Team:
- Four person core team (FORMAT project developers),
- two Whirlpool experts,
- invited Whirlpool experts,
- supporting team (FORMAT project developers)

Please Note: not all steps of the FORMAT methodology were used for this study
Case study: Vacuum forming
Overview - Why are we forecasting Vacuum forming?

Vacuum forming equipment are
• expensive
• not flexible
• and have high-energy consumption.

Once bought they operate for up to 20 years. These machines are due for renewal.

“A huge, expensive, and long lasting investment”
Forecast questions

What will be the evolution of main parameters of polymers forming technologies in 10-20 years, (2013-2033) for Whirlpool refrigerators in Whirlpool factories in Western countries?

a) Will vacuum forming technologies be needed in 10 years, (2013-2023) for Whirlpool refrigerators in Whirlpool factories in Western countries? (Yes/No)

b) What will be the most suitable polymer forming technologies in 10 years, (2013-2023) for Whirlpool refrigerators in Whirlpool factories in Western countries? (list of technologies)

FORmulate Stage (FOR)
Main objectives of Forecast (Project) (Why?)
Definition of knowledge elements for the application of the forecasting results
INTERIM CHECK: Can we get the required results without Forecast?
Definition of Preliminary constraints for the project
List of Questions for Forecast (Questions to be answered at the end of study)
Plan of Project (How?)

FOR Gate
Case study: Vacuum forming

Model Stage (M)

Alternative Technologies

- Additive Technology
- Rotational Molding
- Blow Molding
- Injection Molding

Social
- Cleaning access
- Longer food preservation
- More storage to volume

Economy
- Low energy
- Env. Tax
- HIPS reduction

Environment
- Foam separation
- Easy disposal
- Minimal different materials

Technology
- Cycle time
- CAD/CAM tool development
- Energy supply method

Social
- Height
- Depth
- Limited floor area

Economy
- Initial investment
- Energy to melt polymer

Environment
- Dependence on petrochemicals
- Ozone friendliness
- Polystyrene not scarce

Technology
- Inert to food
- Antibacterial
- Production time

Drivers

Barriers

Polystyrene (HIPS) granules (new: ≤50%)
Polystyrene (HIPS) scrap (reused: ≥ 50%)
Molten HIPS
2D HIPS sheet
2D HIPS sheet with good quality
Softened HIPS sheets
Open 3D form form
Open 3D form (Geometrically and Aesthetically proper Refrigerator liner or door)
Melt
Form
Size and Quality Check
Store and Stabilize
Soften
Shape
Size and Quality Check
Polystyrene (HIPS) scrap
Polystyrene (HIPS) scrap
Polystyrene (HIPS) scrap
Polystyrene (HIPS) scrap
Polystyrene (HIPS) scrap
Case study: Vacuum forming

- Model of STF at the functional level
- Description of Competitive (Alternative) technologies (solutions)
- Measure of Performance & Expenses for STF and for Competitive Solutions
- Description for STF
Dynamization, segmentation and energy harmonization were applied to obtain qualitative forecasts.

Data based logistic curve regression analysis was applied to obtain predict trends in interior volume/annual energy consumption trends.
- List of limiting resources
- Directions of development of new solutions
- Dynamics of parameter(s) measuring Performance & Expenses
- Aggregated conclusions about future traits for STF
<table>
<thead>
<tr>
<th>Main Parameters of evolution</th>
<th>Vacuum Forming after 2023</th>
<th>Most suitable technology after 2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Complexity of mold will increase due to multi-part molds.</td>
<td>Vacuum forming will be needed after 2033</td>
<td>Vacuum forming: very fast equipment option</td>
</tr>
<tr>
<td>2. Maximal Productivity might increase (thanks to cooling time reduction) when minimal Productivity of MP will not change significantly.</td>
<td></td>
<td>Vacuum forming with extrusion and forming combined</td>
</tr>
<tr>
<td>3. Initial Investments into equipment will not increase significantly.</td>
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<tr>
<td>4. Attention to Energy consumption of manufacturing process (MP) will rise.</td>
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<tr>
<td>5. Amount of Materials to produce 3D shapes will decrease when cost might increase slightly.</td>
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<tr>
<td>6. Footprint of MP should decrease.</td>
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<tr>
<td>7. The degree of Automation of MP will increase.</td>
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<td></td>
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<tr>
<td>8. The degree of Integration of MP with other phases of production will increase.</td>
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</tr>
</tbody>
</table>

Transfer Stage (T)
T Gate
Case Study Assessment

**Strengths**
- Repeatability
- Expertise
- Modelling
- Team dynamics

**Weakness**
- Time taken
- Lack of access to historical data

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