



BNSF Railway Advanced Energy Innovation

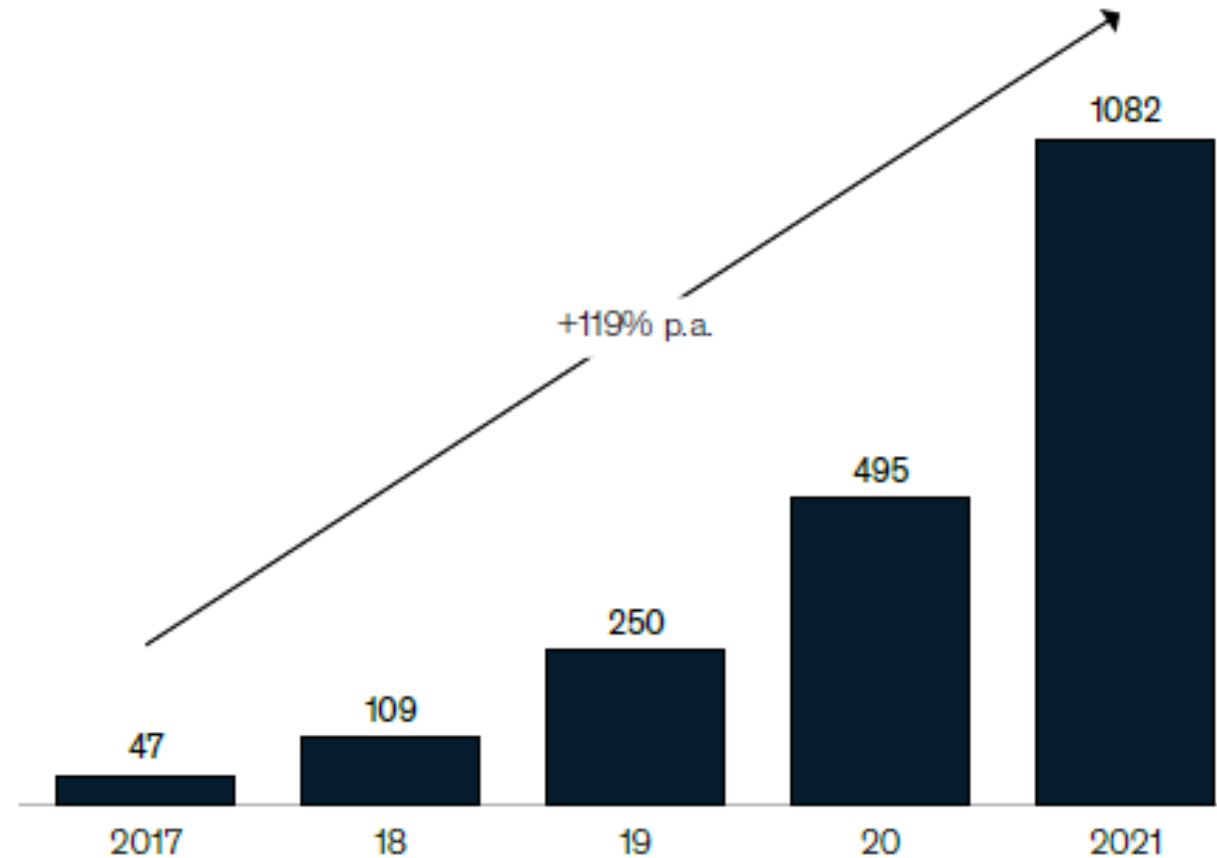
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Customer Demand for Lower Carbon Freight Transportation Increasing

- 96% of companies with approved science-based targets have targets covering scope 3 emissions

More companies set science-based targets for Scope 3²
of cumulative companies with approved targets



Path to 30% Carbon Reduction

- **Headwinds**
 - Business mix
 - Growth
- **Opportunities**
 - Fuel efficiency
 - Renewable fuels

Fuel Efficiency

Initiatives:

- Replace Older Locomotives
- Operational Practices
 - Horsepower per ton
 - Speed limits
- Energy Management Software
 - Locomotive energy management
 - Idle reduction
- Aerodynamics
 - Locomotives, cars, train make-up



Renewable Diesel

- Advancing pilots to enable higher percentage blends
- Policy change/advocacy required for cost-competitive supply
 - State Low Carbon Fuel Standards
 - Multi-year process: legislation, rule-making, establish markets, establish supply chains
- Availability of cost-competitive renewable fuels



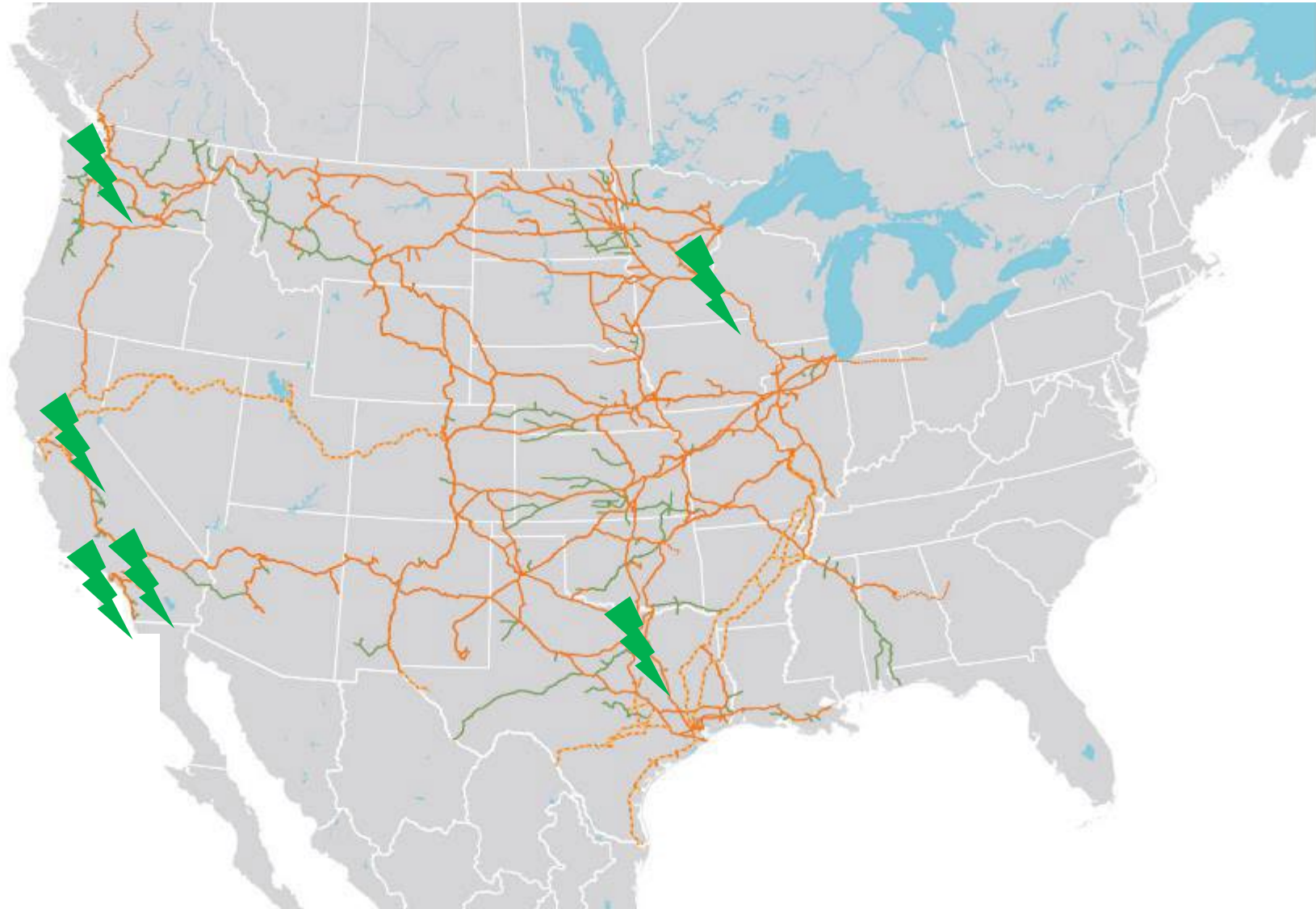


Advanced Energy Innovation

- Objective: **Safe and Sustainable business value**
- Process:
 - Research & Development
 - Demonstration / Pilot
 - Commercial/Operational Prove-out
- Technology
 - Hub Electrification
 - Locomotive Development



BNSF Battery-Electric Cargo Handling Equipment



New Technology Exploration

- Vehicle Fleet Electrification
- Microgrid/Smart Energy Management
- Advanced Energy Modeling



Locomotive Technology

- Battery-electric demonstrations
- Hydrogen fuel cell proof of concept
- Lithium-ion starter batteries



Locomotive Energy Needs

Yard



Operating model:

- Yard & local operations
 - Hump, trim & local work

Energy:

- <5 MWh
- 24 hr+ run time

Charging:

- ~2 MW (2-3 hrs full charge)
- Opportunity charge focus
- Stationary overhead charging at strategic locations

Regional



Operating model:

- Hybrid consist
- Short haul BEL only

Energy:

- 10-20 MWh, route & market dependent

Charging:

- ~3 MW speed (3-7 hrs full charge)
- End point / layover focus
- Stationary overhead

National / Long Haul



Operating model:

- Long distance BELs supported by Moving Charge or H2

Energy:

- 50-100 MWh
- Storage in battery or H2

Charging:

- 5+ MW speed (10-20 hrs full charge)
- Charge-on-the-move
- H2 or Battery Tender

Locomotive Commercial and Operational Prove-Out

Commercial Prove-Out:

- Industry Standard: 30 to 50 locomotive years per model
- Commercial Effectiveness Criteria: Safe, reliable, cost-competitive operations across diverse geographies, modes, and markets



Operational Prove-Out:

- Assess locomotive and train performance
- Demonstrate functional equivalence to diesel units
- Phased approach covering variety of use cases and criteria: power output, energy consumption, charging time, terminal logistics and throughput



Battery-Electric Challenges and Opportunities

Opportunities

- Zero Emissions
- System efficiency
 - Battery Electric vs. Diesel
 - Route-specific regenerative braking

Challenges

- Space Requirements
- Weight Restrictions
- Charge Time / Energy Demand



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