Coatings and Process Development for Reduced Energy Automotive OEM Manufacturing

DE-EE0005777

PPG, Dürr Systems USA & North Dakota State University

January 1, 2015 – December 31, 2017

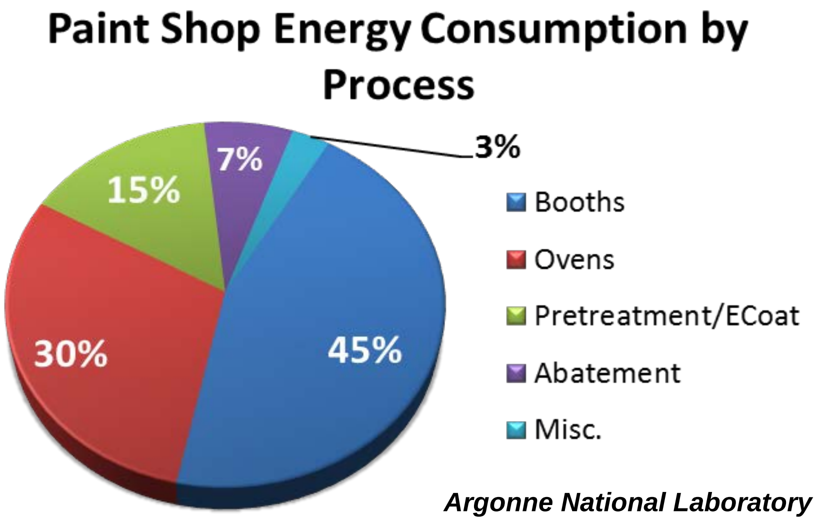
Caroline S. Harris, Ph.D., PPG

U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
June 14-15, 2016

Project Objective

- Develop coatings, processes and facility design to reduce energy consumption in automotive OEM paint shops

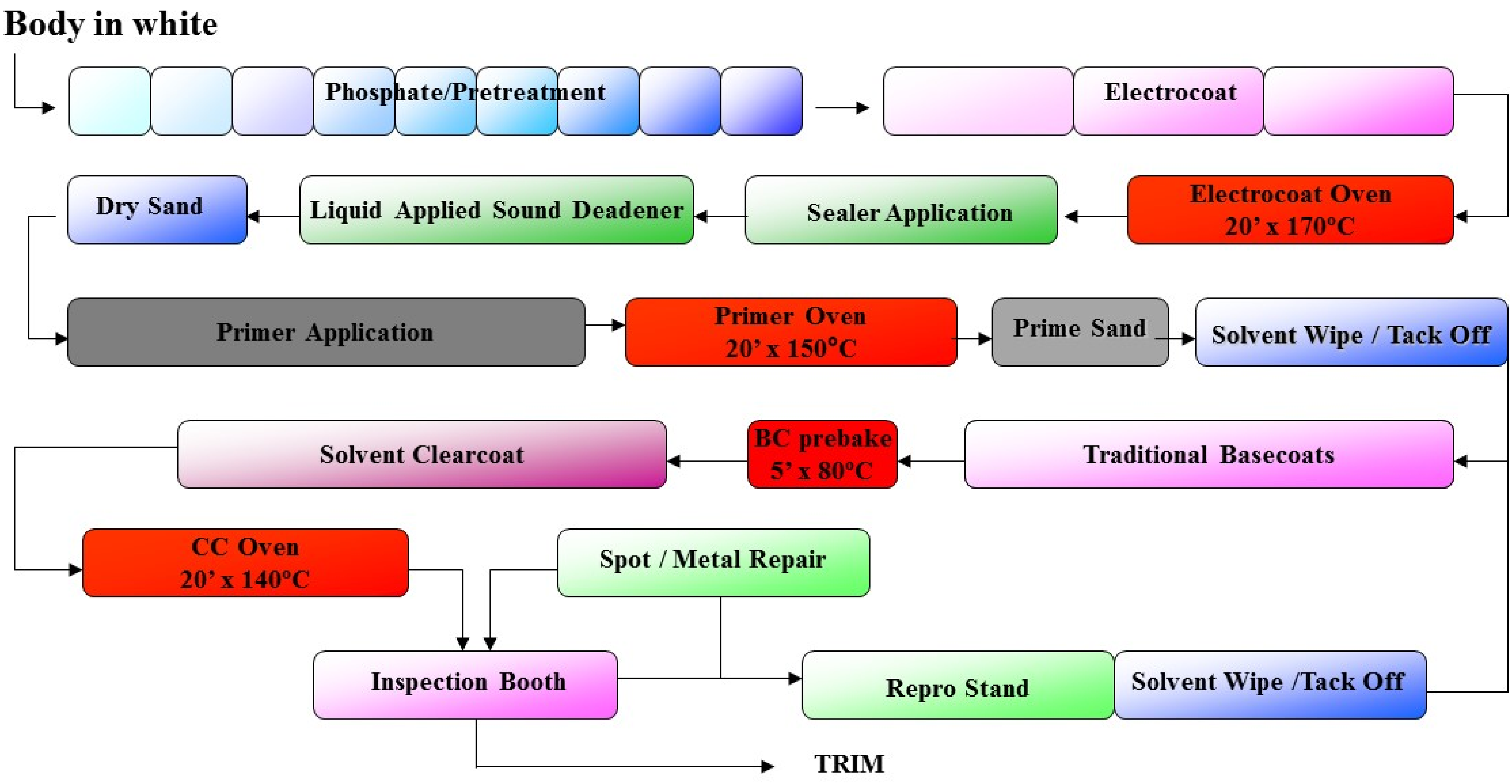
70% of the automotive assembly plant energy is consumed in the paint shop



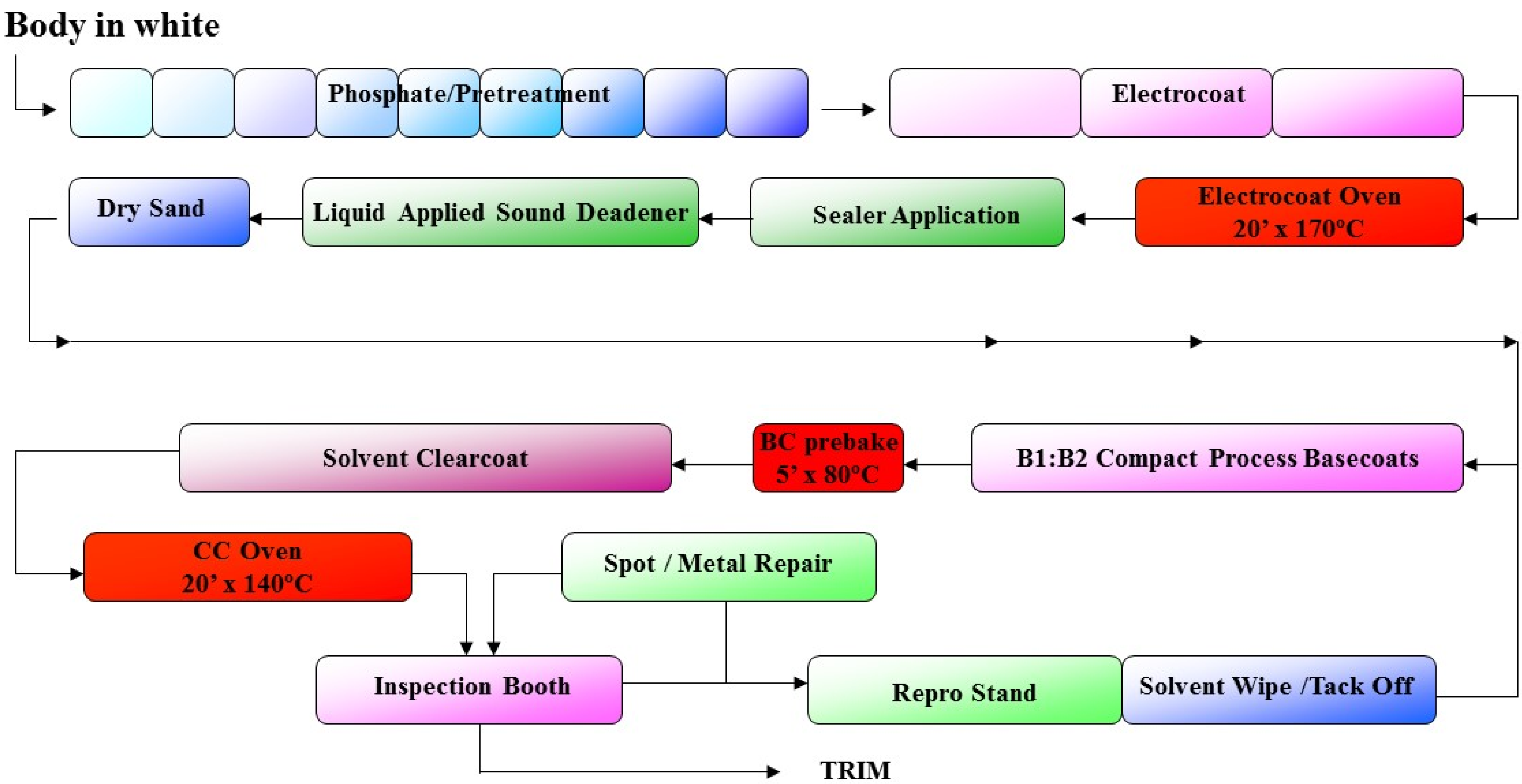
Argonne National Laboratory

- Technical Barriers
  - Maintaining coating properties at lower temperature cure
  - Low temperature cross-link chemistries not commercial
  - Adoption of waterborne technologies and VOC restrictions
  - Process optimization compatibility with “Brownfield” conversion

Technical Innovation – Conventional Process



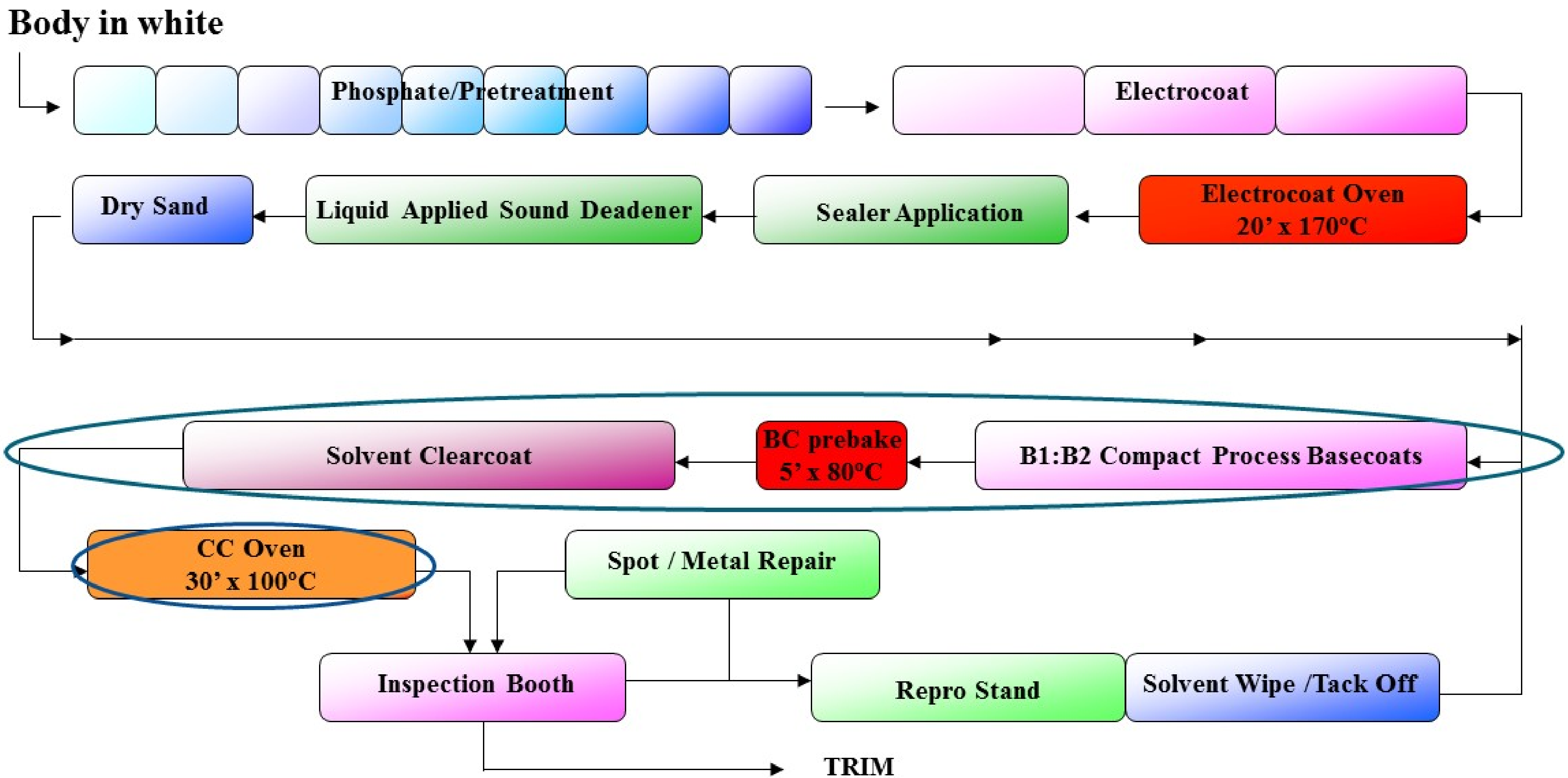
Technical Innovation – PPG B1:B2® Compact Process



Energy Savings – 30%
CO_2 Reduction – 43%
VOC Reduction – 7%
Cycle Time Reduction – 15 minutes

BMW Spartanburg

Technical Innovation – Reduced Energy Process

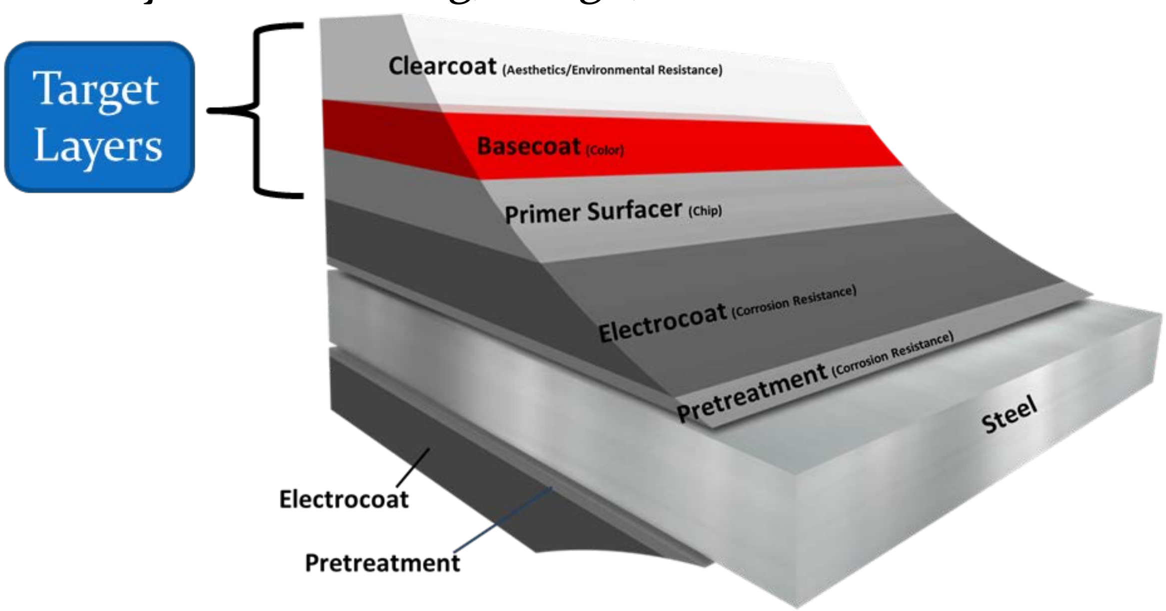


- Lower Oven Temperature
- Reduction in Waste Heat
- Faster Time Between Layer Applications
- Lowers Fresh Air Demand in Oven
- Reduced Temperature/Humidity Control Requirements
- Enable Lightweighting– Temperature Sensitive Substrates

Technical Approach – Low Temperature Cure

Low Temperature Cure Coating

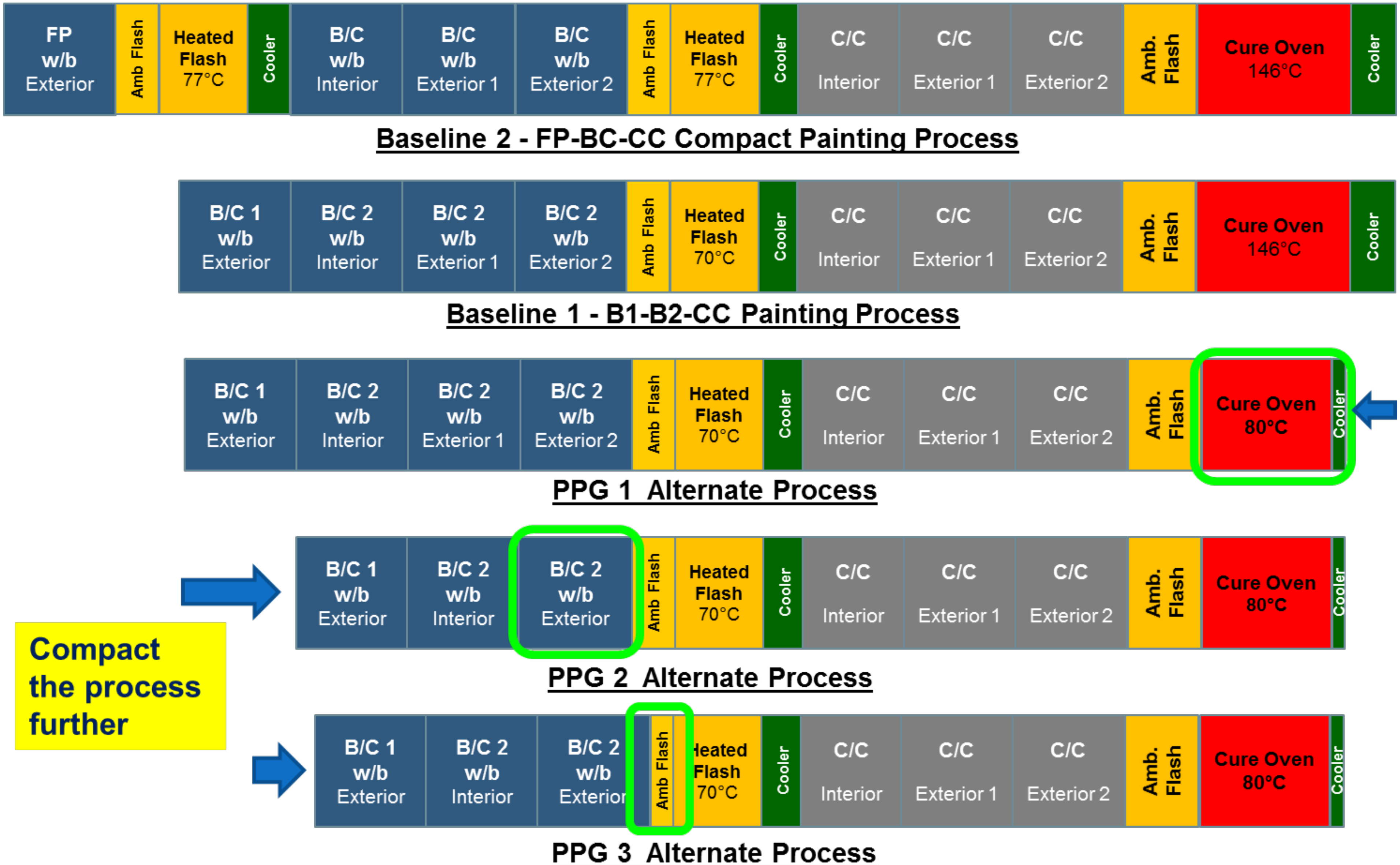
- Development of new low temperature cure polymers and formulas
  - Oven temperature reduction 140°C → ≤100°C
  - Dehydration redesign for smaller footprint, lower energy
- Target layers include; Primer, Basecoat and Clearcoat
- North Dakota State University: High-throughput material analysis
- Dürr Systems Inc.: Application system modeling, design, and fabrication



Technical Approach – Coating System Engineering

- Engineering analysis encompasses
  - Annual energy calculations and costs
  - Capital investment requirements
- Coating System Equipment
  - Applicator design and control
  - Spray booth system – housing, air handling units, particulate scrubber, automation
  - Oven and inter-coat flash/dehydration system – heating and cooling equipment
  - VOC abatement equipment – solvent based spray zones and cure ovens

Technical Approach – Coating System Engineering

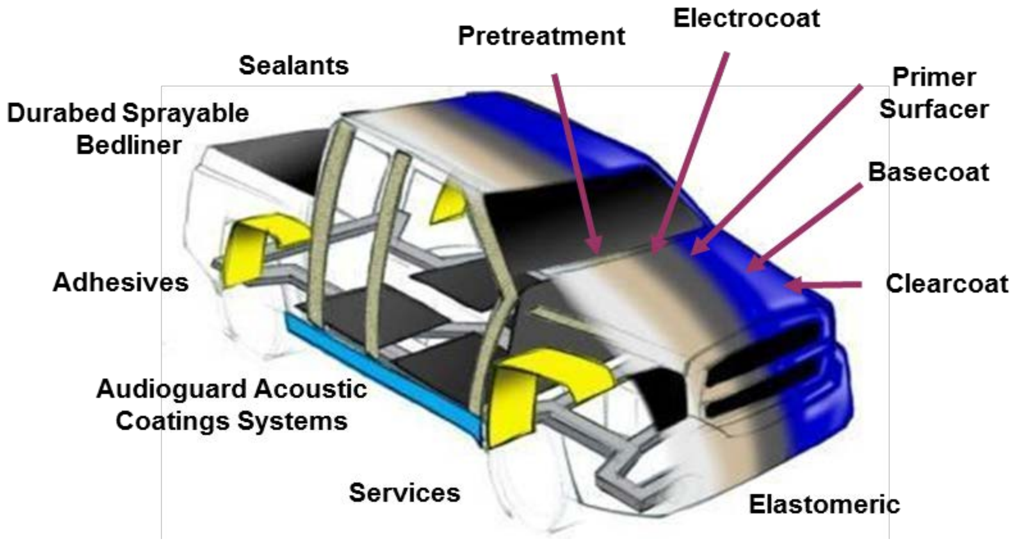


Transition and Deployment

- Automotive Industry

  <u>PPG Innovations</u>

  ❖ Cationic Electrodeposition
  ❖ Powder Clearcoat
  ❖ B1:B2 Process



- Enable application temperature sensitive substrates and lightweighting
- Staged commercialization to manage risk
  - Low temperature application on existing lines
  - Monobooth conversion in target plant
  - Implementation dependent on automotive facility capital depreciation plans

Measure of Success

- Development of low temperature cure topcoat systems that meet stringent automotive performance properties
- Lab scale prototype validation of a consolidated topcoat booth design and associated energy saving
- OEM briefings are included in budget period go/no-go decisions and final deliverables
- Identification of an OEM partner planned for continued development and commercialization

- Project proposal identified 18 TBtu/year savings based on 2012 US vehicle projection
    - Project on track to meet these goals based on BP1 achievements
    - Dürr Systems quantified energy savings of material and process improvements relative to current baseline

Project Management & Budget

BP1
- 15 Mo
- Jan15-Mar16

Develop low temperature cure polymers and formulas

BP2
- 11 Mo
- Apr16-Feb17

Engineering and manufacture of lab scale booth and oven designs

BP3
- 10 Mo
- Mar17-Dec17

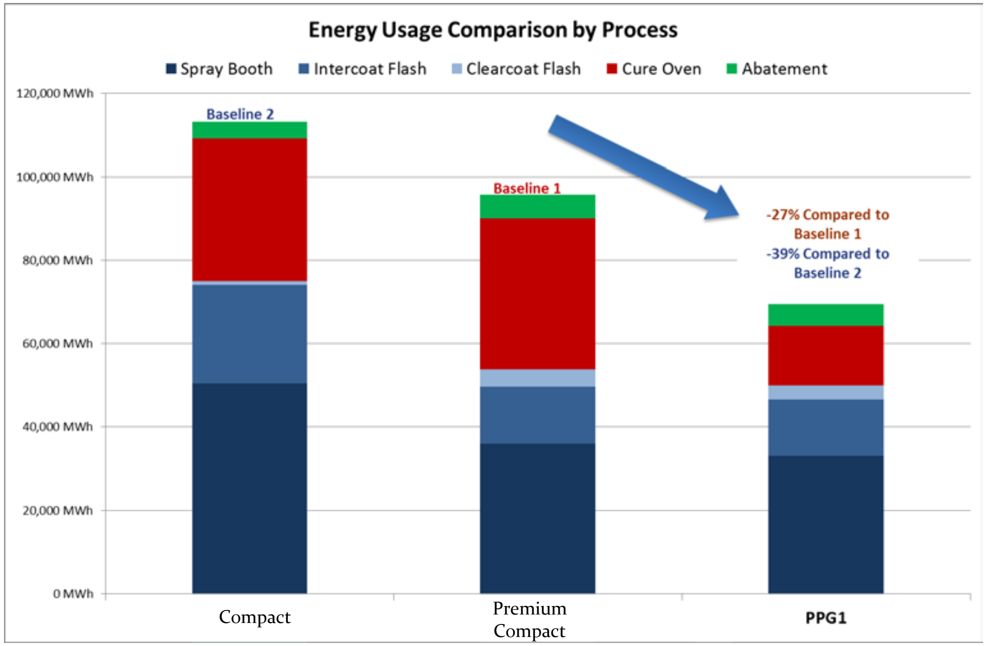
Lab scale validation of materials and process

Title	Milestone	Description	Quarter
Synthesis	M1.1.1 ✓	Physical data on polymer samples	Q1
Initial Formulation	M1.2.1 ✓	Solid color basecoat/clearcoat application	Q2
Monobooth Coatings	M1.3.1 ✓	Metallic color basecoat/clearcoat applications	Q3
Monobooth Process	M1.3.2 ✓	Process variables defined	Q3
Combinatorial catalysts	M2.1 ✓	Catalyst investigations through combinatorial techniques	Q4
Design Principles	M3.3.1 ✓	Coating system design strategies communicated to equipment supplier	Q5
Chemistry Selection	M4.1 ✓	Coating chemistry down-selection	Q5
Combinatorial coatings	M6.1	Coating investigations through combinatorial techniques	Q6
Equipment Design	M7.4.1	Oven/booth equipment requirements defined	Q7
Equipment Fabrication	M7.5.1	Fabrication of lab scale equipment	Q8
Equipment Installation	M9.1	Equipment installation at PPG labs	Q9
Lab Scale simulations	M10.1	Demonstration using newly fabricated monobooth concept	Q10
System Optimization	M11.1	Coating systems demonstrated using optimized equipment and materials	Q11
Final reporting	M12.1	Final Reporting for entire project	Q12

Total Project Budget	
DOE Investment	$2,972,349
Cost Share	$1,273,722
Project Total	$4,246,071

Results and Accomplishments

- Met Go/No-Go criteria for BP1
  - Selected 3 low temperature cure chemistries for the BP2 low-temperature coating
  - Cure at 80 °C in 30 minutes
  - Met BP1 goals for performance parameters, on track for whole-project/OEM performance
- Developed high-throughput screening method; evaluated 140 reactions (48 reactions, 12 catalysts, and four reaction times) for percent conversion (NDSU)
- Completed energy usage calculations (Dürr)
  - 39% reduction compared to a no-bake primer process
  - 27% reduction compared to state of the art compact process



Annual Emission Reductions:
6.3K lb./yr NO_x
4.6K ton/yr CO_2

Annual Utility Operating Cost Savings:
$530K/yr

Capital Cost Savings (Greenfield):
$5.4MM