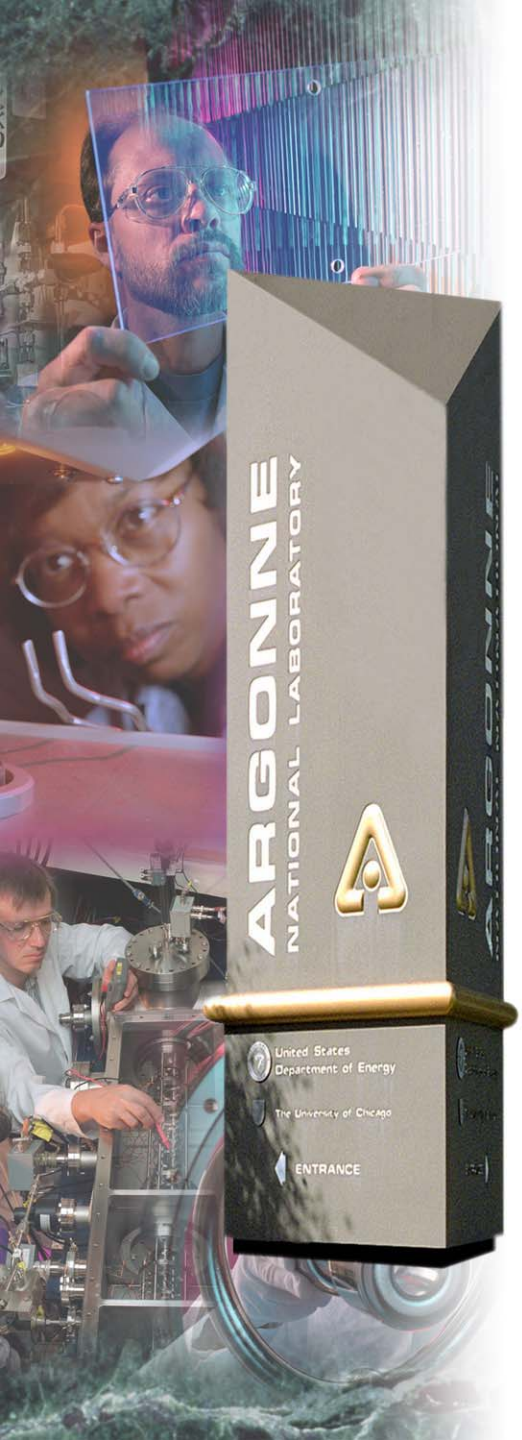
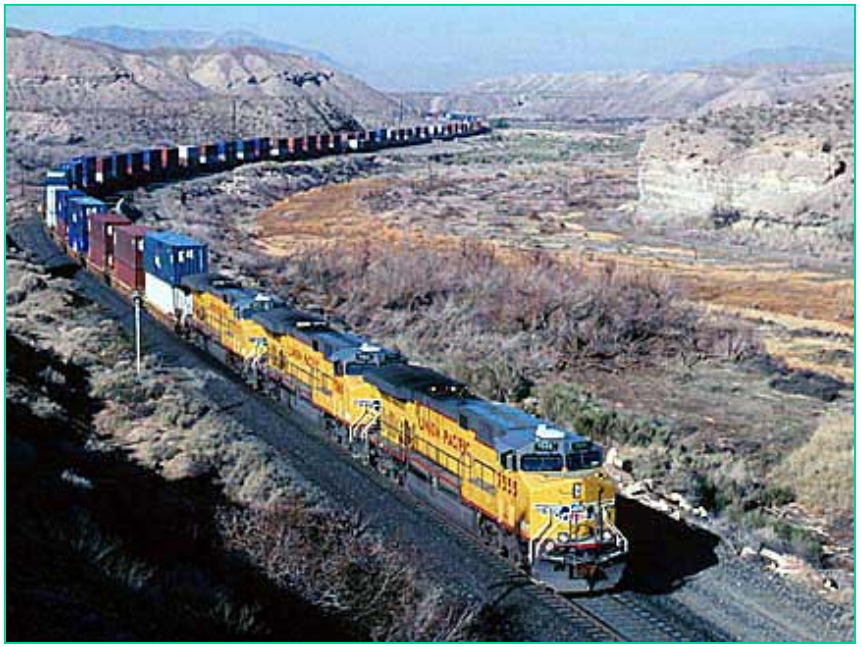


Reduction of Impacts from Locomotive Idling



Linda Gaines
Center for Transportation Research
Argonne National Laboratory

A U.S. Department of Energy Laboratory
Operated by The University of Chicago

What are the impacts of locomotive idling?

- **Petroleum use**
  - Fuel
    - *UP spends $300,000/day to fuel idling locomotives*
    - ***Over 230 million gal/y (6.3% rail freight energy) is wasted***
  - Lubricating oil
    - *CSX estimates up to 0.1 gallons per gallon of fuel*
- **Emissions**
  - New EPA regulations set emission limits
- **Noise**
- **Engine wear**
  - Added usage reduces interval between rebuilds
- **Added maintenance costs**
  - UP estimates $1 per idling hour

Emissions are a serious problem

The time of maximum carbon accumulation is when they (locomotives) are idling or operating at minimum power output. The time of maximum carbon ejection is when power is applied after a period of idling. (Source: Railroad Fire Prevention Guide)

Locomotives idle for several reasons

- **To keep engine warm to ensure it starts**
  - antifreeze generally not used
- **For hotel load while waiting**
  - on sidings and at terminals
- **To keep battery charged**
- **To heat toilet water**
  - frozen toilets cause service loss
- **To avoid Terminal Brake Test**
- **Perceived futility of shutdown**
- **Ingrained operating habits**

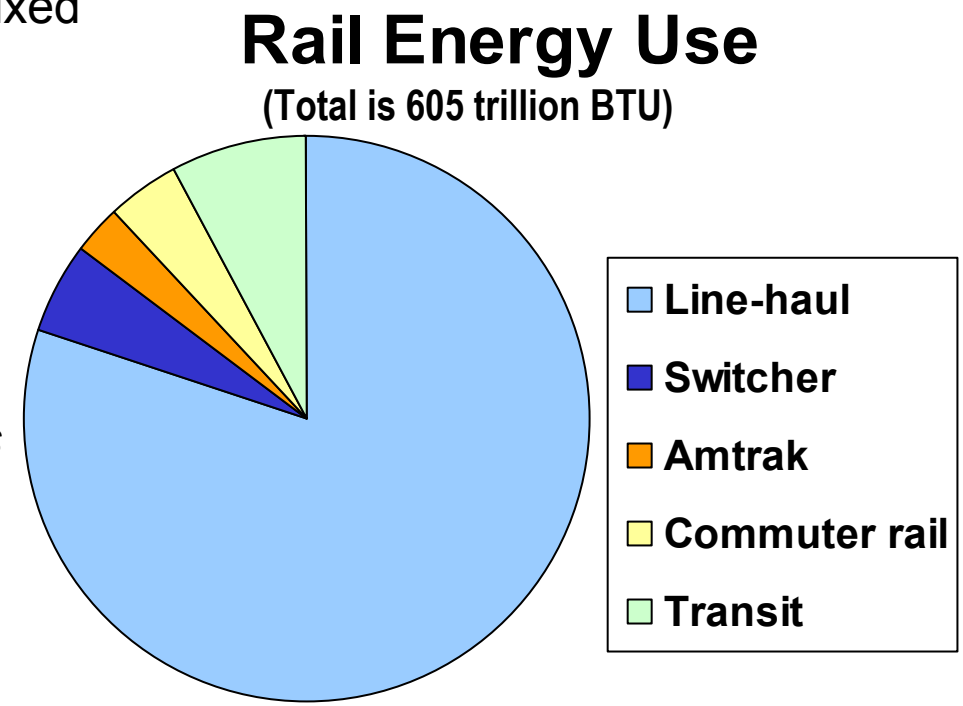
Why don't locomotives use antifreeze?

Typical 4400 HP locomotive diesel engine … *weighs 46,000 pounds*

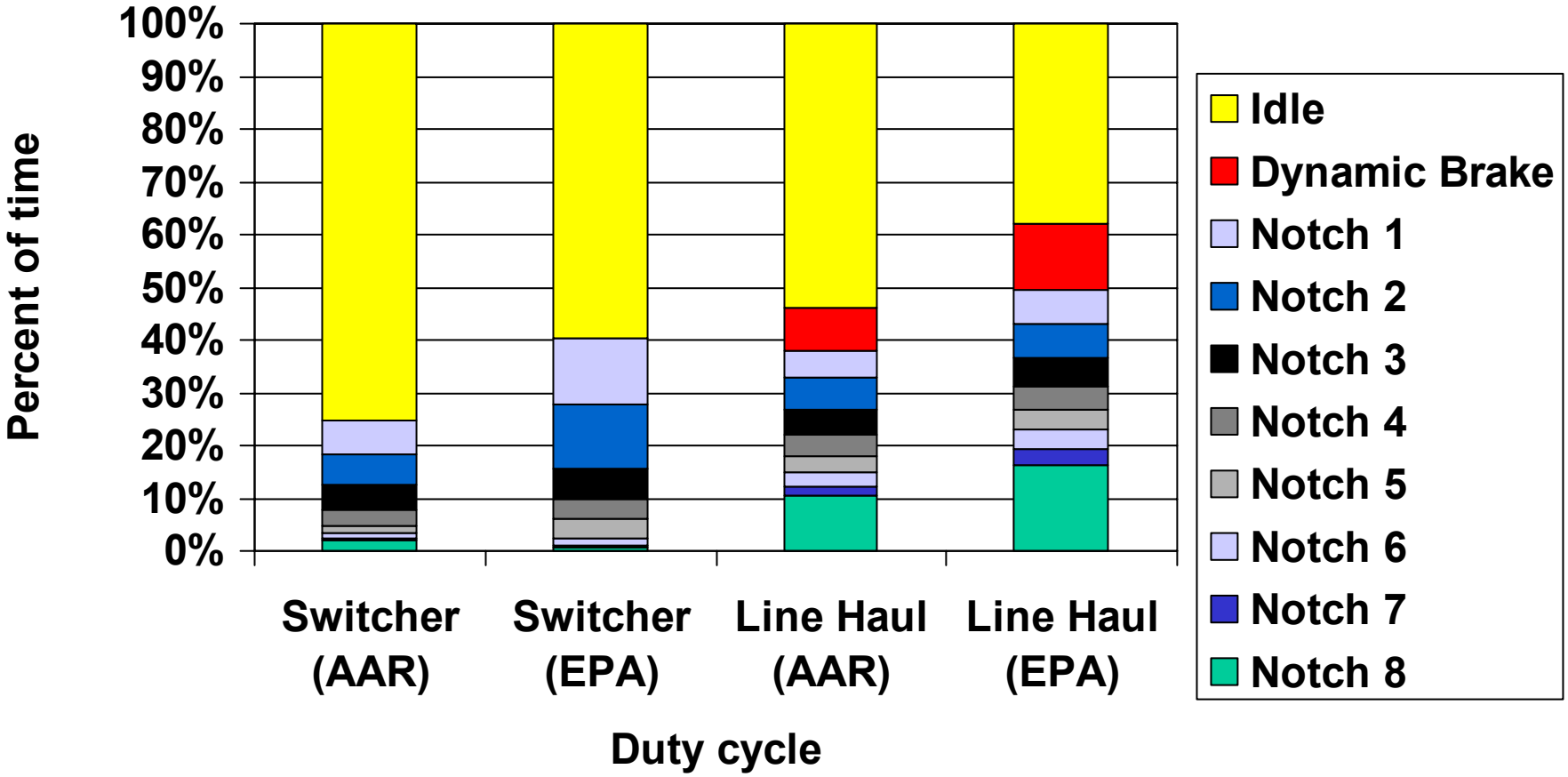
- **Idling protects against**
  - Freezing water
  - Cold oil that's too stiff for cranking
- **Antifreeze can damage bearings in large diesel engines**
- **Antifreeze would reduce HP output**
  - Water better heat transfer fluid
  - Allows 20% smaller radiators
- **Environmental impacts of leaks**

Different considerations apply for different types of trains

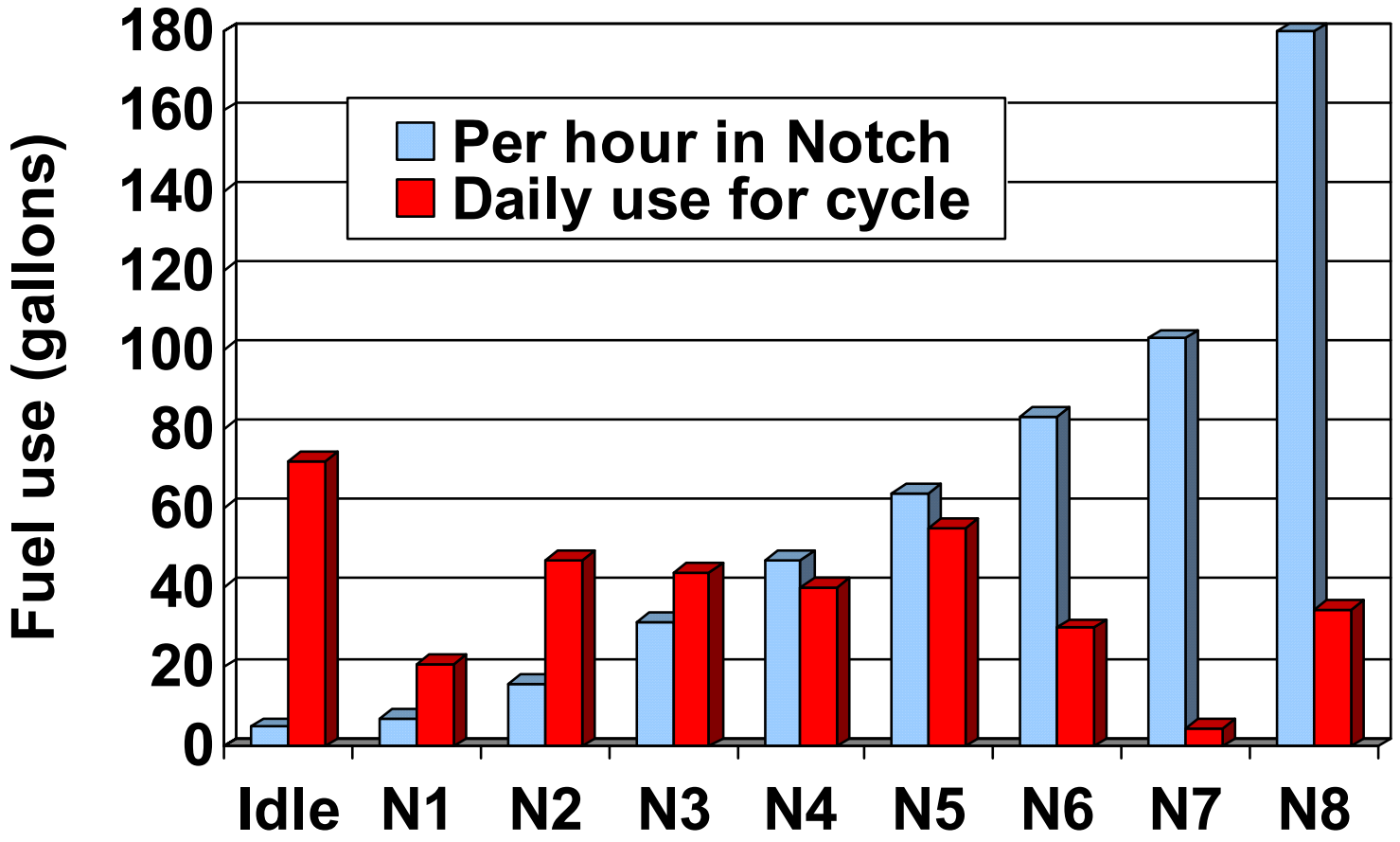
- **Passenger rail**
  - Idle commuter trains cluster at fixed locations
  - Schedules are rigid
  - Loads relatively light
- **Freight rail**
  - Road units (line-haul)
    - *Heavy loads*
    - *May idle in remote locations*
    - *Dominate rail energy use*
  - Yard units (switchers)
    - *Locations fixed*
    - ***Long idle times***
    - ***Source of noise and pollution in populated areas***
    - ***Presentation focus is on switchers***



Even road locomotives idle



Switcher uses most fuel in idle for EPA cycle
(GP38-2 data)



Several technologies could reduce idling

- **Automatic engine stop-start controls (AESS)**
- **Auxiliary power unit (APU)**
- **Diesel-driven heating system (DDHS)**
- **Shore power plug-in unit**

Can be retrofit

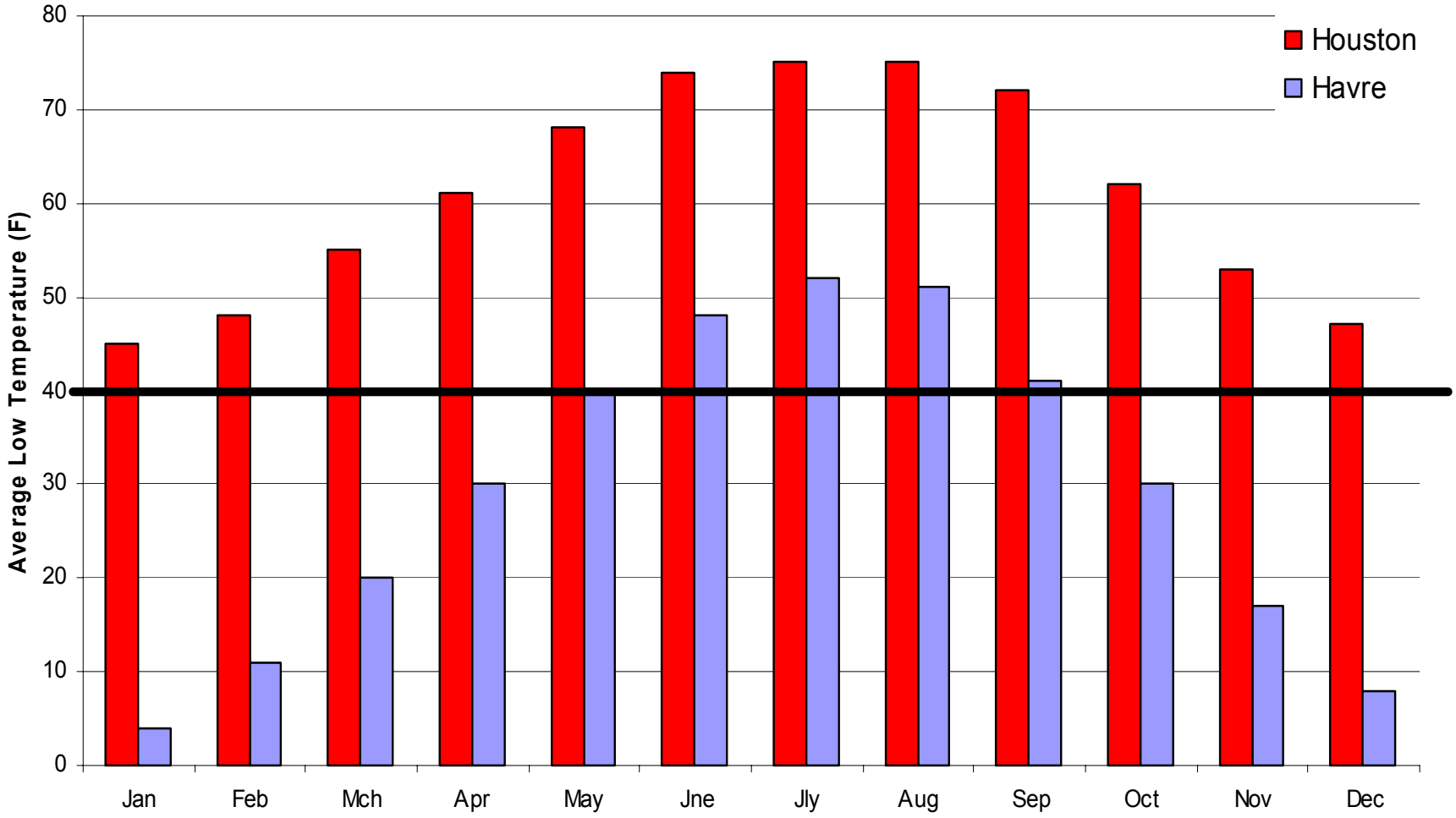
- ***Hybrid switching locomotive***

- **All devices can be used on locomotives from any manufacturer**
- **All reduce fuel use, emissions, and noise**
  - Emission reductions beyond regulated levels could be sold
  - See “Trading Locomotive Emissions: A Potential Success Story,” AWMA 2002
- **Each has advantages and drawbacks and provides different services**

Start/stop systems avoid impacts when engine is off

- **Engine is shut down after set idle time**
  - Operator intervention not required
  - Fuel use, emissions, noise avoided during shut-down
  - No cab comfort provided while engine off
  - Idling reduced up to 50% for road unit, 70% for switcher
- **Sensors monitor water temperature, brake pressure, battery charge**
- **Engine restarts if any parameter out-of-range**
  - ZTR “SmartStart” restarts engine if water drops to 100° F
  - Alarm sounds for safety
  - Starter motor may wear out faster
- **Engine stays on below 40° F**
  - Savings greatest in warm climates

Start/stop has maximum benefit in South



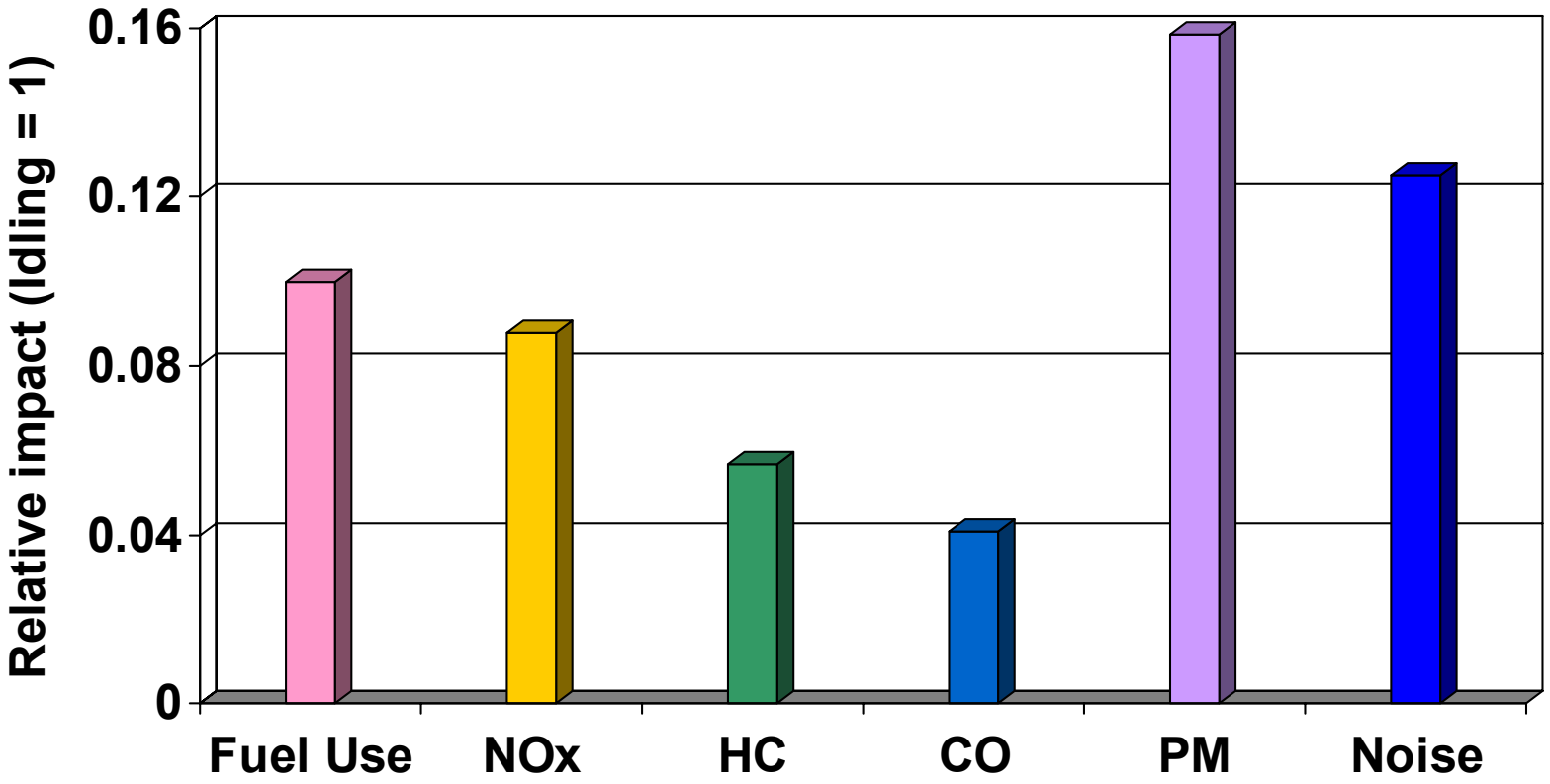
Start/stop systems are being installed on new locomotives and as retrofits

- **EMD SD70M locomotive**
  - 4000 hp DC traction locomotive
  - 1100 unit order (2000-2002)
  - UP received first 20+ units in 2002
- **EMD GP20D switcher**
  - 2000 hp DC switcher (and 1500 hp model)
  - Cooling system has antifreeze
  - 40 acquired by Tyco International/CIT
- **GE C44ACCTE locomotive and automatic stop/start (AESS)**
  - 4400 hp AC traction locomotive
  - 94 delivered to UP in 2002
  - AESS to be retrofitted to older C44ACs
- **SmartStart**
  - UP ongoing program has equipped 375 units since 1998

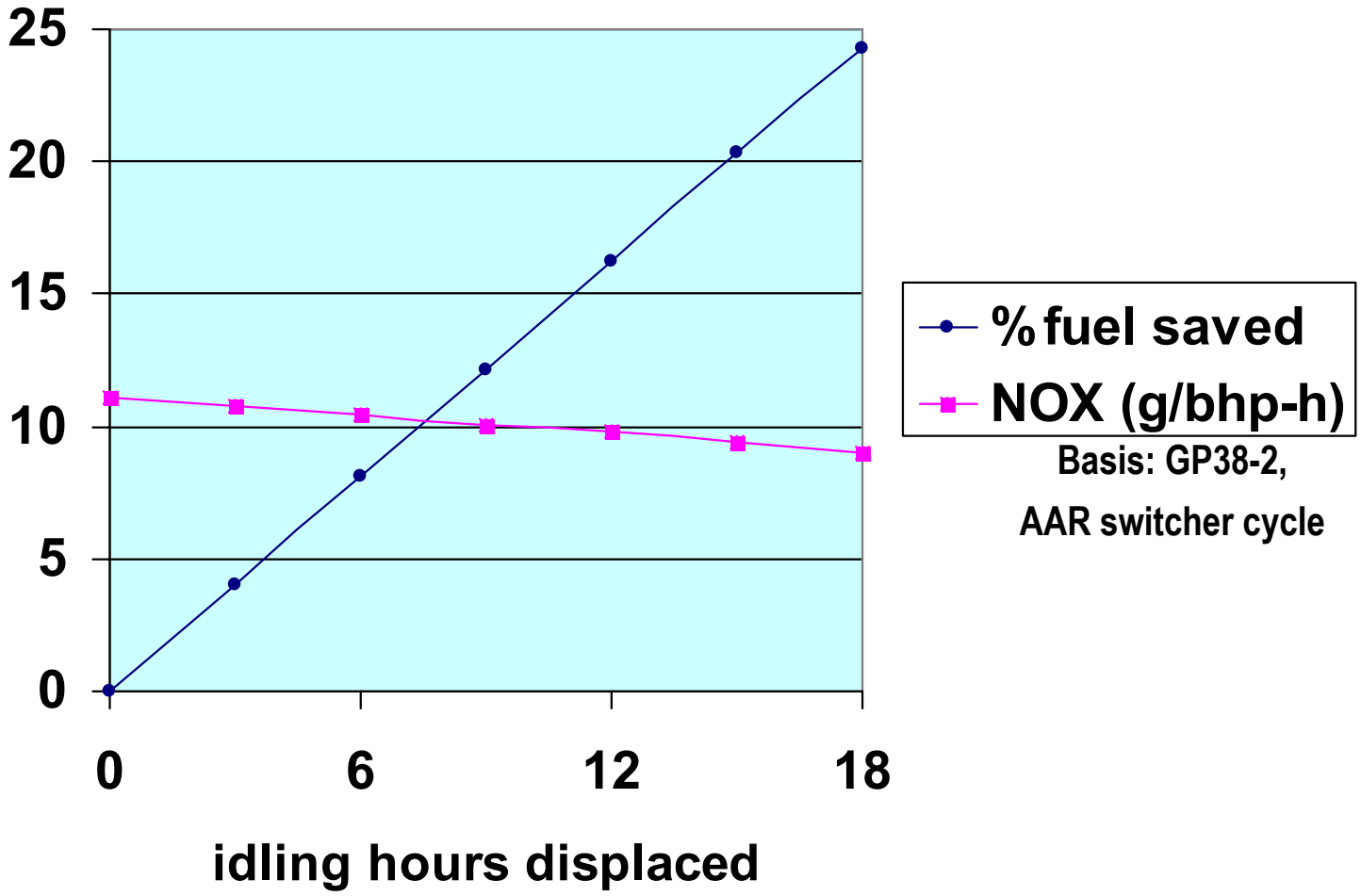
APU supplies heat, power, and cab comfort

- **Shuts off and restarts engine**
  - No operator required
- **Heats water and oil**
- **Enables 60 Hz power**
  - Cost-effective, reliable appliances
    - *optional air conditioning*
    - *lighting and communication*
- **Heats cab and toilet**
- **Maintains brake air pressure**
- **Keeps batteries charged**
- **Enables engine shut-down in winter**
  - Down to –30º F in Alaska
- **Installs behind engine or on walkway**

APU has lower impacts than idling



APU saves fuel and could enable NO_x compliance



Installation of APUs proceeding

- **Ecotrans K-9**
  - CSX installing EcoTrans units on 3,200 locomotives
    - *1,100 installed as of 9/1/03, 1,400 by end of year*
  - DOE funding 70 unit demo in Maryland
    - *30% of the units are equipped and testing is underway*
  - Houston project demonstrated mobile-stationary emission trading
    - *Project completed*
    - *Showed significant reduction in NO_x*
    - *No further emission trading planned*
    - *Texas opted for incentive-based program*
- **Thermo King/Illinois Auto Electric**
    - *Prototype installed at Belt Railway 3/03*
    - *Unit installed at Canadian National 10/03*
    - *Unit installed at Norfolk Southern 11/03*
- **Microphor units patented in 1984**

DDHS heats water and oil with waste heat

- **Variable engine speed generates optimum waste heat**
  - No 60 Hz power
- **Charges batteries and powers cab heaters**
- **Year-round system**
- **Start/stop system optional**
  - Maintains brake pressure
  - Fuel savings reports
  - Remote monitoring
  - Failsafe redundancies

DDHS installed in coldest climates

Alaska RR #2005 GP38, equipped with DDHS 3/02

- Took data on coldest day
- Ambient = -38º F/-39º C
- January 7, 2003
- Fairbanks, Alaska
- 16 hour shutdown
- Engine water > 100º F
- Battery charge maintained
- Locomotive started easily

DDHS installations proceeding

- **Kim Hotstart acquires patent 1996**
- **First walkway installation at POVA Railroad 10/98**
- **First behind-engine installation Idaho Northern 8/99**
- **First DDHS/SmartStart installation on BNSF 8/02**
- **EPA-Chicago project demonstrated reliable cold-weather shutdown**
  - 3 installed on BNSF GP-38
  - 4 installed on WSOR SD 40-2
  - Significant reduction in emissions, noise, and fuel consumption
- **Transport Canada project just underway**
  - 2 installed on Athabasca Northern GP-9
- **11 different railroads, 14 different locomotive models**

The Green Goat is a battery-diesel hybrid switcher

- **Replaces 2000 hp switcher**
- **Uses 125 hp diesel and 60,000 lb of sealed Pb-acid batteries**
- **Small diesel charges batteries**
  - Runs when switcher in use
  - And a bit more
- **Batteries expected to last 10-15 years**
  - Kept at 80% SOC
  - Lifetime unproven
- **Developed by RailPower Technologies**
- **Hybrids are in demonstration stage**
  - First prototypes tested by UPRR in CA and IL
  - Goat demonstrated by Pacific Harbor Line in L.A.
  - Chevron is testing Green Kid at Ventura, CA refinery
  - Southern Railway in B.C. to test Kid
  - U.S. Marines will test Kid in Barstow

Green Goat has pros and cons

- **Small engine is quieter and cleaner than large diesel**
- **Small diesel at full load more efficient than large one at low load**
- **Goat or smaller Kid (1000 hp) can be remote-controlled**
- **Does not need to idle**
- **Designed for yard switching but could haul short distances**
  - Top speed 40 mph
  - Not suitable for long-haul use
- **Costs much more than add-on device**
  - Competitive with rebuild
  - Costs $200 K on old locomotive bed
  - Rebuild costs $100 K- $350 K
  - Cheaper than new unit at $1.5 million

Plug-in units are inexpensive

- **Heat and circulate water and oil**
- **Minimal equipment required**
- **Ideal for commuter trains**
- **Can also be used for yard units**
- **Over 2,000 installed on commuter, short line, regional, and Class 1 locomotives**
- **Locomotive must be at equipped location**
  - Probably not appropriate for line-haul locomotives
- **No local impacts**
  - Yard is quiet and pollution-free
  - Impacts from electricity generation are relatively small

Plug-in unit has optional battery charger

Kim Hotstart
Engine Heating System

Kim Hotstart
Battery Charger

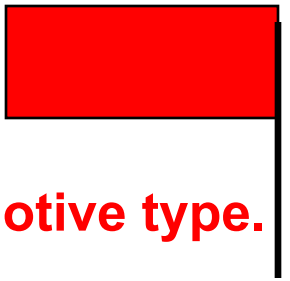
All of the options have good payback times

System	Energy saving (gal/d)	Annual savings ($1000s)	Cost ($1000s)	Payback (months)
Start/stop	36	15	7.5-15	6-12
APU or DDHS	60	25	25-35	12-17
Plug-in	50	19	4-12	3-11
Green Goat	291	122	200	20
Basis: GP38-2 with EPA switcher cycle for all technologies, 330 d/y, 50% idle replacement by AESS (will be less in cold climate), 90% by APU, DDHS, or plug-in unit, .05 gal oil used/gal fuel, $0.10/kWh				

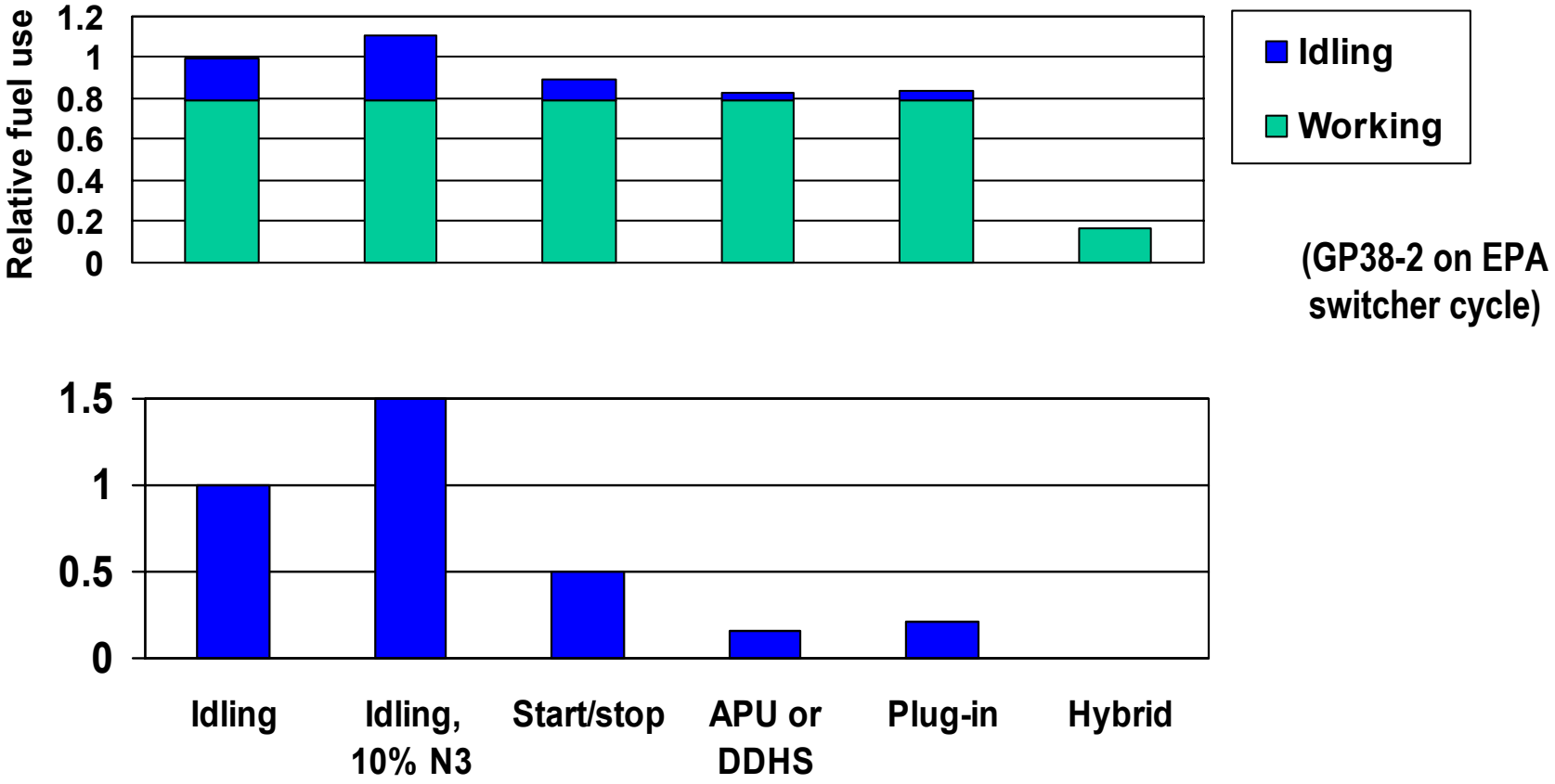
Caveats:

Costs depend on vendor and options included.

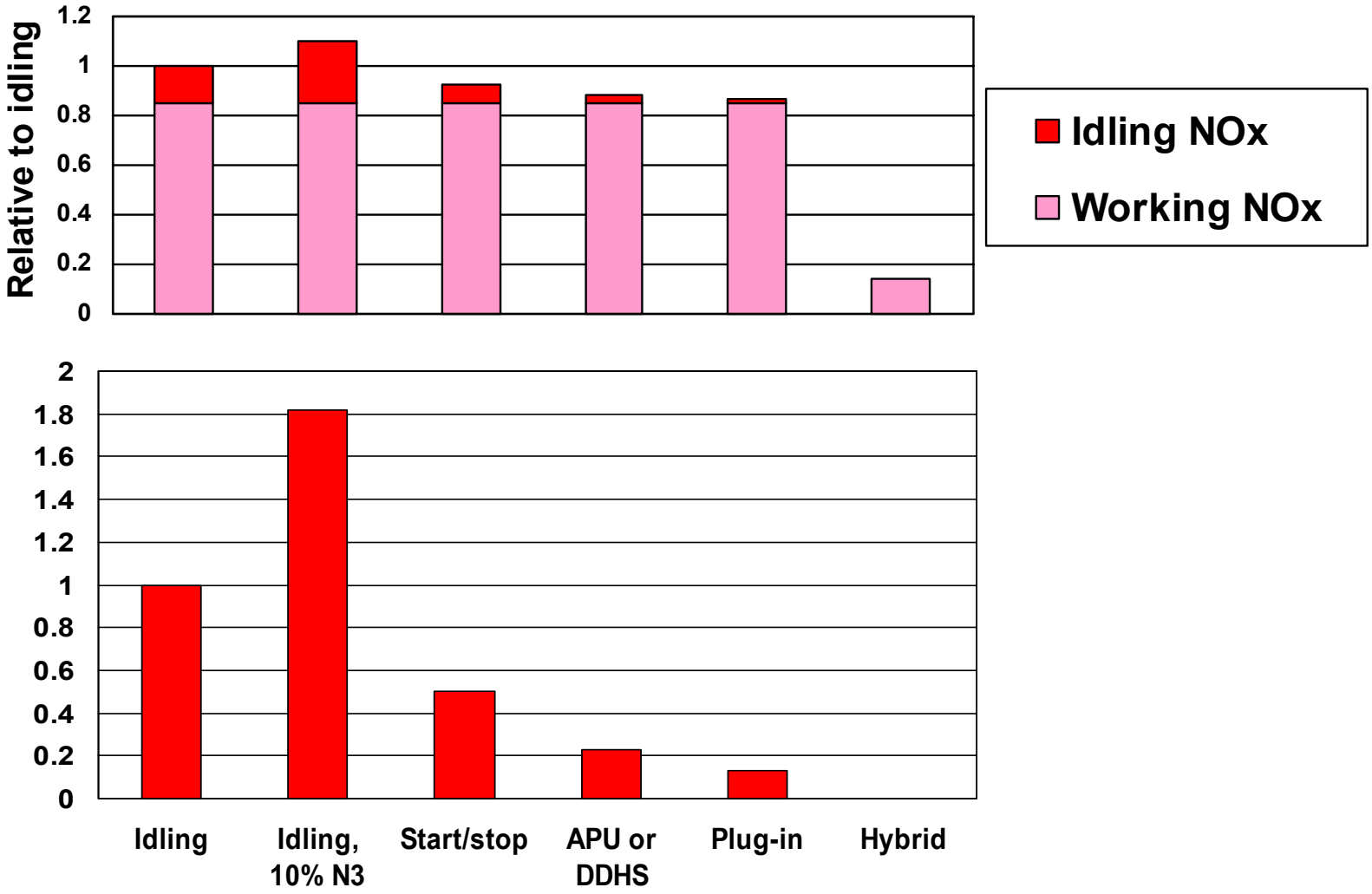
Energy savings depend on climate, duty cycle, locomotive type.



Alternatives reduce energy use



Alternatives also reduce emissions



Technology comparison summary

System	Reduction in energy use and emissions	Working noise	Non-working noise	Advantages/ Disadvantages
Idling	None	Noisy	Noisy	---
Start/stop	Minimum	Noisy	Alternates noisy/silent	No cab comfort, minimal benefit in winter
APU or DDHS	Good	Noisy	Quiet	Anywhere, any time; APU supplies all services
Plug-in	Good	Noisy	Silent	Requires equipped location
Hybrid	Maximum	Quiet	Silent	Switcher only

Thank you's go to:

- **2003 Railroad Environmental Conference**
  - University of Illinois at Urbana-Champaign
- **Sid Diamond– DOE Office of FreedomCAR and Vehicle Technologies**
- **Mike Iden– Union Pacific**
- **Ted Stewart– CSX**
- **Terry Judge– Kim Hotstart**
- **Stephen Farrell– for RailPower**

- **Disclaimer: no endorsements are implied!**