ANALYSIS
TECHNICAL
ECONOMIC
MARKET
Management
DECISIONS

Robert Eller Associates LLC

CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES

TPEs: IMPACT OF GLOBALIZATION, MARKET SHIFTS, AND NEW TECHNOLOGIES

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PREPARED FOR:

RAPRA TPE 2007
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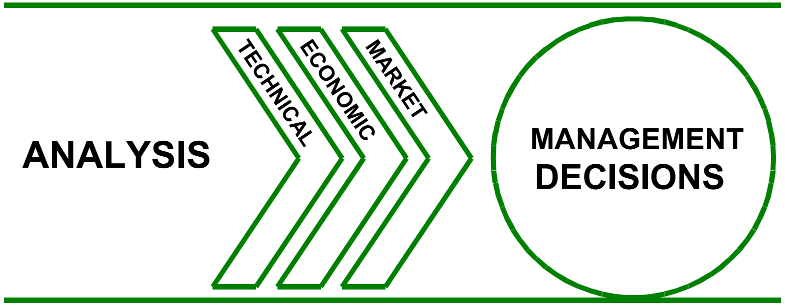
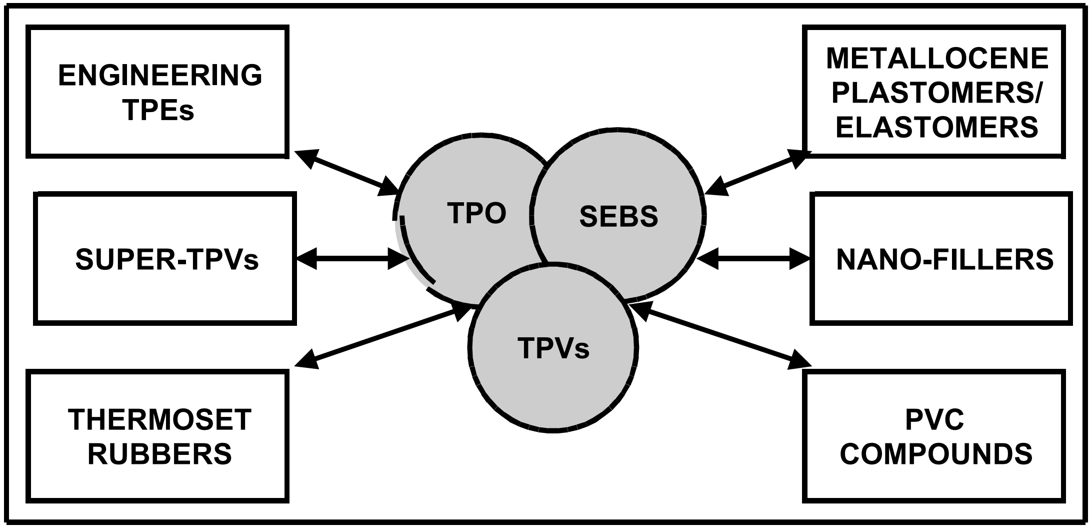
mydox/papers/RAPRA 07.ppt

PRESENTATION OUTLINE

- Globalizing TPE marketplace
- Key TPE marketplace trends
- TPE industry structure shifts
- Expanding properties envelope
- New materials fabrication technologies
- Automotive supply chain implosion effects
- Talc effects
- Body/glazing seals
- The rubber attack
- Non-automotive TPE markets



Specialty Thermoplastic Elastomers . . . Markets, Economics, Technology, Intermaterials Competition



A Europe/U.S./Japan Multiclient Industry Analysis

Completed January 2007

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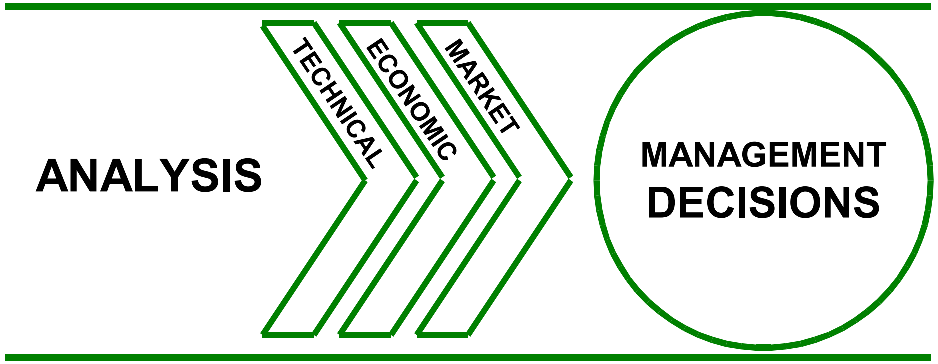
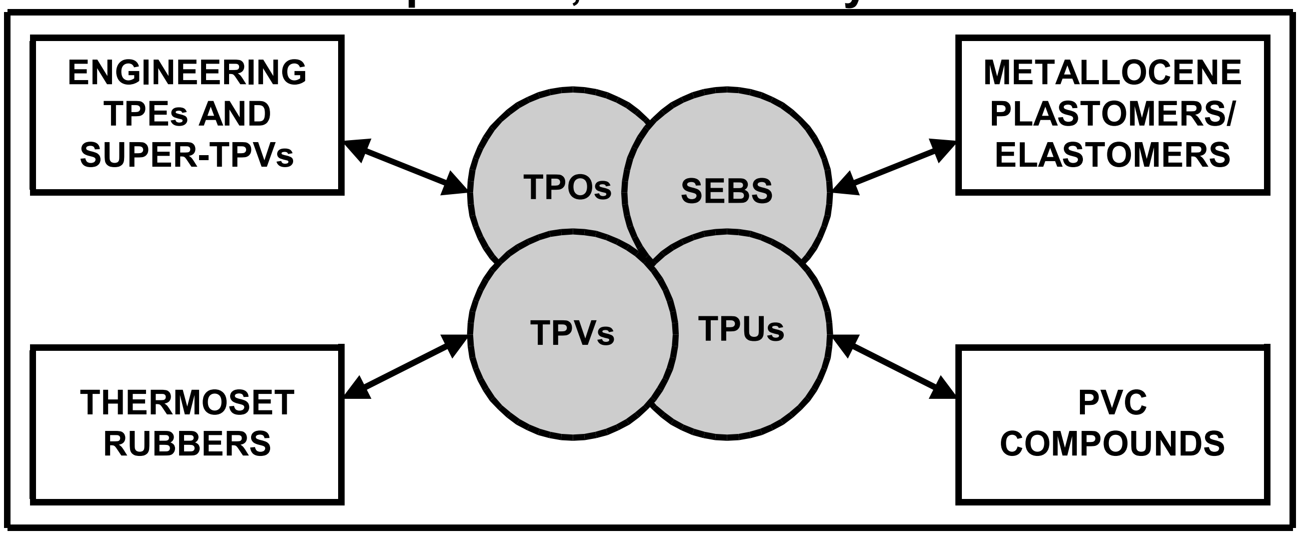


Specialty Thermoplastic Elastomers ... Markets, Economics, Intermaterials Competition, and Industry Structure in China



A China Multiclient Industry Analysis

2006

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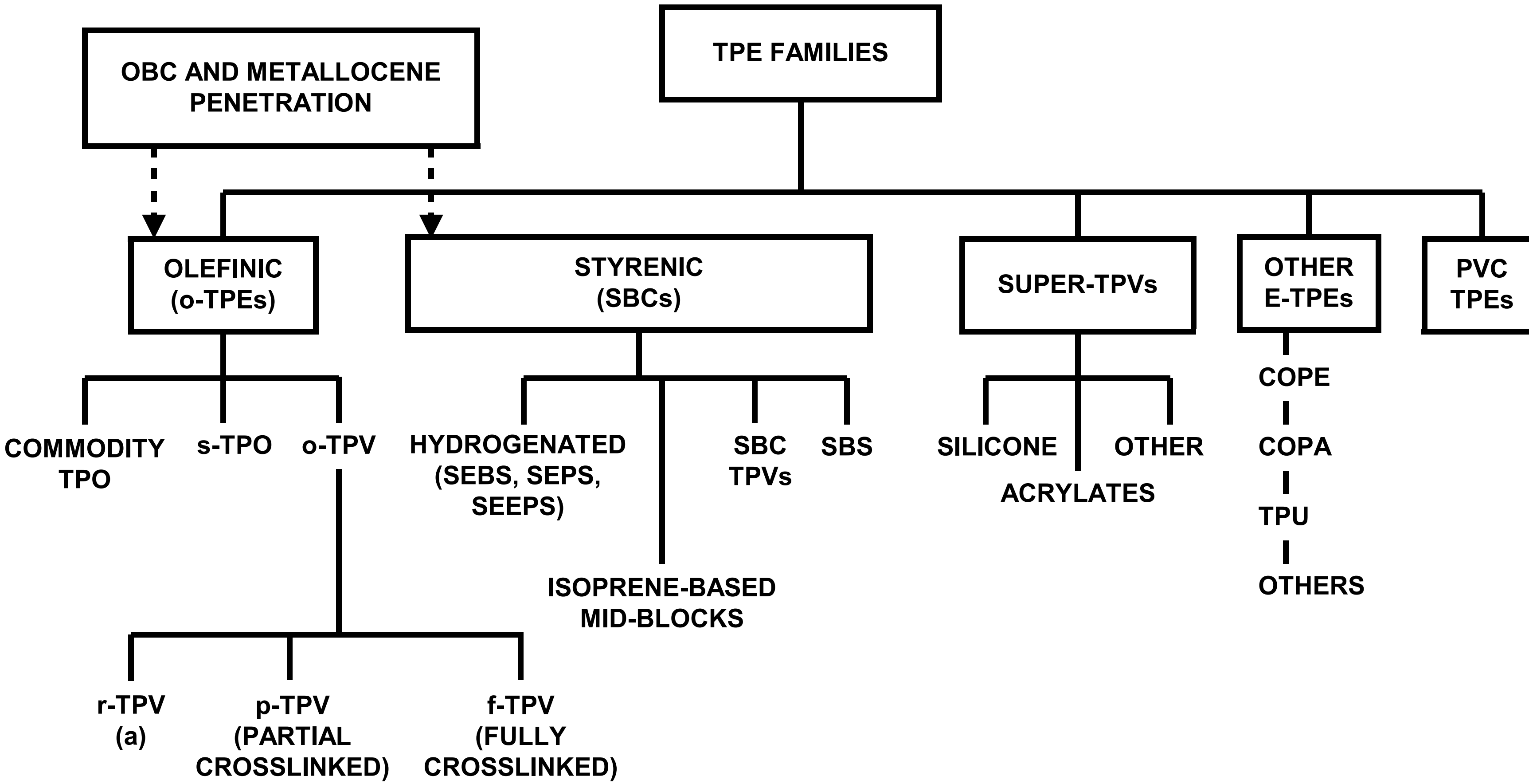
TPE FAMILIES . . .
CHANGING STRUCTURE, INCREASED INTRA-TPE COMPETITION



NOTE: (a) RECYCLATE-BASED TPV

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

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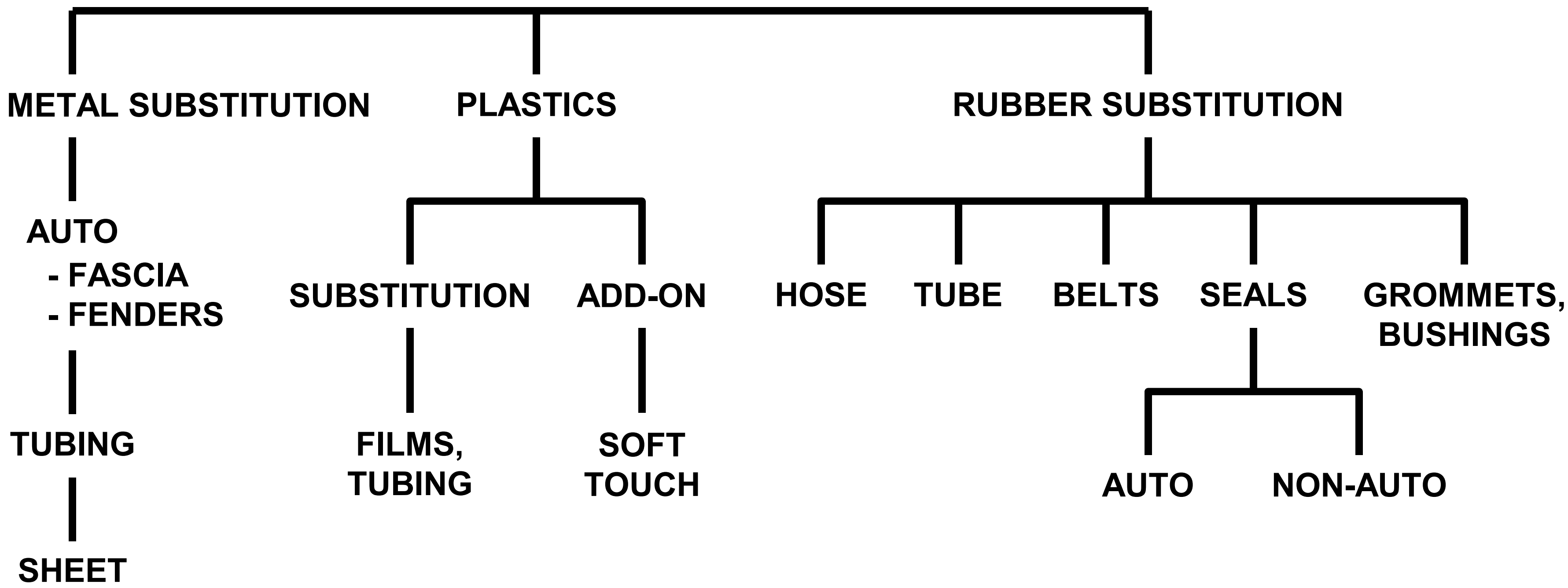
TARGET MARKETS FOR TPEs



SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

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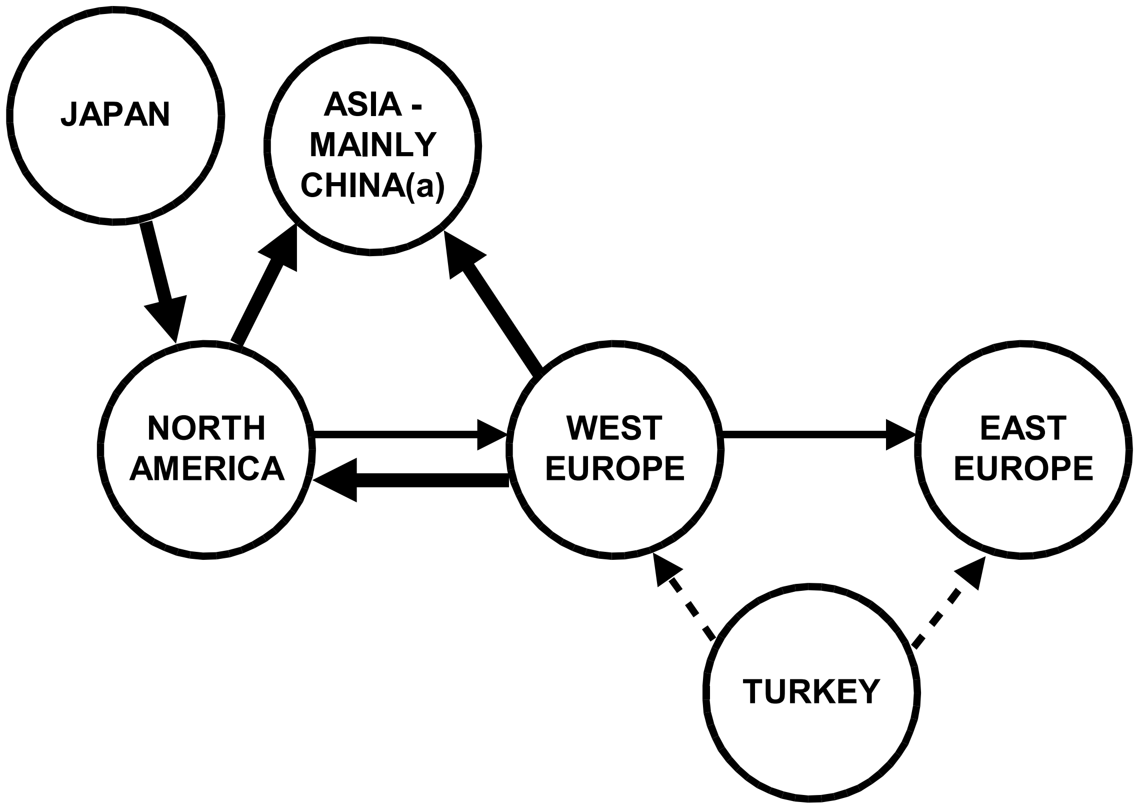
GLOBALIZING TPE MARKETPLACE

- **The TPE marketplace is rapidly globalizing.**
- **Investment and technology flows are following the globalization pattern of the TPE compounding industry.**
- **Most major TPE compounders have established Asia (China) operations.**
- **A new class of Asian TPE compounders is emerging (eventually global competitors?).**
- **China: fastest vehicle production growth region.**

GLOBAL INVESTMENT FOLLOWS THE TPE MKTS.



STRONG FLOW OF CAPITAL INVESTMENT AND TECHNOLOGY

WEAK FLOW OF CAPITAL INVESTMENT AND TECHNOLOGY

FLOW OF TPE COMPOUNDS

NOTE: (a) INDIA IS STARTING

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

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KEY TPE MARKETPLACE TRENDS

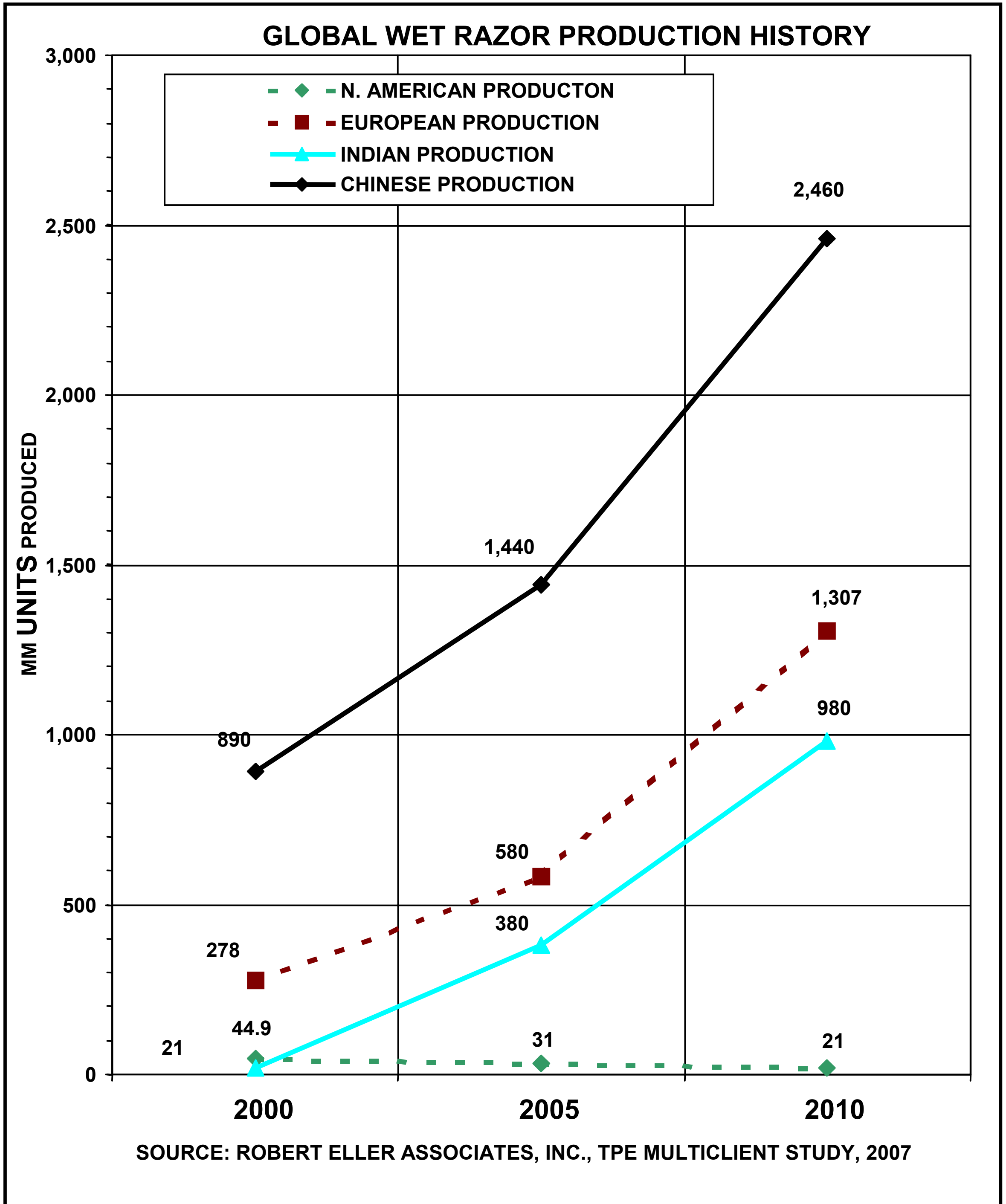
- Automotive vehicle production stagnation in N. America and Europe
- End use market shift to Asia, E. Europe, Mexico
- Forward integration of SEBS resin suppliers to compounding (TSRC, Kuraray)
- Expanding properties envelope (SEBS and o-TPV)
- New metallocene polyolefin and ionomer technologies challenge SEBS and o-TPV
- Improved transparency of SEBS compounds

KEY TPE MARKETPLACE TRENDS

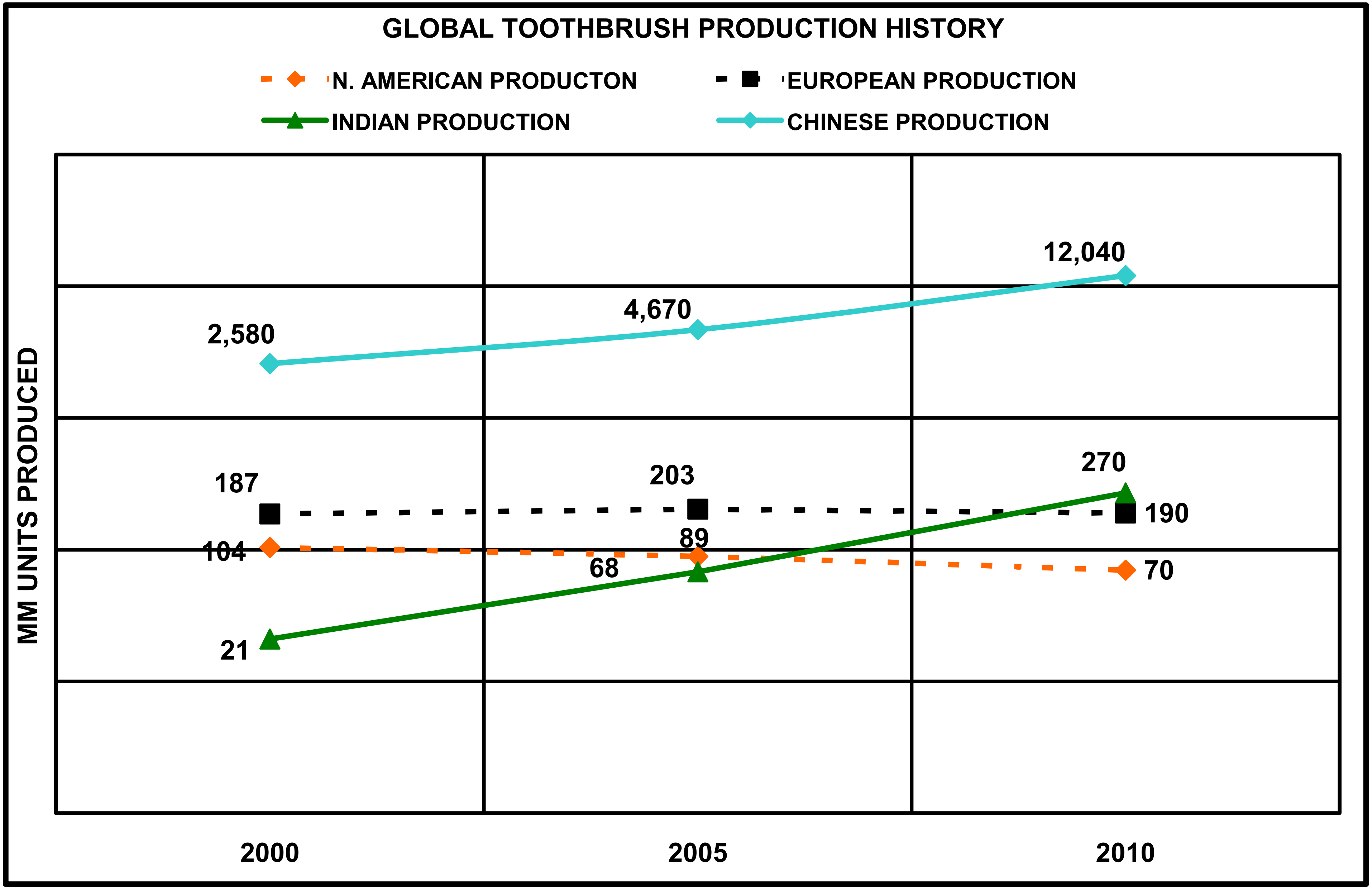
- Renewed attack (SEBS and o-TPV) on rubber applications
- Profitability erosion
- Parallel supply chain in China
- Segregation into commodity and specialty sectors
- Automotive supply chain implosion
- Use of single TPE for all interior applications
- Growing importance of talc
- Shift of resin capacity investment to monomer rich regions

TPE INDUSTRY STRUCTURE SHIFTS

- Strengthening of Japanese resin companies in N. America and Europe
- Korean TPE suppliers challenging the incumbents? (Hyundai EP via SK acquisition)
- TPE compounders broadening product lines
- Renewed growth of European compounders in N. America ($ weakness driver?)
- Resin suppliers riding a wave of new reactor technology (direct access to TPE markets)
- Tier 1s shifting to o-TPE compounding in-house?
- Enhanced role for masterbatch


GLOBAL WET RAZOR PRODUCTION HISTORY
N. AMERICAN PRODUCTON
EUROPEAN PRODUCTION
INDIAN PRODUCTION
CHINESE PRODUCTION
MM UNITS PRODUCED
3,000
2,500
2,000
1,500
1,000
500
0
2,460
1,440
1,307
980
890
580
380
278
44.9
21
31
21
2000
2005
2010
SOURCE: ROBERT ELLER ASSOCIATES, INC., TPE MULTICLIENT STUDY, 2007

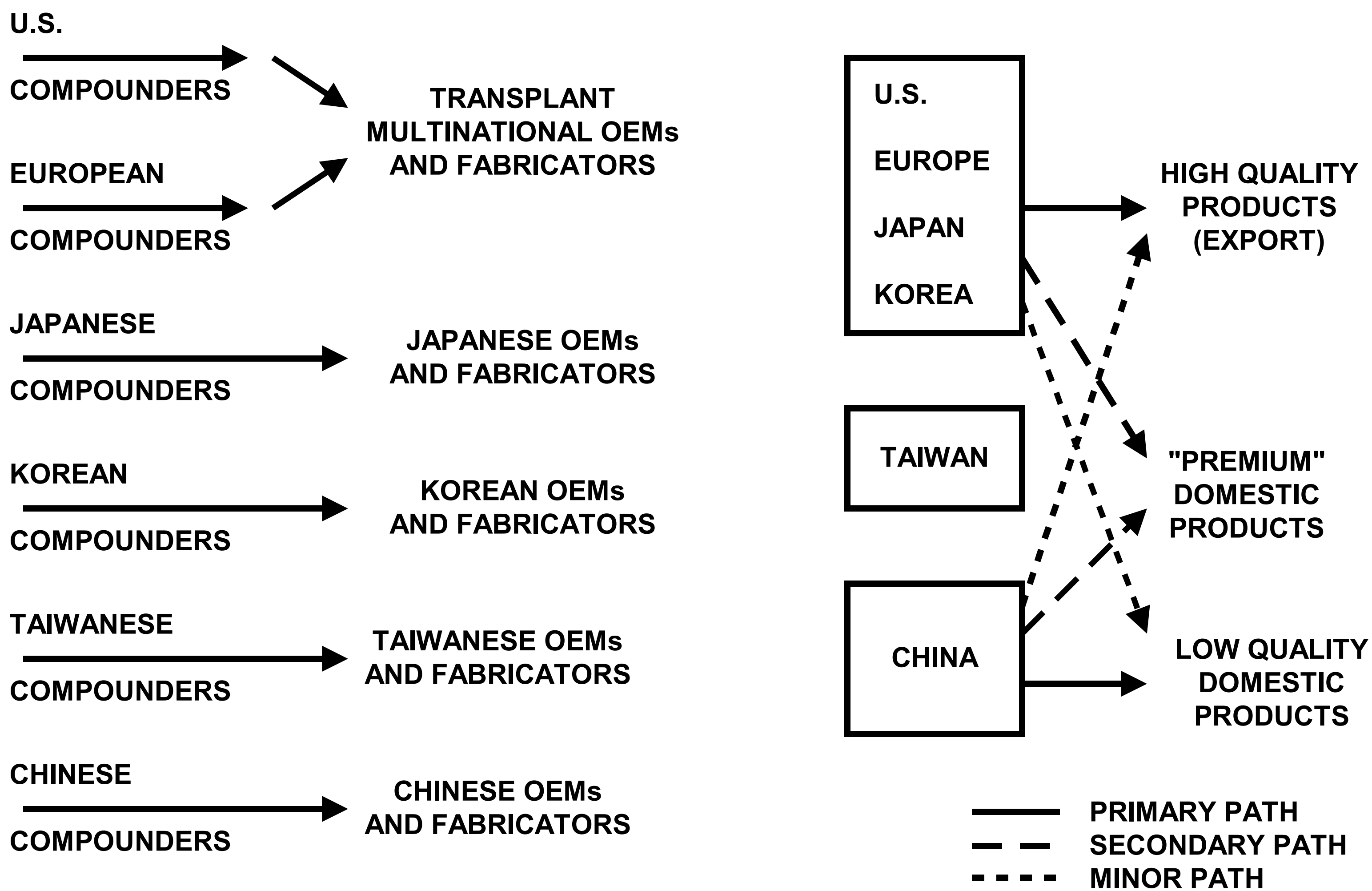
TOOTHBRUSH MANUFACTURING SHIFT



SOURCE: ROBERT ELLER ASSOCIATES LLC, CHINA TPE MULTICLIENT STUDY, 2006

PARALLEL SUPPLY CHAINS IN CHINA TPE MARKETS

NATIONALITY BASED



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2007

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o-TPVs IN CHINA

SUPPLIER	POSITION
EXXONMOBIL	-DOMINATES (VIA EXPORT FROM U.S.) -50% SHARE -NAME RECOGNITION/PREMUIM
OTHER WEST. COMPOUNDERS	-HAVE BEEN SLOW TO INVEST (STARTING) -STARTING TO SERVE DOMESTIC MARKETS
TAIWAN/KOREAN COMPOUNDERS	-MINOR ROLE VIA EXPORT
LOCAL DOMESTIC COMPOUNDERS	-PRIMARILY SMALLER TPV COMP'DRS. -STRONG PRESENCE IN p-TPVS -PARALLEL SUPPLY CHAIN -COST ADVANTAGES (30%) -RECYCLATE USE?
JAPANESE	-PRIMARILY SERVE JAPANESE AUTO OEMs -MORE FOCUS ON INDIA -MITSUI IS LEADER -SHIFT POSSIBLE IN FUTURE?

CHINA vs. INDIA

	CHINA	INDIA
POT'L DOMESTIC MARKET SIZE	• 1.3 BILLION PEOPLE	• 1.0 BILLION PEOPLE
INFRASTRUCTURE	• AGGRESSIVELY BUILDING INFRASTRUCTURE AROUND ECONOMIC DEV'MENT ZONES, FACILITIES OFTEN IN PLACE WAITING FOR NEW PLANTS • CONTINUITY TO A PLAN, A SENSE OF CONSTANCY	• ROADS/PORTS/LOGISTICS POOR • GOLDEN QUADRANGLE A HELP, BUT ONLY A START
GOVERNMENT	• EXCELLENT CENTRAL PLANNING = STRENGTH • BECOMING VERY BUSINESS FRIENDLY – CONTINUALLY OPENING UP FOR MORE FOREIGN INVESTMT – FLOATING OF THE YUAN – BONDED WAREHOUSING	• DEMOCRATIC GOV'T CHANGED FREQ. (ELECTIONS EVERY 4 YEARS) • NEW GOV'TS MEANS A STOP-START • BUREAUCRACY THAT IS NOT HIGHLY BUSINESS FRIENDLY

AUTOMOTIVE TPE MARKET EFFECTS

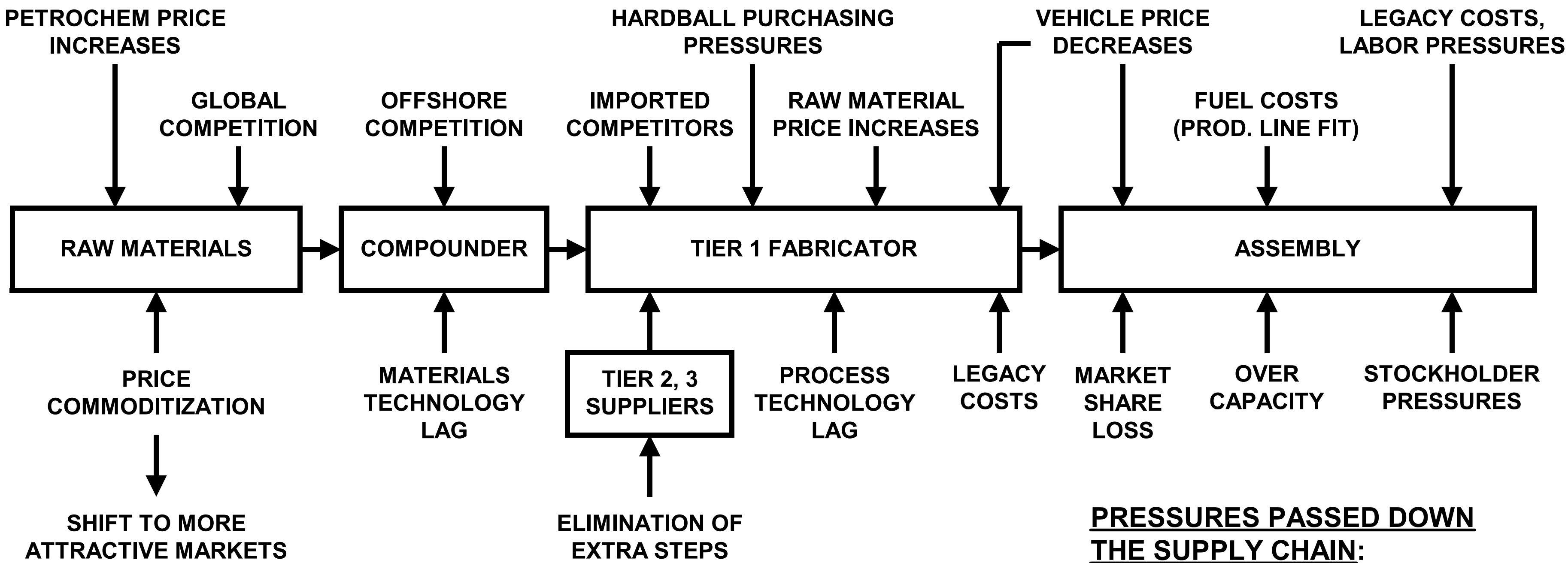
- 40-50% of TPE demand in most regions
- Source of technology innovation
- Supply chain implosion driving technical innovation
- Automotive vehicle production stagnation in N. America and Europe
- In-house compounding by Tier 1s
- Growth of low cost vehicles
- Use of single TPE for all interior applications
- Growing importance of talc filler/ reinforcement/masterbatch

AUTOMOTIVE SUPPLY CHAIN IMPLOSION

- **Reshaped auto supply chain is:**
  - **Accelerating the drive for lower cost technical solutions**
  - **Accelerating modularization**
  - **Encouraging fabrication machinery-driven innovation**
  - **Shortening path between resin and assembled part**

- **Implosion effect is more severe in N. America than in Europe**

AUTOPLASTIC SUPPLY CHAIN IMPLOSION (N. AMERICA)



PRESSURES PASSED DOWN THE SUPPLY CHAIN:

- ← PRICING PRESSURES
- ← SUPPLY CHAIN "MANAGEMENT"
- ← DEMAND SLOWDOWN
- ← REVISED SPECIFICATIONS
- ← GLOBALIZATION PRESSURES

ELIMINATE/REDUCE:
- MULTIPLE STEPS (2-SHOT MOLD, NEG.-FORM)
- EXCESSIVE LOGISTICS
- SCRAP GENERATION
- INEFFICIENT PROCESS TECHNOLOGIES
- SALES/MARKETING COSTS
- EXCESS LABOR COSTS
- OVER-GLOBALIZATION?

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

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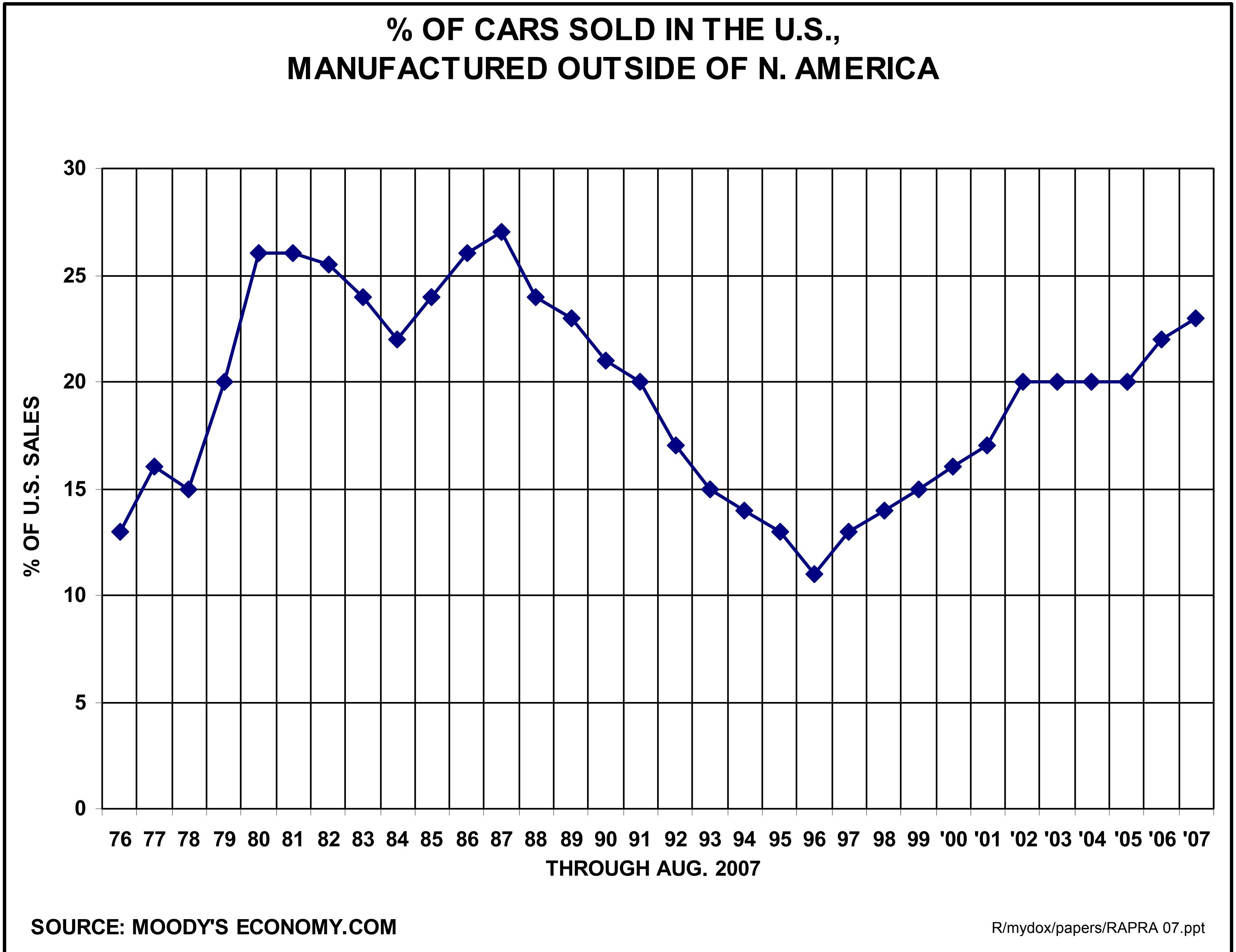
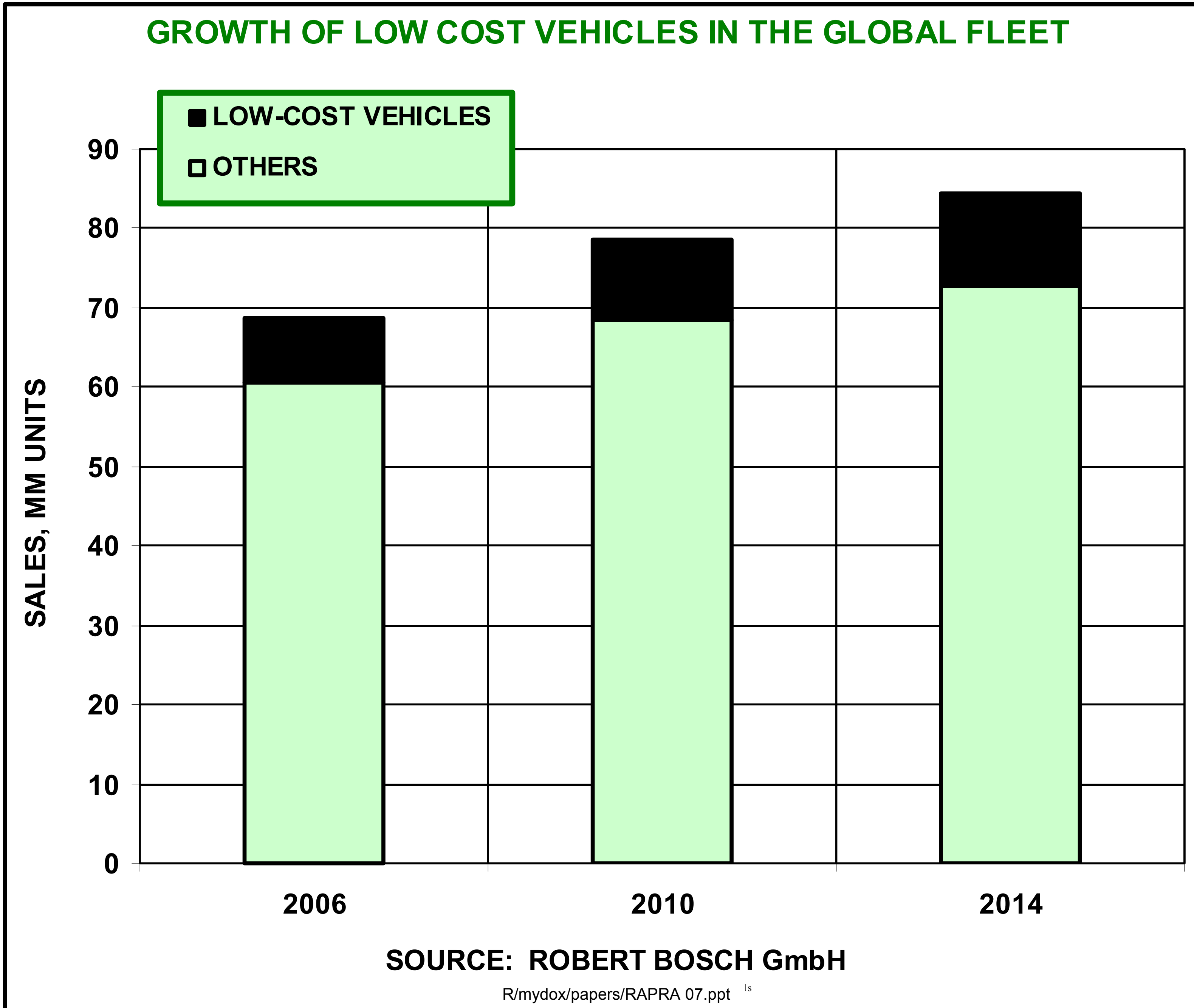

% OF CARS SOLD IN THE U.S.,
MANUFACTURED OUTSIDE OF N. AMERICA
% OF U.S. SALES
30
25
20
15
10
5
0
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 '00 '01 '02 '03 '04 '05 '06 '07
THROUGH AUG. 2007
SOURCE: MOODY'S ECONOMY.COM
R/mydox/papers/RAPRA 07.ppt


GROWTH OF LOW COST VEHICLES IN THE GLOBAL FLEET
LOW-COST VEHICLES
OTHERS
SALES, MM UNITS
0
10
20
30
40
50
60
70
80
90
2006
2010
2014
SOURCE: ROBERT BOSCH GmbH
R/mydox/papers/RAPRA 07.ppt
ls

AUTOMOTIVE TPE TARGETS AND THE RUBBER INTERFACE

AUTO TPE SYSTEMS TARGETS

- BODY/GLAZING SEALS*
  - BODY SEALS*
    - DOORS
    - HOOD*
    - REAR DECK*
  - GLAZING SEALS*
    - FIXED*
    - MOVEABLE*
- HVAC
  - FLAPPER DOOR GASKETS*
  - AIR DUCTS
  - OTHER
- EXTERIOR
- INTERIOR(a)
  - AIRBAG DOORS*
  - SKINS*
  - COATED FABRIC*
  - FLOOR SYSTEMS*
    - ACOUSTIC*
    - CARPET BACKING*
    - MATS*
- BOOTS/BELLOWS
  - STEERING
    - STEER COLUMN BOOT*
    - CVJ BOOTS*
    - R/P BOOTS*
  - POWER TRAIN
    - SPARK PLUG BOOTS*
    - SEALS/GASKETS*?
  - ELEC-TRICAL*
  - DOOR*
- HOSE/TUBE/DUCT(c)
  - HOSE
    - FLEX
    - MANDREL(b)*
  - AIR MGT. - DUCT*
  - TUBE
    - W. WASHER
    - EGR
    - VAC TUBE (NL)
- ELECTRICAL
  - CABLE JACKET
  - LIGHTING GASKETS*
  - OTHER

NOTES:
* = RUBBER/TPE INTERFACE
(a) DOES NOT INCLUDE RIGID-FILLED TPOs USED IN INTERIORS
(b) RE-USABLE MANDREL TO MFR. HOSE (TPVs COMPETING WITH NYLON)
(c) E.G., FUEL, COOLANT, OILS, OTHER HOSE

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

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lg/myfiles/visio/RAPRA07-AutoTPETargets07.vsd

Crank Case Ventilation Hose

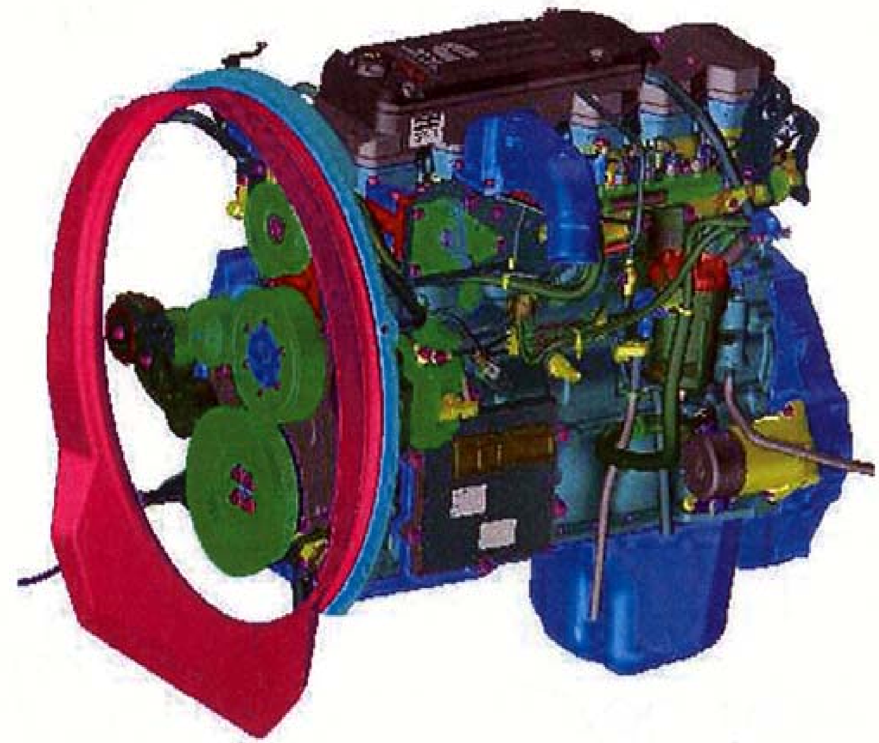
<u>TPE Grade Name</u>: DuPont™ E-TPV

<u>Material Type</u>: s-TPV

<u>Status</u>: Concept

<u>Process</u>: Co-extrusion

<u>Key Features</u>: Blow-by gas resist.



Product: Fan shroud
Manufacturer: Sur-Flo
Material Type: TPV (Nexprene)
TPE Supplier: Solvay Engineering Polymers
Note: Used in Dodge Ram HD pickup

2- color door trim skin on single natural fiber panel substrate
Vehicle: BMW 5 Series
Tier 1: Johnson Controls Photo: BMW

BODY/GLAZING SEALS

- Rapid growth
- High volume potential
- In-house compounding vs. merchant supply
- Evolution to in-line compounding?
- Systems will be key to TPE penetration
- Will be o-TPV vs. SEBS battleground
- 2-shot molding opportunity

BODY/GLAZING SEALS: EPDM SUBSTITUTION ACCELERATES

Vehicle: 2007 DCX Dodge Ram
Supplier: JYCO (compound, profile, design)
Material: o-TPV
- Little guy scoops the big guys
- First o-TPV dynamic body seal

SOURCE: JYCO

EXPANDING/SHIFTING PROPERTIES ENVELOPE

- Inroads into SEBS markets by advanced olefin technologies
- Market share shift between TPEs
  - Reactor TPO
  - Improved metallo-plastomers
  - Dow's Infuse™ OBC
- POEs with high melt strength, broadened service temperature, low gloss
- POE/branched PPs
  - Compete with o-TPVs
  - Profiles/thermoforming
  - Enhanced foam properties

INTRA-TPE COMPETITION:
ROLE OF IMPROVED POLYOLEFIN TECHNOLOGY

- Broad range of new PO technologies becoming avail.
- SEBS and TPO compound ingredients
- POE displacement of EPDM in TPOs almost complete
- Will stimulate transparent TPO, elastic fibers, elastic films
- Versatile molecular architecture control
- Still young technologies with broad growth pot'l., e.g.,:
  - Nano morphology control (clear TPOs, e.g., from Mitsui)
  - Long-chain branching control
- Direct sale to fabricators or compounders?:

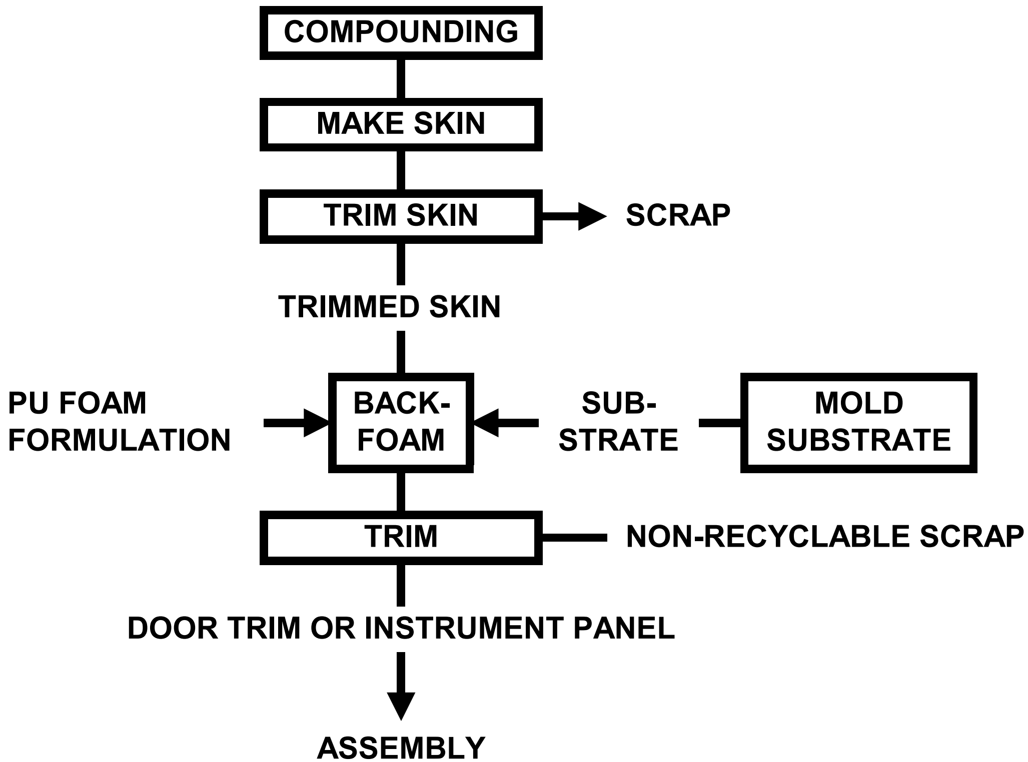
- Dow	- Mitsui Chemical
- ExxonMobil	- Sumitomo
- Borealis	- JPP

NEW MATERIALS/FABRICATION COMBINATIONS

- **Small part, 2-shot molding started**
- **Shift to large part, 2-shot molding**
  - Competition with thermoformed skins
  - Evolving to 3-layer (skin/foam/substrate)
  - Shifts the supply chain
- **Co-fabrication (blow, inject, profile extrude)**
- **Increased role for polyolefin foams**
  - 2-shot injection
  - Acoustics
  - Semi-structural applications
  - Role in all-PO constructions

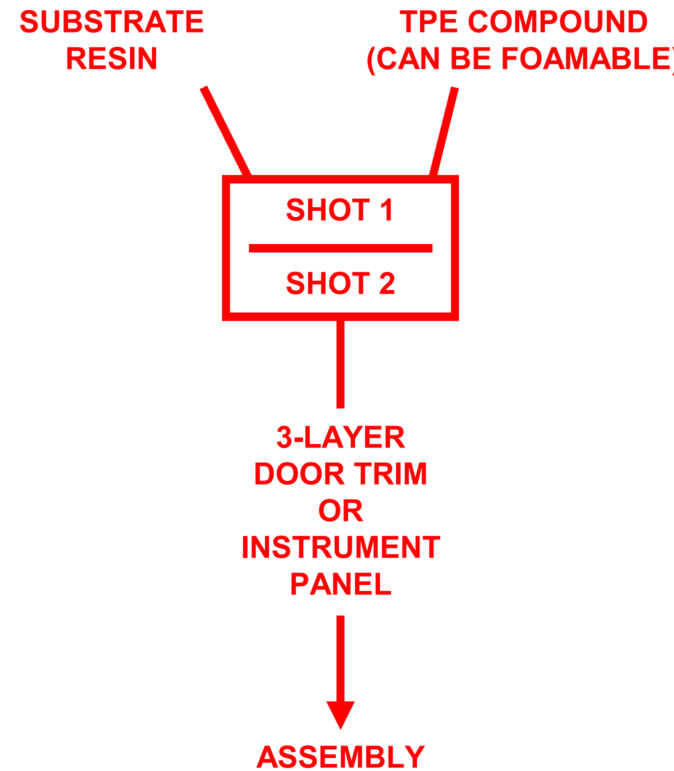
NEW TPE FABRICATION TECHNOLOGY:
LARGE-PART, 2-SHOT MOLDING CHALLENGES SKINS

CURRENT PROCESS



- LABOR INTENSIVE
- HIGH SCRAP
- MULTI STEP
- MULTI MATERIAL
- NON-RECYCLABLE
- DIFFICULT CRAFTSMANSHIP

2-SHOT



- LOW LABOR
- LOW SCRAP
- SINGLE STEP
- 1-2 CLOSELY RELATED MATERIAL FAMILIES
- EASILY RECYCLED
- HIGH CRAFTSMANSHIP

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

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lg/myfiles/Visio/RAPRA07-LgPt2Shot.vsd

2-Shot Molded Door Medallion

Vehicle: Dodge Caliber ('07)

Molder: Lear

Material: Thermoplastic Elastomer On PP

LARGE-PART, 2-SHOT, SOFT TOUCH DEVELOPMENT

Part: Instrument Panel Upper
Skin Compound: COPE (Foamed Pibiflex from P Group)
Substrate: PBT/ASA (Ultradur^{R} S4090IGX from BASF)
Injection Machine: Engel
Foam Technology: Trexel

SOURCE: ROBERT ELLER ASSOCIATES LLC

LARGE-PART, 2-SHOT, SOFT TOUCH: TRUCK IP UPPER

Part: Truck IP Upper
Status: Prototype
Skin Compound: COPE (foamed Pibiflex from P Group)
Substrate: PBT/ASA (Ultradur^{R} S4090IGX from BASF)
Molding Machine: Engel Duo Series (for Dolphin process)
Tier 1: IAC

SOURCES: *POLYMOTIVE*; ROBERT ELLER ASSOCIATES LLC

TALC EFFECTS

- New micro-talcs broaden the properties envelope
- Exterior and interior applications
- For exterior applications:
  - Europe ahead (front-end modules, e.g., BMW X5; hatchback, e.g., Renault Modus)
  - Could accelerate exterior panel penetration
- Role for masterbatch

BMW X5 Front-end Module

Compound: 30% talc-filled TPO
Molder: Plastic Omnium
Filler Type: Jetfine® 3CA (Rio Tinto Minerals)
Key Features: Class A finish, zero gap, low temp. (-40ºC) impact, weight save, high scratch resistance, meets European pedestrian safety requirements

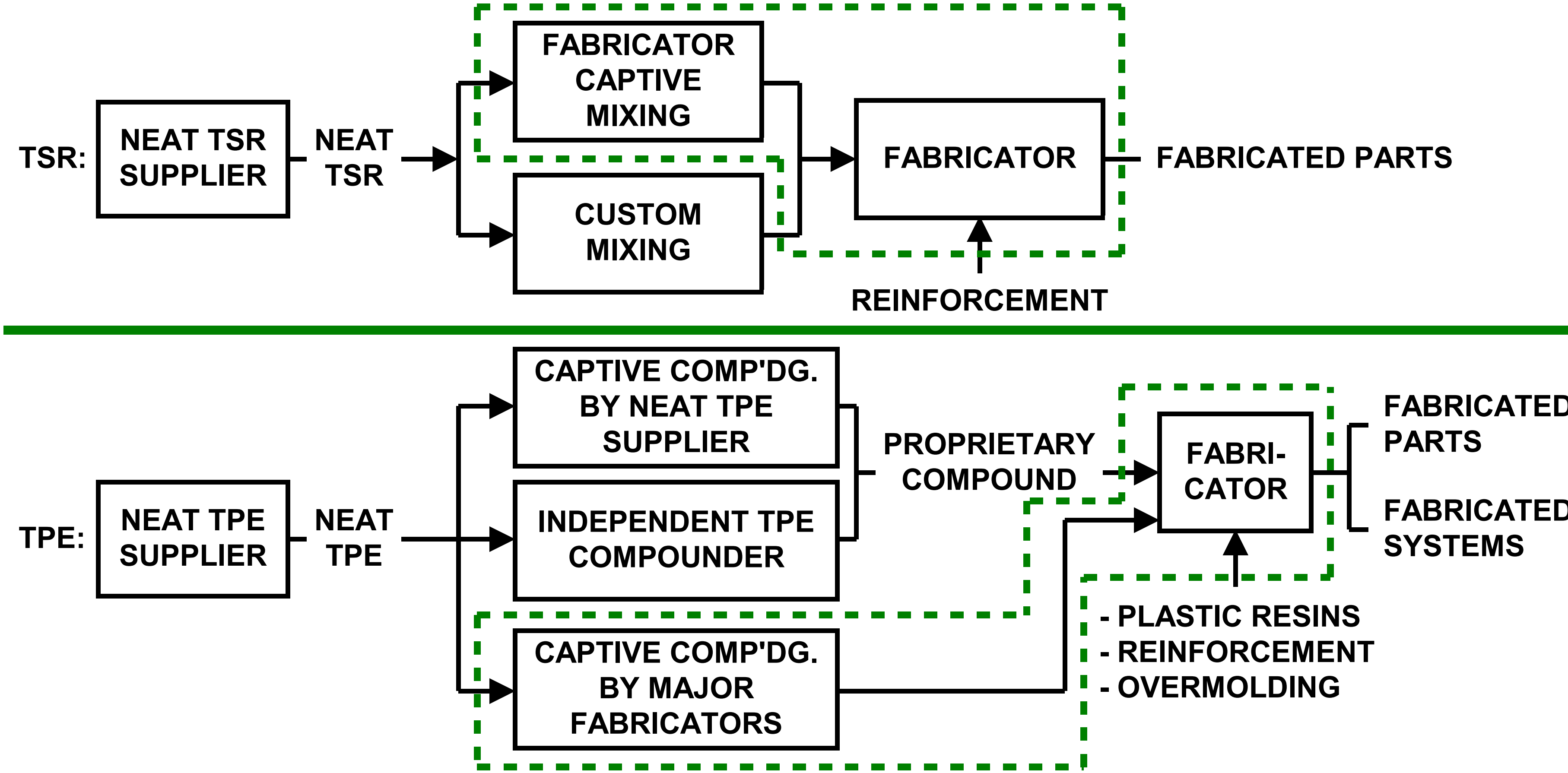
SOURCES: PLASTIC OMNIUM; ROBERT ELLER ASSOCIATES LLC, 2007

TPE/RUBBER SUBSTITUTION STATUS

APPLICATION	STATUS
BODY/GLAZING SEALS	- STARTED - WILL ACCELERATE - FOAMING REQUIRED?
HOSE	- NO SIGNIFICANT PENET. YET - REQUIRES PARADIGM SHIFT
TUBING	- o-TPV STARTING - TPU, SEBS WELL ADVANCED
BELTS	- UNLIKELY PENET. IN AUTO - MAJOR o-TPV, TPU TARGET
BOOTS/ BELLOWS/ DUCTING	- SUBSTANTIAL PENETRATION. - SHIFT TO HIGHER PERF. TPEs?
GROMMETS, BUMPERS, GASKETS	- MODERATE PENETRATION

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

TPE vs. TSR PATH TO MARKET



SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

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KEY DEVELOPMENTS IN NON-AUTOMOTIVE GLOBAL TPE MARKETS

TPE MKT. SEGMENT	ASIA SHIFT	KEY DEVELOPMENTS
Building/ Construction	No	- Stagnation in U.S. & W. Europe - Credit crunch effects - Intermaterials competition in roofing (EPDM, TPO, SEBS, SEBS/SBS construction) - Continued penetration in glazing seals by SEBS & olefinic TPEs in Europe - Severe compound price erosion - Glazing seals under-developed in N. America - Eastward expansion in Europe
Consumer/ Housewares	Yes	- Dominated by SEBS - Increased participation by SBS compounds - Very strong Asia shift - Maturing of soft touch, 2-shot technologies

(Continued)

KEY DEVELOPMENTS IN NON-AUTOMOTIVE GLOBAL TPE MARKETS (Cont'd.)

TPE MKT. SEGMENT	ASIA SHIFT	KEY DEVELOPMENTS
Medical		- Higher value market - Intensified competition by Western compounders seeking to capture value - No significant China shift yet, but starting - PVC replacement (tubing, films, bags, closures) is driver
Footwear	Yes	- Dominated by SBS and TPU - Already strongly shifted to Asia
Appliance/ Tools	Yes	- Dominated by SEBS - Very strong Asia shift - Maturing soft touch, 2-shot technologies
Pers. Care/ Cosmetics		- Anticipated strong penetration of elastic fibers

(Continued)

KEY DEVELOPMENTS IN NON-AUTOMOTIVE GLOBAL TPE MARKETS (Cont'd.)

TPE MKT. SEGMENT	ASIA SHIFT	KEY DEVELOPMENTS
Sports/ Leisure	Yes	- Very strong Asia shift - Dominated by SEBS - Maturing soft touch, 2-shot technologies
Wire/Cable		- Relatively undeveloped TPE market segment - PVC replacement will drive TPEs - Non-halogen requirements starting in Europe (WEEE and RoHS)
Fluid Handling/ Industrial		- TPE tubing growth - Recent o-TPV penetration into EPDM tubing - Enhanced role for high clarity TPEs - Abrasion resistance required for industrial applications
Food/ Pharma Pkg.		- Role for clear TPEs - Role for TPEs in closures, replacing thermoset elastomers

KEY DEVELOPMENTS IN NON-AUTOMOTIVE GLOBAL TPE MARKETS (Cont'd.)

TPE MKT. SEGMENT	ASIA SHIFT	KEY DEVELOPMENTS
Electrical/ Electronic/ Telecomm.	Yes	- Role for conductive TPEs (e.g., gasketing) - Enhanced role for soft touch (potentially high value) - Enhanced role for colored TPEs
Coated Fabrics		- A relatively undeveloped but promising market for SEBS and o-TPEs - Recent improvement of TPU coating grades - Possible entry by improved o-TPE and SEBS grades

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

TPE COMPOUND VALUE KILLERS

- ANY COMMODITY APPLICATION VIA EXTENDED SUPPLY CHAIN
- COMPETITION WITH PVC
- DIRECT 1:1 COMPETITION WITH EPDM
- CASCADE TO LOWER VALUE TPEs
- MOST AUTO APPLICATIONS (NOT ALL)
- COMPETITION WITH CHINESE COMPOUNDERS
- FABRICATOR IN-HOUSE COMPOUNDING
- MULTIMATERIALS CONSTRUCTION
- MULTI-STEP FABRICATION

TPE RESIN/COMPOUND VALUE CREATORS

- **SYSTEMS COST SAVINGS POTENTIAL**
- **MONOMATERIALS CONSTRUCTION POT'L.**
- **IMPROVED ADHESION**
- **2-SHOT MOLDING (ESP. LARGE PARTS)**
- **FOAMING**
- **CO-PROCESSING**
- **GLOBAL SPECIFICATIONS**
- **ELIMINATION OF CROSSLINKING**
- **MASTERBATCHES**
- **CONTROLLED RHEOLOGY**
- **SPECIALTY NICHES (IN-MOLD DECORATION)**
- **IMPROVED ACOUSTIC PROPERTIES**

o-TPV PROFITABILITY DRIVERS

PROFITABILITY	SHORT TERM — TIMING	LONG TERM
INCREASE	- IMPROVED PROPERTIES -- FOAMING -- ADHESION -- COLOR CONTROL - MOMENTUM FROM PREVIOUS MARKETING - CHINA MARKET PENETRATION (FOR EARLY ENTRANTS)	- RUBBER PENETRATION -- HOSE -- BELTING -- SYSTEMS COST SAVE
DECREASE	- AUTOMOTIVE DEPENDENCE - TECHNOLOGY PROLIFERATION - INCREASED COMPETITION - PRICE PRESSURES - CASCADE TO LOWER PRICED TPEs	- CHINA MARKET PENETRATION - DIRECT COMPOUNDING OF TPVs? - COMPETITION FROM IMPROVED STYRENIC TPEs?

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2007

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lg/myfiles/visio/RAPRA07-oTPVprofitDrivers07.vsd

SUMMARY

- Rapidly changing global TPE marketplace:
  - Changing regional character/industry structure (Asia shift in consumer mkts.)
  - Shifting TPE demand to lower cost regions
  - Internationalizing N. American resin/ compound market
  - Imported compounds from China/India to Europe/N. America

- Commoditization of low end TPE compound markets (shifting supplier rankings and target markets)

SUMMARY (Cont'd.)

- New technologies driving TPEs deeper into TSR markets:
  - Seals
  - Hose
  - Tubing
  - Boots/Bellows
  - Roofing
  - Coated Fabrics

- Continued profitability pressure from:
  - Consolidated customer base
  - Raw material price increases
  - Global pricing structures
  - Direct paths to market by resin suppliers
  - Increased in-house compounding
  - Masterbatch use by fabricators

SUMMARY (Cont'd.)

- Expanding properties envelope
- Blurring the interface between SEBS & o-TPV:
  - Compound formulations
  - Market sector dominance
  - Product lines
- Many opportunities for capturing value (via systems approach)