

Blue Papers 2026 (Vol. 5 No. 2), pp. 118–25
10.58981/bluepapers.2026.2.12
Received 26.05.2025; Received in revised form 22.07.2025; Accepted 07.11.2025

The Seine and Energy Transition: Historical Lessons for a Sustainable Future

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Abstract
The history of navigation on the Seine offers a unique laboratory for examining how energy transitions transform the systems that support river transport. This case study explores how the historical management of energy on the Seine – particularly as documented in Bernard Le Sueur's work on the history of French river navigation – can inform contemporary energy transition strategies for river transport. The Seine illustrates a fundamental principle: service always precedes integration. From the organization of hauliers in Conflans-Sainte-Honorine in the 19th century to the current challenges of ensuring low-carbon energy in the Seine Valley, the sector's organizational evolution shows that new energy technologies first appear as external services before being integrated into transport units. This historical analysis contributes directly to the Sustainable Development Goals (SDG 7: Clean Energy, SDG 9: Innovation and Infrastructure, and SDG 13: Climate Action) by proposing innovative organizational models to accelerate the energy transition in European river transport.

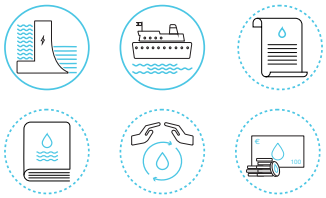
Policy Recommendations

- The European Commission is expected to implement Energy-as-a-Service pilot programs along the Seine–Northern Europe corridor by 2032.
- France is expected to establish a fleet modernization fund by late 2028, prioritizing vessels exceeding 30 years of age, with mandatory hybrid propulsion systems.
- Infrastructure managers are expected to deploy containerized energy exchange facilities at strategic nodes by late 2028.
- A unified framework for multi-energy port infrastructure is expected to be established by 2030, drawing upon the historical towage rights model.

KEYWORDS

energy transitions
Seine River transport heritage
energy-as-a-service model
fleet decarbonization
multi-energy ports

WATER ICONS



< Fig. 1 Barge on the Seine near Pont Neuf, Paris (Source: Pline, 2009. CC BY-SA 3.0, via Wikimedia Commons).

Introduction

The Seine, a life-giving artery of the Île-de-France since Gallo-Roman times, constitutes a remarkable laboratory for observing energy transformations in river transport. As Bernard Le Sueur (1999, 2001) documented in his works on the history of Seine navigation, this waterway has been the theater of three major energy revolutions that shed light on contemporary decarbonization challenges (Le Sueur 2005).

From Rouen to Paris, the Seine first experienced the era of human and animal towage, immortalized in eighteenth-century engravings showing teams of towmen pulling water coaches along paths still visible at Bougival and Saint-Germain-en-Laye. This organization reveals a clear separation between boat owners and so-called "energy providers": the towmen's guilds of Conflans-Sainte-Honorine – the historic capital of French inland waterway shipping – who provided their services to mariners.

The introduction of steam in the nineteenth century maintained this logic of external service. The first paddle-wheel tugboats, such as the *Napoléon*, launched in 1823 for the Paris–Melun route, were operated by specialized companies like the Compagnie Générale de Navigation de Paris à la Mer, founded in 1855. Only with the democratization of diesel engines during the interwar period did the model of energy autonomy that still characterizes inland waterway transport today become established. Diesel power radically transformed the profession of mariners, who were now responsible not only for the transport of goods (on behalf of third parties) but also for the management of energy (refueling and storage) required to carry out their work.

Evolution of Organizational Practices and Contemporary Lessons

Today, the Seine displays many of the energy transition challenges facing French river transport. With its 777 navigable kilometers from Nogent-sur-Seine to Tancarville, it accounts for 40 per cent of national river traffic and forms an essential link in the emerging Seine-North Europe corridor. The river's contemporary management is organized around Voies Navigables de France (VNF), which is gradually integrating decarbonization objectives into its traditional infrastructure management roles, and HAROPA PORT, which oversees numerous river and maritime port facilities in the Seine Valley.[1]

While equipment from the past – historic locks, former towpaths, paddle-wheel boats – have naturally found their place in tourism and museum contexts as demonstrations of technological heritage, the organizational practices associated with these earlier systems have evolved differently. Unlike some obsolete technologies, these organizational models remain remarkably relevant. While wooden boats and steam tugboats are no longer competitive, the logics of specialization and energy pooling that once characterized the Seine's navigation system offer keys to addressing today's energy transition challenges.

The historical organization of Conflans-Sainte-Honorine illustrates this organiza-

1. Voies Navigables de France (VNF) is a government agency that manages inland waterway navigation infrastructure in France (including the Seine) and supports the energy transition of the river transport sector; HAROPA PORT is the agency created from the merger of two major maritime ports (Le Havre and Rouen) and the Port of Paris.

tional richness. The coexistence of boat owners, specialized energy suppliers, shipyards and traders created an ecosystem where each actor developed distinct expertise. This division of labor enabled optimized investment and rapid adaptation to technical innovations: a principle directly applicable today in the energy-as-a-service business model (Fouquet 2016).

From an economic standpoint, the Seine fleet faces a major challenge. The average age of self-propelled vessels exceeds 35 years (VNF data), with hulls depreciated over 30–40 years, propulsion systems over 15–20 years, while new energy technologies – such as battery or hydrogen storage – operate on much shorter cycles of 5–10 years, often at more than triple the initial cost. This is exemplified by the ZULU 06 (CFT SOGESTRAN), a boat intended for hybrid electric/hydrogen urban logistics.

Current electrification initiatives, stimulated by preparations for the 2024 Olympic Games, have led some companies to install fast charging stations. Yet these projects largely perpetuate the energy autonomy model inherited from the petroleum era: each operator remains individually responsible for financing and implementing their own energy transition, without shared investment mechanisms or collective expertise.

Current and Future Challenges of this Water System

The Seine, like most major rivers, faces a conjunction of climatic and energy challenges reminiscent of earlier historical transitions, contributing to growing operational uncertainty for the 20 million tons transported annually on the river.

At the same time, the drive to reduce emissions is expected to bring about a profound transformation of propulsion systems. Unlike the transition to petroleum fuels, which offered clear and immediate benefits, current alternatives each present significant constraints: Electric batteries lack the energy density required for long routes along the Seine–Oise–Marne corridor, hydrogen poses storage and supply problems, and the reliability of biofuel availability for the river sector remains uncertain.

The current structure of the French inland navigation sector – particularly on the Seine – continues to be dominated by artisan boatmen whose limited investment capacity hinders the adoption of costly new technologies. The model of energy autonomy, once a source of resilience, now paradoxically acts as a brake on innovation. This is especially problematic in regions where air quality requirements may soon necessitate a rapid transition to "low emission" navigation mode in densely populated urban areas.

Moreover, the increasing intermittency of renewable electricity production introduces synchronization challenges that the river transport sector could help address, thanks to its regular traffic between major ports (Le Havre, Rouen, Gennevilliers, Bonneuil-sur-Marne) and its potential to serve as a mobile energy storage network.[2]

2. Renewable electricity means electricity produced from sources that naturally and rapidly renew themselves on a human timescale, such as solar, wind, hydraulic, geothermal, and biomass. They contrast with fossil fuel sources (oil, coal, gas), which are depleted and produce CO_2 emissions.



^ Fig. 2 River lock of La Cave in Bois-le-Roi on the Seine; river tug with barges (Source: Pline, 2010. CC BY-SA 3.0, via Wikimedia Commons).

A further concern lies in the risk of premature specialization of port infrastructure. Faced with technological uncertainty, there is strong pressure to invest heavily in specialized facilities – hydrogen stations, high-power electrical networks or battery storage areas. Yet land along the Seine is a scarce and highly constrained resource, particularly in dense urban areas. Such early specialization carries two main risks: immobilizing strategic sites for technologies that may soon become obsolete and diverting capital from the sector's foremost need – the modernization of an aging fleet that increasingly fails to meet emerging standards. Indeed, the history of energy transitions on the Seine shows that the most profitable investments have always focused on modernizing transport vessels rather than prematurely locking in fixed infrastructure.

Conclusion and Future Approaches

Historical analysis of energy organization on the Seine reveals that the principle whereby "service always precedes integration" offers a valuable pathway for innovation in the contemporary energy transition. This approach could take the form of an energy-as-a-service model tailored to the specific conditions of the Seine.

In practical terms, specialized operators could manage standardized, containerized battery exchange sites or racks of biogas or hydrogen cylinders at strategic points: Rouen for the maritime interface, Conflans for distribution to the Oise and Marne, Montereau for access to the Yonne. This logic is inspired by the historical organization that developed around Conflans-Sainte-Honorine, where boat owners, energy suppliers and shipyards coexisted within a specialized and efficient ecosystem.

In this sense, the current rollout of electric charging stations by VNF and HAROPA PORT at the main stops between Le Havre and Paris may be seen as a precursor to such evolution. By developing a unified billing system inspired by the old "towage rights," this initiative revives the longstanding principle of external energy service that characterized the Seine for centuries.

Such an approach would decouple investment in propulsion systems from that in vessel hulls, lowering entry barriers for independent boatmen while fostering the growth of a specialized sector in energy storage technologies. By rediscovering the organizational principles that once made the Seine's ecosystem so dynamic, it becomes possible to design innovative models for the decarbonization of river transport, making the Seine once again a laboratory of innovation, both inspired by its history and able to establish itself as the backbone of a powerful industrial, logistical and energy network.

Acknowledgment
This contribution was peer-reviewed. It was edited by members of the editorial team of the UNESCO Chair Water, Ports and Historic Cities: Carola Hein.

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