

New Performance Measures
 Key decision: Cost avoidance versus purchasing savings?

Infrastructure

Fuel

Technologies

Operative

logistics

demand

Better Growth, Movement

- Sustainable Resource Use
- Improved Reliability
- Reduced Order-to-Delivery Time
- Reduced Emissions
- Increased Safety



Freight Energy Endpoints?

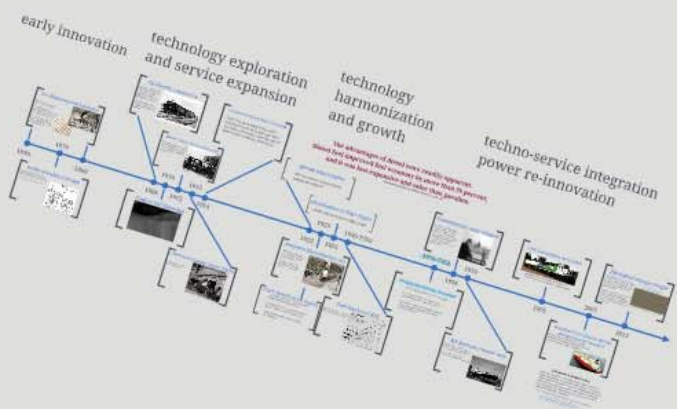
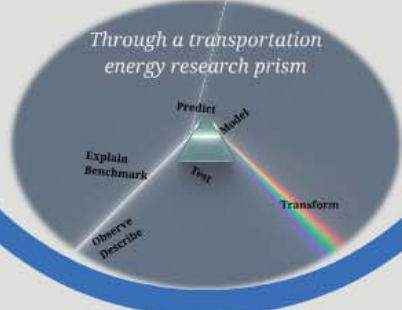
1. Freight systems cling to liquid petroleum in diesel combustion.
2. Freight follows suit with other vehicle sectors' technology and fuel alternatives.
3. Freight follows suit - a la Mode (pun intended) - where trucks play like autos and nonroad doesn't.
4. Networked freight solutions diversify by service range, commodity, region.

Three pathways for discussion:
 Freight leads change
 Freight follows (lags) change
 Freight changes independently

Energy and Work of Freight Systems

Three intersecting stories on how we might imagine scenarios for transportation energy

How might freight energy systems evolve?



Path resistance will depend in part on these factors

- Vehicle design and performance
- Protected niche mode(s) ... Users
- Operation and management
- Infrastructure
- Environmental targets
- Technology production scale

Farrell, Keith, Corbett, Energy Policy, 2003
<http://www.sciencedirect.com/science/article/pii/S0301421502001957>

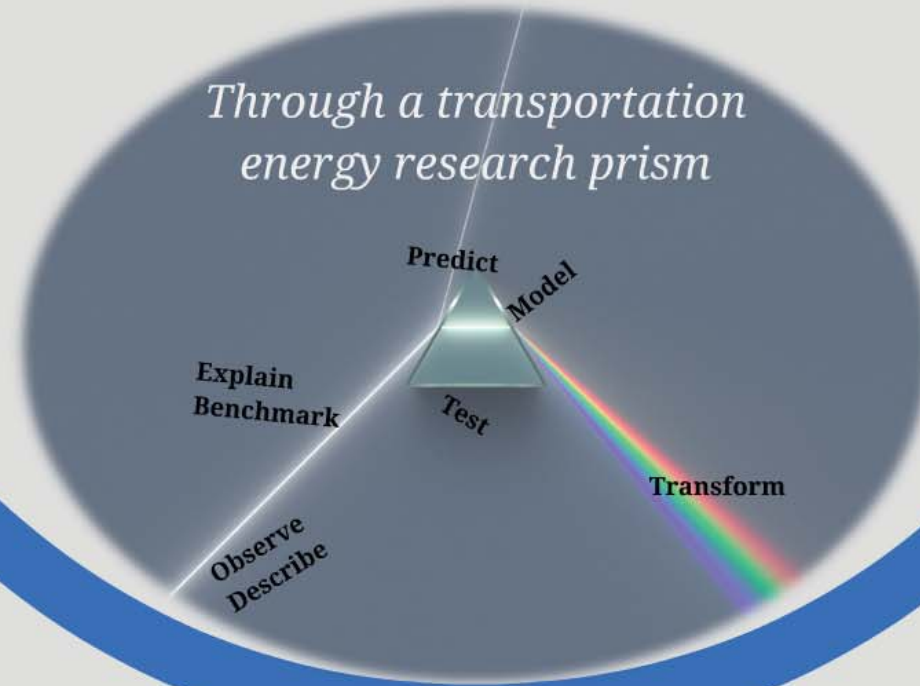


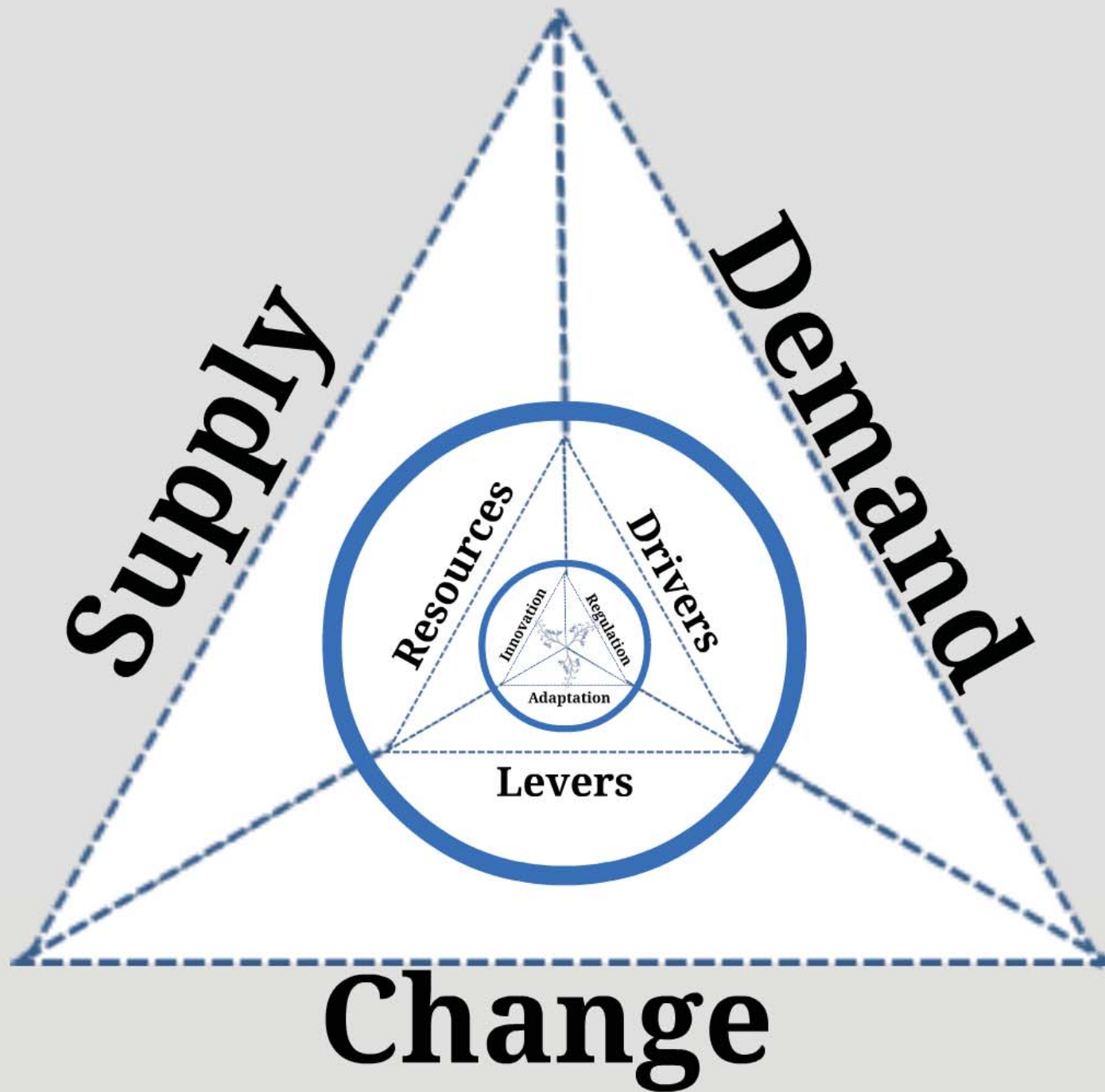
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Energy and Work of Freight Systems

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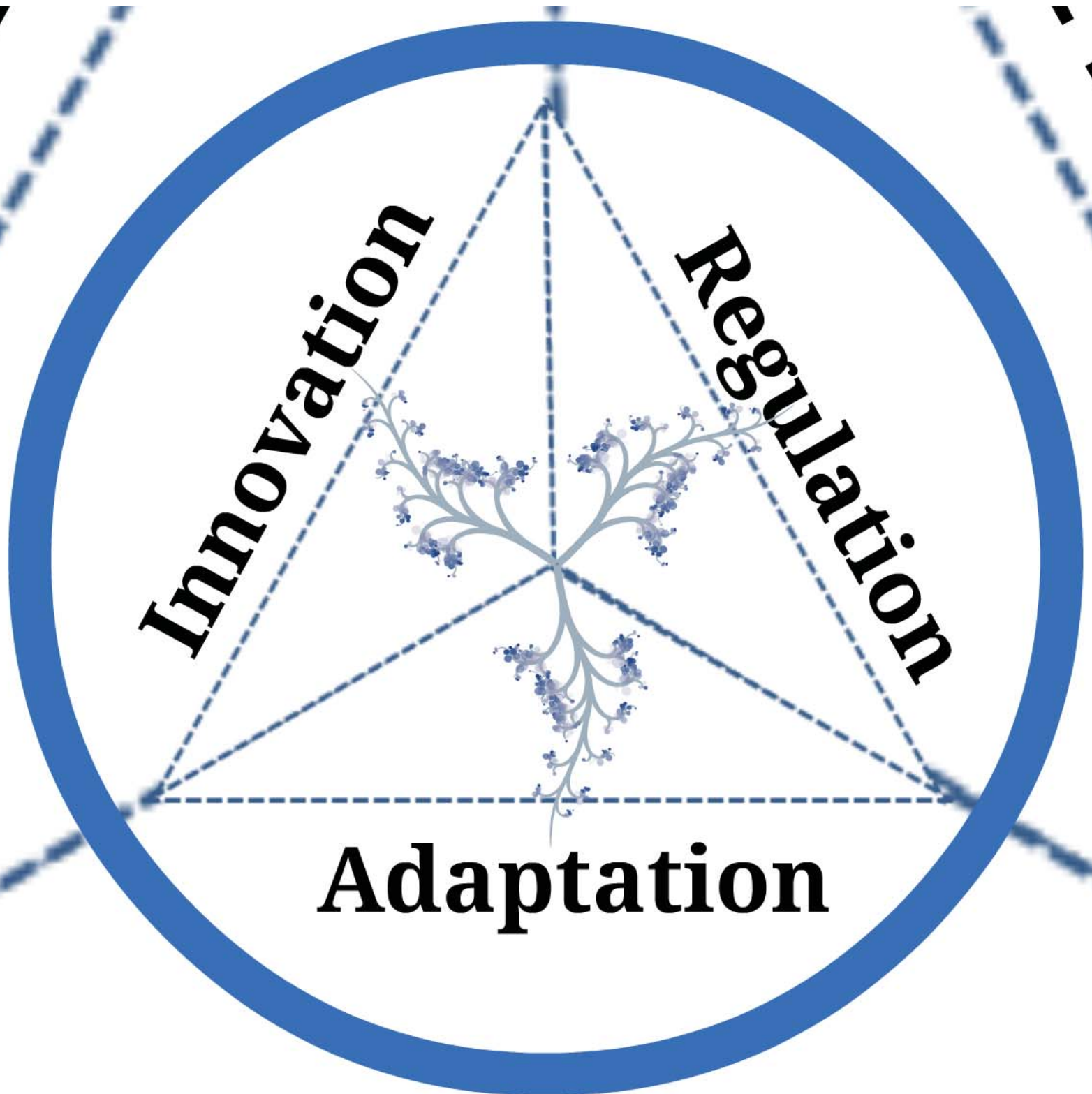
How might freight energy systems evolve?





YOU

IV



Innovation

Regulation

Adaptation

Energy: a crosscutting dimension...
fuel technologies
operational logistics demand

- Key
- Improve transparency
- Reconsider single-mode routes
- Backhaul networks
- Sustainability performance
 - Example: Human Health

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Freight Energy Endpoints?

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Three pathways for discussion:
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freight follows (lags) change

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3. Freight follows suit - a la Mode (partially)

4. Networked freight solutions diversify by service range, commodity, region

Three pathways for discussion:

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Freight follows (lags) change

Freight changes independently

early innovation tech

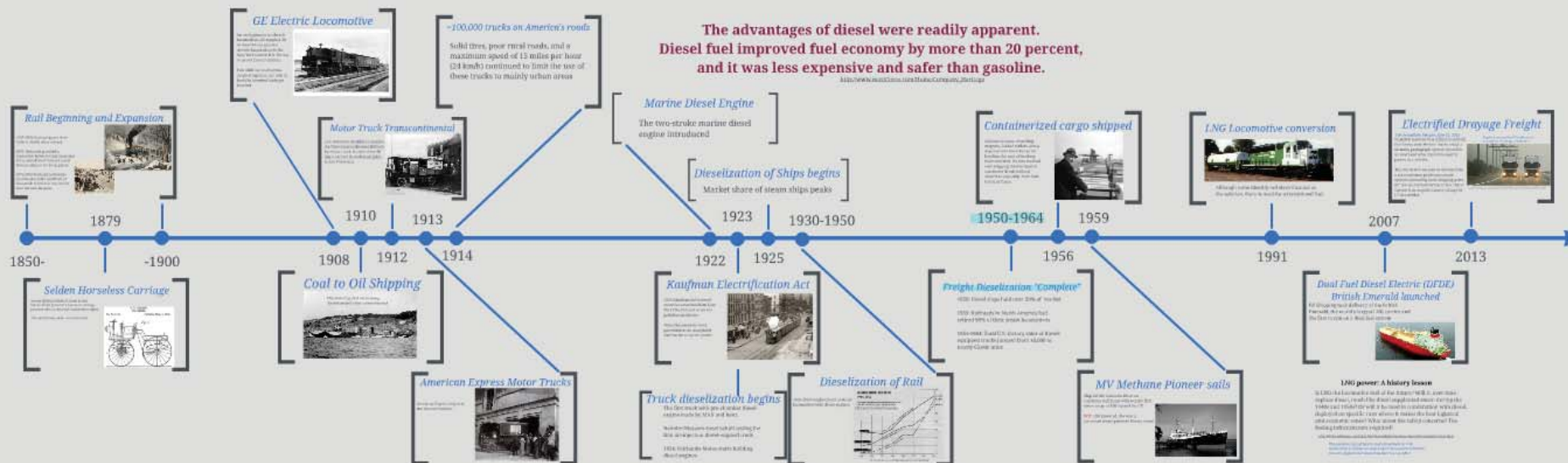
changes in

early innovation

technology exploration
and service expansion

technology
harmonization
and growth

techno-service integration
power re-innovation



Rail Beginning and Expansion

1850-1860: Railroad grows from 3,000 to 30,000 miles of track

1870: Railroads provided a connection between rural areas and cities, and allowed farmers to sell their produce in far away places

1871-1900: Railroad companies continued to build hundreds of thousands of miles of new tracks over the next 30 years



Two 2800 hp locomotives, coupled together, are able to haul the heaviest loads yet handled.



Motor

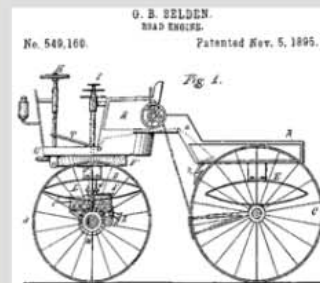
Five Teamster me the first transcon by motor truck. It days to travel from to San Francisco.



Selden Horseless Carriage

George Baldwin Selden (United States) invented and patented a horseless carriage powered with an internal combustion engine.

The vehicle was never manufactured



Coal to C

USS Paulding, fir American destr



Beginning and Expansion

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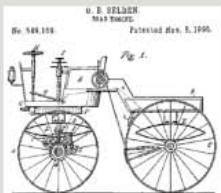


1879

-1900

Selden Horseless Carriage

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n internal combustion engine.
is never manufactured



GE Electric Locomotive

An early pioneer in electric locomotives, GE supplies 30 of these 94-ton gearless electric locomotives to the New York Central R.R. for use in Grand Central Station.

Two 2800 hp locomotives, coupled together, are able to haul the heaviest loads yet handled.



~100,000 trucks on America's roads

Solid tires, poor rural roads, and a maximum speed of 15 miles per hour (24 km/h) continued to limit the use of these trucks to mainly urban areas

Motor Truck Transcontinental

Five Teamster members complete the first transcontinental delivery by motor truck. It takes them 90 days to travel from Philadelphia to San Francisco.



1910

1913

1908

1912

1914

Coal to Oil Shipping

USS Paulding, first oil-burning American destroyer commissioned



American Express Motor Trucks

American Express begins to use the new vehicles.



The Diesel fuel and

Marine Diesel Engine

The two-stroke marine engine introduced

Diesels

Market

1914

1922

Kaufman Act

1923 Kaufman Act banned steam locomotives from New York City because of severe pollution problems.

Diesel locomotives were permitted as an acceptable alternative to steam power.

Truck dieselization

The first truck with pre-chambered combustion engine made by MAN and Daimler-Benz

Daimler-Motoren-Gesellschaft first air-injection diesel engine

1924: Fairbanks-Morse started manufacturing diesel engines.

America's roads

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les per hour
mit the use of
ban areas

The advantages of diesel were readily apparent. Diesel fuel improved fuel economy by more than 20 percent, and it was less expensive and safer than gasoline.

http://www.maxxforce.com/Home/Company_Heritage

Marine Diesel Engine

The two-stroke marine diesel engine introduced

Dieselization of Ships begins

Market share of steam ships peaks

Containerized cargo shipped

Malcom McLean, a trucking magnate, loaded trailers onto a ship and sent them by sea for less than the cost of trucking them overland. He was credited with shipping the first load of containers (truck trailers) aboard a cargo ship, from New Jersey to Texas.



1923

1930-1950

1950-1964

1959

1922

1925

1956

Kaufman Electrification Act

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Freight Dieselization "Complete"

1950: Diesel ships hold over 50% of market

1955: Railroads in North America had retired 90% of their steam locomotives

1954-1964: Total U.S. factory sales of diesel-equipped trucks jumped from 10,000 to nearly 65,000 units

Trucks

Truck dieselization begins

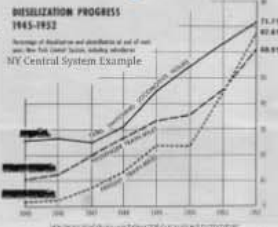
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Daimler-Motoren-Gesellschaft testing the first air-injection diesel-engined truck.

1924: Fairbanks-Morse starts building diesel engines.

Dieselization of Rail

1930-1950: Replacement of steam locomotives with diesel engines



MV Methane Pioneer

Ship left the Calcasieu River on Louisiana Gulf Coast with world's first ocean cargo of LNG bound for UK

NOT LNG powered, she was a converted diesel powered liberty vessel



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com/Home/Company_Heritage

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1950-1964

1959

LNG Locomotive conversion



Although some identify rail electrification as the solution, there is need for a transitional fuel.

1991

Electrified Drayage Freight

For Immediate Release: June 12, 2013
 SCAQMD receives \$1.6 million to retrofit five heavy duty electric trucks using a Siemens pantograph system, in which an overhead wire transmits electric power to a vehicle.

The trucks will be used to demonstrate a zero emission goods movement system connecting local shipping ports for use on Alameda Street in the city of Carson (Los Angeles County) along the I-710 corridor.



2007

2013

Freight Dieselization "Complete"

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Dual Fuel Diesel Electric (DFDE) British Emerald launched

BP Shipping took delivery of the British Emerald, the world's largest LNG carrier and the first to run on a dual-fuel system



MV Methane Pioneer sails

Ship left the Calcasieu River on Louisiana Gulf Coast with world's first ocean cargo of LNG bound for UK

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LNG power: A history lesson

Is LNG the locomotive fuel of the future? Will it, over time, replace diesel, much like diesel supplanted steam during the 1940s and 1950s? Or will it be used in combination with diesel, deployed on specific runs where it makes the best logistical and economic sense? What about the safety concerns? The fueling infrastructure required?

<http://www.railwirepage.com/index.php?blog=william-vantonaonlng-power-a-history-lesson.html>

The economic rate of return on an investment in LNG locomotives is highest on routes where locomotive utilization rates are highest and where they burn the most fuel.

Rail



Path resistance will depend in part on these factors

Vehicle design and performance

Protected niche mode(s) ... Users

Operation and management

Infrastructure

Environmental targets

Technology production scale



Farrell, Keith, Corbett, Energy Policy, 2003

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Let's explore from different angles



Innovation

Regulation

Adaptation

Why Invest in Innovation?

Why Invest in Innovation?

Why Invest in Innovation?

Guiding Hand

Invisible Hand

Firm Hand

Adaptation: a change in behavior or structure due to an outside stimulus that adds a benefit from repeated harmful stimuli

Antifragile adaptation: a change in behavior or structure that adds a benefit from repeated harmful stimuli

Adaptation Example: business changes fuel mix without policy or technology innovation

Almost entirely one year ago - Jun 25, 2012

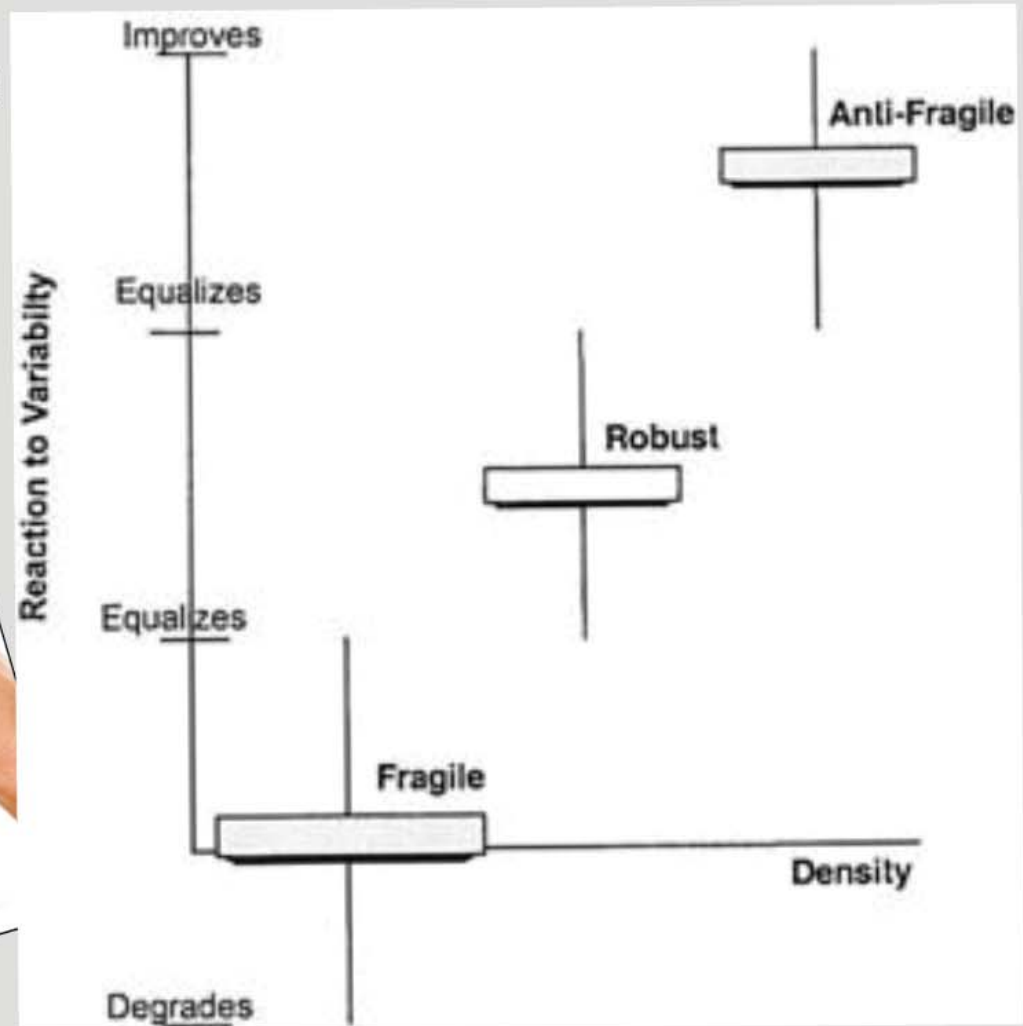
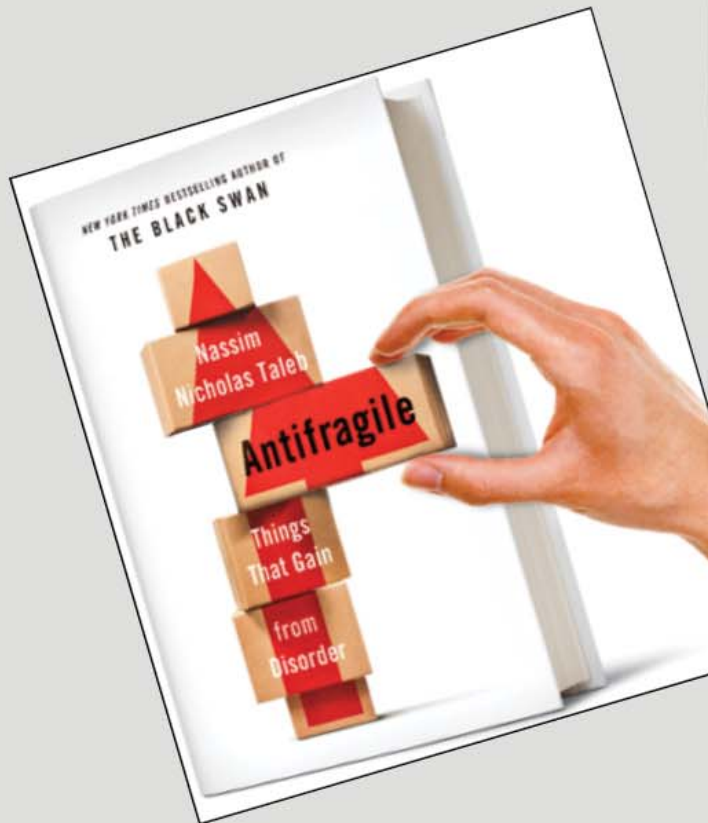
FedEx Corp. Chief Executive Fred Smith pondered fundamental changes in the global freight business, with air carriers being more putting more focus on providing clients with customized, door-to-door delivery options.

FedEx International Economy®

Learn more about FedEx International Economy® at www.fedex.com/international

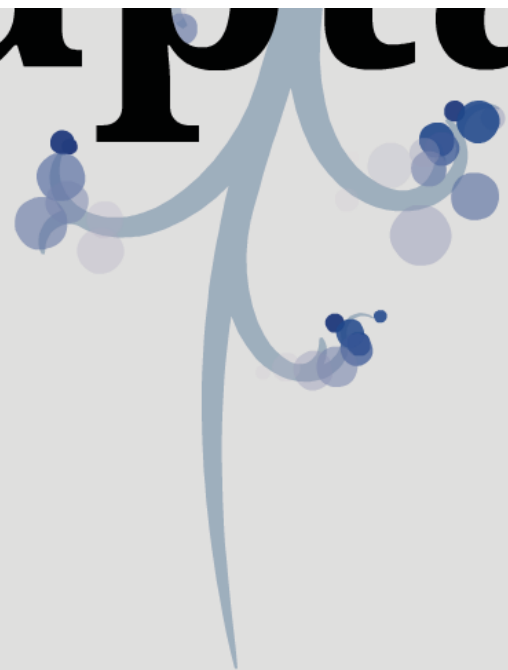
Concept of Antifragile

Nassim Nicholas Taleb

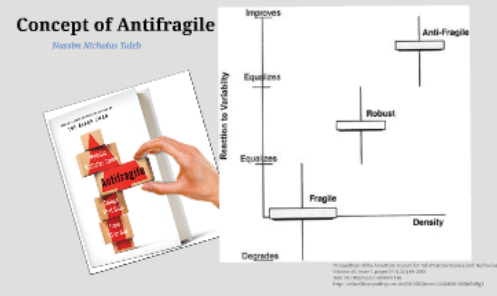


Proceedings of the American Society for Information Science and Technology
Volume 49, Issue 1, pages 1-10, 24 JAN 2013
DOI: 10.1002/meet.14504901168
<http://onlinelibrary.wiley.com/doi/10.1002/meet.14504901168/full#fig1>

Adaptation



Adaptation: *The process by which an organism, group of organisms, or system (herein the "unit") alters itself or is altered in order to retain the essential functions of the unit when the parameters in which the unit operates are changed.*
e.g., Changes in migratory behavior in response to shifting prey distribution; ecosystem regeneration, new growth, and recruitment after a forest fire.



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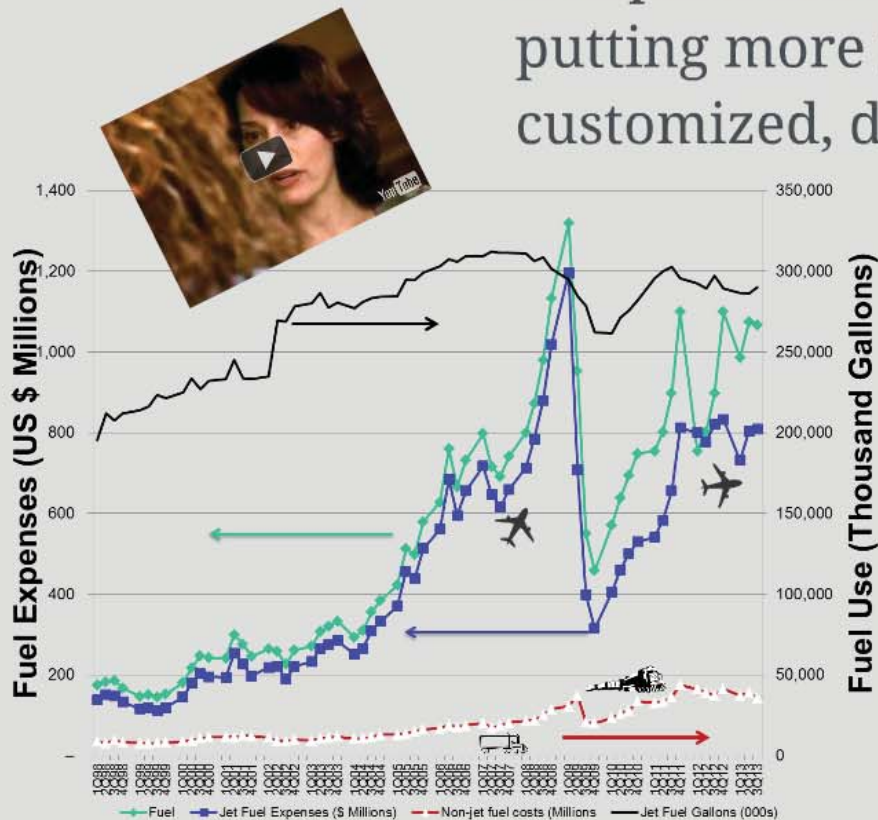
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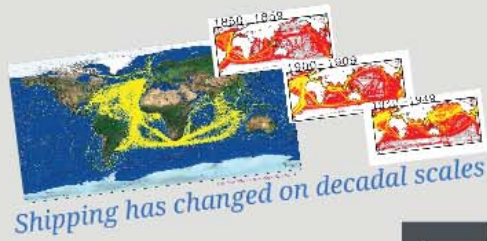
<http://online.wsj.com/article/SB10001424052702303703004577476241416089720.html>

FedEx International Economy®

*"... door-to-door, customs-cleared, time-definite delivery ...
...an economical alternative for less urgent shipments ...
characterized by the same quality, service and reliability*

Tested late 2007; intra-Asia service 2008; Introduced in Brazil in October 2009

<http://www.fedex.com/cg/about/company-info/history.html>



Shipping has changed on decadal scales

When Freight led the Transportation Transformation



Enabled by Rail Expansion
During this time, the number of teamsters doubled, while number of carters declined

Name the transportation mode:

Horse

- Remote Source to City
- Local Markets
- Commodifying Wastes
- Commodifying Salvage
- Sector as Consumer
- Regulation
- Labor and "Machine"
- "Mobility revolution"
- New Transport Technologies
- Public Transportation
- Combining Distance and Regularity
- Reduce fares and rates by utilizing prime movers

3 Ship Innovations Last Century

Marine diesel
~1947-1960

Oil saved ~78% in fuel costs, gained ~30% in cargo space, and reduced crews
Marine diesel engines are fuel-efficient combustion systems; this efficiency has been derived to economic performance more than to environmental performance to date.

Coal-fired steam



Oil-fired Steam
~1911

The efficiency of a steamship consists not so much in her cargo as in the power she carries within herself. The taking of a modern steamship has not the world (though one would not minimize its responsibilities) has not the same quality of intimacy with nature.

Containers
~1956-1975

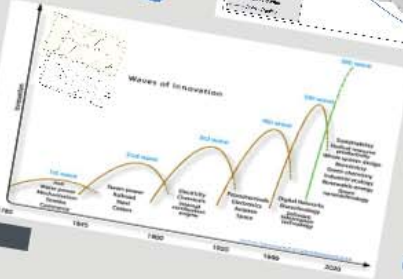


In April 1956, a refitted oil tanker carried fifty-eight shipping containers from Newark to Houston. From that modest beginning, container shipping developed into a huge industry that made the boom in global trade possible.
... No engine, No wheels, No sails

Why Innovate Again?

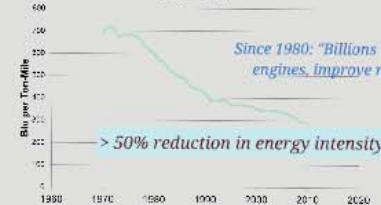


- Infrastructure
- Fuels
- Technologies
- Operations
- Logistics
- Demand



- Projected growth in Freight
- Higher Energy prices for transport
- Health concerns regarding diesels
- Climate change mitigation/adaptation

Energy Intensities Class I freight railroad: 1970-2010



Since 1980: "Billions were spent to purchase better fuel efficient engines, improve rail lines, and maximize the efficiencies."

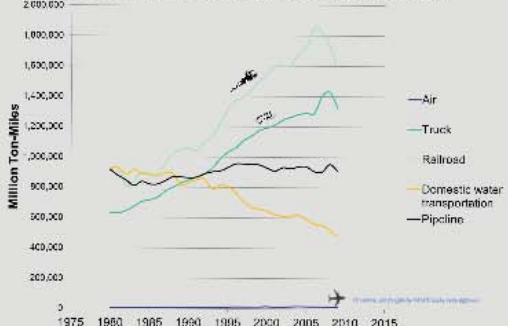
Why Warren Buffett Believes Trains Will Power the Recovery

... by Mary Buffett http://www.huffingtonpost.com/mary-buffett/warren-buffett-trains_b_2952284.html

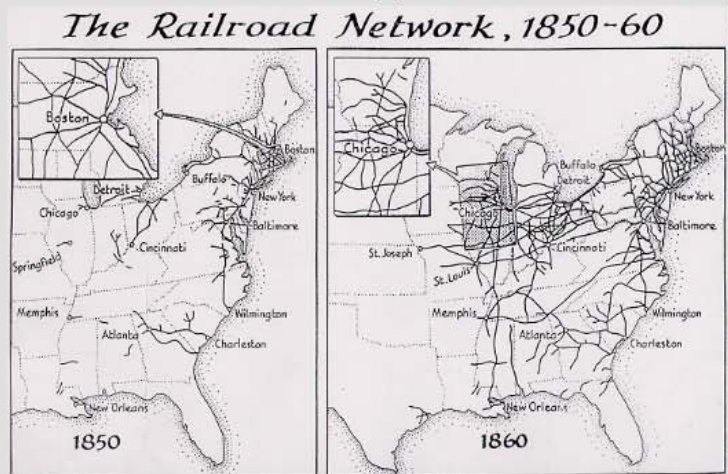
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U.S. Domestic Freight Ton-Miles by Mode: 1980-2009



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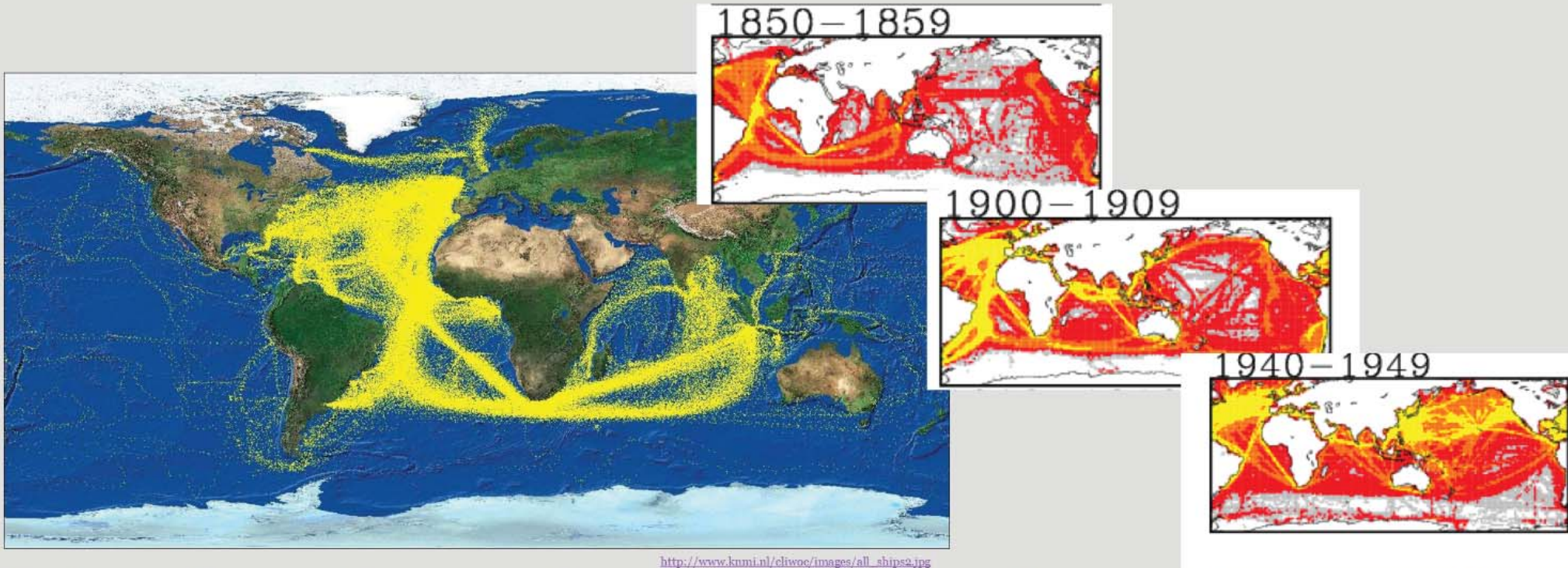
Horse

Markets and Other Influences

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- Local Markets
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- Commodifying Salvage
- Sector as Consumer
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- Labor and “Machine”

Powering Urban Transit

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- New Transport Technologies
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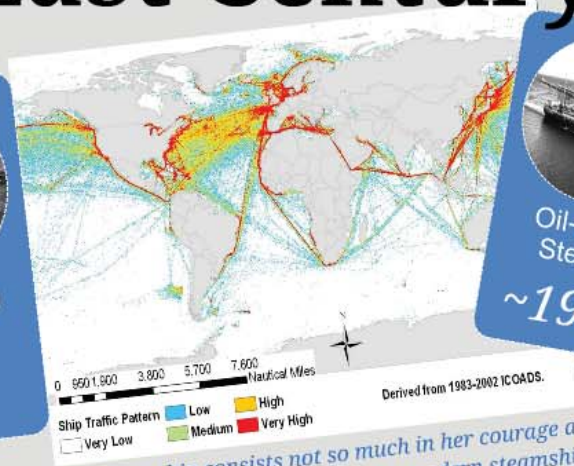
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Joseph Conrad 1904-06: <http://www.gutenberg.org/dirs/etext97/tmots10h.htm>



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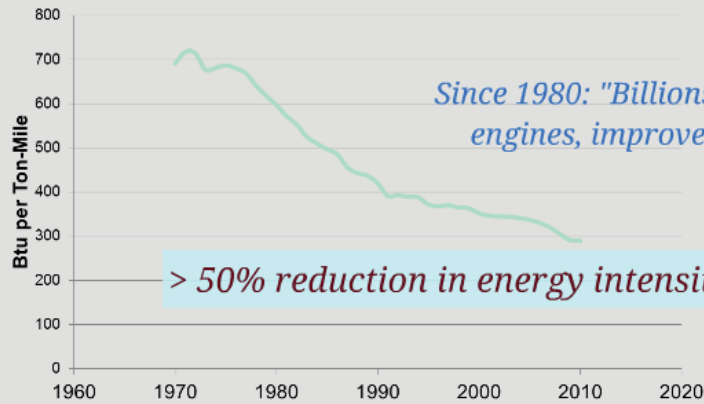
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Marc Levinson, The Box, 2006

Energy Intensities Class I freight
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1970-2010

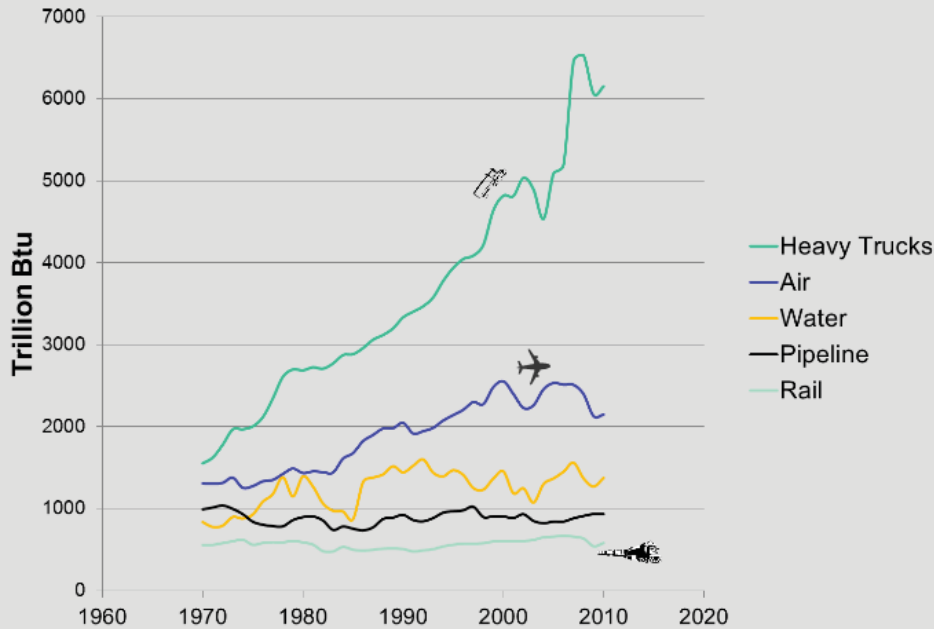
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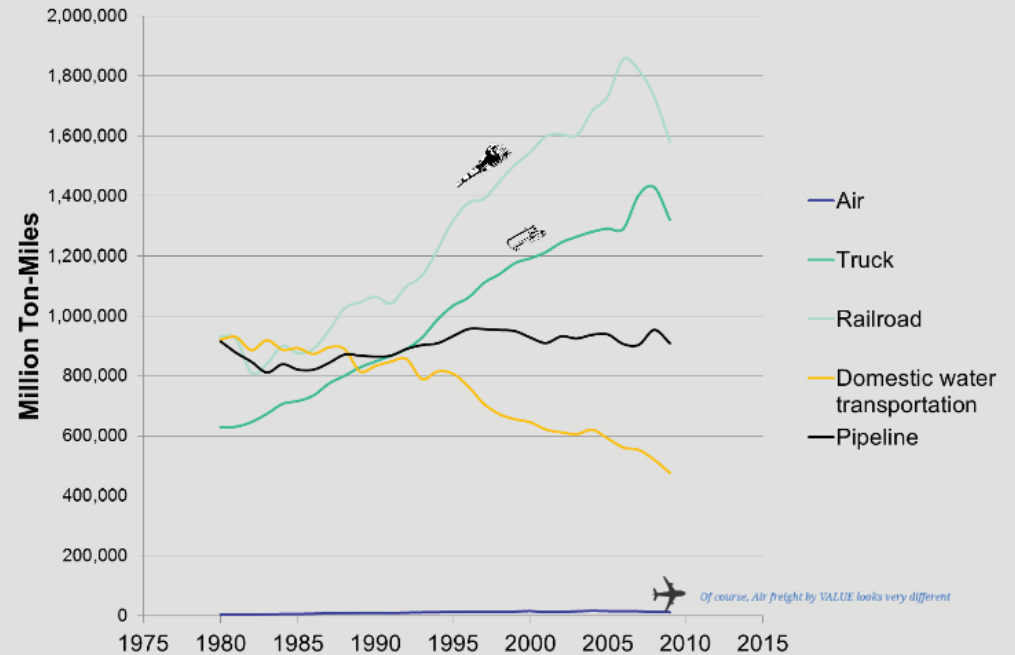
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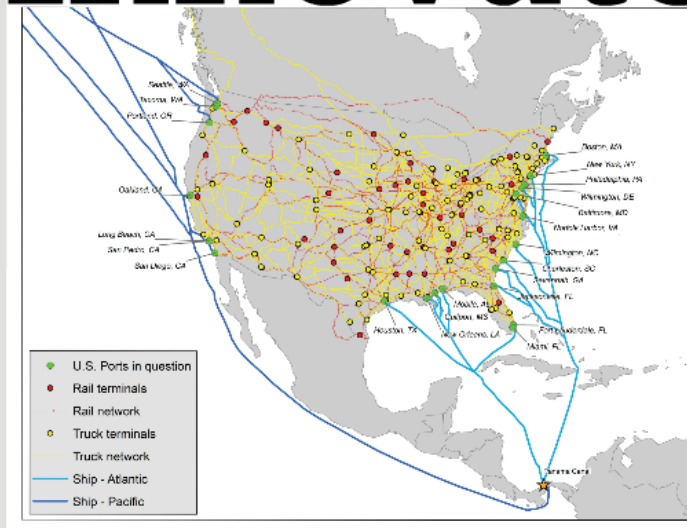
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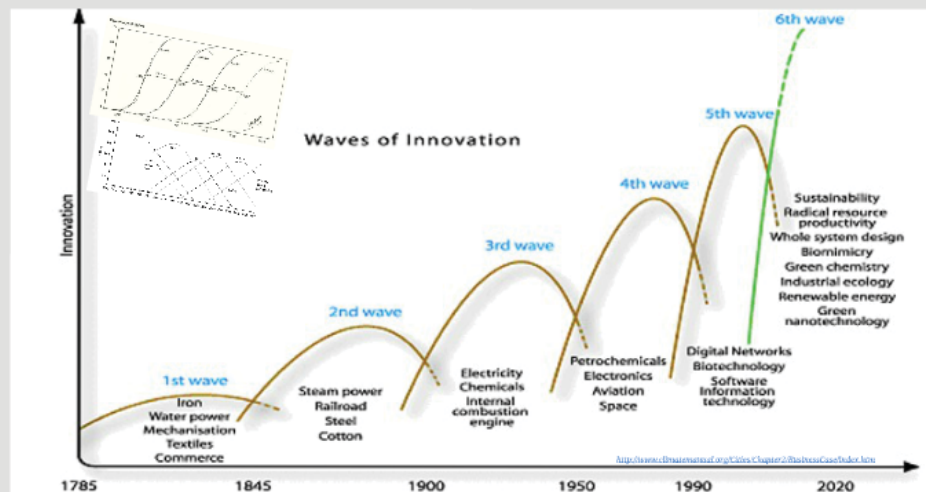
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Climate change mitigation/adaptation

Invisible Hand

Guiding Hand

Firm Hand

Public-Private Partnership to Deploy Hydrogen Infrastructure in the U.S.

Policy Options may be part of the difference

Policy Options	Intermodalism					
	I	F	T	O	L	D
Efficiency standards	•	•			•	
Taxes	•	•	•	•	•	•
Subsidies	•	•	•			
Technology mandates		•	•			
Infrastructure investment	•					•
R&D investment		•	•			
Alternative/LC fuels		•	•			
Size/weight restrictions	•			•	•	
Demand management						•
Information/education	•	•	•	•	•	•



Require LCFS



Access to alternative transportation fuel stations varies across the lower 48 states



Public-private Partnership to Deploy Hydrogen Infrastructure in the U.S.

Invisible Hand

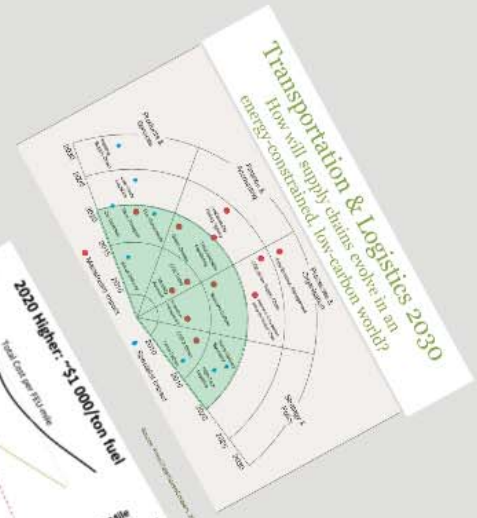
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Demand management	•	•	•	•	•
Information/education	•	•	•	•	•

Guiding Hand

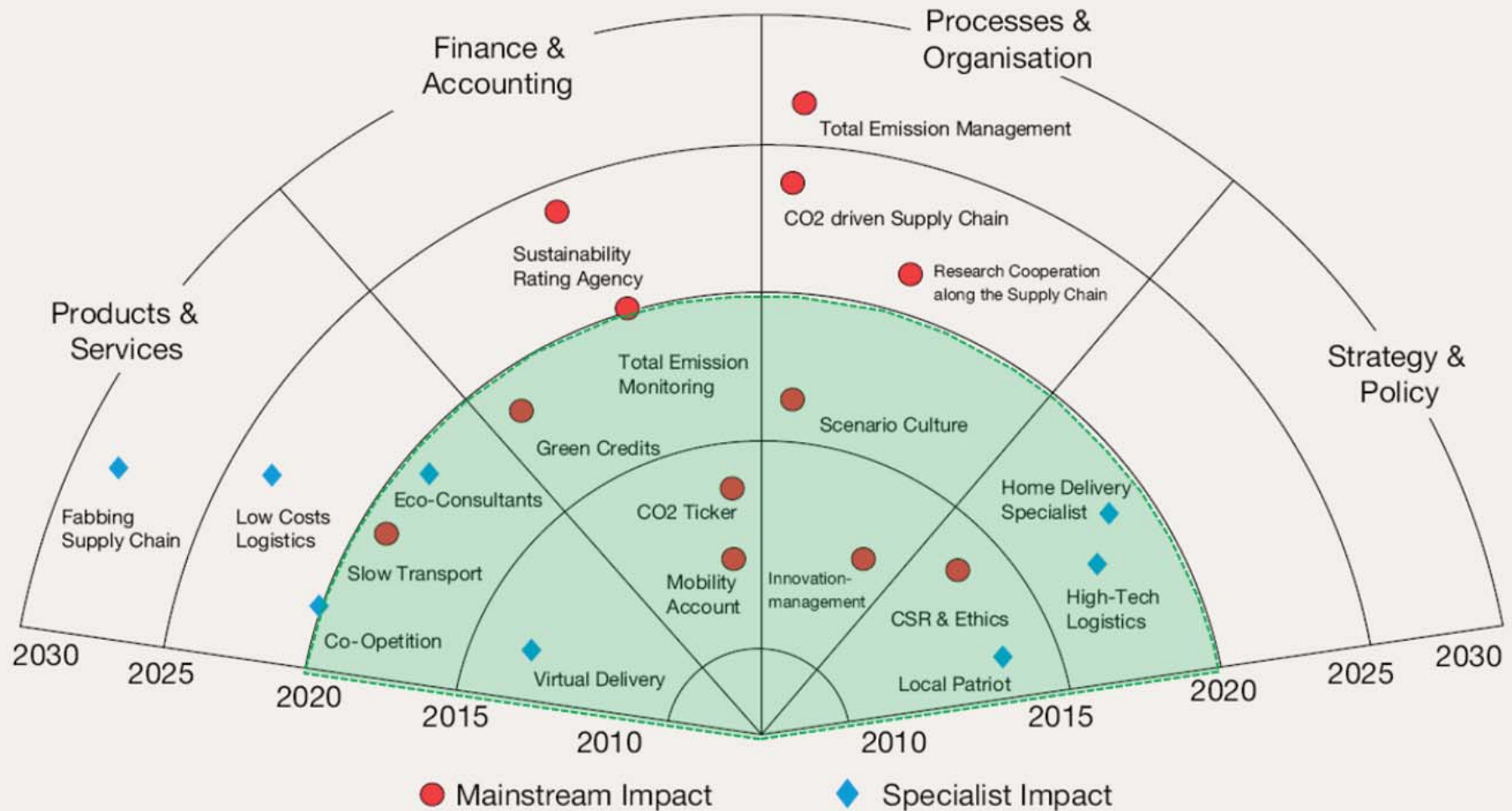
Firm Hand

- Require LCFS
- Promote renewables
- Incentivize alternatives
- Limit access to resources
- Prioritize other resources
- Refresh infrastructure
- Redesign infrastructure



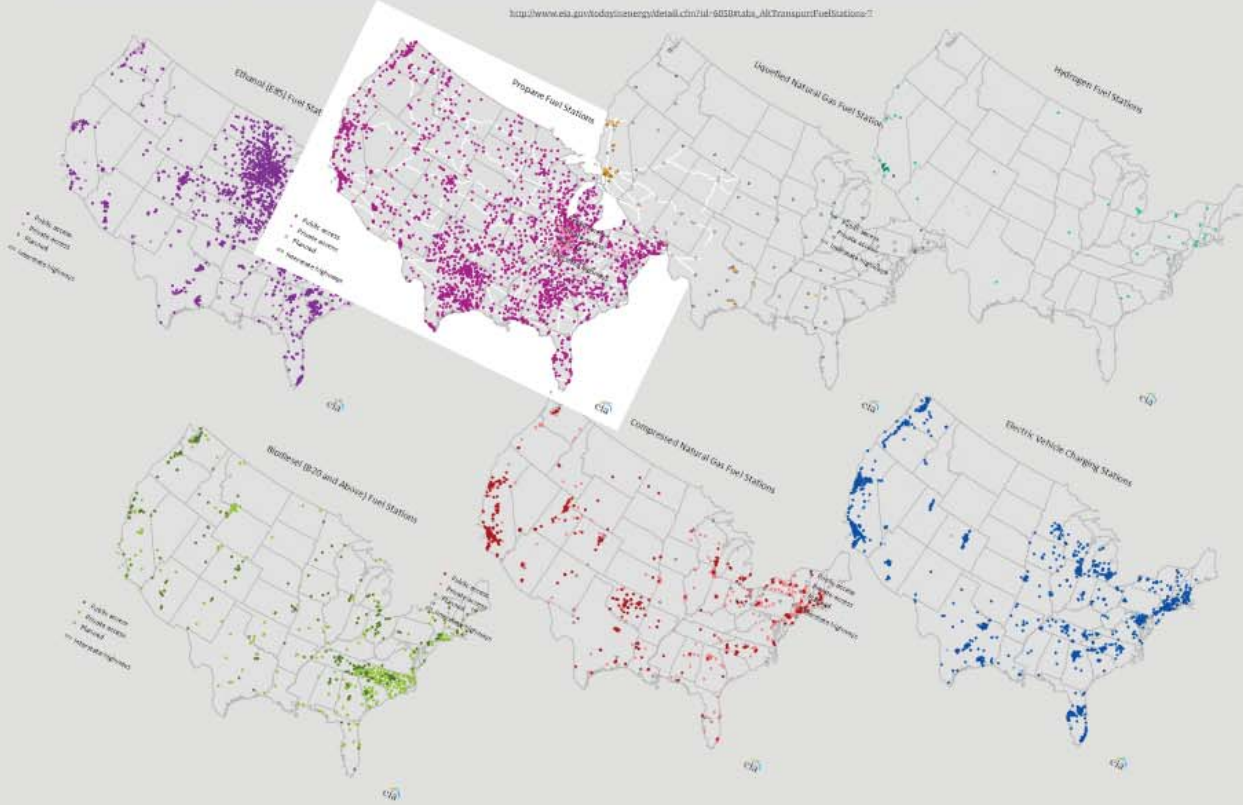
Transportation & Logistics 2030

How will supply chains evolve in an energy-constrained, low-carbon world?



Access to alternative transportation fuel stations varies across the lower 48 states

http://www.eia.gov/todayinenergy/detail.cfm?id=9038#tab_AltTransportFuelLocations?



Public-Private Partnership to Deploy Hydrogen Infrastructure in the U.S.

Invisible Hand

Energy: a crosscutting dimension...
fuel technologies
operational logistics
demand

- Key
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- Reconsider single-mode routes
- Backhaul networks
- Sustainability performance
 - Example: Human Health

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infrastructure

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Energy: a crosscutting dimension...

Better Goods Movement

- Rebalance frequency of delivery
- Improve transparency
- Reconsider single-mode routes
- Backhaul networks
- Sustainability performance
 - Example: Human Health

*Wanted to do something on freight; knew it was important.
Had a little money left over; not a lot of time and not a lot of money.*

**My curiosity is this:
Will transportation energy ideas
be agents of change, or responses to change?**

"I get up every morning determined to both change the world and to have one hell of a good time. Sometimes, this makes planning the day difficult."

E. B. White

*Thank you...
discussion welcome*

James J. Corbett
College of Earth, Ocean, and
Environment
University of Delaware
jcorbett@udel.edu