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OIL GLUT CLAIMS INCORRECT, DEMAND TO RISE: NASSER

BY ABDULAZIZ KHATTAK

Aramco CEO cites robust demand growth and market resilience despite challenges

AMIN Nasser, Saudi Aramco CEO, has firmly rejected claims of an oil glut, insisting the global energy market remains robust and well balanced.

Speaking to *CNBC* at the world Economic Forum (WEF) in Davos, he emphasised that demand for oil, gas and coal hit record levels last year and continues to do so this year, with no evidence of oversupply in physical markets.

Nasser attributed perceptions of a glut to lower prices rather than fundamentals, pointing out that onshore storage levels sit at the lower end of the five-year average.

He acknowledged disruptions from sanctioned producers but stressed the market's resilience, with barrels redirecting across regions.

Nasser argued that apparent excess barrels are largely confined to offshore storage, with sanctioned volumes from Russia, Iran and Venezuela accounting for nearly 70 per cent of such holdings.



Amin Nasser speaks on a panel at WEF in Davos

Turning to the outlook, Nasser projected continued demand strength, forecasting global oil demand growth of 1-1.3 million barrels per day (bpd) in crude for the coming years, following an increase of almost 1.2 million barrels last year.

He dismissed suggestions of peak demand, noting consistent upward revisions to consumption forecasts.

Nasser cautioned that global spare capacity has halved from around 5 million barrels per day, yet the sector has repeatedly demonstrated its

ability to manage volatility.

Aramco maintains maximum sustainable capacity of 12 million bpd and significant spare capacity.

The company is also expanding gas production, targeting 6 million barrels of oil equivalent by 2030, while pursuing renewables to supply nearly 20 per cent of Saudi Arabia's energy needs by the same date.

Nasser highlighted potential in hydrogen and broader energy diversification, provided market offtake materialises. ■

Greenpeace Mena calls for fossil fuel phase-out

GREENPEACE Mena is urging oil-dependent Mena economies to reject GDP-first growth and phase out fossil fuels.

In an exclusive interview with *OGN*, Ghiwa Nakat, the group's Executive Director, proposes scaling distributed renewables via rooftop solar and community microgrids, securing fair climate finance, and enforcing polluter-pays mechanisms.

Through its 'Major Air Polluters in Africa Unmasked' report, Greenpeace exposes energy-sector emissions as a major driver of air pollution and health crises.

She calls the 'Make Polluters Pay' campaign's landmark environmental taxation victory in Iraq instrumental, and calls for oil and gas firms to halt expansion and fund climate damages.

"A just energy transition aligned with a wellbeing economy requires phasing out fossil fuels, prioritising local energy supply, and expanding distributed renewable systems such as rooftop solar and community microgrids," says Nakat.

Full Report on Page 20



Aramco reports \$6bn in AI-driven technology realised value

SAUDI Aramco recorded \$6 billion in AI-driven technology realised value (TRV) during 2023-2024, with Amin Nasser, President and CEO, projecting an additional \$3-5 billion in 2025.

More than 50 per cent of the TRV is directly attributed to AI applications, he said during a panel discussion at the World Economic Forum in Davos.

Nasser highlighted rapid progress in deployment, noting that Aramco's AI use cases expanded from 400 last year to 500 this year.

"(Of these) 100 use cases went from the pilots to actual deployments," he said.

To support this acceleration, Aramco has trained 6,000 subject matter experts in AI fundamentals, enabling frontline staff to identify and prioritise high-impact opportunities.

This is in addition to the hundreds of data analysts the energy giant already employs to turn AI insights into measurable operational gains.

Quantified operational impacts include upstream productivity improvements of 30-40 per cent in certain wells.

In downstream operations, AI systems delivered margin improvements by adjusting parameters in

seconds rather than relying on manual decisions.

Nasser said HUMAIN, a PIF-backed AI company in which Aramco holds a significant minority stake, will pursue growth opportunities in data centres, applications, and chips both locally and globally.

These advances are set against Aramco's substantial investment programme, with annual capital expenditure of \$50-60 billion and approximately \$100 billion in projects currently under construction, illustrating the enterprise-wide scope and potential of AI integration across the organisation. ■

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With the modernisation programme, Bapco's refining capacity increased from 267,000 bpd to about 400,000 bpd



BAHRAIN NAVIGATES GCC'S MOST CONSTRAINED HYDROCARBON FUTURE

As the smallest GCC producer confronts depleting reserves and surging electricity demand, the Kingdom is pursuing a pragmatic hybrid strategy blending refining prowess, gas imports, and cautious renewable deployment

BY ABDULAZIZ KHATTAK

BAHRAIN stands at a critical juncture in its energy trajectory, constrained by geology yet strategically positioned to reinvent itself as a downstream and logistics powerhouse within the world's most carbon-intensive region.

Unlike its hydrocarbon-wealthy neighbours, the Kingdom only produces 200,000 barrels of oil equivalent per day (boepd), predominantly from the ageing Bahrain Field and the offshore Abu Saafa field shared with Saudi Arabia. It also faces the Gulf Cooperation Council's most acute depletion challenge.

Yet Bahrain's integrated national energy champion, Bapco Energies, has emerged from a 2022 merger as one of the region's most vertically integrated operators, combining upstream production, refining, petrochemicals, marketing, and nascent renewable ventures under a single corporate umbrella.

This consolidation reflects a broader strategic pivot: Leveraging refining scale, import infrastructure, and geographical proximity to Saudi Arabia's Eastern Province to secure energy suf-

ficiency even as domestic reserves dwindle.

The Kingdom's 2030 Economic Vision and subsequent National Energy Strategy explicitly acknowledge this reality, prioritising energy security, diversification of supply sources, and incremental decarbonisation over grandiose renewable targets that lack economic foundation.

BAHRAIN'S ENERGY EVOLUTION & STRATEGIC VISION

Bahrain's energy model has historically rested on two pillars: Modest oil production dating to 1932, and a world-class refining sector developed to process both domestic and imported Saudi crude.

The country's refinery, commissioned in 1936 and progressively expanded, now processes 400,000 barrels per day (bpd) following the completion of Bapco Modernisation Programme (BMP), which achieved record throughput in 2024 and represents one of the Middle East's most significant downstream transformations of the past decade.

Shaikh Nasser bin Hamad Al Khalifa, Representative of His Majesty the King for Humanitarian Work and Youth Affairs, Chairman of Bapco Energies, announced in December 2025 that the modernised refinery

had achieved unprecedented production levels one year after its formal inauguration, processing heavier crude grades and producing cleaner fuels meeting international environmental standards whilst improving energy efficiency across operations.

For decades, this configuration allowed Bahrain to punch above its weight in energy exports, but declining production from the Bahrain Field has forced a fundamental re-assessment.

The government's response has centred on three strategic pillars: Maximising recovery from existing fields, securing long-term import agreements, and gradually introducing renewable capacity to offset domestic consumption growth.

This vertical integration allows the group to optimise operations from wellhead to retail forecourt, capture margins across the value chain, and deploy capital strategically in response to market signals and national priorities.

Bahrain's National Energy Strategy, pledges net-zero emissions by 2060, and about 20 per cent renewable penetration by 2035, a modest goal by global standards but realistic given the Kingdom's limited land area, relatively high population den-

sity, and the absence of significant wind or geo-thermal resources.

The strategy also emphasises regional energy integration, particularly through gas imports from Saudi Arabia via the Abu Saafa offshore pipeline and potential future pipeline expansions, as well as liquefied natural gas (LNG) imports through the Bahrain LNG terminal commissioned in 2019.

This terminal has a capacity of 800 million cu ft per day (mmscfd), effectively doubling Bahrain's gas supply and ensuring feedstock security for both power generation and petrochemical production.

CURRENT DEVELOPMENTS IN THE SECTOR

Bapco Energies has prioritised upstream rejuvenation through enhanced oil recovery techniques, and has focused on incremental production gains from existing fields and on downstream expansion.

During Bapco Energies' Q4 2025 board meeting, the company reported significant achievements across its portfolio, including enhanced refinery margins, improved upstream recovery rates, and progress on renewable energy initiatives that underscore the group's commitment to energy transition within a commercially viable framework.

On the power generation side, Bahrain's Electricity and Water Authority (EWA) continues to procure capacity through independent power projects, with the 1,500-megawatt (MW) Al Dur 2 combined-cycle gas turbine plant, commissioned in phases from 2019, now providing the backbone of the national grid.

Renewable energy deployment has advanced cautiously, with a 150 MW solar facility underway. Expected to be completed in Q3 2027, the plant located in the southern region near Bilaj Al Jazayer, will span 1.2 sq km and will generate enough electricity to power over 6,000 homes while cutting over 100,000 tonnes of carbon emissions.

Bapco Energies has accelerated its renewable portfolio through multiple solar initiatives, including a 5-MW solar plant at its refinery that offsets a portion of the facility's substantial electricity consumption and demonstrates the technical feasibility of integrating intermittent renewable power into energy-intensive industrial operations.

The company has also commissioned a 2.8-GW solar plant in Saudi Arabia's Eastern Province, with Saudi developer ACWA Power.

Built over several phases, the plant will be co-located with a battery energy storage system (BESS), and power generated at the project will be transmitted to Bapco Energies.

WHERE BAHRAIN'S REAL ENERGY STRENGTHS LIE

Bahrain's enduring competitive advantage resides not in primary hydrocarbon production but in midstream and downstream activities where infrastructure, expertise, and location converge.

The Bapco refinery complex, with its deep-water port, extensive product storage, and proximity to major Asian and European markets, functions as a critical link in regional supply chains, processing Saudi crude for export and domestic consumption.

The facility's upgraded configuration, following the modernisation programme's completion, enables processing of up to 400,000 bpd of heavier, higher-sulphur crude grades whilst producing ultra-low sulphur diesel, jet fuel, and other products that command premium pricing in increasingly stringent regulatory environments.

Bapco Energies' refining margins benefit from feedstock agreements that provide crude at favourable terms, and the facility's optimisation, in-

corporating hydrocracking units, delayed coking capacity, and advanced distillation, positions it competitively against regional peers whilst reducing emissions intensity per barrel processed.

The petrochemical sector, anchored by GPIC's methanol and ammonia plants and expanding through partnerships with regional players, leverages access to competitively priced gas feedstock and established export infrastructure.

Bahrain's aluminium smelter, Aluminium Bahrain (Alba), though not strictly part of the energy sector, represents another energy-intensive industry that has thrived due to long-term power supply agreements and operational excellence, and its expansion to nearly 1.6 million tonnes per annum (mtpa) underscores the Kingdom's ability to sustain industrial scale despite resource constraints.

In renewable energy, Bahrain lacks the expansive desert tracts of Saudi Arabia or the UAE, but its compact geography, high solar irradiance averaging 2,200 kilowatt-hours per sq m annually, and advanced grid infrastructure provide a foundation for distributed solar and potential rooftop deployment at scale.

The Kingdom's nascent interest in green hydrogen remains speculative but could leverage excess renewable power, desalination infrastructure, and export facilities if costs decline and demand materialises.

THE OPTIMAL PATH FORWARD

Evidence overwhelmingly supports a hybrid energy model for Bahrain, anchored by sustained hydrocarbon refining and petrochemical operations, supplemented by increasing renewable penetration to moderate domestic consumption growth and emissions intensity.

Pursuing a rapid renewable transition would undermine the Kingdom's established industrial base, sacrifice refining revenues that underpin fiscal stability, and impose unsustainable costs on public finances already strained by subsidy obligations and infrastructure demands.

Conversely, ignoring renewable deployment would leave Bahrain vulnerable to carbon border adjustment mechanisms, reputational risks, and the long-term erosion of competitiveness as cleaner alternatives become economically compelling.

The optimal trajectory involves maximising asset life and efficiency in refining and petrochemicals, progressively integrating solar and potential wind capacity to reduce gas consumption in power generation, and exploring niche opportunities in hydrogen and carbon capture where Bahrain's industrial ecosystem provides natural advantages.

Bapco Energies' performance since integration validates this balanced approach, demonstrating that energy transition can proceed incrementally without sacrificing the competitive advantages that sustain Bahrain's economy.

This approach aligns with the Kingdom's fiscal realities, respects physical and geographical constraints, and positions Bahrain as a pragmatic energy partner within a region undergoing uneven decarbonisation.

MAJOR PUBLIC & PRIVATE PROJECTS

Bapco Energies is advancing carbon capture initiatives at its refinery, targeting initial pilot-scale projects that could eventually sequester several hundred thousand tonnes of CO₂ annually, though commercial viability remains contingent on carbon pricing mechanisms and regulatory clarity.

Tatweer Petroleum, as Bapco Energies' dedicated upstream operating company for the Bahrain Field, is implementing advanced reservoir man-

agement techniques, including water injection optimisation and horizontal drilling programmes, to arrest production decline and extend the field's economic life.

In downstream infrastructure, Bapco Energies has commissioned new fuel storage facilities and is expanding its retail network across Bahrain and neighbouring markets, capitalising on brand recognition and supply chain integration through Bapco Trading and Bapco Retail.

GEOGRAPHICAL & LOGISTICAL LEVERAGE

Bahrain's location adjacent to Saudi Arabia's Dammam-Khobar industrial corridor, connected by the King Fahd Causeway and proximate to the Ras Tanura export terminal, provides unmatched access to the world's largest crude exporter and a ready supply of feedstock and gas.

The Kingdom's Khalifa bin Salman Port, expanded in recent years to accommodate larger vessels and increased container throughput, functions as a regional transshipment hub and could support future energy exports, including refined products, petrochemicals, or hydrogen derivatives.

Bahrain International Airport's cargo facilities and the Kingdom's advanced telecommunications and financial services infrastructure further enhance its viability as a logistics and trading centre for regional energy markets. The island's compact geography allows for efficient pipeline networks, streamlined distribution, and rapid infrastructure deployment relative to larger neighbours.

Strategic initiatives such as the proposed GCC electricity grid interconnection, which would allow cross-border power trading and enhance supply security, could position Bahrain as a net importer during peak periods and a potential exporter during periods of surplus renewable generation.

Bahrain's regulatory environment, characterised by relatively transparent licensing, established legal frameworks, and openness to international partnership, attracts investment in ways that some regional peers struggle to replicate.

DOMESTIC ENERGY DEMAND OUTLOOK

Bahrain's electricity consumption has grown at approximately 3–5 per cent annually over the past decade, driven by population growth, industrial expansion, and rising air conditioning demand in one of the Gulf's most humid climates.

Current peak demand exceeds 4,000 MW during summer months, with total installed capacity marginally above this level, leaving limited reserve margins and necessitating ongoing capacity additions.

Natural gas demand similarly continues to rise, fuelled by power generation, Alba's smelter operations, petrochemical feedstock requirements, and the gradual penetration of gas in residential and commercial sectors.

Electricity and water tariffs have been reformed to reduce subsidies for households and commercial users, but industrial consumers and Bahraini nationals continue to benefit from preferential rates that blunt demand-side response.

Projections from the EWA suggest that without aggressive efficiency measures or transformative shifts in industrial structure, demand could reach 6,000 MW by 2035, requiring an additional 2,000 MW of capacity and corresponding gas supply.

Renewable penetration, even if scaled to 10 per cent of generation, would displace only a fraction of this growth, underscoring the enduring centrality of gas imports and the strategic importance of supply agreements with Saudi Arabia and LNG suppliers. ■

The Barakah Nuclear Energy Plant in Abu Dhabi, UAE, serves as a blueprint for the GCC



Bahrain's nuclear pivot: Why SMR model matters for Kingdom

Following Singapore's measured approach, the Kingdom should invest in capability now, preserve options for deployment later, and ensure it controls its energy destiny

BY ABDULAZIZ KHATTAK

NUCLEAR energy represents Bahrain's most viable pathway toward sustainable energy independence, offering a reliable, low-carbon baseload solution that addresses the Kingdom's fundamental constraint: simultaneously meeting soaring industrial demand whilst honouring net-zero commitments within its 786 sq km land area.

The technology would enable Bahrain to maintain energy security without perpetuating carbon-intensive generation, providing round-the-clock capacity that intermittent renewables cannot deliver at the scale required by aluminium production and desalination infrastructure.

For small Gulf states confronting identical geographical and industrial pressures, nuclear power functions not merely as diversification but as strategic necessity.

It's the only proven technology capable of supplying gigawatt-scale baseload without territorial consumption or weather dependency.

Bahrain's emerging interest in small modular reactor (SMR) technology signals recognition that its measured approach to nuclear readiness offers a viable template for small states navigating impossible energy trilemmas.

Electricity consumption has steadily risen over

the last 10 years, rising from 16 GW in 2015 to 19 GW in 2024. That's a 15 per cent increase occurring alongside commitments to achieve 20 per cent renewable energy capacity by 2035.

With a small land area and per capita energy consumption ranking among the world's top five, the mathematics of solar-only decarbonisation simply fail.

Current SMR designs occupy approximately 40,000 sq m per 300-megawatt (MW) unit, according to World Nuclear Association specifications.

Equivalent solar capacity would require 15-20 sq km of dedicated land, approximately 2.5 per cent of Bahrain's total territory for a single baseload replacement unit.

A hypothetical 300-MW small modular reactor operating at 90 per cent capacity factor delivers 2,365 GW-hours annually, replacing approximately 1,200 MW of solar capacity when accounting for intermittency and storage losses.

THE SINGAPORE PARALLEL

Singapore's systematic capability-building programme provides the essential precedent for how resource-constrained states should approach nuclear energy without gambling national budgets on unproven implementation timelines.

In 2022, its Energy Market Authority report con-

cluded that nuclear energy could supply approximately 10 per cent of national requirements by 2050, supporting net-zero targets without commitment to deployment.

The city-state is conducting comprehensive safety and feasibility assessments of advanced nuclear technologies, focusing explicitly on small modular reactors rated below 300 MWs.

Bahrain's recent signals mirror this trajectory.

Mark Thomas, Bapco Energies Group CEO, confirmed at the Middle East Petroleum & Gas Conference that the country is exploring SMR deployment in the 2030s.

The Kingdom has signed a Country Programme Framework with the International Atomic Energy Agency for 2024-2029, establishing cooperation pathways without binding deployment commitments.

REGIONAL PRECEDENT

The United Arab Emirates' (UAE) Barakah nuclear plant provides the most proximate reference case for Bahrain, both evidence of implementation challenges and proof that Arab Gulf states can execute large-scale nuclear programmes.

Barakah's four APR-1400 reactors now supply approximately 25 per cent of UAE electricity, preventing 22 million tonnes of annual greenhouse





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Bahrain's nuclear pivot: Why SMR model matters for Kingdom

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gas emissions equivalent to removing nearly five million vehicles from roads.

The path to this achievement, however, illuminates why Bahrain should favour Singapore's gradualist approach.

Barakah's initial \$20 billion budget escalated to \$32 billion by 2020, a 60 per cent cost overrun that transformed project economics, reported by Power Technology.

This and other examples from around the world underscore why Bahrain cannot simply replicate UAE's traditional gigawatt-scale approach but must instead pursue the SMR favours.

Beyond construction and cost challenges, nuclear deployment in the Arabian Peninsula confronts distinctive operational and security vulnerabilities.

Barakah's Arabian Gulf cooling water source operates at 33–34 deg C, approaching thermal limits for conventional nuclear cooling systems and potentially worsening with climate change.

In December 2017, Yemen's Houthi rebels claimed launching cruise missiles toward Barakah, highlighting vulnerability concerns in a region experiencing the world's highest frequency of aerial attacks on nuclear facilities.

Security and safety considerations matter acutely for Bahrain given its small size and dense population distribution.

Emergency planning zones for SMR typically span 5–10 km, potentially encompassing significant residential areas in Bahrain's compact geography where population density reaches 2,115 people per sq km.

Additionally, Bahrain must invest years building domestic expertise before any reactor commissioning.

ECONOMIC LOGIC & FINANCIAL REALISM

The industrial economics driving Bahrain's nuclear consideration diverge sharply from residential electricity narratives.

Aluminium Bahrain (Alba) operates the world's largest smelter outside China, producing 1.548 million metric tonnes annually with power consumption equivalent to the kingdom's entire national grid; approximately 4,200 MWs of continuous baseload demand.

Barakah's operational experience validates nuclear's cost competitiveness despite construction overruns.

Robin Mills of Qamar Energy projected Barakah electricity costs at approximately 11 US cents per kilowatt-hour (kWh), remaining competitive for reliable low-carbon baseload despite delays.

Finland's Olkiluoto 3, among the world's most expensive nuclear projects at EUR11 billion, still delivers electricity at 7 cents per kWh over its operational lifetime, less than one-quarter the 32 cents per kWh Germany's solar programme costs when accounting for total subsidies.

The economic case for SMRs, however, remains contested territory requiring transparent assessment.

Ontario Power Generation's Darlington project, featuring four GE Hitachi BWRX-300 reactors totalling 1,200 MW, carries a CAD20.9 billion budget, or approximately CAD17,400 per installed kilowatt.

NuScale's Idaho project demonstrated the volatility inherent in nascent technologies.

Target power prices escalated from \$58 per MW-hour in 2021 to \$89 per MW-hour by 2023, a 53 per cent increase driven by construction cost es-



**Pairing SMRs
with continuous
industrial
load, potentially
supplemented by
desalination
requirements
creates anchor
tenancy that
reduces per unit
financing costs**

calation from \$5.3 billion to \$9.3 billion for 462 MW.

These figures require contextualisation against Bahrain's alternatives.

Solar-plus-storage configurations for baseload applications deliver levelised costs of \$135–184 per MW-hour according to Ontario's Independent Electricity System Operator comparative analysis, substantially above nuclear projections even accounting for cost overruns.

However, Bahrain's comparative advantage lies in potential demand aggregation.

Pairing SMRs with continuous industrial load, potentially supplemented by desalination requirements and future green hydrogen production, creates anchor tenancy that reduces per-unit financing costs.

Singapore lacks equivalent industrial concentration, making Bahrain's nuclear economics potentially more favourable despite smaller state resources.

Regional coordination through proposed GCC frameworks could further distribute capital requirements.

The Baker Institute for Public Policy's December 2024 analysis noted that member states hosting nuclear plants could share planning costs with partners like Bahrain, Kuwait, and Qatar.

Realistic SMR reactor deployment would not eliminate Bahrain's hydrocarbon dependence nor should that be the objective.

Two 300-MW units operating at 90 per cent capacity factor would generate approximately 4,730 gigawatt-hours annually, covering roughly 25 per cent of Bahrain's 2024 generation of 19,009 gigawatt-hours.

This level of nuclear baseload would liberate natural gas currently consumed for power generation for higher-value applications including petrochemical feedstock, liquefied natural gas export during price spikes, or green hydrogen production.

Current electricity generation remains 73.68 per cent natural gas-dependent.

Introducing 25–30 per cent nuclear baseload alongside existing renewable capacity targets would create genuine fuel diversity without grid stability complications.

Currently, Bahrain lacks dedicated nuclear reg-

ulatory infrastructure, operational experience pools, and specialised legal frameworks governing reactor licensing, fuel cycle management, and decommissioning liability.

The IAEA's Country Programme Framework provides technical cooperation but cannot substitute for domestic capacity.

Singapore's nuclear programme timeline, spanning pre-feasibility studies through 2025 capability-building towards potential 2030s deployment, illuminates the institutional development required.

Similarly, the UAE established its Federal Authority for Nuclear Regulation in 2009, three years before Barakah construction commenced, investing in regulator training, developing inspection protocols, and recruiting international expertise.

Bahrain would require comparable institutional development spanning 5–10 years minimum before any credible licensing process could commence.

Public acceptance constitutes another dimension, which Singapore addresses through systematic engagement campaigns explaining both benefits and risks.

Decommissioning planning represents frequently overlooked regulatory requirements.

The UAE's Nawah Energy Company submitted decommissioning plans forecasting 13 years per reactor unit beginning five years after final shutdown, with costs potentially reaching several billion dollars.

Bahrain's optimal strategy mirrors Singapore's pragmatic gradualism: Commit to systematic capability development whilst monitoring SMR commercial deployments in Canada, the UK, and Poland that will validate or refute vendor cost and schedule claims.

At home, the UAE's experience demonstrates that well-capitalised Gulf states can execute nuclear programmes when approached systematically with appropriate international technical support.

Bahrain could leverage existing Barakah operational data, UAE regulatory frameworks, and Korean vendor experience whilst avoiding first-of-a-kind risks by selecting proven small modular reactor designs approaching commercial deployment.

The critical insight distinguishes between having nuclear capability and exercising that option.

Singapore demonstrates that small states can build readiness infrastructure preserving strategic flexibility whilst avoiding catastrophic discovery in 2035 that nuclear would have been optimal but institutional capacity was never developed.

Similarly, Finland's Olkiluoto 3, despite 14-year delays and triple-budget overruns, now provides 30 per cent of national electricity whilst reducing Russian import dependency by 60 per cent, validating nuclear's long-term value proposition even when implementation proves difficult.

The question facing Bahrain is not whether to definitely deploy small modular reactors by 2035, but whether to position itself to make that decision from technical competence and strategic optionality rather than improvised desperation.

Singapore's measured approach provides the answer: Invest in capability now, preserve options for deployment later, and ensure the kingdom controls its energy destiny rather than accepting whatever technologies remain available when crisis forces decision. ■

Solar paradox as industrial rooftops surge while residential adoption stalls

Despite leading commercial rooftop projects, Bahrain's residential solar is negligible even as solar resources, falling PV costs and net-zero goals signal untapped potential

BY ABDULAZIZ KHATTAK

BAHRAIN'S November 2025 announcement of the world's largest single-site rooftop solar installation, a 50 MWp system spanning 262,000 sq m atop Bahrain Steel's stockyard (a Foulath Holding and Yellow Door Energy company) shed, demonstrates the Kingdom's technical and commercial viability of distributed photovoltaic (PV) generation.

Yet this industrial achievement, part of a broader 123 MWp programme developed by Foulath Holding and Yellow Door Energy, starkly contrasts with the Kingdom's minimal residential rooftop adoption, exposing a fundamental disconnect between commercial-scale economics and household deployment barriers.

Bahrain's solar resource base provides approximately 2,200 kWh per sq m annually at the optimum tilt angle of 26 degrees, and an average daily sunshine exceeding 10 hours, according to the Global Solar Atlas data cited in Oxford Academic's Clean Energy journal.

Field studies of four government-supported domestic installations recorded specific yields ranging from 1,254 to 1,468 kWh/kW annually, substantially below theoretical projections.

As of late 2024, Bahrain's cumulative solar capacity stood at 66 MW, representing 0.03 per cent of electricity generation in a 99.97 per cent natural gas-dependent grid.

The residential sector accounts for negligible capacity despite consuming over 50 per cent of the Kingdom's total electricity production.

ECONOMIC HEADWINDS SUPPRESSING HOUSEHOLD DEPLOYMENT

Bahrain's non-subsidised categories will see increases from 29 to 32 fils per kWh effective January 2026, though subsidised tiers for citizens remain unchanged.

These artificially suppressed tariffs fundamentally undermine rooftop solar economics.

Academic studies suggest purchase tariffs of 75 to 85 fils per kWh (\$0.20 to 0.23 per kWh) with 30 per cent capital subsidies would enable viable residential deployment.

Alternative analyses proposed 100 fils per kWh (\$0.27 per kWh) feed-in rates to achieve three-year payback periods for domestic installations.

The world's largest single-site rooftop solar power plant at Bahrain Steel will have a capacity of 50 MWp



Current net-metering frameworks, whilst operational since 2017 provide energy credits rather than monetary compensation, a mechanism deemed ineffective given Bahrain's low consumption tariffs.

Projected levelised costs of electricity for solar photovoltaics range from \$0.049 to 0.063 per kWh in 2025, declining to \$0.036 to 0.055 per kWh by 2035.

These figures demonstrate technical cost-competitiveness against conventional generation yet fail to translate into household adoption drivers when retail tariffs remain below 5 US cents per kilowatt-hour.

Global residential system costs average \$2.80 to 3.80 per watt in 2025, positioning a typical 7.8 kWp domestic installation between \$21,840 and 29,640 before incentives.

Without robust financing mechanisms or substantial subsidies, these upfront expenditures exceed accessibility thresholds for most Bahraini households, particularly when extended payback periods eliminate investment rationale.

The government's 2017 pilot programme installing 7.8 kWp systems on 10 residential buildings yielded valuable performance data but failed to catalyse broader market development.

Annual electricity generation from these pilot installations ranged from 9,995 to 11,448 kWh, with performance ratios between 65.6 and 75.1 per cent.

Feasibility analyses for Khalifa Town's 1,724 villas concluded that 17 kW systems could meet 43 per cent of the settlement's total electricity demand, generating 44,953 MWh annually, according to research published in ScienceDirect.

POLICY CHALLENGES

The Foulath-Yellow Door Energy programme operates under a 20-

year power purchase agreement, with Yellow Door Energy financing, designing, constructing, and maintaining the installations.

The 123-MWp project spanning 707,000 sq m across 14 sites will generate approximately 200 million kWh in its first operational year, reducing carbon emissions by 90,000 metric tonnes.

Industrial off-takers benefit from avoided capacity investments whilst accessing clean energy at competitive rates through long-term contracts, arrangements unavailable to residential consumers.

The broader programme includes the 72 MW Sakhr multi-site development combining rooftop, ground-mounted, and car park installations.

Additional major projects include a 100-MW Al Dur utility-scale plant, a 150-MW Sakhr facility, and a 46.2 MW-University of Bahrain installation.

These utility and commercial-scale developments align with Bahrain's National Renewable Energy Action Plan targets of 5 per cent renewable penetration by 2025 and 10 per cent by 2035, later revised to 20 per cent by 2035 following COP26 commitments.

The Kingdom's Net-Zero by 2060 objective provides policy direction yet lacks the residential-focused interventions required to democratise rooftop solar access.

As of mid-2023, Bahrain's installed solar capacity totalled approximately 57 MW, leaving substantial headroom for expansion.

The residential segment's negligible contribution reflects not technical constraints but policy design prioritising large-scale deployment over distributed household generation.

Structural obstacles beyond economics compound residential de-

ployment challenges.

Building stock varies considerably in roof suitability, with older constructions potentially requiring structural reinforcement to support panel loads.

Design aesthetics and social roof utilisation patterns—particularly for gathering spaces—constrain available surface area.

Architectural analyses of Khalifa Town housing revealed that structural and design limitations restricted approximately 65 per cent of total roof area from photovoltaic application.

ENVIRONMENT-DRIVEN OPERATIONAL DEMANDS

Bahrain's desert climate generates frequent dust accumulation on panel surfaces, reducing generation efficiency whilst high ambient temperatures lower PV performance relative to standard test conditions.

Without clear government guidance or standardised quality benchmarks, homeowners face information asymmetries potentially deterring adoption.

The contrast with successful regional models highlights Bahrain's policy gaps.

Jordan's aggressive feed-in tariff structures and net-metering implementation have driven significant residential deployment.

The UAE has advanced distributed generation through Dubai's Shams initiative and Abu Dhabi's regulatory frameworks supporting prosumer models.

Saudi Arabia's Vision 2030 renewable targets include specific residential solar provisions with enabling regulatory architectures.

Bahrain possesses comparable or superior solar resources yet lacks the incentive structures catalysing household participation. ■