Stronger. Lighter. Smarter

Presenter (and authors) background

- Magdalena Sandstrom has a degree in chemical engineering, at Lund University and worked her way through the ranks at Diab, from Material Development to Chief Technology Officer (CTO) at Diab. In this position she is responsible for a global technologies team covering materials, testing, finishing, design and technical services. In addition, she is a member of the Diab Management Team (DMT), which runs the company on a day-by-day basis, reporting to Diab's long-standing owners, RATOS AB. During the last ten years of Magda's rise within Diab, she has worked closely with Market Segment Manager's to best develop products and services which meet customer needs and together, she and Ray Lewis have worked closely.

- Ray Lewis has 39 years' experience of the composites market, not quite going back to a mud-hut!). He combined work and education (professionally in Polymer Technology) which saw him develop from a technical trainee, to Market Segment Manager – Wind Energy, combining both technical, product and business management roles. In the early years he was involved with resins, then vacuum consumables (with Tygavac/Airtech and also Aerovac/Richmond) and tooling (The Advanced Composites Group. He then went on to spend 10 years at SP/Gurit as a Product Manager, working on prepregs, resins and cores for the wind energy market, before joining and working the last 10 years exclusively on Cores, for the wind energy market with Diab.

Abstract

- From the early years of using composites, when our predecessors, when our predecessors combined straw and mud to create mud-huts, the advanced composite market has developed into one of the most exciting growth markets, as it enables designers so much freedom to develop lightweight, complex shaped structures.
- After Aerospace, Formula 1 and America's Cup developments at the "high-end, lower volume" end of the market and boat, panels at the "lower-end, high volume" end of the market, the wind energy market came into being.
- Occupying a niche in-between the aforementioned categories, wind has seen rapid development and growth, with composites being used within the nacelle, spinner and most significantly, blade structures of the wind turbine generator (WTG).
- Simplistically, blades have grown in size and efficiency from 10 to 100m in length, using primarily resin, fibre and core in their structure.
- The use of core materials (balsa, pvc, pet, san and some others) enables designers to work with sandwich construction and design, combining the attributes of a resin/fibre laminate either side of a lightweight core, on such a large structure.
- Diab has been involved with PVC foam technology since the end of the 2nd World War, when in 1950 the company was founded in Sweden by Bertil Deidrichs. It has since developed into one of the major global suppliers of Core, finishing and kitting solutions, with PVC, balsa, PET and PES materials.
- Essentially, Diab's DNA is one of a "knowledge provider" and it has been instrumental in developing the sandwich core concept across many market segments, which today form the platform of the company, namely Aerospace, Industry, Marine, Transport and its largest, Wind Energy.
- As wind energy market has evolved from prepreg to infusion as its manufacturing platform, the use of core has become more significant as it not only provides fundamental properties for design (the same in both manufacturing routes), but it acts as a processing aid during the infusion process, enabling producers to optimize their processes.
- It is in this latter area that Diab has focused much of its knowledge, in order to focus on helping our customers to lower the cost of energy and enable they to become more successful, and the market to grow significantly in market share.
- In accepting this invitation to speak, the authors have decide to combine their knowledge and share openly their thoughts to SAMPE, with the objective to open minds help enable the advancement of materials, processes and engineering within wind, so that (as a consequence) its associated composites technologies grow, to the benefit of all stakeholders.

The development of core materials within the wind energy market

Presented by Magdalena Sandstrom, CTO, Diab
Written by Ray Lewis, Market Segment Manager, Diab

Introduction

The wind energy market has seen major development and growth in its first two decades and now enters it's 3rd decade at a key milestone point, as it seeks to compete subsidy-free against other renewables and more conventional forms of energy worldwide.

The authors presentation reflects on the past (1st decade), present (2nd decade) and future (3rd decade, from 2018-2028), where the lower cost of energy, design, technology, flexibility and global consistency are some of the key drivers.

Composites: evolution of markets/materials

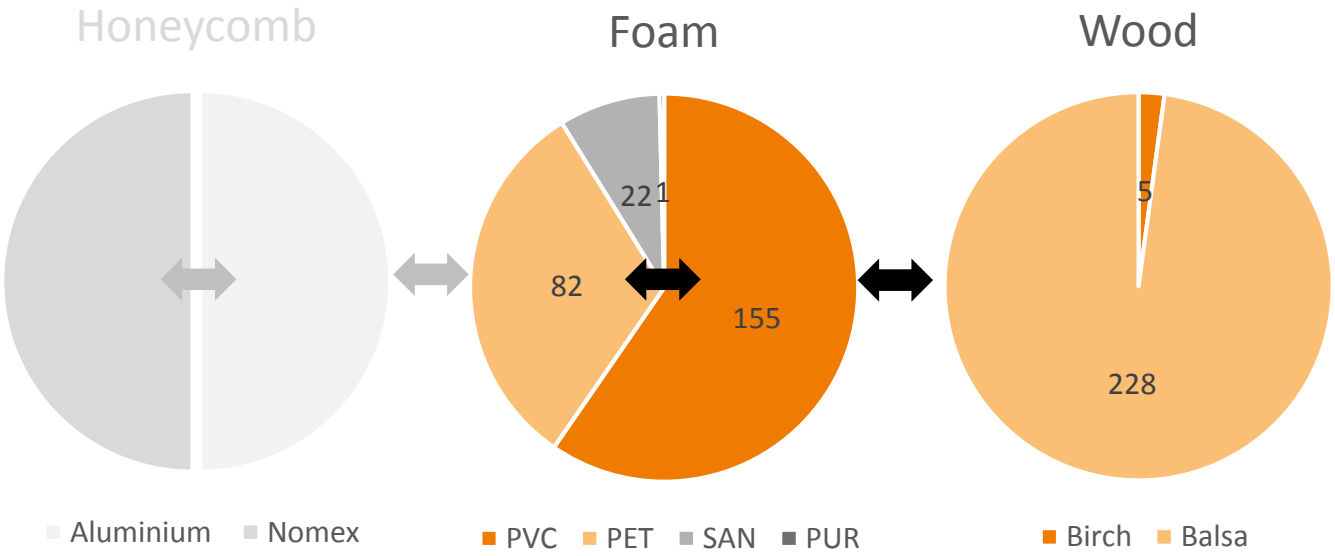
Markets

- Space – lightweight, one-off, high cost
- Military Aerospace – not dissimilar
- Formula 1 – evolving from the above
- Civil Aerospace – reducing weight to carry more cargo and/or passengers, aircraft interiors
- Marine – competition yachts
- Industrial structures – design possibilities
- Wind energy – industrial production

Materials

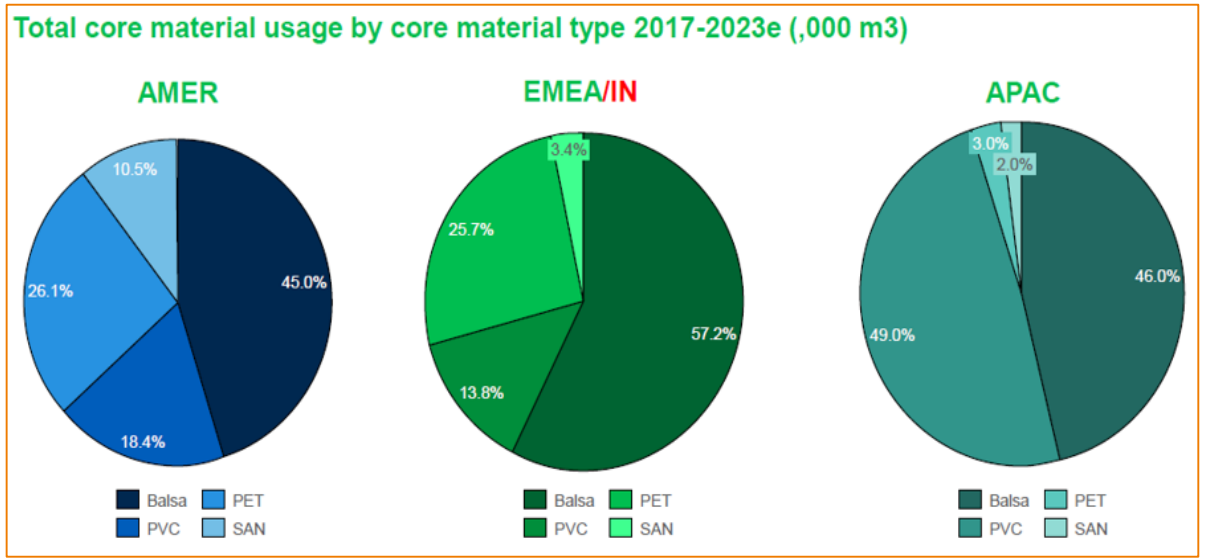
- Simplistically, these typically hi-temperature prepreg applications require the use of high temperature, pressure and strength materials such as epoxy, bmi and peek resins, carbon fibre and aluminium and/or nomex honeycomb core.
- Whereas, these typically low-temperature prepreg and/or infusion applications require the use of vinyl ester and epoxy resins, glass (and in some areas, carbon) and core (balsa, pvc, san and/or pet)

Composites: core types structural sandwich



- Balsa and PVC are defaults
- PET is replacing some SAN, PVC and/or Balsa
- Similar in-box and paradym shifts can also occur
- The complexity of the market means no 100% trend

Composites: wind core types



In all 3 regions, 50% of the core used is foam and 50% balsa

Regarding foam…

In the West, the foam types used are well developed and diverse w between PVC, PET and SAN.

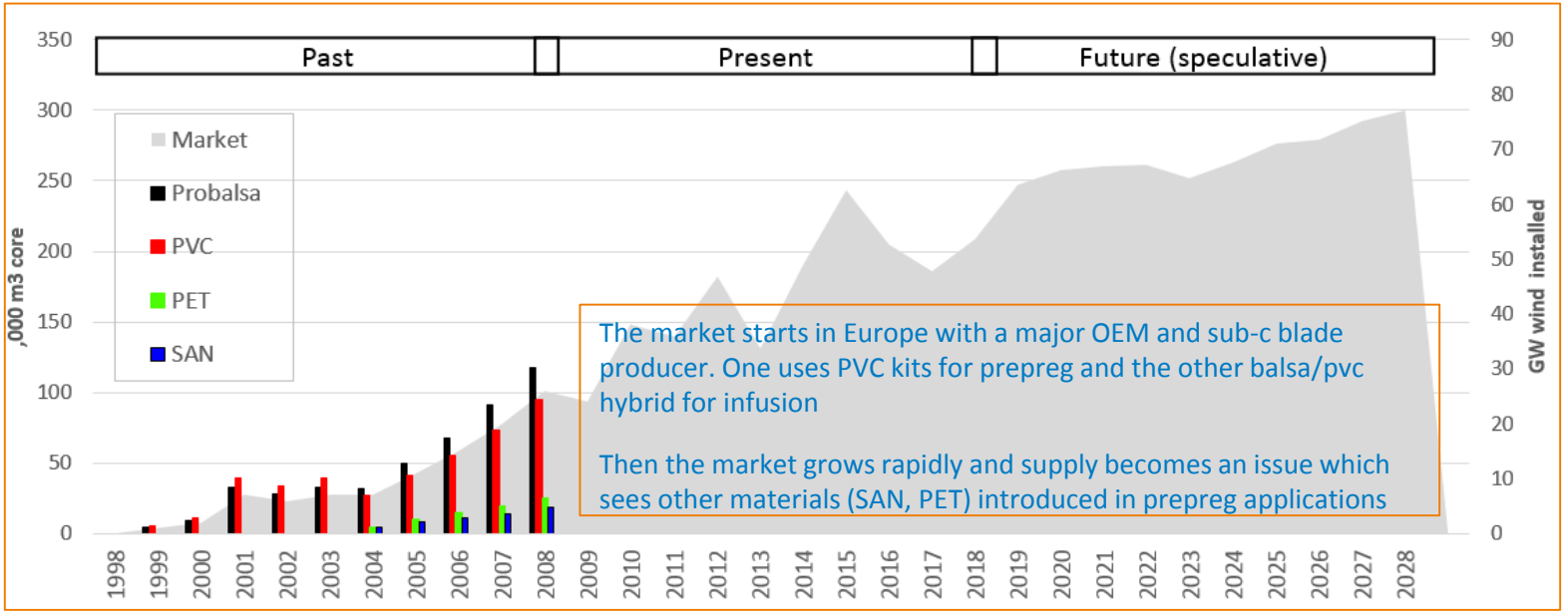
In the East, PVC is the default due to the domestic market their

Wind: a simple overview

Wind has seen a rapid development and growth and with it composites, which are used in the nacelle, spinner and blade structure of a wind turbine generator (WTG).

- Blades have grown in size and efficiency from 10 to 100m in length
- Key materials are resin, fibre and core.
- The use of core materials (balsa, pvc, pet, san and some others) enables designers to work with sandwich construction and design, combining the attributes of a resin/fibre laminate either side of a lightweight core, on such a large structure.
- As wind energy market has evolved from prepreg to infusion as its manufacturing platform, the use of core has become more significant as it
  - not only provides fundamental properties for design (the same in both manufacturing routes)
  - but it acts as a processing aid during the infusion process, enabling producers to optimize their processes.

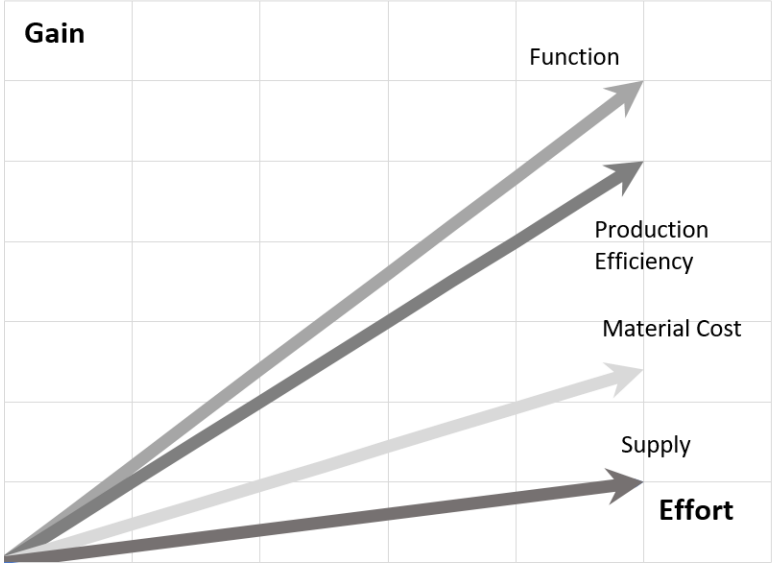
Wind: decade 1, 1998 to 2008 - beginnings



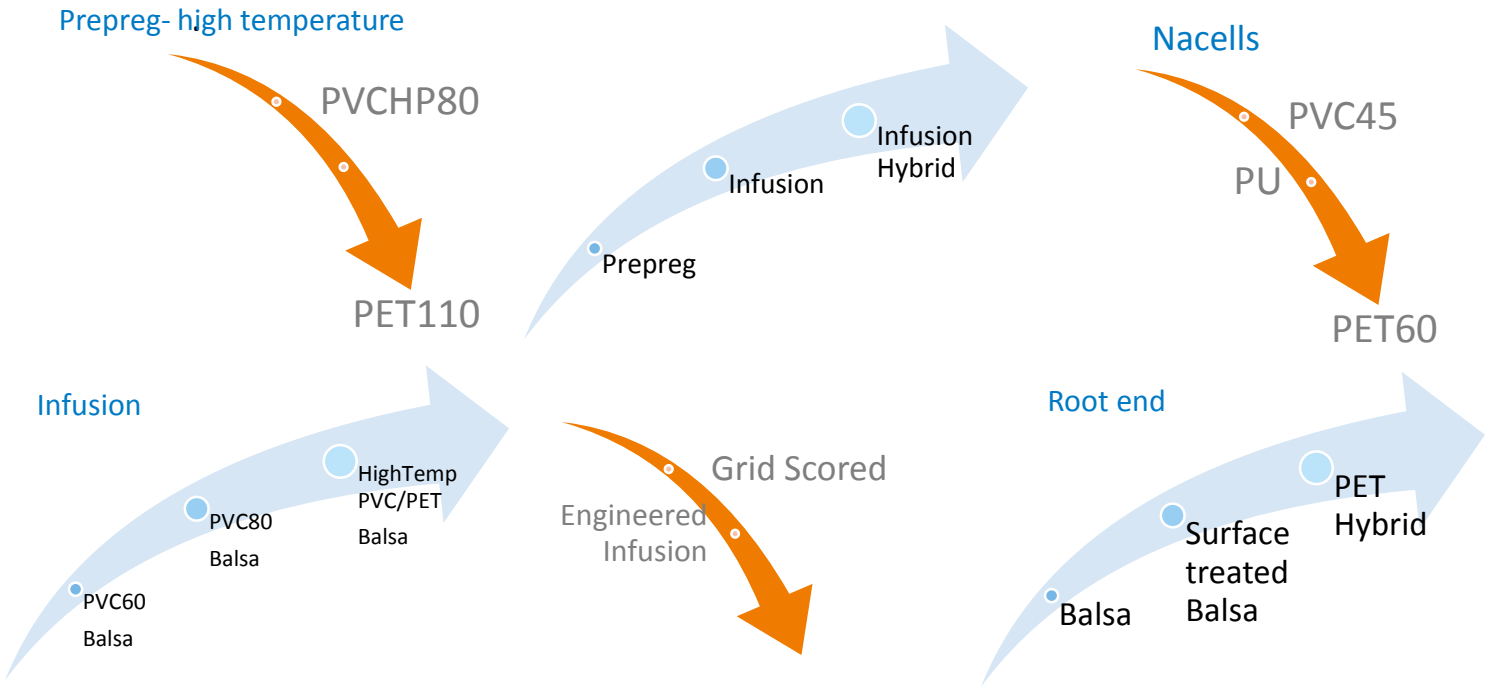
Wind: industrialization in second decade

Industrialization enabler for growth

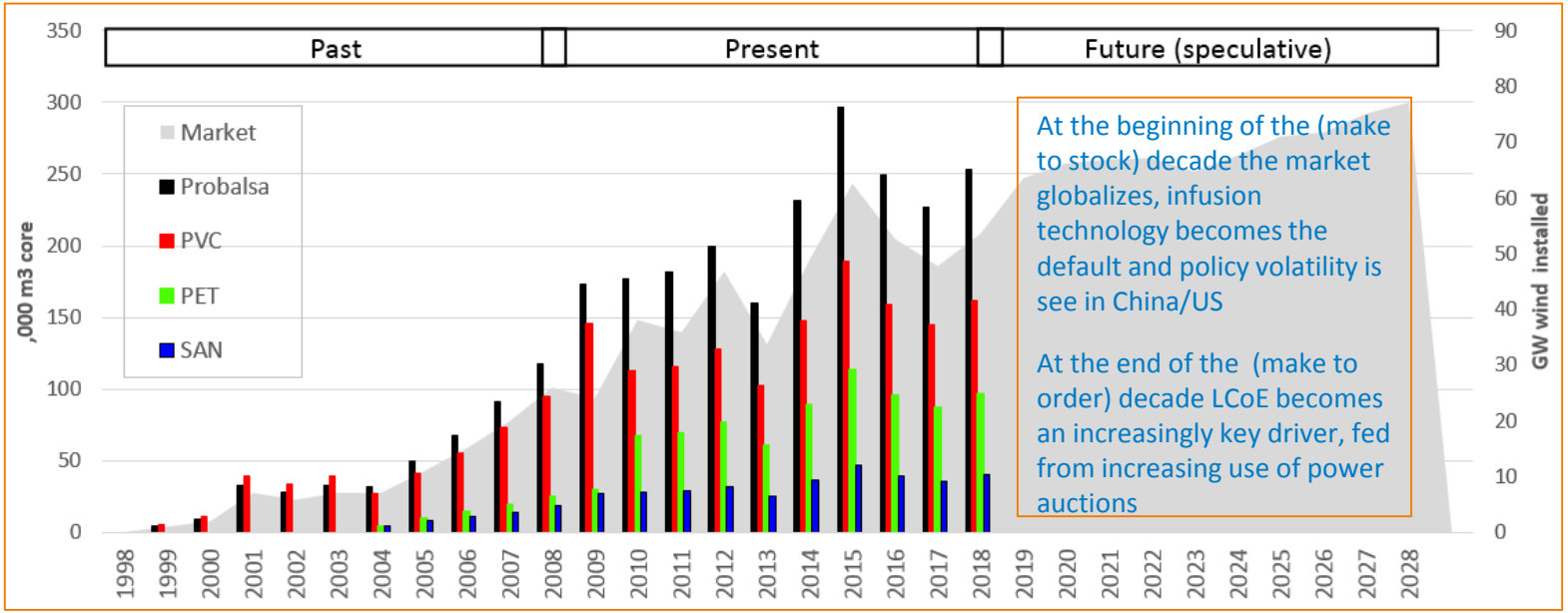
- The second decade was characterized by large efforts for industrialization and striving to take out cost.
- With the drive to reach levelized cost of energy, LCoE, the industry innovates.
- A total concept approach on function, production, materials and supply has proven successful.



Wind: evolution decade 2



Wind: decade 2, 2008 to 2018 – growth/arrival of wind



Diab: features for decade 3 – process time

Shorter cycle time means less CAPEX

- Temperature: Fast curing systems shortens the process times, the draw back is risk of high peak temperatures.
- Insulation: Groves in thick material get extra hot, due to insulation of foam.
- Testing: New test procedures under relevant conditions are required to characterize the final performance of the foam

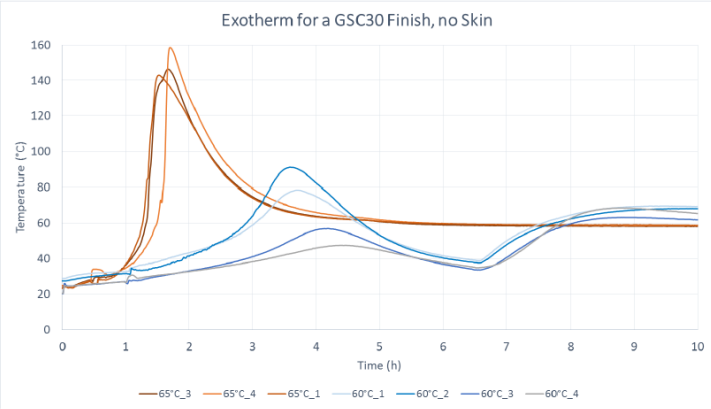
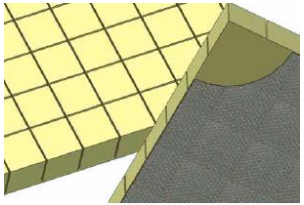


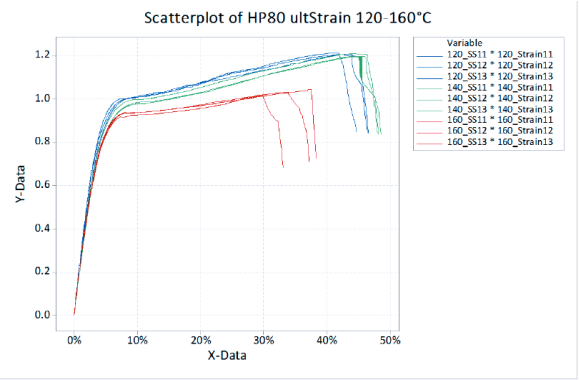
Figure 6. Exotherm Peak over time. Warm colours = 65°C table. Cold Colours = 60°C table



Diab: features for decade 3 – process time

Shorter cycle time means less CAPEX

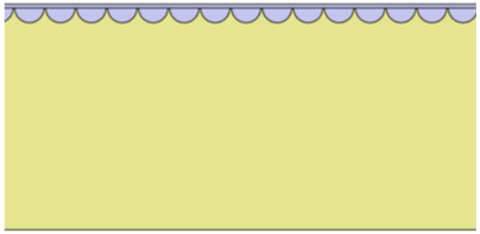
- Testing: New test procedures under relevant conditions are required to characterize the final performance of the foam
- Relevant conditions: In a sandwich structure, under cure, at a time and temperature witch is defined.
- Performance: PVC is coloured from heat, but keep mechanical properties well.
- New finishing: Large blade, means thick core. Innovations in finishing will come, to facilitate process and handle temperature.



Wind: features for decade 3 – resin uptake

Fine cells are saving cost in resin and weight to the article

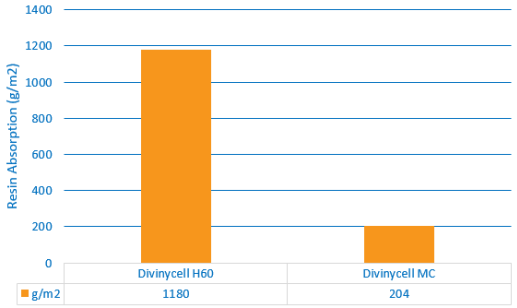
- For closed cell foam cores it is primarily a surface phenomena, as the resin saturates the surface cells but never penetrates into the foam.
- For end grain balsa, the resin is attached to the surface as a thin coat but also partially gets absorbed into the wood's cell structure.
- A need for standardized test methods, results from different studies can not be compared

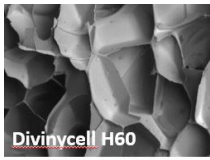


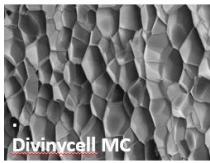
Wind: features for decade 3 – resin uptake

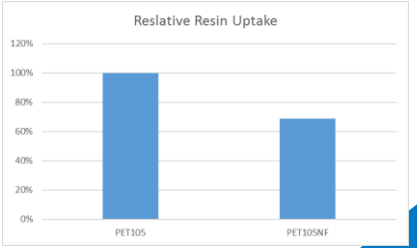
Less resin can be accomplished in different ways

- Fine: Core materials with a much finer cell size, as for example Divinycell H60 MC with only a sixth in resin uptake versus a standard PVC.
- Surface: Also the surface texture is of importance Several patents on how to close the surface are available.
- But again, it is focus on single components.





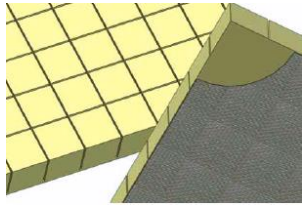


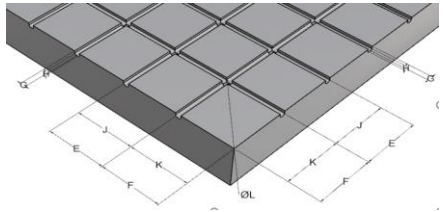


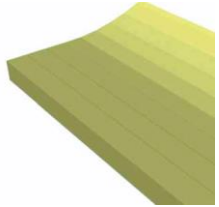
Wind: features for decade 3 – combined functions

A holistic approach – total cost concept

- As seen many times, step changes are achieved when knowledge from different areas are gathered and all aspects of a process are considered.
- As example core materials are used not only as part of a sandwich but as a process aid saving large amounts of resin.
- How the resin is distributed will affect process time , but also final weight, cost to resin and temperature peaks in the process. It will add strength.
- Can the foam do more, add new innovations?







Wind: decade 3 drivers on core choice

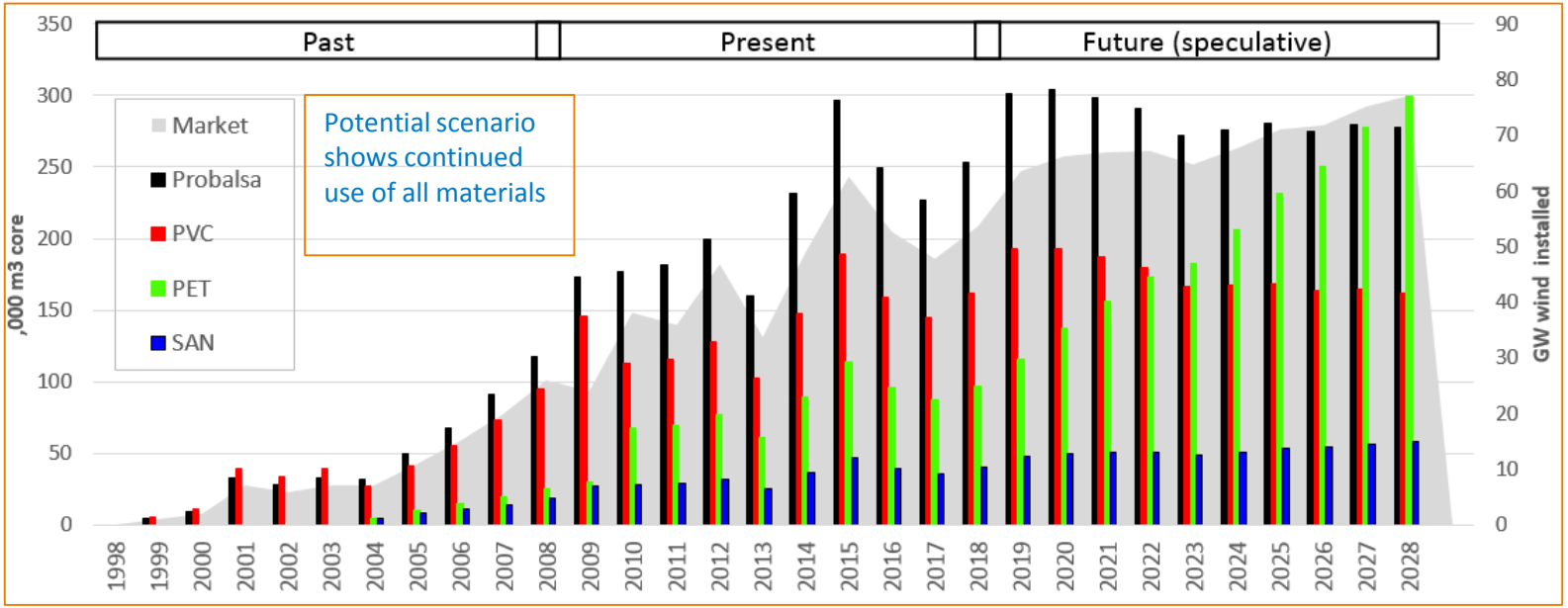
Depending on your view and where you sit, depends on your conclusion. Overall factors are;-

- WTG design: fundamentally, in the next decade, the 3 bladed horizontal axis design will still be the default and this has the need for core materials, so it is a question of which type?
- Onshore/Offshore: due to the risk factors involved, OEM's typically have a higher sensitivity offshore, so this may drive selection
- Blade size: is increasing, so weight can be considered a factor in design, so lighter weight cores are attractive
- Blade design: in-house and 3rd party designers have many designs which drive a complex and non-standard choice of materials today.
- OEM design: these ultimately drive design and their relative market size also has an impact. E.g. if a large OEM with 25% market share uses 100% core x, then that core will have a similar global %

"Wind: decade 3 drivers on core choice"…….continued…..

- OEM consolidation: where OEM's have different designs, consolidation of design will inevitable take place as joint-designed, next generation platforms are developed
- OEM product life cycles: these drive the timing. Typically they have reduced to 3-5 years with material change occurring on new designs, so phasing in and out will see a ramp-up/down
- OEM geography: these also play an impact and there is a massive difference between east and west.
- Supply: History has taught us demand goes up and down and the whole supply chain needs to react at increasingly short notice, as flexibility and lead-times are key.
- Environmental impact: following society trends in using less resources can finally be a game changer. Less material, with low impact and clear end-of-life destination are embraced.
- Cost: a key driver, especially to address the LCoE factor. Of course the cost per m3 of core becomes central, but in reality the "total cost" aspect affords greater savings possibilities

Wind: decade 3, 2018 to 2028 – wind as a default?



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