CHEMISTRY THAT MATTERS™

PLASTICS IN THE AUTO INDUSTRY, TODAY AND INTO THE FUTURE

PRESENTATION TO THE NATIONAL ACADEMY OF SCIENCES, FUEL ECONOMY COMMITTEE

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PREFACE

In preparation for the NASEM Fuel Economy Committee – Phase 3, SABIC prepared the following information in response to the request to provide input on the **feasibility, cost, mass reduction, safety** and **research** required to bring mass saving technologies to widespread industry adoption.

These pages detail technologies available today and those in development to reduce vehicle mass, improve fuel economy and reduce green house gas emissions.

- An implementation timeline is used as a surrogate for **feasibility and research**.
  - **Optimizing existing technologies** are applications that are in production today and are the focus off continuous mass optimization and parts integration
  - **Short-term technologies** are applications that are in production today or could be in production within the next 3 years.
  - **Medium-term technologies** are those that may be available between 3-7 years and may require additional research and development to reach full scale production.
  - **Long-term technologies** may require more than 7 years to reach production and require extensive research and development.
- **Cost** is not discussed in this document, and is left to companies further down the supply chain.
- **Mass savings** are calculated from a combination of specific gravity difference between the incumbent materials and production materials, as well as, design dependent structural considerations and functional integration.
- Many, if not most, of the applications identified in this document require some level of **safety**. Detailed presentations can be provided at a later date if requested.

GLOBAL AUTOMOTIVE MARKET TRENDS AND NEEDS

CO2

LIGHTWEIGHT

MEETING REGULATIONS

AESTHETICS

SAFETY

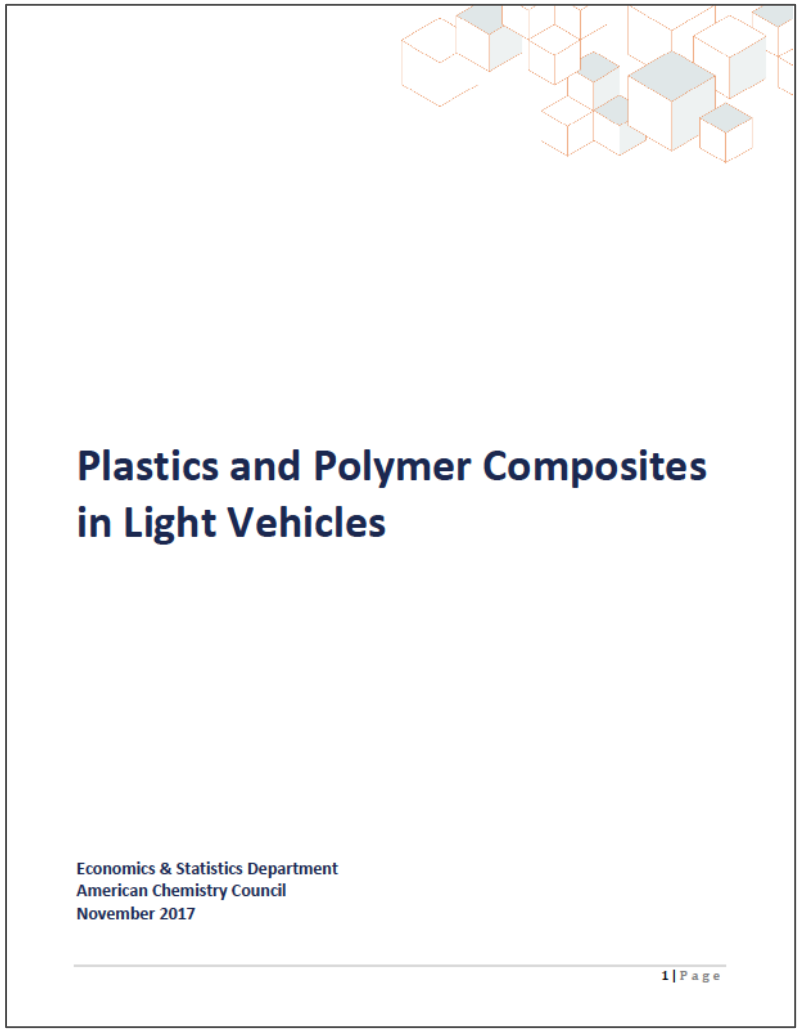
EV/HEV

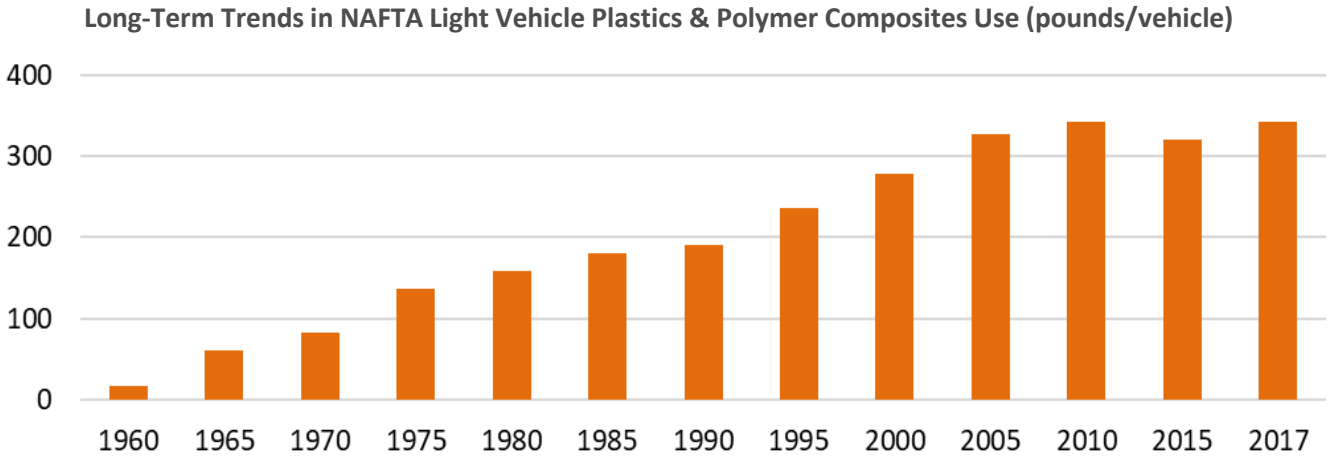
AUTONOMOUS

COST COMPETITIVE

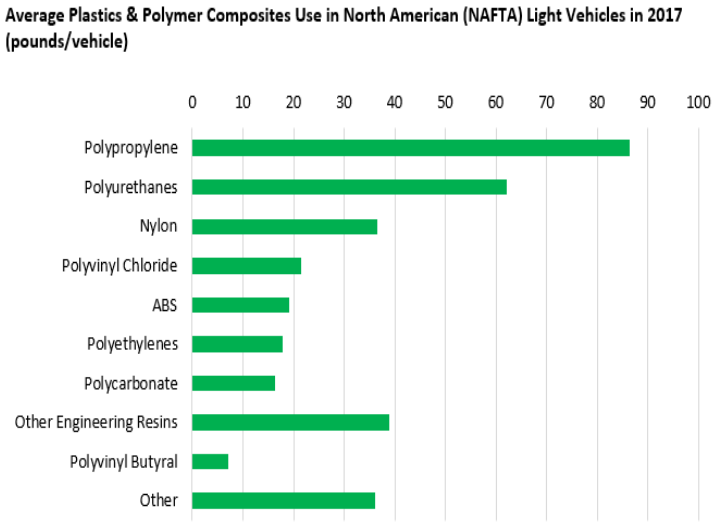
Collaborate to reach the best balance between performance, weight and cost.

GROWTH IN PLASTICS





Note: Data are for the US and Canada only. Mexico is excluded.



Source: ACC Report: Plastics and Polymer Composites in Light Vehicles – July 2018 prepublication

TECHNOLOGY OUTLINE

Optimizing existing applications

- Instrument panels
- Door modules
- Front end modules
- Tailgate inner structures
- Bumper fascias
- Exterior trim
- Interior trim
- Rear quarter window

Short-term technologies

- Floor rocker reinforcement
- B-pillar reinforcement
- Battery protection solutions
- Instrument panel core back molding
- Moving side window
- Fixed front quarter window
- Panoramic roof
- Windscreen

Mid-term technologies

- Instrument panel cross car structure
- Composite B-pillar
- Composite hybrid molding
- Backlight with defroster
- Fixed rear quarter window with integrated lighting
- All-plastic liftgate

Long-term technologies

- Transparent front panel
- Retractable moon roof

OPTIMIZING EXISTING TECHNOLOGIES

OPTIMIZING EXISTING TECHNOLOGIES

The technologies identified on the following pages represent automotive applications that:

- Have been produced for serial production with an automotive OEM

Mass savings from these applications are calculated from a combination of specific gravity difference between the incumbent materials and production materials, design dependent structural considerations, and functional integration

WEIGHT SAVINGS FROM COMMERCIALIZED SEMI-STRUCTURAL PARTS

Instrument panels

Existing

Current design
Thermoplastic olefin (TPO)
Mass = 2.8 kg

Status - Commercial
Replaced TPO at 3.0 mm with LGF PP resin at 2.0 mm

Mass savings
- Up to 30% mass savings
- 1 kg per vehicle savings

Door modules

Existing

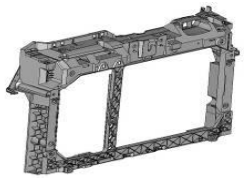
Current design
Steel stamping
Mass = 1.5 kg

Status - Commercial
Optimization of part geometry thru predictive simulation and using LGF PP resin

Mass savings
- Up to 33% mass savings
- 0.5 kg per door
- 2.0 kg per vehicle savings
- 20 parts integrated into 1

Front end module

Existing



Current design
Steel
Mass = 6 kg

Status - Commercial
Multiple vehicles on road with FEMs molded in LGF PP resin replacing multi-piece metal stamping parts

Mass savings
- Up to 35% mass savings
- 2 kg per vehicle savings
  Reduced number of components from 17 to one

Tailgate inner structure

Existing

Current design
Metal (steel) stamping
Mass = 6 kg tailgate inner

Status - Commercial
Commercialized in plastic tailgates and translated on partial plastic tailgate solutions (inner or outer)

Mass savings
- Up to 40% weight savings compared to metal
- Component integration
- Inner trim panel
- Potential assembly cost savings

WEIGHT SAVINGS FROM COMMERCIALIZED AESTHETIC AND TRIM PARTS

Bumper Fascia

Existing

Status - Commercial
Bumper Fascia optimization continues to progress with thinwall, low density, and emission optimized mineral filled TPO's.

Current design
Talc filled TPO
Mass = 4.0 kg

Mass savings
- Up to 25% mass savings
- 1 kg per vehicle savings
- Can contribute to lightweighting, improved aero, lower emissions

Exterior trim

Existing

Status - Commercial
Advanced mineral fillers for PC/ABS enable low CLTE for metal replacement. Maintains OEM gap & flush requirements while meeting mechanical property and aesthetic requirements.

Current design
Steel
Mass = 5 kg

Mass savings
- Up to 50% mass savings
- Up to 2.5 kg per vehicle savings

Interior Trim

Existing

Status - Commercial
Part optimization continues with respect to thin-wall mass reductions for TPO and Engineering resins. Advanced materials enable further lightweighting through part consolidation

Current design
Molded in Color TPOs
PC/ABS and ABS Trim

Mass savings & innovation
- Up to 10% mass savings
- Low density high scratch TPO's for lightweight durability

Rear quarter window

Existing

Status - Commercial
OEM replaced glass with polycarbonate resin to achieve:
- weight saving
- integrated pillars
- aerodynamic functionality

Current design
Glass
Mass = 2*4.0=8.0 kg/vehicle

Mass savings
- 30% to 50% mass savings
- 3.2 kg/vehicle saving (40%) per vehicle savings

SHORT-TERM TECHNOLOGIES
0-3 YEARS

SHORT-TERM TECHNOLOGIES

The technologies identified on the following pages represent automotive applications that:

- Have been produced for serial production, or
- Have been validated with an automotive OEM and meet the specifications of that OEM
- Are applications expected to be in production within the next 0-3 years

Mass savings from these applications are calculated from a combination of specific gravity difference between the incumbent materials and production materials, design dependent structural considerations, and functional integration

WEIGHT SAVINGS FROM PARTS COMMERCIALIZED, VALIDATED OR PROTOTYPED FOR STRUCTURAL AND SEMI-STRUCTURAL APPLICATIONS

Floor rocker reinforcement

Short term

Status –Commercial
Innovative, lightweight and efficient energy absorbing plastic/metal hybrid elements for floor rocker reinforcement that can enhance side crash performance

Current design
High strength steel
Mass = 1.2 kg each x 2

Mass savings
- Up to 45% mass savings potential
- 1.1 kg per vehicle savings
- Can improve assembly: E-coat capable, no structural adhesive

B-pillar reinforcement

Short term

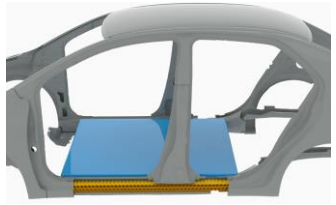
Status – Validated (prototype)
Innovative, lightweight and efficient energy absorbing plastic/metal hybrid elements for B-pillar reinforcement that can enhance side crash and roof crush performance

Current design
High strength steel
Mass = 1.6 kg each

Mass savings
- Up to 30% mass savings potential
- 0.5 kg per vehicle savings
- Can improve assembly: E-coat capable, reduced components, no adhesives

Battery protection solutions

Short term



Status – Validated (prototype)
A structural hybrid solution, using both plastic and metal, to produce a lighter reinforcement part and one that can potentially improve crash performance

Current design
High strength steel
Mass = 40 kg per vehicle

Mass savings
- Up to 50% mass savings potential
- 20 kg per vehicle savings
- Can improve assembly: E-coat capable, reduced components, no adhesives

Instrument panel core back molding

Short term

Status – Commercial
Injection Molding Structural Foaming with Core-back process. Molded at 1.9 mm before foaming to 4.0 mm

Current design
Injection molded plastics
Mass = 3.5 kg

Mass savings
- Up to 15% mass savings potential
- 0.5 kg per vehicle savings
- Low Volatile Emissions, meeting VDA 278 specification

WEIGHT SAVINGS FROM PARTS COMMERCIALIZED, VALIDATED OR PROTOTYPED FOR GLAZING APPLICATIONS

Moving side window

Existing

Current design
Glass
Mass = 7.8 kg

Status – Commercial
OEM replaced glass with polycarbonate resin to achieve:
- First movable side window
- Weight saving
- Windows rail integration

Mass savings
- Up to 33% mass savings potential
- 2.6 kg/vehicle saving per vehicle savings
- Can contribute to HVAC load reduction

Fixed front quarter window

Short term

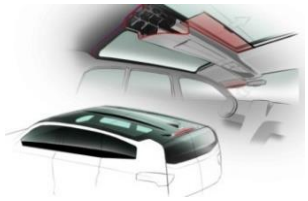
Current design
Glass
Mass = 1.0 kg

Status – Validated
OEM replaced glass with polycarbonate resin to achieve:
- Weight saving

Mass savings
- 30% to 50% mass savings potential
- 0.3 kg/vehicle saving per vehicle savings
- Can contribute to HVAC load reduction

Panoramic roof

Short term



Current design
Glass
Mass = 10 kg each

Status – Commercial
OEM replaced glass with polycarbonate resin to achieve:
- Weight saving
- Aero function
- 3D design

Mass savings
- 30% to 50% mass savings potential
- 3.0 kg/vehicle saving per vehicle savings
- Can contribute to HVAC load reduction

Windscreen

Short term

Current design
Glass
Mass = 15.0 kg

Status – Validated
First front windscreen to replace glass with polycarbonate resin to achieve:
- Weight saving
- Improved aerodynamics

Mass savings
- 30% to 50% mass savings potential
- 4.5 kg/vehicle saving (30%) per vehicle savings
- Can contribute to HVAC load reduction

MEDIUM-TERM TECHNOLOGIES 2021-2025

MEDIUM-TERM TECHNOLOGIES

The technologies identified on the following pages represent automotive applications that:

- Are under development with an automotive tier supplier, and/or
- Are under development with an automotive OEM
- Have significant engineering data available (e.g. crash simulation, impact testing, etc.), such that validation and production launch could occur within the next 3-7 years

Mass savings for these applications are calculated from a combination of specific gravity difference between the incumbent materials and design intent materials, design dependent structural considerations, and functional integration

WEIGHT SAVINGS FROM COMPOSITE MATERIALS IN STRUCTURAL PARTS UNDER DEVELOPMENT

Instrument panel cross car structure

Medium-term

Status – Development
Composite, lightweight, cross car beam molded to replace steel, magnesium or aluminum. Integrated features for steering and center stack

Current design
Steel = 10 to 12 kg
Aluminum = 7 – 9 kg
Magnesium = 5 – 7 kg

Mass savings
- 30% to 60% mass savings potential
- 2.5 – 7 kg per vehicle

Composite B-pillar

Medium term

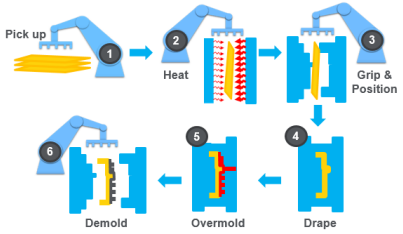
Status – Validated (CAE)
Lightweight composite B-pillar solution meeting side crash, roof crush and durability requirements

Current design
High strength steel
Mass = 3.8 kg each

Mass savings
- Up to 40% mass savings potential
- 3 kg per vehicle savings
- Can contribute to ease of assembly – E-coat, reduced number of components

Composite hybrid molding process

Medium term

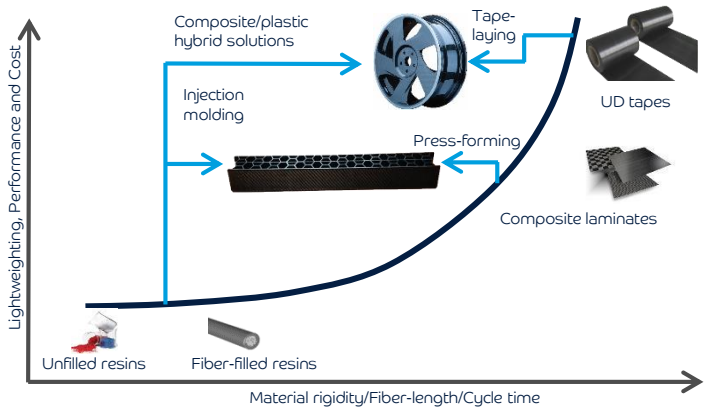


Status – Technology available
Integrated molding of composite plastic hybrids solutions to reduced cycle time

Current Solutions
High pressure RTM for thermoset composites

Advantages
- Reduced cycle time to 1 min
- In mold consolidation of composites

Composite hybrid technology

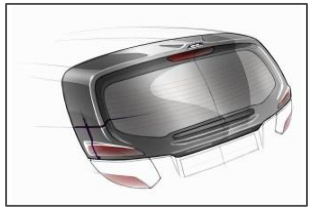


Advantages of Hybrids:
- High strength and stiffness
- High design freedom
- High functional integration
- High degree of automation
- Short cycle times
- Local reinforcement

WEIGHT SAVINGS FROM PARTS UNDER DEVELOPMENT

Backlite with defroster

Medium term



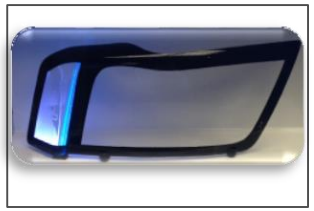
Current design
Glass
Mass = 8.0 kg/vehicle

Status – Validated
Working with OEM to replace glass with polycarbonate resin to achieve:
- Weight saving
- Integrated spoiler
- Pillars / aero function
- Coming next: lighting integration

Mass savings
- 30% to 50% mass savings potential
- 2.4 kg/vehicle saving (30%) per vehicle savings
- Can contribute to HVAC load reduction

Fixed rear quarter window with integrated lighting

Medium term



Current design
Material = Glass
Mass = 2*4.5=9.0 kg

Status - Prototyped
OEM replaced glass with polycarbonate resin to achieve:
- Weight saving
- Integrated pillars
- Aero function
- Lighting integration

Mass savings
- 30% to 50% mass savings potential
- 3.6 kg/vehicle saving (40%) per vehicle savings
- Can contribute to HVAC load reduction

All-plastic tailgate & backlite

Medium term

Current design
Steel, glass, plastic
Mass = 28 kg per tailgate

Status – Validation in process
Working with OEMs to replace glass with polycarbonate resin to achieve:
- Weight saving
- Integrated spoiler
- Pillars / aero function
- Lighting integration
- Backlit logo

Mass savings
- Up to 30% mass savings potential
- 8.4 kg/vehicle saving per vehicle savings
- Can contribute to HVAC load reduction
- Component integration

LONG-TERM >2025

LOOKING FORWARD

Global trends	Mobility challenges	4 trends in automotive / mobility
Environmental challenges	Accidents	**Autonomous** Vehicles drive themselves and replace humans
Urbanization, population growth	Congestion	**Connected** Vehicles exchange data w/ infrastructure / other cars
Shifting global economy	Pollution	**Electrification** Electricity replaces gasoline and diesel fuels
Changing demographics	Consumption	**Shared** Car- and ride-sharing compete w/ ownership
Consumer preferences	Inequality	

LONG-TERM TECHNOLOGIES

The technologies identified on the following pages represent automotive applications that:

- May require a longer time period to develop (more than 7 years)
- Require significant engineering data and validation in order to meet the specifications of automotive OEMs

Mass savings for these applications are calculated from a combination of specific gravity difference between the incumbent materials and design intent materials, design dependent structural considerations, functional integration

WEIGHT SAVINGS FROM PARTS UNDER DEVELOPMENT

Transparent Front Panel

Long term

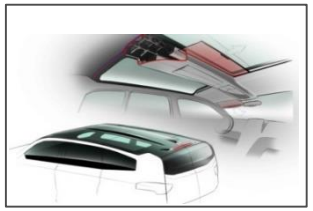
Current design
Plated plastic & Mold in Color Grille

Status - Validation
Absence of ICE powertrain opens door to alternate front end concepts. Electric vehicle front panels incorporating transparent polycarbonate allow for light integration and differentiated styling

Innovation
- Eliminate grille
- Integrated lighting
- Enhanced styling
- Improve safety

Retractable moon roof

Long term



Current design
Glass
Mass = 15.0 kg/Vehicle

Status – Opportunity
Roof module tier1 working with polycarbonate resin to achieve:
- Weight saving
- Window rail integration
- Fixation integration

Mass savings
- 30% to 50% mass savings potential
- 4.5 kg/vehicle saving (30%) per vehicle savings
- Can contribute to HVAC load reduction

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