The Future of Heavy-Duty Powertrains

Issues, technical challenges, outlook, 2007 and beyond.
A unique study designed to comprehensively explore the future.

Global Insight supplies the depth of industry expertise and services that deliver the insights, risk management tools, benchmarking information, and advice the automotive industry needs to make better informed business decisions.

By drawing on the expertise of 60 automotive experts with credentials in engineering, finance, business administration, and market research, plus more than 300 economic forecasters and financial analysts worldwide, Global Insight understands the forces at play—market, product, technological, economic, financial, trade, transportation, energy, regulatory, demographic, and political—and ways they interact to influence automotive industry growth and market opportunities.

Global Insight leverages this knowledge base to help automotive OEMs, component manufacturers, financial organizations, transportation companies, and other suppliers in their decision-making processes.

Whatever their requirements, the clients of Global Insight benefit from thoroughly researched results and a global perspective.

www.globalinsight.com

TIAX LLC is one of the world’s most diverse, independent product development firms. We advance technologies that improve people’s lives by combining science, technology, and innovation to develop novel products and processes. Formerly Arthur D. Little’s Technology & Innovation business, TIAX captures the rich, century-old heritage of one of the world’s foremost technology, product development, and technology-based consulting firms.

Our transportation experts have worked with the world’s major OEMs, engine manufacturers, and suppliers. Extensive assignments with major international oil and gas companies have made us a key player in clean automotive fuels issues. TIAX also has a unique insight into the policy challenges faced by the industry now and in the future based on our work for regulatory agencies in North America and Europe.

Through our in-depth knowledge of alternative energy systems, technology and product development, market forecasting, and environmental technology issues, TIAX positions clients to be leaders in identifying and exploiting the promising opportunities of future markets by tapping the full value of technology.

www.tiax.biz

To purchase this study, please contact one of the following people:

Phil Gott
Director, Consulting Global Automotive Group
Global Insight
24 Harwell Avenue
Lexington, MA 02421-3558
Tel: 1-781-301-9141
Fax: 1-781-301-9410
philip.gott@globalinsight.com

Dr. Robert P. Wilson
Managing Director
TIAX LLC
Acorn Park
Cambridge, MA 02140-2390
Tel: 1-617-498-5806
Fax: 1-617-498-7054
wilson.r@tiaxllc.com
The Heavy-Duty Powertrains of the Future will see Dramatic Changes... Is your Company Prepared?

Hybrid systems, fuel cells, alternative fuels, emission controls, APUs, new engine concepts: How robust is your technology strategy in the face of the variety of engines, motors, and transmissions that may be deployed?

Will the development of the technologies needed to make alternative powertrains practical actually enhance the performance of the diesel engine to a point where it retains its dominant position in the industry?

What will drive OEMs toward alternative sources of power? Why?

How sensitive are the powertrain solutions to changes in the business and regulatory environment? What will be the volume mix of powertrain technologies?

When advanced powertrain technologies are developed, who will manufacture them? Are you positioned to be one of these companies? Or is your strategy an end-game?

Which different technologies will be adopted in Europe? North America? Japan?

Will goods and people still be transported over the road, or will alternative forms of transport replace the truck and the bus?

What will the fuel/energy delivery infrastructure of the future look like? Will that infrastructure dictate future powertrain technologies or enable the optimal solution?

Will changes in the vehicle preclude or enable the commercialization of advanced powertrain technologies?

What technical breakthroughs are needed? What is the probability of success? What opportunities and challenges are ahead for your business?

Do you have the tools needed to answer these questions?

The Future of Heavy-Duty Powertrains

The diesel engine is the king of heavy duty on- and off-highway motive power. It is highly efficient, durable, reliable, easily maintained, and has a globally robust infrastructure to support it. Yet it has come under increasing scrutiny as a source of carcinogens and other pathogens, not to mention often visible soot and a distinctive, rather unpleasant, odor. For well over a decade, government-funded research has explored alternatives to the diesel, as well as means to minimize the negative aspects of this omnipresent heavy-duty engine.

As the world wrestles with the multiple challenges of healthy air, minimal greenhouse gas production, and reduced dependency on highly concentrated, finite fossil fuel reserves, the diesel, although once a prolific polluter, has been our most efficient practical source of mobility for much of the last century. Are the goals of clean air, reduced global warming, and fuel efficiency on a collision course? How clean can the diesel become? Are there any viable alternatives (such as HCCI/CAI) waiting in the wings? Will rail or some other entirely different mode of transport take a greater share of freight traffic away from the diesel-powered truck? These and other long-range questions plague those who invest in ever more efficient, cleaner diesel engines. How much longer will investments in diesel combustion, exhaust gas treatment, and improved diesel powertrains provide good returns on the resources committed to their continued development? Would these resources be put to better use if they were applied to other sources of on- and off-highway motive power, such as hybrid, rail, fuel cell, HCCI/CAI, etc.?

Developers of alternative sources of mobile heavy-duty power are equally curious. Is it realistic for them to hope they can gain substantial market share? What would it take for their developments to become competitive? Will these events ever occur? If so, when?

Even the regulators ultimately face a conundrum. How far can the dual goals of clean air and impact-free mobility be pursued? Will it be necessary to face up to the need to make a trade off of clean air for sustainable mobility? Are these goals achievable in a vital economic environment?

These and other questions are addressed by the team of TIAX and Global Insight. Prior to this study, these two firms completed the widely acclaimed study of light-duty on-highway powertrain technologies, Future Powertrain Technologies, the Next Generation. This renewed alliance probes the future of the heavy-duty powertrain by assessing the prospects for the diesel and its competitors in mobile applications for on- and off-highway engines from 100 hp up to 750 hp. It looks at the factors that are forcing the diesel to evolve, what powertrain performance objectives can be met within the 2020 time frame, the likely future viability of alternative sources of power as they attempt to gain market share, and the likelihood that alternative means of transport will be able to compete with on-highway trucks for the movement of most goods needed for economic vitality.
The prime objective of this study was to help our client organizations prepare for an uncertain future. The study investigates and delivers detailed analysis of the following goals:

- Alternative scenarios for regulatory environments: optimistic, pessimistic, most likely
  - Emissions of currently regulated criteria pollutants
  - New certification and test methods
  - In-use compliance

- Evolution of the heavy-duty diesel engine
  - Combustion systems
  - Fuel injection developments
  - Air control
  - Boosting/Recuperation
  - Exhaust gas treatment

- Applicability of evolving technologies as alternatives or complements to the diesel: Can they ever compete? Are they needed?
  - HCCI/CAI
  - Fuel cell
  - Hybrid

- Contribution of advances in transmission technology
  - Automated manuals
  - Fully automatic
  - CVT

- Benefits and costs of alternative fuels
  - Bio-derived fuels for compression-ignition engines
  - Natural gas
  - Other

- Viability of alternative modes of transportation

- Market share forecasts of powertrain technologies for on- and off-highway (construction, agriculture, etc.) heavy-duty powertrains for each scenario and region
  - Western Europe
  - North America
  - Japan

Who Will Benefit Most?

Which companies will be affected by the coming new powertrain technologies? In short, each and every one. All companies and organizations that conduct business, which relate in some way to the heavy-duty equipment industry, will be affected by these technologies. Original equipment manufacturers, energy companies, tier 1-2-3 suppliers, public utilities, power suppliers, even fuel stations and parts stores will eventually be dramatically impacted. Regardless of the component supplied, the fuel used, or the manner in which the powertrain as we currently know it evolves, the rapid developments within the industry will force strategic planners to reflect seriously upon their own state of preparedness.

We believe this study is of critical importance to the following staff members within your organization:

- CEO
- Business Strategists
- Product Engineers
- Market Planners
- Corporate Planners
- Product Planners / Developers
- Financial Planners
- Manufacturing Planners
The TIAX / Global Insight study developed a number of scenarios encompassing internally consistent, yet challenging, levels of fuel prices, regulatory constraints, and economic growth. The TIAX / Global Insight team then determined the rollout of new technologies (including those listed below), the role of existing technologies, and the relative market shares of each under the various scenarios. Corporate strategies that can meet the powertrain technology needs of each scenario should prove to be the most cost-effective, profitable road map to the future.

Key Areas Researched

The Future of Heavy-Duty Powertrains

Compression Ignition Engines

Other IC Engines (HCCI, CAI, etc.)

Exhaust Emission Controls

Alternative Fuels & Energy Sources

Hybrid Powertrains

Fuel Cells

Transmissions

Issues, Technical Challenges, Outlook, 2007 and Beyond

A Proven Approach

The study employed proven methods previously developed by TIAX and Global Insight for both single- and multi-client studies. It encompassed extensive analysis and assessment of future powertrain technologies under several alternative scenarios.

TIAX / Global Insight experts drew upon recent experience in their respective areas to author position papers on Future Powertrain Technologies under various alternative scenarios.

Select industry experts reviewed Position Papers.

Papers were revised by TIAX / Global Insight authors and synthesized into alternative outlooks for powertrain technology under several alternative scenarios and presented in a draft report.

Draft was discussed with a broad range of industry professionals.

Final report was published.
The TIAX / Global Insight study developed a number of scenarios encompassing internally consistent, yet challenging, levels of fuel prices, regulatory constraints, and economic growth. The TIAX / Global Insight team then determined the rollout of new technologies (including those listed below), the role of existing technologies, and the relative market shares of each under the various scenarios. Corporate strategies that can meet the powertrain technology needs of each scenario should prove to be the most cost-effective, profitable road map to the future.

Compression Ignition Engines

Other IC Engines (HCCI, CAI, etc.)

Exhaust Emission Controls

Alternative Fuels & Energy Sources

Hybrid Powertrains

Fuel Cells

Transmissions

Issues, Technical Challenges, Outlook, 2007 and Beyond
The prime objective of this study was to help our client organizations prepare for an uncertain future. The study investigates and delivers detailed analysis of the following goals:

- **Alternative scenarios for regulatory environments: optimistic, pessimistic, most likely**
  - Emissions of currently regulated criteria pollutants
  - New certification and test methods
  - In-use compliance

- **Evolution of the heavy-duty diesel engine**
  - Combustion systems
  - Fuel injection developments
  - Air control
  - Boosting/Recuperation
  - Exhaust gas treatment

- **Applicability of evolving technologies as alternatives or complements to the diesel: Can they ever compete? Are they needed?**
  - HCCI/CAI
  - Fuel cell
  - Hybrid

- **Contribution of advances in transmission technology**
  - Automated manuals
  - Fully automatic
  - CVT

- **Benefits and costs of alternative fuels**
  - Bio-derived fuels for compression-ignition engines
  - Natural gas
  - Other

- **Viability of alternative modes of transportation**

- **Market share forecasts of powertrain technologies for on- and off-highway (construction, agriculture, etc.) heavy-duty powertrains for each scenario and region**
  - Western Europe
  - North America
  - Japan
The Heavy-Duty Powertrains of the Future will see Dramatic Changes... Is your Company Prepared?

Hybrid systems, fuel cells, alternative fuels, emission controls, APUs, new engine concepts: How robust is your technology strategy in the face of the variety of engines, motors, and transmissions that may be deployed?

Will the development of the technologies needed to make alternative powertrains practical actually enhance the performance of the diesel engine to a point where it retains its dominant position in the industry?

What will drive OEMs toward alternative sources of power? Why?

How sensitive are the powertrain solutions to changes in the business and regulatory environment?

What will be the volume mix of powertrain technologies?

When advanced powertrain technologies are developed, who will manufacture them? Are you positioned to be one of these companies? Or is your strategy an end-game?

Which different technologies will be adopted in Europe? North America? Japan?

Will goods and people still be transported over the road, or will alternative forms of transport replace the truck and the bus?

What will the fuel/energy delivery infrastructure of the future look like? Will that infrastructure dictate future powertrain technologies or enable the optimal solution?

Will changes in the vehicle preclude or enable the commercialization of advanced powertrain technologies?

What technical breakthroughs are needed? What is the probability of success? What opportunities and challenges are ahead for your business?

Do you have the tools needed to answer these questions?

The Future of Heavy-Duty Powertrains

The diesel engine is the king of heavy duty on- and off-highway motive power. It is highly efficient, durable, reliable, easily maintained, and has a globally robust infrastructure to support it. Yet it has come under increasing scrutiny as a source of carcinogens and other pathogens, not to mention often visible soot and a distinctive, rather unpleasant odor. For well over a decade, government-funded research has explored alternatives to the diesel, as well as means to minimize the negative aspects of this omnipresent heavy-duty engine.

As the world wrestles with the multiple challenges of healthy air, minimal greenhouse gas production, and reduced dependency on highly concentrated, finite fossil fuel reserves, the diesel, although once a prolific polluter, has been our most efficient practical source of mobility for much of the last century. Are the goals of clean air, reduced global warming, and fuel efficiency on a collision course? How clean can the diesel become? Are there any viable alternatives (such as HCCI/CAI) waiting in the wings? Will rail or some other entirely different mode of transport take a greater share of freight traffic away from the diesel-powered truck? These and other long-range questions plague those who invest in ever more efficient, cleaner diesel engines. How much longer will investments in diesel combustion, exhaust gas treatment, and improved diesel powertrains provide good returns on the resources committed to their continued development? Would these resources be put to better use if they were applied to other sources of on- and off-highway motive power, such as hybrid, rail, fuel cell, HCCI/CAI, etc.?

Developers of alternative sources of mobile heavy-duty power are equally curious. Is it realistic for them to hope they can gain substantial market share? What would it take for their developments to become competitive? Will these events ever occur? If so, when?

Even the regulators ultimately face a conundrum. How far can the dual goals of clean air and impact-free mobility be pursued? Will it be necessary to face up to the need to make a trade off of clean air for sustainable mobility? Are these goals achievable in a vital economic environment?

These and other questions are addressed by the team of TIAX and Global Insight. Prior to this study, these two firms completed the widely acclaimed study of light-duty on-highway powertrain technologies, Future Powertrain Technologies, the Next Generation. This renewed alliance probes the future of the heavy-duty powertrain by assessing the prospects for the diesel and its competitors in mobile applications for on- and off-highway engines from 100 hp up to 750 hp. It looks at the factors that are forcing the diesel to evolve, what powertrain performance objectives can be met within the 2020 time frame, the likely future viability of alternative sources of power as they attempt to gain market share, and the likelihood that alternative means of transport will be able to compete with on-highway trucks for the movement of most goods needed for economic vitality.
The Future of Heavy-Duty Powertrains

Issues, technical challenges, outlook, 2007 and beyond.
A unique study designed to comprehensively explore the future.

Contacts & About this Strategic Alliance

Global Insight supplies the depth of industry expertise and services that deliver the insights, risk management tools, benchmarking information, and advice the automotive industry needs to make better informed business decisions.

By drawing on the expertise of 60 automotive experts with credentials in engineering, finance, business administration, and market research, plus more than 500 economic forecasters and financial analysts worldwide, Global Insight understands the forces at play—market, product, technological, economic, financial, trade, transportation, energy, regulatory, demographic, and political—and ways they interact to influence automotive industry growth and market opportunities.

Global Insight leverages this knowledge base to help automotive OEMs, component manufacturers, financial organizations, transportation companies, and other suppliers in their decision-making processes.

Whatever their requirements, the clients of Global Insight benefit from thoroughly researched results and a global perspective.

www.globalinsight.com

TIAX LLC is one of the world’s most diverse, independent product development firms. We advance technologies that improve people’s lives by combining science, technology, and innovation to develop novel products and processes. Formerly Arthur D. Little’s Technology & Innovation business, TIAX captures the rich, century-old heritage of one of the world’s foremost technology, product development, and technology-based consulting firms.

Our transportation experts have worked with the world’s major OEMs, engine manufacturers, and suppliers. Extensive assignments with major international oil and gas companies have made us a key player in clean automotive fuels issues. TIAX also has a unique insight into the policy challenges faced by the industry now and in the future based on our work for regulatory agencies in North America and Europe.

Through our in-depth knowledge of alternative energy systems, technology and product development, market forecasting, and environmental technology issues, TIAX positions clients to be leaders in identifying and exploiting the promising opportunities of future markets by tapping the full value of technology.

www.tiax.biz

To purchase this study, please contact one of the following people:

Phil Gott
Director, Consulting Global Automotive Group
Global Insight
24 Harwell Avenue
Lexington, MA 02421-3538
Tel: 1.781.301.9141
Fax: 1.781.301.9410
philip.gott@globalinsight.com

Dr. Robert P. Wilson
Managing Director
TIAX LLC
Acorn Park
Cambridge, MA 02140-2390
Tel: 1.617.498.5806
Fax: 1.617.498.7054
wilson.r@tiaxllc.com