ANALYSIS
TECHNICAL
ECONOMIC
MARKET
Management
DECISIONS

Robert Eller Associates LLC

CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES

TPE INDUSTRY STRUCTURE EVOLUTION, NEW TECHNICAL DEVELOPMENTS AND GLOBAL MARKET SHIFTS

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OUTLINE

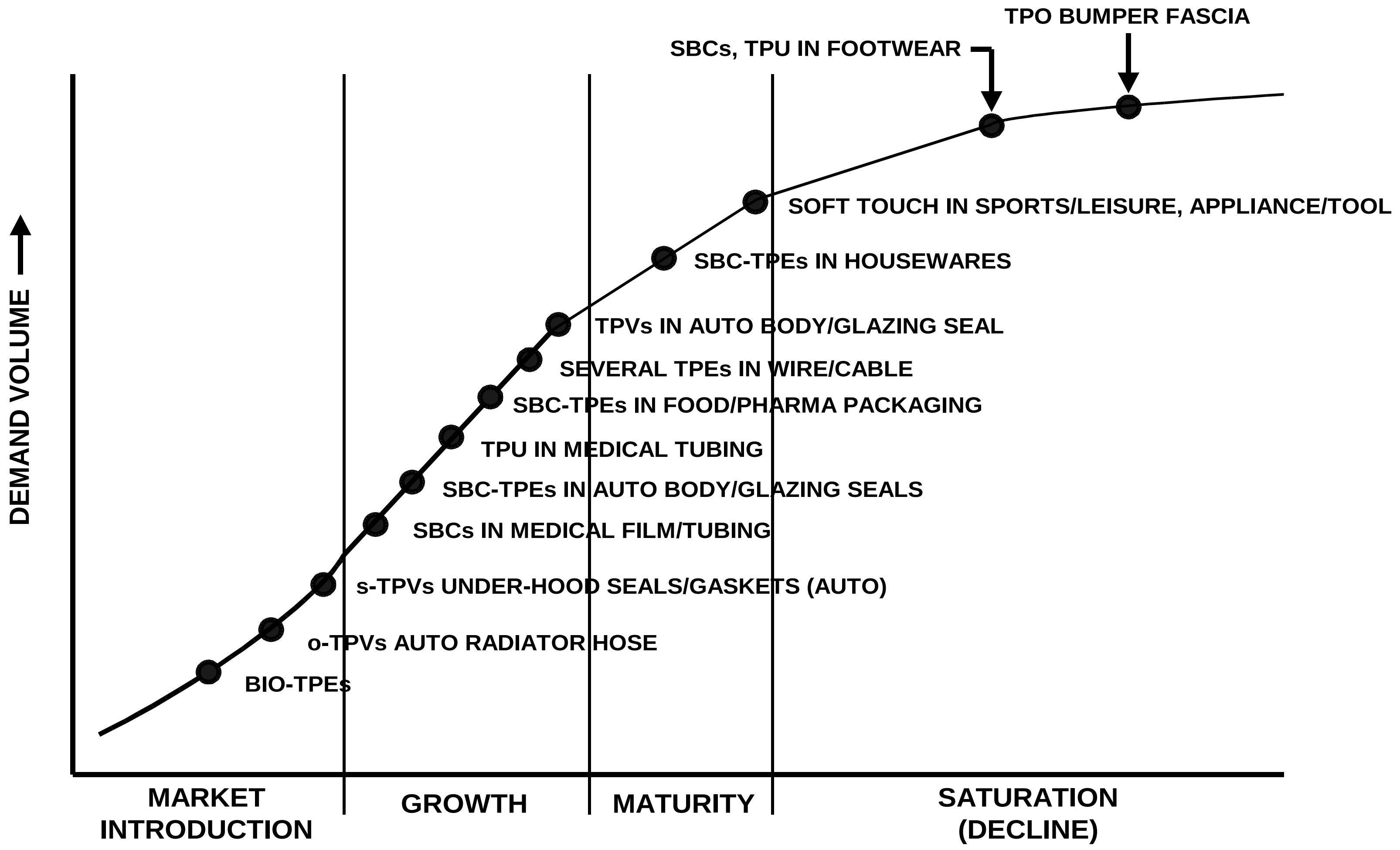
- Market maturity and commoditization of some TPE grades
- Global market shifts: Asian impact on TPE markets
- Industry structure shifts: adapting to new challenges
- The next TPE growth phase: drivers and barriers
- Example growth markets: health care, automotive
- Super TPVs: expanding the performance envelope
- Bio-TPEs

MARKET MATURITY : SOME TPEs EVOLVING TOWARD COMMODITIES

CHARACTERISTIC	COMMODITY	SPECIALTY
Number of grades	- Many standard grades - Compete for same business	- Few grades - Highly targeted
Major TPE suppliers	Continue supply or exit	Enter compounding
Competitive basis	Price. Trend toward global price	Performance (tailored)
Property differentiation	None→ minor	Highly differentiated
Sales/marketing approach	- Pursue existing markets - Take orders/Use distributors	"Shape" new markets
Tech support, Applications dev	Minimal	Substantial
Brand recognition	- Incumbent TPE suppliers(have it) - New entrants enter without it (e.g. Sinopec, TSRC)	No: must be built
TPE examples	- Standard SEBSs, SBS, TPO - Some o-TPVs, TPUs - Some COPEs	- New SEBS grades - s-TPVs, Bio-TPEs - Health care grades - New acrylic grades

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

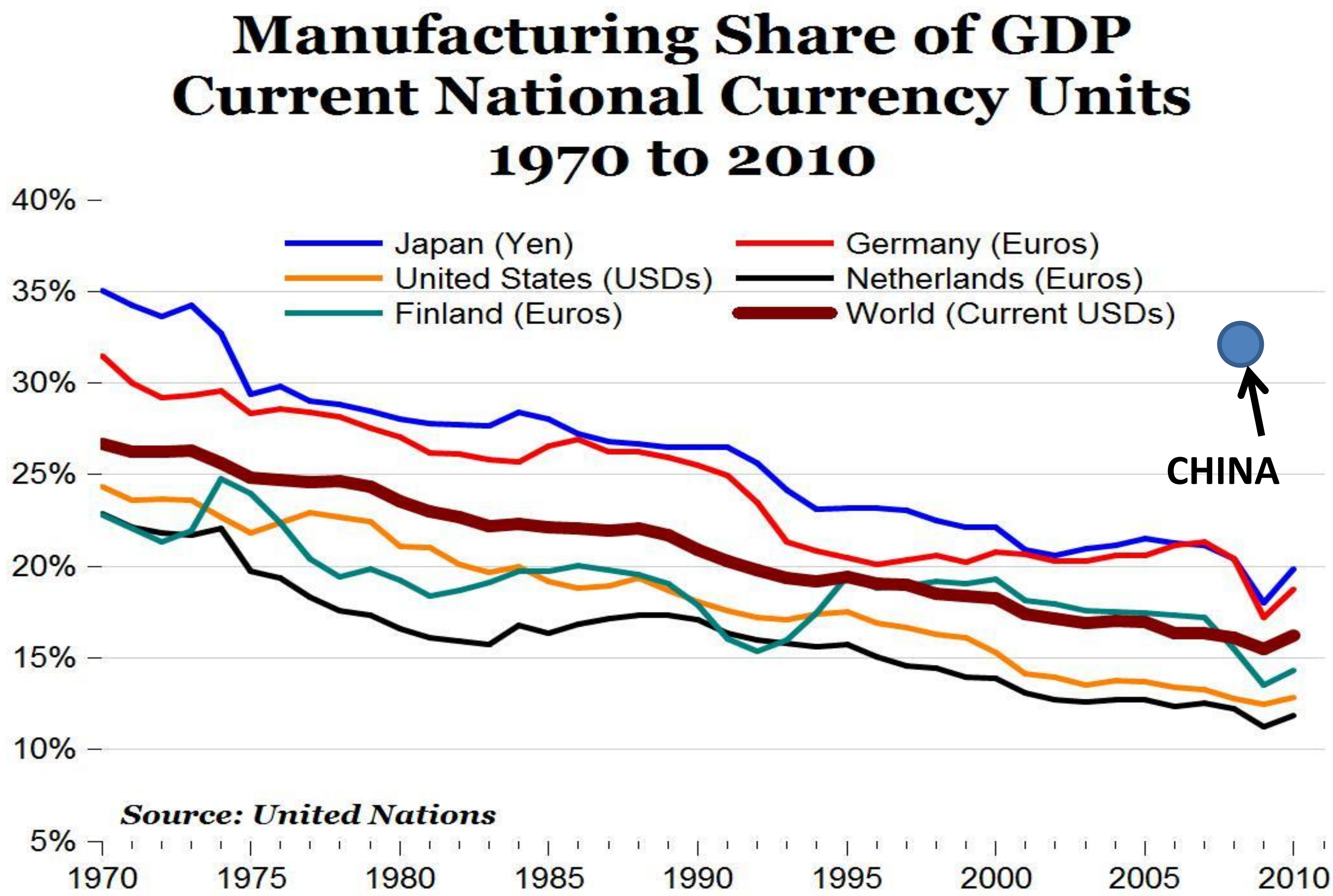
EXAMPLE PRODUCT LIFE CYCLE POSITION OF TPEs



SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

r/mydox/Visio/Prod Life CycleTPEs 081512.vsd

GLOBAL MANUFACTURING SHIFTS: TPE DEMAND SHIFT



THE ASIA SHIFT

- **TPE demand effects:**
  - **Decreased demand in Europe/N. America**
  - **Especially for consumer products-related TPEs**

- **Supply chain effects as Asia infrastructure matures:**
  - **Western companies can become dependent on Asian supply chain even for products with low labor cost share**
  - **Supply chain infrastructure becomes established**
  - **Shift of R/D to region (technology and innovation shift)**
  - **Scale of Asia plants becomes competitive**
  - **Flexibility/speed of response**

- **Investment flow coming out of Asia. Some into TPE sector (e.g. TSRC)**

- **Re-shoring starting in U.S.**

THE CHANGING POSITION OF CHINA

- **Shift within China as cost of labor exceeds cost of capital and real estate costs rise**
  - **Labor intense businesses no longer subsidized**
  - **Textiles, toys, shoes under pressure**
  - **Start of sector shift: higher technology automotive, electronic and healthcare**
- **Domestic volume becomes the business model and export business incremental**
- **Asian gov’t decisions can create rapid growth, high volume markets**
- **China costs remain competitive despite wage increases**
- **Auto production in China**
  - **Focused on domestic market (only 4% of production is exported)**
  - **Domestic market could become saturated by 2020(at 25-30MM units)→ exports?**
  - **Current TPE usage/vehicle is below global average→ growth opportunity**

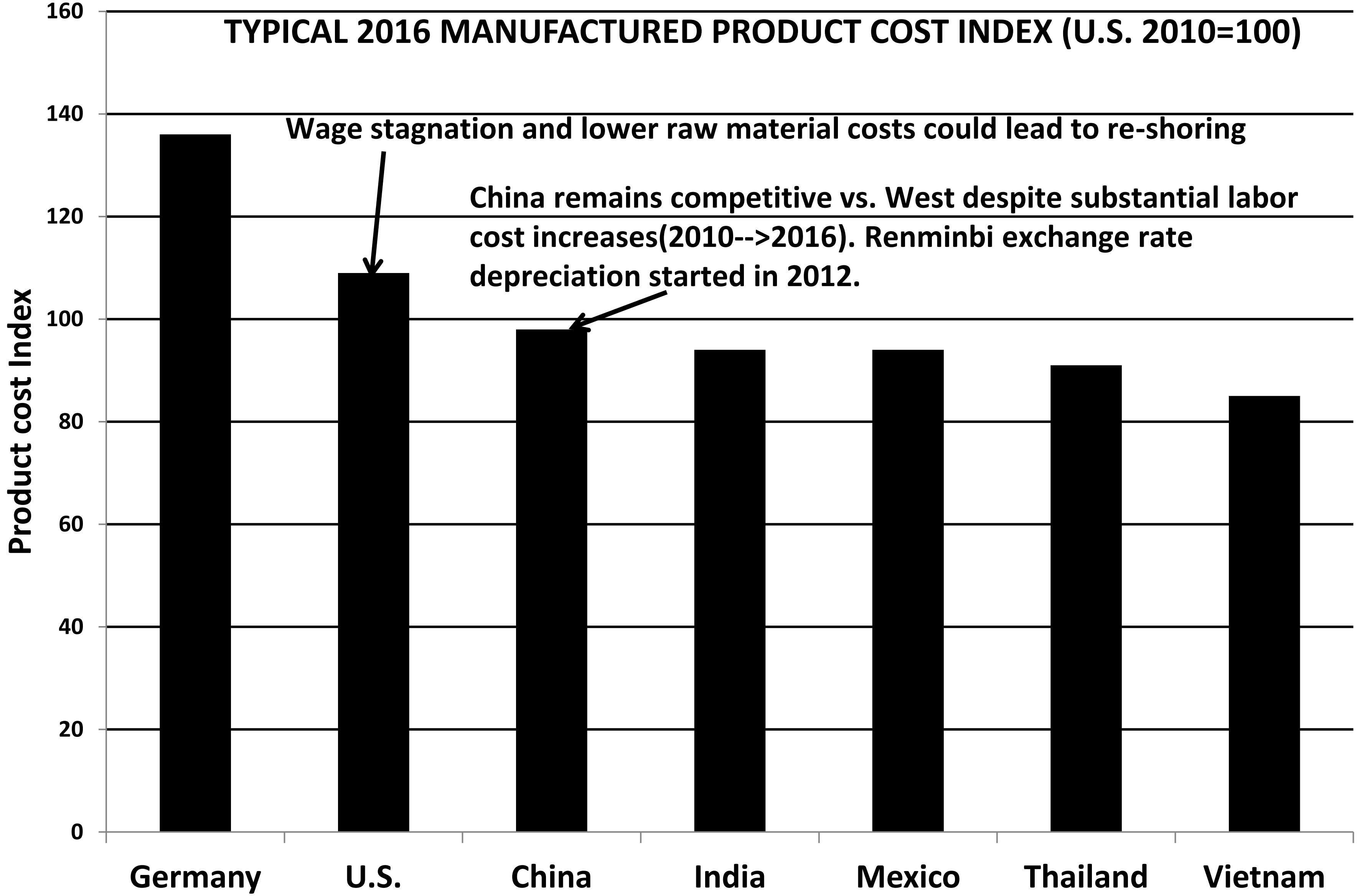
THE ASIA SHIFT AFFECTS WESTERN TPE MARKETS DIFFERENTLY

TPE SECTOR	HIGH ASIA GROWTH INDEPENDENT OF WESTERN CONDITIONS	ASIA GROWTH DECREASES WESTERN TPE MARKETS	ASIA GROWTH NO EFFECT ON WESTERN TPE	NOTE
Auto	X			High Asia TPE growth market
Footwear		X (a)		Shifted long ago
Bldg/Const.			X	A classical stay at home market
Consumer		X (a)		Shifted long ago
Wire/Cable		X		
Food/Pharma			X	Packaging
Health care	X		X	Hi growth West/Asia TPE market
Appliance/Tool		X (a)		Re-shoring candidate
Personal Care/ Cosmetics			X	
Fluid Handling /Industrial			X	Rubber hose is a recent o-TPV target Re-shoring candidate
Sports/Leisure		X (a)		
Coated Fabrics		X		Asia very dominant in textiles
Elec/Electronic		X (a)		Major shifts already occurred

Note: (a) market shift to Asia has already affected Western markets

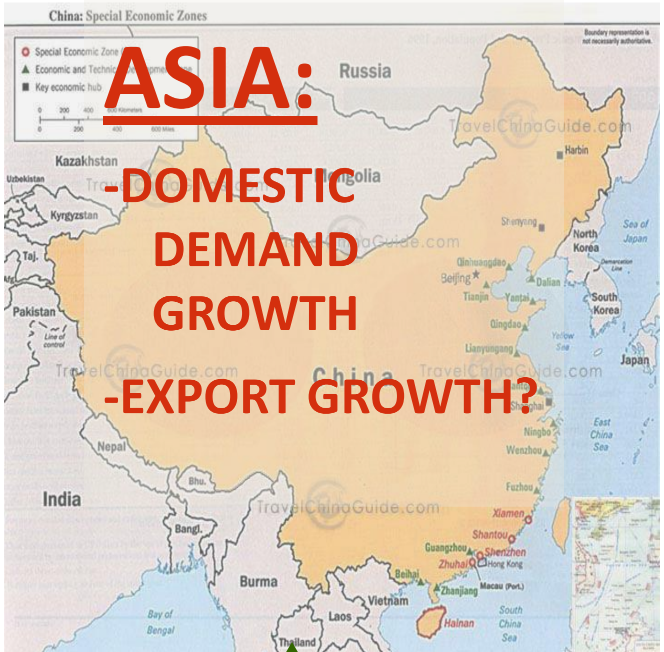
SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

MANUFACTURING COSTS (2016): CHINA REMAINS COMPETITIVE



SOURCE: EIU, WORLD BANK , L.E.K., ROBERT ELLER ASSOCIATES LLC 2012

GLOBAL INVESTMENT, TECHNOLOGY, AND MATERIAL FLOWS



ASIA:

-DOMESTIC DEMAND GROWTH

-EXPORT GROWTH?

MANUFACTURING

INVESTMENT: COMP/ RESIN

INVESTMENT PROFITS

COMPOUND EXPORT

MANUFACTURED GOODS EXPORT ($400BN)

MATURE WESTERN ECONOMIES

- EUROPE STAGNANT
- U.S. GROWTH RESTARTING
- MANUFACTURING DECLINE

INVESTMENT

INVESTMENT, TECHNOLOGY TRANSFER

- INVESTMENT
- RAW MATERIALS

ASSET-RICH REGIONS:

- MIDDLE EAST

TPE INDUSTRY STRUCTURE SHIFT EXAMPLES

SHIFT TYPE	EXAMPLE
Acquisition by major TPE supplier	Merquinsa acquisition by Lubrizol
Distributor entry into TPEs	- Albis TPV entry. Expansion into N. America - Alliance entry into compounding
Small TPE producer acquisitions	New England Urethane acquisition by PolyOne
Resin supplier → compounding	TSRC, PP resin suppliers , others
Compounding equipment	Coperion designs with Chinese gearbox, drives
Investment and imports: Asia to West	- Nantong Polymax (TPE compound supply), LCY - TSRC acquisition of Dexco*
Product line broadening	- Teknor Apex acquisition of DSM's Sarlink®* - Kraiburg entry, high temperature TPE (Hipex®)
Major TPE supplier emphasizing specialty vs commodity grades	- Kraton entry into higher performance grades - Kuraray entry into di-block/tri-block acrylic TPEs
Shifts to Asian production and market development	Recently: CTS, Hexpol, Dow Corning/Multibase Mitsui(Milastomer o-TPV)startup 2014
TPE entry from other sectors	-Automotive foils→ health care films (O'Sullivan) -Hexpol acquisitions: Elasto, Horst Mueller Kunstoffe

*= Major raw materials company exiting "commodity" grades

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

NEXT TPE GROWTH PHASE: TECHNOLOGY PUSH/MARKET PULL

TECHNOLOGY PUSH

E.G.

- **HEAT RESIST**
- **ADHESION**
- **SCRATCH RESISTANCE**
- **FOAMING**
- **CONDUCTIVE**
- **HMS (SBCs)**
- **CO-PROCESSING**

BARRIERS

MARKET PULL

E.G.

- **GREEN INITIATIVES**
- **ANTI-PVC PRESSURES**
- **AUTO DRIVERS**
  - **WEIGHT**
  - **COST SAVE**
  - **LUXURY LOOK/FEEL**
  - **GLOBAL SUPPLY**

- **Entrenched incumbent technology**
- **Low cost incumbents (e.g. PVC)**
- **In-house compounding by fabricators (e.g. rubber)**
- **Shift to commodity strategy by major TPE suppliers**

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

MARKET FACTORS PROMOTING GROWTH OF N. AMERICAN TPEs

- **Auto:**
  - **Recovery of production (adding 0.8-1.0 MM vehicles/yr through 2016)**
  - **Increased penetration, e.g.:**
    - **Body/glazing seals**
    - **Hose**
    - **Exterior body side molding**

- **Health care:**
  - **PVC substitution**
  - **Continued spending growth (3%/yr 2000-2012, in real 2005$)**

- **Construction: recovery starting (slowly)**

- **Packaging: continued TPE penetration, especially SBCs for soft touch**

- **Re-shoring: in industrial, health care, consumer, appliance**

- **Raw material cost reduction: Abundant gas, effect on polyolefins**

NEW PROPERTY/MARKET DIRECTION EXAMPLES

PROPERTY	TPE TYPES	EXAMPLE MARKETS	NOTE
Wet grip	SBS → SEBS?	- Health care - Tools, sports/leisure	With/without tackifiers
Foam	SBC, TPV COPE	- Auto: steering wheels - Body seals, skins	- 2 shot molding, extrusion - Challenge EPDM, PVC, PU
High flow	TPV, SEBS	- Auto: glazing seals, skins (soft touch) - Pkg., housewares	Auto interior soft touch is high growth application
- Hi temp, - Oil resist	s-TPV	Auto under-hood	Challenges specialty rubbers
- "Sustain " - "Green"	SBC, TPU COPE	- Auto - Consumer	Achieved via: monomer, filler, oils
Transparency/ translucency	TPU, TPVs, SBCs	Med., consumer, pkg., fluid delivery	Translucent TPU with long glass reinforcement (Plasticomp)
Slush moldable	SEBS	Auto interior skins	
High melt strength (HMS)	SEBS	Auto, Health care	HMS allows foaming, blow molding, film extrusion

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

INTRODUCTION OF TRANSLUCENT FIBER REINFORCED TPUs

PHOTO: PLASTICOMP
TPE type: TPU
Reinforcement: Long glass fiber

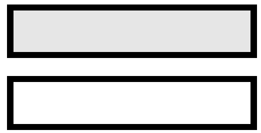
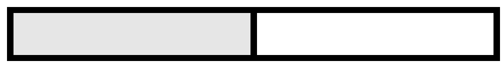
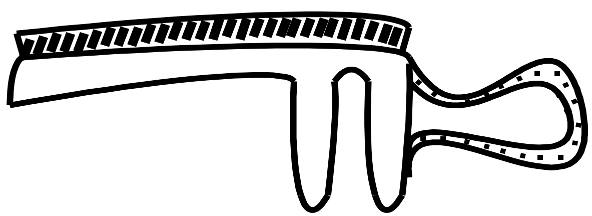
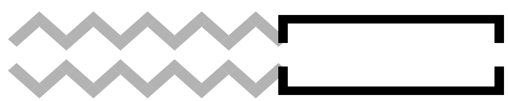
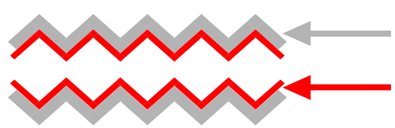
EXTENDING THE SBC PROPERTY RANGE

- The challenges:
  - Steep melt viscosity decline with temperature(good for high filler applications, high flow applications but limits processing and properties)
  - High compression set, especially at elevated temperatures

- Melt strength improvement allows :
  - Blow moldability
  - Foamability
  - Film extrusion/calendaring (for PVC film substitution)
  - Profile/tubing extrusion
  - Thermoformability

- Reduced compression set allows :
  - Competition with o-TPV for rubber substitution (e.g. body/glazing seals)
  - Sealing applications (packaging, automotive)

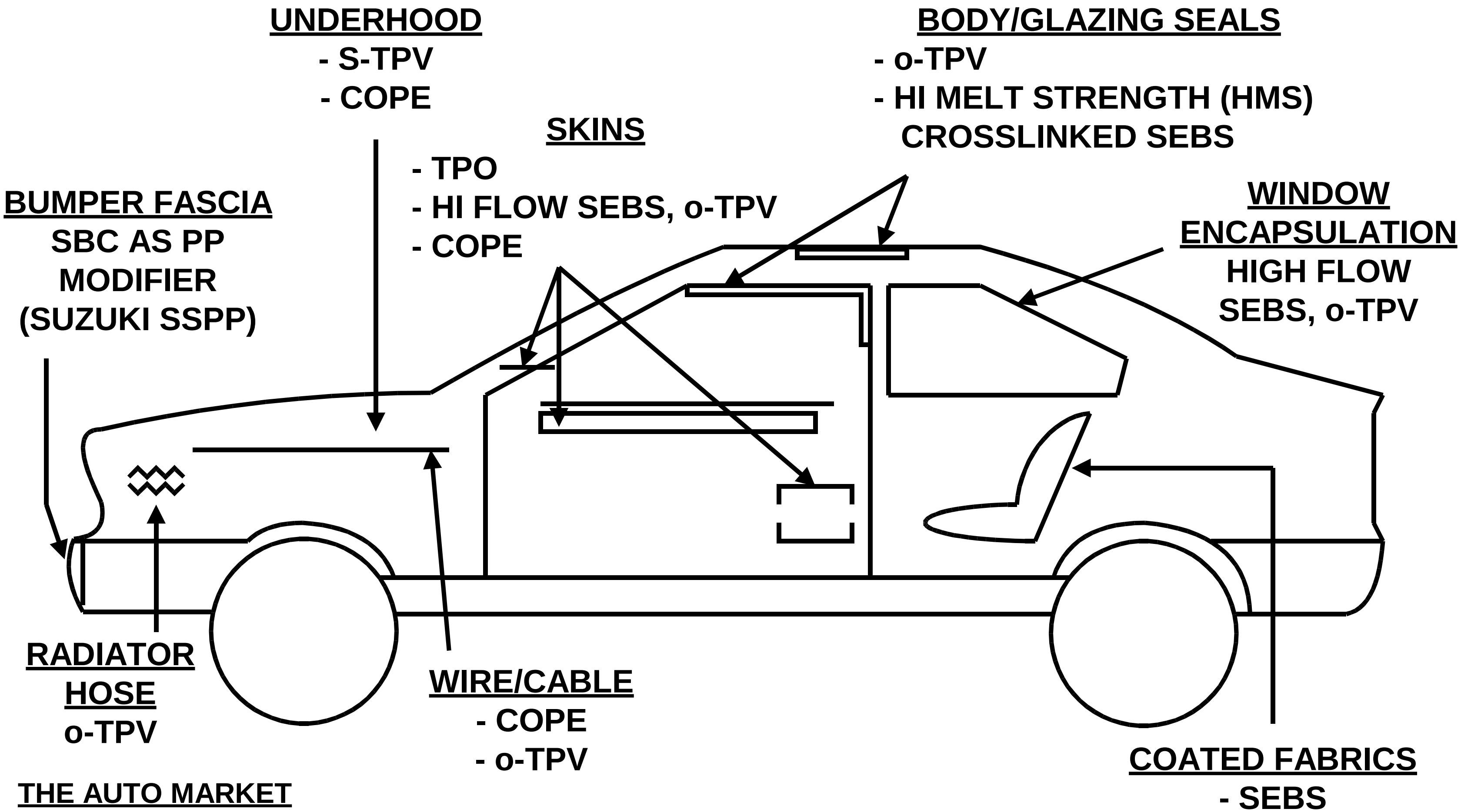
CO-PROCESSING DRIVES TPE GROWTH IN RIGID/FLEXIBLE SYSTEMS

TYPE	STRUCTURE	NOTE/EXAMPLE APPLICATION
Overmold, Film coex, 2-shot mold	 TPE Substrate (rigid segment)	- Soft touch phones - Some 2-tone applications - Vibration damping - Coex films(medical)
Side by Side	 TPE Rigid Segment	- 2-tone - Door trim, console, IP - Bumper fascia
Edging		- Body/glazing seals (profiles) - Cowl vent seals - Co-extrusion or 2-shot
Co-blow Mold	 TPE (flexible) Rigid	- Auto: Boots/bellows,hose - Medical
Co-extrusion Blow Mold or Co-extrusion	 o-TPV s-TPV or ETP inner	Under-hood: - Hose(e.g. fuel) - Duct

Source: Robert Eller Associates LLC,, 2012

r/mydox/Visio/Two Shot OM approaches 2012.vsd

AUTOMOTIVE: KEY TARGET MARKET FOR NEW TPEs



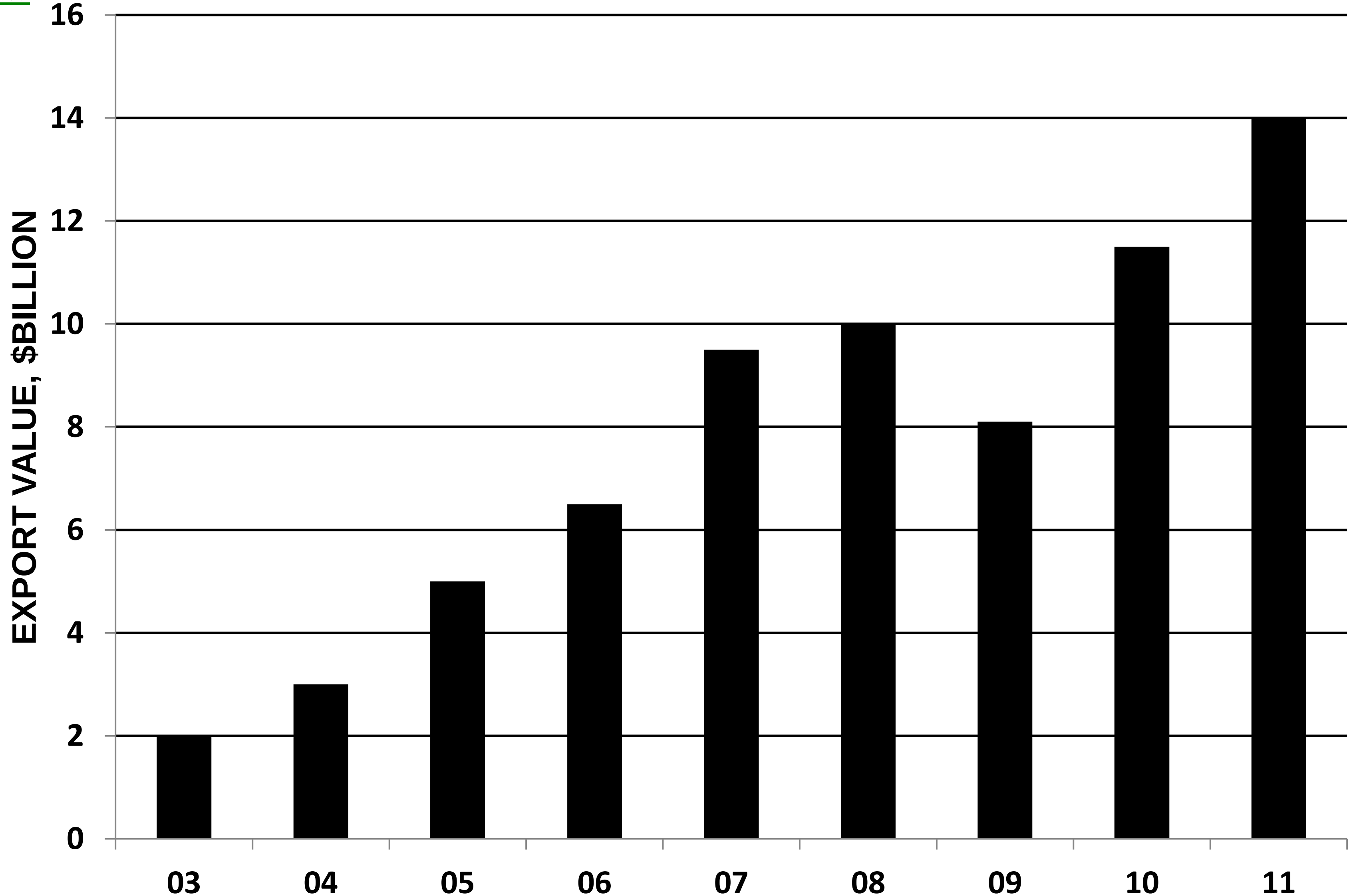
THE AUTO MARKET
- 40-50% of current TPE demand
- Key incumbents: EPDM, PVC, TPO
- Global footprint

- Role for lightweighting, systems cost-save
- Key target properties: low V.O.C., thin wall, low odor, oil/ fuel resistance, heat resistance, sustainable
- Role for process technology, co-processing innovations

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

r/mydox/Visio./Auto Key Tgt for New TPEs 2012.vsd

CHINA AUTO PARTS EXPORTS ARE INCREASING

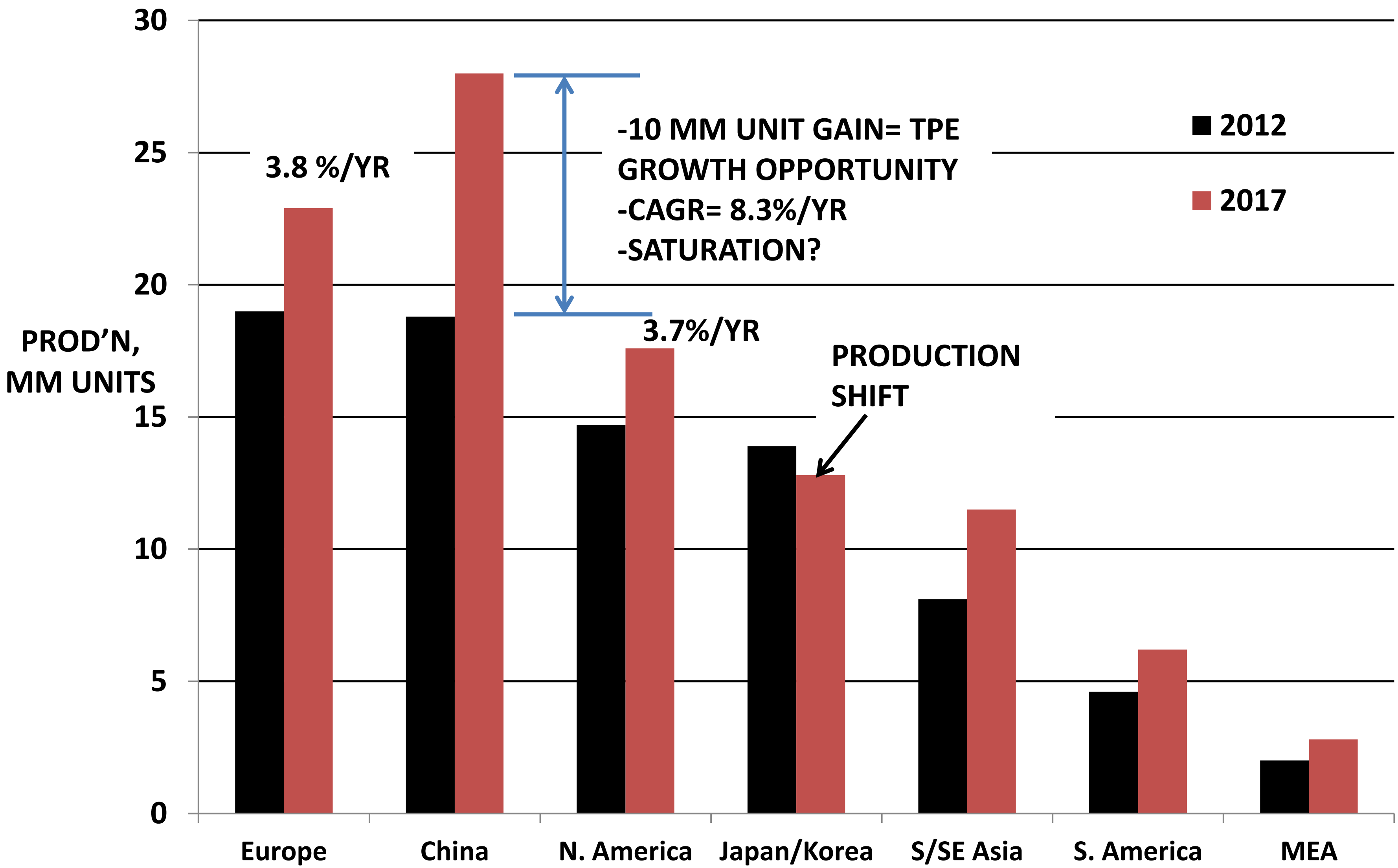


SOURCE: STEWART AND STEWART, ROBERT ELLER ASSOCIATES LLC

2011 estimated based on first 9 months

b/mydox/auto china parts

VEHICLE PRODUCTION GROWTH IN CHINA → MAJOR TPE OPPORTUNITY



DATA SOURCE: IHS

auto/global prod volumes 2012-2017

TPEs STARTING IN COATED FABRICS

PVC: the dominant incumbent strongly entrenched, cost effective

SBC-TPEs: Phthalate-free, UV resistance, low temp properties, hand/drape range

TPEs IN HEALTH CARE: A HIGH GROWTH SECTOR

- **High value market**

- **Driven by PVC replacement:**
  - Kaiser Permanente PVC ban
  - PVC in IV bags ban in China (major stimulus in the region)

- **Example health care targets:**
  - Film for range of bag and film applications
  - IV tubing sets
  - Respiratory therapy
  - Closures

- **Key TPE properties:**
  - Re-sealing
  - Bondability to polyolefins (e.g. for closures and film production)
  - Clarity
  - Melt strength
  - Elastic properties
- **Note: Vinyl Institute resistance. Major R/D focus of TPE industry**

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

TPE IN HEALTH CARE: DRIVEN BY PVC REPLACEMENT PRESSURES

PHOTO: KRATON

Application: IV bag

TPE type: H-SBC (SEBS)

Key properties: Elasticity, low temp , clarity, PP compatibility, melt strength

Processing: Extrusion, calendering

PHOTO: KRAIBURG

Application: Infusion bottle closure

TPE type: H-SBC (SEBS)

Key properties: Re-sealing, bond to polyolefins

Processing: 2 component injection

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

THE SUPER TPVs (s-TPVs)

- **High temperature/oil-chemical resistance: traditionally dominated by specialty thermoset rubbers that have the disadvantages of:**

- **High cost**
- **Thermoset processing (associated cost disadvantages)**
- **Non-recyclable**

- **s-TPV benefits:**

- **Conventional thermoplastic processing**
- **Combine benefits of high performance xlinked rubbers with high performance engineering thermoplastics**
- **Reduced processing costs vs thermoset rubbers**
- **Ability to be integrated into thermoplastic systems**
- **Adequate rubberlike elasticity**

- **Major property focus: high temp, high oil/fluid resistance (auto under-hood)**

- **Dominated by rubber suppliers: TPE suppliers entering (e.g. Kraiburg)**

- **Example applications: seals, underhood ducting (in high temp applications)**

SUPER-TPV FAMILIES

- ACRYLIC RUBBER BASED
  - DuPont™ E-TPV (DuPONT) WITHDRAWN FROM MARKET
  - ZEOTHERM® TPV (ZEON CHEMICALS)
- FLUOROPOLYMER BASED
  - FluoroXprene® (FREUDENBERG-NOK)
  - DAI-EL FLUORO TPV™ (DAIKIN)
- SILICONE BASED
  - TPSiV® (DOW CORNING-MULTIBASE)
- EVA BASED
  - HIPEX® (KRAIBURG)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

r/mydox/…/Super TPV Families 2012.ppt

RENEWABLE BIO-TPEs BEGIN MARKET PENETRATION (EXAMPLES)

TPE FAMILY OR COMPONENT	RENEWABLE RESOURCE EXAMPLE	EXAMPLE SUPPLIERS	NOTE/RENEWABLE CONTENT, %
COPA	Castor oil	Arkema, Evonik	25 – 94
COPE, (TPEE)	Polyols from corn	DuPont, DSM	20 – 60
TPU	Polyols from corn	Lubrizol, BMS, GLS	20 - 70
	Bio-propylene glycol	BASF/Oleon	From fats/oils
PP	Ethanol from sugar	Dow, Braskem	In TPE formulations
Butadiene	Biomass	Versalis (ENI – Italy)	2 step via butanediol
	Waste gas CO	Invista/Lanza Tech	
SEBS (H-SBC)	Oyster shells	CTS	Other renewable fillers
SEBS (H-SBC)	Starch/Hydrocarbon	CTS using Gaialene®/Roquette	Substitute for PP in formulations
Starch/TPE	Starch	Cereplast	30 – 50% starch
PP carbonate	(CO_2+ PP oxide copolymer)	Novomer	- 40% CO_2 by weight - PP substitute? - Clarity/O_2 barrier

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

SUMMARY

- TPE life cycle: Maturing, separating into commodity and specialty segments

- Global manufacturing shift toward Asia:
  - Decreases Western TPE demand
  - Large Asian petrochemical producers entering TPE sector
  - Investment coming toward West from Asia
  - Large multinationals adapting to broader range of Asian quality/price tiers
  - Gov't. decisions →rapid shift in TPE demand (health care, auto subsidies)
  - China remains competitive despite wage increases

- TPE industry structure: Shifting in response to
  - Maturing supply side TPE markets (maturing of some TPE grades)
  - Search for low cost raw materials (effect of gas abundance in U.S.)
  - Global market shifts toward Asia (partially modulated by re-shoring to U.S.)

- TPE properties envelope expanding:
  - New applications in auto, health care, packaging, consumer
  - SBCs, most rapid properties expansion

SUMMARY (cont'd.)

- **Auto: Remains major global TPE demand driver**
  - Demand recovery in U.S.
  - EPDM substitution (e.g. hose, body/glazing seals)
  - Interior skins/soft touch remains battleground
  - Under-hood (enhanced role for s-TPVs)

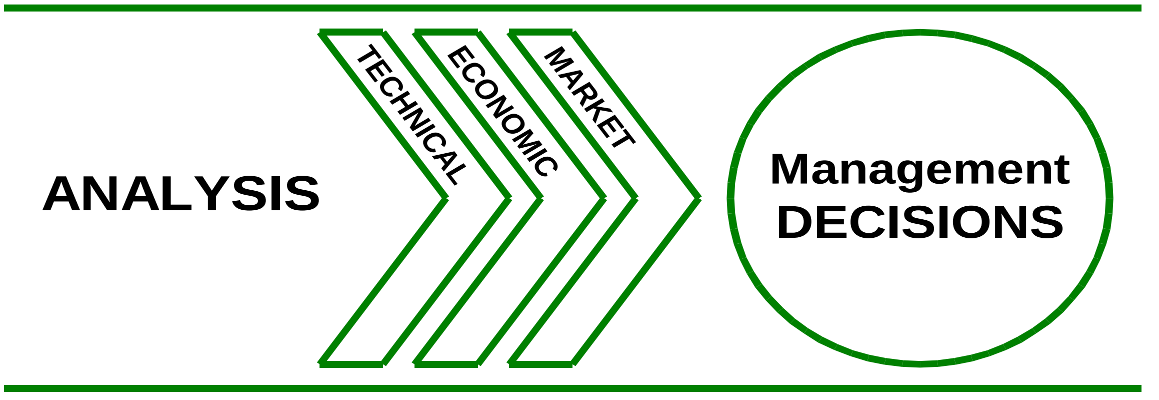
- **Global recession effects:**
  - Decline of China exports→ Europe
  - Slowing China economy
  - Europe in severe auto, consumer and housing recession
  - Some raw material price declines

- **Health care:**
  - Fast growth TPE market
  - PVC replacement decisions(China and West)

- **s-TPVs: Reaching for high performance specialty rubber markets**

- **Bio-TPEs: Momentum starting. Capable of competing in the marketplace**

THANKS FOR YOUR ATTENTION



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