11th Hour Racing Team
IMOCA 60 Sustainable Design & Build Report
- 2021 -

SCENARIO ANALYSIS - FOILS

Supporting the main report, this document - **Scenario analysis - Foils** compares the environmental impacts associated with different methods for constructing IMOCA foils

Measurements used are
kilos (kg), metric tons (t), Greenhouse gas (tC02e) or (kgC02e)

Date & Version: 14th October 2021
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DISCLAIMER

The team's LCA results were calculated using MarineShift360.
Backed by 11th Hour Racing as Founding Sponsor, MarineShift360 is a purpose-built marine industry life cycle assessment tool. MarineShift360 is an ISO 14040:2006 & ISO 14044:2006 compliant and certified life cycle assessment tool. LCA results herein are calculated using MarineShift360, which is under development and is currently in beta stage.
No statements regarding accuracy are made and results may change over time as the development of MarineShift360 continues.

Context

Between 2019-2021, 11th Hour Racing team purchased new foils for the development/optimization of IMOCA Ex-Hugo Boss (11-1) as well as a set(2) for the new IMOCA 11-2 launched in 2021.

Objective

To understand the GHG and waste impacts of two different foil construction methods used by two separate suppliers which represent the key methods currently used (2021)

- Without mold
- In mold

Construction methods and scope

The two construction methods used during the build of foils for 11th Hour racing team are described below.

<u>Without mold ('Out of plan')</u>

The very first step of this process consists in the laying up of prepreg on a flat surface the length and width of the foil length shape. The resulting battens are shaped using a water jet cutting method and then assembled/glued vertically over the entire length of the foil. Successive surfacing and machining processes are carried out before applying a peripheral winding.

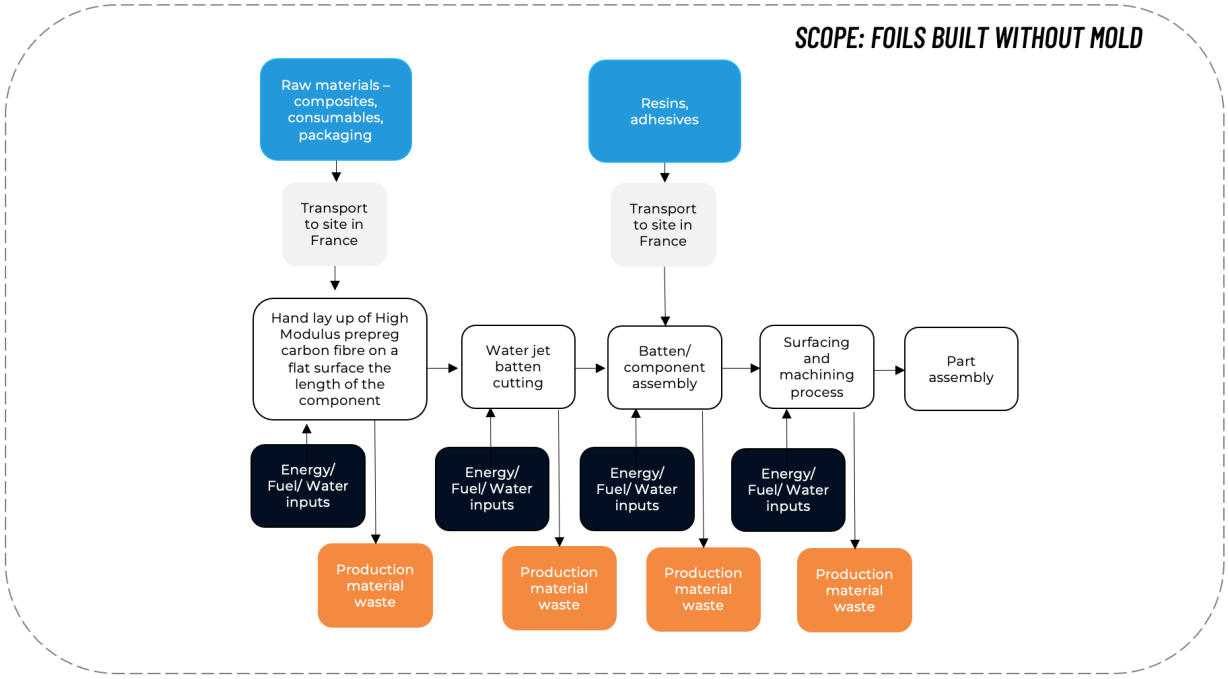


Figure: Scope of manufacturing process - Foils built without mold

From mold

Foils can also be built on a mold that replicates the desired camber profile. The layup of prepreg carbon fibre is cured and then machined to the final shape. The inner layers and core are added before the final assembly and cure.

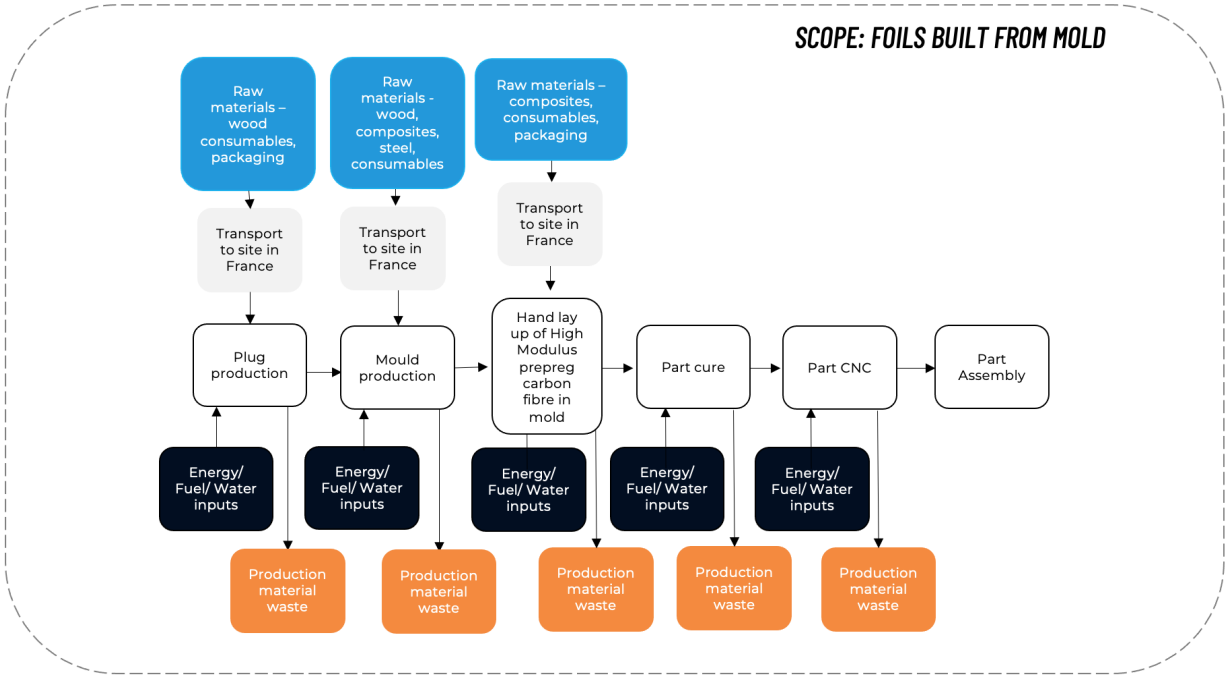


Figure: Scope of manufacturing process - Foils built from mold

Study

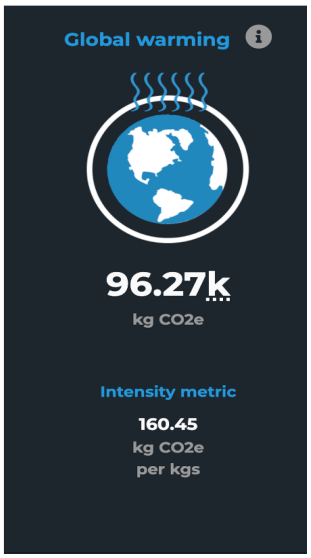
Based on detailed input data provided by the respective manufacturers, and using the Marine Shift 360 Beta Life cycle assessment tool the team compiled the following results.

Figure: Comparing greenhouse gas emissions of of foil construction methods, calculated with MarineShift360 beta software on September 1, 2021

Out of plan foil set

IM based on 686kg final weight of foil set
No freight included

Foil set from moulds



IM based on 600kg final weight of foil set
Includes 2 moulds
No freight included

GHG Results

Intensity metric

In order to compare the two different methods, and foils of different weights we assessed the results using an intensity metric (tC02e/weight = kgC02e per kg).

Adjust for weight results

Using the 'From mold' as the reference weight and impact, and adjusting the 'Without mold' set for the same weight, we get the following results:

Foils	Without mold	From mold
GHG impact (kgco2e)	103	96
Intensity metric	150.29	160.45
Adjusted for weight	90	96

Figure: Comparing the GHG impacts of foil construction methods adjusted for weight, Calculated with MarineShift360 beta software on October 1, 2021

The table above shows that once you adjust the impact to take into account the different weights of the final components, that the two processes return a very similar GHG impact per kg weight of the final component (within 6% of each other). This means that the upfront impact of additional materials used in the molds scenario just about offsets the material and energy intensive layup stage of the scenario without molds.

Waste results and discussion

Version 1: With molds

Waste source	**Material**	**Weight (kgs)**	**Destination**
Moulds	Carbon fibre cloth	800	Recycling (pyrolysis)
Plugs and Moulds	Timber	350	Reuse
Moulds	E-Glass Fibre	136.2	Waste to energy*
Moulds	Resin	1300	Recycling (pyrolysis)
Moulds	Consumables	343.1	Waste to energy*
Foil production waste	Carbon fibre cloth	123	Recycling (pyrolysis)
Foil production waste	Resin	75	Waste to energy
Foil production waste	Foam	4	Waste to energy
Foil production waste	Paint	10	Waste to energy
Foil production waste	Consumables	501.5	Waste to energy
Total		**524% waste**	

*Information not provided, assumed waste to energy

Version 2: Without molds

Waste source	**Material**	**Weight (kgs)**	**Destination**
Foils	Carbon fibre cloth	1113	Recycling (solvolysis)
Foils	Resin	390	Waste to energy
Foils	Consumables	1038	Waste to energy
Foils	Paint	10	Waste to energy
Total		**2550.5**	**371% waste**

When we adjust the waste production to allow for the weight of the final part using the ‘From mold’ as the reference weight, we get the following results.

Foils	Without mold	From mold
Waste production (kg)	2550.5	3144.8
Final component weight (kg)	686	600
Intensity metric (kgs of waste per kg of final part built)	3.71	5.24
Adjusted for weight (kg)	2226.0	3144.8
Waste percentage	371%	524%

Figure: Comparing waste impacts of foil construction methods, adjusted for weight

When we review the tables above, scaling and adjusting for the weight of the final component, we observe that the process without molds produces 371% wastage, while the process with molds produces 524% wastage (2.2 tonnes compared with 3.1 tonnes).

Note that there is certainly a small margin of error here resulting from:

- The foils being built and data provided from two different suppliers
- The final component parts being different weights and designs

A future recommendation would be to compare two identical sets of foils using the two different methods, if possible, to allow for a more accurate study.

Conclusions

Comparing both foils methods we note that using both waste and GHG emissions environmental indicators, the larger impacts are associated with foils made in molds.

Set of foils (600 kilos)	Without mold	From mold
GHG impact (kgco2e)	90	96
Percentage waste	371%	524%

Figure: Comparing GHG & waste impacts of foil construction methods adjusted for weight, Calculated with MarineShift360 beta software on October 1, 2021

Recommendations

This is one simple study, and certainly needs to be repeated to validate these findings, ideally by comparing two identical sets of foils using the two different methods, if possible, to allow for a more accurate study.

We would also recommend studying a third construction method, using 3D printed spars, to understand the relevant GHG and waste implications.

It is important to highlight the opportunities for improvement that come with types of composite construction, as it relates to consumables, energy sources, waste management processes and materials sourcing. These can be found in more detail in the Sustainable Design and Build Report.