Profitable GHG Reduction Through Fuel Economy:

Off-the-shelf technologies that bring savings to your bottom line

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Overview:

- Background on RMI
- Global Warming – What does it mean for trucks?
- Energy Efficiency – Where is energy used on trucks?
- New Concept - "Tunneling through the cost barrier"
- Components That Count – energy saving truck products
- Hybrids – What's coming
- Fleet Examples – On-road proof of fuel savings
- RMI Projects: – Trailers, containers, and more

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80 staff, two offices: Snowmass CO & Boulder CO

Entrepreneurial nonprofit; energy efficiency & policy

Energy & Resources Team, Built Environment Team, MOVE (Transportation) Team

3 Examples from RMI's 3 teams:

- Redesigned a giant platinum mine, 43% energy savings, 2–3 year payback periods
- Redesigned a supermarket, saving 70–90%, better sales, lower capital expense
- Helped Wal-Mart redesign their Class-8 truck fleet, **Saved 25%** of diesel fuel on long-haul operations, Plan in place to double fuel economy by 2015 Net savings of **~$494 million a year by 2020**

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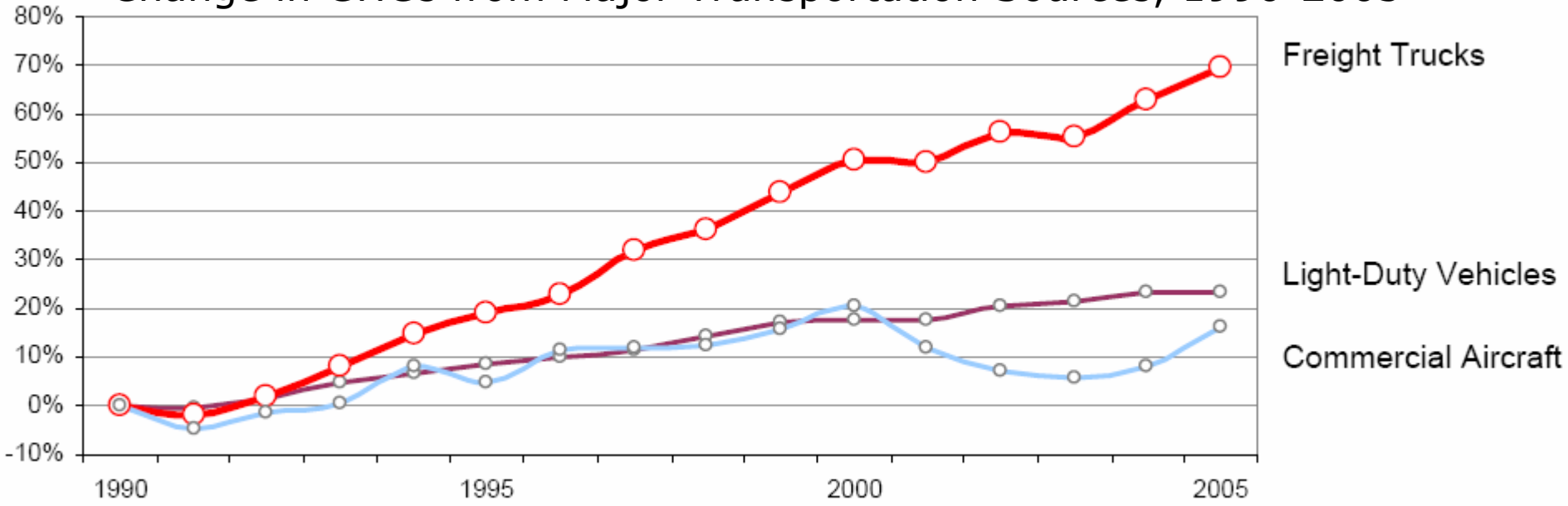
Global Warming: what does it mean for trucks?

Transportation is 27% of US GHG emissions,

Trucking is 19.4% of US Transportation GHG emissions,

US Truck GHG emissions grew 69% between 1990 and 2005

Change in GHGs from Major Transportation Sources, 1990-2005



Source: EPA Inventory of U.S. Sources and Sinks: 1990-2005

Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005

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Global Warming: what does it mean for trucks?

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- **Attention is inevitable**
- **CO_2 reduction can be a marketing benefit.**
- **If a "carbon market" emerges, saving 1 ton of carbon will be worth ~$10**

Smart trucking companies can financially benefit from new emphasis placed on global warming

Marketing Benefits Can Be Significant

- **Growing Interest:**

70% of fleet managers have been asked what they're doing about the environment in the past year

- **Carbon Labeling & Accounting:**

Many companies moving to environmental scorecards and claims that rely on full-life cycle analysis, and green supply chain demands, which includes transport by truck

Knowing how to reduce your "carbon footprint" can help marketing

Source: fleet-central.com ; RMI clients and recent experience.

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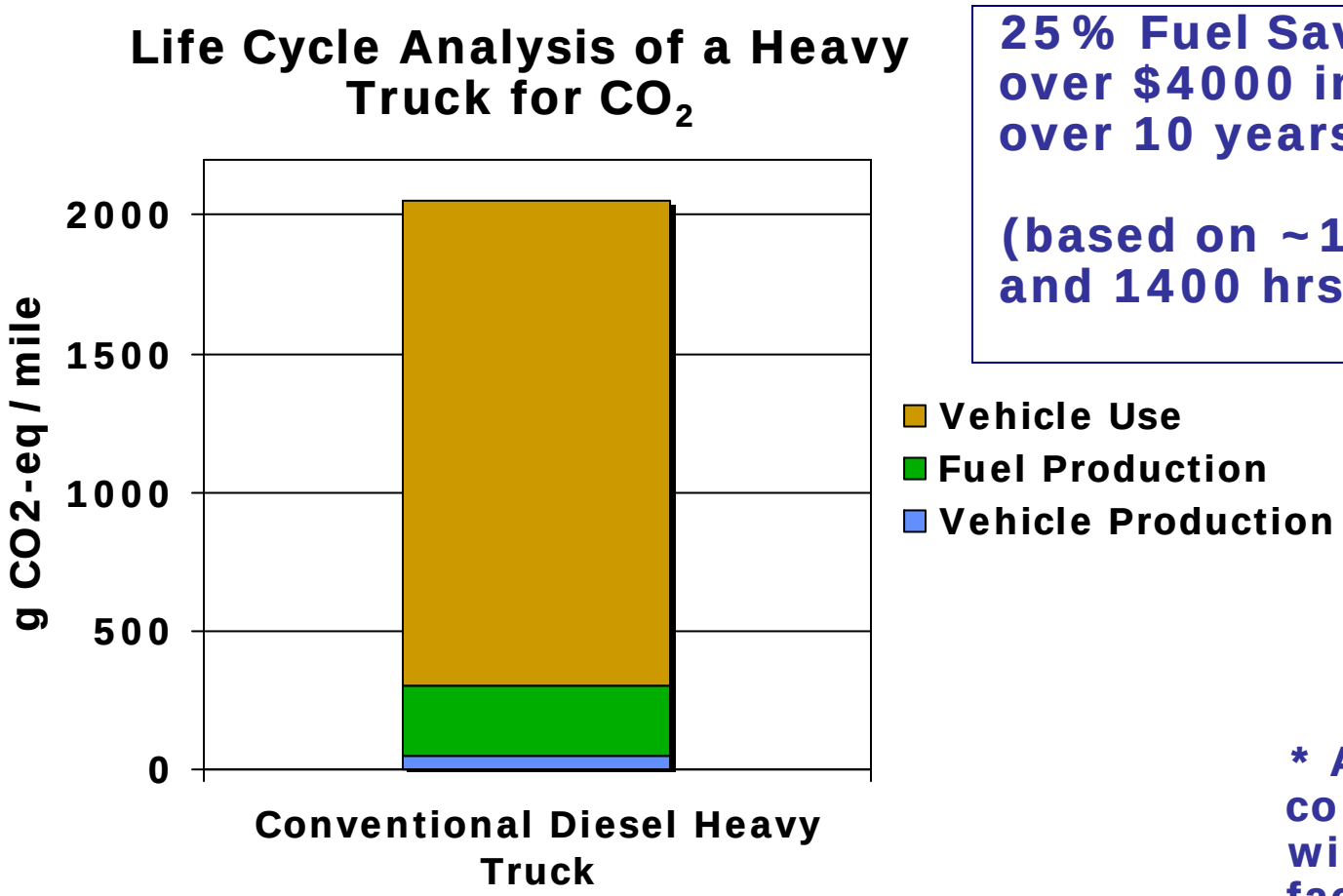
The Carbon Footprint of a Heavy Truck is Dominated by Fuel Use



25% Fuel Savings may yield over $4000 in carbon credits over 10 years.

(based on ~100,000 mi/y and 1400 hrs/y less idling)

*** A trucking company's footprint will also include facilities, offices, etc.**

Source: Gaines et al. (Argonne Nat'l Labs). 1998. "Lifecycle Analysis For Heavy Vehicles." Air and Waste Management Association Annual Meeting. San Diego,

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Bottom Line: global warming can be a business advantage

Old Model: Cost vs. Benefit, Tradeoff

The trucking industry is undergoing one of the heaviest environmental regulatory pushes in history ('07 and '10 emissions reductions of NOx, SOx, and particulates).

Benefit: Cleaner Air (societal benefit)
Cost: Capital Investment, Increased Fuel Use (industry cost)

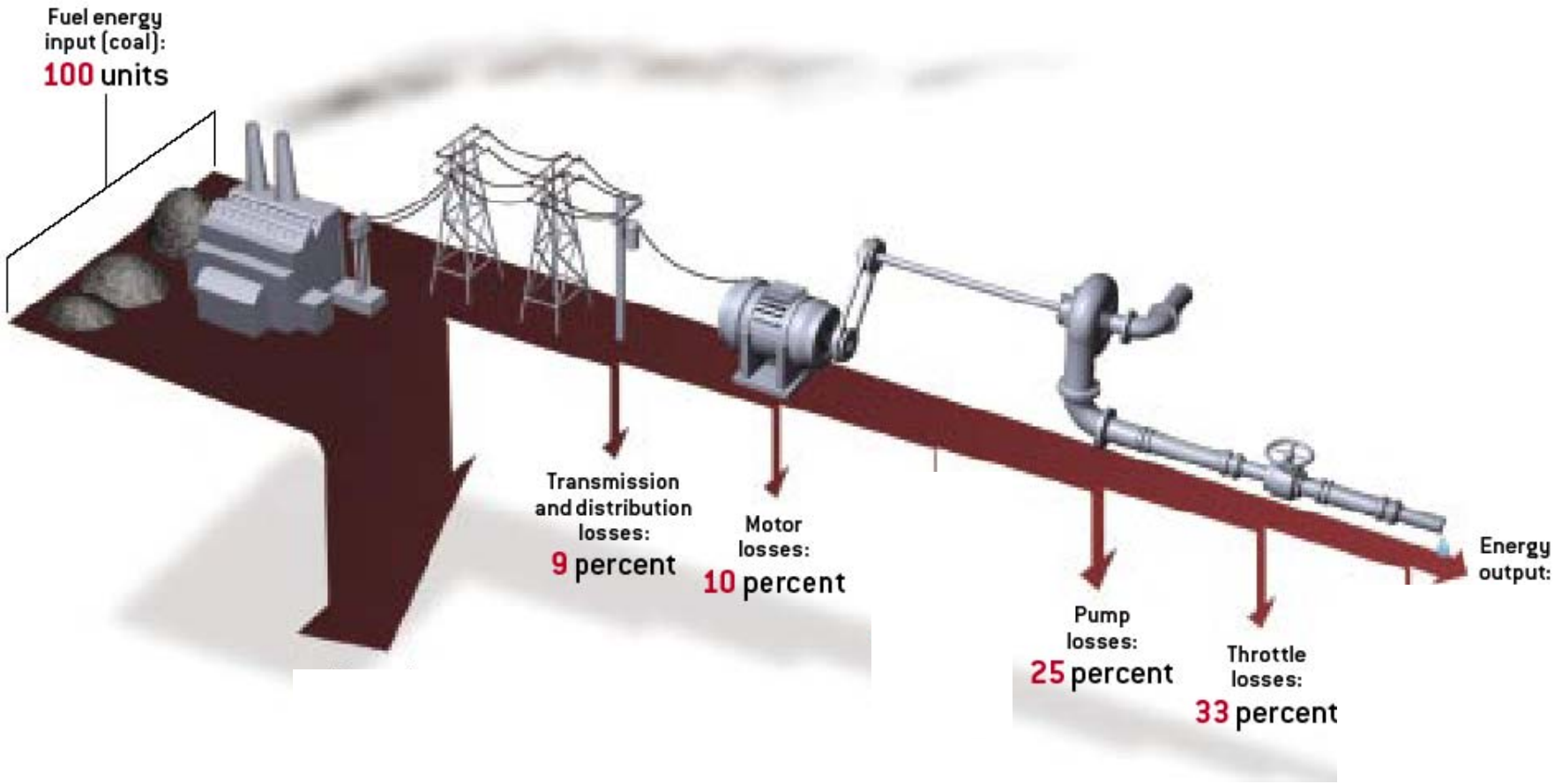
New Model: Dual Benefit, Win-Win

Reducing greenhouse gas emissions can be equally well met, with financial benefit for leaders.

Benefit: Reduced GHG emissions (societal benefit)
Benefit: Lower Lifecycle Operational Costs (industry ***benefit***)

Losses & savings multiply

Savings *downstream* make upstream equipment smaller and cheaper



Each unit of avoided energy flow or friction in the pipe saves ***ten*** units of fuel at the power plant

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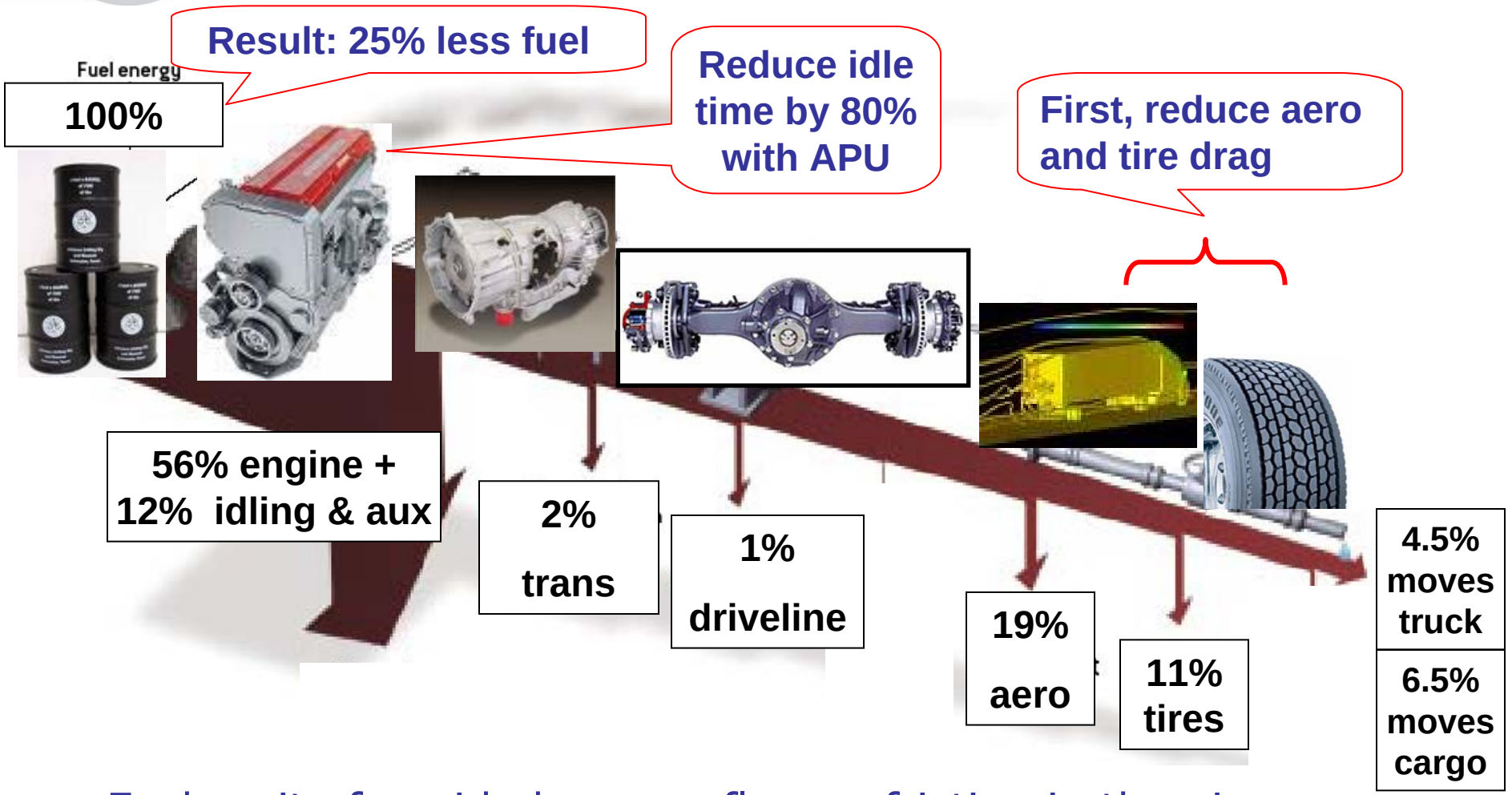

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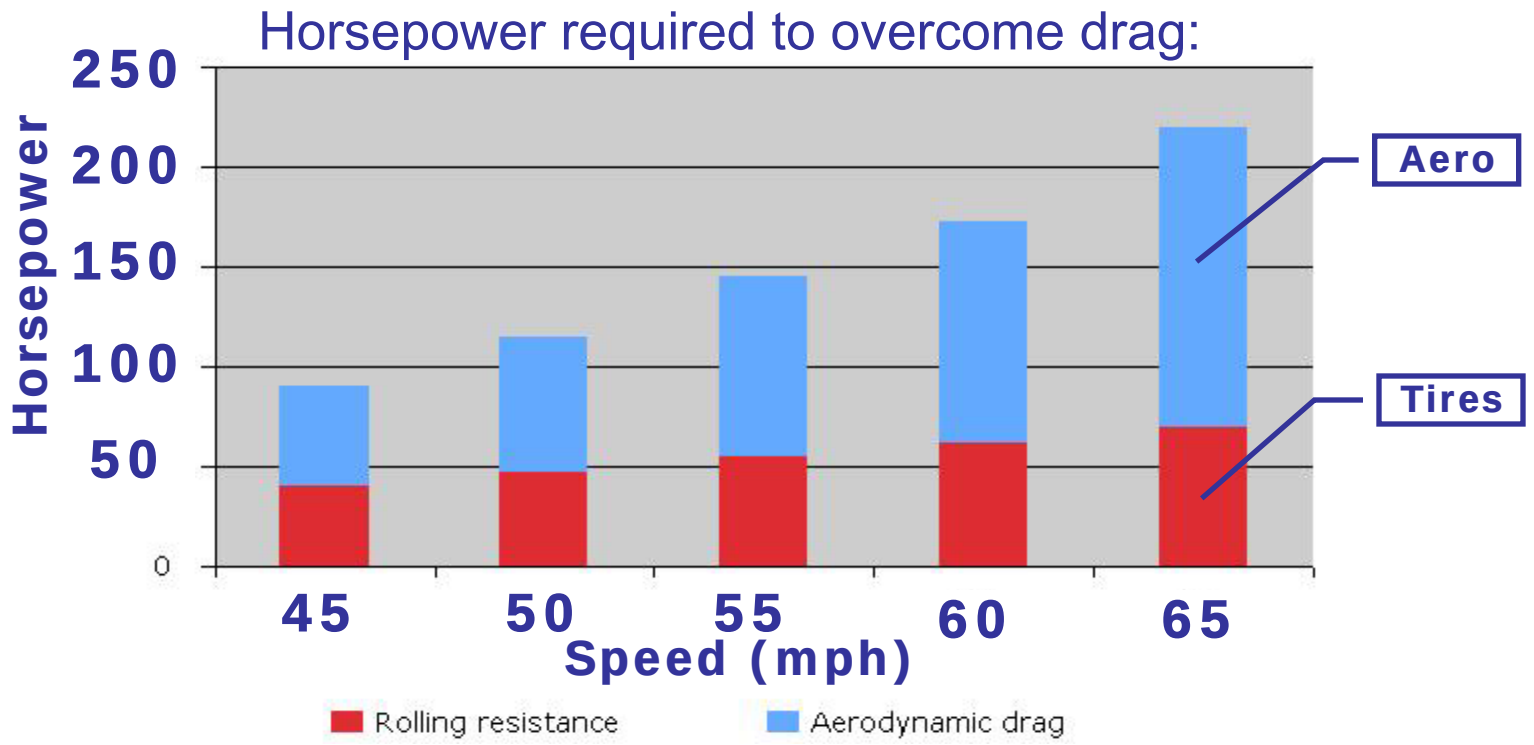
Basic physics:
Aerodynamics and Rolling Resistance are the largest consumers of fuel on a typical highway truck

Total Horsepower = Inertia + Rolling resistance + Air resistance



** Approximate values*

Source: Technology Roadmap for the 21st Century Truck Program (DOE 2000)

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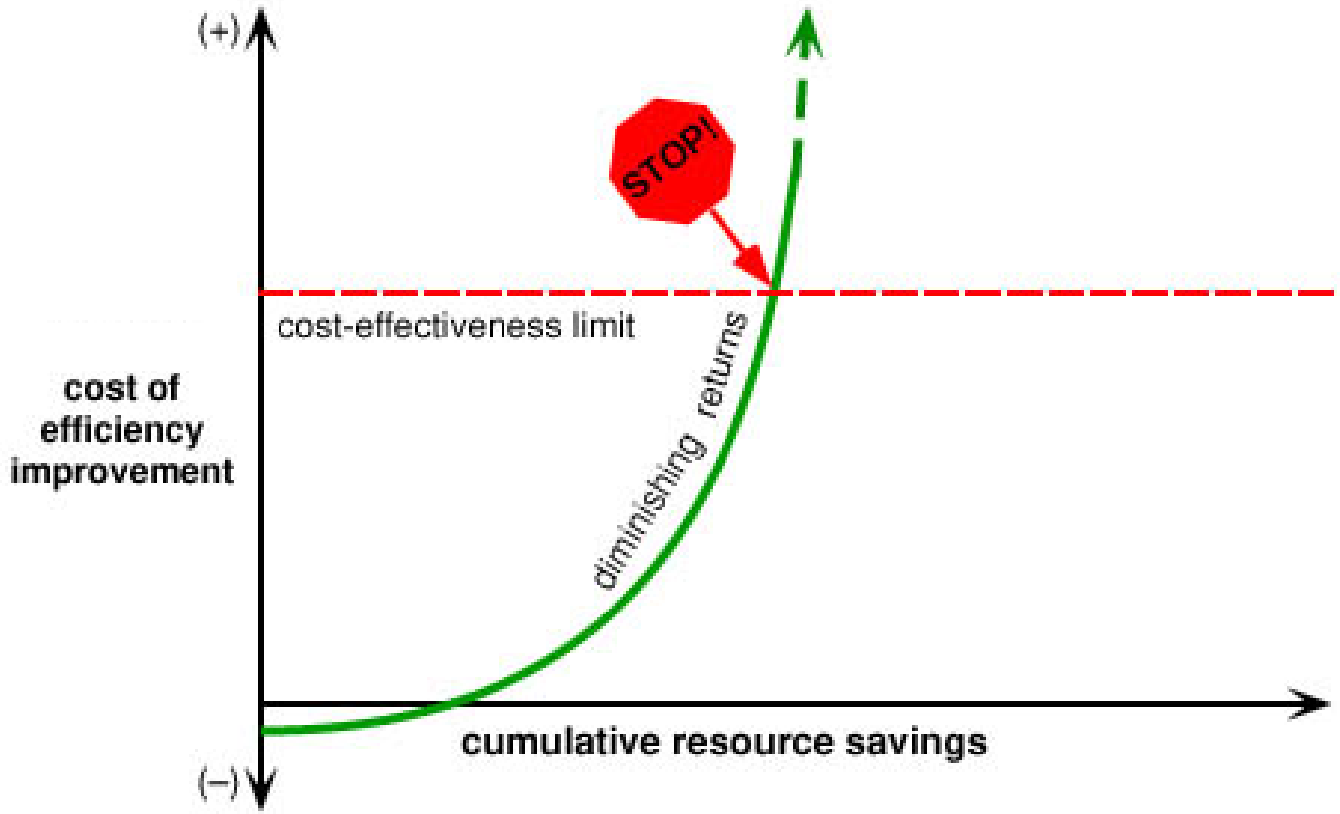
Old way:
Saving money costs money



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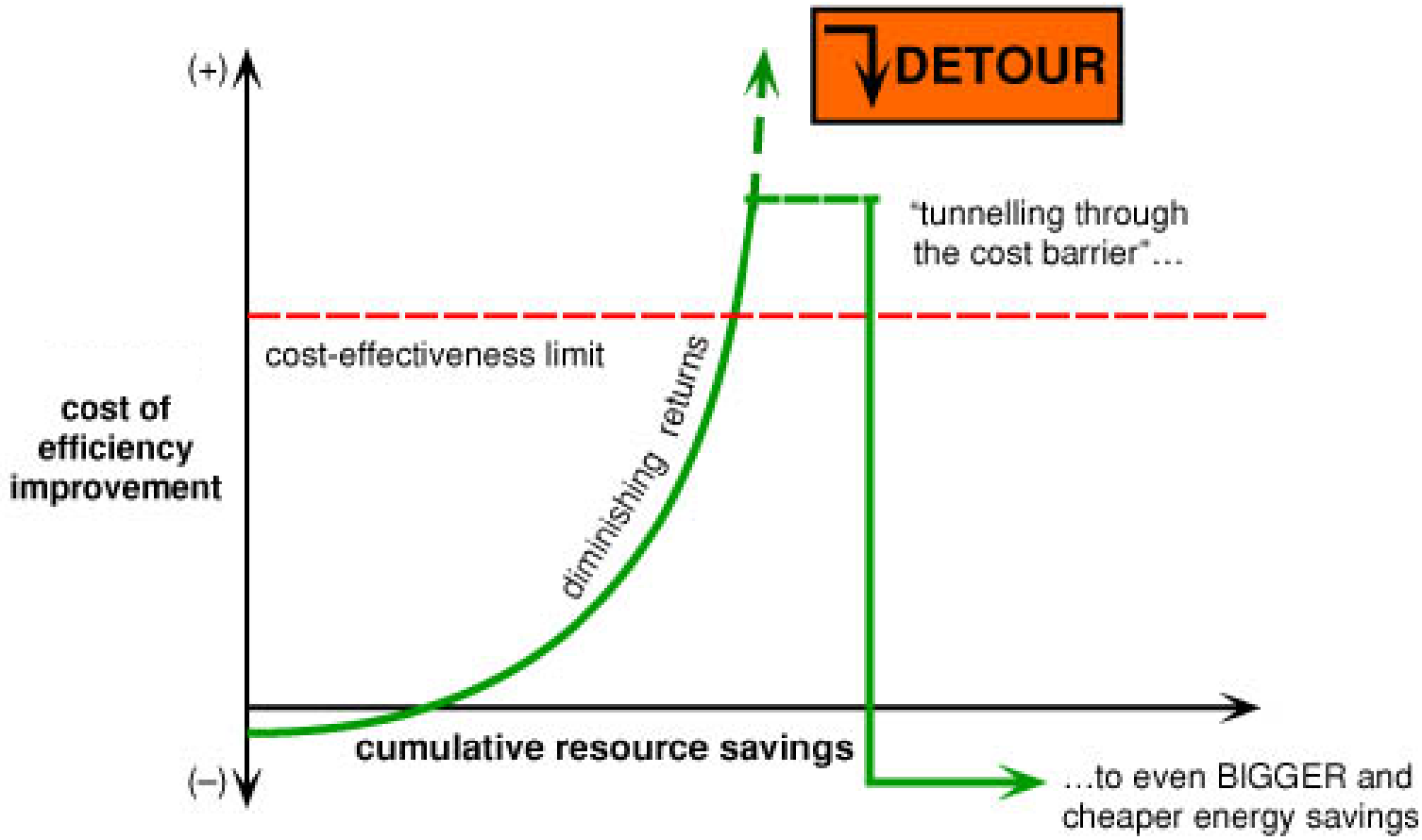
New Design Mentality
"tunnel through the cost barrier"



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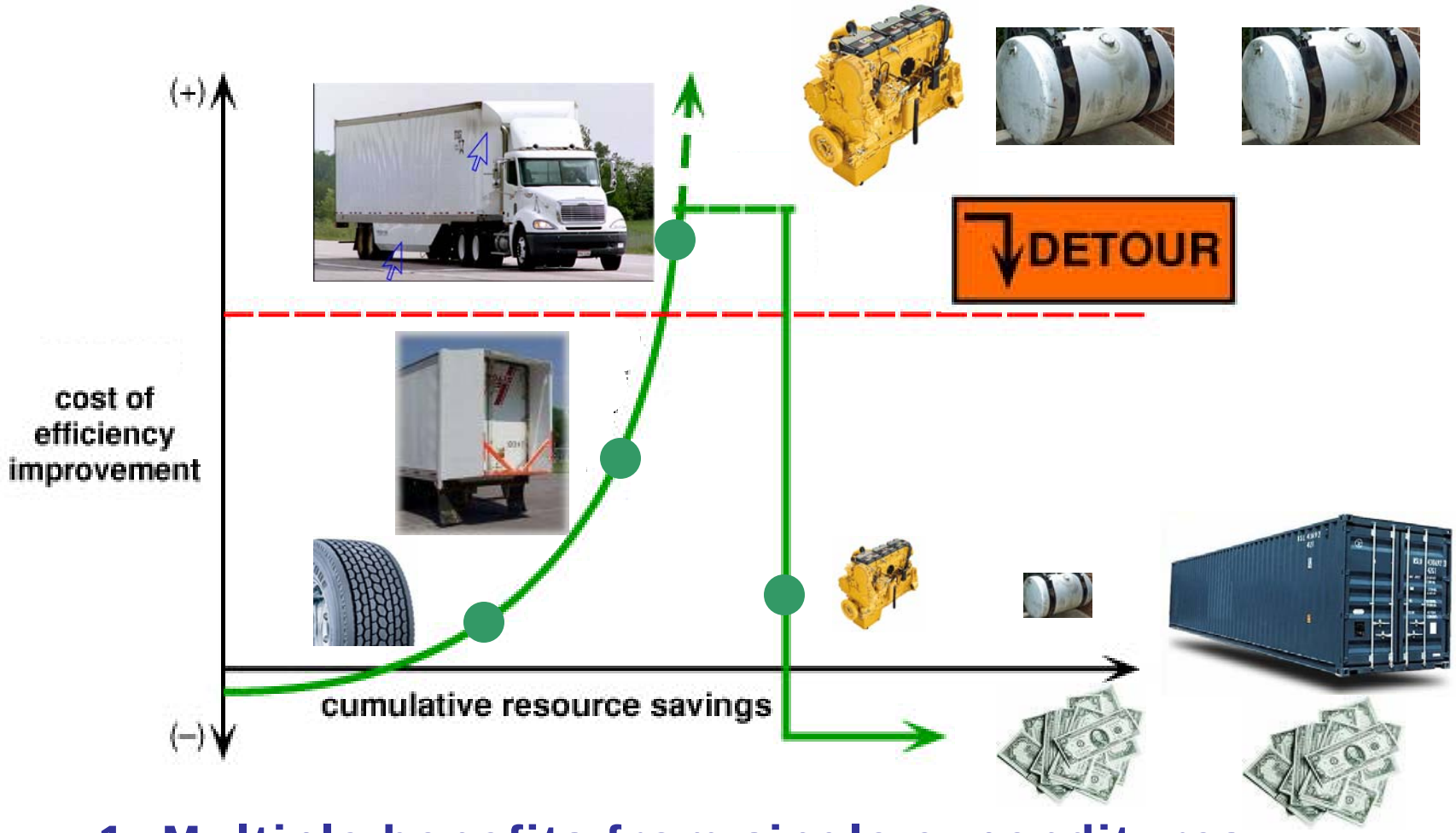

1. Multiple benefits from single expenditures
2. Piggyback on retrofits

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Components

Cut your fuel use 25% today

**If every truck in the US saved 1%,
245,000,000 gallons of diesel per year
would never be consumed**

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An easy change to make: Tires

4-8% fuel savings are possible with tires alone

Traditional twin-tires optimized for fuel economy save ~4% fuel

Don't buy on tread life alone. Long-wear tires cost you more fuel than $$ you save at purchase

"Single-Wide" or "Wide Base" tires save 4-6% fuel + save 200lbs/axle: extra cargo & less dead weight when empty

Bolt-on Savings: Aerodynamics

Better aero all around – truck, trailer, and interface

Side Skirts save 4%

Base Flaps save 6%

Combine these three devices for over 10% fuel savings on the trailer alone.

Gap Fairing, nose cones save ~2%

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Target the Multiple Areas to Make the Greatest Impact

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Use Advanced Diesel-Electric Refrigeration Units Wherever Possible

"Hybrid" = energy from either diesel or grid electricity

Diesel while driving, 440V plug while parked/loading

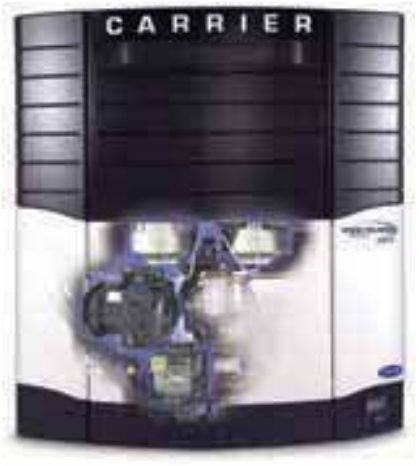
Benefits:

-Fewer moving parts (generator + electric compressor)
-Sealed compressor, reduced maintenance
-Lower fuel consumption (10% or more)
-Clean, cheap electricity when plugged in

Carrier

Vector 1800 MT

DELTEK™



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"Overnight" Savings: APUs

APU's can cut main engine idling by 80+%
Output: 12V, 110V, A/C, heat, even 150psi air
$3500 - $9000 to install & 80,400lb DOT limit
5 times lower fuel consumption than idling

	Main Engine	APU	*Amount Improved*
Gal/hr @ idle	1.0	0.2	*80%*
10 hr rest	10 gal	2 gal	*8 gal less*
1yr total:	3000 gal	600 gal	*2400 g/yr*

$6240/yr

Avg fleet sees ~8% overall fuel savings

Many APU Suppliers to Choose From:

1 or 2 cylinder, 2kW-8kW

Powers TV, Microwave,

Heats and cools cab

Charges start battery

Heats the engine

Reduces engine wear

Extends oil changes

Air for tires/brakes

*Some brands compatible with electrified truck stops

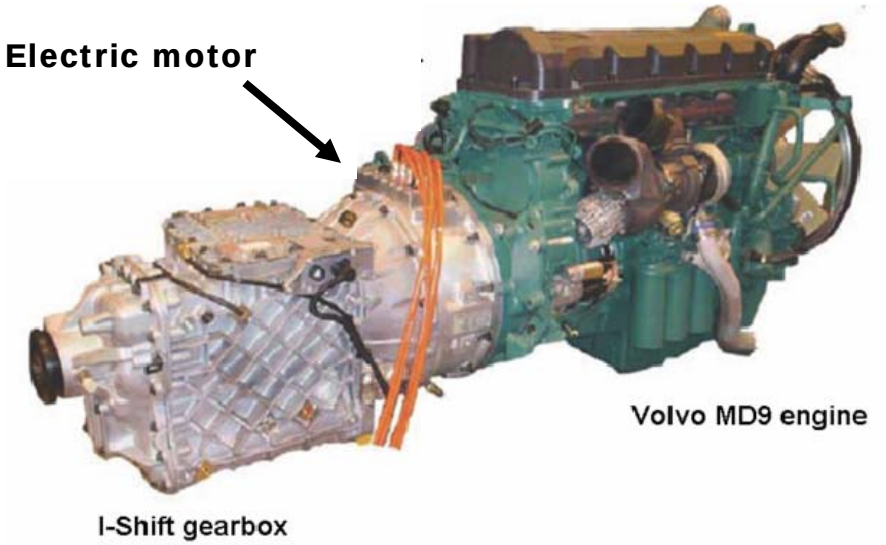
Some brands are electric only- no engine A/C + diesel fired heat w/deep cycle batteries!!

Hybrids: Just around the corner?

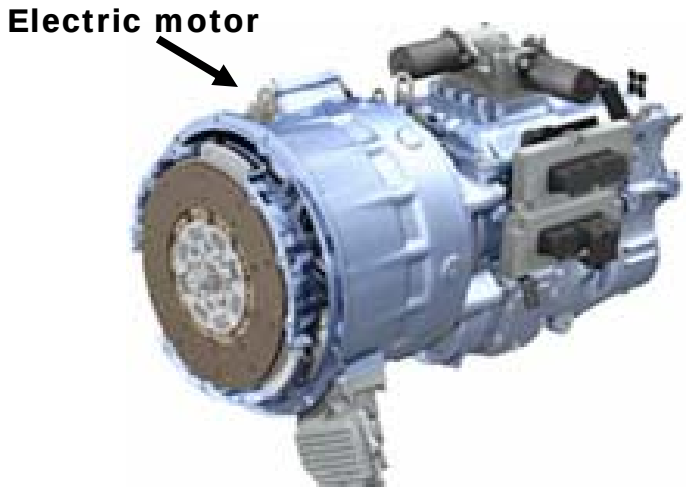
Fed-Ex: Testing 100 Hybrids w/EATON, 6000 lb payload
42-57% MPG gain, 98.6% up-time, 500,000 test miles

EATON study: 5-7% improvement in long-haul 80k GVW

Volvo I-SAM: 35% savings (advertised), 150hp "boost"



Volvo autoshift + I-SAM (120kWe)



EATON autoshift + Hybrid (44kWe)

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Fleet Examples

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Wal-Mart's Success: 25% in 2007

-Tractor (Sleeper)

-Wide Base Tires
-Tag axle (saves two differentials)
-Attention to weight
-APU
-Aero Package

Trailer (Dry Van)

-Wide Base Tires
-Side Skirts

If fuel economy doubles by 2015 as planned:

Net savings of ~$494 million a year by 2020

26 billion lbs CO_2 saved from now till 2020

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APU Conversion: Save fuel profitably on existing trucks

2006 Peterbilt 379

Purchased new by Jay Rohrer, owner operator
Caterpillar 625 hp, locking axles, sleeper, etc
First 30,000 mi ECM download showed:
4.2mpg overall* and 34% idle time
*(includes overnight idle and stoplights)

At 30,000 miles, Mr. Rohrer installed an APU on his truck through Cascade Sierra Solutions (EPA Smart Way partner)

No aero change, no tire change, same routes
ECM download at 60,000 mi showed:
5.5mpg overall and 15% idle time
$4400 saved in just 30,000 miles @ $2.60/gal
~10 month payback

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Contract Freighters Inc.: Tires alone saved $4,000,000/y

- 2400 Tractors operating in US + Mexico: Truckload
- Converted to Wide Base Tires through EPA Smart Way
- Saved over 200lb per axle
- Saved 0.2mpg w/ drive tires + 0.2mpg w/ trailer tires
- Yearly Saving: $4 mill ($1800/tractor) 360,000lbs CO_2

(Presented at the Clean Heavy Duty Vehicle Conference 2/15/07)

Less weight = more Potatoes

Logistics Management Inc, Route: Nebraska -> Colorado

Equipment spec'ed with extra attention to weight

Tractor

-Day cab, (brands vary by over 1000lbs)

-Single drive w/tag axle, wide base tires, single fuel tank

-350hp engine saves ~1000lb or more

-Automated manual – reduces driver variability

~6000lb eliminated

Trailer ***"Spud Lite"***

-Reefer trailer – heater only vs. 60,000BTU cool/heat

-Spread axle, wide base tires, aero: side skirts

~4000lb eliminated

Regulations – 5000lb for free

-85,000lb GVW permitted on secondary roads in NE/CO

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Less weight = more Potatoes

Logistics Management Inc, Route: Nebraska -> Colorado

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Less weight = more Potatoes

Logistics Management Inc, Route: Nebraska -> Colorado

Higher Profit

-15,000lb more freight per trip – 60,000lb per load

-70% of GVW is payload

-Better Potatoes – by accident!

-Low fan speed = less drying = happy customer

-Potatoes arrive fresher – higher quality product

Tunneling through the cost barrier:

Lower Capital Cost

-Operating 3 trucks instead of 4 ***saves an entire truck!***

-Lower lease/purchase cost – 350hp day cabs cost less

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How'd We Do It? Designing Backwards!

- *Conventional design: from fuel to wheels*
- ~3 units of fuel are used to deliver 1 unit of energy to the wheels ("compounding losses")
- 70% of fuel is wasted getting to the wheels, so focus on that area
- Incremental changes:
  –engine efficiency
  –driveline friction
  –accessories

- *Whole-System design: from wheels back to fuel*
- Radically cut the truck's mass and drag *first*
- Then re-match engine to smaller tractive loads
- Each unit of energy saved at the wheels saves ~3 units of fuel at the engine ("compounding savings")
- This makes doubled efficiency possible with conventional engines

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Double the Efficiency of Your Fleet:

Better aero & tires, better engines etc., less weight

6.2 mpg to 11.8 *equivalent* mpg

improved aero drag, tires, engines, hybrid, accessory loads, APU, + *lightweighting*

Double your profit margin, protect against future price shocks.

What's next? Tripled efficiency trucks led by business, for profit

PACCAR high-eff. concept truck

Colani/Spitzer tanker (Europe), reportedly 11.25 mpg

Hybrid Electrics,

Camless Engines,

Advanced Aero

RMI MOVE Projects:
Efficient Trailer Commercialization

Developing Breakthrough Products by Linking Customers and Manufacturers:

10-15% fuel savings through:

-Better Aerodynamics

-Low Rolling Resistance Tires

-Reduced Weight (more payload)

-Efficient Refrigeration: improved insulation w/diesel-electric cooling

Lower your fuel costs

Lower your carbon footprint

Strengthen your competitive edge

Contact:
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RMI MOVE Projects:
Zero Emissions Yard Truck

Fully electric yard truck for clean container transport

Led by RMI, this initiative is a partnership between major US seaports, terminals operators and truck component suppliers

Competitive business case:

-Reliable, low-maintenance electric propulsion system

-Breakthrough Lithium energy storage technology

-Proven rapid recharge capability

-Vehicle-to-grid energy technology

-Full payload capability

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RMI MOVE Projects: CONTAINERS

The world will put pressure on the freight system to reduce impact; a new container may be one solution.

Environmental and financial gain:

-Reduce tare weight to improve efficiency of ships, trucks, and trains that carry containers

-Novel technology/materials that facilitate security checks and improves logistics

-Improve transitions between modes of freight transport: save time and related money/fuel

RMI is looking for trucking companies/groups that have the experience and vision to help us change the freight system for financial and environmental gains.

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Lschewel@rmi.org
***project in research phase, leading to phases with IP opportunity for partners**

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RMI Projects: PHEV Initiative

a fast-to-market disruptive transportation solution

Mission: design and develop a highly efficient plug-in hybrid vehicle

Innovative business and technical approach:

- Focus on platform physics
- Industry consortium
- Thorough research of both market and customer
- Product strategy initiated through Innovation Workshop

85% lower petroleum consumption

23 million ton fleet CO2 reduction

Breakthrough product features

Cost-efficient business structure

Contact:
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The time is now…

"You are the people you have been waiting for."

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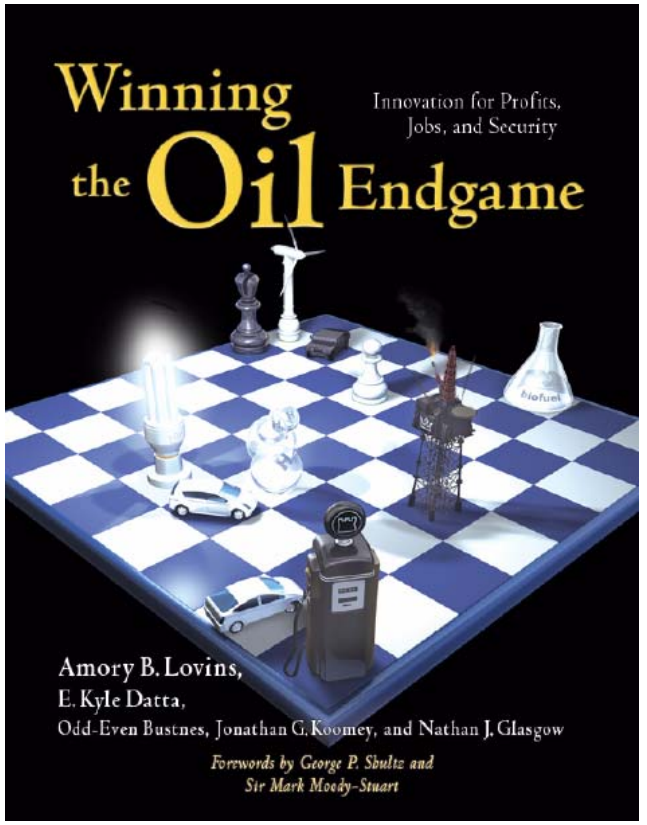

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In 1940, engine power limited top speed

This 1947 truck had just 135 horsepower
Aerodynamics allowed it to reach 50mph,
a revolutionary speed for the era

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How not to build a truck for efficiency: rectangular shapes