 demand is more at risk as the prospects for renewables, especially solar, are strong. However, gas is very dominant in some countries and the prospects for CCS to abate gas and also produce blue hydrogen provides some support to demand in the industrial sector as well as power.

Middle East exposure to the global market is through LNG exports, largely from Qatar. As the lowest cost global producer, there is no difference between the three scenarios, with Qatar being the “last man standing” in the LNG market.

Figure 41: Middle East Demand

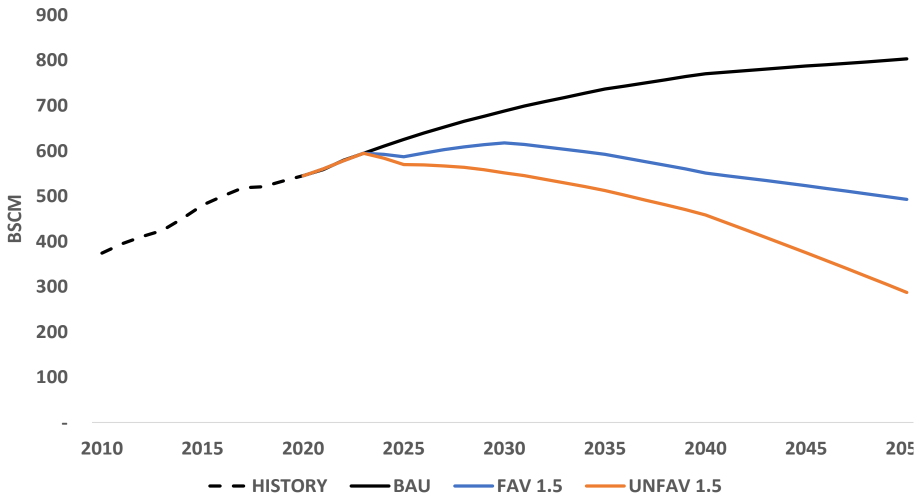
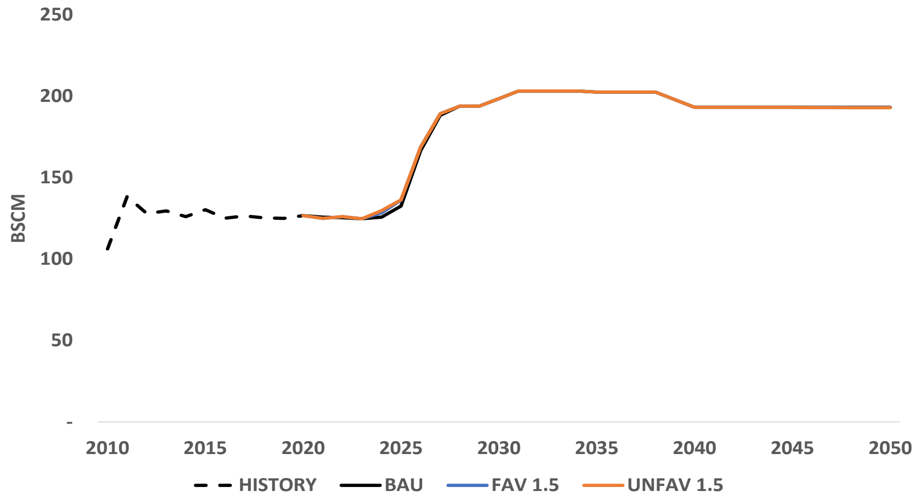


Figure 42: Middle East LNG Exports



Conclusions

There remains a wide range of uncertainty about the role of natural gas in the energy transition, whether the objective is to ultimately limit the global temperature rise to 1.5 degrees C to 2 degrees C in line with the Paris agreement or, more aggressively, net zero emissions by 2050. The alternative scenarios developed by OIES – FAV1.5 and UNFAV1.5 – have a wide range of global gas demand by 2050, with some 4,200 bcm in FAV1.5 and 2,550 bcm in UNFAV1.5, compared to just under 5,000 bcm in the BAU case. UNFAV1.5 is slightly higher than the BP Net Zero scenario but significantly higher than the IEA NZE which is below 2,000 bcm. This is not because of any difference in respect of solar and wind development but seemingly reflects differences in nuclear, hydro, bioenergy and geothermal and marine relative to gas.

The changes under these scenarios are not uniform across the world. Gas demand declines the most in North America and Europe in both OIES scenarios, but also falls sharply in the Middle East in UNFAV1.5 as renewables grow much more rapidly than in FAV1.5, where abated gas is much stronger. In the Asian markets, however, gas demand generally continues to grow, reflecting the need to switch from coal to gas, mainly in power but also in industry and, in China, in buildings as well. The growth in Asian gas demand is particularly evident in the period to 2030, even in Japan, Korea and Taiwan, with an accelerated move out of coal to reduce emissions. The most rapid growth, however, is in India, where there needs to be significant move out of coal to other fuels. However, as in other Asian countries, there is the need for significant infrastructure build out, which may be challenging.

The growth in Asian demand has significant implications for gas trade and LNG trade in particular. In FAV1.5, there needs to be a very rapid expansion of LNG exports in the 2020s, requiring significant additional FIDs on top of those already taken, and a rapid build out. However, in UNFAV1.5, the prospects in the 2030s and beyond look less rosy. By 2050, LNG trade is well under half the level in FAV1.5 at around 350 bcm – lower than the current level of trade. This raises concerns over the prospect of stranded assets and possibly significant early contract termination from the buyers' side and a free-for-all in a plummeting market.

For natural gas to remain relevant under any energy transition scenario which meets either the Paris agreement and/or net zero by 2050, significant abatement is required. In both our scenarios around 60% of natural gas is abated by 2050, either through direct abatement at the burner tip, conversion into blue hydrogen or through biomethane. In the IEA NZE scenario, where gas demand and trade are much lower, the level of abatement is 75%. Any abatement of natural gas will need the development of CCS on a large scale. Other than cost and, in some regions, policies which may prohibit onshore construction of CCS facilities, there do not appear to be any technical obstacles to the roll out of CCS on an extensive scale worldwide.

Just as the IEA NZE scenario depicted a pathway to limiting temperature increases in line with COP21, we have painted two different possible pathways for an energy transition which could achieve the Paris COP21 emissions targets, while involving gas to a much greater degree, especially in FAV1.5. We do not suggest that this is “the” answer, but it does offer an alternative view of the future which may be considered more achievable given current infrastructure in place and the important role that gas can clearly play in many regions as an agent of decarbonisation.

Annexes

Regional Definitions

Demand

Figure 43: Natural Gas Demand by Scenario to 2050

BCM			BAU			FAV1.5			UNFAV1.5		
	2019	2020	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	1,084	1,081	1,160	1,191	1,086	971	918	760	917	620	402
Europe	533	531	553	511	463	564	449	337	457	328	192
Central & South America	162	153	201	241	245	168	160	190	138	117	109
Russia	485	454	491	493	432	480	504	516	444	401	361
Caspian	125	123	138	143	140	141	151	167	134	115	115
China	307	325	558	680	705	615	686	696	526	501	410
South Asia	145	144	189	205	206	259	330	319	223	229	177
Japan, Korea, Taiwan	173	177	195	210	198	230	208	160	219	170	126
ASEAN	170	164	214	253	272	205	207	199	184	172	138
Oceania	52	53	59	58	54	53	43	32	47	36	22
Middle East	533	546	688	770	804	618	551	493	552	458	287
North Africa	127	128	176	192	194	164	144	171	155	107	113
Sub Saharan Africa	34	35	71	114	116	67	92	117	60	60	65
Other Eurasia	50	46	48	52	52	51	58	70	47	46	50
Total	**3,980**	**3,961**	**4,740**	**5,112**	**4,966**	**4,586**	**4,501**	**4,230**	**4,104**	**3,361**	**2,566**

Production

Figure 44: Natural Gas Supply by Scenario to 2050

BCM			BAU			FAV1.5			UNFAV1.5		
	2019	2020	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	1,148	1,136	1,292	1,347	1,234	1,185	1,127	948	1,046	701	424
Europe	231	213	181	160	132	181	153	114	167	113	47
Central & South America	174	164	208	248	244	177	172	204	138	118	111
Russia	750	693	820	916	864	862	888	878	719	654	539
Caspian	209	178	219	224	219	222	232	241	215	189	176
China	178	192	307	370	363	309	370	363	301	337	294
South Asia	88	86	96	107	118	96	107	118	96	108	118
Japan, Korea, Taiwan	3	1	1	1	1	1	1	1	1	1	1
ASEAN	213	212	195	186	185	192	164	152	188	141	98
Oceania	163	159	155	161	159	181	158	141	139	106	74
Middle East	662	670	885	966	994	817	755	710	757	656	486
North Africa	175	170	193	193	196	190	175	178	185	127	124
Sub Saharan Africa	75	76	160	211	243	158	185	176	134	103	68
Other Eurasia	20	20	16	13	10	16	13	10	16	13	10
Total	**4,088**	**3,972**	**4,729**	**5,103**	**4,962**	**4,587**	**4,500**	**4,232**	**4,103**	**3,366**	**2,570**

Interregional Trade

Figure 45: Interregional Trade by Scenario to 2050

BCM			BAU			FAV1.5			UNFAV1.5		
	2019	2020	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	- 46	- 63	- 138	- 157	- 152	- 210	- 210	- 187	- 132	- 75	- 20
Europe	341	317	371	348	330	383	296	223	291	216	146
Central & South America	- 9	- 11	- 7	- 7	1	- 9	- 12	- 14	1	- 2	- 2
Russia	- 227	- 239	- 331	- 423	- 433	- 381	- 384	- 361	- 275	- 253	- 178
Caspian	- 51	- 55	- 81	- 81	- 79	- 81	- 81	- 73	- 81	- 74	- 60
China	125	139	249	305	341	304	315	334	225	164	116
South Asia	48	58	93	98	88	163	223	201	127	121	59
Japan, Korea, Taiwan	179	179	193	209	198	229	207	160	217	169	125
ASEAN	- 49	- 48	19	66	88	13	42	48	- 4	31	40
Oceania	- 111	- 106	- 96	- 103	- 105	- 128	- 115	- 108	- 92	- 70	- 52
Middle East	- 121	- 125	- 196	- 196	- 191	- 199	- 204	- 217	- 206	- 198	- 199
North Africa	- 50	- 42	- 18	- 2	- 2	- 26	- 30	- 6	- 29	- 20	- 11
Sub Saharan Africa	- 38	- 41	- 90	- 97	- 127	- 92	- 93	- 58	- 74	- 43	- 3
Other Eurasia	8	36	32	39	42	36	46	60	33	34	39
Total Interregional Trade	**701**	**729**	**957**	**1,066**	**1,088**	**1,126**	**1,129**	**1,025**	**893**	**735**	**525**

Note: Net imports are positive and net exports are negative

LNG Trade

Figure 46: LNG Imports by Scenario to 2050

BCM			BAU			FAV1.5			UNFAV1.5		
	2019	2020	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	10	4	4	10	10	4	10	10	9	10	10
Europe	118	115	140	95	83	125	68	53	99	69	51
Central & South America	15	10	15	13	21	13	8	6	11	6	5
China	81	94	138	168	203	188	177	196	125	62	27
South Asia	48	58	93	98	88	163	223	201	127	121	59
Japan, Korea, Taiwan	179	179	193	209	198	229	207	160	217	169	125
ASEAN	19	21	101	152	176	94	118	121	77	90	72
Middle East	11	7	21	18	24	15	-	2	9	6	3
North Africa	0	-	5	5	2	5	2	1	1	-	-
Sub Saharan Africa	-	-	7	4	5	7	1	2	4	1	0
Total	**480**	**487**	**719**	**772**	**811**	**845**	**814**	**753**	**682**	**535**	**354**

Figure 47: LNG Exports by Scenario to 2050

BCM			BAU			FAV1.5			UNFAV1.5		
	2019	2020	2030	2040	2050	2030	2040	2050	2030	2040	2050
North America	48	66	143	166	162	215	220	198	141	85	31
Europe	7	4	4	4	4	4	4	4	4	4	4
Central & South America	24	20	22	20	20	22	20	20	11	8	7
Russia	38	40	64	94	102	85	83	91	64	66	26
ASEAN	64	65	77	81	84	77	71	69	77	56	30
Oceania	111	106	98	103	105	129	115	108	94	70	52
Middle East	125	127	198	193	193	198	193	193	198	193	193
North Africa	22	18	16	8	8	16	14	8	16	8	8
Sub Saharan Africa	38	41	97	102	132	98	94	61	78	44	3
Total	**476**	**487**	**719**	**772**	**811**	**845**	**814**	**753**	**682**	**535**	**354**

Pipe Trade

Figure 48: Selected Pipeline Imports by Scenario to 2050

BCM			BAU			FAV1.5			UNFAV1.5		
	2019	2020	2030	2040	2050	2030	2040	2050	2030	2040	2050
Europe	238	212	250	280	277	278	249	194	211	170	117
Russia	12	14	14	14	14	14	14	14	14	13	8
Caspian	10	8	5	6	6	6	5	2	2	2	2
China	44	45	111	138	138	115	138	138	100	101	89
North Africa	0	-	9	14	18	5	-	15	5	-	-

Figure 49: Selected Pipeline Exports by Scenario to 2050

BCM			BAU			FAV1.5			UNFAV1.5		
	2019	2020	2030	2040	2050	2030	2040	2050	2030	2040	2050
Europe	16	5	15	22	26	15	16	20	15	19	18
Russia	197	214	281	344	344	311	316	284	225	201	161
Caspian	60	63	86	86	84	86	85	75	83	76	63
Middle East	9	7	19	21	22	16	11	25	16	11	9
North Africa	28	24	15	12	14	20	18	14	20	11	3