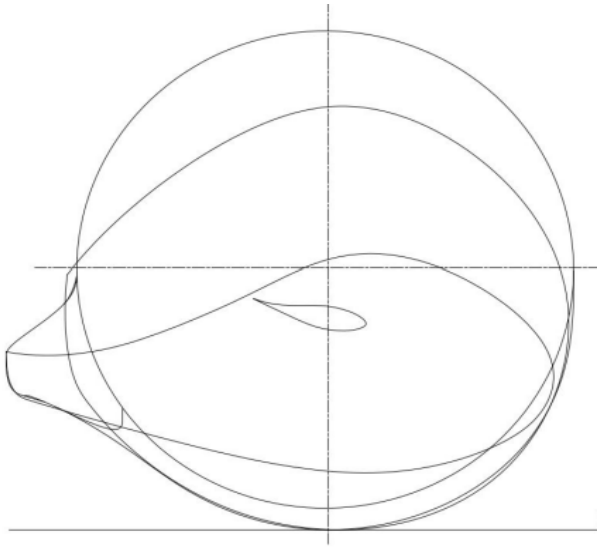
The Growth of Carbon Fibre in the Wind Energy Sector

GOCarbonFibre 2018

9-11 October 2018 | Berlin Germany



Overview

- Commercial benefits of using carbon fibre to manufacture robust, reliable turbine blades whilst ensuring a secure supply chain.
- Carbon fibre growth forecast in wind energy.
- Identification of ‘pain points’ and enabling elements for OEMs to adopt carbon fibre on a significant scale.

STRUCTeam Introduction

- 200+ completed projects
- One of the leading independent composite consultancy
- Cross-sector experience and great flexibility

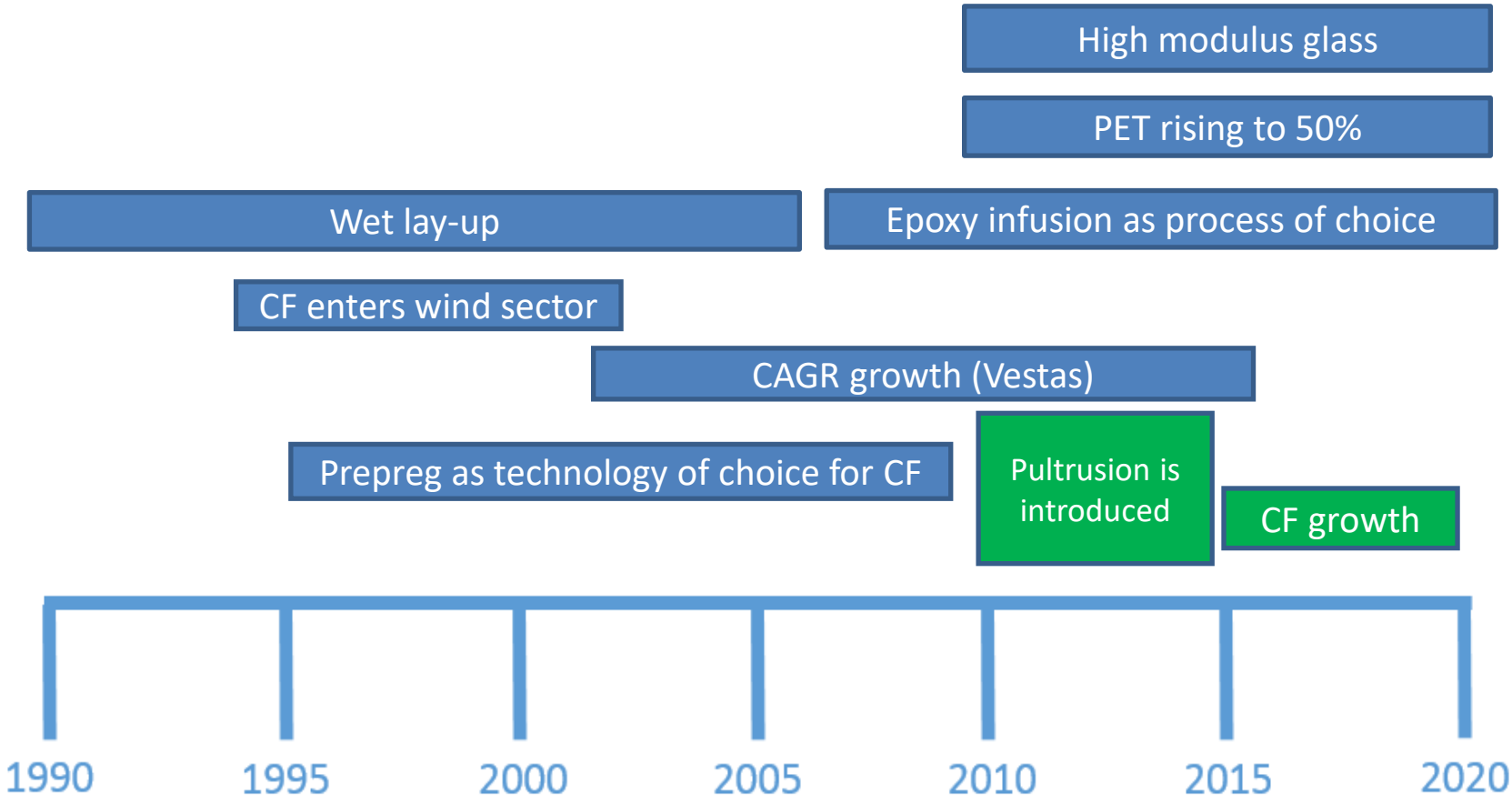
Carbon Fibre – The Reality

- Carbon fibre is not a new application in the wind energy sector. However, it is yet to reach its full potential.

- What are the lessons learned from the past two decades.

- How we can create a sustainable growth path for this highly advantageous product within the composites industry.

Material Technology Adoption in Wind Energy



Introduction- New technology

The challenge for any new technology is to deliver an overall package that is;

- low cost
- high quality
- high production volumes
- scalable anywhere in the world

How to assess new technologies in the wind sector

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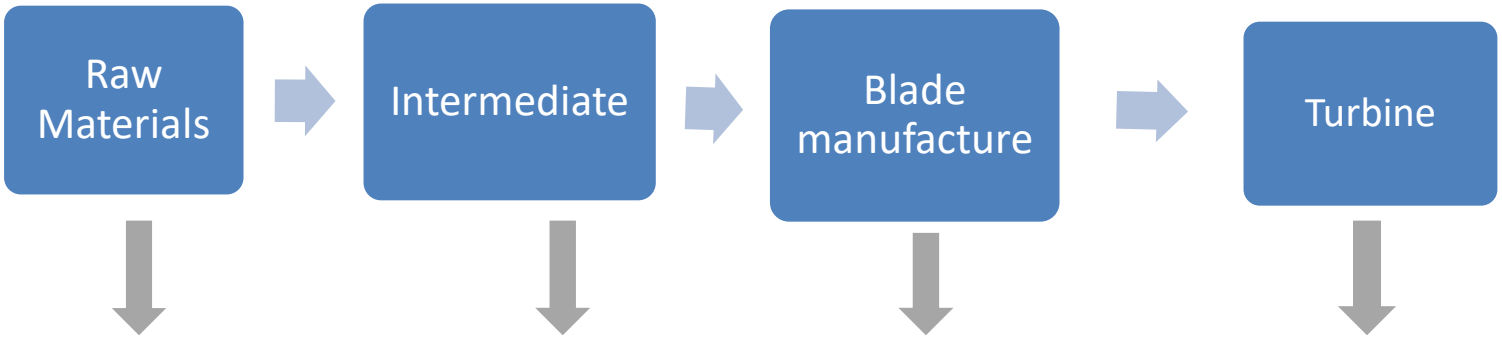
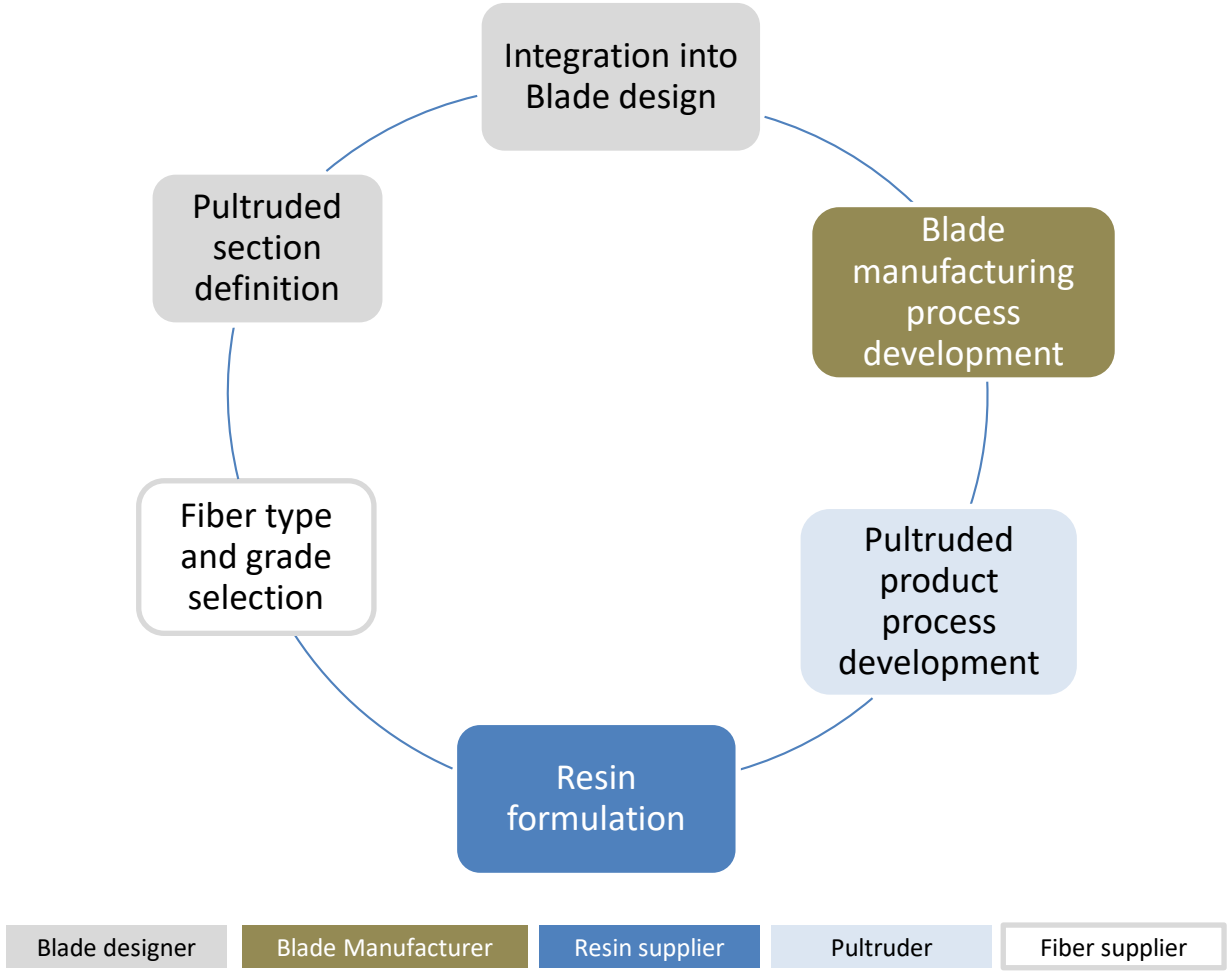


Raw Materials	Intermediate	Blade manufacture	Turbine
Unit cost	Unit cost	Unit cost	Unit cost
Performance	Yield	BoM	LCOE
		Cycle time	

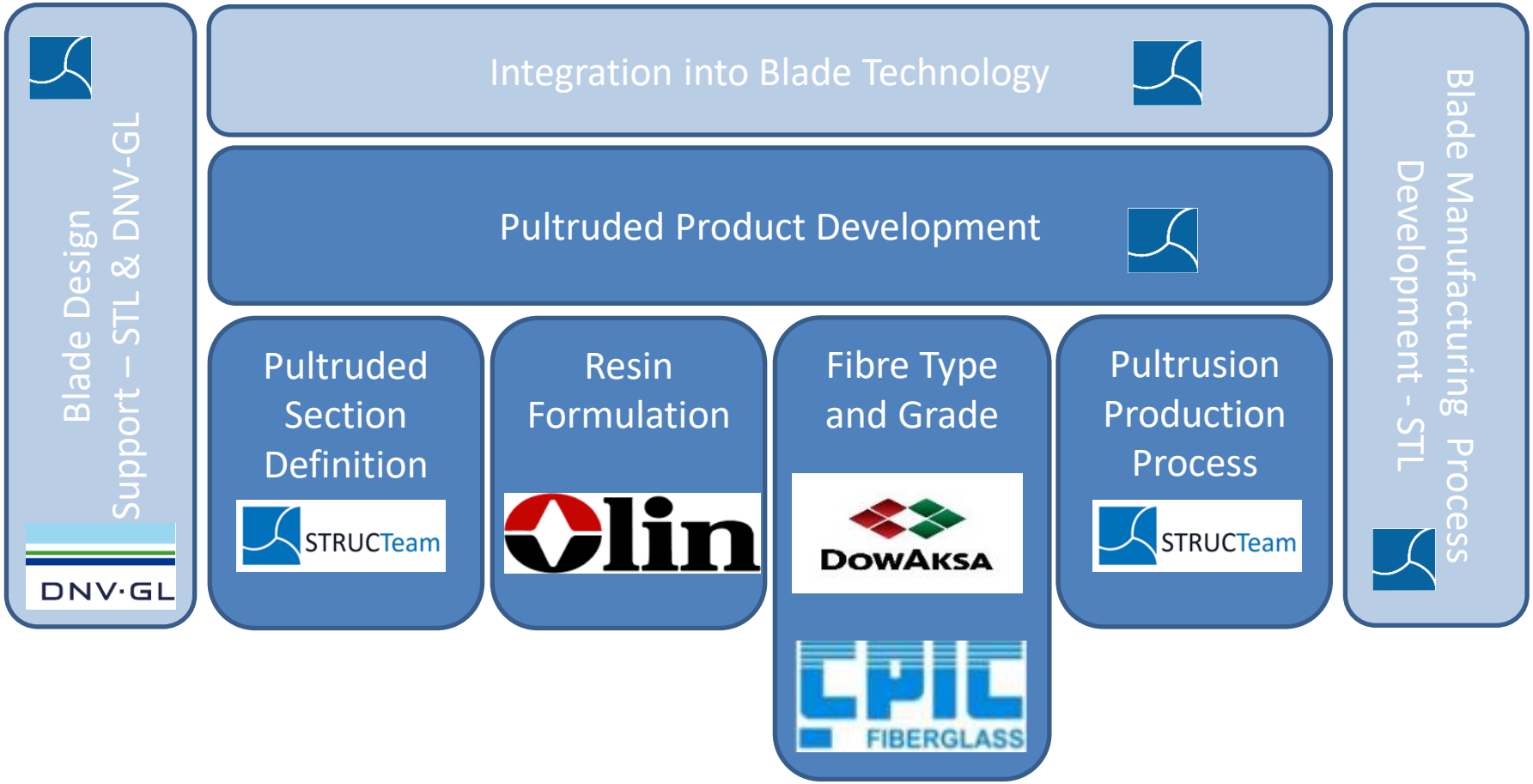
OEM Challenges - adopt pultrusion



PULLWIND – As a solution

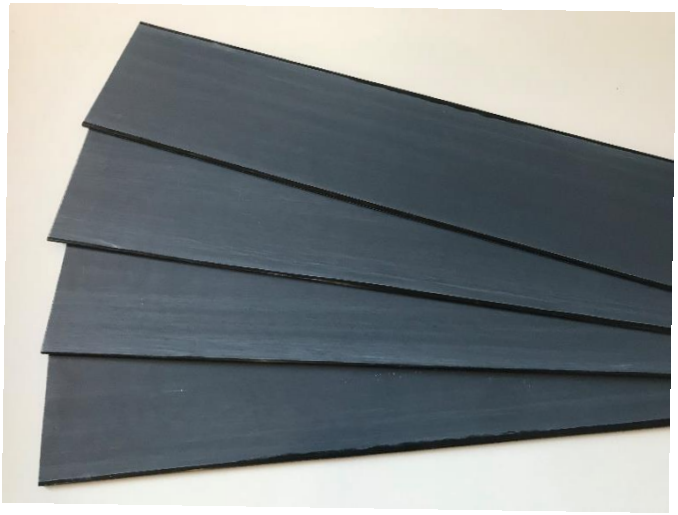
Consortium members

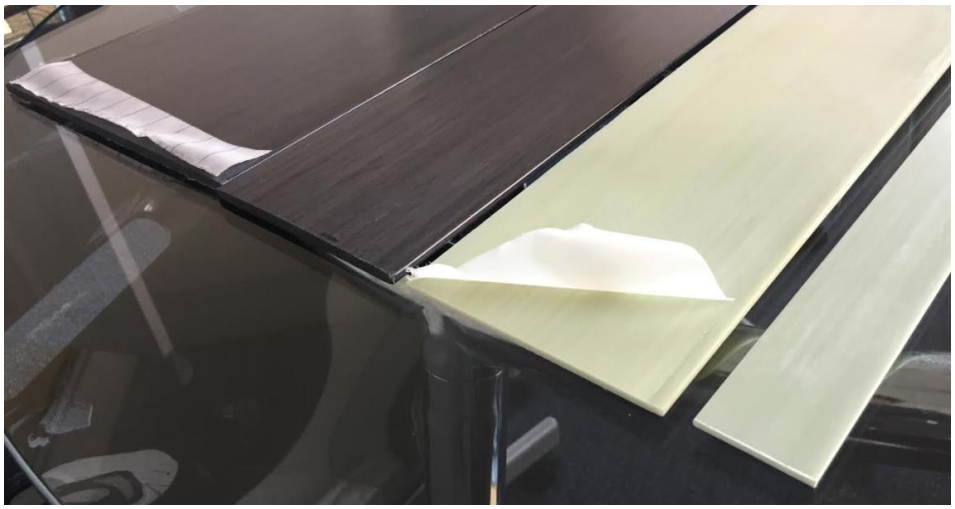
STRUCTeam, OLIN BC, DowAksa and CPIC are committed partners



Current spar cap technology

- ~90% infusion-based
  - ~5% prepreg-based (carbon)
  - ~5% pultrusion-based (carbon)
- CF pultruded spar cap pioneered and patented by Vestas (even since NEG/ Micon era)
- Supply chain Matching expectations:
  - OEMs are seeking commodities
  - CF pultrusion's are niche





Pain points for OEMs
CF vs manufacturing processes

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DOWAKSA

Carbon fibre use in Wind

- Lack of CF standardisation
- Size of wind sector against individual capacity

Infusion

- QA/QC
- Process robustness
- Low yield of CF characteristics

Prepreg

- QA/QC
- Controlled environment
- CAPEX (high temp tools)
- Material/ Logistics and stock
- Multiple processing methods

Pultrusion

- Supply chain is complex
- Design and manufacture is ‘new’ for OEMs
- IP

Business case - STL Blade Portfolio

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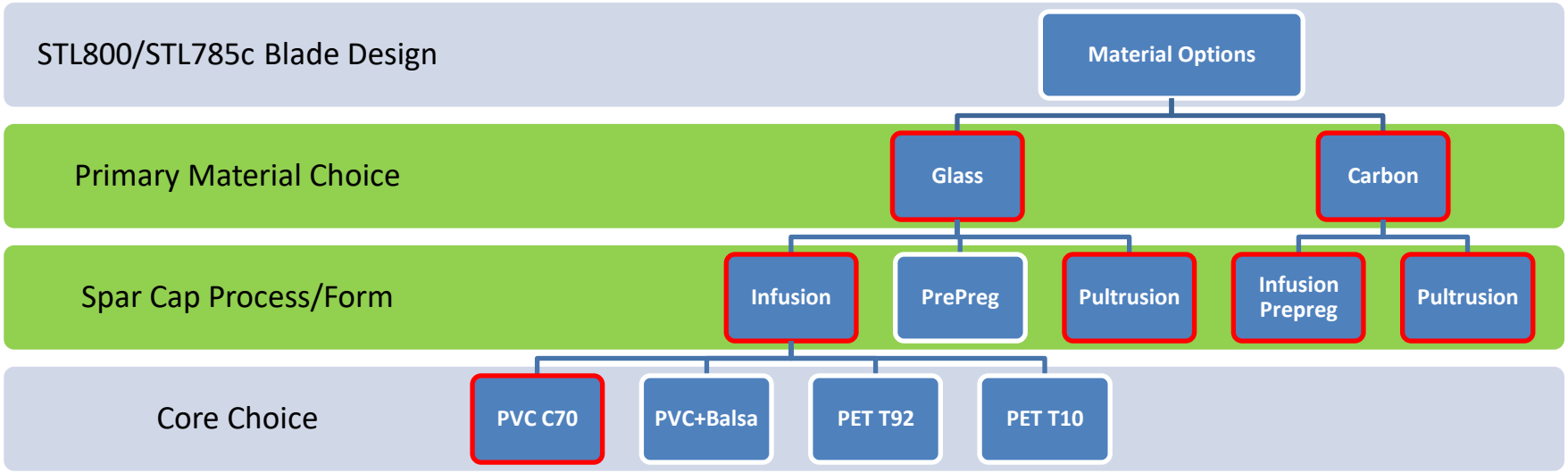
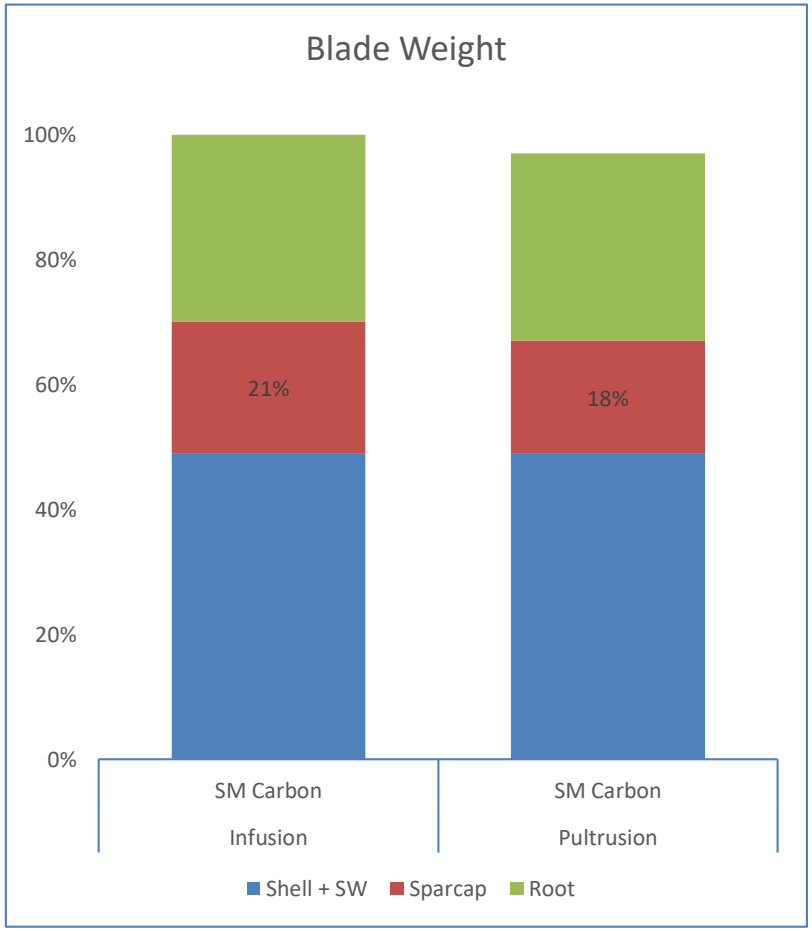
Blade Name	Unit	STL50	STL50c	STL565	STL635	STL635-2	STL690c	STL800	STL785c	STL820c
Blade Length	[m]	50.0	50.0	56.5	63.5	63.5	69.0	78.5	78.5	82.0
Rated Power	[MW]	2.0	2.0	2.0	3.3	3.3	3.0	6.0	6.0	5.0
Wind Class	[IEC]	IIIB	IIIB	S	S	IIIA	IIIA	IIA	IIA	IIIB
Average Wind Speed	[m/s]	7.5	7.5	7	9	7.5	7.5	8.5	8.5	7.5
PCD	[mm]	2110	2110	2110	2600	2600	3000	4100	4100	3600
Root Connection Solution		T-Bolt	T-Bolt	T-Bolt	T-Bolt	T-Bolt	T-Bolt	Insert	Insert	Insert
Root Connection		60xM36	60xM36	64xM36	74xM36	64xM39	82xM36	140xM36	140xM36	82xM36
								96xM42	96xM42	
Pre-bend	[m]	1	1.5	2	2	2	2	2	2	3
Max Chord Length	[m]	3.63	3.63	3.55	4.16	4.00	4.58	5.36	5.10	5.30
Process		Infusion	Infusion	Infusion	Infusion	Infusion	Prepreg	Infusion	Prepreg	Prepreg
Sparcap Material Material		Glass/ Epoxy	Carbon/ Epoxy	Glass/ Epoxy	Glass/ Epoxy	Glass/ Epoxy	Carbon/ Epoxy	Glass/ Epoxy	Carbon/ Epoxy	Carbon/ Epoxy
Core		PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC
Nominal Rotational Speed	[rpm]	15	15	12	12.5	12.5	11.1	12	12	11.34
Cut-in Wind Speed	[m/s]	3	3	3	3	3	3	3	3	3
Cut-out Wind Speed	[m/s]	25	25	25	25	25	25	25	25	25
Center of Gravity	[m]	14.8	12.2	15.9	20.11	22.77	16.35	27.35	23.27	23.65
Weight (excl. root connection)	[kg]	9100	7200	11030	21150	17100	18390	33600	23870	22560
1st Flapwise Freqruency	[Hz]	0.67	0.86	0.547	0.442	0.427	0.652	0.387	0.492	0.531
1st Edgewise Frequency	[Hz]	0.97	1.272	0.878	0.914	0.693	0.989	0.703	0.806	0.823

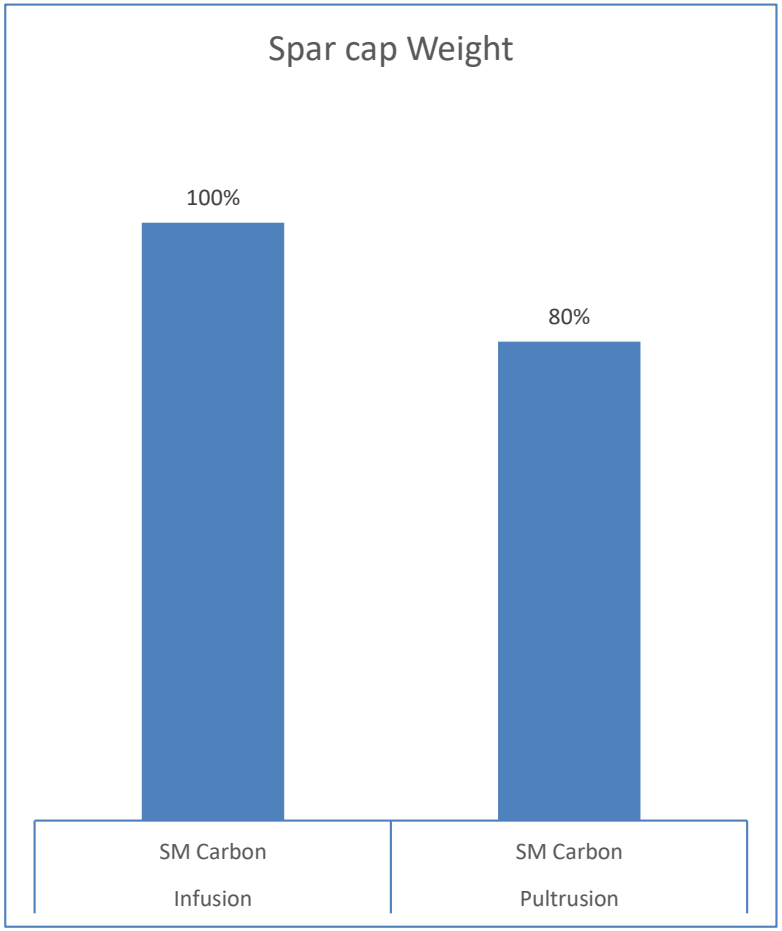
Blade Technology Options



- STL Detailed Cost Model 80m Blade
  - Material Costs
  - Labour Costs
  - CAPEX (Tooling)
  - Cycle Time

Blade Weight





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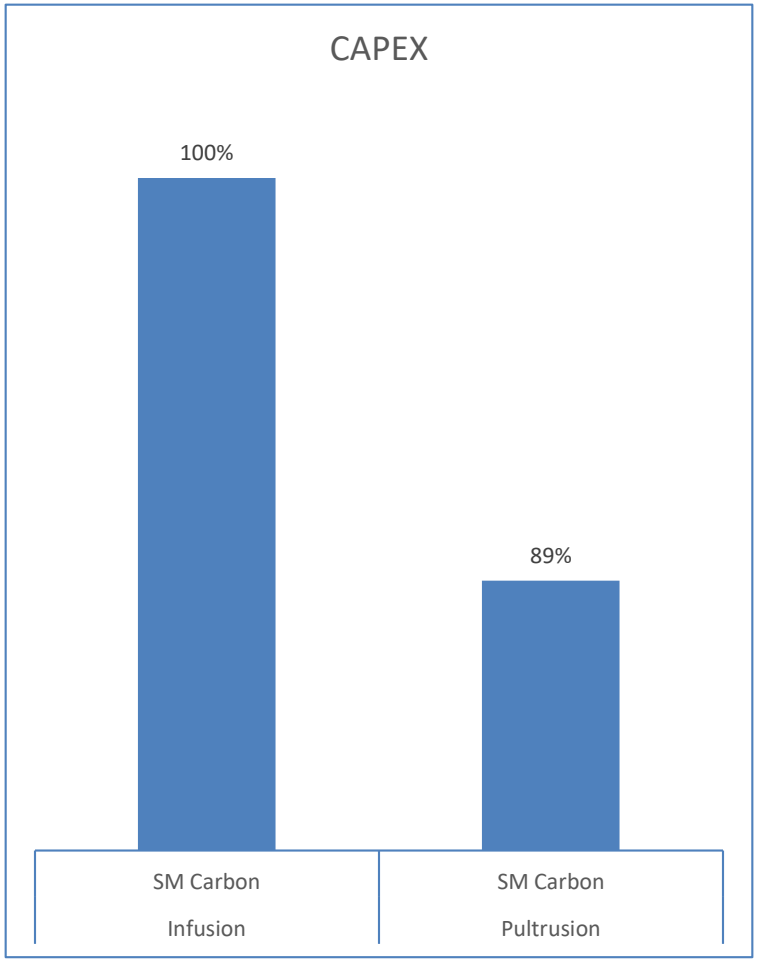
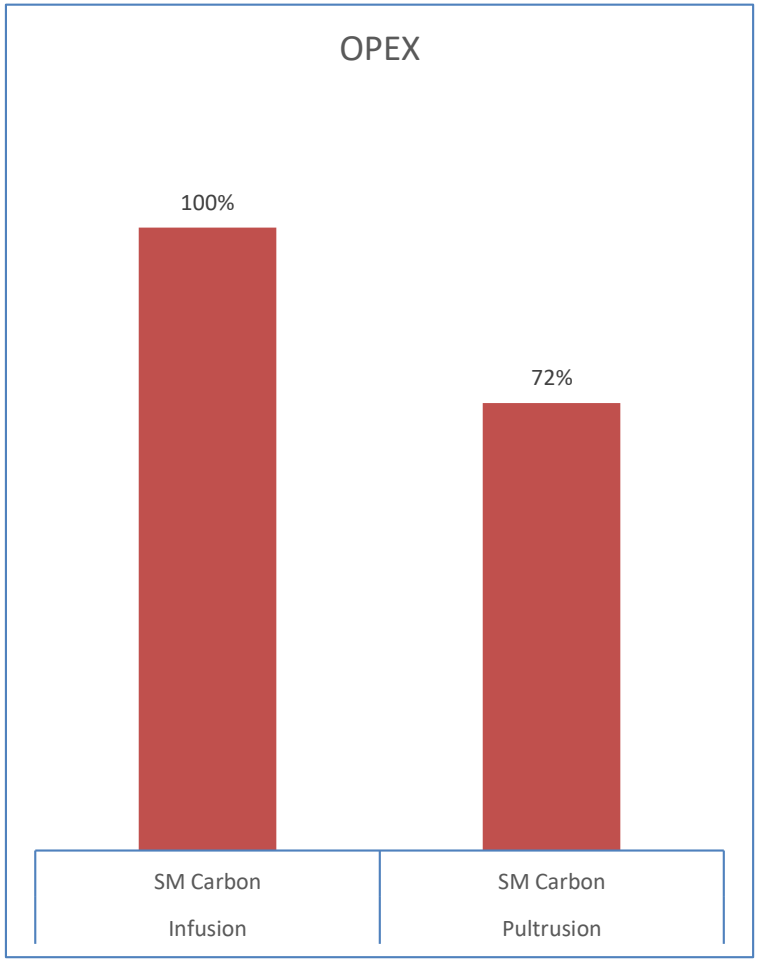
CAPEX & OPEX





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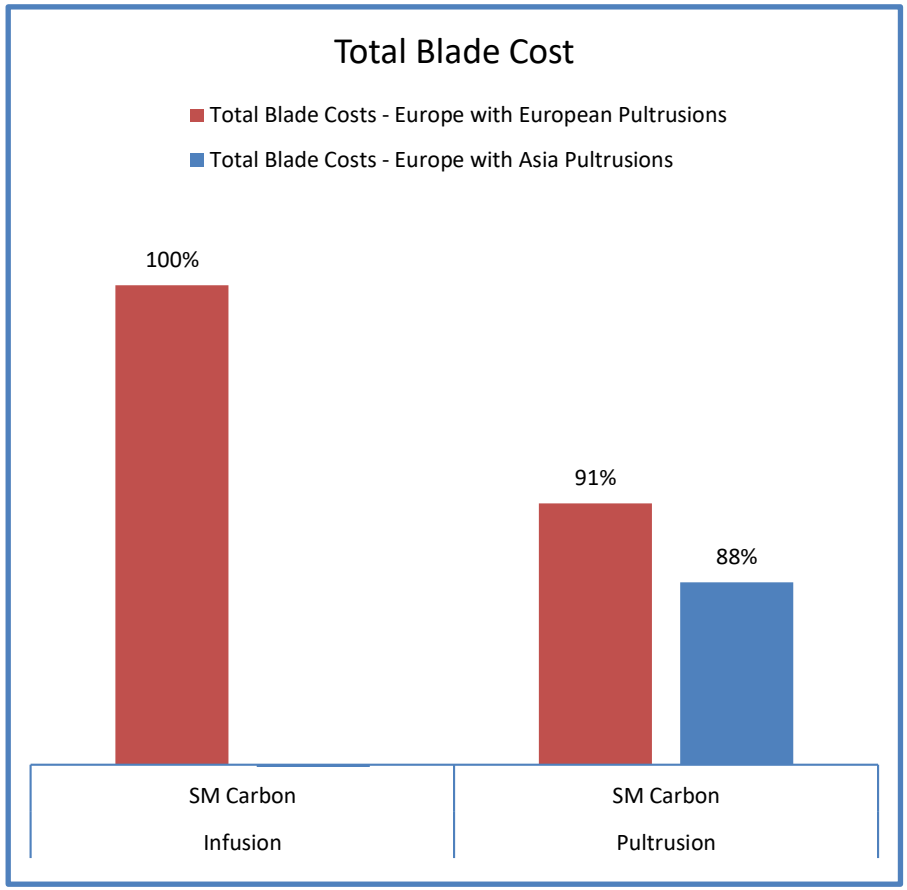
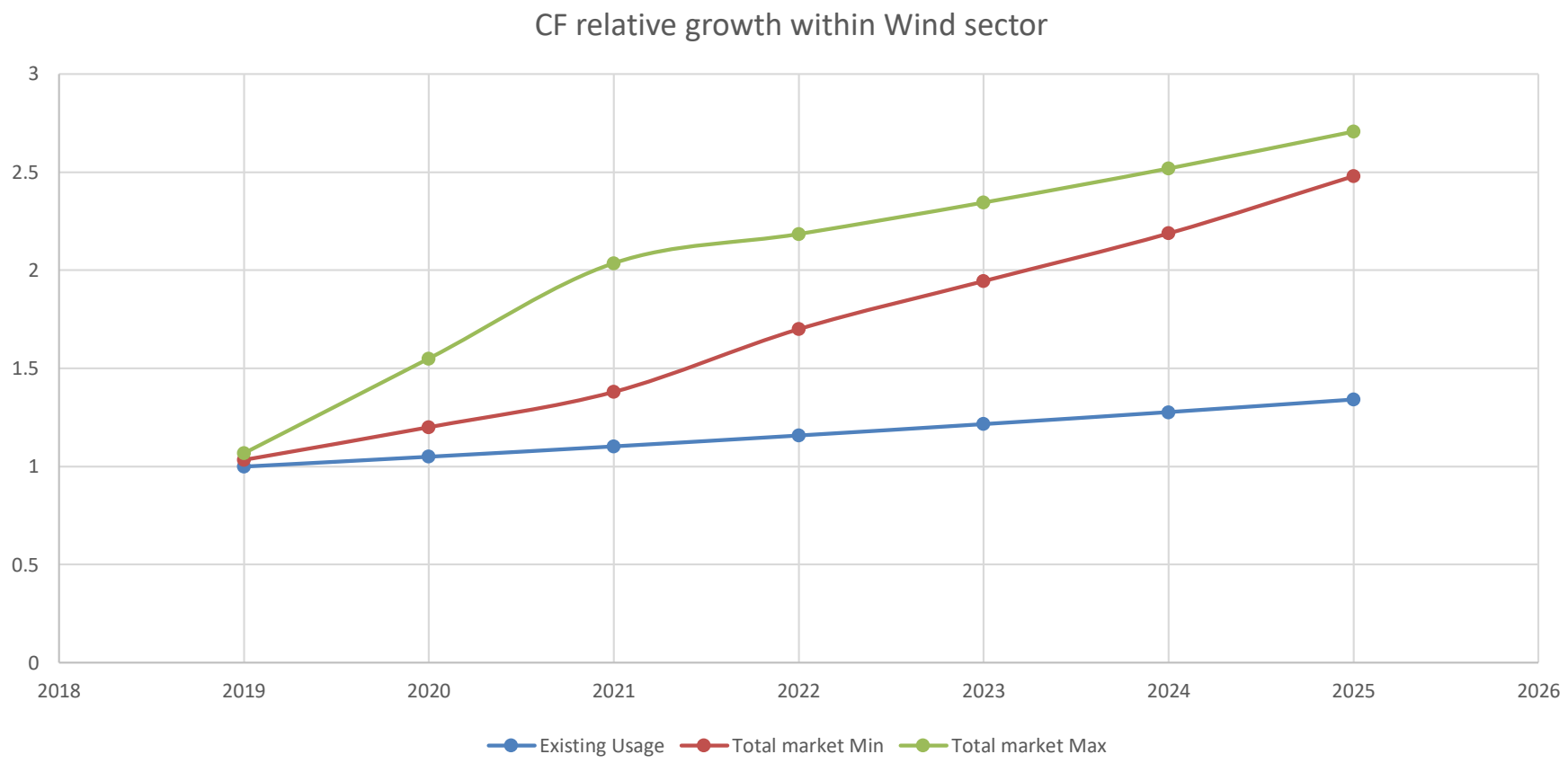
Blade Total Cost



Forecast: Carbon Fibre in the Wind Sector

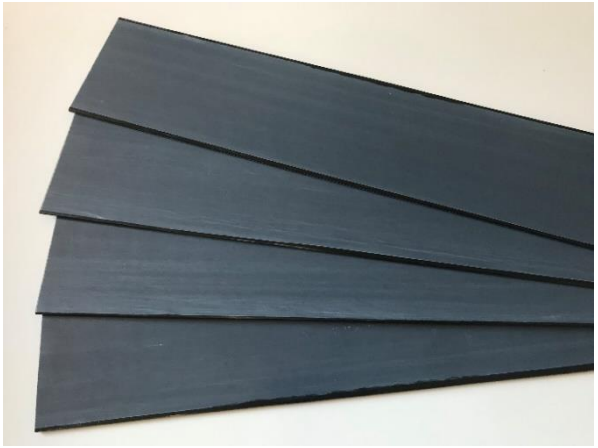


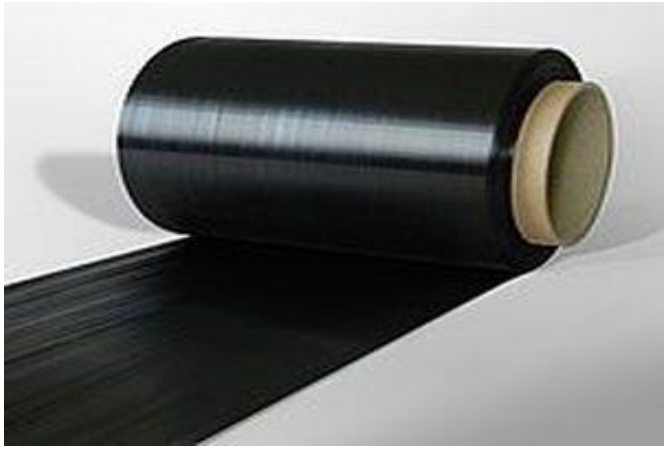
Conclusion

- In such a cost and performance driven industry, small gains have a significant impact.
- Wind energy sector is extremely supply chain focussed.
- PULLWind consortium addresses the supply chain challenges with the use of pultrusions for wind turbine blades.
- It has been recognised for a long time that CF has a key role to play in the wind sector. However, QA and QC issues have been the main reason for the lack of adoption.

Conclusion

- Pultrusions bring economic benefits and through automation address the key issues of QA and QC against infusion prepregs.
- The current challenge is to maintain supply chain growth with OEM adoption increasing the demand.
- Finally, CF manufacturers will have to adjust to this new order. Most OEMs adopting carbon have the potential to use the full capacity of most CF producers.





PULLWind Event Schedule

- **Go Carbon Fibre 9-11th Oct, Berlin**

'The future growth of carbon fibre in the wind energy sector' – Julien Sellier to present

www.gocarbonfibre.com

- **Composites UK Renewable 11th Oct, Glasgow**

'Pultruded components for blade sparcaps ' – Rakesh Raj to present

https://compositesuk.co.uk/composite-materials/applications/renewables

- **China Wind Power 17-19th Oct, Beijing**

STL booth in UK Pavilion

http://www.chinawind.org.cn/cwp2017/index_en.asp

- **Wind Turbine Blade Manufacture 10-12th Dec, Dusseldorf**

'Pultrusion for wind blade sparcaps' – to present

https://www.ami.international/events/event?Code=C845#9881

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