IHS Markit™

Reinventing the Wheel:

The future of cars, oil, chemicals, and electric power

An IHS Markit multiclient study

September 2017

At the crossroads

Major disruptive forces are now reshaping the energy, automotive, and chemical industries. Transportation is at the nexus of these changes. Forces are converging to accelerate the pace and nature of this transformation, pointing to a new reality for transportation—with profound implications.

A broad perspective is necessary to make sense of these changes. Most current analysis takes a single-industry approach. Thus far, there has not been a system-wide analysis that brings to bear a deep understanding of the forces at work within each industry-automotive; oil and gas; electric power; and chemicals—and the interplay among these. IHS Markit uniquely offers the capability and expertise within each industry and the ability to look across industries and at how they interact.

This study leverages our leading expertise, as well as our industry relationships, to engage and convene key participants from across these industries in interactive workshops to bring new perspectives and insights from the range of key stakeholders. The results, published in September 2017, present a new integrated knowledge universe and powerful, unique scenarios that provide industry–specific implications essential for developing and testing strategies.

This knowledge universe and scenarios-based framework enables companies to analyze the opportunities, challenges, and even existential threats facing the energy-automotive-chemicals complex, which looms so large in the global economy.

- For the automotive industry, new entrants and technologies are beginning to challenge incumbent companies and their suppliers. Will today's large manufacturers and suppliers hold their positions in the years ahead? Who will be the players 20 years from now?
- For the oil and gas industry, the implications are critical. The cars that dominate personal transport currently account for more than one-third of global refined product demand. Transportation, altogether, represents fifty-five percent of total world consumption. Will new mobility options such as car/ride sharing and autonomous vehicles accelerate the peaking of world oil consumption. If oil cedes its position as the dominant fuel in transport, the repercussions could profoundly reshape energy supply and demand. Such a change would reverberate globally across adjacent industries. Can natural gas find an expanded role in transportation?

– For chemicals, the outcome will deeply impact a major market, affect available feedstocks, and have critical implications for companies' investments and competitive strategy.

– For electric power, transportation is seen as a possible new frontier for demand growth. What are the policy, regulation, investment, operational, and customer relationship ramifications? Does battery technology evolution change the game in coupling utilities to transportation creating new competition dynamics? How will electric cars fit into the new paradigms of a more distributed electric power industry?

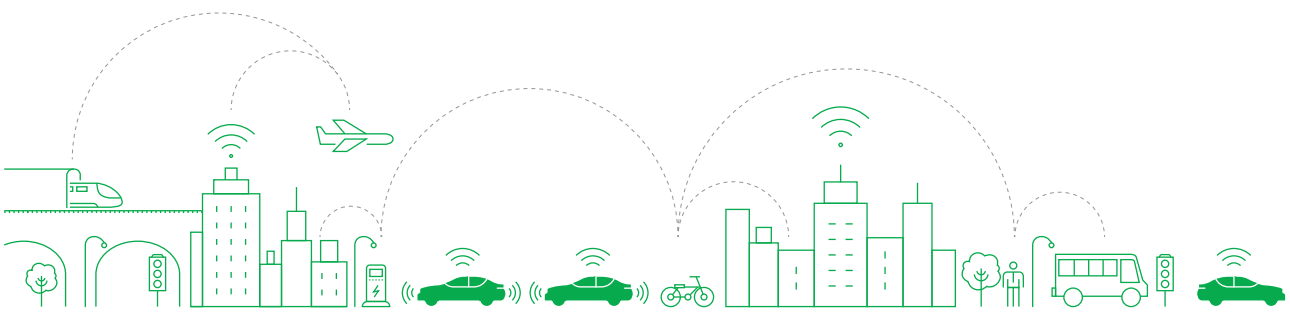
With leading analysts in the automotive, oil, electric power, and chemical sectors, IHS Markit offers unparalleled insight into the coming changes. Our modeling expertise in these industries delivers comprehensive analytics and datasets—a high-value combination to guide decision making during what will be a tumultuous period for the future of these industries.

The project is chaired by Daniel Yergin, IHS Markit Vice Chairman, Pulitzer Prize winner, and author of *The Prize* and *The Quest*. Project Directors are Jim Burkhard, Tom De Vleesschauwer, and Tiffany Groode. Project Advisors are Atul Arya, Tim Armstrong, Jamey Rosenfield, and Dave Witte. Commercial Directors are Kate Hardin, Bjoern Huetter, and Anthony Palmer. Project Manager is Chelsea Havill. Top analysts throughout IHS Markit's automotive, energy, and chemical research teams are engaged in the study.

Approach to *Reinventing the Wheel*

No single issue, technology, or policy is unilaterally fueling the uncertainty and potential for transformative change. Rather, it is being driven by a great convergence of critical factors: climate change and air pollution policies, advances in battery technology, big data, powerful and cheap information gathering and processing, vehicle–to–vehicle communication, vehicle–to–infrastructure communication, urban congestion, and efforts to eliminate accidents and driving fatalities. Trillions of dollars of future investment capital are at stake, and there is no certainty about which technologies—or companies—will win or lose.

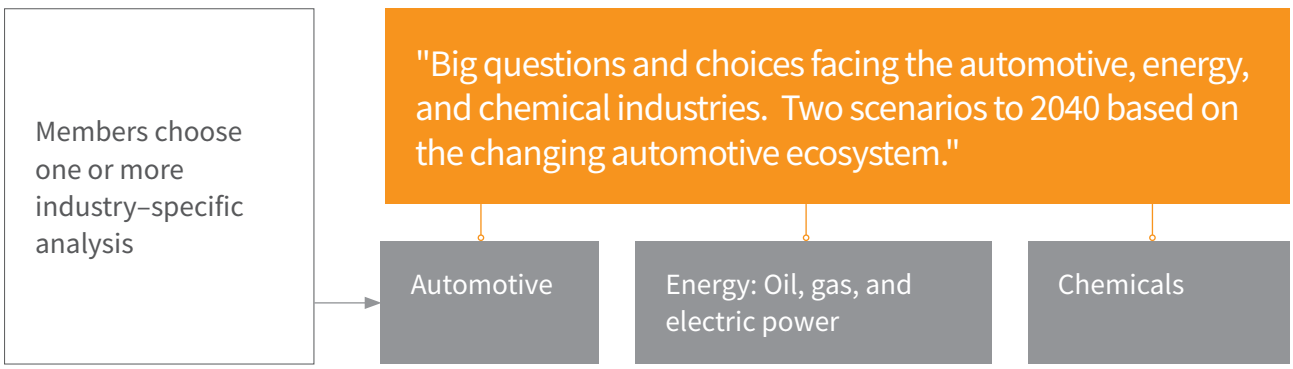
Reinventing the Wheel is not simply about data projections and linear views of the future. At its heart, it is an exercise in understanding how different forces shaping the future can interact and create a future different from the world in which automotive, oil, electric power and chemical companies have operated for a century. Developments in the automotive industry will impact energy and chemicals, and vice versa. An approach that joins expertise and convenes a project community across these industries is essential for grasping how the forces of change are shaping the future.



Deliverables: Community and content

From late 2016 though mid-2017, IHS Markit convened a community of companies and thought leaders to test ideas and foster dialogue about the complex set of forces that are reshaping the automotive industry, challenging the role of oil in transport, and creating new opportunities that have yet to fully form.

Study deliverables



Geographic coverage

The study covers the world's largest automotive markets: United States, Europe, and China. India, a large and fast-growing market is also included. These markets accounted for 71% of global car sales in 2015 and 57% of cars' gasoline consumption. They will set global trends. Our projections go to 2040.

Driving forces of a changing world and scenarios to 2040

Driving forces of a changing world

A sound, fact-based understanding of what is unfolding today is an essential step toward assessing how forces of change will interact and shape the automotive industry to 2040. Our aim was to develop a knowledge universe. Key driving forces that we investigated, unpacked, and assessed included the following:

Automotive policies and regulations that have an impact on light-duty vehicle (LDV) technology and energy choices

- Fuel economy standards
- CO_2 emissions standards
- Air quality standards
- Major restrictions on vehicle sales and use
- Major consumer incentives and taxes on automotive sales and use
- Agenda of major policy initiatives

Car and ride sharing: Impact on ownership and energy consumption

- Who are the key players?
- Business models
- Known impacts to date

The new dimension: Autonomous LDVs-driverless cars are a truly new dimension to the future of transport

- The “5 Levels” of automation
- Attractions and barriers to automation
- Current autonomous capabilities
- Major players and ambitions

Values and behaviors: Millennials in the United States and China

- Generational differences in car buying and car use patterns
- How do millennials differ?
- Historical trends in vehicle miles traveled
- Changing balance between manufacturers and buyers

Industry structure

- Existing major players and emerging entrants in the automotive ecosystem
- Energy supply chains (oil products, electric utilities, battery manufacturers)
- Implications of shifting feedstock dynamics on the chemical industry

Competitive positions of energy sources to power LDVs: Gasoline, diesel, natural gas, electricity/ batteries, biofuels, and hydrogen

- Refueling/recharging infrastructure: Extent and costs
- Onboard energy density
- Energy production costs and prices
- Geographically based chemicals production costs and profitability
- Carbon taxes/environmental taxes/fees
- Impact on electric power demand, distributed energy, and electric power companies

Chemical industry's product interface with the automotive industry

- Impact of automotive design and production volume changes on materials usage
- Future role and impact of lightweighting trends
- Impact of evolving automotive manufacturing technology
- Changing geographic dimension of the supply chain

Scenarios to 2040

IHS Markit has a long track record of scenarios development and use—including scenarios that foresaw the 2008 Great Recession and the oil price collapse of 2014. The development of the knowledge universe and identification and assessment of major "driving forces" of change in the automotive ecosystem set the stage for scenarios development. We conceptualized a range of outcomes for each driving force and how they could influence one another. These variables shape differing outcomes in our scenarios.

IHS Markit, with the input of member companies, developed two scenarios that present distinctive views of the future of the automotive industry and the impact on energy to 2040, each driven by a determinative logic. Two IHS Markit scenarios, Rivalry and Autonomy, will provided the starting point and macro framework. Rivalry is an evolutionary view of the future. Autonomy illustrates a disruptive pace of change.

Each content-rich scenario outlook includes a narrative describing the developments and surprises of a logically imagined future for cars and energy. The use of a scenario framework enhances decision making and tests choices in a complex, dynamic marketplace by illustrating conditions that may lead to success or failure for a company's choices.

The narrative and associated data projections to 2040 address the following in the geographic areas that *Reinventing the Wheel* covers:

- China, Europe, India, and the United States
- Policy and regulatory standards
- How self-driving vehicles, electric cars, and ride sharing unfold and impact the automotive industrial ecosystem
- Car sales by total industry volume (TIV) and by powertrain (gasoline, diesel, natural gas, mild and full hybrids, plug-in hybrid electric vehicles, pure battery electric vehicles, and hydrogen fuel cell vehicles)
- Vehicle energy consumption by source (gasoline, diesel, natural gas, hydrogen, electricity, and biofuels)
- On-road fleet (car parc) by powertrain
- Total vehicle miles traveled and average vehicle miles traveled per LDV
- Average LDV fuel economy (new and on road) for cars and light commercial vehicles
- Oil prices

Success or failure? Big questions and choices facing the automotive, oil, electric power, and chemical industries

IHS Markit, along with participating companies, identified and discussed implications for each of the industries in our study: automotive, oil, electricity and chemicals. The study identifies and addresses the big questions facing companies in each industry and the choices that companies will need to make, particularly regarding growth opportunities and divestment.

Automotive industry: Big questions and choices

The entire automotive industry ecosystem faces existential questions and choices. Will incumbents adapt and endure? Or will new entrants and technologies remake the entire automotive value chain? We identified and assessed key choices related to these big questions using the framework of our two scenarios.

- **How much automotive manufacturing capacity will be needed-and how will it be done?**
  Will the volume of new car sales break with historical trends? What type of manufacturing capacity will be needed? And will future technologies complicate or simplify the manufacturing process?
- **Will today's supply chain endure?**
  Will the automotive industry's supply chain of today still be relevant in the coming years and decades? Will new technologies continue to disrupt the supply chain? Will a new supply community emerge and render existing capital investments obsolete?
- **How will business models evolve?**
  Will automotive manufacturers need to transform into providers of mobility services? Will one business model dominate—or will many flourish? How will business models differ between regions?

How will the new functionality of autonomous driving impact consumer behavior?

- **Will regulators shape the future or follow technology and consumer demands?**
  Will policies be ahead or behind of changes in the automotive industry? What new policies may be needed to support new options for automotive mobility? How will today's policies evolve? Will local policies supersede those at regional or national levels?
- **Are cross-industry partnerships the key to success—or even survival?**
  What opportunities are there for partnership with other stakeholders, including companies outside the traditional automotive industrial ecosystem? Are partnerships essential to success-or are they a distraction?

Oil and gas industry: Big questions and choices

Oil and gas companies will face repercussions stemming from the changes in the automotive industrial ecosystem, particularly with regard to what source of energy will power cars in the years ahead. Each of the big questions are addressed through the lens of each of our two scenarios.

- **What will be the impact on the downstream industry and when will peak oil demand arrive?** Could that come in the next decade? How will gasoline and diesel demand be affected? How much oil refining investment will be needed? How will refining utilization and margins be shaped by long-term, sustained falling demand? Will there be major differences in demand and refining needs across regions? For example, could Europe see greater rationalization while India needs more investment in refining? How will the retail sector for fuels be affected?

- **How will autonomous vehicles impact and reshape the energy industry?** How quickly will autonomous vehicles come onto the market and be adopted? What impact will autonomous vehicles have on vehicle miles traveled and energy consumption? Will these vehicles be fueled by gasoline or electricity?

- **How will crude oil prices be impacted by changes in the automotive industrial eco-system?** Will prices ever reach the $100 level again? If oil demand growth weakens, or even peaks, does that mean oil prices will be permanently low?

- **Upstream implications: What will the global oil supply curve look like?** Will potential changes in the energy of choice for cars have an impact on where oil and gas is produced? Will the cost of production be the sole determinant of success in the upstream industry? Or will integration with downstream markets and environmental variables come into play?

- **What will be the balance between gasoline and diesel, and can natural gas expand its niche in transportation?**

How will changes in mobility impact the future of oil demand?

Electric power industry: Big questions and choices

Electric power companies will see changes in their businesses both from increases in transportation demand and advancements in battery technology. With electricity as a transportation fuel source, the old paradigms of stationary predictable points of consumption and metering will become blurred. Our two scenarios frame the exploration of these implications for the electric power industry.

- **Will electric cars boost the outlook for electric power companies?**
  How much additional electric power demand will come from electric cars? What will be the additional costs for the shift to electric vehicles, and who will bear? Will new business opportunities emerge beyond power supply to leverage customer relationships deeper into transportation? And will electric cars influence the type of energy used to generate power and how they are operated?

- **Will there be a new role and expectations of the electric power industry in reducing carbon emissions from transportation?**
  How will this impact carbon emission reduction policy from power generation? How will regulations evolve with this new load and how do they interact with other technological evolutions occurring such as distributed energy resources? Who is the customer and what are the evolving needs and relationships with these customers?

- **How will electric vehicles help shape a new paradigm of a more distributed electric power system?**

- **What will be asked of the electric grid infrastructure and how will it evolve?**
  Are established grids or new grid infrastructure more accommodating? How will transportation driven battery development change the utility business from customer services to grid design and operation?

Chemical industry: Big questions and choices

Chemical companies are expected to face a new feedstock picture as the energy industry responds to the changing mix and volumes of its products used to power the future automotive industry. It will also face a changing demand pattern in one of its largest end–user demand segments, brought about by alterations in automotive design, production volumes, and manufacturing technology. We address the impact that these two major changes are expected to have on the feedstocks used in olefins production and resulting industry profitability, as well as the demand outlook for the major materials products that the chemical industry provides to the global automotive supply chain.

- **What will the changes in the energy sources powering automotive transportation mean to the supply of feedstock to the chemical industry?**
  How will the relative competitiveness of petrochemical feedstocks (e.g., naphtha, NGLs, natural gas, and coal) compare? How will the changes in feedstock availability impact operating rates and margins for key petrochemical products in each region? How will high-cost producers (regional price setters) change their behavior?

- **What will be the impact of changing feedstocks on chemicals production?**
  How might regional production and future regional investment be affected? What will be the impact on regional operating rates and trade patterns? What will be the impact on production of cracker coproducts? What role will on-purpose production of propylene and butadiene play in supplementing supply and setting prices?

- **How will design changes in the automotive sector affect the demand for chemicals and materials such as thermoplastic polymers and synthetic elastomers?**

- **What are the strategic implications for the chemical industry's structure and participants?**
  What regional investment opportunities will emerge? Will certain asset types, business models, or regions become advantaged or disadvantaged? How will these resulting changes affect regional trade? What actions should participants at each position along the value chain take to further their best interests? Which regions, value chains, and participants might benefit the most from the future scenario? Which might feel the biggest strain?

Study Deliverables

Summary and Data Deliverables

- Data sets for Autonomy and Rivalry scenarios to 2040
- PPT final report which accompanies the data sets
- Report Reinventing the Wheel: the Future of Oil, Cars, Chemicals and Electric Power
- Workshop Materials from wrap up session
- Mobility Modeling Detail and Slides
- Supplemental Slides: Background on Powertrain Choices
- Data: LDV sales and fleet by 6 mobility channels:
- Data: LDV sales and fleet by 7 powertrain breakouts:
- Data: Total miles travelled for personal vehicles and Mobility as a Service (MaaS)
- Data: Average new and on road fleet fuel economy for personal vehicles and MaaS
- Data: Fuel demand by mobility channel;
- Data: EV battery cost assumptions and timeline for both scenarios
- Data: Energy prices (nominal and real)
- Data: Crude oil prices, wholesale gasoline and diesel prices, natural gas, retail electricity prices

Energy Industry Strategy Deliverables

- Fuel demand: the impending peak in crude and refined product demand
- Shape of global supply curve and impact on oil producers
- Implications for downstream operations and investments
- Characteristics of refiners who survive and thrive
- Additional growth opportunities for oil and gas companies in the face of falling LDV oil demand?
- Power demand analysis
- Data Set for Energy Industry Analysis

Chemical Industry Strategy Deliverables

- Chemical Workshop Management-Style Presentation
- Data File: Impact of changing feedstocks on chemicals - Demand, Supply, & Price
- Data File: OEM and aftermarket demand for plastics and chemicals in the LDV sector
- Materials Analyzed: Naphtha, NGLs, and Natural Gas Feedstocks; C2, C3 and C4 Olefins; BTX Aromatics; Methanol; Monoethylene Glycol; Polyethylene and Polypropylene; Engineering Plastics, Synthetic Elastomers, Polyurethanes

Automotive Industry Strategy Deliverables

- A new business dynamic: Vehicle market structure and Mobility business models
- Structural Change Ahead: Impact on vehicle manufacturing and the supply chain

Biographies

Daniel Yergin, Project Chairman

Daniel Yergin is a highly respected authority on energy, international politics, and economics. He is Vice Chairman of IHS Markit and cofounded IHS Cambridge Energy Research Associates®. In selecting Dr. Yergin as one of the "hundred people who mattered" worldwide, *Time* magazine said, "If there is one man whose opinion matters more than any other on global energy markets, it's Daniel Yergin." *Fortune* said that he is "one of the planet's foremost thinkers about energy and its implications."

A Pulitzer Prize winner, Dr. Yergin is the author of the recent bestseller *The Quest: Energy, Security, and the Remaking of the Modern World. The Quest* has been called "a masterly piece of work" by *The Economist* and was described by the *Financial Times* as "a triumph." Dr. Yergin is known around the world for his book *The Prize: The Epic Quest for Oil, Money, and Power*, which was awarded the Pulitzer Prize. It became a number one *New York Times* best seller and has been translated into 17 languages. Of Dr. Yergin's book *The Commanding Heights: The Battle for the World Economy*, which has been translated into 13 languages, *The Wall Street Journal* said, "No one could ask for a better account of the world's political and economic destiny since World War II." Both *The Prize* and *Commanding Heights* were made into award-winning television documentaries for PBS and BBC.

Dr. Yergin was awarded the United States Energy Award for "lifelong achievements in energy and the promotion of international understanding." In 2014 India's prime minister presented him with a Lifetime Achievement Award, and the US Department of Energy presented him with the first James Schlesinger Medal for Energy Security. Dr. Yergin chaired the US Department of Energy Task Force on Energy R&D. He is a member of the National Petroleum Council, a trustee of the Brookings Institution, and a director of the United States Energy Association and the director of Council on Foreign Relations. He is a member of the Advisory Board of the Massachusetts Institute of Technology Energy Initiative and Singapore's International Energy Advisory Board. He holds a BA from Yale University and a PhD from Cambridge University, where he was a Marshall Scholar.

James Burkhard, Project Director

James Burkhard is Chief of Research for Global Crude Oil Markets and Global Energy Scenarios. Mr. Burkhard leads the team that analyzes and assesses the global crude oil market and changes in the oil industry's competitive environment. He also leads the development and delivery of the IHS Markit global scenarios that cover macroeconomics, geopolitics, and the energy and automotive industries. He is also Vice Chairman of CERAWeek, the prestigious global energy conference. He holds a BA from Hamline University and an MS from the School of Foreign Service at Georgetown University.

Tom De Vleesschauwer, Project Director

Tom De Vleesschauwer leads the Automotive Transport & Mobility group at IHS Markit, where he also directs the long-term planning and sustainability activities. He has led many special projects assessing technical, business, regulatory, and societal trends, and is the author of numerous contributions to automotive publications among which was *Automotive Agenda—Urbanisation Special: What is the role of the car in the city of tomorrow.* He is certified by the Institute of the Motor Industry and holds an HBO Automotive Management from IVA Driebergen, BBA from Northwood University, and an MBA from the Cardiff Business School.

Atul Arya, Project Advisor

Atul Arya is Chief Energy Strategist at IHS Markit. His research interests include oil markets, energy transitions, climate change, renewables and strategies of energy companies. He has led a number of research and consulting teams at IHS Markit. Atul previously worked for BP for over 20 years in a number of operational, business, technical and strategic positions around the world, including Head of Strategy. His experience includes leadership in solar energy development as well as oil and gas and technology strategy. Atul holds Ph. D. in petroleum engineering from the University of Texas.

Tim Armstrong, Project Advisor

Tim Armstrong is Vice President of Forecast Planning for the Automotive group at IHS Markit. He is responsible for syndicated automotive research and analysis worldwide. Mr. Armstrong has 25 years' experience in forecasting, analysis, and management, originally specializing in emerging markets. He holds bachelor's degrees from Murdoch University and Curtin University and a Master of Economics from the University of Western Australia.

Jamey Rosenfield, Project Advisor

Jamey Rosenfield is cofounder with Daniel Yergin of IHS Cambridge Energy Research Associates and Co-chair of CERAWeek— the world's leading senior global energy gathering, which he has overseen since its inception in 1983. He also leads strategic initiatives and multi-stakeholder dialogues, including the recent *Fueling North America's Energy Future, The Unconventional Gas Revolution and the Carbon Agenda*, and *America's New Energy Future.* He was Senior Fellow at the Center for Business and Government at Harvard, received his undergraduate education at Harvard College, and holds an MBA from Boston University.

Dave Witte, Project Advisor

Dave Witte leads the Midstream, Refining and Chemical business line at IHS Markit. This Business Line reflects the combined capabilities resulting from the acquisition of the industry-leading companies such as CERA, CMAI, Purvin & Gertz, PFC, Stanford Research Institute and others. He directs the groups' activities and provides strategic insights and advice to leading energy and chemical companies' senior management and Boards. Mr. Witte holds a BS degree from Louisiana State University.

Kate Hardin, Commercial Director

Kate Hardin is a Senior Director with IHS Markit and has led several IHS Markit analytics teams, including Russian and Caspian Energy Analysis and Global Institutional Investor Research. Prior to joining IHS Markit, Ms. Hardin was an energy consultant with PricewaterhouseCoopers, advising on power sector privatization throughout Russia and the Caspian region. Ms. Hardin holds a BA from Wesleyan University, an MA from Yale University and an MBA from Yale School of Management.

Bjoern Huetter, Commercial Director

Bjoern Huetter is a Product Manager in the Automotive group at IHS Markit, where he coordinates and implements product releases and enables go–to–market readiness. Prior roles at IHS Markit include key account management and forecasting European light vehicle production. Mr. Huetter holds a Bachelors degree in Marketing and graduated a Master of Science in International Business with distinction at Leicester Business School.

Anthony J. Palmer, Commercial Director

Anthony J. Palmer is Vice President in the Chemicals group at IHS Markit where he is responsible for the East and West Coast operations of the Americas Chemical Consulting Group. Mr. Palmer directs engagements for clients with interests in the business, technical, and financial aspects of the chemicals, plastics, and related process industries. Mr. Palmer holds both Bachelors and Masters Degrees in Chemical Engineering from Manhattan College, and an MBA in Finance and International Business from Fordham University.

Chelsea Havill, Project Manager

Chelsea Havill, Project Manager for *Reinventing the Wheel*, is a member of the Energy-Wide Perspectives team at IHS Markit, which delivers energy scenarios, integrated modeling, carbon and climate analysis, and other analysis that extends globally across energy sectors. She has held both analytical and commercial roles at IHS Markit, including project managing the recent webinar series entitled, *The Great Shakeout: Strategies for an Uncertain World*. She holds a BA from Furman University and an MBA from Babson College.

IHS Markit forecast models and datasets provide a rigorous foundation for *Reinventing the Wheel*

IHS Markit provides a deep and broad foundation for business-critical decisions through some of the most comprehensive and technical industry insights available over a wide geographic scope. The automotive, energy, electric power and chemical insight services allow clients to create robust, flexible strategies and make informed decisions in the face of inevitable and unforeseeable change. We bring together the insights of IHS Markit experts and analysis with world-class databases and models. Below are some of the models and datasets that will be used in *Reinventing the Wheel.*

Automotive models and datasets

- ***Light Vehicle Sales Forecast*** provides detailed and accurate insights with regards to global vehicle sales outlooks. The forecast offers unparalleled insights to inform original equipment manufacturers (OEMs), suppliers, financial institutions, government agencies, and other stakeholders for critical business decisions.

- ***China Province Forecast*** provides a vehicle sales forecast for the 31 China provinces. Based on registration actuals, IHS Markit has a unique ability to forecast macroeconomic data at the provincial level and for major metropolitan areas to produce critical planning insights.

- ***Light Vehicle Production Forecast*** provides vehicle production forecast insight to suppliers and auto manufacturers, allowing them to evaluate production capacity and utilization as well as validate volumes for request for quote responses and business planning needs.

- ***Light Vehicle Powertrain Forecast System*** provides industry stakeholders with engine and transmission forecasts, which can also be combined with the *Alternative Propulsion Forecast, Driveline Module, or Component Forecasts* to enable seamless analyses across all powertrain systems.

- ***Vehicle Performance & Compliance Monitor (VPaC)***, in partnership with Novation Analytics, provides critical insight into the single greatest area of research and development in automotive. Starting with a view into OEM fleets and competitive CO_2 performance, VPaC identifies who will strike the best balance between performance and emissions (by brand, segment, or model line) and which OEM may face financial penalties. VPaC offers a one-stop shop for vehicle performance and compliance insight.

Oil and gas models and datasets

- ***Global Energy-Economy Model*** is IHS Markit's own in-house energy balance model, which covers 113 countries with 60 regional aggregates that cover the entire world. Full energy balances cover 29 sectors and 34 fuels for each country annually from 1990 to 2040. Econometric time series and stock models are based on EViews software that links with other modeling outputs and a global gas trade model to produce a comprehensive global energy outlook that is used in IHS Markit Global Scenarios analysis and projections. A front-end application has been developed that links all of these elements and stores the results in an SQL Server. In this way, it creates a centralized system that enables multiple, simultaneous use by end users.

- ***IHS Markit proprietary LDV energy demand models*** take vehicle sales volumes across 10 LDV segments and forecast powertrain adoption, vehicle fuel economy, miles traveled, on-road vehicle fleet volumes, and fuel demand by fuel type globally.

- ***IHS Vantage***® leverages world-class tools, proprietary IHS Markit E&P data, industry intelligence, and a transparent methodology to support complex upstream commercial planning, making it possible to analyze over 15,000 global assets including undeveloped discoveries modeled at project and phase level.

- ***Performance Evaluator*** provides unique well-by-well insight into the shale oil industry, its cost structure, and output under different scenarios.

Electric power models and datasets

- ***Regional Electric Demand Models*** broken down by sector and drivers, including technology.

- ***Regional Power Supply and Price Models*** incorporating fuel supply and plant investment and operations economics as well as local resources and policies.

- ***Technology Evolution Models*** for power generation covering gas, wind and solar plant performance and cost.

- ***Demand by sector*** by country in Europe through 2040.

- ***LCOE evolution*** for CCGT and renewable power.

Chemicals models and datasets

- ***Chemical Capacity Dataset.*** IHS Markit's in-house dataset to manage capacity data information is an extensive proprietary program called Commercial Analysis & Planning System (CAPS). CAPS uses capacity information to establish how much of a chemical material can be produced or consumed in a country or region, who the major producers of each product are, and how the industry has changed in terms of ownership. This database contains existing and planned capacity, where planned capacity is either under construction or announced for completion over the next five years.

- ***Chemical Supply/Demand Forecasting Model.*** IHS Markit's in-house model for historical and forecast demand for basic petrochemicals, such as ethylene, propylene, and benzene, is based on preparing demand and production forecasts for all of the derivatives. The production data generated on a country basis are fed back into the "intermediate" or "petrochemical" balances in order to derive demand for these products.

- ***Chemical Pricing & Margin Forecasting Model***. IHS Markit's in-house dataset and model used in the development of chemical product price forecasts is based on a production cost forecast, a margin/profitability forecast, and, where applicable, a forecast of tariffs. IHS Markit's price forecast methodology provides a cycle forecast for one future cycle, generally five to seven years, and then reverts to a trend forecast for the long term based on a margin high enough to provide sufficient return to encourage investment in additional capacity as required to meet demand growth.

For more information about *Reinventing the Wheel:*

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IHS Markit™

About IHS Markit

IHS Markit (Nasdaq: INFO) is a world leader in critical information, analytics and solutions for the major industries and markets that drive economies worldwide. The company delivers next-generation information, analytics and solutions to customers in business, finance and government, improving their operational efficiency and providing deep insights that lead to well-informed, confident decisions. IHS Markit has more than 50,000 key business and government customers, including 85 percent of the Fortune Global 500 and the world's leading financial institutions. Headquartered in London, IHS Markit is committed to sustainable, profitable growth.

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