

FEATURE ARTICLE:

Small-scale LNG expands global energy access through decentralized logistics

The global energy landscape is undergoing a structural shift toward decentralized distribution, driven by the economic and logistical limitations of traditional, large-scale pipeline networks and accelerating decarbonization pressures. This transition is being facilitated by small- and micro-scale LNG solutions, which provide a flexible alternative for producing, transporting, and utilizing natural gas in niche or remote markets that are otherwise inaccessible or uneconomical. By leveraging mobile, intermodal logistics, these solutions transform natural gas from a fixed-route commodity into a versatile energy source, creating a decentralized framework that adapts to localized energy demands. This ensures reliable off-grid energy for critical applications, ranging from local power generation and industrial sites to city gas networks and heavy-duty transport.

Small-scale LNG (SSLNG) is defined as a sector comprising liquefaction and regasification terminals with capacities between 0.05 and 1 Mtpa. This infrastructure employs storage and transport assets such as tank farms and specialized LNG carriers with capacities ranging from 500 to 30,000 m³ or 60,000 m³, depending on industry contexts. Operationally, SSLNG is categorized into two primary value chain models: 1) dedicated chains, where LNG is transported via small-scale LNG carriers from liquefaction plants to small-scale regasification terminals for subsequent maritime (vessels) and inland (trucks) distribution; 2) break-bulk chains, where large-scale regasification terminals serve as hubs to reload LNG onto smaller/bunkering vessels for regional maritime delivery or utilize "virtual pipelines", primarily LNG tank trucks, to supply regional inland end-users directly.

Model 1 (dedicated chains) offers the key advantage of geographic flexibility, as small-scale LNG carriers are able to access remote areas that cannot accommodate conventional large-scale LNG carriers. This model requires lower initial capital investment and can be deployed faster than massive infrastructure projects, making it an ideal "entry-level" solution for rapidly converting smaller power plants from carbon-intensive fuels to cleaner-burning natural gas, while also allowing incremental scaling as local demand grows.

However, this model has a key limitation, as its lack of economies of scale leads to significantly higher unit costs for LNG transport compared with bulk shipments. The dedicated chains are also operationally fragile because supply depends on a specific carrier-terminal pairing; any mechanical failure, scheduling issue, or weather-related delay can seriously disrupt the end-user's energy supply and continuity. Unlike large-scale infrastructure with extensive storage buffers, this model requires careful operational management, proactive monitoring, and contingency planning, which further increases the overall logistical and operational risk.

In this analysis, Model 1 SSLNG trade encompasses seaborne volumes transported by small-scale LNG carriers with capacities below 60,000 m³, covering both primary exports and the growing volume of re-exports from importing hubs. Between 2015 and 2025, global SSLNG trade more than doubled to reach 2.1 Mt, reflecting a significant expansion in the specialized infrastructure required to serve fragmented and off-grid markets. This growth has been underpinned by the proliferation of marine bunkering facilities for ship-to-ship fuelling and the increased use of LNG tank trucks as the final onshore link for distributing seaborne volumes to inland end-users. Despite this robust decade of expansion, the segment remains a specialized niche, representing only 0.5% of total global seaborne LNG trade in 2025.

On the export side, Malaysia solidified its position as the preeminent SSLNG exporter in 2025, followed by Indonesia, Singapore, Spain, and Russia, primarily by leveraging its extensive network of small-scale loading facilities and regional bunkering hubs to capture emerging demand (Figure i). This market leadership in Southeast Asia was mirrored by a significant structural shift in the Caribbean, where the strategic importance of the United States Virgin Islands (USVI) as a break bulk hub diminished substantially. This decline followed the March 2025 commencement of regular, direct LNG shipments from the US mainland to Puerto Rico.

On the import side, Asia and Europe were the major players (Figure ii). China, Indonesia, Japan, Finland and Sweden solidified their positions as the largest individual importers, each utilizing small-scale solutions to address specific logistical and environmental challenges. In Asia, China continued its dominant role, driven by the massive expansion of LNG-powered heavy-duty trucks and regasification stations in industrial clusters, while Indonesia and Japan focused on providing off-grid power to remote islands and supporting LNG marine bunkering. In Europe, Finland and Sweden led the continent by integrating SSLNG into their industrial sectors and expanding small-scale terminal networks to displace carbon-intensive fuels.

Figure i: Trend in global SSLNG exports by country

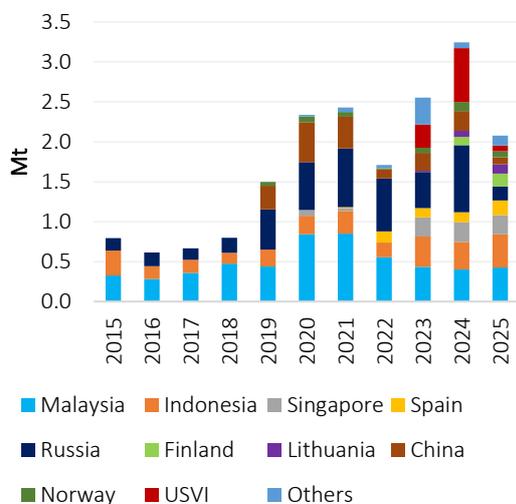
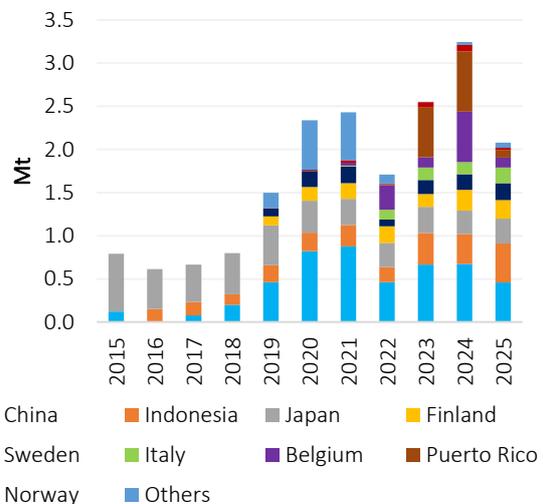


Figure ii: Trend in global SSLNG imports by country



Source: GECF Secretariat based on data from ICIS LNG Edge

In the meantime, Model 2 (break-bulk chains) offers the primary benefit of economies of scale, as it leverages massive liquefaction and large-scale LNG carriers to move the bulk of the volume at a significantly lower unit cost than dedicated small-scale chains. By utilizing large-scale regasification terminals as regional hubs, this model creates a high degree of logistical flexibility, where LNG can be "repackaged" into LNG tank trucks or small vessels to reach a diverse range of inland and coastal end-users without the need for expensive, dedicated maritime infrastructure at every destination.

Conversely, the main disadvantage of this model is the high initial capital requirement and complexity of the regasification terminal, which must be equipped with specialized reloading arms and truck-loading bays to handle small-scale distribution. Furthermore, this model is heavily dependent on existing infrastructure; if a region lacks a large-scale terminal or a well-developed road network for virtual pipelines, the break-bulk approach becomes unfeasible, leaving remote or geographically isolated markets underserved despite its overall cost efficiency.

Break-bulk distribution via trucked LNG functions as an efficient virtual pipeline, bridging the infrastructure gap between large-scale regasification terminals and inland end-users situated beyond the reach of traditional gas grids. This land-based model has emerged as the dominant logistical method within the SSLNG sector, leveraging specialized LNG tank trucks to transport liquefied gas at -162°C to off-grid industrial sites, remote power plants, and refuelling stations. By utilizing the existing road network, these virtual pipelines offer unparalleled scalability. They allow suppliers to match delivery volumes precisely to customer demand without the massive capital expenditure or long-term lead times required to lay physical pipelines.

On a global level, break-bulk distribution via trucked LNG represents the most significant volume driver within the small-scale LNG sector, particularly across Europe and Asia. In Europe, trucked LNG is primarily driven by advanced terminal infrastructure, offering a truck-loading capacity of around 1.8 Mtpa across major import hubs, in particular in Spain, France and the Netherlands, and serving as a critical virtual pipeline for decarbonizing off-grid industries switching from carbon-intensive fuels to meet stringent EU emission standards. This growth is further fuelled by a mature network of LNG refuelling stations supporting a specialized fleet of heavy-duty vehicles as part of a broader transition to cleaner transport fuels. In Asia, trucked LNG growth is driven by large inland gas demand in regions where pipeline infrastructure is either underdeveloped or geographically challenging, making land-based distribution the most practical “just-in-time” energy solution for rapidly expanding decentralized markets. China remains the global leader in this model, using a massive fleet of LNG tank trucks to deliver fuel to industrial users and a domestic fleet of LNG-powered heavy-duty trucks that has now reached 1 million units.

The economics of trucked LNG versus regasified LNG delivered by gas pipelines involve a trade-off between capital intensity and operational flexibility. Physical pipelines require substantial upfront CAPEX but offer the lowest per-unit cost for high-volume, steady-state demand over short-to-medium distances. In contrast, trucked LNG minimizes initial investment but incurs higher OPEX due to fuel, labour and maintenance costs per km travelled. However, trucked LNG becomes economically advantageous for decentralized or remote markets where pipeline construction is geographically challenging. In terms of distances, trucked LNG is economically optimized for deliveries within a 200 to 600 km radius, providing a superior energy-to-payload ratio over CNG while remaining cheaper than constructing new physical pipelines for remote markets at distances up to 900 km. Additionally, the high energy density of LNG, occupying only 1/600th of its gaseous volume, enables cryogenic trailers to deliver “just-in-time” energy with scalable flexibility, avoiding the risk of stranded assets inherent in fixed pipeline networks.

It is important to note that trucked LNG volumes consistently exceed maritime SSLNG deliveries because the majority of loadings occur directly at large-scale regasification terminals (Model 2), entirely bypassing the maritime small-scale transportation step (Model 1).

Furthermore, break-bulk distribution via smaller carriers or bunkering vessels, including ship-to-ship transfers, allows major global hubs like Rotterdam and Singapore to provide just-in-time refuelling at anchorages, bypassing the need for capital-intensive shore-side infrastructure at every berth. By leveraging a global fleet of over 60 active LNG bunkering vessels, this model provides the logistical flexibility necessary to meet stringent international emission mandates while retaining the economies of scale associated with large-scale LNG sourcing.

Micro-scale LNG (MSLNG) represents the smallest and most specialized segment of the small-scale LNG value chain, involving capacities of up to 500 cubic meters. It is focused on either monetizing stranded low-volume gas resources or delivering energy to regions disconnected from conventional infrastructure. MSLNG relies on flexible intermodal transport using ISO containers, forming efficient virtual pipelines. A standard 40-foot cryogenic ISO container holds 20 tonnes of LNG, equivalent to 45 cubic meters of liquid or 27,000 cubic meters in its gaseous state, and can be transported by truck, rail, or ship to final destinations. LNG can be sourced from small-scale liquefaction plants, large-scale regasification terminals, or flared gas recovery sites. The defining characteristic of MSLNG is its modular and adaptable system, distinguishing it from SSLNG, which serves larger regional networks.

The Americas constitute a major regional market, where LNG ISO containers function as a critical virtual pipeline for rapid fuel switching and for providing energy access to off-grid locations. The market experienced a notable shift, peaking at 50,000 tonnes in 2022 before stabilizing at over 25,000 tonnes in 2025. This adjustment was largely driven by the operational maturation of large-scale terminals in Jamaica, which enabled a transition from decentralized MSLNG deliveries to more efficient bulk LNG imports. The US remained the regional anchor, accounting for 24,000 tonnes of ISO-based exports in 2025, while Puerto Rico leveraged its strategic position to re-export 1,400 tonnes to neighbouring Caribbean markets. Currently, Barbados and the Bahamas represent the largest destination markets for these specialized deliveries, while Haiti and Antigua and Barbuda maintain consistent, smaller-volume imports to support localized energy needs.

SSLNG and MSLNG represent a specialized niche within the global energy market. By filling critical gaps in the global distribution network, these segments offer a flexible framework compared to the traditional LNG sector, relying on capital-intensive infrastructure and large economies of scale.

For gas exporters, SSLNG and MSLNG provide a strategic mechanism to monetize stranded assets and diversify their customer base beyond traditional, long-term export contracts. Producers can capture emerging demand in niche markets, such as archipelagic regions, vast continental interiors, and remote industrial or residential zones that are too small for world-scale infrastructure, while minimizing investment risks and avoiding stranded capacity. This flexibility allows exporters to respond dynamically to market shifts and optimize their production by supplying smaller, high-value volumes to niche sectors like LNG bunkering and LNG-fuelled trucks.

For gas importers, SSLNG and MSLNG serve as critical instruments for enhancing energy security. These solutions function as virtual pipelines, providing a reliable energy supply to remote end-users that are geographically or economically isolated from national grids. By utilizing intermodal logistics such as ISO containers and LNG tank trucks, importing nations can scale their gas infrastructure with far lower capital intensity compared to conventional pipeline projects.

These LNG solutions are particularly important for developing nations across Africa, Asia and the LAC region, providing a scalable entry point into the global gas market. SSLNG requires targeted investment in small-scale coastal infrastructure to serve regional hubs, whereas MSLNG bypasses permanent infrastructure by using standardized ISO containers, allowing rapid deployment in remote or hard-to-reach locations. These solutions promote economic and social development by replacing expensive and carbon-intensive fuels in off-grid industries and isolated communities, reducing energy poverty and fostering local employment. By leveraging these flexible virtual pipelines, emerging economies can quickly establish decentralized energy systems that support industrial growth and enhance long-term resilience, while minimizing the risk of stranded assets.