

Deep Dive Renewable Polymers: Path to Flagship Plant

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Amsterdam

Technology & Markets Day



Marcel Lubben
Managing Director



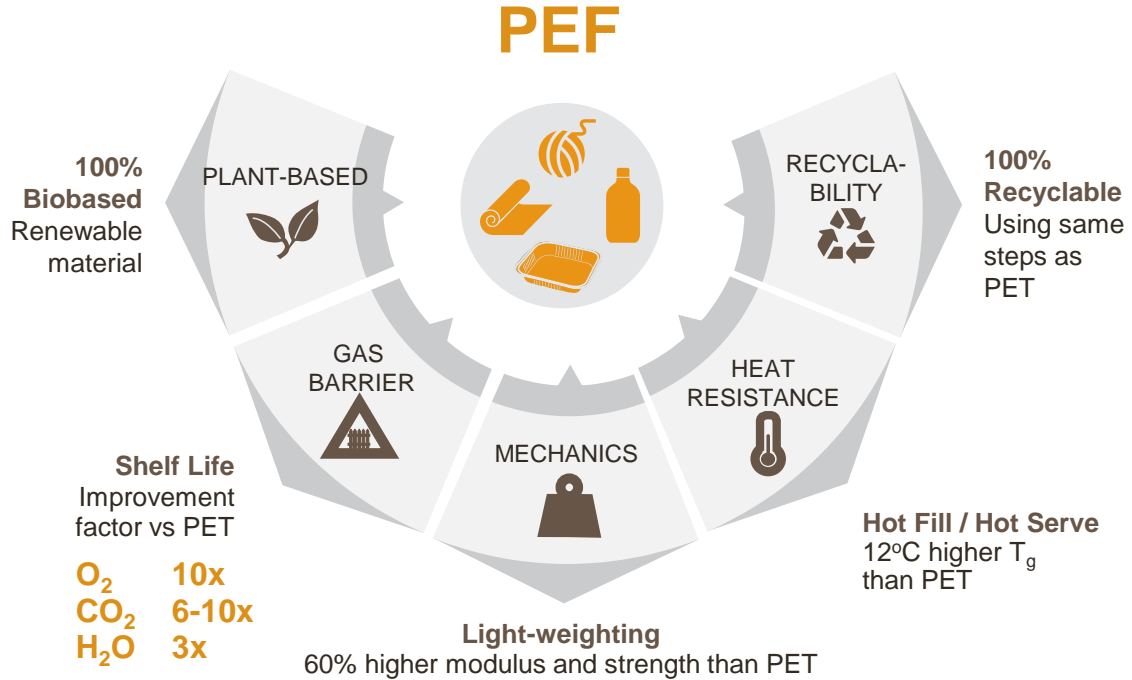
PEF – An Exciting Novel Plant-Based Polymer

Performance benefits

- Extending shelf life
- Lighter / stronger material -> reducing the amount of packaging
- Simplifying packaging -> from multi to monolayer
- Reducing manufacturing costs during packaging / filling process

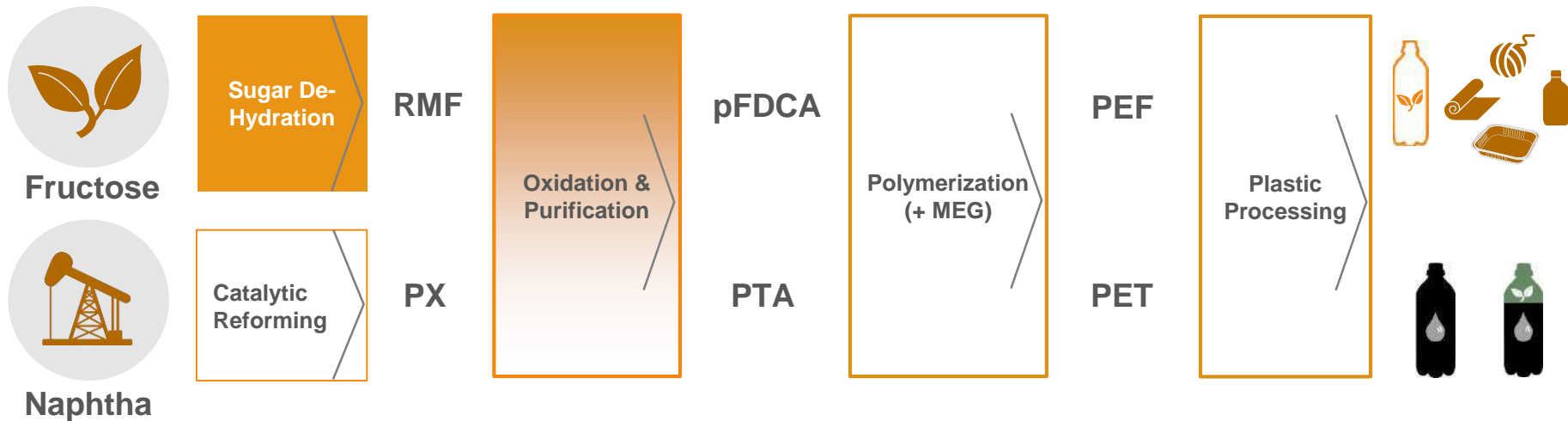
Societal benefits

- Enabling full circularity
- Reducing carbon footprint



FDCA / PEF Foundation & Assets

FDCA / PEF is based on a strong technology foundation and can be used in existing assets



Each step proven at pilot plant scale

The Way towards Flagship Plant & Licensing Business



LAB SCALE

- 2008
- Amsterdam
- Kilograms
- Innovative research



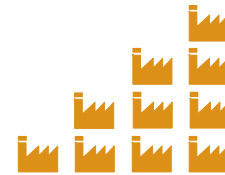
PILOT PLANT SCALE

- 2011 - now
- Geleen
- Tons
- Technology development



COMMERCIAL SCALE

- 2023
- 5 kiloton
- Commercial launch of FDCA & PEF



INDUSTRIAL SCALE

- 2024 onwards
- Global deployment
- Roll out on industrial scale (> 100's kilotons)
- **Licensing**



Must-Haves for Next Phase of Commercialization

- Commercial traction for FDCA & PEF
- Construct value chains through partnering
- Engineering package (5 kiloton flagship plant)
- Site selection
- Financing



Pilot Plant Geleen

Commercialization Curve – Initial Focus on High-Value Markets

From high-value to high-volume applications

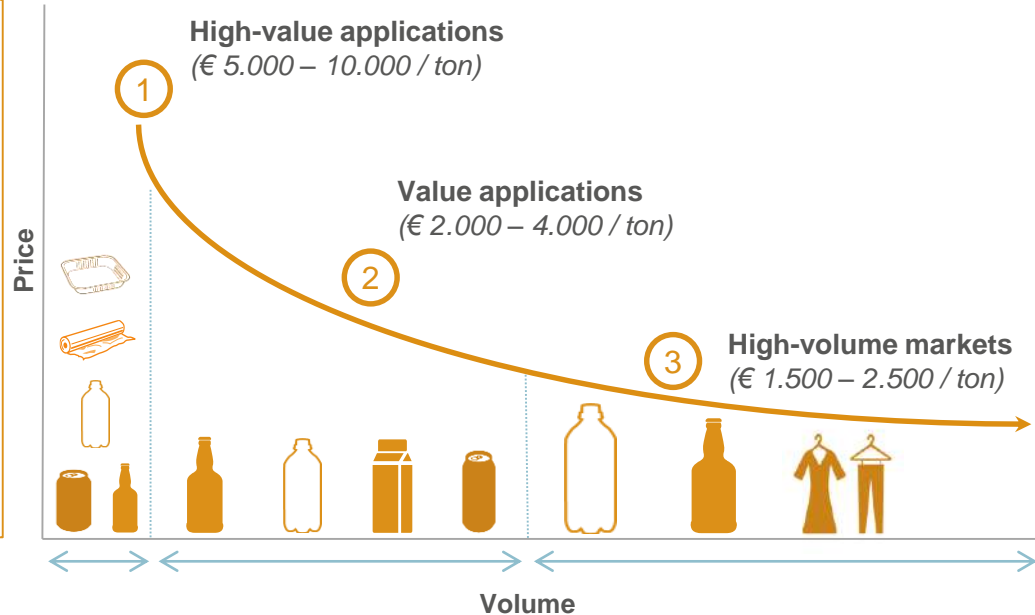
A staged approach

① & ②

Initial focus on high-value markets where PEF competes on performance. Further scale-up and learning curve will lower the cost price of PEF.

③

Lower cost price of PEF will enable it to compete in high-volume markets



PEF Market Traction in High-Value Applications



Multilayer packaging

Replace with single material PEF layers, reducing cost of packaging while enabling recycling



Enhanced bottles

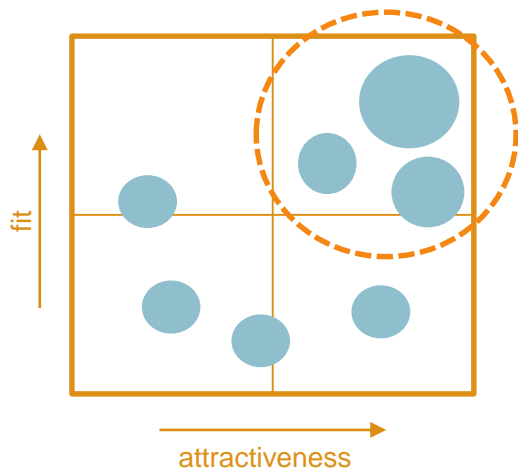
PEF in small volume CSD/beer bottles or as barrier layer providing performance and enabling recycling



Optical film

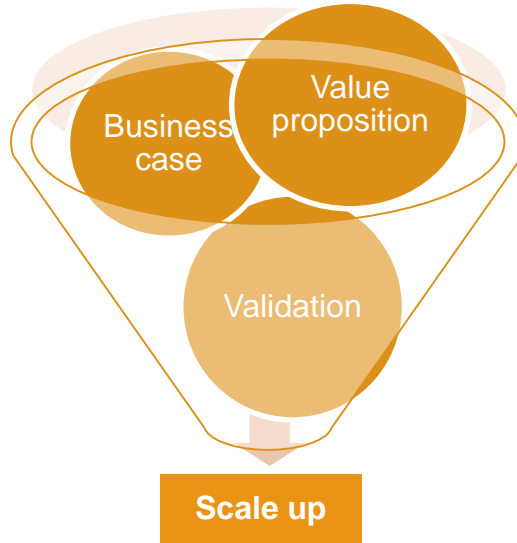
Enable thinner LCD/OLED displays

From Multiple Leads to Profitable Flagship Business



Selecting the best opportunities from hundreds of leads

1



Growing the best opportunities in a stage-gate process

2

Top 20

Landing top 20 contracts for (i) flagship plant and (ii) licensing business

3

Commercializing Renewable Polymers with Value Chain Partners



Industrial production location (NL, B, G)

National & regional development agencies providing incentives

PEF manufacturing / licensing partnerships



MITSUI & CO.



Horizon 2020
European Union Funding
for Research & Innovation

Engineering Studies for the 5 Kiloton Flagship Plant



Geert Reyniers

Manager Process and Technology, Worley

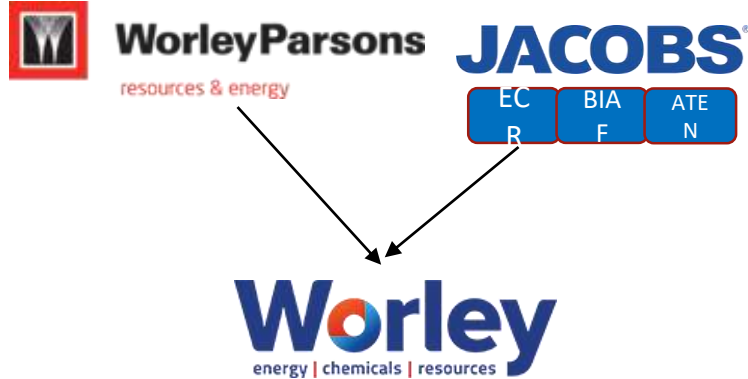
YXY technology: an assessment

Prepared for Avantium Renewable Polymers

Content

- Worley organization and capabilities
- Current work for Synvina
- Synvina Achievements
- Assessment of current status

Worley organization and capabilities



Nearly 60 000 people
Located in over 50 countries
Supporting Innovation on a global scale
Fast adapting to the digital revolution

Worley Belgium

Over 750 people

Regional lead office for chemicals

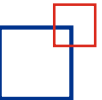
Proven Expertise in technology development and assessment:

Vinylloop, trimellitates, ACH and MMA,

Proven expertise in first of a kind plants and scale up:
Green Epichlorohydrin, Butylrubber, Steeanol

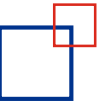
Proven expertise in PTA/PIA technology (products used in the PET value chain and manufacturing technology representative for YXY technology)

BP, OMPIA



Current work for Synvina

- Process Design Package for the 5 kiloton Flagship Plant
 - Full cycle: fructose to purified FDCA,
 - ‘Industrial’ unit operations: fit for full scale proven technology
 - Industrial standards for HSE in designing the plant
 - Industrial standard for reliability
- Results
 - Defined solutions for all processing steps
 - Robust investment and operating cost data



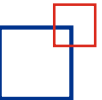
Synvina: an organization aimed for achievement

Synvina research team:

- Solid in size
- Well equipped
- Long history of development
- Well structured and well managed
 - Research specialists
 - Process development specialists
 - Application specialists

Synvina pilot plant and team:

- Very comprehensive
- Fully automated to obtain consistent operating data
 - Possibility to trace back observations to process conditions and thus gain thorough understanding
- Well equipped lab to analyze product specifications and quality of intermediates
- Continuous operation allows long term campaigns and assess the stability of the operation
- Knowledgeable and experienced operations staff



Assessment

In the pilot plant the full cycle from fructose to FDCA has been realized and delivered product quality that allowed to make 'on spec' PEF.

Technology development inspires confidence:

- Structured step by step approach

- Expert/multidisciplinary team

- Sufficient resources

It is time to move to demo/industrial scale

- No fundamental open issues in technology

- The remaining challenges can be solved, key is to find the most economical solution



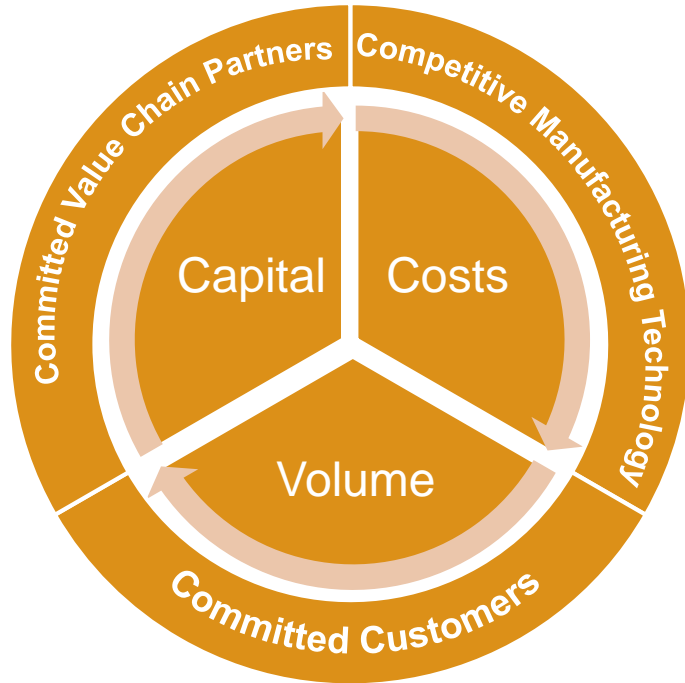
Site selection



- Objectives:
 - > Locate in northwestern continental Europe
 - > Required utilities and services available
 - > Operational and financial attractiveness
 - > Targeted second half 2019

- Current status:
 - > Several sites available which fulfill operational criteria
 - > Commercial discussions ongoing
 - > Selection process on schedule

What makes an Investible Business Case for the Flagship Plant



Flagship Plant

- Scale: 5 kiloton per year*
- Technology: de-risked
- Market focus: high-value / performance products
- Funding: EUR 150m
- Financial objective: cash-flow positive
- Purpose:
 - market launch of PEF
 - enable licensing for high-volume markets

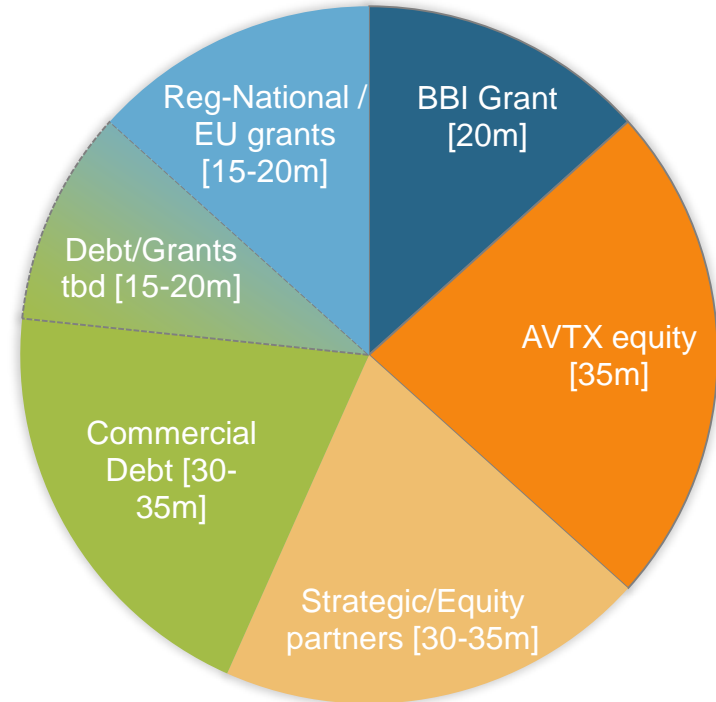
* 5 kiloton PEF corresponds to 250 million 0.5 L soft drink bottles per year

Funding Requirements Flagship Plant to produce FDCA

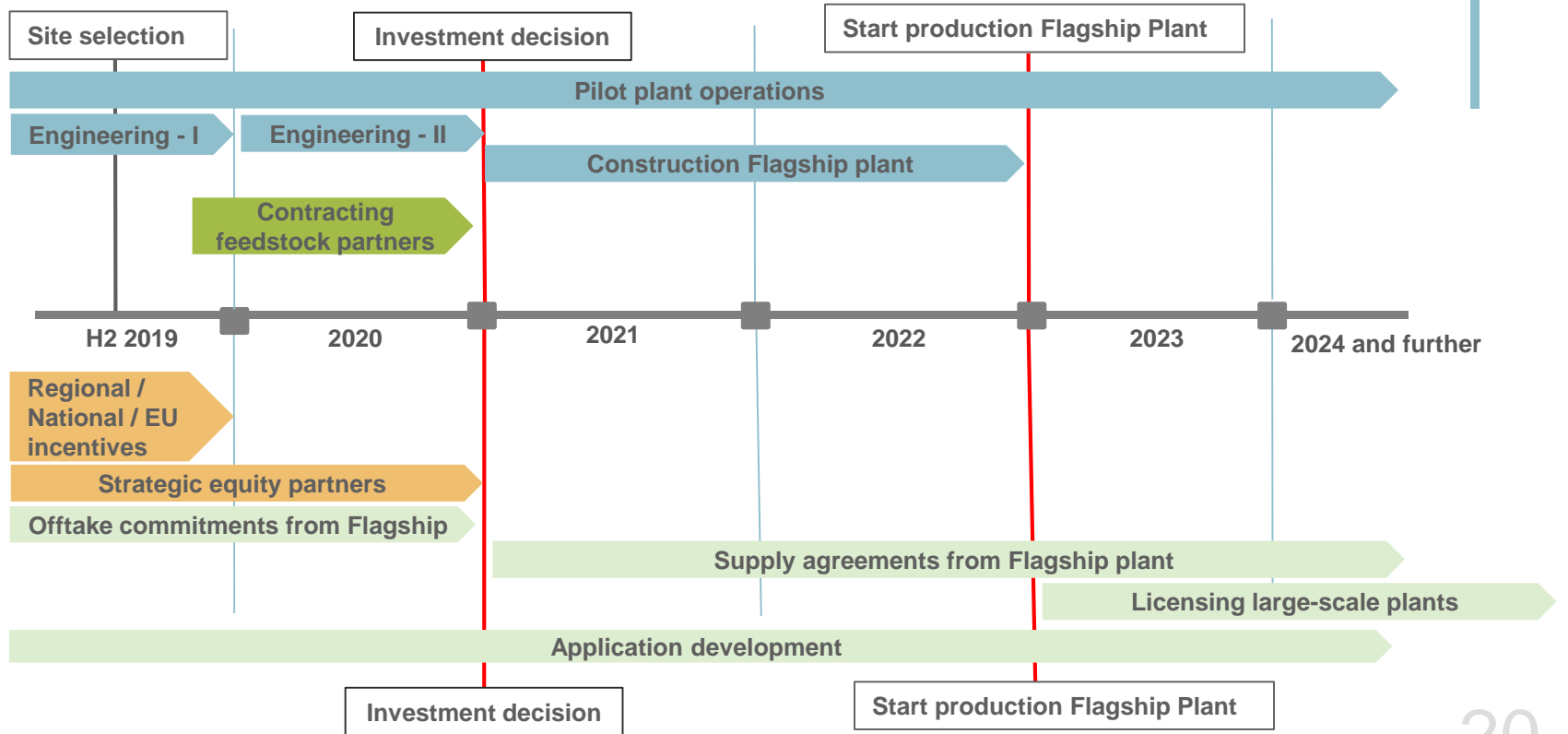
Total funding need

- EUR 150 million (\pm 20% contingency)
 - CAPEX (ISBL + OSBL)
 - Start-up costs
 - Working capital
 - Ongoing Renewable Polymers expenses until cash-flow positive (2019-2023)
- Objective to have funding sources in place before end of 2020

Total funding sources



Timeline Path to Commercialization



Q&A

