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Trans-ASEAN gas pipeline and ASEAN gas market integration: Insights from a scenario analysis

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Abstract: In order to promote ASEAN gas market integration, this paper offers four scenarios to renew momentum towards continuing with the marginalised Trans-ASEAN gas pipeline (TAGP) and further development of cross-border pipeline gas trading. The paper four subregional and regional market integration scenarios could be used as stepping-stones to achieve ASEAN gas market integration. The impact of each scenario was estimated with a least cost world gas market model and the impact is indicated by the difference between each integration scenario and the baseline scenario, respectively. The simulations suggest that integrated gas markets in ASEAN are beneficial through the reduction of total procurement costs for ASEAN and the World. The TAGP is also beneficial in terms of incentivising ASEAN production that can be transported cost effectively to demand centres within the region. The development of marginal production due to the availability of lower cost transportation is in line with ASEAN's goals for resource optimisation and energy security enhancement. The paper suggests that ASEAN should advocate the gas market integration, and that ASEAN member states could take various institutional measures to achieve higher levels of integration.

Key worlds: ASEAN; Southeast Asia; Trans-ASEAN Gas Pipeline (TAGP); Energy market integration; World Gas Model;

1. Introduction

Natural gas that plays an important role in the current energy transition faces many opportunities as well as challenges in the Association of South East Asian Nations (ASEAN). Due to its relative lower emissions intensity compared with other fossil fuels, its flexibility in power generation, and general presence across the world, natural gas is expected to be a 'bridge fuel' to lower carbon emission world (IEA,

2012). This is particular true in ASEAN. Due to rising population and rapid economic growth, ASEAN's energy demand will experience dramatic increase. ASEAN's total primary energy supply (TPES) is expected to increase from 627 Mtoe in 2015 to 1,450 Mtoe in 2040 in the Business As Usual (BAU) scenario (ACE, 2017a). Despite the 4% annual growth of renewable energy (RE) in 2015-2040, fossil fuels continue to dominate the TPES in ASEAN from 2015-2040 maintaining a share of close to 75-80% in the BAU. This fossil fuel dominance will increase its CO2 emissions from 1,446 Mt CO2eq in 2015 to 3,460 Mt in 2040 (ACE, 2017a). ASEAN's additional CO_2 emissions between 2015 and 2040 are close to those of the world's third highest emitter (India, 2238 Mt-CO2 eq) in 2014 (World Bank, 2017). Such a dramatic increase in carbon emissions will undermine global efforts in carbon mitigation. A recent assessments shows that none the assessed ASEAN countries, i.e. Indonesia, Malaysia, Thailand and Vietnam, have demonstrated adequate efforts towards meeting their Intended Nationally Determined Contributions (INDC) goals (Gao et al., 2019). Given the significant natural gas resources in the Association of South East Asian Nations (ASEAN), and the projected coal-dominated generation mix, replacing coal with natural gas is an economical way to significantly reduce ASEAN's emissions (Shi, 2016).

ASEAN gas market integration is a keep strategy to promote the use of natural gas, but has not been well promoted. The gas resource is unevenly distributed in ASEAN and there is a mismatch between production and consumption, which, together with the projected dramatic growth in the use of natural gas in ASEAN, call for regional gas market integration (ACE, 2017a, b). More broadly, the fragmented natural gas markets (IEA, 2017), the shift away from oil indexed pricing mechanism (Shi and Variam, 2016), the rise of US as an LNG exporter (Geng et al., 2016b), and ongoing

gas market financialization (Ji and Zhang, 2019; Shi et al., 2019) signal an urgency to integrate the natural gas markets at regional and global levels. The need of market integration is well recognized in ASEAN. With the successful launch of the ASEAN Economic Community (AEC) in 2015 and ASEAN's continuous economic development, ASEAN member states (AMS) continue to pursuit an integrated, competitive and resilient ASEAN (APAEC, 2015). However, there is no multilateral energy trade in ASEAN and bilateral trade is limited to long-term contracted supply. Even worsen, the foundation of the gas market integration, the Trans-ASEAN Gas Pipeline (TAGP), has lost momentum (ACE and KEEI, 2013; Shi, 2016). Moreover, there is no plan, or even agreement, on how to move ASEAN gas market integration forward.

Quantitative studies of energy market integration would help ASEAN to advance gas consumption and thus mitigate ASEAN's future emission growth, but are notably missed in the literature. There are two notable gaps in the literature regarding the ASEAN gas market integration. First, there is no discussion on how the ASEAN gas markets might be integrated. The existing studies on energy market integration (EMI) in ASEAN and East Asia, such as Ahmed et al. (2017), Nurdianto and Resosudarmo (2011), Sheng et al. (2013), Sheng and Shi (2013), Wu (2011), and Shi et al. (2019), focus on broad issues or electricity market integration. Second, among the existing studies that discuss the ASEAN gas market integration, including TAGP (Shi, 2016; Sovacool, 2009a, b), there is no attempt to quantify the impact of ASEAN gas market integration. The only paper close to ours is Liu (2015), which develops a gas network model of existing and potential gas pipelines and LNG terminals within ASEAN and analyses whether the present gas infrastructure plans in ASEAN are sufficient to meet future ASEAN gas demand until 2045.

To fill the gaps in the literature, this paper proposes various scenarios for pipeline gas trade across ASEAN and quantifies their economic impacts. It assumes that RGTs could possibly alter the destinations of LNG tanks and thereby provide additional flexibility to the ASEAN gas markets. It also proposes scenarios in which the current TAGP pipelines are used to transport gas from some shared RGT; more dramatically, it envisions scenarios in which gas can be traded with open access to pipelines, initially between a few countries and ultimately at the regional level. It also considers the case that gas hub prices are used to replace oil indexation and that regional gas trading becomes spot trading.

This paper makes the following contributions. First, it proposes a concept for ASEAN gas market integration that is new to the literature and could therefore stimulate debates in both the academic and policy arenas. Gas market integration could also be useful in mitigating energy security risks (Ji et al., 2019). Second, it is a pioneering study, which quantifies the associated benefits of gas market integration. This analysis could be useful to ASEAN policy makers tasked with determining how and when to upgrade ASEAN gas cooperation into market integration. Lastly, the discussion about switching gas pricing from oil indexation to hub indexation in ASEAN could also be informative. While there are some studies on the pricing switch in East Asia (Shi and Variam, 2015, 2016), there is no dedicated study on it pertaining to Southeast Asia. Given the ASEAN gas market is unique in having a mix of gas and LNG exporters and importers that likely have opposite interests in the pricing transition, this study may offer insights into the policy debates in Southeast Asia. Given the increasing importance of ASEAN in the global energy landscape, this topic is important not only regionally, but also globally.

The paper proceeds as follows: the next section presents some background information on ASEAN gas market. Section 3 presents explains the methodology for how we developed the study, including various scenarios for simulations. This is followed by the simulation results, including both the baseline scenario and policy scenarios. The concluding section discusses the policy implications.

2. ASEAN gas market development

With rising gas consumption, slowing gas production, and the geographical mismatch between regional demand and production centres, ASEAN will become a net gas importer. ASEAN holds 3.4% or 6.8 tcm of the world's proven recoverable natural gas reserves, with roughly 90% of the region's natural gas reserves concentrated in four member states, namely Indonesia (43%), Malaysia (35%), Vietnam (9%) and Brunei Darussalam (4%). The 5th *ASEAN Energy Outlook* projects regional natural gas production to decline from 205 bcm in 2015 to 177 bcm by 2040. At the same period, natural gas growth of 2.9% per year sends the ASEAN demand for natural gas from 153 Mtoe (170 bcm) in 2015, to 305 Mtoe or 339 bcm in 2040. With a demand of 339 bcm, ASEAN becomes a significant net gas importer (162 bcm) by 2040 (ACE, 2017a).

The TAGP is one of the two flagship energy infrastructure programmes (the other is ASEAN Power Grid (APG)) geared to optimising regional energy resources, ensuring sustainable energy development and reinforcing renewable energy development and cooperation (APAEC, 2015). The TAGP aims to connect various gas fields in the ASEAN region through pipelines to ensure the reliability of gas supply for the AMS and encourage its use. As of 2017, the TAGP had built 3,673 km of transboundary pipelines connecting six AMS and six LNG RGTs (ACE, 2017b). The existing links

allow transmission of gas from Myanmar to Vietnam or to Indonesia, and from Singapore's liquefied natural gas (LNG) terminal to Thailand (ACE and KEEI, 2013). The remaining missing links are those from East Natuna gas field, which seems to be not commercially attractive (ACE and KEEI, 2013). In addition to infrastructure, the TAGP also promotes institutional development such as financing, technical harmonisation, open access to pipelines, cross-border tariffs, and environmental impact mitigation (The ASEAN Secretariat, 2002).

Although the TAGP proposal demonstrates ASEAN's aspiration to optimise gas utilisation in the regional block, the development of the TAGP has lost momentum. One reasons is the unexpected delayed development of the East Natuna gas field, which is the largest natural gas field yet be developed in the region (Shi and Malik, 2013). Another reason is the growth of LNG regasification terminals to fill the gap between supply and demand (ACE and KEEI, 2013). The widening indigenous supply and demand gap has led to the development of LNG RGTs in the coastal AMS including Indonesia, Thailand, Singapore, and Malaysia, with a total regasification capacity exceeding 30 bcm per year. Other member states including Vietnam, Philippines and Myanmar are also looking into developing LNG RGTs. In 2012, the ASEAN Council on Petroleum (ASCOPE) modified the TAGP concept by including Regasification Terminals (RGTs) as virtual connections between the AMS. With the popularisation of RGTs in ASEAN, the regional gas supply can be secured and optimised through virtual connection of LNG and thus the role of natural gas pipelines is diminished (Shi, 2016).

Integrating ASEAN's gas markets, mainly through the trading of natural gas, would renew the lost momentum for the TAGP, as it would truly allow gas infrastructure and resources to be optimised within the whole ASEAN region. Trading natural gas across

the region, or gas market integration, is probably the best instrument to achieve: "integrated networks of electricity and gas pipelines that offer significant benefits both in terms of security, flexibility, and quality of energy supply" (APAEC, 2015). Compared to the bilateral purchase of natural gas, trading would allow gas to be transported to places where it can generate the most continuous benefits, and thus maximise the benefits of gas across the trading zone, or markets.

Trading natural gas is implied in the original plan of the TAGP and in the AEC's vision, but has not been explicitly articulated. The *ASEAN Economic Blueprint* published in 1997 stated that: Regional collaboration in the TAGP, together with APG, is meant to enable the optimisation of the region's energy resources for greater security (The ASEAN Secretariat, 2008). The current APAEC also reiterates that the TAGP aims 'to transport gas across borders to ensure greater security of gas supply' (APAEC, 2015). However, as of yet there is no official published target for spot gas trading, even between countries.

The integration of markets is expected to generate net benefits for the region, but there is no estimation so far. For instance, through sharing the current RGTs in Thailand, it may be possible for Myanmar to purchase LNG from the international markets and deliver it to Thailand's RGT in substitution for Myanmar's pipeline export. This is a Pareto optimisation because Myanmar can increase its domestic gas supply without additional investment in LNG receiving terminals, while Thailand will not be disadvantaged. Similarly, Singapore's RGTs could be used by Indonesia and Malaysia to receive LNG. Other AMS can use Singapore's RGTs to reload LNG to small size tanks to supply their islands. Small LNG cargos could replace the more expensive diesel generation in islands. However, no study that has demonstrated such benefits although such estimation is needed for policymaking.

3. Methodology

The discussion on the TAGP, including its vision, status, and challenges were drawn from the literature. Whenever possible, official documents from ASEAN bodies were used as sources of information (ACE, 2017b; APAEC, 2015; The ASEAN Secretariat, 2008). In the gas policy scenarios, we specified a few scenarios that could occur when achieving the ultimate truly integrated regional gas market. The scenarios were then simulated by the Nexant World Gas Model (WGM) (Nexant, 2016).

The WGM is a linear programme that aims to minimise the world's total gas-procurement costs (including production, transport, and liquefaction costs) under technical constraints such as capacity and costs of infrastructure (pipeline, LNG liquefaction terminals, RGTs, and storage) as well as institutional constraints (e.g. contractual obligations, destination restrictions, and 'take-or-pay' (TOP) terms). This model has been intensively used in recent literature (Mitrova et al., 2016; Shi and Variam, 2015, 2016; Shi and Variam, 2017; Shi et al., 2017).

Covering every country in the world that consumes or produces natural gas, the WGM model simulates the real world trading of gas and LNG. It is optimised at the node level on a quarterly basis, but the results are reported at country and regional levels. The regional definitions can be found at Shi and Variam (2017). Countries are modelled as either a single node, or a few nodes (mainly for larger countries such as Australia, Canada, China, Indonesia, Russia, and USA). Each node's profile includes supply, demand, pipeline capacity, LNG liquefaction and regasification infrastructure, and contract characteristics, which are provided in the WGM database (Nexant, 2016). The assumption of oil price (in 2015 real price) is taken from World Bank

forecasts (World Bank, 2016) for the years up to 2025, and EIA (2016) forecasts spanning 2025 to 2040. Oil indexed gas prices are measured as a function of oil prices with time lags (Shi and Variam (2017).

A base scenario is first developed to study how the international gas market might evolve to 2040. In this reference scenario, all the long-term contracts have 'take-or-pay' (TOP) constraints, and the destination clauses are indexed to oil prices. The historical data are available from 2006 to 2016 and the outlook period is up to 2040. For the purposes of this paper, we extended the historical data (2006-2015) to 2040.

The impact of each scenario is indicated by the difference between each integration scenario and the baseline scenario, respectively

A total of four sets of policy scenarios were set up and simulated in this paper. The scenarios consider ASEAN's plan, that is, the common LNG destination (S1) and the envisioned full functional TAGP (S2) (APAEC, 2015). They also include trading arrangements that are critical to market integration (Shi and Variam, 2016), but has not been considered in policy development, such as hub indexation (S3) and pure spot market (S4).

We assumed that all the scenarios applied from 2025 onwards. The year 2025 was set as a reasonable estimate of a time during which such changes in the regional gas market might be possible. The year 2025 allowed us 16 years of simulation data or analysis, thus allowing better study of the impact of the changes to help make policy conclusions.

In Scenario 1 – 'ASEAN Club – Integrated LNG market' (S1), the entire ASEAN region is an aggregated entity to buy LNG. This reflects ASEAN's ongoing efforts to address gas-related commercial, legal, and technical matters including making a

standard clause for LNG cargo diversion and destination flexibility for ASEAN LNG Contracts (APAEC, 2015). We simulated this scenario by modifying the existing and planned infrastructure of LNG regasification terminals in the region to allow for such a change in contractual arrangements to occur. We treat LNG as a virtual pipeline and assume a common "virtual" ASEAN LNG receiving node with the regional average cost of operation. In the single virtual node for ASEAN LNG imports, LNG is assumed to be redirected to demand nodes via zero cost (virtual) pipelines. Destination (DES) clauses in the LNG contracts destined to any of the ASEAN LNG import countries are removed which allow LNG to be delivered to any of the ASEAN member countries without contractual constraints. The distribution of the supply among the ASEAN countries is based on the fundamentals of demand and supply, prices, and cost of procurement in the respective countries.

Scenario 2 assumes a full operation of the TAGP in the ASEAN region. The details of the TAGP pipeline, such as the capacities, expected costs, and proposed start dates of pipeline flows are taken from the TAGP masterplan of the TAGP network with the completion of the last sections of the network assumed to happen by 2027. The pipelines also allow reverse flow to simulate the trading nature of pipeline gas in the region. The existing regional pipeline trade contracts are also allowed to continue, but with no take-or-pay conditions in this scenario for the region. This reflects the assumption that commercial contracts are amended with fewer restrictions on the trade and movement of gas.

Scenario 3 assumes a regional ASEAN market where the trade of natural gas (both pipe and LNG) is indexed to the regional hub price (Singapore spot price). This allows us to simulate the impact of hub indexation in the ASEAN gas market. Considering the gas trading hubs and hub prices that are likely emerging (Shi and

Variam, 2015, 2016), switching from the prevailing oil indexation to hub price indexation is a scenario that is of real policy interest.

Scenario 4 simulates a fully integrated spot-only South East Asian market, like that in Northwest Europe. The European Union is the global pioneer in gas market integration, as evidenced by the numerous EU market policies.[1] This scenario is a combination of the previous three scenarios. Here LNG is traded free of destination clauses and take-or-pay obligations in the whole region. The TAGP and regional pipelines also allow for reverse flow and gas trading happening without any contractual restrictions. Prices are all spot driven with the Singapore spot price forming the role of benchmark.

Our design of the scenarios is with progressively increasing regional gas market integration and enabling of TAGP infrastructure as envisioned in the AEC document. The gradual differences allow a study of the full range of impacts and implications for each of the ASEAN member countries, the region and the world. A summary of the scenario and model setting is presented in Table 1.

Table 1 ASEAN gas market integration scenarios

	Scenario name	Brief information	Modelling strategy
S1	Common LNG Destination (ASEAN Club)	An integrated ASEAN gas market as a single buyer of LNG cargoes, which can be delivered to any ASEAN gasification terminals.	All the LNG infrastructure (at the receiving side) is modelled as a single node, connected to host ASEAN countries' aggregate regasification capacity by pipelines of zero transportation cost (virtual pipelines).
S2	Full functional TAGP (TAGP Scenario)	Gas is freely traded among ASEAN member states through the TAGP infrastructure.	The TAGP infrastructure is built and is made fully bi-directional from 2025.
S3	Hub indexation	Trade of gas in ASEAN, including exports and imports, are priced on hub prices.	Using Singapore spot prices (2025) for all ASEAN LNG only. For pipeline trade, a netback price from Singapore spot is used.
S4	ASEAN Spot trading	A combination of scenarios 1, 2 and 3,	LNG has common ASEAN destinations, TAGP infrastructure is

[1] A full list of EU gas market policy can be found at: https://www.euractiv.com/section/energy/special_report/european-gas-markets/

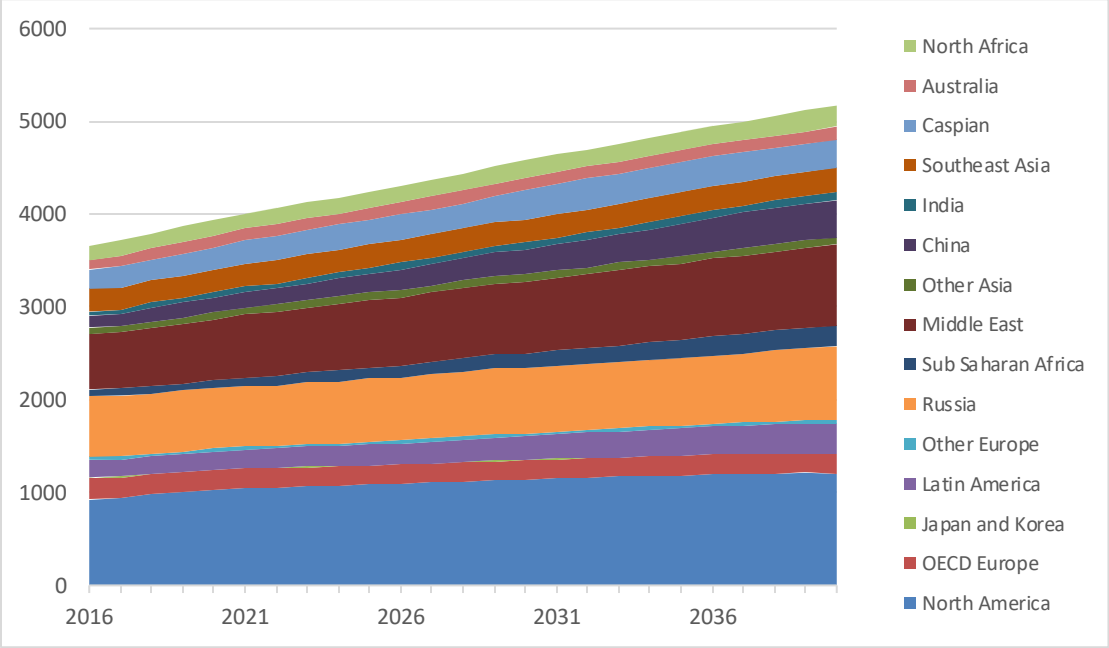
		forming complete ASEAN spot market scenarios.	ready and flow is bi-directional; and prices are indexed to spot prices; and contracted trades are indexed to the regional price benchmark.

4. Simulation results

4.1. The Baseline scenario

In the baseline scenario, global natural gas production and consumption grow at a CAGR of 1.40% during the outlook period (2017-40). Global natural gas production and consumption increase from 3,654 bcm in 2016 to 5,170 bcm in 2040 (Figure 1), which is consistent with the IEA's forecasts (IEA, 2017).

Figure 1 Gas production by region, Baseline scenario, in bcm (2017-2040)

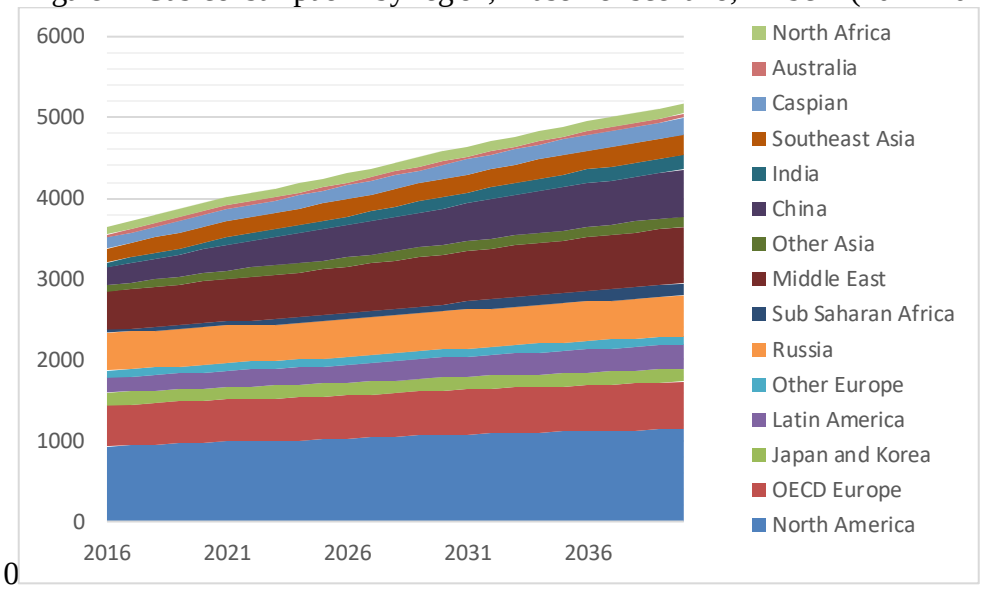


Source: Model's projections.

Asian gas production increases significantly due to its rising domestic demand as well as increased Australian production. African production increases after 2020 and is export-driven. The production growth in the Middle East, Latin America and Central

Asia is driven mostly by rising domestic demand for gas. European production decreases along with the declining conventional gas production, although the emergence of shale gas slows down the rate of decline after 2025 (Figure 1). Gas consumption grows rapidly in Latin America and Sub Saharan (East) Africa, more moderately in the Caspian region, but slowly in Europe. The largest growth comes from Asia, particularly from China and India (Figure 2).

Figure 2 Gas consumption by region, Baseline scenario, in bcm (2017-2040)



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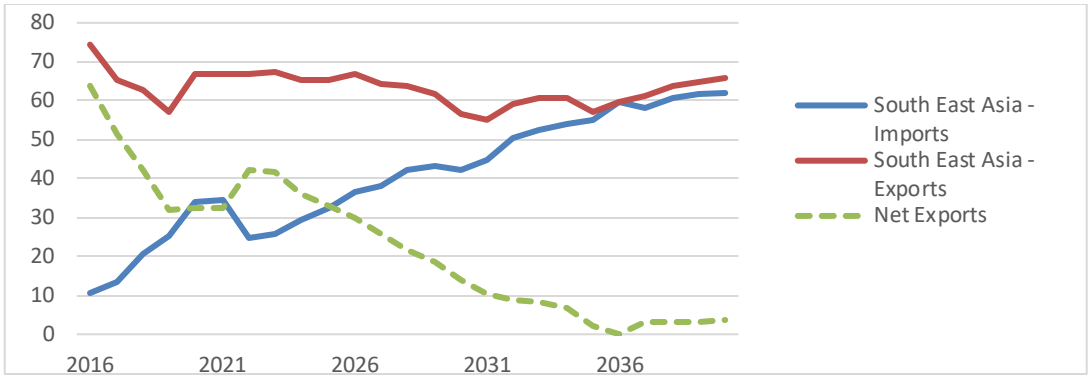
Source: Model's projections.

Global LNG trade flows increase from 351 bcm in 2017 to 514 bcm in 2040. This is dominated by LNG imports in Asia, mainly East Asia (China, Japan, Korea, and Chinese Taipei). South East Asia remains a net exporter of LNG during the scenario horizon (Figure 3). However, the region as a whole imports more than 30 bcm from 2020 onwards and by 2035, the region almost becomes a net importer of LNG.

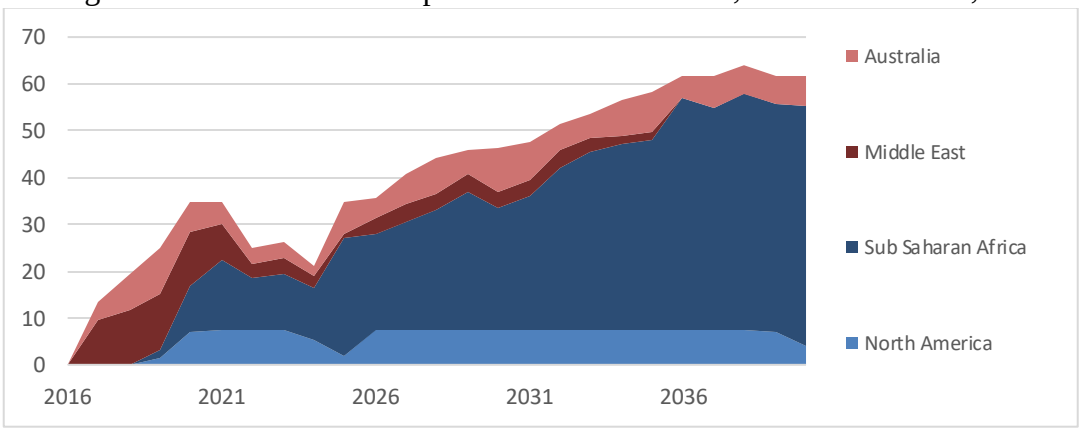
Figure 3 Total LNG Exports and Imports (South East Asia), Baseline scenario, in bcm



Source: Model projections.

Southeast Asian LNG imports will be mainly from 4-5 countries/regions (Figure 4). The major emerging supplier to the region after 2020 will be Sub Sahara Africa, whose share will be increasing over time. North America and Australia are the two other major suppliers, whose shares are relatively stable. South East Asian importers are mainly Thailand, Singapore, and Vietnam and, to a lesser degree Indonesia and Malaysia. Assuming that the East African LNG projects are functional, the South East Asia imports most of its LNG from these new emerging sources and can potentially replace the Middle East LNG (Figure 4).

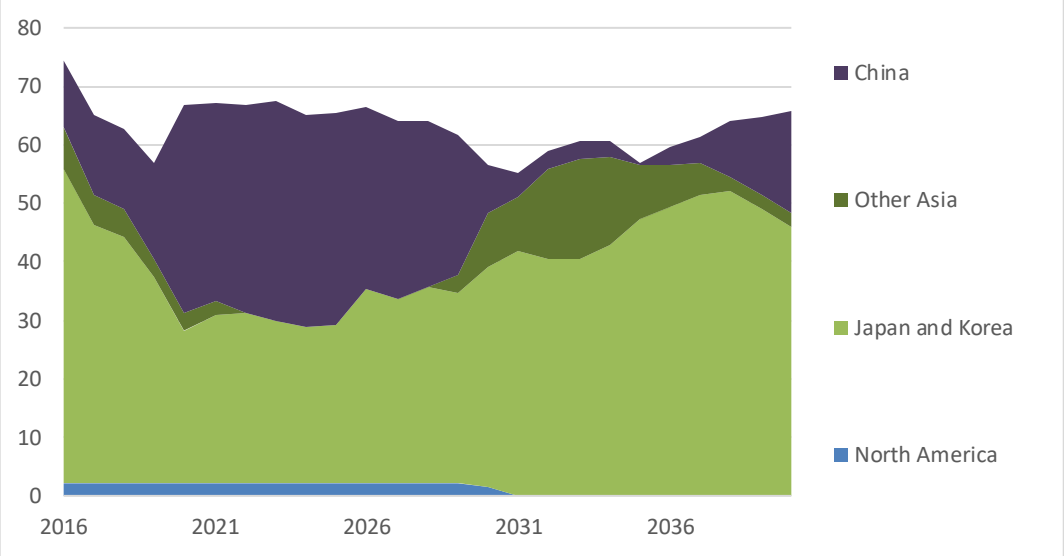
Figure 4 Sources of LNG imports to South East Asia, Baseline scenario, in bcm



Source: Model projections.

South East Asia exporters dominate LNG supply in the East Asia region (China, Japan, Korea, and Chinese Taipei) (Figure 5). The decline in South East Asia exports to China after 2030 is due to the decline in Indonesian exports, and the start of Russia's exports to China from the second pipeline. The Indonesian exports that are displaced by the second Russia-China pipeline gas are partly redirected to Other Asia (mainly Chinese Taipei). South East Asia exports the largest share of LNG to Korea and the share is expected to increase in the medium term due to expiry of oil-indexed contracts from the Middle East post 2026, which can potentially be replaced by cheaper supply sources from Malaysia and Australia.

Figure 5 Composition of LNG exports from South East Asia, Baseline scenario, in bcm

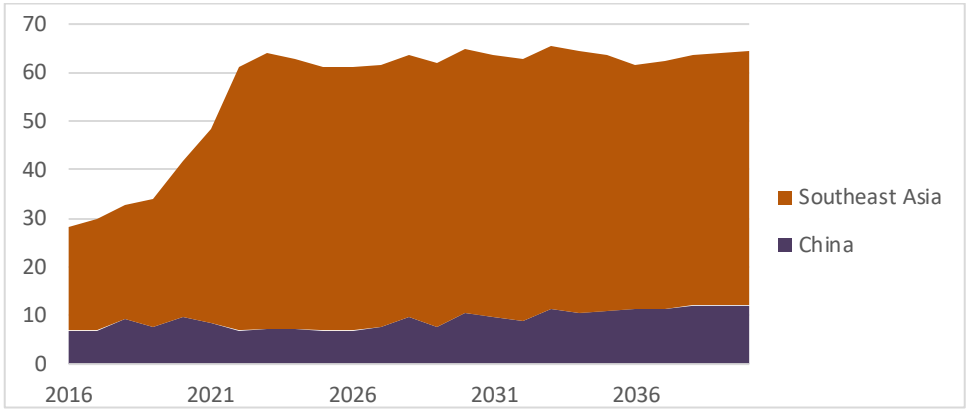


Source: Model projections

As for pipeline trade, the region is self-reliant with more than 90% of the trade within the region (

Figure 6). The only inter-regional trade occurs between China and Myanmar, and that is forecasted to remain constant. The increase in exports/imports (intra-regional) is due to trade between Myanmar and Thailand, and the development of trade through the domestic pipeline network between Indonesian islands.

Figure 6 South East Asian regional pipeline trade and exports, Baseline scenario, in bcm

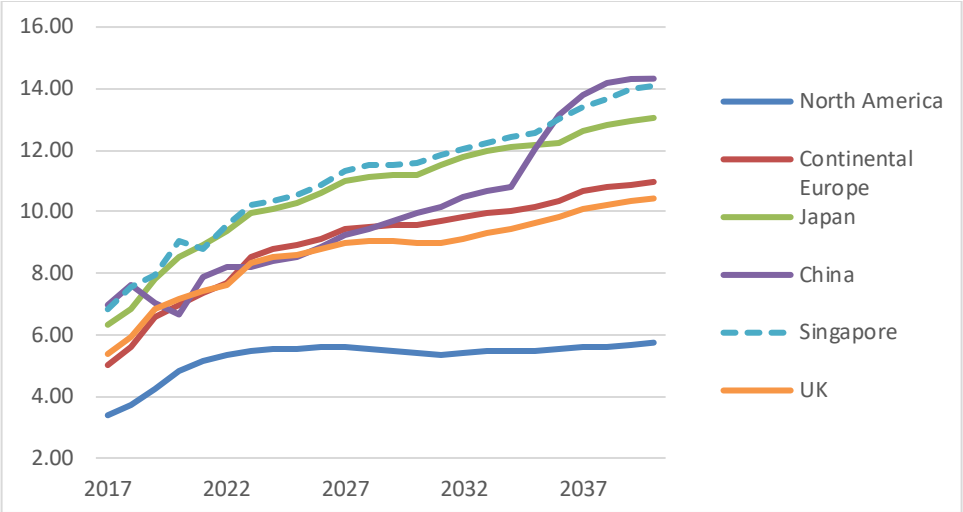


Source: Model projections

Asia's spot prices generally show an increasing trend (Figure 7). China will experience a rapidly increasing spot price, and the Chinese spot price is the highest among the nodes ($14/MMBtu) after 2035. The Chinese market is expected to tighten starting from the mid-2030s, when the prices increase to become the highest spot prices in the region and the world. However, the Japanese and Singapore prices will be higher than the Chinese price over the next 15 years due to their reliance on LNG.

European spot prices also move upward due to increased spot LNG exports and decreased contracted pipeline exports from Russia. All this would imply that Asian prices are expected to be higher compared to other markets, a typical phenomenon of 'Asian Premium' in gas trading (Zhang et al., 2018a).

Figure 7 Selected spot prices, Baseline scenario (USD/MMBtu) (2017 – 2040)



Source: Model's projections.

4.2. Policy scenarios

The results of policy scenarios are separately explained for each of the scenarios and wherever applicable, the common trends and differences in responses are highlighted and discussed. This section presents a brief overview of the scenario results (in terms of production, consumption, LNG trade, and spot prices) compared to the baseline.

4.2.1. Regional LNG club scenario (S1)

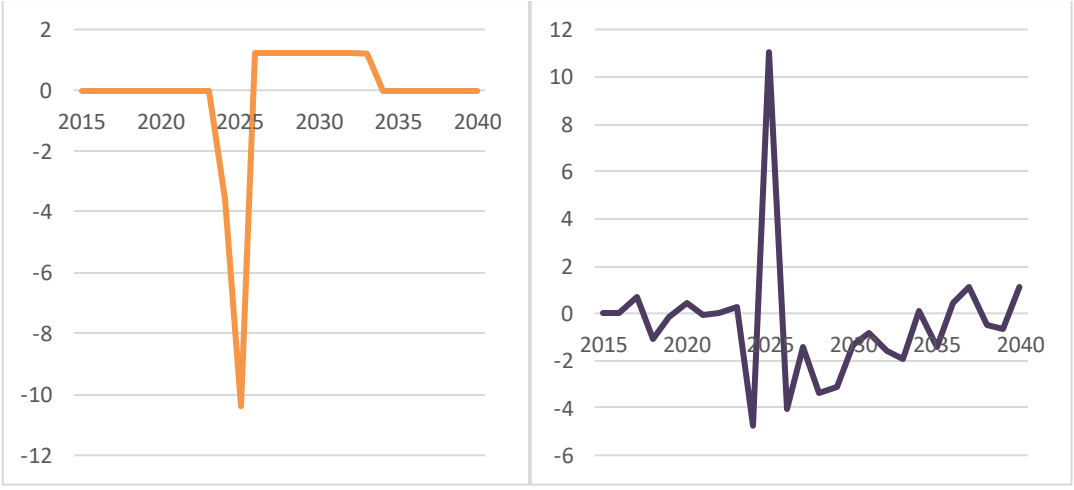
In Scenario 1, we assumed LNG exports to ASEAN would have an ASEAN common destination clause, that is, there is no further restriction of delivery of LNG cargos among ASEAN members. The impact on the production and consumption of natural gas in the region is minimal. This is because the rearrangement of contractual terms leading to a regional LNG supplier has no effect on the regional demand and supply fundamentals.

Gas production in the region is slightly increased, especially during the transition years (by +2 bcm, between 2025 and 2028) for regional LNG exporters, Malaysia and Indonesia. This increased production is consumed domestically and is not traded i.

The impact on total regional LNG trade, especially on regional LNG imports is minimal (Figure 8). This is expected as the aggregated supply of LNG with destination-free clauses within the ASEAN region changes the mode of supply but does not affect the quantity of supply. The total contracted and uncontracted imports by source see changes mostly during the transition period of 1 year (2025-26). The spike in uncontracted imports during 2025 is due to the expiry of LNG contracts from the Middle East and North America, which get substituted by uncontracted LNG imports from East Africa, Nigeria and Australia.

LNG exports are unaffected, as contracted and uncontracted LNG exports see no significant changes. This is due to the regional LNG procurement arrangement not changing the competitiveness of the exports or export contracts. Therefore, the region exports as much LNG as in the baseline scenario.

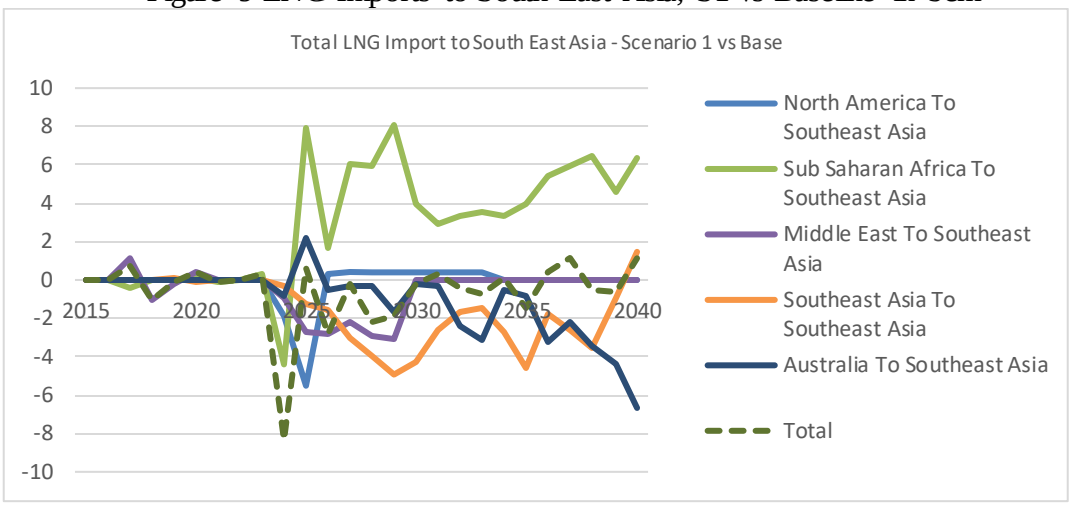
Figure 8 Total contracted (left) and uncontracted (right) LNG imports to South East Asia. S1 vs Baseline in bcm



Source: Model's projections.

However, if we examine composition of LNG imports, changes can be observed, but in small scale. The start of aggregation in LNG supply in ASEAN results in reductions in North American and Australian imports (from 2026 onwards) and corresponding increases in imports from the East African (Sub Saharan Africa) region (Figure 9).

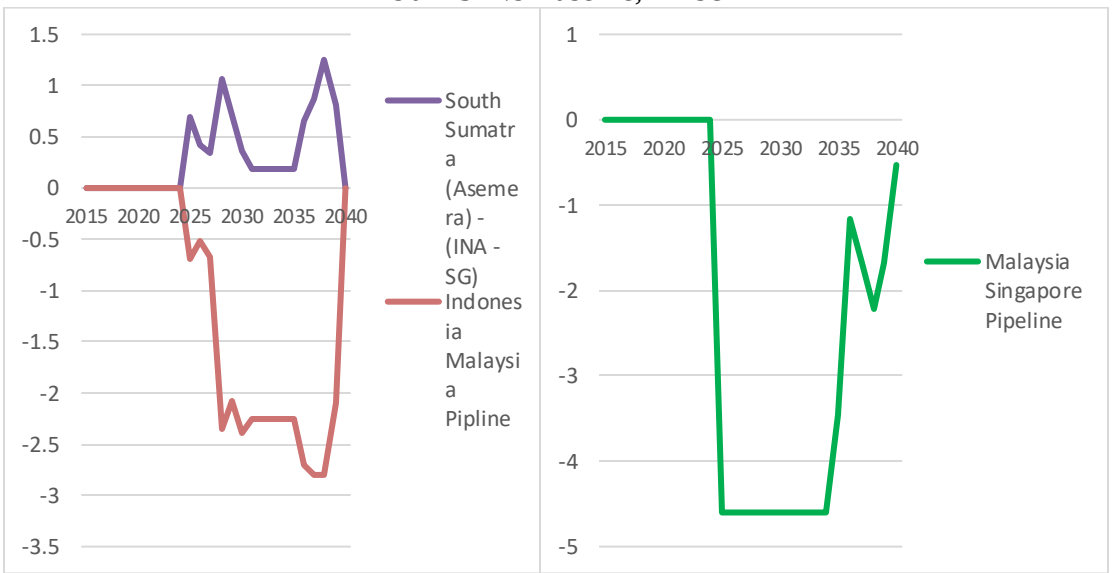
Figure 9 LNG Imports to South East Asia, S1 vs Baseline in bcm



Source: Model's projections.

Total pipeline trade changes are not significant for most AMS (Figure 10).

Figure 10 Pipeline contracted (left) and uncontracted (right) flows in South East Asia - S1 vs Baseline, in bcm

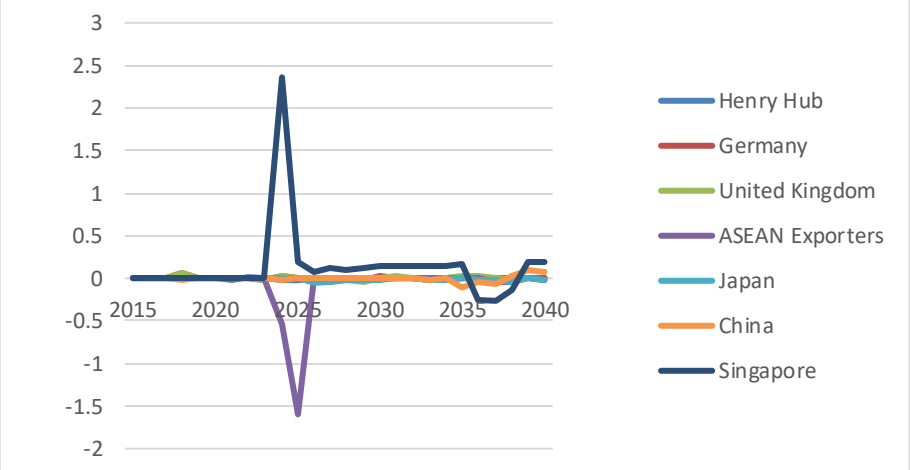


Source: Model's projections.

This is expected due to the scenario setup having no changes in the pipeline infrastructure and contractual arrangements in the region. However, we see changes in the reorganisation of pipeline trade flows in both scenarios for Singapore, Malaysia and Indonesia pipeline trades. Singapore imports less uncontracted pipeline gas in an integrated market scenario, substituting it with LNG because pipeline gas is diverted to other markets, such as the Philippines and this affects Malaysian and Indonesian trade.

The relatively lower uncontracted (spot) trade changes and overall small differences in trade patterns result in only minor changes in spot prices (Figure 11). The spike in Singapore spot price in 2024 is due to an increase in market tightness due to the start of re-arrangements in trade flows, and is largely normalised from 2025 onwards. The Asia Pacific exporters' decrease in spot price is due to the reduced Australian trade flows, as they get substituted by LNG from East Africa, thus resulting in a less tight export market in the region.

Figure 11 Spot price S1 vs baseline, in USD/MMBtu



Source: Model's projections

Regional gas market integration and the consequent aggregation of LNG demand sees more purchasing of cheaper LNG sources destined for the region. Intra-South East Asian trade marginally declines in this scenario (S1) due to higher domestic production, especially from Indonesia and Malaysia. East African LNG supply is preferred because of relatively smaller shipping distances and favourable Henry hub (HH) indexed prices. This would mean integrated LNG markets that can aggregate cheaper LNG sources and thus reduce total procurement costs, hence beneficial for regional trade. All of these factor result in the costs of procurement differing by 0.1% from the baseline scenario for the world total (Table 2). Even though the South East Asian market is an important LNG supplier, this small difference is not surprising since the market's significance will decline over time. Furthermore, LNG trade and Southeast Asia's gas consumption are only a small proportion of global gas consumption.

Table 2 Normalised, total cost of procurement for all South East Asia scenarios (2017-40), %

	World's Total (%)					ASEAN Total				
Normalised cost	Base line	S1-Club	S2 – TAGP	S3-Hub	S4-Spot	Base line	S1-Club	S2 – TAGP	S3-Hub	S4-Spot
Production	100	99.97	100.0	99.9	99.95	100	100.2	100.3	100.0	100.6
Pipe Contract	100	100.2	99.9	100.2	99.5	100	100.0	90.0	106.4	82.9
Pipe Uncontracted	100	99.8	100.3	100.0	100.4	100	94.8	107.7	98.3	99.96
LNG Contracted	100	99.8	100.0	99.8	94.7	100	94.5	100.0	95.4	38.0
LNG Uncontracted	100	89.0	98.9	99.2	88.0	100	98.4	91.2	98.4	106.9
Liquefaction cost	100	99.8	99.4	99.96	98.2	100	100.2	94.2	100.4	95.3
Regas cost	100	100.3	99.3	99.9	98.9	100	101.7	92.9	100.0	95.1
Total procurement cost	100	99.9	99.98	99. 9	98.4	100	97.9	99.0	99.0	94.5

Source: Model's projections.

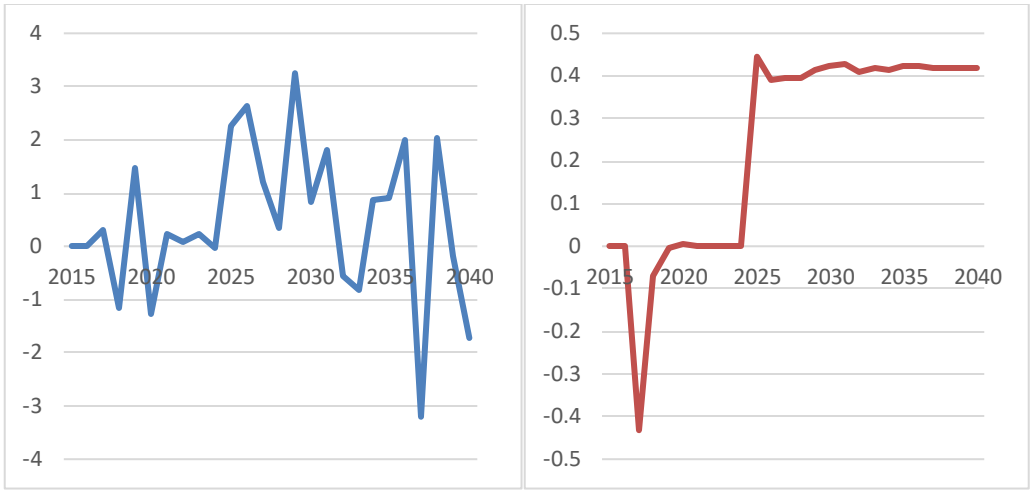
However, the impact for the South East Asian region is relatively significant. The reconfiguration of trade arrangements results in an integrated LNG market, which sees increased procurement of cheaper LNG cargoes, without affecting total production, consumption, and pipeline trade in the region. The cost of procurement is lower in ASEAN by 2.1% (Table 2). Most of the cost savings are the result of buying lower cost LNG.

4.2.2. Full functional TAGP scenario (S2)

In the TAGP scenario (S2), the whole TAGP infrastructure network spanning the region is assumed to be operational, including the provision of reverse flow in each of the pipelines. This is a well-established scenario that the AMS are in the process of implementing. But the current implementation does not consider reverse flow of pipelines because the plan is to build up bilateral contracted trade which is often unidirectional.

The effect of the TAGP results in the viability of marginal production from higher cost sources due to the availability of lower cost transportation in the TAGP network. There is marginally increased regional production, especially in Malaysia due to the presence of the TAGP pipeline enabling transport of the produced gas within the regional demand centers (Figure 12).

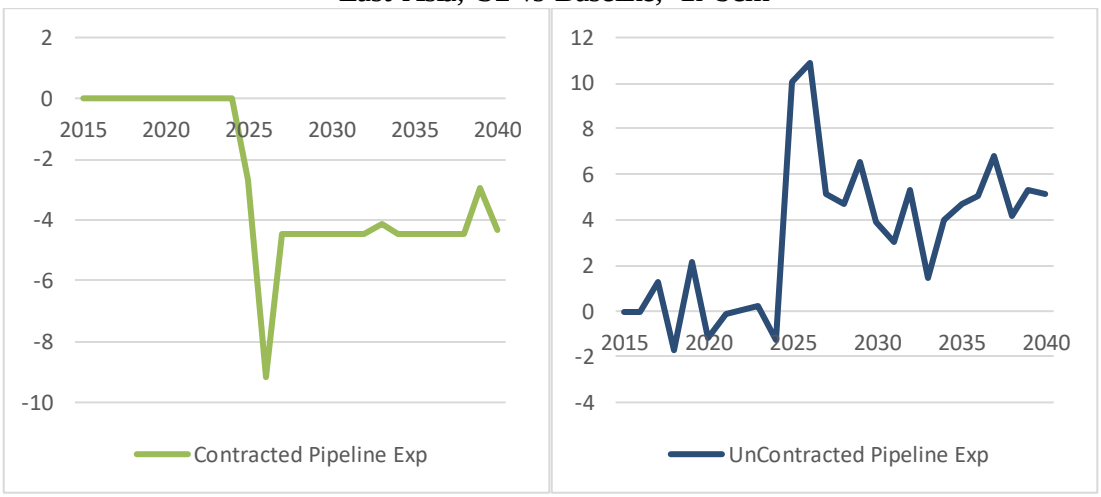
Figure 12 Production (Left) and Consumption (Right) in South East Asia, S2 vs Baseline, in bcm



Source: Model's projections.

The key change in the TAGP scenario is in the increased intra-regional pipeline flows at the expense of LNG flows. Since this scenario ensures that all pipeline contracts post-2025 expire and the gas is traded freely in the TAGP network, contracted flows decline and uncontracted pipeline flows increase (Figure 13).

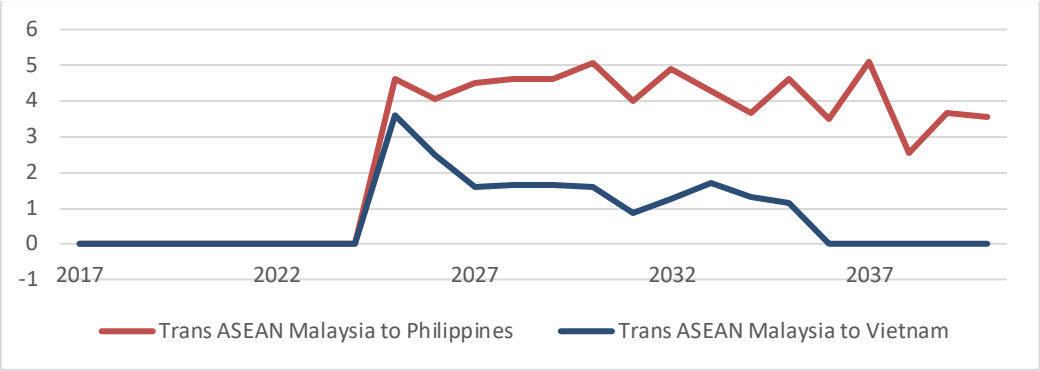
Figure 13 Contracted (Left) and Uncontracted (Right) pipeline exports to South East Asia, S2 vs Baseline, in bcm



Source: Model's projections.

Significant pipeline trade through newly enabled TAGP pipelines connecting Malaysia to neighbours Vietnam and Philippines show the viability of the TAGP (Figure 14).

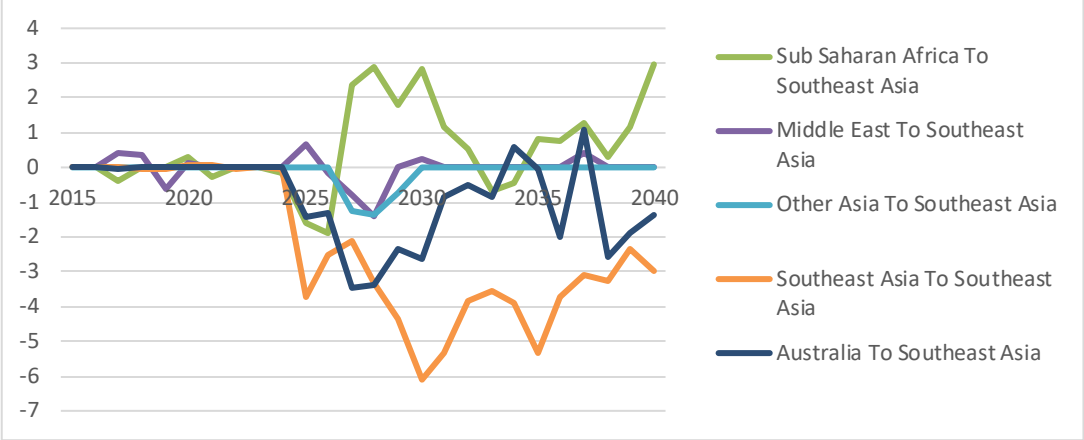
Figure 14 Uncontracted pipeline flows in TAGP pipelines -S2 vs Baseline, in bcm



Source: Model's projections.

The increased spot traded pipeline flows displace intra-regional LNG trade in the region, mainly on uncontracted exports and imports. There is reduction in intra-ASEAN LNG trade from Indonesia and Malaysia and the decline in intra-regional trade results in an overall decline in LNG imports. This is on account of the increased yearly production of +3 bcm that is transported via the TAGP pipeline, which is cheaper than the marginal supply of LNG from Australia, the Middle East, and North America. This reduced intra-regional trade is re-routed to East Asia. LNG exports from the HH indexed sources such as East African (Sub Saharan) LNG are largely unaffected and marginal gains in market share occur. We conclude that the intra-regional pipeline trade flows increase at the expense of LNG flows (Figure 15).

Figure 15 LNG imports to South East Asia, S2 vs Baseline, in bcm



Source: Model's projections

This rearrangement of trade flows has only minimal impacts on the regional and global spot prices. This is due to the small sizes of the extra volumes transmitted via gas pipeline vs LNG.

The impact of the TAGP is understood to be beneficial for higher production within ASEAN, and to assure utilisation of pipeline resources instead of costlier LNG. This results in a marginal reduction of 1% in ASEAN's procurement costs when compared to the baseline scenario (Table 2). Most of the savings are due to the reduced LNG supply due to increases in ASEAN production transited through the intra-regional Trans-ASEAN gas pipeline.

4.2.3. Hub indexed regional gas markets (S3)

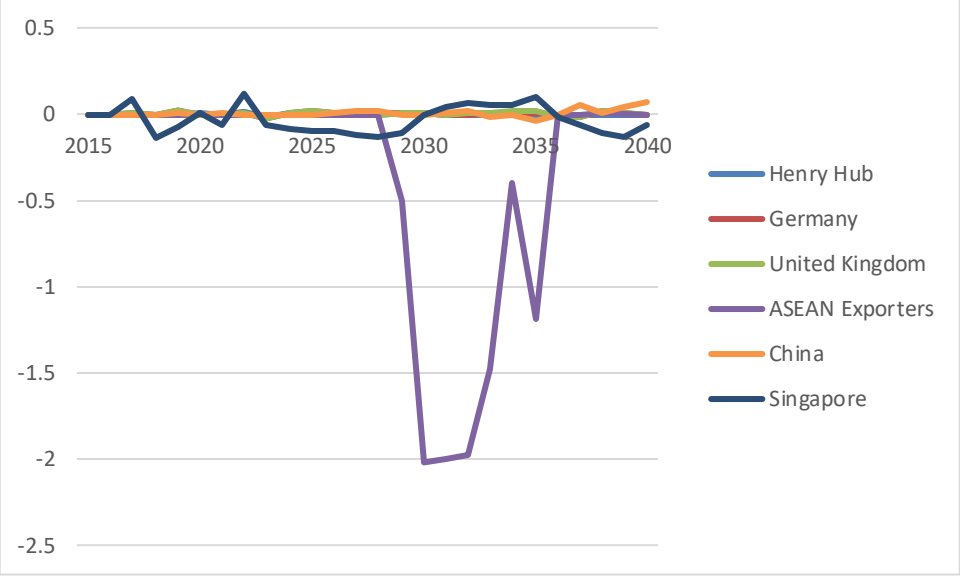
In Scenario 4, we set a single benchmark price that acts as reference for all the trade contracts and spot trades in both pipelines and LNG trades in the ASEAN region. It is simulated with the same infrastructure, contractual, and trade arrangements as the baseline scenario. The key difference is that all the trades are indexed to Singapore spot prices from 2025 onwards. Considering that the Singapore spot price is an LNG DES price, we set a natural gas version of the Singapore benchmark price by

subtracting a US$2.3/MMBtu liquefaction cost (following Shi and Variam (2017) with further update) for indexation of pipeline contracts in the region. We also assumed that the regional gas prices are formed on pure gas competition. More details about the modelling of this scenarios can be found in a Northeast Asian study (Shi and Variam, 2016).

After switch to hub indexation, production in the region fluctuates in small scale but there is no clear change in the trend. Another key result is that with the change in hub indexation, the ASEAN gas market is relatively unaffected in terms of trade.

Spot prices in the region are declining with all the pipeline and LNG trade indexed to Singapore hub prices. Spot prices show a decrease for both Asia Pacific exporters due to the increased production leading to less tight export markets in the region. This can potentially result in reduced overall procurement costs for LNG in the region (Figure 16).

Figure 16 Selected spot price, S3 vs Baseline, in USD/MMBtu



Source: Model's projections.

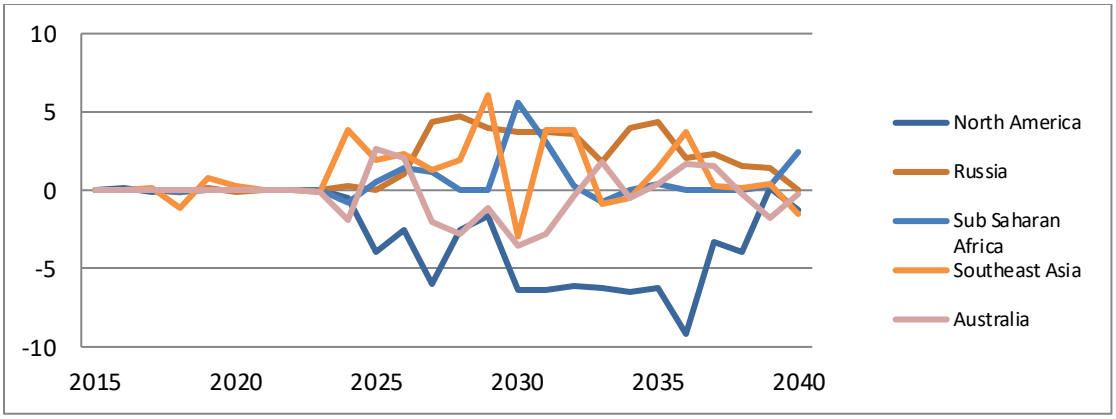
The cost saving potential is supported by the cost of procurement for the region (Table 2). Both contract and uncontracted LNG costs have been reduced. Despite the fact that pipeline gas has seen a rise and fall in contracted and uncontracted form, the total procurement cost saving for the region is about 1%.

While we use the Singapore price as the benchmark, the results are robust in terms of different price benchmarks. Our earlier study (Shi and Variam, 2016) of the East Asian markets with similar scenario settings suggests that changes in benchmark prices (to other spot price indexes in the region) do not influence the conclusions regarding the production, consumption, prices, and trade patterns of an integrated market.

4.2.4. ASEAN spot market scenario (S4)

In the simulation for Scenario 4, we assumed that the Singapore spot price was the regional benchmark price for both LNG and pipeline trades. Any pipeline and LNG existing contracts that expire before 2025 are not renewed. All contracts in the South East Asian region that are active are allowed to continue but after 2025, their destination and TOP clauses will be removed. Supply contracts without destination and take-or-pay clauses that are indexed to regional spot prices are effectively spot only contracts. This scenario is modelled as a combination of Scenarios 1, 2, and 3. As a result, only 15.35 bcm of pipeline contact is changed, specifically for the Myanmar-Thailand and Indonesia- Malaysia pipeline contracts (Figure 17).

Figure 17 Production in key producers - S4 Vs Baseline, in bcm

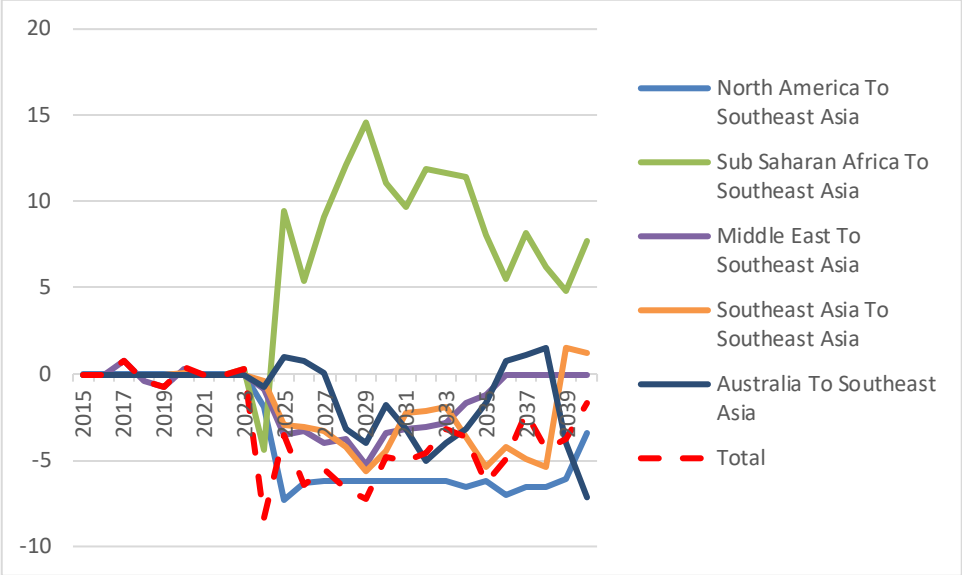


Source: Model projections.

There is an increase in global natural gas production in Scenario 4 when compared to the baseline, but the scale is limited. This is in line with the larger changes in the scenario that enable infrastructural and contractual changes for a fully integrated spot-only market in ASEAN. In general, The South East Asian production is incentivised in a spot regional integrated market. The presence of a pipeline network that enables cheap transportation of domestically produced gas that would otherwise be shut causes the increase in South East Asian production. North American production declines (<1%) and Australian production also declines which is due to the decrease in LNG exports to ASEAN. Consumption patterns remain the same as in the baseline scenario.

Further changes are observed in the LNG and pipeline trade patterns in Scenario 4, both within the region and globally. Increases in ASEAN production result in displacement of some of the intra-regional LNG trade; hence, there is a net decline in LNG imports for the region. Similarly, imports from HH-indexed East African LNG can displace imports from other regions and thus become the only increasing source of supply for Southeast Asia (Figure 18).

Figure 18 LNG imports to South East Asia, S4 vs Baseline, in bcm

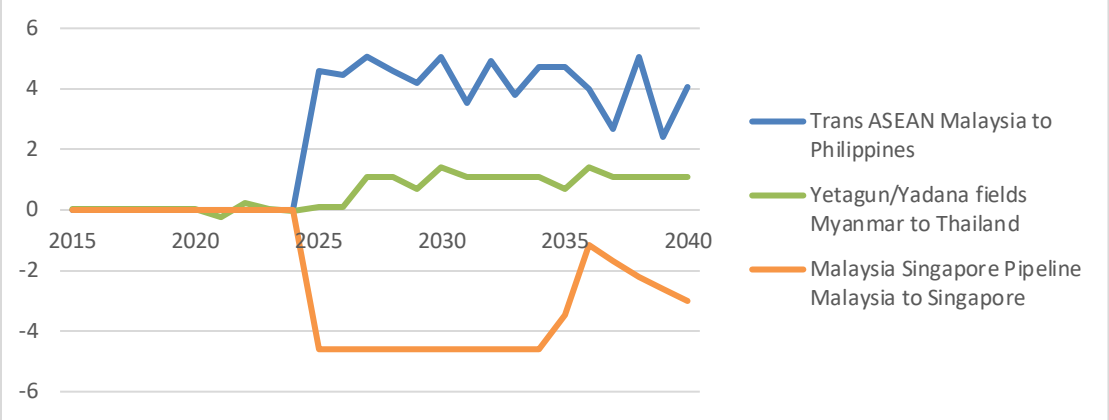


Source: Model projections.

With the change of all the LNG supply contracts post 2025, there is a sharp decline in contracted LNG imports and an increase in spot imports. Contracted LNG exports are not affected because they are not phased out in the simulation. However, the region exports less uncontracted LNG, mainly to Japan and South Korea.

For pipe imports, with the expiry of pipe contracts we see a spot-only pipeline gas market. There are no changes to the inter-regional pipeline exports, namely the Myanmar and China pipeline trade. Changes and reorganisation of intra-regional trade are observed (Figure 19).

Figure 19 Major uncontracted pipeline trade (imports/exports) to South East Asia, S4 vs Baseline, in bcm



Source: Model projections.

The key point to note is that Malaysia exports more gas to the Philippines than to Singapore, where LNG trades dominate. This would imply a reorganisation of ASEAN gas trade flows based on the relative costs of gas. Being the price hub, Singapore sees more LNG trade that displaced pipeline gas from Malaysia because it is more economical region-wide to export Malaysian gas to the Philippines through the TAGP. We also observe good utilisation of the TAGP network, especially for Malaysian and Indonesian trades.

Spot price changes follow the same pattern as in Scenario 1 (integrated ASEAN market scenario), i.e., only minor changes in spot prices.

The key takeaway is that, as a market with predominantly LNG-based trade, any changes in the LNG trade patterns will have larger effects on prices than on pipelines. This is observed in the small change in spot prices for the TAGP only (S2) scenario. However, this does not mean that efficient utilisation of pipelines does not result in cost savings. The cost savings result from the higher production in the region being transported more efficiently via the pipeline network too.

If we compute the cost of procurement of natural gas for both the global case and for the ASEAN region, we find that the spot scenario of gas market integration (S4)

results in lower costs for the region (Table 2). This scenario results in the lowest procurement costs for the ASEAN region (about 5.5%) and the world (1.6%). The cost savings are due to incentivised domestic production, lower priced pipeline shipments, and LNG imports from a less tight market. The lower cost results are also due to efficient utilisation of both the pipeline network and LNG terminals to re-route to the best markets as appropriate, based on demand and supply fundamentals.

5. Conclusions and policy implications

Natural gas is playing an important role in the current energy transition and ASEAN is a useful example for the study of gas market integration. This region will play an important role in future global energy markets due to its vast energy demand growth potential. The efforts to battle climate change and the projected continued dominance of coal in the energy mix call for ways to increase the share of natural gas in the energy mix over the next two decades.

Given ASEAN's uneven level of economic development and its abundance of natural gas resources, gas market integration could optimise gas supply and demand across the region and thus reduce the cost of gas supply. This will further encourage the penetration of natural gas as an immediate substitute for coal, and therefore lower overall emissions. However, the ASEAN gas market integration in ASEAN has not be advanced yet. Even the TAGP that is the foundation of gas market integration has been marginalised because of a widening supply-demand gap and proliferation of LNG terminals.

This paper develops four subregional and regional gas market integration scenarios that can achieve the AEC vision of optimising the use of natural gas. The major instrument is cross-border trading of pipeline gas. Along with an integrated LNG

market, the TAGP network can support the transportation of natural gas in a more efficient way. These trading scenarios are expected to reduce ASEAN gas supply costs by further utilising the existing TAGP and LNG RGT infrastructure and increasing the cost competitiveness of natural gas compared to non-trading scenarios, thereby improving the penetration of gas in the national energy mix and ultimately adding momentum to the TAGP development. The impacts of these scenarios were simulated using the Nexant World Gas Model.

The simulation results confirm that integrated LNG markets and pipeline markets are beneficial for the region in terms of total gas procurement cost savings. The TAGP is beneficial as a transportation network that incentivises the production of natural gas that can be transported cost effectively to demand centres. In the various policy scenarios, there is a displacement of LNG imports, even though the impact on prices is minimal. The relatively lower price of pipeline gas to LNG and displacement potentially result in lower procurement costs for the region and the world. The further development of marginal production from higher cost sources in ASEAN due to the availability of lower cost transportation is in line with ASEAN's interests in resource optimisation and energy security enhancement.

Another key takeaway is that, as a market with predominantly LNG-based trade, any changes in the LNG trade patterns will have larger effects on prices than on pipeline trade. If we study the scenarios separately, the scenario of a fully integrated and spot-traded ASEAN LNG market (S4) results in the largest impacts on trade and prices and the least cost.

The estimated economic benefits resulting from regional gas market integration are conservative. In the simulation, we considered only the current play on infrastructure, such as the TAGP and RGT. We did not consider further optimisation of infrastructure, such as building new pipelines and sharing of RGTs among countries, which could be developed immediately if there were no significant cross-country barriers. We also did not account for benefits from demand response in our model, as demand was exogenously set and fixed.

Based on the study, we can make the following policy recommendations:

First, in addition to TAGP, ASEAN members needs to advocate gas market integration. The TAGP, even with the inclusion of RGTs, is only an infrastructure project. Though essential, it is not sufficient for gas market integration. A key element that is missing is the willingness to conduct cross border trading. The widely held concern for energy security in ASEAN need not prevent the envisioning of gas market integration. First, the process will be time consuming because infrastructure planning requires long lead time. Therefore, the current barriers are not a problem. Second, the continuous development of trust building in the AEC is much needed for the integration. However, given the existing numerous barriers that need to be overcome to enable freer transport of gas across borders, the development of ASEAN gas market integration would have to be incremental.

Second, key institutional gas trading issues such as open access of infrastructure, harmonisation of gas quality specifications, gas transit principles (transport of gas involving three or more countries), and business models need to be established to enable regional wide gas trade. The AMS could start to consider third party access (TPA) to pipelines and RGTs unilaterally and thus pave the way for potential utilisation of infrastructure by their parties, particularly, from other countries. This

unilateral action has been taken in Singapore and is in progress in Malaysia. Other AMS could follow and gradually open their gas sectors.

Last, for ASEAN's own economic interests, the AMS need to expedite the development of a more flexible market, including relaxing destination limitations, changing price indexation, and relaxing contractual terms. Nevertheless, since ASEAN has a mix of LNG and gas exporters and importers, there may be opposing economic interests in this process. However, the presence of the AEC offers a unique opportunity to reconcile the different interests and thus create change. Such a successful change would offer lessons for Northeast Asia, which is in the process of a similar transition (Shi et al., 2019; Shi and Variam, 2016). The ASEAN gas market integration could also win ASEAN a benchmark hub price for the natural gas market, which was proved to be fragmented in East Asia (Shi et al., 2019).

This present paper has some limitations, which could be addressed in the future. First, the model assumes exogenous determined consumption and no market power. Therefore, the possible interaction between oil and gas markets or between gas markets, such as identified in the recent literature (Ji et al., 2018a; Shen et al., 2018; Zhang et al., 2018b), are not able to be captured. Second, the model does not endogenize LNG infrastructure and contracts and thus is not able to accommodate the significant dynamics of LNG trade (Zhang et al., 2018a). Third, the price in the model is mainly driven by production costs with no consideration of other market factors that have been well documented in the literature, such as other regional gas markets (Geng et al., 2016a), the US shale gas revolution (Geng et al., 2016b; Ji et al., 2018b), oil markets (Ji et al., 2018a; Shen et al., 2018; Zhang et al., 2018a), and gas market financialization (Ji and Zhang, 2019; Shi et al., 2019).

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