The Energy Port: The Conversation Has Changed – *Recognizing an Emerging Inflection Point in Port Energy Systems*[1]

Paul E. Kent, PhD[2]

Several months ago, I explored a question in an article that, at the time, seemed more speculative than practical: *Could ports someday consider small modular reactors (SMRs) or microreactors as part of their long-term energy strategy?*[3]

The purpose of that article was not to advocate nuclear energy. Rather, it presented a structured framework for evaluating one option among many as ports confronted an increasingly uncertain energy future. Electrification, automation, shore power, and the prospect of hydrogen production were all pointing toward one conclusion: tomorrow's ports would require far more electricity than yesterday's.

Since then, something important has happened – the conversation has moved beyond theory. In July 2026, the U.S. Maritime Administration (MARAD) and the Port of Long Beach announced a first-of-its-kind partnership to examine the role of advanced nuclear technologies in commercial vessels, ports, and other maritime assets.[4] The agreement does not commit either party to deploying nuclear reactors. Instead, it commits them to something arguably more important: developing the institutional, operational, safety, and regulatory frameworks that would be required if advanced nuclear technologies become part of the maritime sector's future. That distinction is important because it signals that the discussion has begun shifting from *"Could this happen?"* toward *"How should we prepare if it does?"*

More fundamentally, this shift reflects something larger than the emergence of a single technology. Throughout history, transformative infrastructure has rarely succeeded because of engineering alone. It has emerged through the interaction of physical assets, industrial capabilities, institutions, and knowledge. Ports are no exception. Understanding the future of the energy port therefore requires looking beyond reactors themselves and toward the broader systems where they would ultimately operate.

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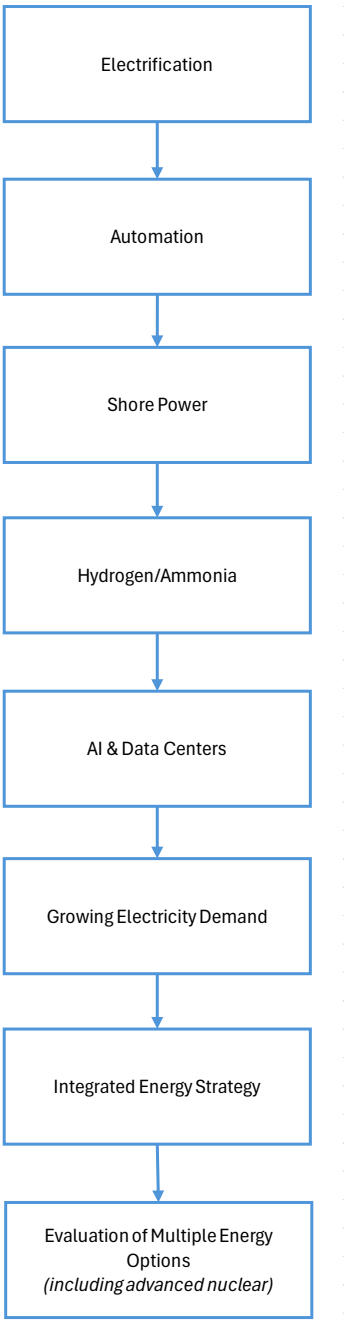
[1] **Introducing *The Beauty of Logistics Notebook*:** The articles in *The Beauty of Logistics* series explore enduring themes in infrastructure, systems, and connectivity. They examine how ports, logistics networks, institutions, and technologies evolve over time, often through the lens of systems thinking and practical experience. Occasionally, however, developments occur that do not warrant a completely new article but nevertheless change, deepen, or reinforce ideas explored in earlier work. Sometimes a new policy is announced. Sometimes an unexpected project emerges. Sometimes geopolitical events alter the context in which earlier ideas were developed. And sometimes several seemingly unrelated developments begin to converge, suggesting that an earlier question deserves another look. *The Beauty of Logistics Notebook* was created for those moments. Rather than replacing earlier articles, these Notebook essays revisit them in light of new developments, offering observations, reflections, and emerging perspectives as the conversation continues to evolve. They are less about providing definitive answers than about recognizing when the questions themselves begin to change. In that sense, each Notebook essay is intended not as a sequel, but as a continuation of an ongoing dialogue about infrastructure, systems, and connectivity.

[2] Senior Vice President, Ports and Logistics, Monument Economics Group, pkent@megconsulting.com.

[3] See Kent, Paul E., "Ports Going Nuclear? A TCO and Risk-Based Assessment of SMRs and Microreactors", *For the Beauty of Logistics* series, available at https://www.linkedin.com/feed/update/urn:li:activity:7407886056202862593/.

[4] Port of Long Beach, "Port of Long Beach, MARAD Sign First-of-its-Kind Partnership Agreement on Nuclear Energy in Maritime", 22 July 2026, available at https://polb.com/port-info/news-and-press/port-of-long-beach-marad-sign-first-of-its-kind-partnership-agreement-on-nuclear-energy-in-maritime-07-22-2026/.

Figure 1. The Convergence Driving the Energy Port



Sometimes the Question Changes Before the Answer Does

Ports and shipping have always adapted to technological change. Steam replaced sail. Diesel replaced coal. Containers transformed breakbulk operations. Automation is reshaping terminal productivity and efficiency. None of these transitions occurred because ports consciously set out to reinvent themselves. They occurred because the systems surrounding ports changed, and ports adapted.

Energy may represent the next such transition. Ports have historically enabled energy transport. Increasingly, they may also need to produce, manage, and distribute it.

1. Ports Are Becoming Energy Systems

One lesson emerges repeatedly in infrastructure planning: major technological transitions rarely arrive as isolated events. They occur when multiple independent trends begin reinforcing one another.[5]

For ports, that convergence is now becoming apparent. Electrification of cargo-handling equipment, automation, shore power requirements, hydrogen production, artificial intelligence, and digital infrastructure are often discussed separately. Yet viewed through a systems lens, they are all manifestations of a broader transformation: ports are becoming increasingly dependent upon reliable, large-scale electricity. The convergence can be visualized as a progression rather than a collection of independent trends (Figure 1).

2. Emerging Port Candidates: Where the Energy Port Concept May Take Shape

Not every port is equally positioned to participate in the emerging energy transition. Rather than focusing on cargo volumes or traditional port rankings, the examples below were selected because they illustrate different combinations of enabling conditions that could support future advanced energy manufacturing or integrated energy strategies.

These conditions may include heavy industrial infrastructure, energy-intensive industries, electrification initiatives, supportive public policy, research institutions, advanced manufacturing capabilities, marine

[5]Nobel Laureate Herbert Simon's concept of *bounded rationality* (*The Sciences of the Artificial*, 3rd ed., MIT Press, 1996) emphasizes that decisions in complex systems are made under conditions of limited information and computational capacity rather than perfect optimization. Laureate behavioral economists Daniel Kahneman and Richard Thaler, along with Amos Tversky subsequently demonstrated that organizational decisions are also influenced by predictable cognitive biases, including status quo bias and loss aversion. Together, these perspectives help explain why institutions often respond cautiously to technological inflection points despite mounting evidence that change is already underway.

logistics, or strategic geographic location. No single factor is decisive. Rather, it is the convergence of several factors that makes these ports noteworthy.

Accordingly, the ports identified below should not be viewed as predictions. Instead, they illustrate different pathways where the "energy port" concept could evolve over the coming decades.

A. Established Industrial Energy Platforms

These are ports where energy-intensive industry already exists. They already function as large-scale industrial systems. For them, advanced nuclear technologies would represent one possible extension of existing energy infrastructure rather than a fundamentally new role.

Port	Why It Matters
Houston	Petrochemicals, hydrogen, industrial electricity demand
South Louisiana	Refining, ammonia exports, Mississippi industrial corridor
Rotterdam	Europe's hydrogen gateway and industrial decarbonization hub

B. Ports Driving Electrification and Innovation

Here, the principal driver is less traditional heavy industry than the convergence of automation, electrification, and digital infrastructure.

Port	Why It Matters
Long Beach	MARAD partnership; shore power; electrification
Port of Virginia	Automation, naval adjacency, shipbuilding, data infrastructure
Tuas (Singapore)	Fully automated mega-port; limited domestic energy resources

C. Emerging Wild Cards

These ports illustrate that the "energy port" concept is not solely about electricity generation. In each case, advanced manufacturing facilities, logistics, research capability, or industrial policy provides a distinct pathway for participating in emerging modular energy supply chains. Their common denominator is adaptability rather than scale.

Port	Why It Matters
Albany	Beacon Island (energy-related industrial facility), adaptable heavy-industrial infrastructure, NYSERDA (New York State Energy Research & Development Authority) policy alignment, and marine logistics
Cartagena	Free zones; advanced manufacturing potential; Caribbean logistics
Busan	Shipbuilding and advanced manufacturing

Port	Why It Matters
Yantai	China's coastal nuclear development and marine industrial strategy

Looking across these examples reveals a broader pattern. No single port possesses every advantage, nor is any one characteristic likely to determine future success. Instead, ports appear most likely to emerge as energy leaders when multiple assets reinforce one another: adaptable infrastructure, supportive public policy, industrial capability, research partnerships, workforce development, and access to capital. In other words, advanced energy strategies are likely to emerge not from ports alone, but from port-centered industrial energy systems.

3. Why Ports Are Becoming Energy Systems

The convergence described in the previous sections has implications extending well beyond any single technology. Individually, electrification, automation, shore power, hydrogen production, artificial intelligence, and digital infrastructure appear to be separate developments. Collectively, however, they point toward one unmistakable conclusion: ports are becoming major energy systems. While ports historically serve as gateways where energy commodities flowed, increasingly they may also become places where energy is produced, managed, converted, stored, and distributed.

A. Why the Conversation Has Changed

For decades, discussions about port energy focused primarily on fuel supply and electrical reliability. Electricity was certainly important, but it was generally treated as a supporting utility rather than a strategic asset.

That assumption is beginning to change. Terminal electrification, automation, shore power, hydrogen production, artificial intelligence, and digital infrastructure are all increasing electricity demand simultaneously. Individually, none of these developments necessarily points toward advanced nuclear energy. Collectively, however, they suggest something much more fundamental – ports are becoming major consumers, and potentially producers, of energy.

That realization changes the discussion. The question is no longer simply how to supply electricity to port operations, but it is how ports should think strategically about long-term energy resilience, reliability, scalability, and competitiveness. Seen in this context, advanced nuclear technologies are not the starting point of the discussion. They are one possible consequence of a much broader transformation.

B. Reflection

Infrastructure planning has traditionally emphasized demand forecasting, engineering feasibility, and financial evaluation. Those disciplines remain necessary. Yet experience suggests that another dimension often influences outcomes just as profoundly: how institutions respond to uncertainty. Organizations, like individuals, frequently display a preference for familiar solutions, even when new technologies begin reshaping the environment around them. Behavioral economists have described these tendencies as *status quo bias*, *loss aversion*, and *bounded rationality*.[6] Infrastructure planning is not immune.

[6] Richard H. Thaler, *Misbehaving* (2015); Richard H. Thaler and Cass R. Sunstein, *Nudge* (2008); Daniel Kahneman, *Thinking, Fast and Slow* (2011).

One objective of systems thinking is not to predict the future with certainty. It is to recognize when multiple trends begin pointing in the same direction. At that point, the most valuable question may no longer be *"Is this technology ready?",* but rather *"Should we begin preparing for the possibility that it soon will be?"*[7] Institutions rarely prepare for technologies they believe impossible. They prepare for technologies they believe increasingly plausible.

Sidebar 1. Six Questions Every Port Authority Should Begin Asking

Not because every port will require advanced nuclear energy—but because every port will require an integrated long-term energy strategy.

- What will our electrical demand look like in 2045?
- How will terminal electrification affect peak loads?
- What impact will expanded shore power have on regional grid capacity?
- Will hydrogen or ammonia become part of our future business model?
- Should energy resilience become an explicit objective of our next master plan?
- Which investments preserve flexibility while technologies continue to evolve?

4. From Possibility to Planning

For years, advanced nuclear energy occupied the margins of discussions about port infrastructure. It was technically interesting but largely hypothetical. The July 2026 Port of Long Beach memorandum suggests that the discussion has entered a new phase. Rather than focusing on deployment decisions, the agreement brings together MARAD, the U.S. Coast Guard, the Department of Energy, and the Nuclear Regulatory Commission to begin developing the operational, regulatory, inspection, and safety frameworks that would be required should advanced nuclear technologies become part of the maritime sector. The distinction is important. The agreement is not evidence that ports have decided to adopt nuclear energy. Instead, it is evidence that public institutions have concluded the subject warrants serious preparation.

Infrastructure planning often begins not with construction, but with standards, governance, and institutional readiness. In that sense, the Long Beach initiative may prove to be less about one port than about establishing the framework where future ports may evaluate an entirely new class of future energy options. Its significance lies not in a decision to deploy advanced nuclear technologies, but in a transition from possibility to planning. Recognizing an inflection point does not mean predicting the future; it means realizing that the questions themselves are beginning to change.

[7] This perspective draws on several complementary strands of thinking about complex systems and decision-making under uncertainty. Jay W. Forrester's work on system dynamics emphasized the importance of interactions, feedback, and change over time in understanding complex systems (*Industrial Dynamics*, 1961; *World Dynamics*, 1971). Herbert Simon's concept of bounded rationality similarly recognized that decisions in complex systems are made with incomplete information and limited cognitive capacity (*The Sciences of the Artificial*, 3rd ed., 1996). and the design of complex systems under uncertainty (*The Sciences of the Artificial*, 3rd ed., 1996). Related insights from behavioral economics, particularly Daniel Kahneman (*Thinking, Fast and Slow*, 2011) and Richard Thaler (*Misbehaving*, 2015; with Cass Sunstein, *Nudge*, 2008), help explain why organizations often respond cautiously to emerging technological inflection points.

5. Beyond the Port: Building the Broader Industrial and Institutional System

If advanced nuclear technologies eventually find a place within maritime infrastructure, they are unlikely to do so because a port, acting alone, decides to build a reactor. Rather, they are more likely to emerge within broader industrial and institutional systems in which ports serve as one participant among many.

Successful innovation centers — from Silicon Valley and Boston's biotechnology corridor to Toulouse's aerospace cluster, DP World’s Jebel Ali, and Shanghai/Yangshan's — demonstrate how multiple reinforcing elements can combine to support technological and industrial change with:[8]

- industrial infrastructure;
- advanced manufacturers;
- research universities;
- workforce development institutions;
- government agencies;
- investors;
- technology developers; and
- transportation networks.

The port examples are particularly instructive: innovation can involve not only new physical infrastructure, but also new ways of integrating information, operations, and decision-making across the logistics system.

Ports provide the physical gateway. Industry provides commercial demand. Universities generate knowledge and workforce. Government establishes policy and regulatory frameworks. Together, these “building blocks” create conditions under which new industries can emerge (Table 1).

Table 1. Building Blocks of a Port-Centered Innovation System – A General Framework Applicable Across Countries

Layer	Illustrative Participants
Physical Platform	Port, terminals, utilities, industrial land, marine infrastructure
Industrial Platform	OEMs, manufacturers, hydrogen/ammonia producers, technology firms

[8] Jebel Ali demonstrates innovation in the physical architecture of the terminal — rethinking how containers are stored and moved — while Shanghai/Yangshan demonstrates innovation in the information and control architecture of the port — rethinking how operations are observed, modeled, optimized, and controlled. DP World's BOXBAY pilot at Jebel Ali tested high-bay container storage in individual rack slots, allowing automated direct access to containers without conventional reshuffling. Following the successful proof of concept, DP World moved to the first commercial implementation of BOXBAY at Pusan, South Korea; see DP World, “Pusan Newport Corporation has commenced work to integrate BOXBAY technology following a successful proof of concept at Jebel Ali”, 8 March 2023, available at https://www.dpworld.com/en/news/dp-worlds-pusan-terminal-first-to-implement-boxbay?. Shanghai International Port Group (SIPG), working with Huawei, has also developed centralized remote-control capabilities, including remote operating centers at Tongsheng Logistics Park and in Shanghai; see Huawei, “Huawei and Shanghai International Port Group Launch Centralized Remote Control Project for Smart Ports”, 30 June 2021, available at https://e.huawei.com/gr/news/ebg/2021/intelligent-command-control-center?. SIPG has also employed digital-twin technology at the Phase 4 Automated Container Terminal at Yangshan Port, integrating near-real-time operational data with simulation, resource optimization, vessel-delay warnings, and operational decision support; see Yi Ding, et al, “Real-Time Monitoring and Optimal Resource Allocation for Automated Container Terminals: A Digital Twin Application at the Yangshan Port”, *Journal of Advanced Transportation*, 21 March 2023, available at https://onlinelibrary.wiley.com/doi/10.1155/2023/6909801?.

Layer	Illustrative Participants
Institutional & Governance Platform	Maritime or transport ministry, energy ministry, port authority, maritime safety department, nuclear energy regulator, regional/state development agencies *(e.g., in the United States: MARAD, DOE, NRC, U.S. Coast Guard, state agencies)*
Knowledge Platform	Universities, national laboratories, technical institutes, workforce development organizations

Every country will organize these building blocks differently. Some may rely primarily on national ministries; others may emphasize regional governments, port authorities, universities, or private-sector leadership. The specific institutional arrangements are less important than the interaction among the various components. It is their combined effect, not that of any single organization, that creates the adaptive capacity needed to support emerging industrial systems.

For example, the Port of Albany provides an adaptable industrial platform; New York State contributes an evolving policy framework through NYSERDA; nearby Rensselaer Polytechnic Institute contributes research capability, systems engineering expertise, and workforce development; and future OEM (Original Equipment Manufacturers) partnerships could supply manufacturing expertise. None of these elements alone would create an advanced manufacturing cluster. Together, however, they begin to resemble the type of innovation environment increasingly associated with advanced industries.

The significance of these systems extends well beyond advanced nuclear technologies. The same institutional architecture could support hydrogen production, advanced battery systems, resilient microgrids, maritime electrification, offshore energy manufacturing, and other emerging industries. In that sense, the strategic question is not whether ports should prepare for one particular technology. It is whether they are developing the adaptive capacity to participate in industries that have not yet fully emerged.

Concluding Thoughts

The purpose of this article has not been to suggest that ports should adopt advanced nuclear technologies, nor to predict which ports will do so first. Rather, it has been to suggest that the conversation itself has entered a new phase. The ports most likely to shape that conversation are unlikely to do so because they possess a single competitive advantage. Instead, they will succeed by bringing together adaptable infrastructure, industrial capability, effective governance, and knowledge institutions into coherent innovation systems.

That observation extends well beyond advanced nuclear energy. Whether the next inflection point involves hydrogen, artificial intelligence, autonomous shipping, advanced manufacturing, or technologies yet to emerge, the same lesson is likely to apply: infrastructure adapts most successfully when engineering, institutions, industry, and knowledge evolve together. Yet recognizing such inflection points is rarely easy.

Organizations, like individuals, naturally favor familiar solutions, established practices, and proven institutional arrangements. Herbert Simon described this reality through the concept of “bounded rationality”: decisions are made with incomplete information, limited time, and finite cognitive capacity. Decades later, Richard Thaler and other behavioral economists demonstrated that these limitations are

compounded by predictable biases, including status quo bias and loss aversion, that can delay institutional adaptation even when the direction of change is becoming increasingly apparent.

The challenge for today's port leaders is therefore not simply to evaluate a new technology. It is to recognize when multiple trends begin reinforcing one another and to prepare institutions capable of adapting before change becomes unavoidable. Advanced nuclear energy may or may not become part of that future. The broader lesson is that the ports most likely to succeed will be those that recognize emerging inflection points and possess the adaptive capacity to respond. The Port of Long Beach offers an early illustration of what such institutional preparation might look like.

Notebook Essay Reflection

Every major infrastructure transition begins long before it becomes obvious. The purpose of this Notebook essay has not been to predict the future, but to observe that the conversation surrounding ports and energy has already begun to evolve. Whether advanced nuclear technologies ultimately become part of that future remains uncertain.

What seems increasingly certain is that tomorrow's ports will be asked to think differently about energy than yesterday's ports ever had to. Sometimes recognizing that the question has changed is itself the most important insight.