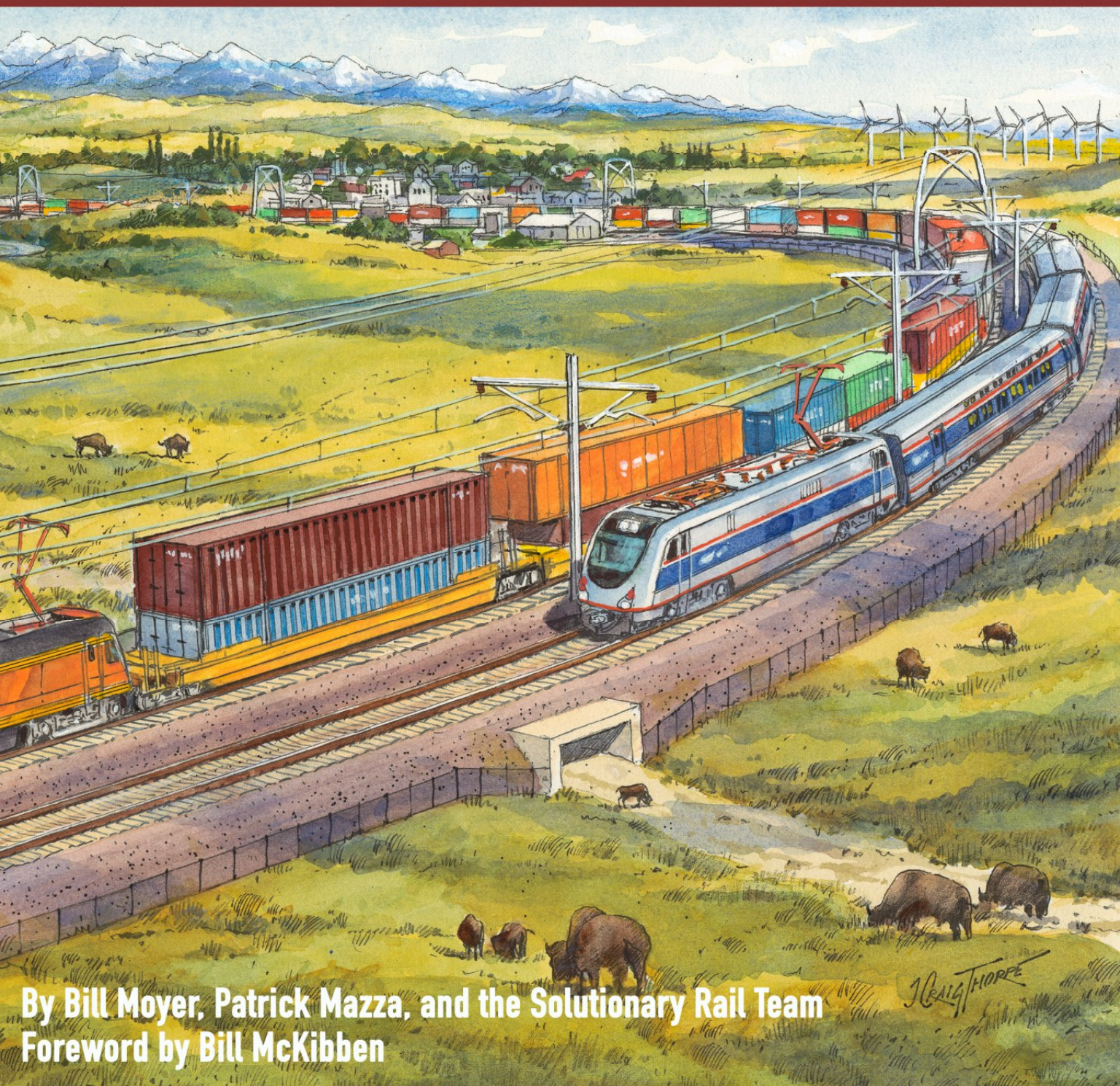
SOLUTIONARY RAIL

A people-powered campaign to electrify America's railroads and open corridors to a clean energy future



By Bill Moyer, Patrick Mazza, and the Solutionary Rail Team
Foreword by Bill McKibben

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Praise for Solutionary Rail

"Rail electrification, as proposed in this remarkable book, is that rarest of things: a genuinely new idea, and one that makes immediate gut sense." (From the Foreword)

~ **Bill McKibben**, climate activist, author and co-founder of 350.org

"Don't miss this provocative book! The time is now for big picture solutions like railroads powered by renewables."

~ **Wenonah Hauter**, Executive Director, Food & Water Watch, author of *Frackopoly* and *Foodopoly*

"While corridor concepts go back generations, your group has brought **fresh ideas** as to what a future corridor might look like. Without new concepts to stimulate innovation, progress stagnates. ***Solutionary Rail* provides something tangible for all stakeholders to consider and to build on.** Congratulations to your team for taking the corridor challenge, putting pen to paper, and producing a finished work."

~ **Mike Elliott**, Brotherhood of Locomotive Engineers and Trainmen

"Electrification is not only our best option for passenger rail travel but also for freight rail. Both are commonplace throughout the rest of the industrial world. With analytical rigor, Backbone Campaign's Solutionary Rail Team shows how we can break through barriers to bring mass rail electrification to the US. This is an indispensable book for everyone curious about how to move people and goods long distances at high speed in a carbon-constrained world."

~ **Denis Hayes**, President, Bullitt Foundation; principal national organizer of the first Earth Day in 1970; original director of Solar Energy Research Institute, now National Renewable Energy Laboratory

"Our continued reliance on extractive industries is untenable and unjust. *Solutionary Rail* provides a wonderful example of how tackling problems systemically—and planning long-term, on a regional scale—opens up tremendous opportunities. By reinvesting in electrified rail, shippers and passengers can enjoy higher speeds, more predictable schedules, and increased efficiency. **Renewable resources—like Great Plains wind—can flourish as rural energy cooperatives and Native American utilities gain access to distant markets.** Collectively, we can begin to restore the commons by investing in publicly-owned electrification infrastructure and high-speed tracks. And railroad workers can secure a 'just transition' building a greener economy. **Combining bold thinking with on-the-ground problem solving, *Solutionary Rail* helps us imagine what's next."**

~ **Gar Alperovitz**, author and President, National Center for Economic and Security Alternatives

"Gil Carmichael gave us the concept in 1999. RAIL Solution later provided a logo, a brand name, and a website. **Now *Solutionary Rail* has contributed a valuable next step in this fine work drawing together in one place a comprehensive statement of the benefits of electrification and the Steel Interstate**."

~ **David Foster**, Executive Director, RAIL Solution

"The railroads were the engine that built the commercial heart of America. Lincoln foresaw how the transcontinental railroads would be crucial to uniting a continental country, and subsequent advances such as the telegraph were therefore enabled. The concepts laid out in ***Solutionary Rail* show that once again railroads can lead the way from the fossil fuel based society to an electric society dominated by renewable energy and more energy-effective commercial transportation.**"

~ **Alexander E. MacDonald**, President, American Meteorological Society,
Retired Director of NOAA's Earth System Research Laboratory,
Director, Global Validation Model, Spire Global, Inc.

"*Solutionary Rail* is a visionary demonstration project that will not only help keep fossil fuels in the ground, **Solutionary Rail will catalyze an economic renaissance in rural communities along the line.** What an elegant solution. Read this book and get inspired to create a more sustainable future!"

~ **Luther Propst**, Founder, Sonoran Institute, board member, George B. Storer Foundation.

"Extreme extraction and the transport of fossil fuels has been devastating for Indigenous peoples in the US, Canada and around the world. Railroads have been a tool of colonization, the political takings of indigenous lands and genocide. Indigenous peoples have however persevered despite all odds. A new era of Indigenous Peoples rising up in strategic resistance in defense and protection of the sacredness of Mother Earth is taking place from the North to the Global South. It is renewing humanity, guiding it away from self-destruction all across this continent and specifically in the corridor from the Great Lakes, across the prairie lands, the Rockies, to the Salish Sea.

"The seventh generation principle and responsibilities to the rights of Mother Earth—Nature is not some abstract, romantic idea, but an ethic for survival of communities, the environment and all Life. ***Solutionary Rail* taps into that spiritual challenge to change course and returns with a transformative vision for redeeming railroads and a society addicted to their dangerous cargo. Indigenous and non-indigenous rural communities can be part of this solution by powering these trains and their communities with renewable energy, and transmitting the surplus to the cities.** So, when on behalf of future generations there is so much to which we must fiercely say 'No!' — *Solutionary Rail* offers us something to which we can all proudly say 'Yes!' "

~ **Tom Goldtooth**, Executive Director, Indigenous Environmental Network,
www.ienearth.org, www.indigenousrising.org

"Agriculture was started and sustained by high quality transportation and now transportation, especially rail, is heavily sustained by the largest user of the US transportation network, agricultural traffic and attendant revenue streams. Public participation in all modes has historical precedent: rail land grants, highway funding and waterway development. But the issue now is the historical efficiency and sustainability of fossil fueled rail transport. **The proposition of electrically powered railroads offers agriculture a more positive future, since electricity may be cost effective, is environmentally appealing and offers a future of high capacity and fast service, leading to environmental and economic sustainability.** Agriculture critically needs railroads and railroads need agriculture."

~ **Kenneth Casavant**, Director, Freight Policy Transportation Institute, Washington State University

"The positive impacts of implementing Solutionary Rail are much broader than first meets the eye. It could very well help resolve existing stalemates on dam removal by giving farmers the confidence that they will have the rail capacity to get their grain to market. That could in turn dramatically increase the return of salmon to the Columbia and Snake rivers, which in turn would increase orca whale populations and improve the fishery. We need win-win solutions and that's why Save Our Wild Salmon supports this inspiring and doable proposal."

~ **Sam Mace**, Inland Northwest Director, Save Our Wild Salmon

"We are what we eat. But also we are how we travel. We need to move beyond gloom and doom to holistic solutions. America desperately needs a new transportation system, as well as a regenerative food, farming, energy, and political system. Part of the transformation is outlined in this visionary new book, Solutionary Rail by Bill Moyer and his able team. All aboard!"

~ **Ronnie Cummins**, Director, Organic Consumers Association

"*Solutionary Rail* provides a pragmatic and sustainable approach for revitalizing our national economy and infrastructure. In particular, rural America will benefit from the economic stimulus, new jobs and the source for renewable energy from this state-of-the-art rail electrification system. Solutionary Rail provides a path to the future in which everyone will benefit."

~ **Patrick Cox**, Ph.D., Director, Cooperative Leadership Network and Past President and Director, Pedernales Electric Cooperative, Texas

"The *Solutionary Rail* book addresses an issue which I have long advocated with regard to electrification of railways as **an essential step in modernizing America's railway network for improved freight and passenger transportation between cities which is long overdue."**

~ **Dr. Hal Cooper**, consulting engineer and infrastructure expert

"This book is a must read for anyone who works for a railroad, wants to work for a railroad, or wants to come to a better understanding on how transportation can be restructured to fill the needs of a planet killing itself on fossil fuels."

~ **Jeff Kurtz**, Retired 41-year locomotive engineer with BNSF. and Iowa State Legislative Board Chairman (2004–2014)with the Brotherhood of Locomotive Engineers and Trainmen

"Reaching 100% clean energy means finding fossil free solutions for 100% of our economy. *Solutionary Rail* dares to take one of the toughest challenges for long-distance ground transportation in a modern economy, and double dares us to envision integrated solutions for rural economic development and renewable energy development in the same landscape of opportunity."

~ **Dr. Holmes Hummel**, Clean Energy Works, former Department of Energy policy advisor

"As a society, we must move away from the use of fossil fuel; however, a modern technological society requires mobility. Merely saying no to fossil fuel is not a solution. This project is an excellent positive step. We are running out of time. Tomorrow cannot be a copy of today."

~ **Thomas White**, railroad operations consultant and co-author of *Traffic*

"Bill Moyer's Solutionary Rail team outline a truly exciting and equitable vision for the ever elusive 'just transition' we're all searching for as we move away from fossil fuels. This is systemic change in action!"

~ **Daphne Wysham**, Director, Climate and Energy Program, Center for Sustainable Economy

"A key policy discussion is going on across North America about the role of railroads with respect to Climate Change. Railroaders and community safety activists alike need to understand we must be part of that discussion. The publication of *Solutionary Rail* is an important contribution to that discussion. I encourage every railroader to read it...and think about it."

~ **Fritz Edler**, retired 37 year veteran railroader and BLET Division Chair, Special Representative for Railroad Workers United

"A brilliant solution to our simultaneous need to cut carbon emissions and improve our transportation infrastructure. Brilliant!"

~ **Thom Hartmann**, author, radio and television journalist

"Americans are eager for big projects that reduce our dependence on fossil fuels. *Solutionary Rail* should certainly get the attention of our fellow citizens—especially those surrounded by giant diesel-guzzling trucks tearing up our already crumbling interstate highways. This new proposal might very well kindle a new fire in the public debate about our country's transportation and energy future."

~ **Roger Hickey**, Co-Director, Campaign for America's Future

"Electrification of transportation is a critical part of decarbonizing our economy. *Solutionary Rail* makes the vital link between clean renewable energy as the necessary electricity supply to reducing emissions from the diesel trains and long-haul trucks. This book challenges us all to re-envision our energy infrastructure."

~ **Nancy Hirsh**, Executive Director, NW Energy Coalition

"As the US population grows, along with the attending to the need for greater movement of goods, we have to protect mobility for people from the surging demand across a constrained network. *Solutionary Rail* thinks big in laying out its capacity building blueprint for how to keep America moving efficiently and sustainably."

~ **Sean Jeans-Gail**, Vice President, National Association of Railroad Passengers

"Well reasoned and comprehensively documented – this book will jumpstart an energy transformation in the United States that has already been demonstrated as a success in other countries."

~ **Ralph Nader**, author, consumer protection, environmental and democracy champion and former independent and Green Party presidential candidate

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A people-powered campaign to electrify America's railroads and open corridors to a clean energy future

By Backbone Campaign's Solutionary Rail Team

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Dedicated to Jack Barbash,
Jay Marx, Jerry Henley,
and Jean Bosch.

Solutionaries all.

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Foreword: A Genuinely New Idea

by Bill McKibben

I'VE BEEN FOLLOWING THE DEBATE OVER ENERGY, transportation, and climate change since the late 1980s. I've written thousands of articles and op-eds, talked to tens of thousands of people, and read a daily dose of scientific journals and the popular press. So it's hard to come up with an idea I haven't come across before.

Rail electrification, as proposed in this remarkable book, is that rarest of things: a genuinely new idea, and one that makes immediate gut sense. The instant I started reading it, I flashed on those trains I've ridden elsewhere in the world that run on electricity. For those who travel widely, the decrepit state of our rail network is a constant reminder that America no longer dominates the world in technological terms. As the writer James Howard Kunstler once remarked, we have "a train system of which Bulgaria would be ashamed."

But it's the double promise of this proposal that makes such intuitive sense. Just as we needed the railroads in the first place to unlock the vast granary that was the American prairie (an unlocking that we could have done a lot more sensibly, not to mention humanely, it must be said), so now we need a way to unlock the vast pool of electrons represented by the windpower that howls across that beautiful land, and the solar power that is wasted daily in the great American desert. Transmission lines are hard to site—but railroad right-of-ways are the perfect option. Especially if there's built-in demand for some of the power from day one because there's a train that needs the juice.

The race against climate change is going to be, at best, a close call. We're seeing enormous damage already: the droughts, fires and floods that increasingly plague the American heartland are one harbinger of what's to come. But against that tide of destruction, there are an increasing number of human beings rising to the occasion with innovative ideas. We're watching the cost of solar panels and storage batteries plummet; we're seeing electric cars that put the old internal combustion models to shame. And now this proposal that makes our original mass transit system young again. Hey, if podcasts can rejuvenate radio, then electric trains can help bring back the age of rail.

Which is, when you get right down to it, one of the most romantic ideas in the American lexicon. How many songs do we have devoted to the lonesome whistle of the train? We're in a rapture about the self-driving car right now, but as far as the passengers are concerned, the train has been self-driving for a couple of centuries. You sit back and watch the continent click by. That we let this experience degrade so badly is a mark against America. That we have now a realistic plan to revive the rails in a way that moves us toward a desperately needed future is a great gift!

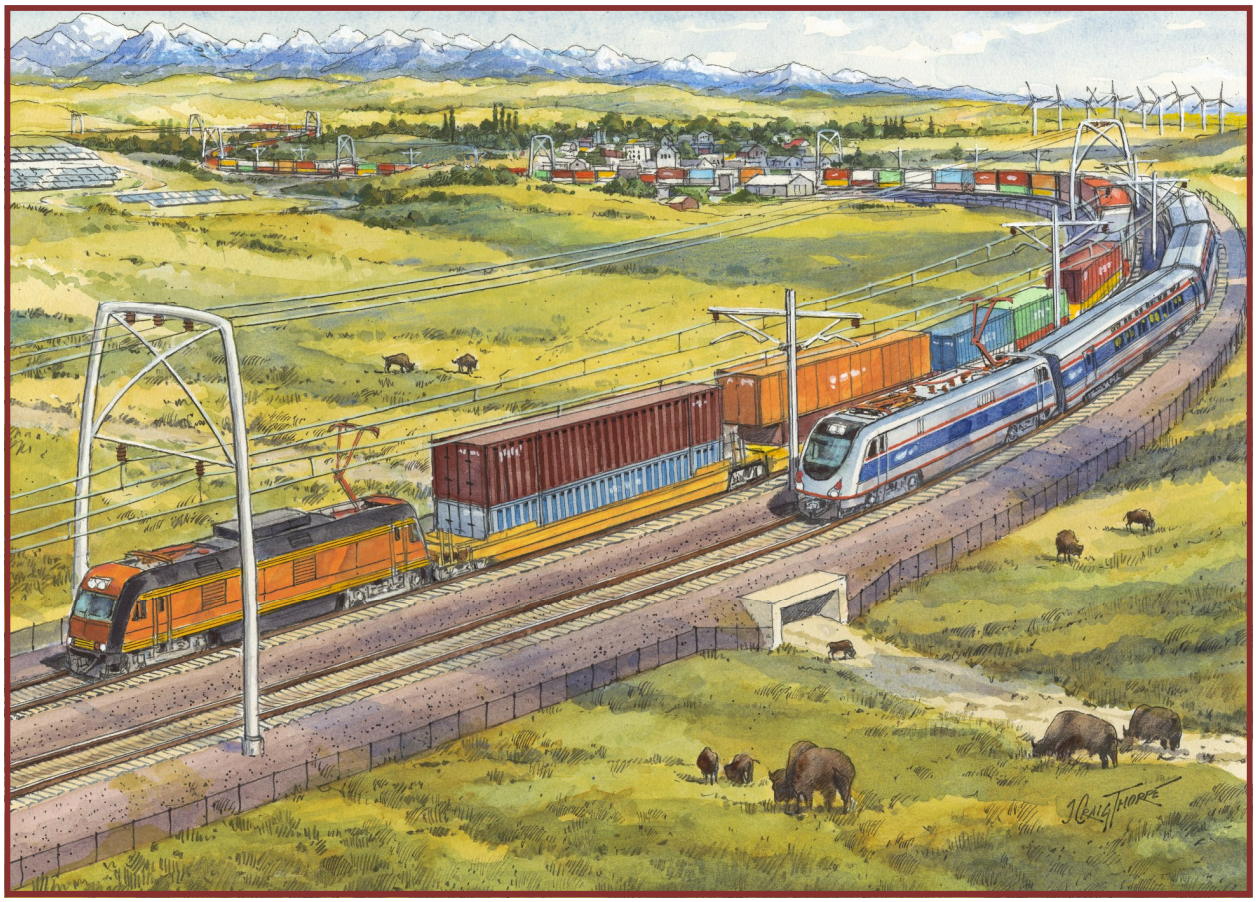


Image by J. Craig Thorpe

Unique among heavy, long-haul transport modes, railroads can run on electricity, and do so in much of the world. The fixed infrastructure of rail lines enables delivery of power by wires. This opens the door to employing clean, renewable electricity. Railroad corridors could also serve as electricity superhighways transmitting wind and solar energy from remote rural areas to metropolitan markets.

PREFACE: Rebuilding Rail to Meet the Challenges of the 21st Century

RAIL WORKERS SIT AT HOME ON INDEFINITE FURLOUGH while locomotive fleets idle in remote switchyards. An industry that was recently riding high, carrying massive bulk shipments of coal and oil to feed a world addicted to its payload, is now itself suffering symptoms of withdrawal. An economic downturn in fossil fuels, and the hard fact that they must be phased out rapidly to prevent the worst effects of climate disruption, mean that coal and oil producers are no longer reliable customers for railroads.

Increased rail shipments of oil from shale and tar sands have also raised public safety issues. Since 2013, 11 oil trains have exploded in fiery derailments, from a 2013 Quebec crash that killed 47 to a conflagration in the Columbia Gorge in 2016, and there have been a number of close calls. Public safety concerns on top of the climate pollution impacts of coal and oil have created stiff public opposition to proposals for new export facilities. Many such plans have been cancelled.

Overreliance on bulk fossil freight has posed other challenges over recent years. When shipments were booming, line capacity was stressed. Farmers had difficulty getting crops to market, especially the high-value perishable produce for which city residents pay most. Delayed Amtrak passenger trains lumbered into stations hours late. Ports lost container business to other destinations with more reliable rail connections. While these situations have somewhat eased, capacity issues could rise again with an increase in global oil prices. Passengers and shippers are exposed to the international political manipulations that control oil markets.

In a broader sense, the loss of diversified freight and passenger service hurts multitudes. Rural communities lacking good service suffer from economic isolation and cannot fund even basic services. Long-distance transport of goods relies on deteriorating highway infrastructure and trucks that contribute significantly to climate pollution. Public road maintenance budgets struggle to keep up. Rail passenger service, still popular where it is offered, is only a shadow of its former self. Many folks want to ride the train, but Amtrak's fleet is in poor repair, and tickets must be booked months in advance.

Rail was once king in freight and passenger markets. But the tide turned against railroads with the growth of publicly subsidized transportation alternatives. In the 20th century, federal and state governments built a comprehensive network of roads and highways, culminating in the Interstate system. That made long-haul trucking a powerful competitor for freight, and pushed rail to dependence on bulk shipments, predominantly coal, and more recently, oil. Those highways also drew passengers from trains, as did the public development of airports and air traffic control systems.

This array of challenges has a common solution, the subject of this book. We call it

Solutionary Rail. Its essence is a strategy to rebuild the role of diversified rail transportation in the US economy through a new public-private partnership aimed at rail electrification and modernization. Rail electrification can contribute to the transition from fossil fuels to clean energy by electrifying with renewables, and also by making rail corridors transmission routes from remote solar and wind resources to metropolitan markets.

Just about everyone will benefit from rail electrification. Through innovative public financing strategies, railroads will gain an infusion of capital to modernize lines. Increased speed and service-time reliability will make rail transport attractive to freight shippers and passengers, while diminishing reliance on bulk fossil fuel shipments. Shippers at every scale will have access to faster, more reliable cross-country freight transport. A new generation of passenger trains will provide fast, reliable and comfortable transportation to millions.

Rural and tribal utilities will be able to sell power generated on their lands, energizing the build-out of renewable energy across the country, with enormous benefits for communities that have been physically and economically stranded in recent decades. Utility customers will gain a reliable supply of renewable energy that can reduce consumer costs while allowing power companies to shut down old fossil-fuel generators.

Rail electrification offers a powerful engine for just transition, a concept popularized by labor leader Tony Mazzochi in the 1990s. Just transition entails that when workers are displaced and communities impacted due to improved environmental protections, they should be provided with means to transition into new economic opportunities. For both rail and fossil fuel industry workers, Solutionary Rail offers pathways beyond job dependence on extreme extraction and transport, and toward opportunities in a sustainable, clean energy economy. Rail workers will thrive in an increasingly robust industry, with strong protection for workers' rights.

Many will benefit from an electrified, modernized rail system. Residents near rail lines, now disproportionately affected by air pollution and noise from diesel engines, will enjoy cleaner air and quieter nights, reducing stress and improving health. Shifting freight from trucks to trains will reduce traffic congestion, accidents, and wear and tear on roads and bridges, taking pressure off stressed public budgets. Everyone on Earth, and future generations, will benefit from a rapid transition away from fossil fuels.

Rail enthusiasts and "rails," the name by which rail workers describe themselves, recall a time when loved and thriving railroads served as the circulatory system for vibrant communities and strong local economies. Our nation was woven together by the railroads and grew along their tracks. Cities and towns on and near rail lines could rely on rail service to access the world, to transport people and products to and from their regions. Those days can return. We can create a much brighter and more sustainable future for our country and the world by rebuilding rail transportation. Electrified and modernized rail is technically realistic and economically achievable.

SOME OF THE BENEFITS OF SOLUTIONARY RAIL

- **A modernized railroad network propelled by renewable electricity will provide a clean transportation option.**
- **Greater speeds and schedule reliability will draw freight back from highways and aviation.**
- **Intercity passenger service will become a faster, more practical alternative to driving and flying.**
- **Rail corridors will be electricity superhighways sending now inaccessible wind and sun energy to metropolitan areas.**
- **Rural electric coops and native tribes will have new power markets enabling them to develop renewable energy.**
- **Better and more reliable transportation will promote rural development and diversified agriculture.**
- **Rail workers will gain improved working conditions that help them perform their role as the first line of rail safety.**
- **People living near rail lines will have cleaner and quieter living environments.**
- **Traffic congestion will be reduced, resulting in fewer accidents and less wear and tear on highways.**

Bringing the vision to reality will require broad public alliances and creative public policies to spur needed investments.

For the hard working people who keep the trains rolling, we celebrate the tradition from which they hail and identify a public interest in their well being and the sustainability of their vocation. For farmers, utilities, tribes and trackside communities large and small, we point to railroads as a unifying force and source of new economic vitality. Solutionary Rail outlines a way to put railroads back on track, re-center their role in US transportation, and leverage this infrastructure treasure as a driving force for energy and economic solutions in a world urgently needing them.

Rail, the oldest form of mass mechanized transportation, is uniquely situated to meet the need for development that is both environmentally and economically sustainable. Modern electrified rail can lead a just transition to an economy based on renewable energy, and become an engine for sustainably and broadly realized prosperity. Solutionary Rail offers a strategy to achieve these goals. How to get there from here is the topic of this book.

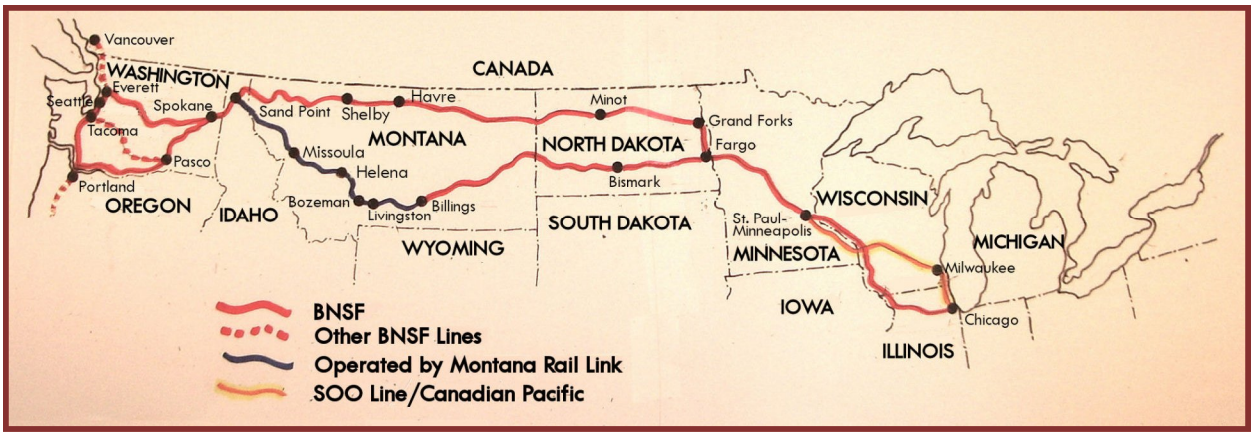


Image by J. Craig Thorpe

Electrification and modernization on a major US rail line will demonstrate success and create competitive pressure that spurs adoption throughout the industry. Solutionary Rail has identified the BNSF Northern Transcon from Seattle to Chicago and major Northern Corridor branch lines as ideal candidates for such a demonstration. The corridor is among the world's most important rail shipping routes, a key and sometimes capacity-constrained link to Asia transporting containers and agricultural products. Lines run through mountains and face challenging weather conditions. Northern Corridor electrification represents a robust proof of concept for electrifying lines across the nation.

CHAPTER 1
RAIL ELECTRIFICATION: A LIVE OPTION

The Solutionary Rail Strategy: An Overview

FEW INDUSTRIES ARE AS WELL POSITIONED AS RAILROADS TO LEAD a transition to an economy based on clean, renewable energy. Unlike other forms of heavy, long-haul transportation such as ships, planes and semi trucks, rail can be electrified, and electricity is increasingly coming from clean sources such as sun and wind. Already the most efficient form of ground transportation, rail has an unparalleled capacity to provide clean freight and passenger mobility.

In 2013, when a fossil fuel boom was driving a dramatic increase in rail traffic, the Backbone Campaign assembled a national team of rail experts, economists and public interest advocates to develop a transition proposal for rail that would address the industry's dependence on bulk coal and oil shipments. Motivated by concerns caused by the cargo, ranging from climate disruption to public health and safety threats, the team's goal was to provide economic transition options for rail and rail workers that would reduce reliance on fossil fuel transportation, and make rail itself an engine to build a clean energy economy. The team developed the Solutionary Rail strategy, building on a legacy created by rail electrification pioneer Gil Carmichael, who envisioned an electrification and modernization of the the nation's primary rail lines, and the advocacy groups he inspired, RAIL Solution and the Steel Interstate Coalition. In 2016, as this book goes to press, and fossil shipments have plummeted, the bust side of the equation makes the transition envisioned by Solutionary Rail even more urgently needed.

The Solutionary Rail strategy centers on railroad electrification with renewable energy, accomplished in conjunction with a campaign of track modernization. This will bring the US the reliable, electrified, higher-speed service now common on public railroads in countries from Europe to Asia. In this strategy, existing mainline tracks are upgraded to accommodate speeds up to 125mph. High-speed passenger rail that operates above 180mph in Europe and Asia, and is being developed in California and

the US Northeast, generally requires its own dedicated tracks. The more modest increase in speed envisioned by Solutionary Rail is the economically practical option for most US lines because existing tracks can be upgraded without building new lines, and both freight and passenger trains can be accommodated on the same lines. Investing in an electrified, modernized rail network can begin to reduce dependence on bulk trains by making possible express mixed freight service and more competitive intercity passenger service.

Electrified rail can move the economy as a whole beyond reliance on fossil fuels. Not only can railroads provide new demand for renewable energy, they can also help increase the supply. Electrification infrastructure will require high-voltage transmission that can carry energy surplus to rail requirements. Railroad corridors could serve as electricity superhighways transmitting wind and solar energy from remote rural areas to metropolitan markets. With assured markets, utilities large and small could obtain renewable energy project financing that is currently unavailable. This can unleash massive untapped potential such as Great Plains wind now stranded by insufficient transmission. Rural co-ops and tribal utilities in remote sun- and wind-rich regions especially stand to benefit. Linking renewable energy generation across diverse geographies would overcome the major challenge facing variable solar and wind sources by making overall production more predictable and reliable.

Railroad corridors could serve as electricity superhighways transmitting wind and solar energy from remote rural areas to metropolitan markets.

Rail electrification offers many advantages for railroad operators including far lower fuel costs. Electricity costs significantly less than the diesel that now runs train engines. Electric locomotives are less expensive to operate, and have fewer moving parts than diesels. A British study cited in this publication puts savings at 35% compared to conventional rail (see p. 20).

Drawn by these advantages, US railroads have been exploring electrification, but high upfront costs pose a huge barrier. A rule of thumb is that electrification costs on average $2 million for a single-track mile and $2.5 million for a double-track mile. To be economical, electrification must be done on a systemic basis in increments of at least 500 miles. That could represent a $1.25 billion investment. Railroads already devote a far larger portion of their revenues to capital investment than most US industries. And unlike public railroads in countries with mass electrification, US railroads must carry interest rates as private borrowers, and pay property taxes on improvements. While these hurdles discourage modern rail electrification in the US, nations from Europe to Asia are making massive investments in publicly owned railroads. They are

creating 21st century electrified rail that rapidly transports goods and people across nations. Electrified rail propels close to a quarter of global track mileage, but under 1% in the US.

Electrification is a major systems transformation that will require a large investment of public capital. The Solutionary Rail strategy proposes an innovative public financing mechanism, a Steel Interstate Development Authority (SIDA). Jointly created by states along main rail lines, a SIDA would leverage the ability of public agencies to raise low-cost public capital, and invest in rail electrification in partnership with railroads. Electrification infrastructure and potentially some tracks would be publicly owned. Public ownership would begin to restore the commons to our economy and society, reversing the privatization trend that has caused so much damage over recent decades.

Electrification and modernization of one main line by one of North America's seven major railroads will demonstrate success and create competitive pressure that spurs adoption throughout the industry. Solutionary Rail would jumpstart US rail electrification with a Northern Corridor demonstration on the BNSF Northern Transcon line from Seattle to Chicago, and connecting branches, altogether totaling around 4,400 track miles. Priority would be on the Transcon, the major intermodal line carrying containers between the Northwest and Midwest, with branches electrified later. The Northern Corridor is an ideal candidate for such a demonstration. Running from the Midwest to the Northwest, the corridor is one of the world's most important rail shipping corridors, a key link to Asia transporting containers and agricultural products. Amtrak's Empire Builder operates on the Transcon and branches. Running across the Great Plains, Rockies and Cascades, the Northern Corridor lines face challenging weather conditions and topography. For all these reasons, Northern Corridor electrification represents a robust proof of concept for electrification of main lines across the nation.

Northern Corridor electrification represents a robust proof of concept for electrification of main lines across the nation.

A Northern Corridor demonstration would upgrade and add track to facilitate higher speeds, opening the way for express delivery of high-value freight and enhanced passenger service on intercity corridors in the Northwest and Midwest. It would also provide a market and potential transmission corridor for one of the world's greatest, and currently under-developed, renewable energy resources, Great Plains wind. Added transmission could benefit BNSF owner Warren Buffett's substantial investments in renewable energy. BNSF has already explored electrification along its lines in conjunction with transmission development, but has not moved forward because of capitalization challenges.

Achieving a Northern Corridor demonstration will require a broad alliance including BNSF and Warren Buffett, governors and legislators of Northern Corridor states, state transportation agencies, railroad workers, corridor communities, tribal governments, agricultural interests, ports, major industries and shippers. Building new partnerships among the many interests needed to successfully reinvent rail can help bridge economic and social divides that have grown wider in recent decades. We can re-create the place of the commons in American life by developing publicly owned rail electrification infrastructure, and building new partnerships among states, railroad companies, rail labor and rail-served communities.

Solutionary Rail's concept to jumpstart Northern Corridor rail electrification would provide phenomenal benefits to BNSF. It is fair that in return BNSF and Warren Buffett will build a new social contract with railroad workers as a model for improved labor relations across the United States. A fair deal for rail labor is an integral element of the Solutionary Rail vision.

The Northern Corridor states can lead the way in the US in jumpstarting electrification. In fact, the Northern Corridor once led the world in electrified rail. That story, to which we now turn, has lessons for the future.

How the Northern Corridor Once Led the World in Rail Electrification

THOUGH US RAIL ELECTRIFICATION LAGS BEHIND the rest of the world today, once the US was the leader, and that leadership centered in the Northern Corridor. This history holds important lessons for the new electrification initiatives proposed by Solutionary Rail.

It began in 1909 with Great Northern electrification of the 2.5-mile Cascade Tunnel under Stevens Pass on the route between Wenatchee and Skykomish, Washington. A mishap in the tunnel six years before led to near suffocation of crew and passengers with steam engine smoke and gases, so the Great Northern undertook the Western Hemisphere's first three-phase alternating current (AC) electrification. It was the first electric rail system anywhere to employ regenerative braking, capturing braking energy much as hybrid cars do today. The system fed power back to the grid. It worked so well train superintendents could use power flow gauges to tell if engineers were exceeding the 20mph speed limit on downhill tracks.[1]

That success led to electrification of 73 miles of the mainline in the mid-1920s, including a new eight-mile-long tunnel. For hauling up steep grades, electric engines provided superior power to the steam engines that then prevailed in the rail system.

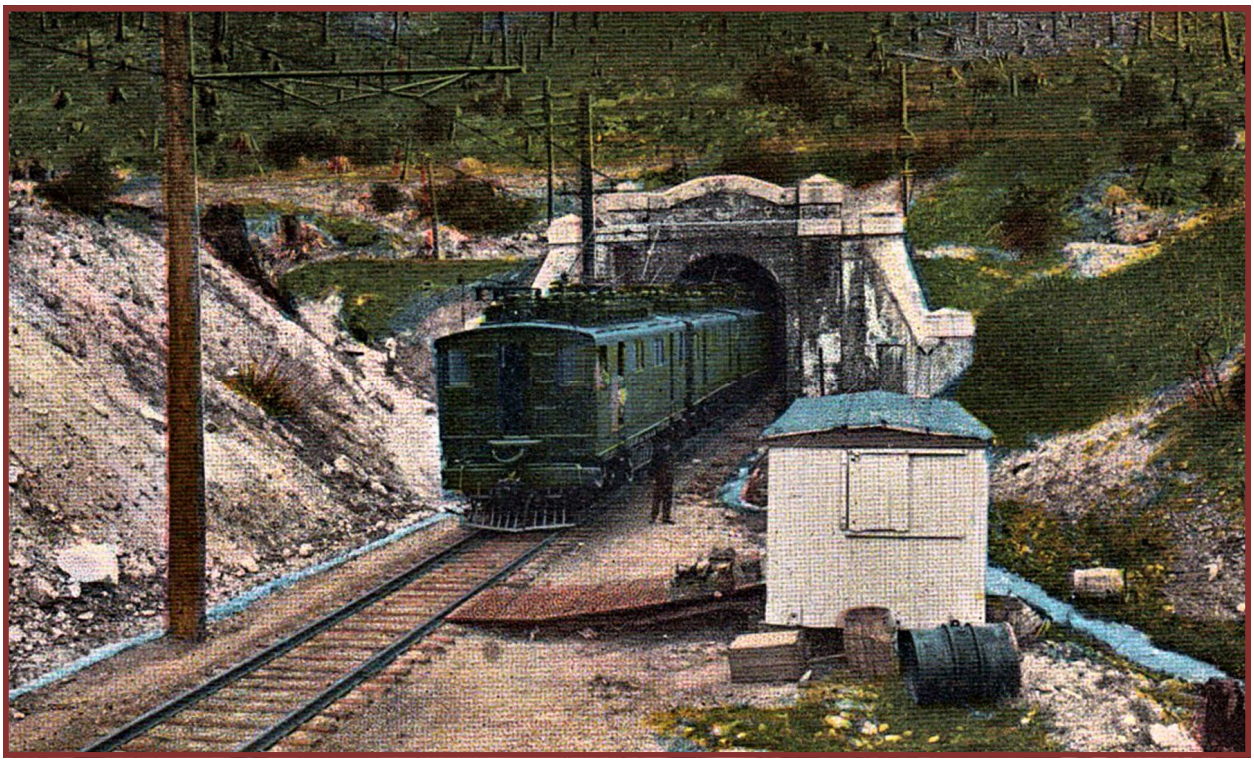


Photo by Curtis and Miller, 1924

One of the first electric engines emerging from the Cascade tunnel on the Great Northern Railway, circa 1924.

The system lasted well into the diesel engine era. It was removed only in 1956 when the tunnel was ventilated.

The next instance of Northern Corridor electrification leadership came in Montana in 1913 when the Butte, Anaconda and Pacific Railway (BA&P) installed a direct current (DC) system. Electrification of US urban commuter rail dates to the 1880s in Cleveland and Richmond, Virginia, and the Baltimore and Ohio undertook a four-mile mainline electrification in 1895. But the Montana short line serving the huge copper mine at Butte was the continent's first mostly freight railroad to fully electrify.

The most memorable American rail electrification initiative came on what later was known as the Milwaukee line, then called the Chicago, Milwaukee, St. Paul & Pacific. Between 1914 and 1920 it undertook the "first long-distance electrification of a main-line railroad," Richard Steinheimer notes in *The Electric Way Across the Mountains: Stories of the Milwaukee Road Electrification.*[2] "It became the prototype for similar high-voltage direct current systems in Argentina, Brazil, Chile, France, India, Russia, Spain, Asia and Africa," Steinheimer writes.[3]

The Midwest-based St. Paul originated in 1851. In the early 1900s the company

planned an extension to the Pacific to match its hefty competitors, the Great Northern and Northern Pacific. Stretching almost 1,400 miles, the Pacific Extension was completed in 1909.

Because the railroad was the last mainline to the coast, it needed a competitive advantage, so it took the shortest route. That avoided major cities served by its competitors, which proved a weakness over time. The direct route also pushed it over some of the continent's most rugged terrain, the Rocky, Belt and Bitterroot Mountains in Montana and Idaho, and the Saddles and Cascades in Washington. Needing traction to ascend steep and curvy grades where steam fell short, the railroad began looking into electrification in 1907. John D. Ryan, president of BA&P parent Anaconda Copper, who held interests in two Montana hydropower companies that later became Montana Power, sealed the deal after he became part of the St. Paul board in 1909. The Milwaukee let contracts for electrification of its Rocky Mountain Division to GE in 1914. By 1917, 440 miles from Avery, Idaho to Harlowton, Montana were electrified and running on 3,000 volts of renewably generated DC current. The railroad was the first big customer for the hydropower utilities.

Previous electrifications in the US were all less than 160 miles, typically to reduce smoke in urban areas. "The Milwaukee's 654-mile electrification was uniquely important to General Electric and Westinghouse because it demonstrated the practicability of long distance steam railroad electrification," Noel Holley recounts in *The Milwaukee Electrics*.[4]

The Milwaukee's 654-mile electrification was uniquely important… because it demonstrated the practicability of long distance steam railroad electrification.

As part of the deal, GE supplied 84 electric locomotives that were assembled into two-unit packages, some of which were running 58 years later. They were "huge compared to anything previously built and billed as the 'World's Mightiest,' " Holley recalls. As with previous electrifications, they both saved brake wear and reduced electricity costs with regenerative braking, the first such use on a DC system.

The railroad then opted for a second phase, electrifying 220 miles of the mountainous Coast Division from Othello to Tacoma, Washington between 1917–20. The railroad "was the proud owner of the world's longest electrified railroad," Jim Scribbens writes in *Milwaukee Road Remembered*. It "quickly became the object of attention throughout the world. Representatives from the railways of Western Europe and Japan traveled to Tacoma and Deer Lodge to gain firsthand knowledge of this brilliant star of the rail world."[5] They included visitors from France and Japan, today two of the world's electrified rail leaders. The electrified line even had a presidential engineer. Warren Harding took the controls in Montana July 2, 1923 on his way to an Alaska hunting trip.

Electrification demonstrated success.

"The Milwaukee's announced reasons for electrifying were to improve general operations and to reduce operating costs," Holley writes. "It was successful on both counts. Electrics easily bested the schedules operated by steam, and they did so at an operating cost which was only 54% of what it would cost to run steam." A substantial portion of the savings was due to electric engines needing far less maintenance than steam locomotives.[6]

Source: Holley[4]

Unfortunately, World War I inflation had pumped up the cost on the coast electrification to four times what was originally projected. Traffic on the single-track line also did not meet expectations. The coast branch had capacity for ten times the traffic it carried.[7] While electric operating costs were lower, comparative capital costs were three times as great. "The large investment exacted a heavy toll as bond interest and payments devoured much of the money which was saved." Thus net annual cost reductions on the mountain line were around $1 million a year, and on the coast line were only $100,000 a year.[8] Unexpected costs in acquiring and upgrading two Midwest lines and a postwar recession pushed the railroad over the edge. The St. Paul declared bankruptcy in 1925, and emerged as the Milwaukee in 1927.

With the coming of the Depression in 1929 the Milwaukee faced general economic problems. It went into a second bankruptcy in 1935 that lasted until 1945. By that time diesel locomotives were appearing, and the Milwaukee was a house divided against itself. The Mechanical Division based in Chicago, which ran the steam and then diesel engines, resented the autonomy of the Electrification Division based in Seattle. As the postwar era dawned and emergence from the second bankruptcy heralded new investments, the Chicago side saw diesels as a way to beat its Seattle rivals. "The old and worn electric fleet was in need of replacement and the powerful

new diesels looked like just the locomotives to do it," Holley writes.[9] The need to beef up substations to provide enough power for the heavier trains then emerging also made diesel conversion look like a better deal.

Electrification might have ended then. In 1947 an orderly phase-out of electrification was ordered along with a ten-year plan to replace all steam engines with diesel locomotives. But Electrification Department head Laurence Wylie reversed that with the railroad's first study of comparative costs. It found that running existing electrical locomotives was cheaper than buying new diesels. Here the investment balance tipped to electrification. Wylie also pushed to buy new electric locos. "Wylie felt that if the Milwaukee were running modern electrics, diesels would simply be unable to match them in any way," Holley recounted.[10]

The Cold War then ramping up between the US and the Soviet Union provided an opportunity. GE had built twenty engines for extension of electrification on the Trans-Siberian railway, but with increasing tensions the government barred export of an obviously strategic product. Wylie managed to pick up 12 of them for a bargain basement $1 million. Crews quickly dubbed the Little Joes after Soviet leader Joseph Stalin.

Wylie proved a genius at low-cost modernization through the 1950s by rebuilding existing electrics and assembling them into four-unit locomotives capable of pulling 3,500 tons on a 1.7% grade. He automated substations and invented a control system

Source: US National Park Service

A "Little Joe" on the Milwaukee Road in Montana.

capable of meshing electrics and diesels on the same train set. Regarded as a hero among rail electrification advocates, Wylie successfully continued to fend off pressures from the Mechanical Department to de-electrify.

The electric fleet remained largely intact until 1963. Of the original 84 locomotives, 76 still operated. But efforts to buy new engines were frustrated by company management, and many of the old ones were moving past their useful service life. Only 31 units remained by 1970.

The 1960s were a low point for the rail industry. The publicly subsidized Interstates ate away their freight business, while similarly subsidized aviation eroded passenger service. The industry was regarded as a "sick man." The Milwaukee started to seek merger partners. In 1967, during efforts to join with Chicago & Northwestern, Milwaukee President Curtis Crippen commented, "all capital improvements we make will be directed toward the ultimate consolidation of the two roads."[11] Since none of its potential partners were electrified, further investment in electrification was starved.

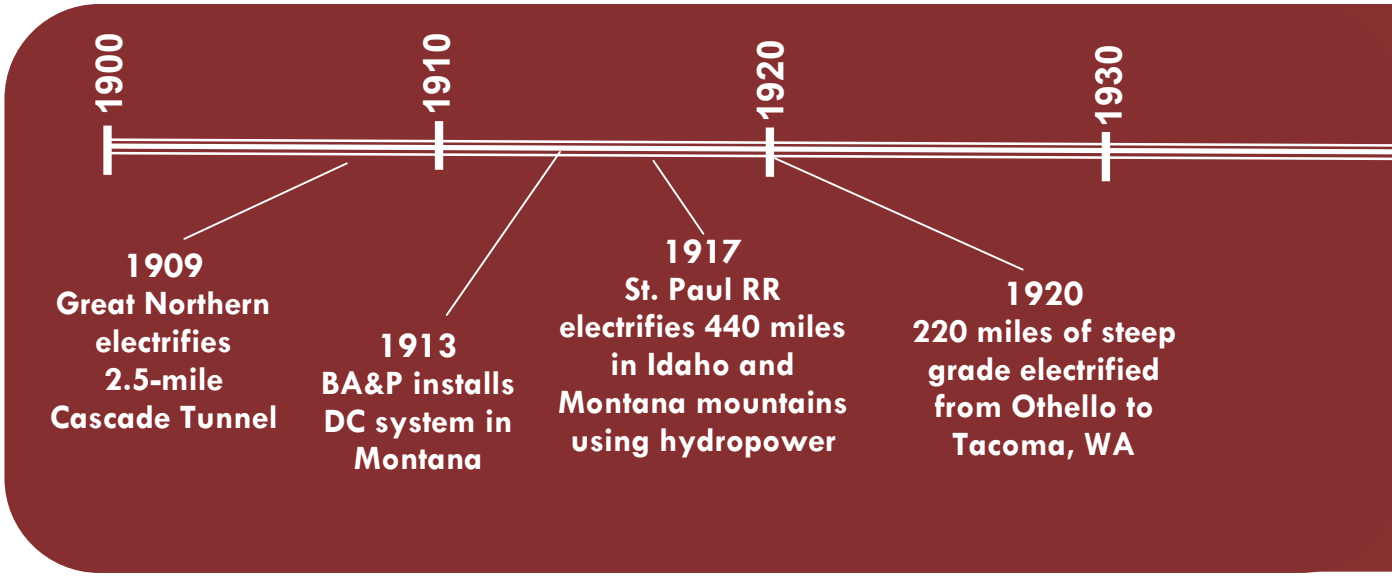
By the end of the decade the railroad was running in the red. After the Northwestern effort failed, the company continued to seek merger partners. With the losses and deterioration of the electrification infrastructure, a committee was appointed in 1971 to consider the fate of the system. In February 1973 the decision to terminate electrification was announced. A month later the railroad sought to become part of Burlington Northern, and it was thought that some of the Pacific Extension would be abandoned in the deal. That never came to fruition, but the end of electrification did.

The last electric engine on the Coast Division ran in 1972. The end of electric operations on the mountain stretch was originally slated for Oct. 31, 1973. Ironically, the Arab oil embargo started on Oct. 17. Fuel shortages and high prices pushed electrification's last day to June 15, 1974.

"The main problem was that the Milwaukee didn't have much money," Wylie recalled. "In addition, the decision-making was in Chicago, a long way from the electrification. Most of the people at the top only came west a few times. They never really understood the electrification and didn't like it."[12]

But there was another path, and another potential outcome. The railroad had drawn up a plan to modernize infrastructure, buy new engines and electrify the gap between Avery and Othello. It would have cost $39 million. GE was willing to finance it. Transfer of $21 million worth of diesel engines to the east would have cut the net investment to $18 million. But a management facing losses and seeking mergers tilted against the deal, and instead sought financial relief selling copper wires for surplus, for which it ultimately gained $5 million. In the end, diesel conversion cost just as much: $39 million.[13]

Not long before the abandonment of the Pacific Extension electrification, Michael Sol surveyed it as part of an engineering team. He found, "The remaining locomotives

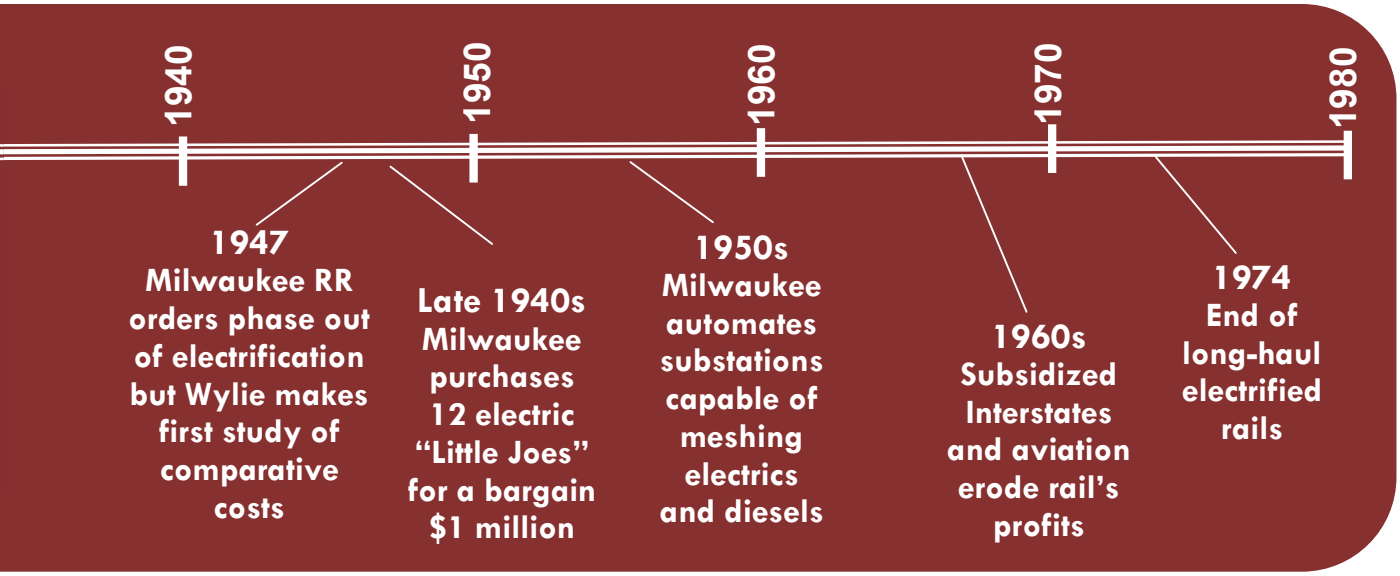


Timeline of Pacific Northwest railroad electrification

were not worn out, or even close to the end of their economic service life. Rather, there were just not enough of them. In fact, they were performing far out of proportion to their rated horsepower, and far, far beyond the expected availability of diesel-electric motive power of not only the same age, but even of modern vintage." Sol estimate that the railroad would have saved $64 million in fuel costs between 1974 and 1980 if the electrics had continued to run with the frequency they did in 1972.[14] Such savings would have rapidly repaid a new electrification investment.

As it was, the Milwaukee again declared bankruptcy in 1977, and shut down the Pacific Extension in 1980. The company name disappeared with takeover by a Canadian Pacific subsidiary in 1985. Would a renewed commitment to rail electrification have saved the railroad, or put it in a stronger position to retain its identity in an era of railroad consolidation? Those are unknowns. But clearly the railroad's overall decline was of a piece with the loss of the innovative edge that spurred the original electrification. In a recovering rail industry, electrification represented a sound investment alternative, a track not taken.

Gaining sufficient investment to properly maintain and upgrade the electrified lines remained the primary challenge facing Milwaukee electrification through most of its history. This underscores a crucial insight at the center of the Solutionary Rail proposal. Electrification provides superior operating performance, but high upfront investment costs pose an obstacle for privately-owned railroads that must carry private borrower interest rates. Solutionary Rail seeks to overcome this barrier through



new partnerships between the public, railroads and other stakeholders focused on securing the benefits of electrification for railroads and society in general. The proposal is detailed in a later chapter.

The Milwaukee electrification, its challenges and benefits, provides important lessons. First, electrification will require a solid and unified commitment by railroad managements convinced of its value. Second, electrification will require partnerships beyond railroads that include public agencies, labor unions, communities and advocacy groups in order to overcome the capitalization challenges evidenced in the Milwaukee experience. These key insights inform the Solutionary Rail strategy.

Electrified rail works around the world

AROUND A QUARTER OF THE WORLD'S RAIL LINES ARE ELECTRIFIED, 186,000 miles out of a total of 808,000. Western Europe leads with 53% of lines propelled by electricity, while North America trails with 1%. The global electrification market "continues to grow dynamically," particularly in Western Europe, Africa and the Middle East, SGI/Verkehr reports.[15] Electricity's share in fueling rail is growing, up from 17% in 1990 to 36% in 2012, while oil has held steady at 58% and coal decreased from 25% to 6%.[16]

Electrification plays a significant role in some of the world's largest and richest nations, as the table below shows.[17]

	Total Rail Lines in Miles	Percentage Electrified
China	53,437	41%
France	18,417	52%
Germany	26,085	48%
India	39,741	30%
Italy	12,585	64%
Japan	16,890	18%
Russia	54,157	46%

However, these figures understate the significance of electrification. Typically it is the more heavily used lines that are electrified. For example, though France is only 52% electrified, 85% of freight and 90% of passengers run on electrified lines.[18] [19]

In Russia the Trans-Siberian, the longest continuous rail line in the world, was fully electrified by the end of 2002. This is notable because it runs in one of the world's harshest environments and because reliable operation is critical to Russia's strategic control of its eastern regions. The rail line carries 30% of Russian exports.[20] Overall, elec-

By Vadim Anokhin, Wikimedia Commons, CC BY-SA 3.0

Electric VL80T-831 Locomotive carrying freight in the countryside near Chaltyr, Russia.

tric lines carry 70% of Russian freight, the equivalent in ton-miles of 80% of US rail freight.[21] Russia has 24,912 electrified rail miles, and extended electrification to the Arctic port of Murmansk in 2005.[22] China rail electrification has expanded rapidly. Concerted efforts have grown the percentage from only 5% in 1975 to over 40% today.

Smaller economic powerhouse nations have largely electrified rail systems. Sweden grew electrification from 61% in in 1970 to 77% of its system in 2005. The Netherlands has increased its electrified network from 52% in 1970 to 73% in 2005. Switzerland is a global standout with a 100% electrification rate.[23] That nation is in the midst of a major rail line improvement program, a central goal of which to move freight from trucks to electric rail. In 17 European nations the rail network is at least 40% electrified.[24]

Great Britain, which has lagged other European nations with only 33% of its rail network electrified, in 2007 announced a £1.1 billion effort to expand electrification.[25] The Great Western Line linking London with Wales is slated for full electrification by 2017.[26] Liverpool-Manchester, one of the world's oldest rail lines, was electrified in 2015.

Nations around the world that have recently expanded electrified rail or are engaged in significant efforts to do so include Chile, Taiwan, Malaysia, Iran, Israel, Saudi Arabia, Kazakhstan, Uzbekistan, Ethiopia, South Africa, Denmark, Norway, and New Zealand.

Electrified rail is working around the world. It can work in the US again.

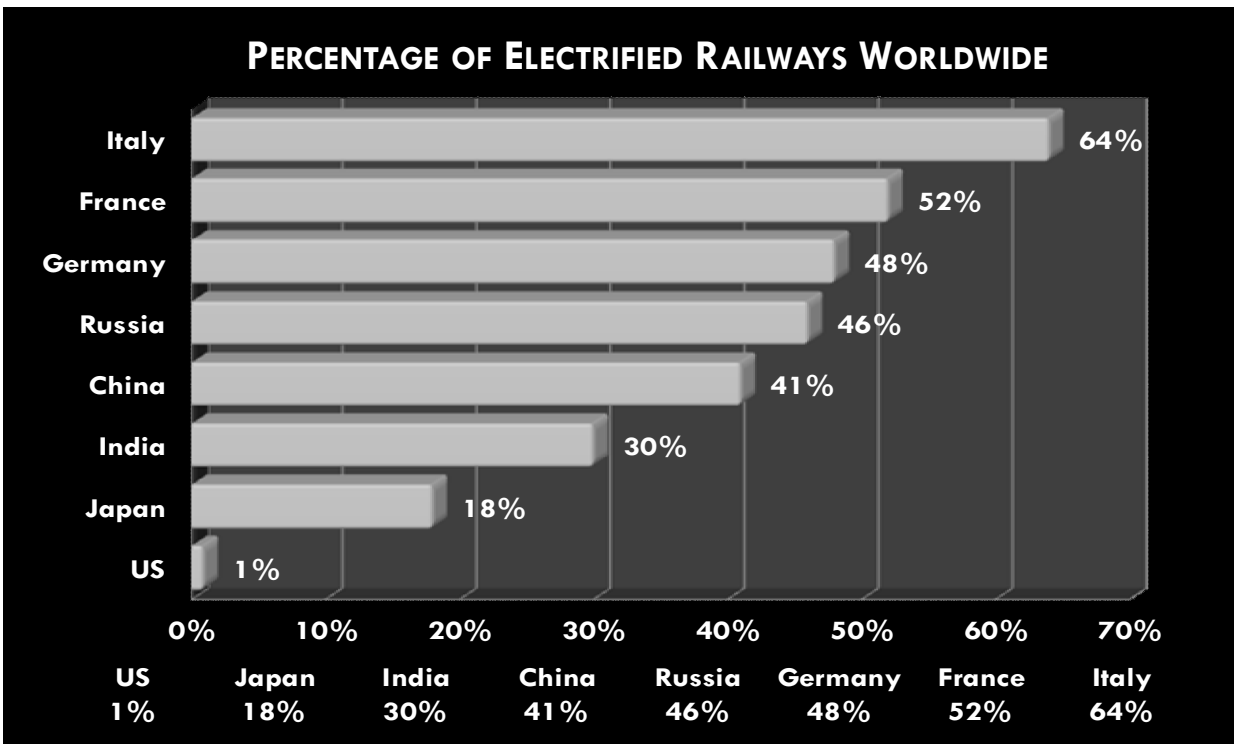


Image by J. Craig Thorpe

Rail electrification would enhance health and quality of life in major cities and across America. Diesel exhaust poses health threats, and disproportionately affects people of color and the poor, who tend to live near yards and lines. Electrification eliminates diesel emissions, reducing health impacts and associated costs. Electrification also cuts noise pollution, reducing stress for people living near lines.

CHAPTER 2
RAIL ELECTRIFICATION'S MANY ADVANTAGES

Rail's Efficiency Advantages

CONVENTIONAL DIESEL-POWERED RAIL ALREADY WINS hands down for transport efficiency.

The Federal Railroad Administration finds, "For all movements, rail fuel efficiency is higher than truck fuel efficiency in terms of ton-miles per gallon. The ratio between rail and truck fuel efficiency indicates how much more fuel efficient rail is in comparison to trucks…rail fuel efficiency varies from 156 to 512 ton-miles per gallon, truck fuel efficiency ranges from 68 to 133 ton-miles per gallon." At the low end, a unit auto train is 1.9 times more efficient than its truck equivalent, while a double-stack container train can haul freight 5.5 times more efficiently than trucks.[27]

Trucks cannot be eliminated entirely from freight transport. A short haul by truck is usually required at each end of the trip, because most origins and destinations are equipped with truck loading docks rather than rail sidings. And because rail lines are fewer than roads, and cannot operate on the steep grades that trucks can, rail shipments may require more miles to complete. Yet even if the rail trip is 50% longer than the road trip it replaces, this still yields substantial energy savings.

Rail's efficiency advantage rests on basic physics. Steel rolling on steel has about one-fifth of the friction of rubber on concrete. Trains are more efficient aerodynamically than an equivalent number of trucks since one rail car reduces drag for the following car.

Building on these efficiency advantages, electrification offers additional economic advantages in the form of reduced fuel costs. Diesel-powered trains already employ a hybrid-electric system. The diesel engine generates electricity to run electric traction motors that turn the wheels. On average around 30–35% of the energy in the fuel makes it to the wheels.[28] Supplying electricity directly from an overhead power line offers railroads substantial cost savings because about 95% of the electricity taken from the power grid is employed by the wheels: no more than 5% is lost through the engine transformer and overhead wires. Thermal power plants, much as diesel generators on

board engines, lose energy converting fuel to electricity. But these inefficiencies are upstream from customer use and are already factored into the price that the rail system would pay when it purchases electricity from the transmission grid. This provides substantial operating cost advantages to electrified rail.

A calculation based on $2.50/gallon diesel underscores the advantage. (While diesel prices at the time of this writing are generally ranging lower, over coming years they can be expected to rise. Even at lower diesel prices, electricity still provides significant cost benefits.) At that price the equivalent electricity cost is $0.0614/kilowatt hour (kWh). At a 33% energy conversion, the efficiency-adjusted price is $0.1842/kWh. By contrast, the average price of electricity in Nebraska is $0.0784 kWh. This is typical of where a freight railroad would draw electricity (the average price of electricity in the US is skewed toward major population centers where railroads would only draw a small portion of their electricity). Used at 95% efficiency, the cost is $0.0825 kWh. Thus an electrified locomotive can provide the same service for 44.7% of the energy cost.[29] This is a conservative estimate, since railroads would buy in bulk at heavily discounted rates.

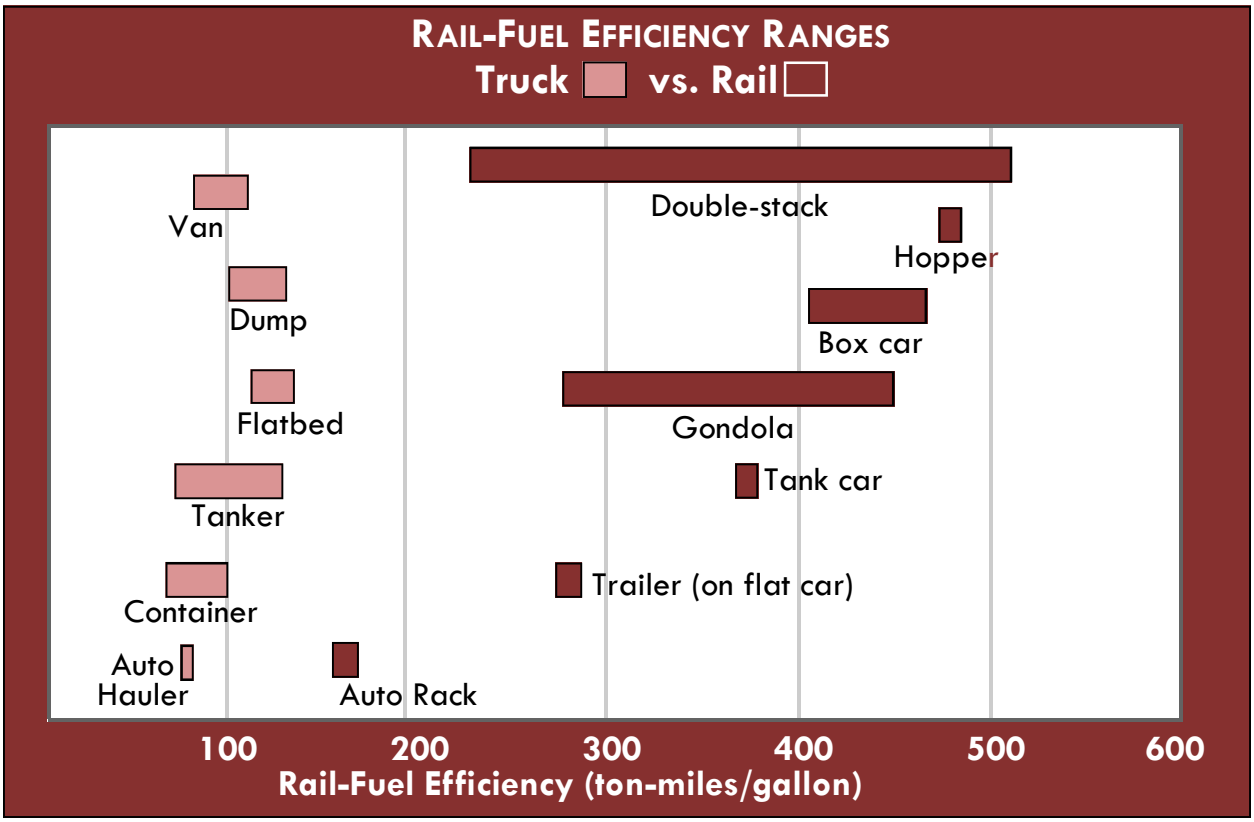
...an electrified locomotive can provide the same service for 44.7% of the energy cost.

These figures understate the electrified rail advantage in another way. Similar to hybrid cars, modern electric locomotives can regenerate power during braking, feeding electricity back into the grid. This would cut overall electrical bills.

Electrified rail has another advantage over diesel power. Around the world electric locomotives are cheaper to buy and operate. One estimate from Britain puts purchase costs at 20% less, and the gap will grow even greater with stricter emissions standards on diesel locomotives,[30] the costs of which are expected to increase by 20–25%.[31] Since the market is less developed in the US, initial electric locomotive purchase prices may be higher until the market grows. In any event, maintenance costs will be less because electric locomotives have fewer moving parts than diesels. A Hungarian study shows they break down around 40% less on intercity lines.[32] Overall, electrified rail advantages provide substantially lower operating costs than diesel. The Hungarian study puts the figure at 25–30% less.[33] The UK Department for Transport sets savings even higher: “Electric trains are over 35% cheaper to operate than diesels.”[34]

Electric locomotives do depend on a reliable power grid. The US grid is up to the task. On average US electricity customers are without power less than two hours per year or about 0.02% of the time.[35] Japan, by contrast, has one of the world’s most reliable electric grids. Customers there are without power on average only four minutes per year, less than 0.001% of the time.[36] These statistics exclude interruptions from major, infrequent catastrophic developments, like Superstorm Sandy.

Even so, the figures probably overstate the expected impact of power outages on



Source: Federal Railroad Administration

electric railroad operations. Most power interruptions result from weather-related incidents, such as downed trees, which mostly affect distribution systems downstream from the substations that would directly feed railroad power lines. Incidents that would impact electrical generation, transmission systems, or railroad power lines are substantially less frequent.[37]

The US power grid has been gradually becoming less reliable. Principal reasons cited are under-investment in an aging grid, low levels of research by the electric power industry, and the increasing intensity of extreme weather events driven by climate change.[38] However, even if this adverse trend in reliability is allowed to continue, grid reliability would constitute only a minor factor affecting electric railroad operations, particularly when viewed in the context of the superior availability and reliability of electric locomotives when compared with their diesel counterparts.

Despite electrified rail's many advantages, it still faces an uphill battle in the US, and the obstacles include bad information. That was illustrated when in late 2015 Backbone's Solutionary Rail technical team learned that a study was making broad claims against the feasibility of rail electrification.

EFFICIENCY ADVANTAGES OF SOLUTIONARY RAIL

- **Trains are more efficient aerodynamically than trucks.**
- **Steel rolling on steel has about one-fifth of the friction of rubber on concrete.**
- **Electricity costs much less than diesel fuel.**
- **Regenerative braking reduces fuel costs even more.**
- **Electric locomotives are cheaper to buy and operate than diesel.**
- **Electric locomotive maintenance costs are lower.**

The study, commissioned by the Federal Railroad Administration (FRA) and carried out in part by Booz Allen Hamilton, was titled *Cost-Benefit Analysis of Rail Electrification for Next Generation Freight and Passenger Rail Transportation.* The study's scope was limited to a 75-mile stretch of rail in Pennsylvania called Keystone East. It concluded, "As a result of this analysis, the study finds that the costs for electrification infrastructure remain significant, while the benefits are only modest, or in some cases nonexistent."

Backbone's Solutionary Rail team went to work. The team uncovered bad math, false assumptions, and erroneous assertions. At first the team thought that limited scale was the only problem. Team economist Bruce McFarling said, "...the Keystone itself is too short to take full advantage of the benefits...given the relatively low cost of electrifying between Chicago and the Keystone, an electrified Chicago to Harrisburg freight corridor looks a lot more interesting than simply extending the current Keystone East electrification over into Pittsburgh."

Then team electrical engineer and transmission specialist Gerry Callison uncovered a nearly unfathomable flaw in the core assumptions of the study, "I discovered that the report assumed that a given amount of energy contained in diesel, when subjected to a 50% efficient combustion engine, would carry a train 2.5 times further than the same amount of energy contained in power grid electricity, which is subjected to a 95% efficient transformer. Such an assumption is unable to support the report's conclusion that freight electrification is uneconomical."

In effect, the Booz study inverted the actual economic profile. The study justified its conclusion in large part due to energy cost calculations that put the cost of diesel at $1.27 per mile and electricity at $3.57 per mile, approximately 260% more. What Callison determined quickly is that using Booz' own numbers the true cost is $0.70 per mile. Even that is based on electricity cost assumptions that might be high.

Callison and track engineer Steve Chrismer appealed to the Federal Railway Administration and were heard. The team delivered a quiet victory with potentially huge consequences. It successfully had the flawed study removed from the Federal Railway Administration website.

As this development illustrates, when the real story is known, it is clear that for lower-cost, energy efficient transportation, rail wins, and electrified rail is the champion.

Running Rail on Renewable Electricity

FULL ELECTRIFICATION IS NOT PRACTICAL FOR MOST LONG-HAUL heavy vehicles including airplanes, ships, barges and over-the-road trucks. Unique among heavy, long-haul transport modes, railroads can run on electricity, and, as demonstrated above, do in much of the world. The fixed infrastructure of rail lines enables delivery of power by wires. This in turn opens the door to employing clean, renewable electricity, meeting the challenge of carbon pollution reduction. One of the great advantages of moving to electrified rail is the potential to propel a significant portion of the transportation sector with renewable electricity.

The Netherlands rail network already draws half its energy from wind. That country has committed to 100% wind-powered rail by 2018.[39] Belgium runs its rail network 5% on windpower,[40] and has covered a two-mile canopy on the Amsterdam-Paris high-speed line with 16,000 solar panels that power the line.[41] Canada is exploring a Toronto–Montreal passenger line running at speeds exceeding 100mph and propelled by Quebec hydropower.[42]

Renewable power for transportation will address one of the greatest challenges in reducing carbon emissions, replacing petroleum-based liquid transportation fuels. Transportation is the source of 27% of US climate-altering greenhouse gas (GHG) emissions.[43] The National Academy of Sciences notes that 86% of U.S transportation runs on oil-based fuels.[44] Oil replacement is the greatest challenge in shifting to a fully renewable energy supply. The convenience and energy density of oil-based liquid fuels are hard to match.

In the electrical sector, where fossil fuel energy generation is almost entirely with coal and gas, the picture looks different. The cost of renewable generation is dropping rapidly. “Solar and Wind Energy Start to Win on Price vs. Conventional Fuels,” the *New York Times* reported in late 2014. “The cost of providing electricity from wind and solar power plants has plummeted over the last five years, so much so that in some markets renewable generation is now cheaper than coal or natural gas,” the *Times*

noted.[45] Solar energy will be competitive with electricity from the power grid in at least two-thirds of the global market, and up to 80%, by 2017, Deutche Bank projects.[46] The success of renewable electricity makes it a powerful contender to replace oil in transportation.

Electrification is emerging in the light-duty vehicle fleet. US electric vehicle sales more than doubled to nearly 120,000 in 2014, from 53,000 in 2012, and 2015 sales remained near 2014's at 116,000 despite low oil prices. The pace continued steady in 2016 with nearly 28,000 in the first three months.[47] Growth is expected with new offerings and major initiatives by automakers including Tesla and General Motors that lower costs and extend ranges, overcoming the prime obstacles to market growth.[48] When the 200-mile-range Tesla Model 3 was unveiled in March 2016, the number of orders surprised even company founder Elon Musk.[49] Other emerging electrified ground transport options include bicycles, delivery trucks and buses.

Biofuels such as ethanol and biodiesel also provide substitutes for petroleum. But they have lower energy density than petroleum-based fuels. And biofuels in general have come under scrutiny as competitors for other uses of the land such as food crops, timber and carbon storage. Advocates and critics have established criteria to evaluate which biofuels can be sustainably produced, such as those from waste materials.[50] At the same time there is growing consensus that sustainable biofuel feedstocks are limited and should be reserved for sectors with no other feasible options. That primarily means the heavy vehicles where electrification is not practical. The airline industry has targeted transition to sustainable biofuels that offer energy density equivalent to petroleum fuels.[51] Other priority sectors for sustainable biofuels are long-haul trucking that cannot be replaced by rail, river and ocean shipping, and less-used rail lines.

...there is growing consensus that sustainable biofuel feedstocks are limited and should be reserved for sectors with no other feasible options.

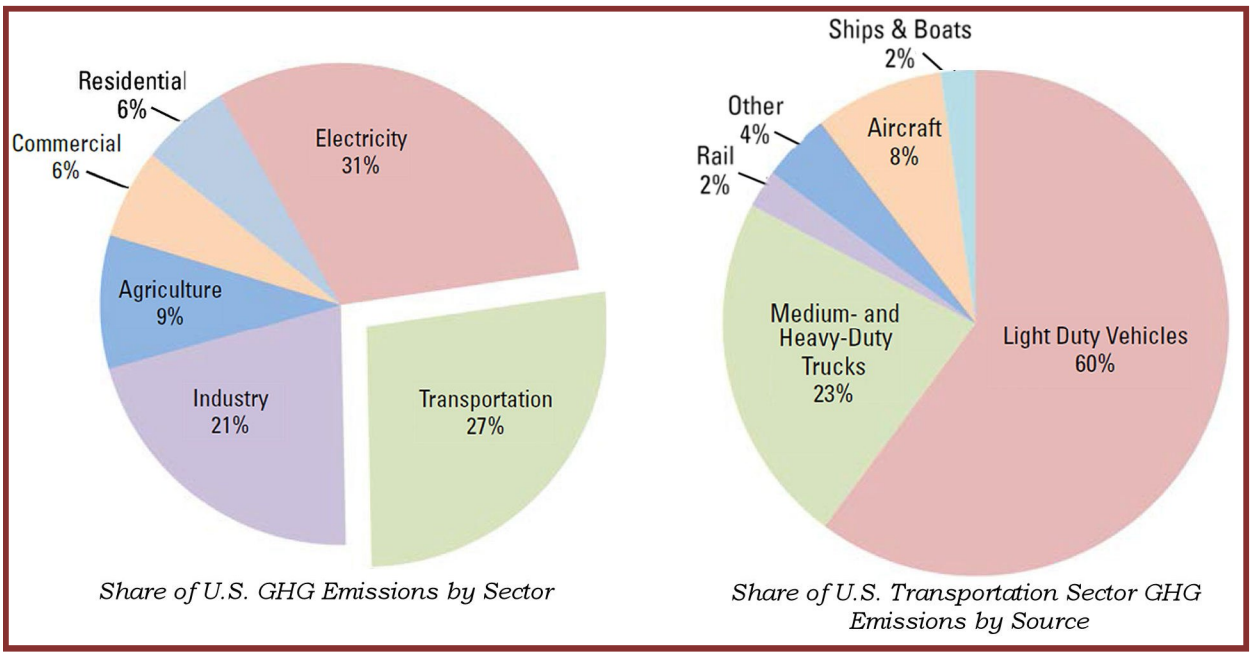
Hydrogen, also envisioned as an alternative vehicle fuel, has been slow to emerge due to factors such as inefficiency of production and difficulties in distribution and storage on board vehicles.[52] These challenges might be overcome with use of hydrogen-based fuels delivered in liquid form including methanol and ammonia, but these would require an entirely new fuel production and distribution network. These forms also have their own environmental risks, and lower energy density than petroleum fuels.

With other oil-replacement options facing challenges, rail electrification with renewable electricity has an important part in reducing transportation GHGs, and meeting the challenge of climate disruption. Averting unacceptable risks and costs of climate disruption entails reducing atmospheric carbon dioxide concentrations to 350 parts per million,

down from current levels of over 400 ppm. To reach that goal would have required annual global carbon pollution reductions of 6% starting in 2013. The yearly rate will increase to 15% if the world waits until 2020, a recent scientific study by leading climate scientist Jim Hansen concludes.[53] Such deep carbon pollution cuts demand rapid conversion from coal, oil and natural gas, together by far the largest source of GHGs, to renewables.

Because rail uses energy more efficiently and can run on renewable electricity, a transportation strategy that aims at deep carbon reductions will seek to divert freight and passengers to rail where possible. (Following sections line out these opportunities.) Today, rail locomotives are responsible for two percent of US transportation GHGs, while trucks account for another 23%.[54] Aviation emits eight percent of US transportation GHGs, while light-duty vehicles constitute a 60% share.[55] By improving service speed and reliability, rail electrification and modernization makes possible a broader shift in transportation modes. Moving a substantial portion of truck freight to rail powered with renewable electricity would yield significant carbon reductions, as would moving passengers to electrified rail on intercity journeys.

"Electric trains generally perform better than equivalent diesel vehicles even on the basis of the current electricity generation mix," the U.K. Department for Transport reports. "Typically, an electric train emits 20–35% less carbon per passenger mile than a diesel train. This advantage will increase over time as our power generation



Share of U.S. GHG Emissions by Sector

Share of U.S. Transportation Sector GHG Emissions by Source

Source: US EPA

mix becomes less carbon intensive."[56] Compared to cars, electric trains produce 60% lower carbon emissions per passenger mile, and over four times less carbon than the equivalent miles of air travel.[57]

Long-haul trucks might be electrified in the future. A system using overhead wires strung above a highway is being tested on a two-kilometer stretch north of Stockholm. Another test is planned for 2017 around the Los Angeles–Long Beach Harbor complex. The system is designed for use with diesel-hybrid trucks made by Scania. A halving of energy use is claimed.[58] While this is a step in the right direction, where freight can move by rail, it will retain significant advantages. Investment costs to install the highway system will likely be in the same range as rail electrification. But rail will move freight 1.9 to 5.5 times more efficiently, and with far lower overall labor costs. Electrified trucking will also not reduce the disproportionate amount of highway wear-and-tear caused by trucks, nor the highway congestion that results from over-reliance on truck shipping.

Investment costs to install the highway system will likely be in the same range as rail electrification. But rail will move freight 1.9 to 5.5 times more efficiently...

For long-haul mobility that dramatically reduces carbon emissions, electrified rail powered by renewable electricity stands out as a critically important option. The railroad, the oldest form of mechanized mass transportation, is one key to addressing the toughest carbon emissions reduction challenge of the 21st century, oil replacement.

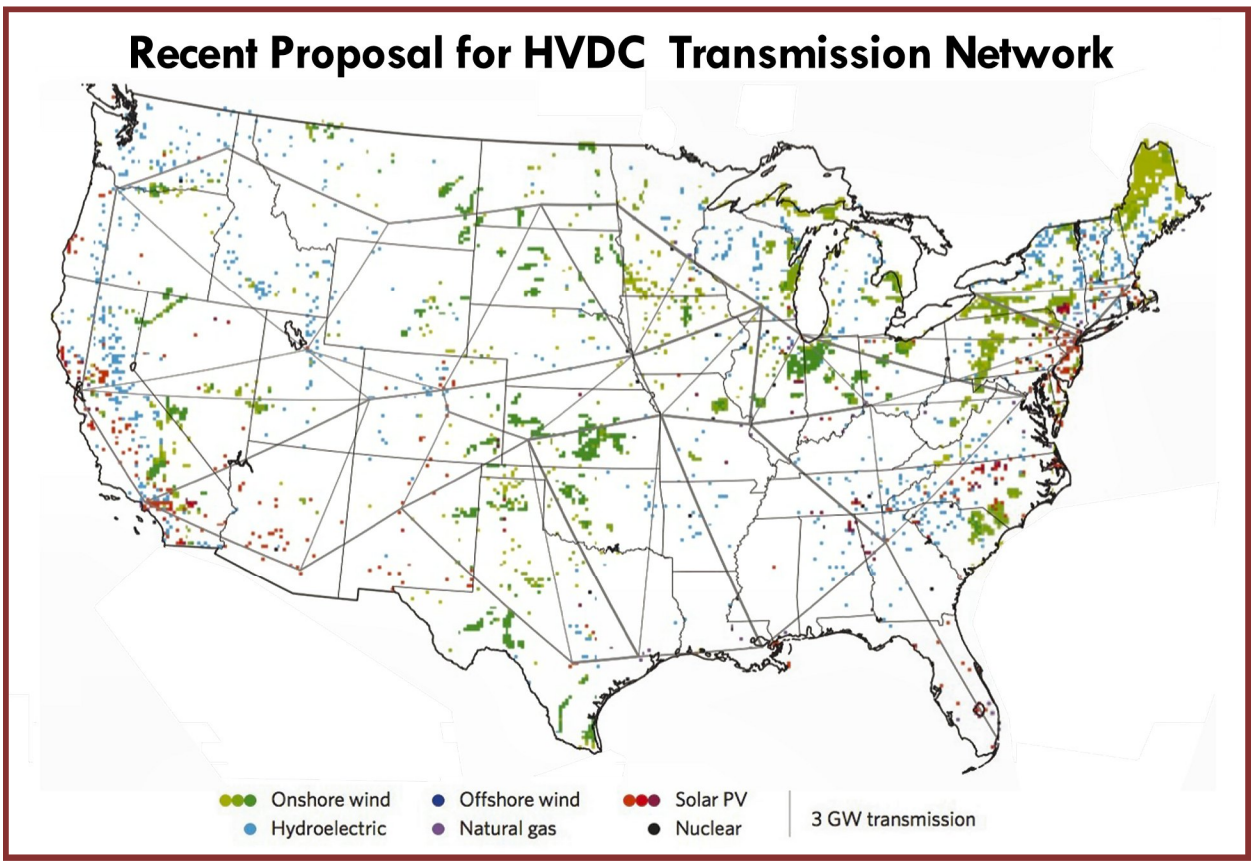
Leveraging Rail Electrification to Grow Renewable Energy

THE PROSPECT FOR AN ECONOMY SUBSTANTIALLY OR EVEN COMPLETELY run on renewable energy, which was dismissed as a dream a few years ago, now looks realistic. Scenarios have been developed for conversion to 100% renewables in all sectors by 2050.[59] Electrified rail can be an engine to help reach this goal. Not only can railroads provide new demand for renewable energy—they can also help increase the supply. Railroad corridors could serve as electricity superhighways transmitting wind and solar energy from remote rural areas to metropolitan markets. This could unleash renewable energy sources now stranded by lack of sufficient transmission line capacity to send power to distant urban centers.

Tremendous untapped potential to generate renewable electricity exists.[60] The National Renewable Energy Laboratory (NREL) estimates potential generation from wind in just the Dakotas and Texas is three times greater than total electricity currently consumed annu-

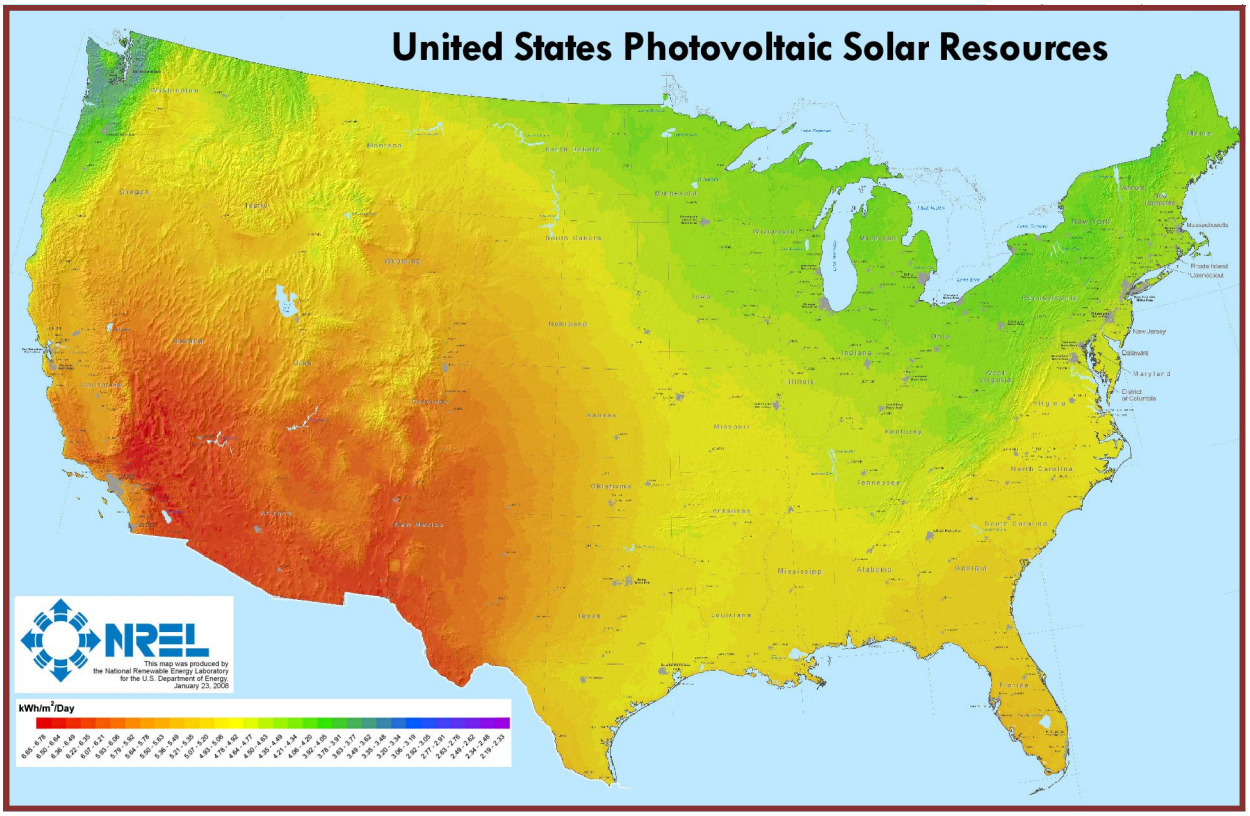
ally in the United States.[61] NREL also puts the potential for photovoltaic electricity production from Arizona at three times US yearly power use.[62] The greatest barrier to realizing these opportunities is lack of transmission capacity from remote rural regions to metropolitan demand centers. Electrification of railroad corridors offers a way to overcome this obstacle. Corridors could function as electricity superhighways.

Linking renewable energy generation across broad landscapes overcomes a major challenge to reliance on renewable energy: the variability of sources such as sun and wind. Such sources surge and fall, creating peaks and valleys at the local level, but offer a substantially more reliable and predictable supply when multiple producing regions are connected together. Linking diverse sources increases the probability that wind will be blowing and sun shining in enough areas to assure a stable power supply. This eases the



Source: Nature Climate Change, January 25, 2016

In 2016, a report by two NOAA scientists proposed these general transmission routes, and this distribution of energy production in order to stabilize the variability of renewable energy supply across weather systems and achieve an 80% decarbonized energy supply by 2030.

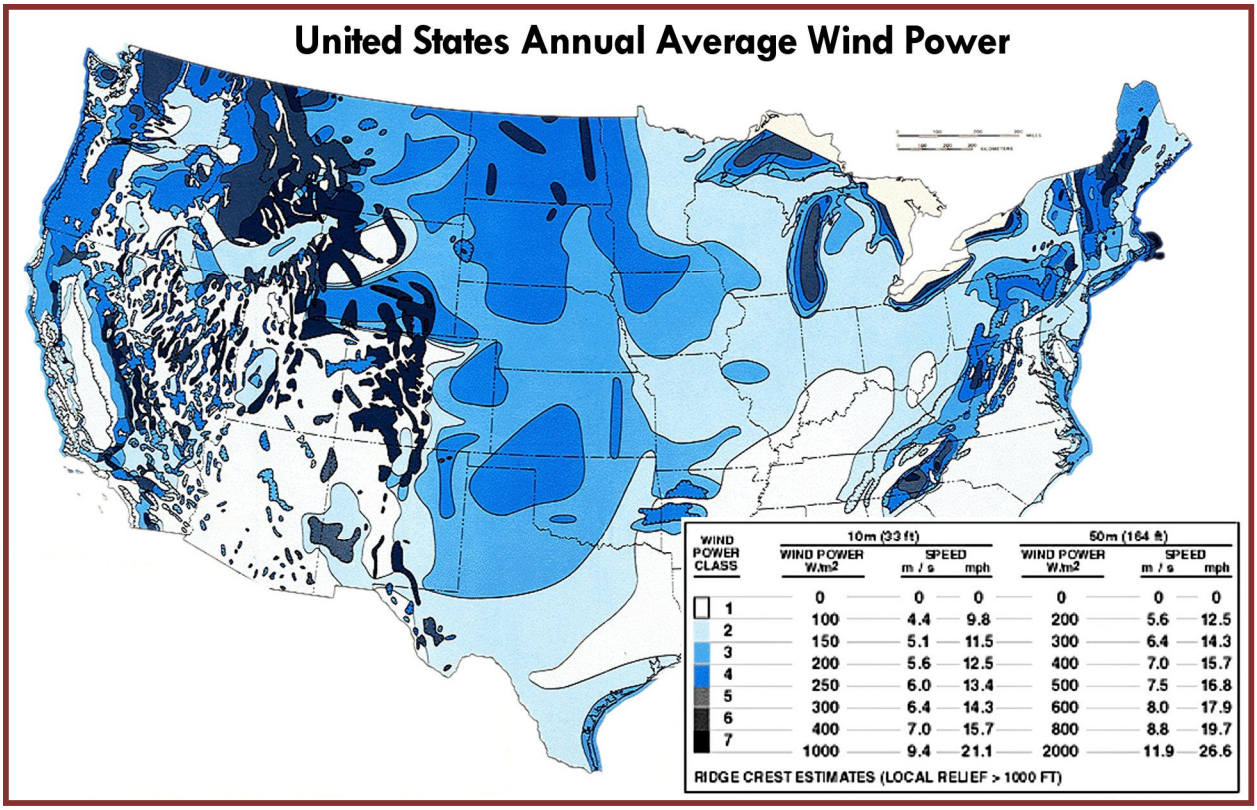


Source: National Renewable Energy Laboratory

The nation has vast, untapped solar resources, but needs capacity to transmit energy to urban areas. Rail electrification envisioned in Solutionary Rail could open the way for rail corridors to become electricity superhighways.

task of integrating wind and solar power into the grid. A 2016 study from the National Oceanic and Atmospheric Administration found that building a nationwide high-voltage direct current transmission network would enable a substantially renewable power grid. Carbon dioxide emissions would be reduced 80% compared to 1990 levels, with no increase in electricity costs, and no need to build storage.[63]

Important cost savings can be realized through coordinated efforts to co-deploy rail electrification infrastructure and transmission lines for the inter-regional sharing of renewable energy. Rail electrification will require high-voltage transmission lines with capacity of 115 to 345 kV, and substations every 20 to 50 miles to transfer power from the transmission grid to the overhead catenary lines that supply power to trains. In more remote areas, the railroad will not be able to tap into the local grid, and will have to provide its own transmission lines. Most railroad right-of-ways are 100 feet or more wide. This allows for multiple tracks and high voltage transmission towers that could carry far more energy than is required by trains.



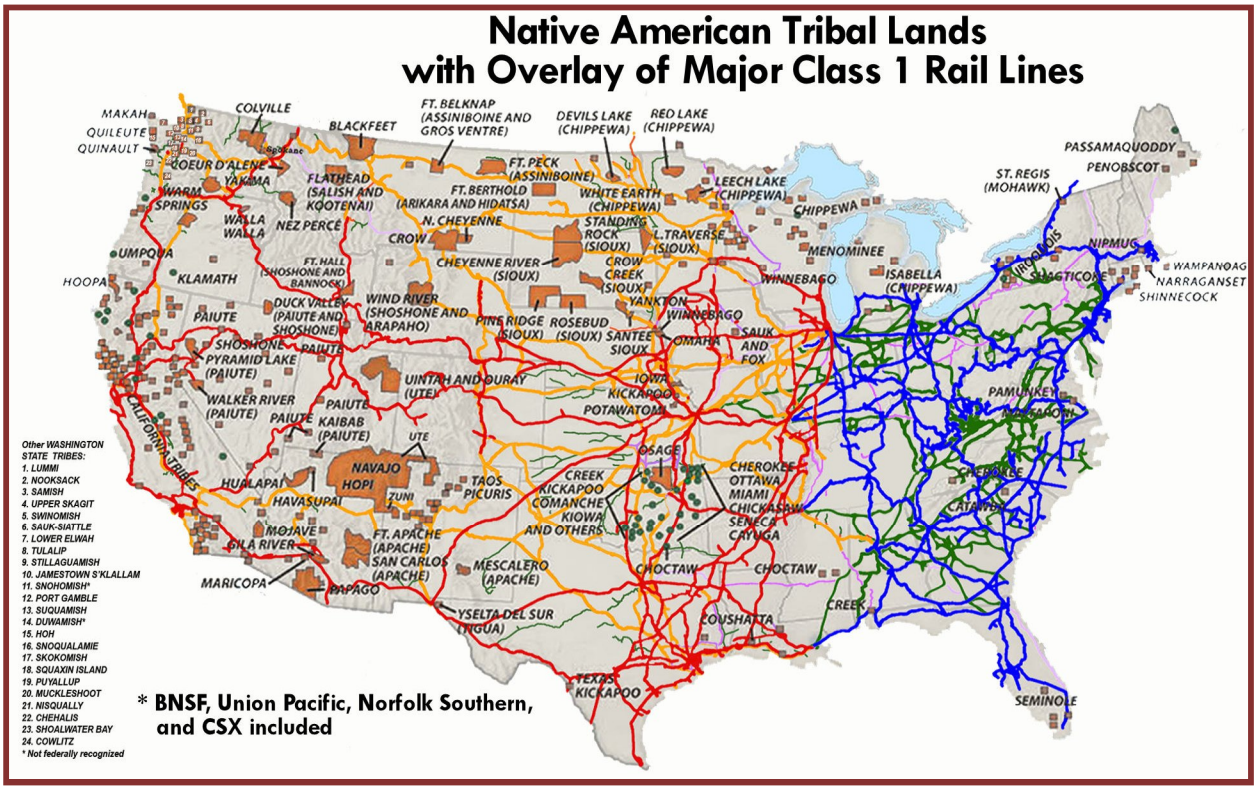
Source: National Renewable Energy Laboratory

Map illustrates the huge wind energy potential of the US, notably in the Northern Corridor regions where Solutionary Rail proposes a rail electrification demonstration that could also unleash the power of Great Plains wind.

Many of the ownership and environmental impediments that slow approval of new transmission lines can be avoided by using transcontinental rail corridors. These lines occupy lands that are owned by a single entity and have served industrialized uses for more than a century. By dealing with a single landowner instead of hundreds, new transmission could be erected in a far shorter timeframe. Utilities would also have a new customer immediately underneath their wires. An important caveat is that land rights of tribes must be taken into account, discussed below (p. 72–76).

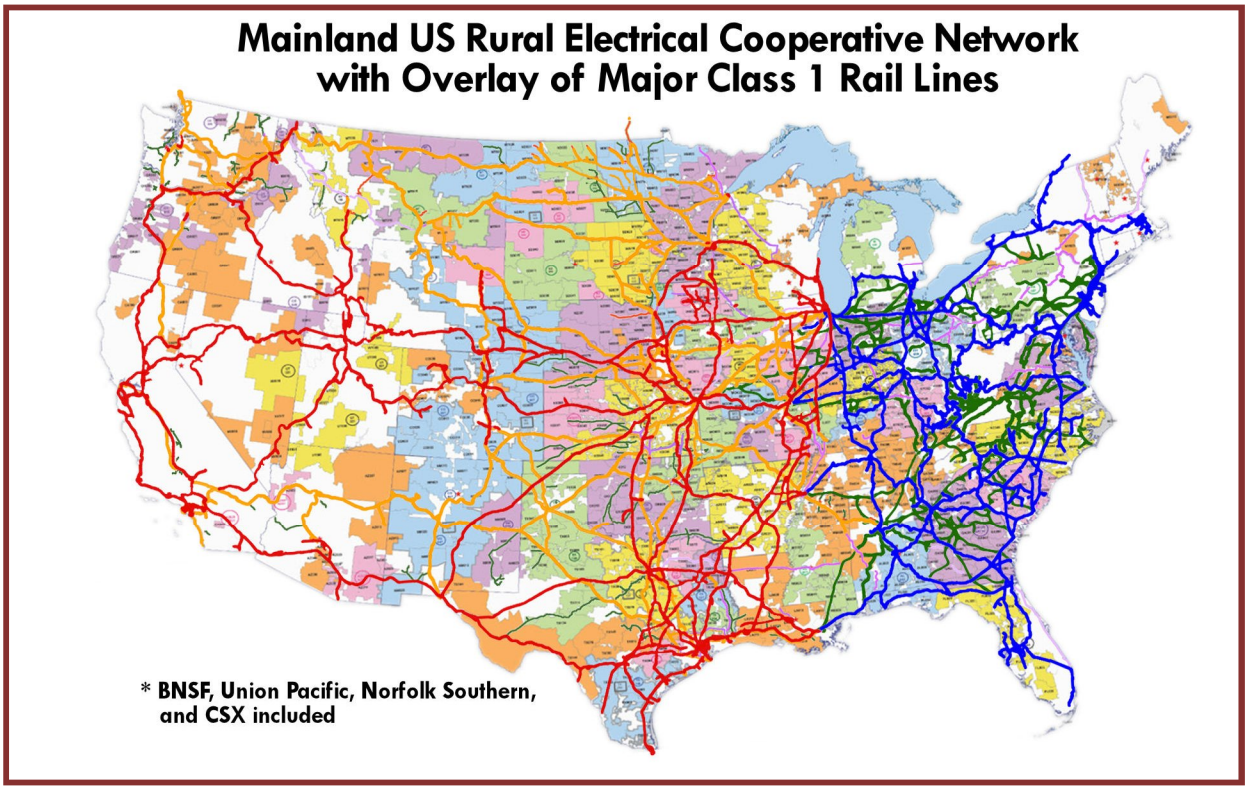
The railroads could choose to go into the electrical transmission business. But Solutionary Rail envisions public financing of publicly-owned electrification infrastructure, which would relieve railroads of property tax burdens and the need to develop a set of new competencies in power grid management. A public authority could contract with utilities already skilled in that area. It could operate lines and sell power to the railroads.

With transmission capacity, rural utilities would have additional opportunities to develop renewable resources for export to urban markets. With assured markets, utili-



Underlay map: source unknown

Native American tribal lands offer some of the greatest solar and wind potential in the US. Interest in renewable energy in Indian country is strong and diverse: The energy sovereignty work of Lakota Solar differs from the tribal utility mission of Yakama Power. 29 tribes are listed in the 2010 Native American Wind Resource Atlas *as seeking investors and wind development companies to develop commercial-scale renewable energy generation projects. Rail electrification provides an important long-term customer for smaller producers and tribal utilities to access financing to build more capacity. High-voltage transmission on the railroad rights of way could unleash a game-changing shift in renewable energy generation and decarbonizing of our economy, but rights of way issues for rail and transmission are complex in Indian country and require special attention.*



Source: National Rural Electrical Cooperative Association

The 930 rural electric co-ops cover transmission for 75% of the US landmass and serve 42 million people in 47 states. Many are located where a substantial portion of the nation's renewable energy potential is situated. Solutionary Rail's electrification plan includes a public mandate to power the system with renewable energy. This new long-term customer will allow rural co-ops to confidently develop new wind and solar generation. Electrification of the trains combined with high-voltage transmission above could stabilize the variability of renewable energy supply, deliver clean energy to distant cities and bring opportunity to rural communities.

Source: US DOE

Power County Wind Farm, Idaho

ties large and small could obtain renewable energy project financing that is currently unavailable. This could unleash massive untapped potential such as Great Plains wind now stranded by insufficient transmission.

Rural co-ops and tribal utilities in remote sun- and wind-rich regions especially stand to benefit. Much of the rural turf through which railroads run is served by customer-owned coops, a legacy of New Deal rural electrification efforts. Tribal utilities are also significant players in those regions. Rural utilities currently heavily rely on coal power, but if large new markets for renewables opened, they would have incentives to develop wind and solar plants. Local ownership multiplies the economic development benefits of renewable energy plants.[64]

Rail electrification linked with expansion of renewable energy transmission could provide social and economic benefits far in excess of the electrification itself, enabling development of rich renewable energy resources that currently cannot access markets. It would promote the broader goal of moving society beyond reliance on fossil fuels.

Electrification Reduces Air Pollution and Highway Deaths

DIESEL-POWERED LOCOMOTIVES ARE A MAJOR SOURCE of air pollution. Major diesel pollutants affecting human health include particulate matter, volatile organic compounds, nitrogen oxides, and sulfur oxides. Diesel-powered rail lines concentrate these pollutants in urban areas and along heavily used rail corridors. For example, the Northern Transcon runs through central districts of Seattle, Tacoma, Spokane, Minneapolis, St. Paul, and Chicago, in addition to many smaller cities. Health effects from diesel pollutants include asthma and other respiratory diseases, lung cancer, and cardiovascular disease.[65]

Diesel exhaust disproportionately affects people of color and the poor.

Diesel exhaust disproportionately affects people of color and the poor. "Rail yards also tend to be located in or near low-income, minority communities that suffer heavy burdens from air pollution," notes David Pettit of Natural Resources Defense Council. "The pollutant of concern from the rail yards is diesel particulate matter, found in diesel exhaust. The simplest way to get rid of it would be to switch from diesel to electric locomotives…"[66]

The US Environmental Protection Agency's new Tier 4 emission standard for locomotives took effect in 2015, and will return more than ten times their cost in improved public health.[67] Yet with average locomotive age at 15 years, it may take a decade to noticeably reduce diesel pollution. Electrification would eliminate diesel emissions more quickly, reducing health impacts and associated costs. Electrification would also reduce noise pollution, reducing stress for people living near the rail line, thus enhancing health and quality of life in major cities and across America.

Electrified rail also could reduce traffic deaths by shifting freight from truck to rail. Nearly 4,000 Americans die each year in traffic accidents involving heavy trucks, and nearly 100,000 are injured.[68] Getting trucks off the road would reduce the likelihood of such accidents. Rail freight is responsible for only about one-eighth as many fatalities and one-sixteenth as many injuries as truck freight per ton-mile.[69]

Increasing the use of rail in our transportation system and electrifying the lines will save lives.

Image by J. Craig Thorpe

A key element of Solutionary Rail is moving a significant portion of freight from trucks to rail. Strategic reinvestment to increase rail speed and reliability will help recapture the market for rapid delivery of high-value mixed freight. Because rail uses energy more efficiently and can run on renewable electricity, a transportation strategy that aims at deep pollution reductions will seek to divert freight to rail where possible.

CHAPTER 3
RESTORING A BALANCED TRANSPORTATION SYSTEM

How Highway Subsidies Tipped the Field Against Rail

THE PUBLIC EXTENSIVELY SUBSIDIZED RAILROADS in the nineteenth century with grants of land and money. Rail was the king of freight. But by the twentieth century railroads were on their own. They had to own and maintain their rails and roadbed, and pay property taxes on those assets. Meanwhile, trucks gained through the 20th century with the spread of publicly financed roads.

"By 1940, the local road network was largely complete, with truck as the dominant short haul, local conveyance," writes Noel Perry of the firm, Transport Fundamentals. "By 1990, the long haul highway system was largely built out, with trucking supplanting rail for moves of less than 300 to 500 miles, or for longer distance where speed or high reliability is required."[70]

The playing field tilted sharply in favor of trucking with the development of the Interstate Highway System. One of the most profound changes in the physical structure of the American economy, the Interstate System was already in the planning stages during World War II. Construction was finally initiated during the 1950s by the Eisenhower Administration. As an Army officer in 1919, Dwight Eisenhower was assigned to traverse the country on existing roads. World War I had brought tanks and military use of trucks, so roads were increasingly seen as strategically important. Eisenhower found the roads in sorry shape, and never forgot.[71] In 1956 he led passage of the Interstate Highway Act, memorialized in the 1990 renaming of the network as the Dwight D. Eisenhower National System of Interstate and Defense Highways.

The Interstate system gave trucking overwhelming advantages for speed and on-time reliability. Railroads have surrendered a large number of higher-value and time-sensitive freight transport markets to semi trucks making heavily subsidized trips on the Interstates. Railroads were driven to the bulk freight market where they still held a competitive edge. They could offer the rock bottom rate per ton-mile. But the slowness of bulk trains added to trucking's competitive edge. On a single track, when a

bulk train is running several hundred miles at a typically slow speed, a train heading the opposite direction is held in a marshaling yard or on a siding until the track is clear. This results in slower deliveries. One reason railroads have pulled up double tracks on thousands of miles of line is to reduce property taxes, magnifying their competitive disadvantage.

The Interstate system gave trucking over-whelming advantages for speed and on-time reliability… Railroads were driven to the bulk freight market where they still held a competitive edge.

But the tide is beginning to turn.

Says Perry, "The length of haul at the beginning of the decade for the trucking industry was in the neighborhood of 1,000 miles. Over the past decade, the average length of haul in trucking has fallen to the 500-to-600-mile range as distribution centers have grown and the long-haul model has changed. One of the factors driving the change in the long-haul market in the 2000s was the re-emergence of rail as a viable alternative to cross-country truck transit. The development of unit trains and expedited services opened up new options for customers and carriers alike."[72]

Train efficiency, already multiples of truck efficiency, is widening its lead, so the increased fuel costs of recent years have hit trucking harder. Notes *Scientific American*, "…the fuel efficiency of rail has been ramping up at a far faster rate than trucks. Between 1990 and 2006 rail efficiency improved by about 20%, or 1.1% annually. Further, as rail privately invested $40 billion in new infrastructure over the past five years, the trucking industry has suffered high fuel and labor prices—the two largest costs—which have forced it to contract since 2005. Accordingly, rail has gradually taken market share away from trucks since 1999."[73]

At $54.79 per oil barrel, rail fuel cost per mile is $0.36, compared to $1.75 for trucking. A 2020 scenario done for the U.S. Department of Transportation looks at the impact of oil at $157.18/barrel.[74] At that rate, the per-mile cost would be $0.60 for rail versus $3.24 for trucking. Such increases can be reasonably anticipated. Mode shifting to more efficient rail mitigates economic impacts of high fuel costs. Fueling with renewable electricity adds to the advantage, because costs are more certain. Once a renewable generation facility is in the ground, costs are known and fixed over a long period.

Despite heavily subsidized competition, the natural advantages of rail have allowed it to rebuild its place in the US transportation network. With the public commitment and partnerships envisioned by Solutionary Rail, the lines can take an even more important place in freight and rebuild their role in passenger service. They can also save taxpayers significant money by reducing truck wear and tear on highways, as will be seen in the next section.

Photo by Alex Garland

Trucks running on public highways now dominate much of the freight market. But the costs are congestion, highway wear and tear, pollution and thousands of deaths each year. All these impacts could be reduced with rail electrification and modernization, which would provide the speed and reliability improvements needed to move a portion of freight back to rail.

How Trucks Are Driving the US Highway Funding Crisis

In a recent American Society of Civil Engineers (ASCE) infrastructure report card, America's major highways received a grade of "D": "The infrastructure is in poor to fair condition and mostly below standard, with many elements approaching the end of their service life. Much of the system exhibits significant deterioration. Condition and capacity are of significant concern, with strong risk of failure."[75]

Costs are large. "Currently, 32% of America's major roads are in poor or mediocre condition, costing US motorists who are traveling on deficient pavement $67 billion a year, or $324 per motorist, in additional repairs and operating costs," ASCE calculates. The report card says congestion in 2010 clogged 42% of major urban highways, took a toll of 1.9 billion gallons of wasted gasoline, and forced the average driver to spend an additional 34 hours behind the wheel each year.

According to the ASCE, the price tag for maintaining major highways in their current state would be $101 billion annually from 2008–28. Even at that figure, only 46% of pavement would provide good ride quality under the US Department of Transportation's State of Good Repair benchmark. To elevate that portion to 74% by 2028 would require an additional $69 billion annually, for a total of $170 billion annually.

Source: California Alliance for Jobs

Heavy trucks cause a disproportionate amount of highway damage that is not fully covered by taxes and fees levied on trucking.

"Unfortunately," says ASCE, "federal, state, and local governments are only spending $91 billion annually on capital investments, meaning that each year our roads deteriorate further." At the same time, "the Federal Highway Trust Fund, which contributes the bulk of federal funding for transportation, is on a path to bankruptcy as it relies on dwindling gas tax revenues," ASCE notes.

Gasoline and diesel taxes that supply the fund have been set at a level rate since 1993—18.4 cents for gasoline and 24.4 cents for diesel. If gas and diesel taxes had been indexed to keep pace with inflation since then, today they would be 29 cents and 38 cents per gallon respectively, or more than 50% higher.[76] Ironically, increasing fuel efficiency and the spread of electric vehicles will further undermine highway funding from vehicle fuel taxes. The Congressional Budget Office estimates that tightened fuel economy standards will cut revenues 21% by 2040.[77]

Because heavy trucks do disproportionate damage, they play a disproportionate role in the highway funding shortfall. The Federal Highway Administration (FHWA) estimates that 44% of the cost of maintaining highways is due to semi-trailer and multi-trailer trucks, 16% due to heavy unit trucks, and 40% due to passenger vehicles and light trucks.[78] FHA finds that large trucks combining tractor and trailer paid user fees that cover only 80% of their share of highway costs. The heaviest of these combination vehicle classes paid less than half of their fair share.[79]

Road damage increases disproportionately with weight. A 16,000-pound axle causes 16 times the damage of an 8,000-pound axle and 4,000 times the damage of the 2,000-pound axle of a typical automobile. One heavy truck does more damage than 5,000 compact cars, and pays far less in fuel taxes per mile than those 5,000 cars combined.

Wear and tear from large trucks is concentrated on the National Highway System (NHS), the network that includes the Interstates and other major US highways,[80] the roads most exposed to Federal Highway Trust Fund shortfalls. FHA reports that 22% of NHS roads carry high-volume truck traffic of more than 10,000 trucks daily, and a further 13% carry moderate-volume truck traffic of between 5,000 and 10,000 trucks daily. By contrast, fewer than 1% of the miles of non-NHS roads carry moderate or high volumes of truck traffic.[81]

A freight train can carry the equivalent of 300 semi-trailers. [82] Shifting freight from heavy trucks to rail will reduce wear and tear on highways. This is an effective means to diminish the highway funding shortfall.

Attracting Freight to Rail Through Reinvestment

Freight transportation is a vital link in the US economy. In 2007, 18.5 billion tons moved by truck, rail, water, air and pipeline, with a total value of $16.7 trillion.

Trucking has come to dominate the field, as this table demonstrates.[83]

	Tons	Ton-miles	Commodity Value
Truck	72%	42%	70%
Rail	11%	28%	3.5%

The contrast between the figures tells an important story. Ton-miles are an expression of the number of tons multiplied by the miles they travel. Though railroads carry only 11% of tons, they carry them longer distances. The freight for which such long distance shipping is cost-effective tends to be lower-value bulk goods such as grains, coal and oil. That is reflected in the small share of commodity value. Trucks gain the higher-value shipments. Thus even though trucks carry only 6.5 more times freight by tonnage, they carry 20 times more freight by value.

These numbers also express important opportunities. Carbon emissions are tied to ton-miles. As reported in this paper, the superior energy efficiency of rail already

provides a carbon emissions advantage. Shifting freight from trucks to rail captures this advantage. Rail electrification with renewables would create highly efficient, low-carbon transport for a substantial share of US freight transport. Ton-miles are also the most important metric when it comes to highway wear and tear. Mode shifting to rail reduces maintenance costs. Meanwhile, improvements in reliability and speed that come with electrification and track modernization represent an opportunity for rail to increase its share of commodity value, and thus its revenues.

The Solutionary Rail strategy for freight has as one of its centerpieces a strategic reinvestment in rail to recapture the market for rapid delivery of high-value mixed freight. To accomplish that, scheduled freight service must become the industry standard for all but the lowest value cargoes. Service that operates on a fixed timetable allows for more efficient use of labor, equipment and track capacity. It provides shippers with assurance of much greater reliability.

The Solutionary Rail strategy for freight has as one of its centerpieces a strategic reinvestment in rail to recapture the market for rapid delivery of high-value mixed freight.

Shortening delivery times increases the value of the service, as demonstrated when people pay three times as much to deliver a parcel in one day instead of one week. Making rail shipping faster and delivery times more reliable requires investments. These include improving track to support higher speeds, restoring track in areas where it has been lost, eliminating system bottlenecks such as single track on major trunk lines, deploying advanced signaling and electrifying main lines. These improvements, detailed below, will reduce the speed and reliability advantages of trucks over rail. Reducing uncertainty about transit times and delivery will attract many shipments back to rail.

Studies have validated the mode-shifting effect of improved speed and reliability. A Virginia Department of Transport study looked at Shenandoah Corridor rail investment as an alternative to adding lanes to Interstate 81:

- Investing $267 million in infrastructure and $229 million in rolling stock would improve average speed to 28.1mph from 22.5mph, and transit time reliability (a measure of delivery time predictability—lower scores are better)[84] to 0.43 from 0.45. Rail load/unload times would be cut down from 34 minutes to nine minutes. This would shift 8.2% of long-haul truck freight by ton-mile, defined as trips over 500 miles, to rail.

- An additional $13 million in infrastructure investment would improve average speed to 33mph and transit reliability to 0.42, moving 10.1% of long-haul truck freight to rail.[85]

A Virginian organization called RAIL Solution called for more substantial improvements. The group proposed investment in infrastructure of $3.2 billion and rolling stock of $300 million along with substantial dual tracking and grade separation from roads. This investment would improve average speed to 40mph and reliability to 0.38 from 0.45, while also reducing load/unload time to nine minutes, diverting 16.6% of long haul truck freight to rail. That investment figure was less than proposals to spend around $5 billion expanding I-81. The rail proposal would have been fully recovered by user fees, whereas most of the ongoing maintenance cost of an Interstate Highway expansion project is subsidized by taxes.[86]

A critical obstacle was that the Virginia evaluation spanned only 325 miles of the Virginia I-81 corridor. Since truck shipments most readily shifted to rail go 500 miles and longer, the full benefit of rail investments will be realized only on a rail corridor at least that length. To make the proposition economically viable, a multi-state initiative as proposed by RAIL Solution would be required. In presentations to Norfolk Southern and in public advocacy, RAIL Solution has promoted a 1,000-mile-long Harrisburg-to-Memphis corridor.

Rail reinvestment improves speed and reliability of service, takes trucks off the road, saves taxpayers money, and provides a more efficient transportation network overall. It also creates opportunities to improve the growing linkage between trucking and rail.

Rail reinvestment…creates opportunities to improve the growing linkage between trucking and rail.

Trucks have some inherent advantages over rail. They are more flexible and operate on the far more extensive road network. They will continue to be an important part of the transportation system. Meshing the advantages of trucks and rail in intermodal operations will yield the greatest economic and environmental efficiencies. This is already taking place in a big way.

Two of the largest transcontinental trucking firms, J.B. Hunt and Schneider, have substantially moved long-haul shipments to trains carrying trailers and containers.[87] Railroad deregulation in 1980 made the way for these arrangements. J.B. Hunt's 1989 deal with the Santa Fe "reignited partnerships between railroads and motor carriers," Brooks Bentz of Accenture notes. Trailers and containers carried by rail increased from three million in 1980 to around 15 million in 2013.[88] Faster and more reliable rail service will reinforce this trend.

Containers are central to intermodal operations. In the United States double stack containers dominate, and stacking is increasing because this is the most efficient mode of freight transportation. Double stack service is available today only on most main lines, but restricted on others due to clearance issues. Single stack containers can operate on virtually all rail lines. Electrification can accommodate double stack

By Doug Wertman, Wikimedia Commons, CC BY-SA 2.0

Container shipping by train is an important part of intermodal connections with trucking, and is the most efficient form of ground transport.

container trains, and already does on the Keystone electrified line from Philadelphia to Harrisburg, Pennsylvania.

Some large retailers have gone almost exclusively to trucking. Many regional distribution centers were built with only trucks in mind. New facilities that can accept container trains from ports and domestic factories are needed, as is innovation focused on quick and efficient handling of trailers and containers going in diverse directions. Rail can come to some factories and distributors with new spur lines. In other cases, factories and distributors will move to rail spurs. Virginia, Pennsylvania and Maine subsidize such rail spurs. The master key to such a large-scale migration is improved rail service.

Innovative railroad management, building partnerships with trucking firms to move trailers and containers on modernized and electrified railroads, will foster transformation of the transportation system. The economic and environmental benefits will go far beyond the railroad corridor.

Restoring Passenger Rail

OVER THE PAST HALF CENTURY, INTERCITY PASSENGER RAIL has fallen victim to cheap oil and the cost advantages cars and planes receive from public infrastructure subsidies. With new competition, passenger rail became a money loser for railroad companies. In the midst of a wave of industry bankruptcies Congress created Amtrak in 1970, and has since partially subsidized the service.

Solutionary Rail envisions substantially restoring rail's role as a major passenger carrier, furthering a trend already underway. Today's rail revival is already returning passengers to tracks. Investments in better tracks and equipment, plus improved on-time performance, helped give Amtrak a record year in 2012. The 31.2 million passengers carried that year represented an almost 50% gain over 2000. Amtrak plans for 43.5 million passengers on the Northeast Corridor by 2040, four times today's numbers.[89]

Creative Commons 4.0 Sunil Prasannan

Birmingham, UK New Street Station Concourse: High-speed passenger rail is widespread internationally, and offers a significant alternative to highway and aviation travel. Electrification and modernization envisioned in the Solutionary Rail strategy can make intercity high-speed passenger rail service a more competitive option in the US.

"Maintaining adequate track capacity to address expanding passenger and freight needs is among the largest challenges in creating a competitive passenger railroad network," says the American Society of Civil Engineers.[90]

The High Speed Intercity Passenger Rail program conducted by the Federal Railway Administration[91] distributed $10 billion to 39 states and the District of Columbia in 2010. That is laying the groundwork for improved service in five regions. Very high-speed rail (VHSR) service, defined as operating above 125mph, is planned for the electrified Boston–Washington and San Francisco–Sacramento–Los Angeles corridors. Speeds could reach 220mph. Efforts on the California line are underway, while completion of the Northeast line is projected for 2040. Increased speeds of 90–125mph are planned for branches in New York State, Virginia–North Carolina, and California branches, as well as Midwest corridors linking Detroit-Chicago-St Louis-Milwaukee, and the Northwest line from Vancouver, B.C. to Eugene, Oregon. Several 90mph lines are also envisioned, including Oklahoma City–Dallas/Ft. Worth.

Since trains can add a station stop with much greater efficiency than planes can add an airport stop, and go downtown-to-downtown, intercity rail will be more convenient than air travel in corridors up to several hundred miles. Journeys of 300–500 miles will attract more passengers when they are VHSR. High-speed rail operating in the 90–125mph range works well in corridors of 300 miles and under. Lines at these speeds mesh well with the Solutionary Rail strategy for improved passenger and express freight service detailed in the next section.

Intercity passenger rail will work best when improved rail and mass transit options are available at metropolitan destinations. Metropolitan transport corridors with the highest levels of ridership should be served by regional electric heavy rail and high-capacity electric elevated and subway trains. At lower ridership levels, a range of transport modes should be offered including light rail, streetcars in both dedicated corridors and corridors shared with express buses, and rapid streetcars extending beyond their on-street core onto conventional rail corridors. In city and suburban neighborhoods, electric buses are emerging, along with hybrid battery-electric trolleybuses that can draw from overhead lines or from batteries on sections where there is no overhead power. Another important priority is reviving interurbans, electric trolleys running between nearby towns that were common in the early 20th century. Interurban electric rail transit offers fast and comfortable service, and can operate using low-carbon grid electricity.

Reviving urban and interurban rail is important to spur a shift to more energy-efficient land use patterns. Rail is high-capacity permanent infrastructure, so it is more effective in spurring dense, transit-oriented development, providing Americans with alternatives to auto-dependent lifestyles.

Today's passenger rail revival shows the service is still an attractive choice for many. Passenger rail can be further revitalized by electrification and modernization to improve speed and on-time reliability. In conjunction with other improvements in public transportation, this will take cars off the highways and provide cleaner mobility options for everyone.

Train stations were once centers linking communities to the world. But now most are gone. By rebuilding the place of rail in the US transportation system, communities can regain diversified transportation connections, and the social and economic potentials that come with them.

Investing in a Modernized, Electrified Rail Network

VHSR SYSTEMS OPERATE IN EUROPE AND ASIA at speeds of 180mph and above. The VHSR model mostly provides passenger service, although very light cargo like mail and packages can be shipped on the same tracks. Regular freight trains cannot operate on the same line as VHSR trains due to track designs for curves, grades, axle loadings and more.

VHSR is an expensive proposition. Planned US VHSR corridors such as those in California and the Northeast have sufficient passenger demand to justify the investment. The 800-mile-long California HSR is estimated to cost $68 billion, or $85 million per mile, making it one of the most expensive public works projects in US history.[92] The International Union of Railways estimates the average cost to add a mile in Europe is $19–53 million, but some new lines range far higher. However, electrification represents only around 5% of the cost.[93]

The Solutionary Rail strategy focuses primarily on high-speed rail operating at 80-125mph because that is the more economically practical option on most lines. Unlike VHSR that requires costly new tracks, high-speed trains can run on upgraded, existing tracks. Tracks modernized for higher speeds allow regular freight at 50–70mph as well as speedier freight and passenger services. Express freight at 80–100mph can transport lighter items such as refrigerated produce, electronics and retail inventory. Reliable express freight service would draw shipments not only from trucks but from air freight as well, with substantial savings in carbon emissions. Intercity rapid passenger rail at 90–125mph would run mostly on the same rails as express freight. Control systems will allow freight and passengers to share rail corridors safely and efficiently, optimizing capacity and flexibility.

Combining long distance express freight with medium distance passenger service makes a much larger network of high-speed rail economically viable. Positive synergies between the two will provide greater reliability and lower per-mile operating costs than today's long-distance Amtrak trains. The demand for express freight increases with distance, while the demand for intercity passenger rail service begins to drop off after 300 miles. On most segments freight alone would justify the investment with high-speed passenger service as a supplement. On segments where two metropolitan areas are close together, passenger trains could provide most of the business.

In the past, increasing freight speeds produced an increase in track damage and required maintenance, but recent developments in vehicle engineering allow an increase in speed with much reduced track forces and damage. New, advanced electric locomotives can attain speeds of 125mph and greater, while keeping dynamic forces between wheels and rails very low. Current technology and engineering also allows freight

vehicles that can be stable for express service speeds of 90mph and above, while causing minimal track deterioration.

Electrification and track improvements will increase the capacity to carry freight and passengers. The faster the train, the more trains can be run on a line. Electric locomotives can also accelerate more rapidly than diesel locomotives, and can stop quicker because they can more effectively dissipate braking heat through regenerative braking systems. Improved ability to accelerate and brake means trains can run closer together, another factor increasing capacity.

Creating this high-capacity, modernized, electric rail system will required investments in electrification infrastructure, electric locomotives, upgraded tracks and improved control systems. Following is an overview of such a system.

Electrification infrastructure Electricity is transported from power plants to the rail network by high-voltage transmission lines running along the rail corridor. They typically operate at 115–345 kilovolts. Every 20–50 miles, traction power substations transfer electricity to the overhead catenary wires that directly provide 25,000–50,000 volts to locomotive pantographs, the structures atop the locomotive that draw power from catenaries. (Third rails would not be practical.) Alternating current is employed because it can deliver power more easily at higher voltages and requires fewer substations than direct current. Switching stations set more closely together isolate sections of the catenary with different high voltage feeds. The switches can be cut during contingencies in order to limit the effect of grid power failures.

BENEFITS OF A HIGH-CAPACITY, MODERNIZED, ELECTRIC RAIL SYSTEM

- **Improved speed trains can run on upgraded, existing tracks.**
- **Express freight service would draw from both truck and air freight.**
- **Savings in carbon emissions would be substantial.**
- **Rapid passenger rail operates on the same rails as express freight.**
- **Carrying capacity for both freight and passengers is increased.**
- **The ability to accelerate and brake faster means trains can run closer together.**
- **Electric locomotives need less maintenance, require no fueling stops or refueling infrastructure.**
- **Electric locomotives perform better on grades than diesel.**
- **Double tracking provides three to four times the capacity of a single track.**

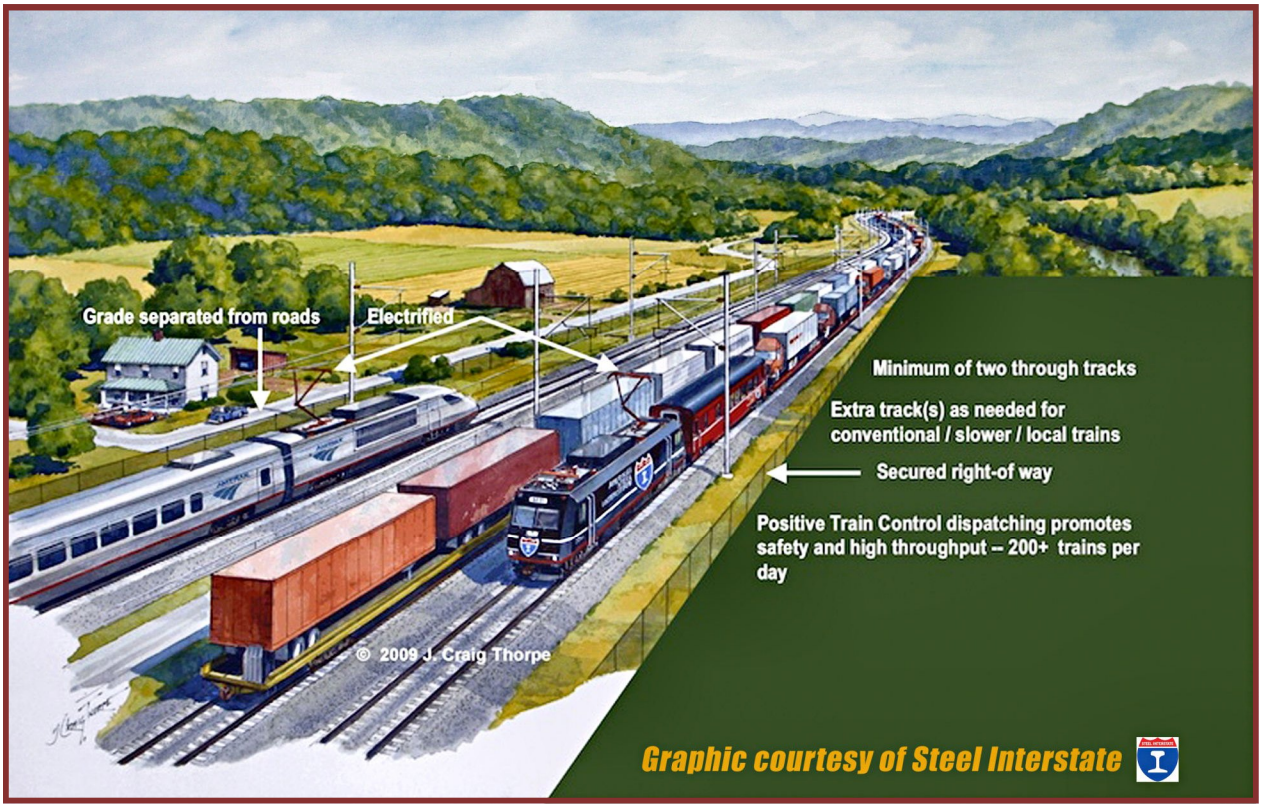


Image from original lithograph by J. Craig Thorpe for RAIL Solution

This graphic from Steel Interstate Coalition depicts improvements to electrify and modernize rail for higher speeds and greater service reliability, enabling a shift of freight and passengers from highways and aviation to rail.

Electric locomotives Electric locomotives perform better on grades. Because they are not limited by on-board generating capacity, they can be substantially more powerful than their diesel equivalents. Drawing power from the grid, electric traction motors can be larger. With fewer moving parts, electric locomotives also spend less time in the shop, and require no fueling stops or refueling infrastructure.

Electrified track will allow use by both electric and diesel-electric locomotives. A third type of locomotive, known as a dual-mode, can operate either as an electric or a diesel-electric locomotive and therefore can operate on both electrified and non-electrified track. Another fully electric dual-use option would employ onboard energy storage such as a battery or fuel cell. The dual-mode locomotive provides the distinct advantage of being able to operate continuously as it moves between electrified and non-electrified track sections. This also provides an advantage after electrification is complete because there are typically some track locations that will remain non-electrified such as some siding track or terminals and yards. The disadvantage of the dual mode locomotive is that its weight is approximately equal to that of diesel-electric locomotives. The value of dual-mode locomotives may not persist as a long-term solution, but will be critical during the transition from diesel-electric locomotives to electric locomotives.

Double tracking Dual tracks allows two-way traffic, and provide a "passing lane" that allows express freight to share the corridor with regular heavy freight trains. The second track also lets faster passenger trains pass express freight trains. Double tracking can provide seven times the capacity of a single track, but does not double costs since the right of way, signals, grade crossings and most other components are already part of the existing single-track operation. A double track with many medium speed cross-over switches has significantly more capacity than double track with few cross-overs. A single track with tightly spaced sidings and centralized traffic control signaling systems that centrally consolidate traffic management has over twice the capacity of a single track with few sidings and simple controls, but average speeds are still slow. Double tracking dramatically increases speed and reliability since trains will not have to queue for their turn or wait on a passing siding as trains come the opposite direction. This also lowers labor and rolling stock costs and improves customer certainty about delivery dates. Where full double tracking is uneconomical, passing tracks can be added to speed traffic. Ten miles of passing track could run every 20–50 miles of single track.

Road grade and rail-line separation An at-grade crossing between two busy rail lines creates an obvious bottleneck. Likewise at-grade crossings of roads can slow rail traffic and reduce capacity. Eliminating these blockages with bridges speeds rail considerably, and reduces road congestion as well. For example, CREATE is a $3 billion

Photo by Thomas White

Rail/highway grade separations reduce the impact of roads and highways on rail operations.

series of projects built in and around Chicago to reduce congestion which can cause substantial time or delay. Much of this improvement comes from six rail over rail bridges and 25 rail/highway grade separations.[94] Creating grade separation between railroads and roads is often costly and can be time consuming. Highway funds saved by reducing heavy truck wear and tear should be diverted to reduce the impact of roads and highways on rail operations.

Improved track alignment Straightening curves and reducing inclines through hilly terrain can be done by either excavation or relocating the line. This can significantly increase rail line capacity and speed up rail traffic while reducing operating and maintenance costs.

Better Signals By synchronizing train movements, improved signaling is often the most effective way to expand capacity. One option is Positive Train Control (PTC), a centralized system that monitors and controls the movement of trains by means of equipment on board each train. PTC systems provide train separation, collision avoidance, normal and temporary speed limits, and restrictions to ensure wayside worker safety. PTC assures safe train operation and has the potential to greatly increase speed and expand capacity. But the rail industry has argued that the cost of implementing PTC is greater than the benefits, and that the technology is still immature. It maintains that cab signaling, which sends track status information to crews, and Automatic Train Control, which can slow or stop trains in response to signals, provide adequate safety. A 2008 federal law requires PTC on major freight lines by the end of 2018.

Image by J. Craig Thorpe

The Solutionary Rail strategy proposes a Public-Private Partnership to electrify approximately 4,400 Northern Corridor track miles. Because of the substantial public benefits to be realized by modernizing and electrifying major rail corridors, it makes sense for the public to partner with private railroads to make the improvements financially feasible. The foundation of the effort is the establishment of a Northern Corridor Steel Interstate Development Authority by states along the corridor. It would be chartered with the authority to raise funds for electrified rail infrastructure investment along the line.

CHAPTER 4
HOW TO MAKE SOLUTIONARY RAIL HAPPEN

Why Is the US Lagging in Rail Electrification?

MOST URBAN RAIL MASS TRANSIT SYSTEMS IN THE US run on electricity, but electrification is sparse in the intercity rail network. Amtrak runs electrified passenger service along the 457-mile Northeast corridor from Boston to Washington, and the Keystone Corridor from Philadelphia to Harrisburg, Pennsylvania. While electricity is now a major source of motive power for freight railroads in most advanced economies, the percentage of US rail freight hauled using electricity is close to zero. Three lines totaling 122 miles carry coal from mines to power plants in Arizona and Utah, while the Iowa Traction Railway runs 18 miles of electric line from Mason City to Clear Lake.[95]

For many reasons US railroad electrification has been a recurrent topic of discussion since the oil price shocks of the 1970s. As this publication has documented, electrification can lower energy and maintenance costs, improve system performance, and provide significant environmental benefits. But several major impediments hold back US freight rail electrification.

Inertia caused by existing commitments constitutes a large barrier. Railroads operate on a systems basis, and electrification represents a systems change requiring new power delivery infrastructure, electric locomotives and a different set of skills for operations and maintenance. It is most efficient to operate a system of electrified corridors. These challenges set up a series of chicken-and-egg problems.

By far the greatest problem is high upfront costs. As we have documented, operating costs of electrified rail are substantially lower than diesel, but installing electrification infrastructure is costly. An average estimate is $2 million/mile for single-track lines and $2.5 million/mile for double track. Thus, electrifying a 500-mile double-track line would cost $1.25 billion.

The need to make system-wide investments magnifies the fundamental challenge to electrification, raising the necessary capital. Railroads are already one of the most

THE CUMULATIVE CHALLENGE OF ELECTRIFYING RAIL

- **The switch to electrification cannot be made incrementally, but must be done on a systems basis.**
- **The upfront cost of electrification infrastructure is high.**
- **Railroads are privately owned, so they must raise capital at high commercial interest rates.**
- **Railroads pay property taxes on improvements, while trucks run on publicly subsidized highways.**
- **Railroads must maintain their own infrastructure, while taxes and fees do not fully cover wear and tear trucks impose on highways.**
- **Electrification might obsolete diesel locomotive fleets before their useful life-times are completed.**

capital-intensive industries. BNSF alone budgeted a record $6 billion investment in 2015 to maintain and expand lines.[96] Railroad after-tax cost of capital in 2013 was 11.32%, the Surface Transportation Board determined.[97]

Railroads must raise capital as private entities, so they lack the advantages of lower-cost capital and public financial support that has made electrification possible for public railroads operating in Europe and Asia. Also, because they are private, US railroads must pay property taxes on improvements such as electrification infrastructure, setting up another barrier to electrification. If railroads invested in electrified, modernized corridors to allow them to compete on delivery time and quality of service, they would pay high commercial interest rates and property taxes on improvements. They would have to recover those extra costs through shipping rates while competing against trucking companies that run on publicly built and maintained roads, yet pay no property tax to the communities where they operate.

Railroads gained tremendous public support in the 19th century with land grants and direct cash subsidies to extend service to the West and across the continent. But in the twentieth century public support diminished, while highway and aviation competitors received the lion's share of government transportation subsidies. Automobile drivers also subsidize the trucking industry, which does not carry the full cost of damage it inflicts on highways. The playing field is tilted in favor of trucking and aviation, taking away many freight markets that would otherwise be dominated by rail. Subsidized infrastructure provides trucks and planes competitive advantage.

Cumulatively, the challenges of raising capital for a systemic upgrade of rail combined with a generally uneven playing field vis-à-vis competitors points to the solution. New public-private partnerships (PPPs) are critical to realize the economic, environmental and societal advantages of a modernized, electrified rail network. A plan for creating such partnerships is the subject of the next section.

Building Public-Private Partnerships to Modernize Rail

EVEN WITHOUT AN ELECTRIFICATION INITIATIVE, there is increasing consensus that PPPs are needed to address the investment challenges faced by railroads. Even if new land is not needed, it costs at least $2 million to add a mile of single mainline track with modern signaling.[98] The nation's Class I railroads, which operate the main lines, channeled 17.2% of 1996-2005 revenues into capital investments. That's around five times the average industrial rate.[99]

"However, the amount of railroad investment in capital is not sufficient to keep up with the growth of American freight transportation," write rail experts Mark K. Ricci and Frederick C. Gamst in a report commissioned by the Transportation Trades Committee of the Pierce County (WA) Central Labor Council. "Accordingly, constraints on railroad capacity and freight transportation arise. The citizenry and their political leaders have been unwilling to recognize this economic dilemma."[100]

They quote *Railway Age* editor William Vantuono, foreseeing "a grave danger to America not far down the line as demand for freight service outstrips the nation's ability to supply it." Vantuono points to PPPs as "the antidote to the nation's most pressing transportation problems."[101]

Rail PPPs have added rail capacity across the nation. The Norfolk Southern Heartland Corridor has greater capacity to haul trailers and containers with $500 million of investment in tunnels and terminals by the railroad, federal government and Ohio, West Virginia and Virginia. The Alameda Corridor is a $2.4 billion public investment to reduce congestion and pollution with a 22-mile rail spur linking the Long Beach–Los Angeles port complex with railroad main lines.[102]

In Washington State, BNSF has worked with public agencies to add track and signaling to serve commuter trains in the Puget Sound region. Washington has coordinated investments to promote intermodal transportation from ports. The effort included re-opening a trans-Cascade Mountains BNSF line through Stampede Pass. The state has also invested in improvements between Seattle and Vancouver, B.C. to speed passage of an Amtrak passenger line.[103]

Ricci and Gamst note, "… an accord is necessary between the parties in a partnership to overcome the prejudice that profitable corporations 'should not' receive public contributions. The crux of this issue is not helping a for-profit corporation but gaining valuable public benefit not otherwise affordable by a private railroad."[104]

Policy support for a rail electrification-modernization initiative is needed and justified by substantial economic and environmental benefits including:

- Improving rail service and economic development opportunities for communities across the landscape, especially in rural areas
- Substantially cutting transportation carbon emissions by running rails on renewable electricity
- Supporting the growth of renewables overall by providing new markets and transmission corridors
- Thinning highway congestion by offering new options for freight and passengers
- Reducing unfunded maintenance costs of truck freight by taking it off roadways
- Eliminating thousands of deaths annually from air pollution and highway accidents
- Mitigating the impact of oil price shocks on freight transport, allowing the energy cost share of freight transport to remain at or below historic levels.

Because of these substantial public benefits to be realized by modernizing and electrifying major rail corridors, it makes sense for the public to partner with private railroads to make the improvements financially feasible. While the federal government is a logical partner, states also have tools that can jumpstart the process. Public agencies can use their size, credit-worthiness, and tax-privileged status to borrow capital at lower rates than private industry and surmount this obstacle.

As this paper has documented, railroads have strong incentives to electrify and modernize. They can operate at lower costs, gain new markets, and increase the value of their service. If the obstacle of high upfront capital costs can be overcome, the pull to electrify will be powerful.

The Solutionary Rail team proposes a new, state-based institution to capitalize rail electrification and modernization, the Steel Interstate Development Authority (SIDA). The SIDA would be a not-for-profit corporation operating under a board appointed by participating states. It would be chartered with the authority to raise funds for infrastructure investment on both publicly and privately owned rights-of-way. The SIDA

EXISTING PUBLIC-PRIVATE RAIL PARTNERSHIPS	
Norfolk Southern Heartland Corridor	$500 million of investment in tunnels and terminals creating a greater capacity to haul trailers and containers
Alameda Corridor	$2.4 billion public investment to reduce congestion and pollution with a 22-mile rail spur
BNSF & public agencies	Add track and signaling to serve commuter trains
Chicago Region Environmental and Transportation Efficiency Program	A package of more than 70 distinct projects to improve passenger rail service, reduce motorist delays, increase safety, improve air quality and create jobs
AMTRAK and Washington State	Improvements between Seattle and Vancouver, B.C. to speed passage
Heartland Corridor	Creating a shorter, faster route for double-stacked container trains between the Port of Virginia and the Midwest
National Gateway Project	Enabling trains to carry double-stacked containers, increasing freight capacity, and making corridors more marketable
Crescent Corridor	Strengthening freight distribution in the Southeast, Gulf Coast, and Mid-Atlantic by connecting a 2,500-mile network of existing rail lines with regional freight distribution centers

Source: Association of American Railroads

would issue tax-free bonds to sell at low interest rates, and oversee funding and construction of electrification infrastructure.

This would not be a giveaway to railroads, or an extra cost for the states. Funds would be raised from private markets and federal loan funds. The system would be self-financing through user fees paid by railroads drawing energy from the lines and utilities transmitting electricity. Electrification infrastructure would be publicly owned, overcoming the property tax disadvantage railroads face. The electrification could be operated on a leased basis by utilities already familiar with such systems. The SIDA would negotiate with right-of-way owners to site infrastructure, and the same owners would make commitments to use it. The SIDA charter would include the requirement that electrified rail corridors be powered by renewable electricity to the greatest degree possible, whether directly or through Renewable Energy Credits.

STEEL INTERSTATE DEVELOPMENT AUTHORITY (SIDA)

A not-for-profit corporation chartered with the authority to raise funds for infrastructure investment on both publicly- and privately-owned rights-of-way would:

- **Issue tax-free bonds to sell at low interest rates**
- **Oversee funding and construction of electrification infrastructure**
- **Self-finance through user fees paid by railroads**
- **Negotiate with right-of-way owners to site infrastructure**
- **Make direct investments in track improvements**
- **Oversee construction and management of infrastructure dedicated to the use of rapid freight rail**
- **Seek financing in the form of TIFIA loans.**

RECs are a tool that allows power users to buy renewable energy on the grid to offset non-renewable electricity used on site.

Railroads would be required to make complementary track modernization investments to improve quality of service. This division of labor makes sense. As noted previously, track improvements can occur on an incremental basis, and are indeed taking place. Electrification is best implemented on a broader system-wide basis. Facilitating these "lumpy" investments is an appropriate role for public agencies.

The SIDA could also make direct investments in publicly-owned track improvements, for example adding additional fast track and signaling capable of handling express freight and fast passenger service. Reduced capital costs and property tax payments could make public ownership of the higher-speed track attractive to the railroad. In that case, the SIDA should be empowered to oversee construction and management of infrastructure dedicated to the use of rapid freight rail, with the agreement of the host railroad.

In the United States, financial instruments have been created to provide improved access to capital markets for major transportation projects. For example, the Transportation Infrastructure Finance and Innovation Act (TIFIA) program provides direct federal loans and loan guarantees for transportation projects of regional and national importance. The interest rates are far lower than those used internally by private railroads in capital allocation decisions. (For instance, as of February 2016 the rate was 2.55%).[105] In 2016, five-year TIFIA funding of $1.435 billion was announced by the US Department of Transportation. Based on past experience, each dollar could

leverage $14 of TIFIA loan funding, or $20 billion in TIFIA loan funding. Overall, every TIFIA dollar can leverage another $30 to $40 from all sources.[106]

The SIDA would seek financing in the form of a TIFIA loans and/or loan guarantees. It would also seek an allocation from the US Secretary of Transportation of available Private Activity Bond (PAB) financing. PABs are issued by state and local governments on behalf of private organizations engaged in infrastructure investments. Private Activity Bonds hold tax-exempt status; that is, interest earned by bond holders is generally not subject to state or federal income taxes.

Public subsidies to highways and aviation tipped the balance against rail. Now low-cost public financing and infrastructure development can begin to level the playing field. That public capacity can be brought to bear through the SIDA to create a self-funding system. The enormous public benefits to be realized from rail electrification provide ample justification for such an investment.

Making Labor a Full Partner

LABOR WILL BE AN IMPORTANT PART OF THE ALLIANCE needed to gain public support for new public-private partnerships to electrify and modernize railroads. These partnerships will provide highly valuable benefits to the industry. In return, it is fair to ask a new commitment to a provide railroad unions and workers with family wages and working conditions which promote rail safety. As rail workers are the first line of rail safety, this benefits everyone.

Solutionary Rail originated in a challenge from a rail labor leader, Mike Elliott of the Brotherhood of Locomotive Engineers and Trainmen, to Backbone Campaign Executive Director Bill Moyer, to develop a green option for railroads. In response, Moyer convened what became the Solutionary Rail team, which included Ron Kaminkow of Railroad Workers United, a cross-trades organizing group among the many craft unions representing rail labor.

Labor is already forwarding Solutionary Rail. In July 2016 the Washington State Labor Council (WSLC) passed a resolution in favor. A fiery oil train derailment a month before in the Columbia Gorge community of Mosier, Oregon, "places a heightened focus on the safety challenges posed by Crude by Rail shipments," WSLC noted. "…by illuminating the pitfalls of dangerous commodity transportation, other opportunities can be progressed demonstrating the vital importance of modern infrastructure to improve upon the overall plight of all workers…The Solutionary Rail concept provides a transition strategy that leverages rail's unique capacity among long-haul

Image by J. Craig Thorpe

Rail can offer a major transportation option that is powered by clean, renewable energy, ensuring jobs for rail workers and creating new clean energy jobs for displaced fossil-fuel industry workers. Labor must take an active role in new partnerships to electrify and modernize rail. With this should come a new commitment to a fair deal for labor.

transportation modes to operate on electricity, unlike many other modalities. (See full resolution, p. 64 below.)

Herb Krohn, Washington State Transportation Division Legislative Director of the International Association of Sheet Metal, Air, Rail, Transportation Workers, said he wrote, sponsored and lobbied this resolution to "bridge the gap" between sometimes varying positions held by labor and environmentalists on fossil fuel controversies "in order to demonstrate we can and do work together on common issues."

Railway Workers United has developed a fair deal agenda for rail labor.[107] We present it as an integral element of the Solutionary Rail vision:

- Bargain in good faith with the unions and share the wealth.
- Establish real safety programs focused on hazard elimination, as opposed to "behavior-based safety" programs that shift the blame for accidents and injuries onto workers.
- Preserve and protect the established minimum of two-crew members on every train crew, to avoid stress and information overload, and to guarantee back-up in emergencies.
- Recognize the need for paid sick time for train and engine service personnel, a practice that has come to most industries.
- Put an end to crew fatigue by providing scheduled days off, as opposed to unlimited on-call requirements to which workers are now subject.
- Stop the use of invasive and intimidating technology such as inward-facing cameras.
- Stop excessive discipline and firings.

Kaminkow's own freight rail experience underscores why good working conditions such as set schedules are important not only for rail workers, but also for rail safety.

"In fact, most freight railroaders don't have any set schedule at all," Kaminkow says. "Generally, freight trains have a two-person crew: an engineer and a conductor. Rail carriers are trying to eliminate one of these positions. Both get a call, usually two hours before scheduled on-duty time. The call could come at midnight tonight, then 3 pm the next day, 8 am after that…never knowing when you'll be called, when you'll finish, how many hours you can rest, or when you'll return home. You're working and resting around the clock; it's completely unscheduled…If you work twelve hours and get ten off, day after day, it's easy to get exhausted."

Jen Wallis, a BNSF conductor, says, "The company uses behavior-based safety programs to blame workers, but the reality is that all industrial accidents are caused by hazards on the job. We wouldn't get hurt if we weren't at work. Because the system punishes workers for accidents, people who get injured on the job will say that they did it at home, so they don't lose their jobs. They've created such a chilling effect that workers are afraid to report injuries or hazards, so how does this make for a safer workplace?"

See Appendix for rail labor stories from from Kaminkow and Wallis.

As described above, railroad companies were drawn deeply into the fossil fuel economy when the US government created the Interstate Highway system. The creation of a publicly subsidized highway infrastructure was a major cause of high value freight abandoning trains for trucks. Coal was the customer that saved the railroads. This dependency on heavy commodities did away with regular schedules. Freight trains now depart when deemed full. Not having regular work schedules is a systemic cause of a fatigue-plagued, unsafe work environment that endangers workers, our communities and the environment. Because this problem is inherent to the way railroads do business, it is not something that can be negotiated or regulated away.

Not having regular work schedules is a systemic cause of a fatigue-plagued, unsafe work environment that endangers workers, our communities and the environment.

That risk has until recently been unquestioned, assumed acceptable for lack of an alternative. The nearly catastrophic Mosier, Oregon derailment and explosion of June 2016 fueled a growing public awareness of "bomb trains." People are asking serious questions about the risks and role of the current freight rail business model. Solutionary Rail provides a timely alternative to move beyond dependence on bulk fossil fuel transportation.

That alternative embodies a key priority for labor, a concept known as just transition. In the transition to a low-carbon world many industries will be disrupted, and many jobs will be eliminated, particularly those associated with fossil fuel industries. Just transition strategies aim to shift workers from declining to rising industries such as clean energy.

Today the rail industry is troubled by the coal and oil downturn, which is driven by many factors including tighter environmental rules. Coal power is being replaced by lower cost natural gas, which is in its own way a troubling development. Much of the gas is fracked, polluting water tables and leaking powerful climate-warming gas methane into the atmosphere. Cheap gas prices masks costs not accounted on balance sheets.

The slowdown in China is rippling back to US coal markets. China is also replacing coal plants because of public uproar over air pollution. Oil prices are subject to

political manipulations by major oil producers, notably Saudi Arabia. Over the longer term, coal and oil use will be reduced by concerns over the climate-heating impact of fossil fuel carbon pollution and tighter vehicle efficiency standards.

For the transition to a clean economy to be just, workers and affected communities must enjoy access to new industries and good jobs. Investing in rail electrification and modernization is a just transition strategy. In a time when reducing fossil fuel use is critical to restore the stability of a disrupted global climate, rail can offer a major transportation option that is powered by clean, renewable energy, ensuring jobs for rail workers and creating new clean energy jobs for displaced fossil fuel industry workers.

Fortunately, there will be many jobs in new clean energy sectors. A plan for 100% renewables in the US done by Mark Jacobson of Stanford projects that while 3.9 million old energy jobs will be lost, 5.9 million jobs will created in new energy sectors.[108] Old energy skills are highly transferrable to the new, and displaced workers should be given explicit preference in hiring. They should also be provided with job training, and full pay and benefits until they are placed in new jobs.

Railroad Workers United has adopted a just transition resolution, carried in full on the following page. RWU recognizes the fossil fuel threat to the climate, and the shaky ground of railroads relying on fossil fuel shipments: "the future of this traffic appears uncertain or possibly even non-existent within a few decades…"

RWU calls "upon the rail industry and the rail unions to work together to move away from unsustainable practices—specifically the hauling of environmentally destructive commodities—and work towards expanding the railroads' business prospects in areas such as mail, passengers, trailers and containers, renewal energy components, etc."

This illustration from an 1874 edition of Harper's Monthly highlighted an unnecessary risk to trainmen. The caption reads "So long as brakes cost more than trainmen, we may expect the present sacrificial method of car coupling to be continued." The 1893 Railroad Safety Appliance Act mandated air brakes and automatic couplers on all trains, greatly reducing worker injuries and deaths.

As the United Steelworkers said in its just transition resolution, "a clean energy job is any job that helps our nations achieve our goals of reducing greenhouse gas emissions and protecting our environment." [109] With Solutionary Rail all railroad jobs can be clean energy jobs.

RAILROAD WORKERS UNITED JUST TRANSITION RESOLUTION

Whereas, the continued extraction and combustion of fossil fuels such as coal and oil has been scientifically proven to represent a threat to the environment and the future of the planet; and

Whereas, there is a mass movement domestically and globally to radically reduce the continued use of such fuels to power economic development; and

Whereas, other alternative energy sources—wind, solar, geothermal, hydroelectric—are developing rapidly and appear to be the wave of the future; and

Whereas, railroad corporations have traditionally hauled large amounts of fossil fuel—especially coal—but the future of this traffic appears uncertain or possibly even non-existent within a few decades; and

Whereas, the burden of shifting from an economy based on fossil fuels to one based upon renewal energy should not be unfairly born by workers, including railroad workers; and

Whereas, to ensure that such a transition to alternative energy does not create an economy of low paid jobs for working people—including railroad workers—whose jobs could conceivably be threatened by such a transition;

Therefore, Be it Resolved that RWU supports a "Just Transition" to an economy based upon renewal and clean energy; and

Be it further Resolved that RWU demand workers who are displaced from environmentally destructive industries be provided living wage income and benefits through public sector jobs or a universal basic income; and

Be it Further Resolved that RWU demand that workers who are displaced from environmentally destructive industries be provided with commensurate rates of pay and benefits while retraining; and

Be it Further Resolved that RWU demands that fossil fuel extraction dependent regions such as Appalachia be locations where investments of alternative energy are made to offset the economic dislocations that workers and communities would face from such a transition; and

Be it Finally Resolved that RWU call upon the rail industry and the rail unions to work together to move away from unsustainable practices —specifically the hauling of environmentally destructive commodities—and work towards expanding the railroads' business prospects in areas such as mail, passengers, trailers and containers, renewal energy components, etc.

WASHINGTON STATE LABOR COUNCIL SUPPORTS SOLUTIONARY RAIL

At the July 2016 Washington State Labor Council Convention, the membership unanimously approved a resolution supporting Solutionary Rail. The Transportation Division of SMART (Sheet Metal, Air, Rail, Transportation) United Transportation Union Local #1348 sponsored this resolution with the assistance of Mike Elliott of the Brotherhood of Locomotive Engineers and Trainmen.

Whereas, the fiery crash of an oil train in Mosier, Oregon along the Columbia River on June 3 places a heightened focus on the safety challenges posed by Crude by Rail shipments. The Mosier derailment resulted in forced evacuations, a regional first-responder alert, and shutdown of a wastewater treatment facility polluted by spilled oil. Fate was on the side of Mosier as unusually calm winds aided in containing and controlling the oil fire.

Whereas, significant oil train derailments leading to spills, and some to fires, have totaled over twenty-five in North America over the past 10 years with the Lac Mégantic, Canada disaster of 2013 the most devastating: 47 people incinerated.

Whereas, in years past as crude by rail dominated capacity as the profit generators for the railroad, ports and agricultural producers faced increased delays in getting other food related commodities to market. Additionally, knee jerk manpower reductions by efficiency fixated rail management resulted in crew shortages that further impacted rail capacity. Now that energy prices are lower, many railroads have furloughed recently hired workers and mothballed locomotives waiting for the "next" commodity surge to fill capacity.

Whereas, railroad labor whistleblowers have brought many railroad carrier operational and safety shortfalls into the public spotlight, there is a long way to go in improving rail worker safety. Minimum, mandatory two-person train crews are essential, crew fatigue issues must be addressed, and adequate and available rail crews who are properly trained and maintained are essential.

Whereas, by illuminating the pitfalls of dangerous commodity transportation, other opportunities can be progressed demonstrating the vital importance of modern infrastructure to improve upon the overall plight of all workers.

Whereas, within organized labor, most support improvements and upgrades to infrastructure and recognize the importance trade has to the Washington State economy. However, improved bulk commodity infrastructure has drawn the wrath of many because of the commodities that are shipped today. We believe rail and trade modernization opportunities made today are essential in attracting the trade commodities of tomorrow.

Whereas, a strategy for rail line electrification provides an opportunity to create an even more sustainable transportation mode and a pathway for providing economic options beyond diesel power. The Solutionary Rail concept provides a transition strategy that leverages rail's unique capacity among long-haul transportation modes to operate on electricity, unlike many other modalities. Solutionary Rail centers on electrification of major rail lines using renewable energy.

Whereas, in conjunction with a program of track modernization, Solutionary Rail enables increased speeds, capacity and reliability. It is not a proposal for high-speed passenger rail that must run on its own line. Rather, Solutionary Rail is for practical increases in speeds, attracting back freight cargo and passenger services previously lost, and would modernized existing rail line to carry both.

Whereas, by providing a low-carbon transportation option, Solutionary Rail provides significant climate benefits. Rail electrification could also be leveraged to create transmission corridors for renewable resources now stranded by lack of capacity, providing even greater carbon reductions.

Whereas, the Solutionary Rail team developed a concept to overcome these hurdles, a Steel Interstate Development Authority (SIDA) created by an alliance of state governments. The SIDA raises funds in public capital markets and joins in public-private partnerships with railroad companies to erect electrification infrastructure and potentially fund track upgrades.

Whereas, Solutionary Rail proposes a demonstration on one major line to jumpstart rail electrification in the US The team has identified the BNSF "Hi-Line" corridor for initial rollout of the concept. It is the intermodal line from Seattle to Chicago on which higher speed is critical and it also runs through some of the most wind-rich regions in the world.

Therefore be it resolved, to further the concept, the Washington State Labor Council calls on Governor Inslee to direct the Washington State Department of Transportation and other appropriate state agencies to evaluate Solutionary Rail feasibility and to bring the general concept of rail corridor electrification, powered by renewable energy, into the broader "green" industrial transportation system.

Agriculture's Vital Interest in Rail Capacity

IT IS HARD TO THINK OF AN ECONOMIC SECTOR MORE TIED TO RAILROADS than agriculture. In much of the US, the laying of track made the growth of agriculture and rural America possible. Many of the nation's farms trace their origins to transcontinental railroad land grant sales. A few are still farmed by the original families. While water transportation has always been important to farmers, and trucking has grown in importance, rail still holds a vital position in agricultural shipping, especially in accessing long distance markets.

Agriculture overall has a tremendous stake in reliable and economical transportation. Farm products represent the largest share of goods moved in the nation's transport system. In 2012, they constituted 22% of tons and 31% of ton-miles moved through all modes of transportation.[110] The following chart shows the modal shares for agricultural products.[111]

	Tons	Ton-miles
Trucking	42%	47%
Rail	35%	41%
Barge	6%	7%

Rail plays a substantially larger role in transportation of wheat, where bulk shipping is most economical, taking a 67% share, compared to 32% for trucks and 1% for barges.[112] Along the Northern Corridor, especially in Great Plains states where barging is not an option, good rail service is crucial. Four of the nation's top six wheat producers are in this region: North Dakota, Montana, Washington and Idaho.

"Railroads transport nearly all the grains and oilseeds produced in Montana, more than 70 percent of the commodities produced in North Dakota," the USDA reports.[113]

One-half of the US wheat crop is exported, and much flows through the Northern Corridor to Pacific Northwest ports. The region is the top US wheat export shipper, with 35.4% of the total.[114]

"US wheat exports rely mostly on rail transportation to reach the ports," notes the USDA. "An efficient and flexible US transportation network, particularly the rail system, is important for keeping US wheat competitive in the world wheat market."[115]

Thus, capacity bottlenecks and increased transportation costs tied to growing coal and oil traffic in recent years have hit agricultural producers particularly hard.

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"Some North Dakota grain elevators, for instance, entirely rely on rail shipment to keep business flowing. Rail congestion in 2014 stopped service to them for weeks and months at a time—a total collapse in the system that supports their livelihood. Ultimately, family farmers bore the costs of scarce rail service," the American Farm Bureau Federation reports. "The USDA estimates grain and oilseed producers throughout the Upper Midwest may have received $570 million less for the crops they marketed in 2014 than they could have earned in a normal freight environment."[116]

In November of that year, rail congestion drove wheat basis bids, the difference between prices paid to local farmers and the futures market, 30 cents lower than normal. On the Grand Forks, North Dakota to Portland run, higher transport costs averaged $0.69/bushel. Indications are that this increase reduced spot prices for wheat by an average of $0.18/bushel.[117]

The Farm Bureau traces many of the recent problems to increased traffic in North Dakota Bakken shale oil. Between 2009–2013, oil shipments grew 38 times to 407,642 carloads. In 2013 the Dakotas experienced the worst price losses of any US grain-growing region.[118]

"...crude oil's relatively small portion of rail traffic is the most problematic for agriculture because of its safety concerns and because geographically, oil's rail routes directly pull resources, like locomotives, personnel and track capacity, away from grain service," the Farm Bureau says.[119]

Image by J. Craig Thorpe

Communities along the Northern Corridor would be among the greatest beneficiaries of an electrification initiative. Economic development opportunities would expand with improved freight and passenger service. Smaller, trackside communities that have lost rail service could see it restored. Express service from hubs in farm regions would provide new options for agricultural commodities that must move to market quickly, such as fruits and vegetables.

This resulted in a 6-to-16 times escalation in rail car costs from late 2013 to spring 2014.[120]

Farmers are particularly vulnerable to shipping cost increases.

"Agricultural producers are 'price takers' rather than 'price makers,' with little control over the price they receive for their products," notes Ken Casavant, Director of the Freight Policy Transportation Institute at Washington State University. "They are unable to pass cost increases onto customers and must absorb them because of their lack of market power. Consequently, increases in transportation costs result in decreased producer profit. For agricultural shippers with no cost-effective alternative to rail, and located far from markets, rail is the only transportation available. The rail rate determines the net price the producer receives."[121]

In 2007 at a market high, average rail tariffs stood at 11.3% of wheat prices, Casavant reports. Those tariffs came to 23.1% in 1999 when wheat prices were low.[122]

North Central Washington is one of the nation's most diverse agricultural areas...

Grain growers have not been the only agricultural producers to feel the bite of increased fossil fuel traffic. North Central Washington is one of the nation's most diverse agricultural areas, producing tree fruit, vegetables and everything from apples and cherries to mint, carrots and squash. Cold Train was an innovative refrigerated container service for perishables, providing three-day express shipping from Quincy, Washington to New York City. But when BNSF doubled the guaranteed service time to six days, this forced the company to cancel the service in August 2014.

"The announcement by Cold Train follows a number of scheduling issues on BNSF Railway's Northern Corridor line that have been occurring with BNSF, beginning late last fall because of increased rail congestion as result of a surge of oil and coal shipments on the Northern Corridor line," Cold Train said in its announcement. "In fact, from November of 2013 to April of 2014, BNSF's on-time percentage dramatically dropped from an average of over 90 percent to less than 5 percent."[123]

Since 2014, lower oil prices and coal demand have reduced fossil traffic, so farmers are having an easier time moving their products to market. But long-term trends point to increased strains on capacity. Freight traffic could increase 90% over its 2002 rate by 2035, causing severe congestion on one-third of US primary rail corridors, the US Department of Transportation says. "Investment in the railroad industry...is not expected to keep up with demand...especially in agricultural areas," the USDA projects. "This shortfall of investment could threaten the United States' competitive position as a low-cost supplier of high quality grain."[124]

With these trends, agricultural producers should regard problems caused by fossil traffic as a harbinger, the Farm Bureau says; "...as the nation's overall freight capacity

Raspberries are loaded into a refrigerated train car for express shipping to markets. For perishable commodities, reliable, scheduled freight service is crucial.

Source: WA DOT

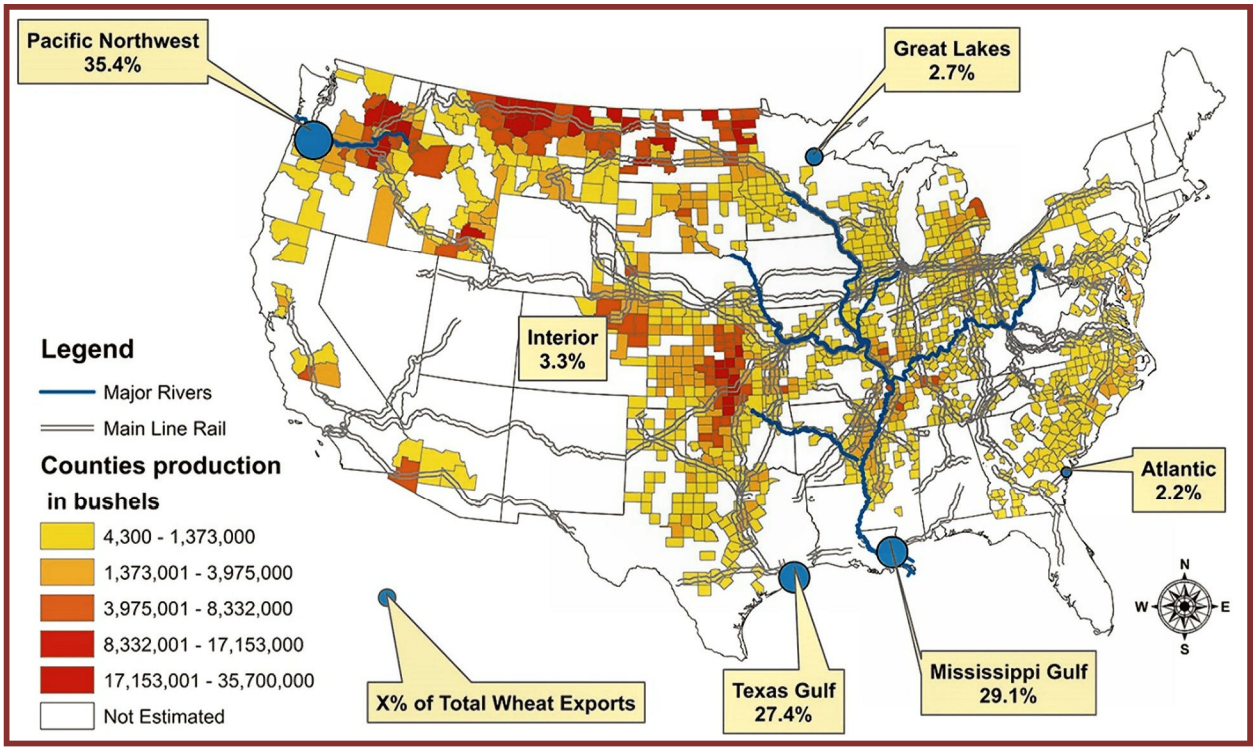
continues to be overstrained, other regions should note these economic effects and view them as a warning for what might occur to their own agricultural revenue, if total freight capacity…continues to underserve the demand."[125]

The Solutionary Rail strategy provides answers for these challenges. Earlier chapters documented how electrification and modernization can increase rail capacity. Trains can run at higher speeds, and because they can accelerate and brake faster, they can be run closer together. Scheduled express service, such as the Cold Train offered, would be a boon to producers of perishable crops. Reliable access to markets promotes agricultural diversity, which can be a hedge against dependence on one or two major crops subject to large price swings. Small, family farmers can gain new market opportunities, while local economies will be strengthened.

Preserving the family farm has profound value, as writer and farmer Wendell Berry calls out:

> "The small family farm is one of the last places…where the maker—and some farmers still do talk about 'making the crops'—is responsible, from start to finish, for the thing made…In fact, from the exercise of this responsibility, this giving of love to the work of the hands, the farmer, the farm, the consumer, and the nation all stand to gain in the most practical ways: They gain the means of life, the goodness of food, and the longevity and dependability of the sources of food, both natural and cultural."[126]

Farmers small and large depend on market access, which requires reliable and



Source: USDA

USDA map illustrates concentration of US wheat production in the Northern Corridor, and the importance of Pacific Northwest ports in US grain exporting. Agricultural producers have lost hundreds of millions of dollars from delays and capacity constraints caused by increased oil and coal rail traffic. The Solutionary Rail strategy would increase capacity on rail lines.

economical shipping. Maintaining capacity requires sufficient investment in transport infrastructure. Solutionary Rail offers a public capitalization strategy to overcome shortfalls in railroad investments, which can also take stress off rural roads.

"Public investment in railroads has until recently been directed largely to the preservation of branch line rail service to rural areas," the USDA says. "However, the time may now have arrived when public investment in main lines and intermodal facilities is economically justified."[127]

Diversion of farm goods from trucks to rail could justify public investments. Compared to the damage a loaded semi does to a rural interstate, a rural collector highway suffers 13.5 times more wear and tear, and a minor rural collector 21 times, the US Department of Transportation reports.[128] Costs tend to fall on rural taxpayers, particularly farmers who pay property taxes on large stretches of land. "Studies undertaken by Kansas State University and the University of Iowa indicate that in these states,

state investment in rail branch lines may be a lower-cost alternative to improving local roads," the USDA says.[129]

Agricultural producers, the greatest users of transportation in the US, have a deep interest in high-quality rail service, and have been among the most disadvantaged by recent capacity challenges. Solutionary Rail offers a strategy that helps ensure producers will be able to move products to market economically and reliably.

Right-of-Way Justice for Native Tribes

THE HISTORY OF US WESTERN EXPANSION is one of war and genocide against the indigenous peoples of this continent. Railroads played a critical role in that conquest and settlement. On the Great Plains, rail lines cut buffalo migration routes and facilitated the near extinction of the buffalo. Railroads opened the way to establishment of towns and ranches on tribal lands in the west. As Tom Goldtooth**,** executive director of the Indigenous Environmental Network says, "Railroads have been a tool of colonization, the political takings of indigenous lands and genocide. Indigenous peoples have however persevered despite all odds."

"Gen. William Tecumseh Sherman's first postwar command…covered the territory west of the Mississippi and east of the Rocky Mountains, and his top priority was to protect the construction of the railroads," writes Gilbert King for *Smithsonian*. "Gen. Philip Henry Sheridan, assuming Sherman's command, took to his task much as he had done in the Shenandoah Valley during the Civil War, when he ordered the 'scorched earth' tactics that presaged Sherman's March to the Sea….As the railways expanded, they allowed the rapid transport of troops and supplies to areas where battles were being waged."

"The Transcontinental Railroad made Sheridan's strategy of 'total war' much more effective," King continues. "In the mid-19th century, it was estimated that 30 million to 60 million buffalo roamed the plains….Then the completion of the Transcontinental Railroad accelerated the decimation of the species….Massive hunting parties began to arrive in the West by train, with thousands of men packing .50 caliber rifles, and leaving a trail of buffalo carnage in their wake. Unlike the Native Americans or Buffalo Bill, who killed for food, clothing and shelter, the hunters from the East killed mostly for sport. Native Americans looked on with horror as landscapes and prairies were littered with rotting buffalo carcasses."

"The Texas legislature, sensing the buffalo were in danger of being wiped out, pro-

Image from LegendsOfAmerica.com

Expansion of railroad lines to the west accelerated the near-extinction of the buffalo, the basic subsistence of Great Plains tribes. Railroads made it possible for large numbers of hunters to reach the west and ship hides to markets back east. Hunters even shot buffalo from trains, as shown in this June 1871 depiction of a hunt on the Kansas-Pacific line carried in Frank Leslie's Illustrated Newspaper.

posed a bill to protect the species," King recounts. "General Sheridan opposed it, stating, '…They are destroying the Indians' commissary.' "[130]

Today, Solutionary Rail's proposal for a new partnership between railroads and the public offers an opportunity to deliver some measure of redress, and a chance to partner with tribes to determine the future of railroad rights-of-way across tribal lands.

Indigenous communities in the US continue to struggle from the impacts of conquest, but are renewing their cultural, territorial and economic sovereignty. Many tribal governments and cultural leaders are leading the way in the fight against the expansion of fossil fuel extraction and transport infrastructure by asserting their treaty rights and moral authority.

Coastal Salish canoe families, though not overtly political, have nurtured a cohesion among tribes in the Pacific Northwest that has bolstered the resistance to coal and oil trains, pipelines and export facilities. In 2016, the Lummi Tribe in Washington State successfully asserted treaty rights to stop what would have been the world's largest coal export terminal. Also in Washington, the Swinomish Tribe is currently embroiled in a lawsuit over the non-negotiated expansion of oil train traffic through their land. Representatives from over 250 tribes from across the continent gathered in 2016 to support the Standing Rock Sioux of North Dakota in their struggle to protect Missouri River waters from the proposed Dakota Access Pipeline that would carry Bakken Shale oil.

The crux of the issue is reclaiming treaty-protected cultural and territorial sovereignty. A long succession of court decisions and laws has undermined that sovereignty. The General Allotment Act of 1887 led to a surge of white ownership on lands that had previously been under treaties, creating a checkerboard pattern that persists to this day. Through changes in laws the Secretary of the Interior gained increasing power to grant easements across tribal lands. Railroad rights-of-way were the earliest. Laws passed in 1934 and 1948 began to restore tribal rights, and now tribal permission is required for new rights-of-way, but many older easements remain because they were granted in perpetuity.[131]

The public benefit mandates under which a Steel Interstate Development Authority (SIDA) operates should require that no publicly financed improvements can occur on rights-of-way over tribal lands that have not gained tribal permission, neither track electrification nor power transmission. Solutionary Rail creates a significant opportunity to renegotiate if and how these rights-of-way on tribal lands are utilized in the future. Renegotiation provides an exit strategy from the regressive easements granted in perpetuity and an opportunity to right old wrongs with a new era of rights-of-way justice. The negotiation process can also help clarify issues surrounding checkerboard ownership.

As presented in an earlier chapter, the infrastructure that Solutionary Rail proposes offers many advantages for tribes seeking to expand renewable energy generation for local energy sovereignty and even more for those with aspirations to export power. Tribes may choose to leverage rail corridors to develop their own substantial wind and solar energy sources. Some tribes may utilize this opportunity differently.

"Indian Tribes have historically been 'colonized' by energy companies; meaning that energy companies have a history of entering Indian reservations, often with federal government support," writes the Affiliated Tribes of Northwest Indians Economic Development Corporation. "Indian tribes as sovereign governments are now seeking to change the paradigm of their relationships with energy companies, and to become full

partners in the use of their resources. Land is one of those resources and as such, tribes do prefer to use their land resources to become part of energy development rather than a victim of energy development."[132]

Principles for energy development on tribal lands adopted by a number of tribes should guide Solutionary Rail investments:

- **Tribal Sovereignty and Consent** The power of tribes to prevent third parties from using tribal lands without tribal consent is a critical element of tribal sovereignty that has been established in Federal law and policy for over 200 years. The tribal consent requirement to the use of tribal lands should be honored and preserved.

- **Preservation of Tribal Jurisdiction** No right-of-way agreement or other business arrangement that permits third-party use of tribal land should reduce the sovereign power of a tribe over its lands or the activities conducted on its lands in the absence of the specific consent of the tribe.

- **Restricted Duration of Rights** Federal law and policy should not be changed to require perpetual rights-of-way or automatic renewals of rights-of-way because such changes would deprive tribes of management and control of their lands.[133]

Tribes have other concerns over railroad rights-of-way. Many rail lines run along shorelines, conflicting with restoration of habitat for fisheries and other wildlife. Some lines, such as certain stretches of track along the Columbia River, interfere with access to traditional fishing grounds. This results in tragic fatalities of American Indian fisherman attempting to exercise their treaty-protected right to harvest. Other stretches of rail along the shoreline of Puget Sound undermine habitat for treaty-protected fisheries.

Honoring treaty rights and addressing the grievances of tribes is inevitable and necessary. The Steel Interstate Development Authority (SIDA) that finances, builds, owns and maintains the new electrification and modernization infrastructure provides an opportunity for right-of-way justice with tribes as well as environmental sustainability. Curving shoreline routes are not appropriate for the higher speeds envisioned under Solutionary Rail. Many shoreline rail lines will need to be moved to mitigate the impact of rising sea levels. Moving tracks inland from shorelines or to higher elevations opens the way for large-scale habitat recovery and access to treaty-protected fisheries. In the Puget Sound, this habitat recovery could support a more robust fishery without sacrificing an aquatic reserve system, averting potential conflicts between tribes and environmentalists. Here again, Solutionary Rail creates an opportunity to resolve

intractable conflicts by building a broad partnership and recalibrating our infrastructure for a just and sustainable society committed to the well-being of future generations.

In 2007, Tom Goldtooth introduced the Backbone Campaign to the *seventh generation principle*. Most simply, it is the precautionary principle to "do no harm" applied across a span of seven generations. This is conservation in its truest form. To consider the impacts of our actions today with this level of awareness adds a spiritual challenge to addressing policy challenges. As the proposal blossoms into a campaign in the coming years, the Solutionary Rail effort aspires to meet that challenge head on to, as Goldtooth recently said, "redeem railroads and a society addicted to their dangerous cargo."

Jumpstarting Electrification in the Northern Corridor

ULTIMATELY, THE GOAL OF THE SOLUTIONARY RAIL STRATEGY is to modernize and electrify all or most of the nation's 52,340 miles of primary rail freight corridors. These lines "carry the preponderance of rail freight traffic (and) constitute about one-third of all continental US rail freight miles," notes a study done for the American Railway Association. Primary corridors will absorb the bulk of freight growth and nearly all investment in capacity expansion.[134]

With the consolidation of the railroad industry since the 1990s, by far most of those tracks are owned by seven Class I railroads. Service to the eastern US is mostly through Norfolk Southern and CSX. Kansas City Southern and the US branch lines of Canadian Pacific and Canadian National provide a third Class I alternative in a few states. Most of the western US is served by BNSF and Union Pacific (UP). While UP extends service from the south to the Pacific Northwest, BNSF is the primary east-west carrier along the Northern Corridor.

Northern Corridor electrification represents a robust proof of concept for electrifying lines across the nation.

Successful electrification and modernization by one Class I railroad on one of its major lines will both demonstrate success and create competitive pressure that spurs adoption throughout the industry. Solutionary Rail has identified the BNSF Northern Transcon and major branch lines as ideal candidates for such a demonstration. The major east-west railroad serving the Northern Corridor, the Transcon[135] from Seattle to Chicago represents a rich railroad history. Railroad pioneer Jim Hill's Great Northern was one of three early Northern Corridor lines. That history is memorialized in Amtrak's Empire Builder, which runs on the

Transcon and connectors. Today the corridor is among the world's most important rail shipping routes, a key link to Asia for transporting containers and agricultural products. Lines run through mountains and face challenging weather conditions. The Northern Corridor has also faced capacity constraints. For all these reasons, Northern Corridor electrification represents a robust proof of concept for electrifying lines across the nation.

A Solutionary Rail demonstration along the Northern Corridor would increase system capacity and train speeds using electric locomotives with power superior to their diesel counterparts. It would upgrade and add track to facilitate higher speeds, opening the way for express delivery of high-value freight and enhanced passenger service. It would also provide a market and potential transmission corridor for one of the world's greatest, and currently under-developed, renewable energy resources, Great Plains wind. Added transmission could benefit BNSF owner Warren Buffett's substantial investments in renewable energy. Successful implementation would provide important benefits in its own right and demonstrate the viability of electrification and modernization for primary freight rail across the nation.

Communities along the corridor would be among the greatest beneficiaries. Improved service and reliability would speed delivery of goods to urban and overseas markets. Smaller trackside communities that have lost rail service could see it restored. Express service from hubs in farm regions would provide new options for agricultural commodities that must move to market quickly such as fruits and vegetables. Good transportation is the foundation of economic development. New opportunities would expand with improved freight and passenger service.

Communities along the corridor would be among the greatest beneficiaries.

BNSF has already explored electrification along its lines in conjunction with transmission development, BNSF President and CEO Matthew Rose reported in 2009. In exploring opportunities to place power lines along tracks, "We have had conversations with two, if not three, outside organizations."[136] The railroad also asked locomotive makers about costs and timelines to produce dual-mode engines that can use both diesel and grid electric power.

The prospect of carbon regulation motivated the railroad to seek alternatives. "I think we're going to start pricing carbon out at some point in time in the future," Rose said. "You hear everybody talking about a carbon-constrained world, and a carbon-priced world." Rose called out the carbon emissions advantage rail already has over trucks due to its superior efficiency, and noted how electrification would extend that advantage. He estimated that the cost to fully electrify BNSF would range around $10 billion. That level of investment would require public support, he added.[137]

The Northern Corridor is a place to begin bringing public support to bear and demonstrating success for the rail industry as a whole. The Solutionary Rail strategy proposes a PPP to electrify approximately 4,400 Northern Corridor track miles.[138] This might be accomplished in phases. First priority would be electrification of the main Transcon route from Seattle to Chicago, the major intermodal line carrying containers across the corridor. It would include a loop in Washington State that transits Stevens Pass and the connector line between Portland and Seattle. The latter would further the development of higher speed passenger rail between those cities. Also proposed is electrification of the 220-mile Stampede Pass line in Washington. These lines currently total around 3,100 miles. The next phase could electrify the Montana Rail Link from Sandpoint, Idaho through Billings, Montana, and the connecting BNSF line to Fargo, North Dakota, and a connector between Glendive and Snowden, Montana, together totaling around 1,300 miles.

The Northern Corridor is a place to begin bringing public support to bear and demonstrating success for the rail industry as a whole.

The foundation of the effort is the establishment of a Northern Corridor Steel Interstate Development Authority by states along the corridor including Washington, Idaho, Montana, North Dakota, Minnesota, Wisconsin and Illinois. It would be chartered with the authority to raise funds for electrified rail infrastructure investment along the line.

While it might be difficult to line up all states at once, Washington and Montana have a crucial role because two-thirds of track mileage is located in these two states. Washington has approximately 1,300 miles, while around 1,550 miles run through Montana, including approximately 665 on the main Transcon. These are sufficient mileages to start electrification. Solutionary Rail proposes that these states play a leadership role in creating the Northern Corridor SIDA.

These states have particular interests in leadership. The significance of ports and major aerospace and agricultural shippers in the Washington economy builds the case for the state taking the lead. Montana also has huge stakes as a major wheat growing state whose producers are heavily dependent on rail shipping. Faster service for goods and passengers would also open new economic development opportunities for Montana communities.

Significant groundwork has already been accomplished toward PPP development along the corridor. Mark Ricci and Fredrick Gamst in their 2008 report call for coordination among Northern Corridor stakeholders, “bringing together political leaders, state agencies, ports, local governments, nongovernmental organizations, truckers and railroads to create a vision of a modern, efficient and economically desirable transportation option tapping foreign and domestic markets.”[139]

The effort advanced with creation of the Great Northern Corridor Coalition in late 2012. It includes BNSF; the transportation departments of Washington, Oregon, Idaho, Montana, North Dakota, Minnesota, Wisconsin and Illinois; the Washington Public Ports Association; and ten port authorities including Seattle, Tacoma and Portland.[140]

"The Coalition's primary purpose is to promote regional cooperation, planning, and shared project implementation for programs and projects," the group's self-description states. The coalition vision is "a globally competitive, multistate freight Corridor consisting of a seamless road and rail network that promotes economic growth for neighboring communities and accommodates the demand for safe, efficient, and environmentally sound transportation services."[145]

The Coalition has completed a corridor analysis that has tentatively identified 136 projects to speed freight mobility, and is now working to create a coordinated improvement program.[142] The analysis builds the case for public investment with a quantification of nationwide public benefits from Northern Corridor rail service in 2012 with projections to 2035, by which time rail volume is expected to grow by nearly three times. (See table below. Figures are given in 2012 dollars.)[143]

PUBLIC BENEFITS FROM NORTHERN CORRIDOR RAIL SERVICE

	2012	2035
State of Good Repair	$574,403,029	$1,425,293,875
Economic Competitiveness	$2,740,234,982	$6,621,979,305
Livability	$55,068,075	$134,699,504
Sustainability	$903,577,891	$2,213,892,981
Safety	$1,361,372,987	$3,326,219,873
Total	$5,634,658,976	$13,722,087,574

Creating the Northern Corridor SIDA will require a broad alliance including:

- Warren Buffett, primary stockholder in Berkshire Hathaway, owner of BNSF, who can expect increased returns on his investment
- BNSF management, which can enhance the competitiveness of their railroad by increasing speeds and improving service
- Montana Rail Link and its owner, the Washington Companies

- Governors and legislators of Northern Corridor states, who will benefit from employment and productivity gains as well as from the reduced maintenance burden on highway systems
- Railway workers, who will benefit from growth in secure employment in their industry
- Communities on and near the rail corridor, who will gain improved access for business and passengers, spurring economic development and building sustainable prosperity
- Northwest ports, which will enhance their competitive position among West Coast ports by providing a faster, lower-cost pathway between the nation's heartland and Asia
- Agricultural interests, which will gain more reliable express service for perishables and improved shipping of bulk commodities
- Tribes, who stand to gain economic development opportunities, and whose treaty rights must be respected
- Utilities, who could gain a new railroad customer and power transmission, and run electrification infrastructure
- Major industries such as Boeing, which rely on rail to manage their manufacturing supply chain
- Retail and express shippers, who will gain improved options beyond trucking for rapid and reliable service.

A fair deal for workers is an important foundation for securing public participation. In their call for Northern Corridor rail PPPs, Ricci and Gamst point out a challenge. "The BNSF railroad controls the largest part of the Northern Corridor rail network. Thus, the opportunity to realize the potential for enhancement of the corridor's economy for public benefit could inequitably help a single rail carrier."[144] BNSF could help tip the scales to equity by adopting the fair deal agenda of Railroad Workers United lined out in the above chapter.

Warren Buffett and BNSF have the opportunity to blaze a new trail in railroad labor-management relations on the railroads. By following these proposals, BNSF can

achieve high employee morale, low accident and injury rates, and high productivity and efficiency. BNSF should become the industry leader in positive labor-management relations. Wages and benefits secured by labor unions played a key part in creating the middle class, and the weakening of unions has a great deal to do with the decline of the middle class. An agenda to rebuild the role of rail in the American transportation system can also help begin rebuild the American middle class. Both are vitally necessary to revitalize the American dream.

One issue that needs to be addressed forthrightly is coal and oil shipments by rail. The Northern Corridor is a prime conduit for North Dakota Bakken shale oil, and coal from the Powder River Basin. These shipments have displaced agricultural commodities from fruit to wheat and soybeans, shifted container traffic to other lines, and slowed passenger traffic. Fossil fuel traffic has also drawn opposition from environmentalists concerned about carbon emissions and spills, as well as communities worried about health and safety issues. Electrification and modernization would increase rail capacity, reducing challenges for other traffic. But some may be concerned that increased capacity would also facilitate increased coal and oil shipments, although it would not make sense for these typically slow trains to operate on new tracks devoted to faster rail.

The honest answer is that Solutionary Rail is not a means to either enable or restrict coal and oil shipments. It is, however, a way to provide railroads with new options to move higher-value freight that pays much better returns than bulk commodities like coal and oil. As this paper has documented, subsidies to highways and aviation have undermined rail's role in shipments where speed and delivery reliability are crucial. *Solutionary Rail* maps out a course for rail to regain a share of those markets, making railroads less dependent on coal and oil traffic.

The alliance that can make Solutionary Rail a reality will necessarily include people on both sides of this issue. Solutionary Rail challenges us to overcome partisan divides and, despite disagreement in some areas, find common ground for our common benefit.

Solutionary Rail offers a better alternative for Northern Corridor communities. It's better for farmers who need reliable service and additional rail capacity to get their products to hungry world markets. It's better for rail labor and railroad stockholders, since it positions rail to play a much larger role in the nation's economic life. Finally, Solutionary Rail is better for the nation, whose security and economic resilience will be enhanced by moving towards an efficient, 21st-Century rail system powered by domestically produced renewable energy. It's time to join in new partnerships to reinvest in railroads for the many benefits they generate for society and the economy. The place to start is the Northern Corridor.

Solutionary Rail Is People-Powered: How You Can Take Action

THIS BOOK MAKES A BROAD SET OF ARGUMENTS for why and how to electrify America's railroads and open corridors to a clean energy future. But Solutionary Rail is not just a proposal, it is a people-powered campaign. This book is a resource for communities and leaders to protect the common good while negotiating a win-win with railroad owners.

As a reader, you have a crucial role to play by bringing the power of your community, group, or association to bear on key players and institutions. We conclude this book with practical steps you can take to move Solutionary Rail from concept to on-the-ground reality.

The Backbone Campaign, originator of Solutionary Rail, is fundamentally about reviving democracy through people-powered movements. Solutionary Rail emerged from just such a movement, one in which Backbone is deeply enmeshed. That is the movement against the extraction of climate-twisting fossil fuels from such sources as the North Dakota Bakken shales, Alberta tar sands and Powder River Basin coal. Because the Pacific Northwest sits between these globally significant fossil fuel reserves east of the Rockies and growing markets in Asia, regional activists have formed "the thin green line" against proposals for massive expansion in fossil fuel shipping facilities along the Northwest coast.

But our "No!" is only as powerful as our "Yes!" is compelling. And in saying, "Yes!" we can build bridges with people on the other side of the divide by providing economic alternatives to fossil fuel extraction. Solutionary Rail is about spanning that gap, drawing support from constituencies such as labor that have not always been on the same page in the fossil infrastructure debate. So even if you don't agree with us on fossil fuels, we still reach out to ask your support for a proposal with large potential economic and environmental benefits for rail communities, working people, farmers and others.

Solutionary Rail is a necessary, timely, and doable infrastructure proposal to power higher speed freight and passenger service with renewable energy. It provides a pathway to shift the economic model of US railroads from dependence on bulk fossil fuel traffic to higher value freight and increased passenger service. By leveraging electrification to expand power transmission, Solutionary Rail could unleash a boom in renewable energy development, providing rural areas with huge new job creation and business opportunities.

Solutionary Rail is an example of how bottom-up, people-powered initiatives can effect change on larger scales. It grew out of a regional movement on the Backbone Campaign's Northwest home ground. It grew into a model to jumpstart rail electrification on the Northern Corridor as a demonstration for the entire nation. It is part of

the larger agenda needed to address the climate threat, a transformation of energy and transportation systems to 100% renewable energy.

Shortly before this book was published, Bill McKibben, who wrote the foreword, issued a clarion call for a World War II-scale mobilization to achieve this goal. Citing a dramatic upsurge in climate impacts—temperature spikes, Arctic ice loss, massive wildfires, huge floods, and the spread of new diseases, McKibben wrote, "World War III is well and truly underway. And we are losing...The question is not, are we in a world war? The question is, will we fight back?"[145]

Solutionary Rail is a way to fight back. This proposal needs folks across the country to lock arms and champion Solutionary Rail. We need people like you to help grow the alliance of labor, farmers, tribes, urban and rural community leaders, fishermen, environmentalists and climate justice advocates needed to put Solutionary Rail over the goalpost. Together, we need to press governors, members of Congress, the next president, and BNSF owner Berkshire Hathaway to implement this proposal while vigilantly protecting its public benefit components:

- Access to railroad rights-of-way for publicly-owned-and-operated electrification and transmission infrastructure
- 100% renewable energy powered
- Labor protections, also vital for public safety, including regular work schedules and minimum crew size
- Protection of tribal treaty rights including access to usual and accustomed lands and waters, with a requirement that right-of-ways have tribal permission.

What You Can Do to Make Solutionary Rail a Reality

In your community:

1. Learn more about the proposal and demonstration project at **www.SolutionaryRail.org**.
2. Endorse Solutionary Rail at **www.SolutionaryRail.org/endorse** (for individuals and organizations)
3. Pass a Solutionary Rail resolution in your trade, labor, municipal or party association/organization/coalition. Sample resolution at **www.SolutionaryRail.org/resolution**

1. Make a tax-deductible contribution to the Solutionary Rail organizing campaign at **www.SolutionaryRail.org/donate**

2. Host a Solutionary Rail house party, book reading, or town hall meeting. **www.SolutionaryRail.org/outreach**

3. Buy *Solutionary Rail* for your friends and elected officials. **www.SolutionaryRail.org/buythebook**

4. Ask your local library to buy and stock two or more copies of *Solutionary Rail* Sample letter at **www.SolutionaryRail.org/libraries**

Ask your state's Governor:

Have your state's transportation, energy and financial agencies conduct feasibility studies of the Solutionary Rail proposal. Ask them to work with other governors to jointly charter a Steel Interstate Development Authority (SIDA). The SIDA would be a not-for-profit corporation operating under a board appointed by participating states, chartered with the authority to raise funds for infrastructure investment on both publicly and privately owned rights-of-way. The SIDA would leverage the ability of public agencies to issue bonds and provide low-interest capital to invest in rail electrification in partnership with railroads, and oversee funding and construction of electrification and transmission infrastructure.

Ask the President and Congress:

As the Solutionary Rail proposal is fully implemented and the concept spread, federal action to increase the financing capacity of TIFIA and other supportive federal programs. Ask the president and Congress to add to the capacity of these programs.

Find updates on needed citizen action at: **www.SolutionaryRail.org/takeaction**

For Berkshire Hathaway shareholder activists:

1. Invite Solutionary Rail presentations from the Backbone Campaign. Contact Executive Director Bill Moyer: bill@backbonecampaign.org

2. Buy this book and distribute it to fellow activists and your other constituencies, including contacts at Berkshire Hathaway.

3. Introduce resolutions at Berkshire Hathaway shareholder meetings calling on Warren Buffett and BNSF to work with governors and states to implement Solutionary Rail.

It's up to you:

Solutionary Rail has tremendous potential to provide benefits to all involved, from railroad companies to rail labor, from farmers and rural communities to urban residents. Because the proposal aims to use renewable energy, it would clean the air and benefit all of us who live on this small planet. And because Solutionary Rail provides such a broad range of gains, it can do something all too rare in our fractious nation, build bridges across political divides. Accomplishing all of that will take people power to move elected officials and major institutions. In the end, getting Solutionary Rail on track is all about you, and the actions you take. Act today to make Solutionary Rail a reality.

Visit us at SolutionaryRail.org

THE BACKBONE CAMPAIGN SOLUTIONARY RAIL TEAM

SOLUTIONARY RAIL IS A PROJECT OF THE BACKBONE CAMPAIGN, a nonprofit advocacy group devoted to civic renewal of America's democratic heritage.

Backbone Campaign's vision is a world where human dignity, community resilience, and ecological well-being are built upon a foundation of democratic economic and political systems and a diverse, thriving culture. Backbone provides creative strategies, artful activism trainings, and creative action support to progressive activists, organizers and organizations around the US and beyond in order to invigorate and nurture a people-powered, community-based, and internationally networked social movement for human rights, thriving communities, and ecological wellbeing.

Backbone has drawn together a team of railroad visionaries, economists, engineers, railroad workers, public interest advocates and communicators from across the country to develop and present the Solutionary Rail proposal.

MARGOT F. BOYER co-authored *Beyond Inclusion, Beyond Empowerment: A Developmental Model to Liberate Everyone* with Leticia Nieto et al. She lives on Vashon Island with husband Bob Powell; they manage Meadow Creature LLC, maker of artisan tools for modern times. Margot grew up in Chicago and has fond memories of travels on the Blackhawk, the Empire Builder, the Pioneer, and the Coast Starlight.

ROB BRIGGS is a retired national laboratory scientist with more than 30 years of experience performing energy-related research. He has participated in a wide range of studies involving economic analysis, computer modeling, software development, climate analysis, the development of codes and standards, and the development of innovative systems for improved energy efficiency.

GERRY CALLISON is an electrical engineer with Commonwealth Associates, Inc. Gerry's experience includes interconnecting Independent Power Producers and alternating current electrified rail systems to the power grid, transmission level protective relaying, and the study of electromagnetic interference from power lines co-located with railroads.

STEVE CHRISMER has worked for more than 30 years in the freight and high speed passenger railroad industry, and is a registered professional engineer specializing in vehicle and track engineering. Currently Steve works at LTK, one of the nation's major rail electrification consultancies. Previously he worked at Amtrak to develop high speed rail to an eventual maximum of 220 mph in the US.

ALAN DRAKE is a consulting engineer who works on complex, interdisciplinary problems. He wrote the chapter on freight for *Transport Beyond Oil* by Island Press. He was lead author on an econometric modeling paper with Millennium Institute on the benefits of a massive push for renewable energy plus urban rail and electrified railroads.

CATHY FULTON is a graphic designer specializing in book layouts and illustration consultation. She has worked with historical organizations and individuals in Western Washington to publish a wide array of books to preserve our local history. She has been a volunteer graphic designer with the Backbone Campaign since its inception.

RON KAMINKOW has served as the general secretary of the cross-union group Railroad Workers United (RWU) since 2008. In 2005, he helped to found Railroad Operating Crafts United (ROCU), an RWU predecessor. Ron currently works as an Amtrak engineer in Reno, NV where he is a member of Brotherhood of Locomotive Engineers & Trainmen Division

PATRICK MAZZA is an advocacy journalist, analyst and organizer with an emphasis on ecological sustainability broadly conceived. In his over 30 years of experience, Patrick has worked for forest preservation, sustainable cities and clean energy. He is a founder and former Research Director for Climate Solutions, and now works in his own sustainability practice, MROC.

BRUCE MCFARLING is a development economist who has written extensively on rail sustainable transport and energy issues in the "Sunday Train" series appearing at Daily Kos and a variety of other community blog sites. Bruce promotes the strategy of the Steel Interstate System across the US. He first focused on the role of rail in passenger transport in Newcastle, New South Wales.

BILL MOYER is a fourth generation Washingtonian who lives with his wife and daughter in the woods of Vashon Island in the Salish Sea near Seattle. He co-founded the Backbone Campaign and has served as executive director since 2004. A leader in the theory and practice of *artful activism*, Backbone combines lessons of the performing arts with grand strategic principles from the *Art of War* to invigorate nonviolent social change movements. Bill and his Backbone colleagues have designed and produced

hundreds of creative protests and trained thousands of change agents. They have helped transform mundane demonstrations into cultural happenings with innovative tactics like spotlights to project messages onto buildings, and introduced the world to *kayaktivism* during the *sHellNo!* campaign to stop Arctic drilling.

Bill presents on the application of *grand strategy*, creative tactics and campaign design in workshops around the country. His moral and strategic commitment to always balance critique with proposal resulted in the Solutionary Rail project. Bill convened and directs the Solutionary Rail team to plot a path for America to transform a broken and dangerous railroad business model into a catalyst for social and environmental solutions that can act as an integral component of a just transition to sustainable society.

J. CRAIG THORPE is a nationally recognized artist specializing in conceptual renderings and landscape paintings. He has produced commissioned works for Amtrak including the commemorative centennial paintings of Washington D.C. Union Station (2008) and Glacier National Park (2010). His most recent work is a collection of vignettes celebrating Amtrak's 40th anniversary in 2011. Craig is widely known for these and commissions by other rail clients.

CARLO VOLI is a climate and environmental justice activist and community solar and sustainability advocate. Carlo helped establish the Edmonds Community Solar Cooperative, the first fully citizen-owned community solar cooperative in Washington State, and is involved in community organizing to prevent the Pacific Northwest from becoming a fossil fuel corridor.

APPENDIX: RAIL LABOR STORIES

Ron Kaminkow: "Most Freight Railroaders Don't Have Any Set Schedule."

I'VE WORKED IN THE RAILROAD INDUSTRY NEARLY 20 YEARS. I started in freight. Now I work in passenger service, which gives me a more tenable schedule. Demanding work schedules are typical on US railroads, but this problem is most acute in the freight industry. In fact, most freight railroaders don't have any set schedule at all.

Generally, freight trains have a two-person crew: an engineer and a conductor. Rail carriers are trying to eliminate one of these positions. Both get a call, usually two hours before scheduled on-duty time. You're expected to be rested, sober, and ready to take that call, day or night, and report to the on-duty location within two hours, and be ready to work for up to 12 hours.

The call could come at midnight tonight, then 3 pm the next day, 8 am after that…never knowing when you'll be called, when you'll finish, how many hours you can rest, or when you'll return home. You're working and resting around the clock; it's completely unscheduled.

In 2012, the Rail Safety Improvement Act mandated 10 hours of undisturbed rest between tours-of-duty, and three days off after working six. That's actually a bit of an improvement, but chronic fatigue continues to be a central aspect of railroad life. If you work twelve hours and get ten off, day after day, it's easy to get exhausted. Being fatigued is like being intoxicated. The railroad is dead set against being inebriated on the job, but when it comes to being fatigued, they show no concern. They won't even acknowledge that fatigue is a hazard!

Railroad companies want you to believe they're interested in safety. From the company's perspective, accidents and injuries are the result of workers' behaviors. Workers know they're caused by hazards like fatigue, short staffing, task overload, excessively long and heavy trains, poor lighting, uneven walking surfaces, and faulty equipment. If we're concerned about safety these hazards must be eliminated. The railroad won't talk about hazards; they resort to words like "barriers" to avoid the terminology. The railroad shifts the blame for accidents and injuries from the carrier to

the workforce, from hazards to behaviors. They blame worker behavior for every accident.

Many times I've felt at risk when over-worked to the point of exhaustion. In 1999 I was at the terminal in Chicago. I'd put myself "off-duty," and was on my rest. I had ten hours coming to me and had planned my sleep accordingly. Late that night there was a derailment near Toledo, so the railroad declared "an emergency" which voided our union agreement about rest time. This should not have applied to workers already off-duty. But the phone rang at 2 AM. I was ordered to report for duty, unfit or not. The conductor and I had a difficult trip out of Chicago, leaving before dawn. We were both very tired and found it almost impossible to stay awake, as a result of the company reneging on our agreement. It's just one example among millions: a rail company talks safety, but routinely puts its workers in harm's way.

Jen Wallis:
"Behavior-based Safety Programs...Blame Workers"

I'M A SWITCHMAN AND CERTIFIED CONDUCTOR FOR BNSF. I put trains together and take them apart: move cars from one track to another, test them, and send them on their way. It's a physical job—I might walk four miles a day, climb a dozen ladders, and spin dozens of handbrakes.

I'm a member of Brotherhood of Locomotive Engineers and Trainmen, and proud to be a union railroader. Both of my great-grandfathers were railroad men, and what I do is not much different from what they did. Our equipment hasn't changed much; someone who worked on the railroad 100 years ago could pick up this job today.

I got injured in 2008, through no fault of my own. I was working with a new employee, who was operating a locomotive. It used to take years to become an engineer, but it's been cut to about eight months. I knew someone was going to get hurt. I had to jump off a locomotive before it crashed into another. The engineer lost sight of me and was supposed to stop, but didn't. It took a year before my mobility returned enough to work. I filed injury and whistleblower claims against the carrier for retaliating against me for reporting an injury, so it took another six months to be cleared by company lawyers. I lost my home, my credit, and was subjected to years of litigation. The company spent over a million dollars fighting me. In the end, my attorney made over half a million. The jury heard only about 10% of what happened to me; they awarded me $20,000 for pain and suffering.

When rail workers get injured, the company says we did something wrong. Compensation is based on our liability versus the company's liability. Naturally, the company prefers to lay most of the liability on us. The General Code of Operating Rules is huge. About half of it is operating rules, which are good and necessary. The rest was created by the carriers to avoid paying claims. You can be terminated for violating rules, and will likely lose your claim. I got disciplined for "conduct." They didn't like that I refused to allow management into my hospital room to interfere with my care.

The company uses behavior-based safety programs to blame workers, but the reality is that all industrial accidents are caused by hazards on the job. We wouldn't get hurt if we weren't at work.

Because the system punishes workers for accidents, people who get injured on the job will say that they did it at home, so they don't lose their jobs. They've created such a chilling effect that workers are afraid to report injuries or hazards, so how does this make for a safer workplace? Those of us who decide to fight give up our privacy, and we experience retaliation. We shouldn't be the only people who sacrifice to make the industry safer.

I stay with this job because I love the work and camaraderie. It takes a certain kind of person to do this—a person willing to be on call 24/7, miss birthdays or anniversaries. We endure harassment from management. Your whole family must sacrifice.

Rails are a tight-knit group. We're the only ones who can understand our lives, and we take care of each other. I've seen horrible things happen to friends, even being killed on the job. I love the people that I work with and I want to make this better.

ACKNOWLEDGEMENTS

THE BOOK IN YOUR HAND IS THE PRODUCT of an incredible chain of serendipitous moments, a collection of overlapping collaborations, and a ton of work by a lot of talented people. I feel honored and deeply grateful to have worked with them and learned so much over these past three years directing this project. I am even more excited for the campaign that follows the publication of this first edition of *Solutionary Rail*. But now it is a moment to celebrate and appreciate the technical team, book team and so many others who have pitched in important and timely ways.

The list of people and the ways they contributed is long and varied, thus leaving someone important out by mistake is almost inevitable. So, I apologize in advance to anyone whose role I fail to mention here. Please send me a note and we'll address the omission in the second edition. For now, here's my best shot at expressing my gratitude and recognizing incredible people who have made Solutionary Rail possible.

At the very start, rail labor activist Jen Wallis provided a basic education in environmental and labor issues surrounding Warren Buffett's BNSF railroad. Jen connected me to Ron Kaminkow of Railroad Workers United (RWU), the organization that links workers across the industry's many trade unions. Ron concurred that railroads are an essential component of a more just and sustainable future. Jen, Ron and Mike Elliott of the Brotherhood of Locomotive Engineers and Trainmen tutored the Backbone Campaign about railroads and the lives of "rails," the name by which rail workers describe themselves. After a long conversation about bridging differences and finding common ground, Mike made me a challenge. He shared a 2008 labor-commissioned report on modernizing Northern Corridor rail (cited later in this book) and said, "See if you can 'green this.' " That was back in 2013.

A bit daunted, but taking this challenge quite seriously, I shared the 2008 report with people who might know where to start. A couple of them agreed to check it out. The first was Rob Briggs. Rob is passionate about climate and railroads and had recently retired from Pacific Northwest National Laboratory. Amtrak's principle track geometry engineer at that time, Steve Chrismer, who I'd met during Occupy was the second. Together, Steve and Rob bolstered each other's interest and gave our project the gravity it needed to draw in others. Bruce McFarling was the next to join. Bruce is an econo-

mist and who has taken enthusiasm about rail to an entirely new level. Bruce lent his indomitable capacity to navigate the bureaucratic labyrinth of things like state and federal transportation finance, the true cost of freeways, etc., and then connect the dots and solve problems. He generated a number of articles that serve as the source material for many aspects of this book. Bruce brought in Alan Drake, a rail electrification evangelist. During our year of weekly conference calls, Alan consistently tuned us into what was happening in rail electrification around the world from Siberia to Ethiopia, France to India. As transmission became an increasingly more important aspect of the proposal, technical questions loomed. Engineer Gerry Callison joined the technical team. Gerry anchored our vision with his real-world experience refining the California high speed rail project's grid interaction and saving California taxpayers millions if not billions of dollars. David Foster and Robinson Foster (not related) coined the term "Steel Interstate" and formed the Steel Interstate Coalition and Rail Solution projects that predated and inspired *Solutionary Rail*. They generously shared a large body of work with our team. Along with Alan and Bruce, they also shared a common mentor, electrified rail visionary Gil Carmichael, who passed in 2016. Gil inspired these protégés to lay the foundation for this Solutionary Rail proposal and we hope he'd be very proud of this next step forward.

Project editor Patrick Mazza, a veteran writer and analyst on climate and sustainability solutions, bridged the technical and the book phases and teams. Patrick deserves a huge amount of credit for weaving many people's ideas together and making the technical literature generated by our expert team accessible. Wordsmith Margot Boyer gave us perspective and helped hone and proof the manuscript. Book designer Cathy Fulton brought indispensable skills, humor and passion to the layout work that kept this fun even when I was missing deadlines. In the home stretch, Jeff Berend generously stepped up to skillfully design the cover and accompanying Solutionary Rail poster. Both the cover and poster feature original artwork by J. Craig Thorpe, whose commitment to detail and illustrative prowess made him a joy to work with. Craig's reverence for rail and ability to build upon the historical and technical to "Paint the Possible" transcends words to communicate an aspirational future within our grasp.

Many others played key roles as well. Todd Manza provided an early editorial reality check. Rail savant Hal Cooper offered invaluable insights on rail technology and politics. Thomas White came in with important final improvements. Jeff Dunnicliff's photography, videography, editing and sage advice aided Solutionary Rail's evolution. Carlo Voli bridged the world of direct action for climate justice with the long term need for broad alliance building. Barbara Tarburton booked our budget travel to affordably get us where we needed to go. Paul Krueger of Cascade Rail foundation and Mary Pittis of the Iron Horse Inn supported our venture into the future of rail by initiating us into

the rail electrification's history in the Pacific NW. I owe a special thank you to Elizabeth Sanchay of the Yakama Nation, and Cris Stainbrook, Jim Wabindato, and Nichlas Emmons at Indian Land Tenure Foundation for your inspiration and guidance for the right-of-way justice section. As always, Washington State Senator Bob Hasegawa gave great advice and support, as did Luis Moscoso, who embraced the vision and invited us into the Washington State Railroad Caucus when others would not have. John Paul Wright of Railroad Workers United brought moral power of song and story to weave a deeper solidarity for all those coming together around this project. I'm grateful to all the RWU folks who mentored, critiqued, embraced, and even donated to help us evolve our proposal. RWU helped the our team remain grounded in the real impacts on real people.

Nothing happens except through collaboration and Backbone Campaign has a lot of angels and friends who lock arms with us in every way imaginable. There are too many members of Team Backbone to mention, but my staff Eric Ross and Judy Olson, along with my longtime collaborator and now deputy director Amy Morrison and social media genius Danny O'Brien have been indispensible. Deepest gratitude to the Backbone Campaign board past and present who have supported this project: Stan Sorscher, Sandra VanderVen, Kyle Tanner, Kristen Beifus, Denise Henrikson (and Lars), Serina Holmstrom, Susannah Hale, Kevin Tracy, Mary Lou Finley, and Jeff Snyder.

The solidarity of many volunteers, allies, advisors, and collaborators make our heaviest of lifts infinitely lighter. Thank you to: Laura Daughenbaugh, Martin Adams, Bob Powell, Lotus, Diane Cortese, Diane Wittner, Matthew Horwitz, Margo Polley, Kyle Britz, Karen Boyer, Zarna Joshi, Rob Harmon, Rod Tharp and Susan McRae, Luther Probst, Doug Skove, Tom Gross-Shader, Cathy deSmet, Jim Farrell, Bill Jarcho, Beverly Naidus, Bob Spivey, Lisa Marcus, Peter Weston and Linda Greenway, Elaine Hickman, Glen Anderson, Dan Leahy, Thomas White, Barb and Heather Rhoads-Weaver, Paul Cheoketen Wagner, Tom Bangasser, Patrick Christie, Yve Susskind, Martha Baskin, George Draffan, Jeff Johnson, Paul Loeb, Sen. Maralyn Chase, Kevin Zeese and Margaret Flowers (and so many unnamed others).

For years, the Nathan Cummings Foundation supported Backbone Campaign to take risks on the creative edge of movement building. Our incredible allies at the Lush Cosmetics Charity Pot program continued that by providing the first grant specifically for Solutionary Rail. The University Unitarian Church, Puffin Foundation, Kelly Ann Brown Foundation, Credo, Patagonia, Whatcom Community Foundation, and 4Culture have all provided critical support for aspects of our work for which we are extremely grateful. Timely contributions from other change agents are especially encouraging. David Cosman made one of the first individual contributions that paved the way for more. Portland attorney Greg Kafoury provided two generous challenge grants

that inspired many others to pitch-in. Climate scientist Richard Gammon contributed and opened his home for our first Solutionary Rail house party at a critical moment. And my dear friend, activist "Kit" Kittredge made a pivotal gift in tribute to her mother Sallie Kittredge, who as Kit says, "is still rooting for us!"

The Lumbar Club, our members who provide monthly support are the backbone of the Backbone Campaign. They and generous collaborators like George Heidorn, Rick Bodlaender, Dal LaMagna, Lauren Taubman, Stephen Silha, Bob Fertik, Harvie Branscomb, Ellen Kritzman, John Wilborn, Ryan Provonsha, Mark Early and Lolly Bates, Katy Jo Steward and Steve Paschall, Jim Burke and Mary Shackleford, Merrilee and John Runyan, Janie and Kirk Starr, Marnie and Jim Jones-Koenig, Marcie Rubardt and Charlie Pieterick, Leslie Harris, Jerry Henley, Java and Mark Kitrick, Janet McAlpin and David Godsey, Mike Vandebos, Willoughby, Peter and Martha, Will and Jenny, and so many others whose investment of love and energy into Backbone Campaign propel us forward!

Personally, this "work" that I am ever grateful to call my "job" would be impossible without my loving, supportive family near and far. The wonderful Pizarro family (Gonzalo, Dianna, Lucia, and goddaughter Olivia), along with my mom Doreen Moyer and my brother Jerome provide unfathomably generous hospitality whenever I'm on East Coast missions for Backbone. And lastly, it is the two amazing women who put up with retold stories, recurring struggles, and last minute forays to whom I owe the most. My wise and talented wife and soul mate Esther and my forever inspiring daughter Aziza not only provide the first feedback on ideas, design, and quandaries but have my back in the biggest project of all—a life well lived.

Knowing that our "No" is only as powerful as our "Yes" is compelling, the Backbone Campaign's unique approach has always paired opposition with proposition, critique with proposal. I am honored to be conducting this vast orchestra, but the music belongs to the many mentioned here and more. Creating the Solutionary Rail proposal and propelling this campaign is something we can all be proud of and take part in. I look forward to locking arms in the coming months and years to witness the once barely imaginable become inevitable. And it will, because together we have created a compelling vision to which all can proclaim a resounding "Yes!"

With deepest gratitude and solidarity,

Bill Moyer
Solutionary Rail Campaign Director
Co-founder and Executive Director
Backbone Campaign

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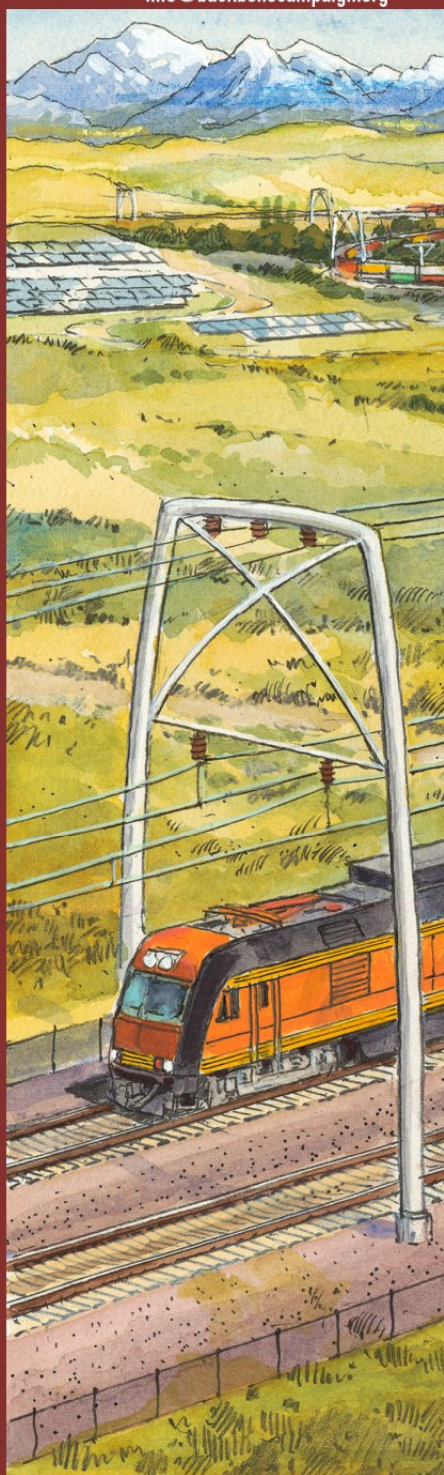

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