IMPROVING ENERGY EFFICIENCY OF AUXILAIRIES

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Electrically Powered Auxiliaries
Includes: Oil Pumps, Coolant Pump, A/C, Fans, Air Compressors, and 100/220V AC

• Improved Efficiency
  – Packaging Constraints Removed by Localizing
    • Streamlined Flow
    • Pumping Losses Reduced
  – Improved Control w/Electronics
    • Speed Control Allows Press & Temp Modulation
    • On/Off Operation Eliminates Idle Losses
    • Constant Speed Pumps Can by Downsized
  – Improved Efficiency Reduces Cooling Loads
Water Pump Power Requirement

- Actual Power
- 1.25 kW
- Operating Range w/ Controllable Electric Pump

Graph showing the relationship between engine speed and input power.
Oil Pump Power Requirement

6068 Oil Pump
500 kPa Discharge Press
Nominal Flow 1.2 l/s
@ 2500 RPM

Actual Power

Input Power KW

Required Power

1.0 kw

Engine Speed
Fan Power Requirement

![Graph showing Fan Power Requirement vs Engine Speed]

- **Actual Power** at 3.0 KW
- **Typical Requirement**
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Electrically Powered Auxiliaries

• Improved Vehicle Functionality
  – Increased Cab Comfort
  – Improved Performance
  – Improved Vehicle Architecture
Generator Requirements

• High Efficiency (>85%)
• High Power Output (10 - 75 kW)
• High Voltage (42V for light loads only)
• Multiple Voltages Likely Required
• Compact Packaging
• Improved Reliability & Durability
• Fail Safe w/Backup
Generator Options

• Large Flywheel Mounted Motor/Generator
  – Advantages
    • 90% Efficiency Demonstrated
    • Compact Packaging
    • High Power Capacity
    • Simple Hardware w/Excellent Reliability Potential
    • Known Technology
Generator Options

• Large Flywheel Mounted Motor/Generator
  – Disadvantages
    • Increased Cost (Infrastructure Needed)
    • Unique Application Specific Hardware
    • Safety Protocols Needed
    • Requires Electric Auxiliaries
System Definition: Motor/Generator
Flywheel/Coupling/Rotor Assembly

Stator and Housing Assembly
Integration into Vehicles

624H Loader

6910 Agricultural Tractor
Inverter/Controller Assembly
Generator Options

- Turbo Generation
  - Advantages
    - Provides Supplementary Power (20%) Using Waste Exhaust Heat
    - Compact Unit
    - Existing Technology
    - Could be Combined w/Combustor for Engine-Off Power and Heat
    - Excess Power Can Be Used for Propulsion
Energy Distribution

*All percentages based on Total Fuel Input Energy*
Turbo Generator
Generator Options

• Turbo Generation
  – Disadvantages
    • Complex Controls
    • Significant Output only at High Engine Loads
    • Not a Stand Alone System
Generator Options

• Fuel Cell Powered APU
  – Advantages
    • Very High Efficiency
    • Low Noise
    • Engine-Off Power
  – Disadvantages
    • Increased Cost (Infrastructure Needed)
    • Complexity w/Reformer (Diesel)
    • Additional Technical Development Needed
    • Package Size
    • Safety Protocols Needed
Summary

• Economics Ultimately Dictates Direction
• Electric Auxiliaries Provide Solid Benefits. The Impact on Vehicle Architecture Will be Important
• Integrated Generators With Combined With Turbo Generators Can Meet the Electrical Demands of Electric Auxiliaries
Summary

- Implementation Will Follow Automotive 42V Transition
- Availability of Low Cost Hardware Will Slow Implementation
- Industry Leadership and Cooperation Needed
- Standards and Safety Protocols Will be Important
Summary

• Government Can Play an Important Role in Expediting
  – Funding Technical Development
  – Incentives for Improving Fuel Economy
  – Developing Standards, Allowing Economy of Scale
  – Providing Safety Guidelines