



INFEASIBILITY OF SOLAR-POWERED RAIL ELECTRIFICATION AT BIG

BNSF RAILWAY

BARSTOW INTERNATIONAL GATEWAY

#172845

REVISION 0

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Executive Summary

The Commenter suggests that a 171-mile heavy-haul freight corridor can feasibly and economically be powered by an expanded Barstow solar facility, yet he does not evaluate the infrastructure necessary to deliver that power.

Using the Commenter's own assumptions for electric locomotive power requirements, corridor electrification self-supplied by BNSF would require more than **1,030 MW of solar generation, 9 GWh of battery storage**, more than **5,000 acres** of land for those facilities, and **at least \$500 million in additional transmission and traction-power infrastructure** not accounted for in the Article. The Commenter identifies a theoretical energy source for electrification of the corridor between BIG and the Ports, but he does not demonstrate a feasible power delivery system.

The Comment does not evaluate the electrical infrastructure necessary under either plausible implementation scenario. If power were supplied by Southern California Edison ("SCE"), corridor electrification would still require multiple traction power substations, utility interconnections, and transmission upgrades. If BNSF were expected to self-supply power, a dedicated high-voltage transmission network would be necessary to distribute power across the 171-mile corridor.

As is noted in other documents provided in support of this Project, there are numerous technological barriers to electrified locomotives that are not discussed in this document. Instead, this document focuses on the energy infrastructure limitations of the Commenter's claims. Because the Commenter does not evaluate the availability of power, transmission infrastructure, utility interconnections, permitting requirements, implementation timelines, land requirements, or associated costs necessary to support corridor-wide rail electrification, the Comment materially understates both the complexity and cost of the proposed electrification scenario. These omissions could significantly alter the Article's economic conclusions.

Authorship and Statement of Qualifications

This memorandum was prepared by Connor Smith, Project Delivery Manager at 1898 & Co., the consulting arm of Burns & McDonnell, and Eric Putnam, Senior Associate Technical Consultant at Burns & McDonnell, under the responsible charge of Jonathan Leffert, P.E., Managing Director of 1898 & Co. California.

Connor has over 7 years of professional experience in load modeling, utility system planning, behind-the-meter renewable project development, and business case assessments. He has prepared and reviewed technical memoranda evaluating the impact of electrification and the benefits of distributed energy resources (DERs) at industrial sites for public and private sector clients throughout California and the broader United States, including other facilities within BNSF's rail network.

Eric has over 30 years of professional experience developing electrical systems for critical infrastructure facilities ranging from hospitals to long-distance telecommunications switch centers to facilities for the US Department of War. These projects have ranged in voltage from 208V to 230kV and in capacities from 15kW to over 2GW. He has supported projects throughout California and at sites around the world.

Jonathan is a licensed professional engineer in California and Kansas and has nearly 20 years of experience in utilities and energy infrastructure. He has led teams overseeing analysis, assessment and strategies for utility and energy infrastructure projects as well as assisting in commissioning solar projects in Nevada and California during his career.

The opinions herein are based on Burns & McDonnell's experience in combination with public information, market research, forecasts and data provided by BNSF and their service providers. Burns & McDonnell represents that this report was prepared in a diligent, skillful, and workmanlike manner consistent with the prudent practices and standards generally accepted as an energy analysis consultant. Any reuse of the report for a different purpose than originally intended is at the user's own risk.

Comment Summary

On May 15th, 2026, Narayan Gopinathan ("the Commenter") submitted an initial public comment (ARI_I166) along with an accompanying Article, *Techno-economics of low-carbon freight rail transportation in California*¹ in response to the Final Environmental Impact Report (Final EIR). Following the May 16th, 2026 City of Barstow Planning Commission special hearing to consider the proposed General Plan Update, Barstow International Gateway (BIG), BIG Specific Plan, and related actions and entitlements, BNSF filed a formal Response to Comment², contained within Attachment B-4 of the City Council Public Hearing materials.

¹ Narayan Gopinathan 2026 Environ. Res.: Infrastruct. Sustain. 6 025004

² City of Barstow. (2024). *Barstow International Gateway Project Draft Environmental Impact Report, Attachment B-4* (SCH No. 2023080732). City of Barstow. Available at: <https://www.barstowca.org/home/showpublisheddocument/15991/639153897536800000>

On June 1st, 2026, the Commenter re-submitted his authored Article along with a new letter again summarizing the conclusions of the Article and also introducing multiple new assertions, most notably that BNSF “can expand the solar farm on their project to generate the power to run the railroad”. As this is both a new comment and a substantial assertion, BNSF solicited 1898 & Co. to provide its professional opinion of the viability of utilizing solar power as a replacement for diesel fuel to power the locomotive fleet serving BIG via an expansion to BIG’s planned solar generation facility.

The Commenter suggests that BNSF could power an electrified POLA-Barstow freight corridor through expansion of the proposed BIG solar facility. However, neither the Commenter nor the accompanying Article’s analysis adequately evaluates the electrical infrastructure necessary to support such a system. While the analysis estimates train energy consumption using locomotive efficiency assumptions and route topography, it does not disclose corridor-level electrical demand, peak traction power requirements, traction substation sizing, feeder requirements, transmission infrastructure needs, utility interconnection requirements, or implementation timelines. As a result, the analysis does not demonstrate that the assumed electrical infrastructure costs are sufficient to support the level of rail operations being modeled. This omission is particularly significant because the Article’s economic conclusions are highly sensitive to electricity costs, within which it has amortized all new infrastructure costs associated with the modeled electrification scenarios.

Given the late submission of this comment and the limited time available for review, 1898 & Co. has performed a preliminary, high-level assessment of the electrical generation and delivery infrastructure that would be required to power a fully electrified POLA-Barstow freight corridor using privately owned renewable generation. Additional engineering, utility interconnection, and power system studies would be necessary to refine these estimates; however, a preliminary review demonstrates that the scale of infrastructure required is substantial and has not been evaluated by the Commenter nor adequately addressed in the Article.

The reader is encouraged to read the other expert documents relied on by the City, including Attachment B-4, *Feasibility Analysis of New Propulsion Locomotive Technologies and Overhead Catenary for the BNSF BIG Project*, *Analysis of BELs: San Pedro Bay Ports to Barstow*, and *Operational and Economic Feasibility for Switcher BELs and Linehails*, which refute the fundamental assumption that electrified locomotives are a feasible technology. This document should be interpreted in the context of, and in conjunction with, those analyses. Rather than revisiting the feasibility of locomotive electrification technologies, it focuses on the power generation, storage, and transmission requirements that would be necessary should such technologies become feasible.

For purposes of this assessment, it is further assumed that SCE, the California Public Utilities Commission (“CPUC”), and all other applicable regulatory agencies and Authorities Having Jurisdiction would support and approve the development of the generation, storage, transmission, and traction-power infrastructure necessary to serve the corridor’s electrical demand. It is also assumed that BNSF could obtain the land, easement rights, utility interconnections, and other property interests necessary to site and operate such facilities throughout the corridor. These assumptions are made solely to facilitate a preliminary order-of-magnitude analysis and should not be construed as findings regarding the legal, regulatory, permitting, or practical feasibility of implementing such infrastructure. The Commenter proposes that BNSF could power an electrified POLA-Barstow freight corridor through expansion of the proposed Barstow solar facility. However, neither the Comment nor the underlying Article evaluates the electrical demand associated with operating a fully electrified heavy-haul freight corridor.

Traction Power Requirements

The Article does not explicitly disclose the corridor-level electrical demand associated with the operating scenarios evaluated. However, using the Commenter's own assumptions, the implied electricity demand can be estimated. For the purposes of this memorandum, the use of the Commenter's assumptions and methods is made for convenience and direct comparison only and does not represent the professional opinion of 1898 & Co. or BNSF.

The Article assumes an electric freight train efficiency of approximately 31.06 ton-miles per kWh, a route length of approximately 171 miles between the Port of Los Angeles and Barstow. Using the Article's modal assumptions of 105 cars per train and 105 short tons of cargo per car, the implied train payload is approximately 11,025 short tons. Applying the Article's methodology yields an estimated electricity requirement of approximately 61 megawatt-hours (MWh) per one-way train movement.

- $11,025 \text{ short tons} \times (1 \text{ short ton} / 2,000 \text{ lbs}) \times 171 \text{ miles} \times (1 \text{ kWh} / 31.06 \text{ short ton-miles}) = 60.7 \text{ MWh per one-way train movement}$

In 2028, the BIG Project is anticipated to facilitate up to 51 one-way train movements per day through the San Bernardino-Barstow corridor. Applying the Article's estimated energy consumption to this operating profile yields an electricity demand of approximately 3,095 MWh per day:

- $51 \text{ one-way train movements/day} \times 61 \text{ MWh/train movement} = 3,095 \text{ MWh/day}$

This daily energy requirement is equivalent to a continuous average electrical load of approximately 129 megawatts (MW) operating 24 hours per day:

- $3,095 \text{ MWh/day} \div 24 \text{ hours/day} = 129 \text{ MW average power draw}$

Accordingly, under the Commenter's own assumptions, powering an electrified POLA-Barstow freight corridor would require the equivalent of a continuously operating 129 MW power supply, without accounting for any losses in the distribution system. The Article does not disclose this corridor-level electricity demand, nor does it evaluate the resulting peak traction power requirements, feeder requirements, utility interconnection needs, or system reliability considerations associated with supplying power at this scale. The actual peak power draw from this system will likely be higher than the 129 MW stated above.

The use of this 129 MW figure in subsequent calculations is purely for the purpose of calculating the approximate electrical energy requirement for corridor electrification via the Article's methods. A more thorough and detailed analysis will almost certainly yield a much higher power demand, so this assumption errs in favor of the Commenter's position. Accordingly, this typical power draw assumption of 129 MW is used to inform the solar and energy storage sizing requirements in line with the Commenter's suggestion that these avenues be utilized to supply carbon-free power to electrify the corridor.

Generation & Storage Requirements

The following analysis is preliminary and intended only to provide an order-of-magnitude assessment of the generation and storage infrastructure that would be required under the Commenter's proposed concept of powering an electrified freight corridor through privately owned solar generation. Additional engineering studies, utility interconnection analyses, and power system modeling would be necessary to refine these estimates. However, based on preliminary review, 1898 & Co. sees the Commenter's modal assumptions

regarding locomotive energy requirements to be acceptably accurate for the needs of this high-level assessment.

Using the Commenter's assumptions regarding train operations and energy consumption, the estimated traction load associated with corridor electrification is approximately 3,095 MWh per day, equivalent to a continuous average load of approximately 129 MW operating 24 hours per day. To estimate the generation required to support this load, 1898 & Co. performed preliminary solar production modeling for the Barstow area. That modeling indicates that a utility-scale single-axis tracking photovoltaic system would generate approximately 3 MWh per day in December for each MW of installed capacity, averaged across both sunny and cloudy days. December production was selected as a conservative planning assumption because it represents one of the lowest solar production periods of the year.

Based on this production profile, more than 1,030 MW of installed solar generation would be required to produce the 3,095MWh of electricity needed each day. This sizing requirement reflects the fact that the system must generate enough electricity during limited daylight hours to satisfy a load that operates continuously, including nighttime periods when no solar generation is available. As a result, the installed solar capacity must be substantially oversized relative to the average electrical load in order to generate an entire day's energy requirement during the available solar production window.

Please note that 1,030 MW of solar would provide sufficient energy only if the electrical system has no losses and the energy is used directly to power the locomotives. Real world losses due to imperfect electrical systems and roundtrip inefficiencies of battery energy storage systems mean that a realistic solution would require significantly more solar production capacity. Again, the use of the 1,030 MW solar array in this Document is only for simplicity and errs in favor of the Commenter's position.

In addition to generation capacity, long-duration energy storage would be required to maintain reliable freight operations during nighttime periods and extended periods of reduced solar production. For planning purposes, this preliminary assessment assumes approximately 72 hours of backup capability, reflecting the possibility that multiple consecutive days of below-average solar production could occur. Under this assumption, approximately 9 GWh of battery energy storage would be required to provide three days of backup power. For comparison, the required 9 GWh battery system would be nearly twice the size of the planned Darden Clean Energy Project in Fresno County, which is expected to be the largest battery storage facility in the world³ with an installed capacity of 4.6 GWh.

The associated land and capital requirements are similarly substantial. Utility-scale solar facilities typically require approximately 5 acres per MW of installed capacity. Accordingly, a 1,030 MW_{dc} solar installation would require over 5,000 acres of land, or roughly 8 square miles. The associated 9 GWh battery storage system would likely require hundreds of additional acres depending on technology selection, facility configuration, and fire protection requirements. These land requirements would represent a doubling of the project's current physical footprint of approximately 5,000 acres.

Based on planning-level cost assumptions, approximately 1,030 MW of solar generation would cost roughly \$1.6 billion, and approximately 9 GWh of battery storage would cost roughly \$2.7 billion, for a combined generation and storage cost exceeding \$4 billion. These estimates do not include transmission infrastructure, traction power substations, catenary infrastructure, utility interconnections, land acquisition, permitting, environmental mitigation, operations and maintenance, financing costs, or contingency allowances. Also, as is noted in other documents submitted in support of the EIR, it is highly likely that an all-electric locomotive

³ California Energy Commission. (2025, June). *CEC approves world's largest solar and battery storage project in Fresno County under streamlined permitting process*. California Energy Commission. <https://www.energy.ca.gov/news/2025-06/cec-approves-worlds-largest-solar-battery-storage-project-fresno-county-under>

fleet is significantly larger than the planned Tier 4 diesel fleet assumed in the EIR. In short, \$4 billion is significantly understating the total cost of such an undertaking.

Transmission Requirements

The Commenter suggests that BNSF could power an electrified POLA-Barstow freight corridor through expansion of the proposed Barstow solar facility, but does not evaluate how that power would be transmitted from said facility along the 171-mile corridor between BIG and the Ports. Regardless of whether traction power is supplied by Southern California Edison ("SCE") or by BNSF-owned generation, corridor-wide electrification would require substantial transmission and traction-power infrastructure that is not evaluated in either the Comment or the accompanying Article.

If BNSF were expected to self-supply power from an expanded Barstow solar facility, a 33 kV solar interconnection could not directly serve a 171-mile freight corridor. A more realistic planning assumption would require a dedicated high-voltage transmission system, reasonably assumed to be a 115 kV network supplying approximately 3-6 traction power substations distributed throughout the corridor. Using SCE's 2025 planning-level unit costs⁴, 115 kV transmission and associated substations could exceed \$500 million, before accounting for utility upgrades, right-of-way constraints, system reinforcement, permitting, environmental review, or construction contingencies. The Commenter also does not evaluate the regulatory and operational requirements associated with transmitting privately generated power across multiple jurisdictions and properties between Barstow and the Ports.

Alternatively, if BNSF relied on SCE to provide traction power, a utility-supplied 2 × 25 kV autotransformer traction system would still require approximately 3-6 traction power substations, multiple autotransformer and paralleling stations, utility interconnections, line extensions, and potentially upgrades to SCE's existing transmission system. The Commenter does not evaluate these costs, utility power availability, implementation requirements, or the schedule impacts associated with utility planning and infrastructure upgrades.

The Commenter does not evaluate the transmission infrastructure, traction-power facilities, utility interconnections, permitting requirements, implementation timelines, or associated costs necessary to support corridor-wide rail electrification. These omissions materially understate the complexity, cost, and time required for construction of the proposed electrification scenario and could significantly alter the Article's economic conclusions.

Conclusion

The Commenter identifies a theoretical source of electricity for corridor-wide rail electrification but does not demonstrate a technically feasible, economically realistic, or implementable power delivery system. The Article estimates train energy consumption but does not evaluate the generation capacity, long-duration energy storage, transmission infrastructure, traction-power facilities, utility interconnections, land requirements, permitting obligations, regulatory constraints, or implementation timelines necessary to support electrification of a 171-mile heavy-haul freight corridor.

⁴ Southern California Edison Company, *2025 Per Unit Cost Guide (2025)*, available at <https://www.caiso.com/documents/sce-2025-per-unit-cost-guide-final.xlsx>

Asset	Size	Rough Order of Magnitude Equipment Cost	Land Requirements*
Expanded Solar	1,030 MW	\$1.6B	8 sq. mi
Energy Storage	9 GWh	\$2.7B	
New Transmission Infrastructure to Serve Corridor from BIG	171 mi of new sub-transmission circuit construction (BNSF self-supply)	\$500M	Substantial and numerous new land acquisitions along corridor for substations and transmission infrastructure

* Land Acquisition Costs are not Included in ROM Costs

As demonstrated above, supplying the electrical demand associated with the Commenter's proposed electrification scenario would require infrastructure on a scale far beyond that evaluated in the Article, including a gigawatt of solar generation, gigawatt-hours of battery storage, thousands of acres of land, multiple traction power substations, and substantial high-voltage transmission infrastructure. These requirements would entail billions of dollars in additional capital investment, significant utility coordination, extensive permitting and environmental review, and substantial implementation uncertainty.

Because these costs, infrastructure requirements, and regulatory considerations are not incorporated into the Article's analysis, the Commenter materially understates both the complexity and cost of the proposed electrification scenario. If these omitted factors were properly evaluated and incorporated into the analysis, they would materially affect—and likely alter—the Article's conclusions regarding the economic feasibility of corridor-wide freight rail electrification powered by the proposed Barstow solar facility.



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