From Cans to Cars –
Saving Energy and Resources with Polymers

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1. Introduction

While requiring relatively little energy and raw materials in production, polymers are contributing significantly to comfort, security and efficiency on a global scale. Just how much energy can be saved with modern design involving polymers and replacing more "traditional" materials like metal, glass or paper will be outlined with the help of some examples:

- Advanced Packaging (Protecting food and medicine with low energy and material consumption)
- Insulation solutions (Keeping heat and cold where it should be)
- Mobility today and tomorrow (Bridging distances with reduced energy use)

These three areas cover by far not all possible present and future uses of this uniquely versatile class of materials, which also contributes to environmental protection in such diverse areas as water filtration and transport, wind energy usage and the prevention of flood and erosion damage. Even in developed countries the use of modern polyethylene (PE) pipe grades for replacing or retrofitting drinking water installations can save up to 30% of water presently lost through leaky installations; benefits in other parts of the world are much higher.

2. Key Features

The public discussion of polymers is very much focused on packaging, which however only makes up 37% of the global use [1]. This is by far not the only common misconception about polymers; others include the wrong judgment of a material requiring less energy to produce than most others, and the commonly overestimated contribution of plastics to municipal solid waste which in Europe is just about 13% (with paper ranging at 10% despite many years of collection and recycling efforts).

Advanced packaging solutions are protecting food and medicine with little material & energy consumption. The low energy demand of polymers (see Figure 1) contributes to their advantages just as well as the low density and high mechanical strength [2]. An important aspect is the recoverable energy content, which cannot just contribute to electricity production (in which one average shopping bag can deliver enough energy for supplying a 60 w lamp for 10 minutes), but also act as reduction agent in steel production. One of the most stunning examples are stand-up pouches (SUP) based on

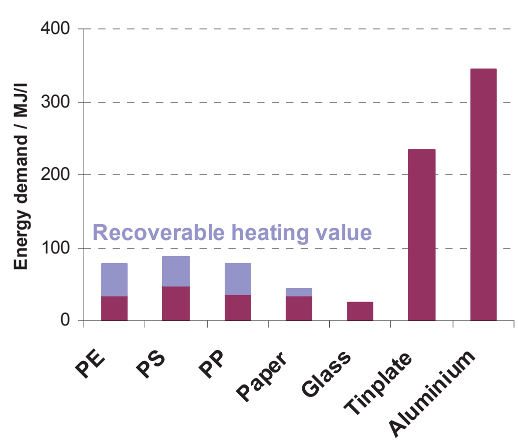

Figure 1. Specific energy demand per unit volume of typical packaging materials (polymers and non-polymers); upper blue part of the bars indicating recoverable heating value (from combustion).

polypropylene which are saving 95% of energy over tin cans, and still more than 80% over glasses [3]. The massive weight reduction is accompanied by other positive effects such as reduced space demand and comfort features for the customer. Polypropylene (PP) makes up the support layer and more than 50% of this packaging form applicable for a wide variety of food, pet-food and non-food uses (see Figure 2). The volume of SUP's is expected to grow at about 13% per year until 2011. Also, polymer-based medical pouches being safer to transport and to use than glass bottles, are contributing to peoples' health. When produced from soft PP copolymers, these pouches also offer the advantage of avoiding plasticizer leaching in comparison to plasticized PVC.

Insulation layers from polymer foams are keeping both heat and cold where it should be, allowing the construction of "zero energy" houses in many parts of the world. Approximately 25% of world energy consumption is used for heating, and another 8% for cooling (via electricity). Here, effective insulation can not only improve living standard but also health. Polymer foams are extremely efficient insulators, with one cm polymer foam providing as much insulation as 15 cm brick wall or 50 cm concrete (see Figure 3), and the energy use for insulation foam applications being recovered within one year under German conditions [4]. As energy-neutral buildings are only possible with an efficient usage of solar energy, the high relevance of polymers for this area – from collectors through storage tanks to low-temperature heating systems – should be mentioned as well here.

But also in the appliance sector, clever new solutions involving multimodal polyethylene allow new refrigerator generations with higher efficiency. Today's standard constructions suffer from water uptake to the Polyurethane (PU) foam layer through the Polystyrene (PS) inner liner of a refrigerator, resulting in an increase of energy demand over time. Replacing the PS sheet with a mineral compound based on Borstar™ Polyethylene (PE) can save about 200 kWh electricity per unit over its lifetime [5] at equal processability and weight. This amounts to an overall saving potential for the European Union countries (EU 27+2) of half the output of one nuclear power station at ~ 25 mio freezers and fridges being produced per year.

Figure 2. Typical construction for sterilizable SUP film laminate (OPET – oriented poly (ethylene terephtalate), Al – aluminium, PP – polypropylene) and application example highlighting user comfort.

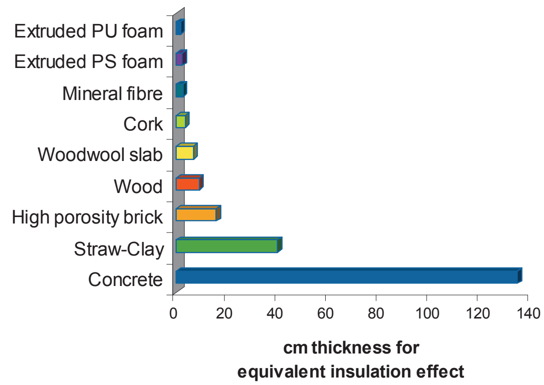

Figure 3. Thickness of insulation layers from different polymeric and conventional materials required to achieve an identical insulation effect (data from [4]).

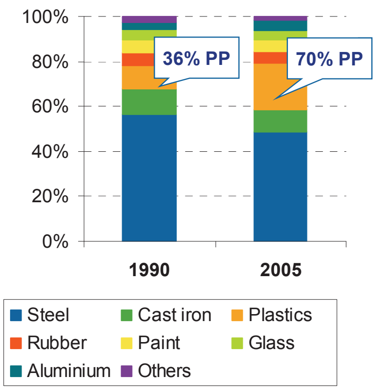

Figure 4. Developments in material composition of European passenger cars (example data from FIAT and VW, internal documentation).

Mobility in the end means getting people and freight "from A to B" with as little energy use as possible. Vehicles such as passenger cars have approximately 90% of energy use during their lifetime, making weight saving an important factor. Presently traffic is the fastest growing source of energy demand [6] with the global population presently traveling about 30 mio km per year. Even under the most optimistic assumptions it is quite clear that the high level of individual mobility cannot be replaced by public transport. The relative amount of polymers used in passenger cars has doubled from 1990 to 2005, and about 70% of the present fraction is PP (see Figure 4) – both factors contributing positively to the energy balance.

Polypropylene-based body panel solutions as those used for the SMART (see Figure 5) not only help to reduce the lifetime energy demand by more than 65%, but also make cars safer traffic partners for pedestrians through an increased flexibility and energy absorption capacity. It can even be molded in the desired color, reducing the demand for paints and coatings on the respective parts, adding to weight saving and reducing production cost. Like other recent applications in the automotive segment, the main task now is to develop load.-bearing components able to fully replace metal, using a combination of material and component design. Combining sophisticated polymer design with performance mineral fillers or long glass fibers (LGF) allows to achieve these property requirements and also to integrate different parts into bigger constructional units (again reducing assembly time and production cost).

High-performance composites from glass or carbon fibers in combination with thermosets (polyester and epoxy resins) earn some special attention here. Modern airplane developments would be quite unthinkable without them; the amount of composite usage in passenger airplanes presently ranging at 30% and likely to increase to about 60% (see Figure 4). Also in such diverse areas as shipbuilding and traffic infrastructure, these composites, often exceeding steel or aluminum in strength, contribute significantly.

Figure 5. PP-based body panel system for the SMART for two lightweight passenger car (Daimler AG, Germany).

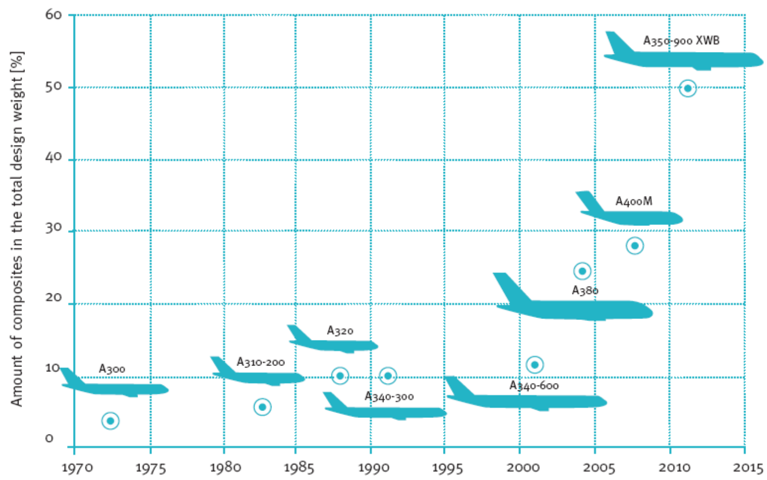

Figure 4. Development of composite content in passenger airplane construction for the Airbus product family (courtesy of Plastics Europe, 2007).

3. Conclusions

While using only 4% of the global raw oil production, polymers are helping to reduce the energy and resource demand in many ways [7]. Having grown in volume largely by substituting other materials for cost and comfort reasons, plastics now are capable also to solve at least part of our present and future energy problems in various applications. "Traditional" polymers and especially polyolefins further offer the advantage of a uniquely low carbon footprint resulting from high production efficiency which will be difficult to match for completely new developments.

4. References and Bibliography

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Speaker's Biography

Dr. Kent Abbas holds a position as Senior Advisor Innovation & Technology in Borealis. Previously he was General Manager PP in Borealis, Vice President of the Business Unit PP, and Senior Vice President for Research and Technology. Dr. Abbas has also worked in the automotive supply industry, holding positions as Technical Director and CEO, and in Telecommunications as a Project Manager and a specialist in plastic materials. He was also Professor in Polymer Engineering and Science at the Royal Institute of Technology Stockholm, Sweden. He is a member of the Swedish Royal Academy of Engineering Sciences.