Sustainable Vaccines Manufacturing in Africa

Business case simulation for a Fill & Finish Contract Manufacturing Organization in Africa to cover the demand for human vaccines on the continent

April 2023 - Project 20.2155.8-015.00

Commissioned Service Provider: Unizima

Unizima is a biomanufacturing services provider, delivering the expertise and technology needed to enable geographically diversified manufacturing of biologics such as vaccines, monoclonal antibodies and insulin. We are part of the Univercells Group and share its ground-breaking technology and engineering innovations.

We provide a full suite of solutions that includes strategy, product licensing, design and build of facilities and workforce development, allowing clients to accelerate the implementation and operations of their facilities and projects. Our team has extensive global experience in manufacturing strategy, investment profitability analysis, engineering, biologics manufacturing, GMP and Quality Assurance, Regulatory Affairs, supply chain, logistics management, training and recruitment.

Since our inception in 2020, we have served as a trusted partner for biopharma manufacturers, governments and global health agencies to make sustainable biologics production in low- and middle-income countries and emerging markets a reality. We are driven by the end goal of delivering life-changing biologics to people who would otherwise lack access to them.

Learn more: www.unizima.com

Presented by UNIZIMA:
Benoit GREGOIRE, BD Manager & Sr Tech Transfer Expert
Introduction and Content
GIZ commissioned a study to allow investors and funders to assess the competitiveness of a CMO for Vaccines F/F in Africa (ToR – Sep 2022)

<table>
<thead>
<tr>
<th>Scope</th>
<th>Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Facility design for a model greenfield F/F CMO, including lab, office and warehousing space</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Costing simulation tool</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Recommendations and strategic advice for sustainable CMO plants in Africa</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Partnership for African Vaccine Manufacturing set out the vision to localize the manufacturing of 60% of vaccines used in Africa by 2040 *

Commitment to localize vaccine manufacturing, to improve the resilience of Africa’s healthcare systems

1% Achievable first step: Transfer of Fill/Finish operations to CMOs in Africa

2023 TODAY 99% of vaccines are imported

2040 PAVM vision Produce 60% of routine vaccines on the continent by 2040

Capacity needed to achieve PAVM goal

<table>
<thead>
<tr>
<th>2.1 billion doses</th>
<th>280 million containers*</th>
</tr>
</thead>
</table>

Capacity needed in 2040

* as number of doses per container defined by PAVM including diluents for freeze-dried vaccines

Should be allocated to a network of circa 5 factories

- Leverage economies of scale
- Leverage existing investment and infrastructure on the continent

* Refer to annex 1 for the African market vaccines demand; refer to annex 2 for the F/F factories capacities

---

Page 5 | March 2023 | Sustainable Vaccines Manufacturing in Africa
Part 1 - Facility design for a model greenfield F/F CMO

• Process assumptions

• Capex and Opex estimates
The model F/F factory used for the baseline financial model includes 4 filling lines & three filling technologies (liquid vaccines in glass vial, freeze-dried vaccines in glass vial and oral vaccines / diluents in BFS tube)*

Key project parameters:
Medium F/F factory:

- **CAPEX**: 89 million EUR
- **Project Management & Tech Transfer expenses**: up to 35 million EUR
- **TIME**: 5 years

* Note: see annex 3 for F/F factory lay-out & process flows chart; see annex 4 for F/F factory project planning; inputs and assumptions can all be changed and tested in the model.
Part 2 – Costing simulation tool

• Simulation calculator for operating the facility, including ability to enter variable data points for Capex and Opex

• Costing stimulation for various vaccines from different origins to fill capacity

• High level comparative import costing calculation for same vaccines, including freight
The Excel financial simulation model has been constructed in a flexible way based on inputs and assumptions which can be changed to test multiple variables and sensitivities*

**CapEx inputs (EUR, +/-25%)**

- Engineering studies, assumed to be supplied by a mix of India based and Europe based experts.
- Construction & black utility costs estimated per m² based on various investments executed.
- Clean utility & process equipment costs based on quotations from renowned European suppliers or cost estimations from internal experts.
- Contingencies +15%, transport +10%, import duties +0%, Qualifications +15%, based on industry experience.

**PM / Tech Transfer expenses & OpEx inputs (EUR)**

- Project Management & Tech Transfer support based on industry experience.
- Tech Transfer raw materials & consumables based on industry experience.
- F/F factory Org Chart, headcounts and number of expatriates based on industry experience; baseline salaries as per Kenya’s data.
- General & Admin expenses based on industry experience.

**Raw Materials inputs (EUR)**

- Filling raw materials from Indian suppliers’ quotations.
- Packaging raw materials based on industry experience.
- Single use systems, formulation (except bulks) and QC materials based on industry experience.

**Financial parameters’ outputs**

- Net Present Value, Internal Rate of Return, Cumulated Free CashFlow and Payback period.
- F/F costs per container / dose.

*Note: see annex 5 for the Excel financial model’ instructions and financial parameters definition.
The baseline financial model shows only a modestly positive net present value (NPV), before incentives or CapEx subsidies for that model factory.

**Assumptions**

- **Factory location:** medium factory, East Africa
- **F/F capacities:** 80 million containers per year, 4 F/F lines, 9 SKUs
- **CMO F/F costs:** + 5% markup
- **WACC:** 11.33 %
- **Time period:** 2024 to 2040

**Financial parameters***

**CONCLUSION: Net Present Value estimated at + 449 K EUR**

<table>
<thead>
<tr>
<th>Internal Rate of Return</th>
<th>Payback period</th>
<th>Cumulated Free Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.48%</td>
<td>16 years</td>
<td>42 million EUR</td>
</tr>
</tbody>
</table>

*Note: refer to annex 5 for financial parameters’ definition*
There are four main profitability drivers with very high impact on the NPV: capacity utilization, cost of raw materials, salaries and cost of capital investment*

- **Capacity utilization**
  - IF vaccines volumes down by -18% (to 68 million containers)
  - THEN NPV down by -14 million EUR

- **Raw Materials costs**
  - IF Filling Raw Materials costs down by -10%
  - THEN NPV up by +10 million EUR

- **Salaries**
  - IF salaries up by 20%
  - THEN NPV down by -9 million EUR

- **Capital Expenditure**
  - IF process equipment costs down by -15%
    - THEN NPV up by +3 million EUR
  - THEN NPV down by -3 million EUR

- **WACC**
  - IF WAAC up to 15%
  - THEN NPV down by -8 million EUR

*Note: refer to annex 6 for simulations summary table

**CONCLUSION**

- F/F capacities utilization should be optimized
- Global purchase contracts should be negotiated to reduce raw materials prices
- Salaries budget should not be underestimated
- Pool orders of process equipment across several factories to bring discount on CapEx
- Lower costs of capital / loan to reduce WACC
The financial model provides the vaccines F/F costs estimations in the model factory, for 18 vaccines and 2 diluents clubbed into 9 presentations*

Assumptions

- **F/F factory’ CAPEX:**
  89 million EUR depreciated on 20 years for building and 10 years for equipment

- **PM Tech Transfer expenses:**
  35 million EUR spread over 6 years

- **Annual Operational Expenditures:**
  10.3 million EUR (Kenya’ salaries and energy costs)

- **Raw materials:**
  Fill / Pack from India, others from Europe

- **F/F capacities:**
  80 million containers, used at 90% for glass vials, 50% for BFS

- **NPV:**
  +449 K EURO

*Note: Annex 9 includes a detailed F/F costs summary table

CONCLUSION

- F/F costs impacted at +/- 85% by raw materials and half with Filling raw materials
- Indirect costs represent +/-10%
- Direct costs and depreciation with minor weights

---

*CONCLUSION*

- F/F costs impacted at +/- 85% by raw materials and half with Filling raw materials
- Indirect costs represent +/-10%
- Direct costs and depreciation with minor weights

---

*Note: Annex 9 includes a detailed F/F costs summary table*
Based on these estimations from the model factory, vaccines F/F costs in Africa remain higher than in India, before considering transport costs or any CapEx subsidy.

Assumptions

Indian F/F costs estimated based on intelligence data, vaccines industry experience and F/F costs extrapolated from the UNICEF vaccines’ procurement prices*:

- **PCV 10 antigens** (5 doses vial): Y2023 price = 2,9 USD per dose; F/F costs from to 7,5 to 10%
- **ROTA 1 antigen** (1 dose BFS): Y2023 price = 0,95 USD per dose; F/F costs from 15 to 20%
- **MMR 3 antigens** (10 doses vial): Y2023 price = 1,70 USD per dose; F/F costs from 12 to 15%

* From UNICEF Supply Division, Vaccine price data in USD, from Indian suppliers

Disclaimer: The figures presented in this slide are tentative estimations.
Imported bulks (rather than finished packed vaccines) bring substantial shipping cost savings (preliminary conclusion, deeper logistics analysis to be done)

CONCLUSION
Smaller volumes of vaccines’ bulks* shipped from India to African CMO factory:

- **PCV** (12 antigens / bulks): **5x less volumes** (than 5 doses vial)
- **ROTA** (1 antigen / bulk): **44x less volumes** (than 1 dose BFS)
- **MMR** (3 antigens / bulks): **6x less volumes** (than 10 doses vial + diluent)

African CMO factory to supply to local Health Ministry and local airport; UNICEF caring of logistics to regional countries

*Tentative estimations based on quotation from one shipping company

Disclaimers:
- Estimated shipping costs of finished vaccines vs bulks (EUR per dose)
- Shipping costs in passive cooling pallet (+2+8°C for finished vaccines & -25°C for bulks) as per current air freight tariffs + insurances – based on quotation from one shipping company
Vaccines produced by the African CMO F/F factory could be cost competitive to UNICEF once shipping costs are considered.

Estimated total costs to UNICEF (EUR, average per dose)

- Vaccines produced by African CMO F/F factory would bring to UNICEF net costs savings thanks to lower bulks shipping costs off-setting the higher F/F costs.

**Disclaimer:** The figures presented in this slide are tentative estimations.
Conclusions from the study

• Fill/Finish costs in Africa are higher than in India, but difference could be compensated by savings in **intercontinental shipping costs**

• Ambition of 60% Vaccines manufactured in Africa by 2040 could be achieved
  • Requires top-down approach with at least **5 small and medium factories**, either new or leveraging existing F/F capacity *
  • **89 million EUR** (CapEx) + **35 million EUR** (OpEx & Tech Transfer) for one medium-sized greenfield factory

• Executing this strategy must build on existing and already planned Drug Product infrastructure in Africa to avoid over-capacity.

• Optimized greenfield factory design includes 2 glass vial filling lines, 1 BFS tube filling line, and 1 filling & freeze-drying line

• Lead time to commencing GMP production = **5 years**

• **Raw materials** (specifically containers) account for **85%** of F/F costs

• Base case simulation leads to a **modestly positive NPV**

• Profitability mainly influenced by **capacity utilization, raw material costs, capital investment**

* See Annex 11, PATH / CHAI report about existing vaccines F/F capacity in Africa
Part 3 - Recommendations and strategic advice for sustainable CMO plants in Africa

• Optimal capacity and product mix, including mono vs multi product lines
• Optimal technology choice Glass vs BFS
• Optimal number of CMO sites based on financial viability
Multiple factors must be addressed pro-actively to enable success of an investment in an African Vaccines Fill/Finish facility

- Ensure reliable and efficient supplies of raw materials
- Close gaps in cold chain transportation networks
- Complexity of vaccine manufacturing and modern factories requiring thorough competence and project execution
- Ability to demonstrate successful transfer

- Strong willingness to continuously support local biomanufacturing
- Building competence of local regulatory authorities
- Providing access to local talent – education programs

- Leveraging well established international networks
- Proven quality standards, certified through WHO prequalification
- Become a new CMO with proven credibility

- Access to funding at low interest rates, long payback periods
- Government incentives to compensate for higher manufacturing cost
- Long-term advance purchase commitments

Factors to be addressed

- Logistics
- Political buy-in and support
- Vaccine license holders as a new player
- Access to finance and financial sustainability
- Technical project risks
Use facility to manufacture other biopharmaceutical products to ensure high capacity utilization rate and improve profitability

- **Biotherapeutics**: +/- 5 million vials free capacities on glass vials F/F lines
- **Insulins**: no free capacities unless vaccines demand reduced
- **SVPs**: +/- 42 million free capacities on BFS F/F line
- Minor investment in additional filling format
- Tech transfer costs
- Biotherapeutics: additional net revenues, NPV up to >1.5 million EUR
- Insulins: prevent revenue drop in case of reduced vaccines demand
- SVPs: additional net revenues, NPV up to >5 million EUR

*Note: refer to annex 7 for other revenues’ summary & pandemic readiness*
Engage in the development of Blow-Fill-Seal (BFS) presentations for injectable vaccines to enable substantial cost reduction in the longer term

**CURRENT SITUATION**

- Injectable vaccines use glass containers
- Cost mainly driven by raw materials (glass vials, stoppers)
- Oral vaccines in BFS have drastically lower manufacturing costs driven by raw materials
- Feasibility of BFS presentation shown for multiple vaccine types

**OPPORTUNITY**

- **Blow-Fill-Seal technology:** container formed by injection of LDPE resins at high temperature into a mold, then product filled, and container closed
- **Development of multi-dose BFS containers** to be completed
- **Development pathway:**
  - Confirm feasibility for each type of vaccine
  - Confirm user acceptance
  - Development cost per vaccine: 1.5 million EUR
  - Time to launch: 3 to 4 years

**RECOMMENDATION**

- Engage vaccine license holders
- Seek support of global health authorities e.g. WHO and other stakeholders
- Development of BFS technology to be sponsored by supranational organizations

**CONCLUSION**

- Injectable vaccines use glass containers
- Cost mainly driven by raw materials (glass vials, stoppers)
- Oral vaccines in BFS have drastically lower manufacturing costs driven by raw materials
- Feasibility of BFS presentation shown for multiple vaccine types
- Higher CAPEX to fill liquid vaccines in BFS but,
- NPV increased to + 3 million EUR
- \( F/F \) costs multi doses BFS reduced by +/- 40%
Avoid too much complexity and limit risks: Focus initial efforts on a mid-size facility with optimized conditions

• Allocation of resources to one F/F factory to limit complexity and risks
• Integration of existing local F/F capability and capacity, if available
• Use of a business-led approach with focus on financial sustainability
• Facility designed to be flexible
  • Ability to manufacture variety of different products enables to cope with demand variability
  • Ensuring high-capacity utilization
• Concept optimized for profitability and financial sustainability
  • Product mix: Liquid products offer better return than freeze-dried products
  • Location: West Africa provides a lower energy and salary cost than most other regions in Africa
  • Drive for reduction of raw material cost through purchase agreements and/or local sourcing
  • Drive for reduction of CapEx
Disclaimer

This report has been prepared based on Unizima’s contract with GIZ for a study on Sustainable Vaccines Manufacturing in Africa – Business Case Simulation for Fill & Finish Contract Manufacturing Operations (project: 20.2155.8-015.00).

The study had the following objectives only:

1) Capex and Opex of a CMO Vx Formulation, Fill & Finish (FF/F) factories for both glass and BFS vials
2) Costing simulation tool to assess financial viability and compare local production to import
3) Provide recommendation and strategic advice for sustainable CMO plants across Africa

By reading this report, GIZ (the client) accepts and subscribes to the following terms:

1. GIZ acknowledges and understands that the work performed by Unizima was performed (i) exclusively in accordance with instructions provided by our client and the agreement signed by that client and (ii) exclusively for our client’s sole benefit and use.

2. Any person gaining access to our report other than on the basis of an agreement with Unizima, does so entirely on his or her own responsibility.

3. You agree that Unizima, its affiliates, partners, employees and agents neither owe nor accept any obligation, duty or responsibility to any other person than its client, and shall not be liable, whether in contract or in tort (including without limitation, negligence and breach of statutory duty), in respect of any loss, damage or expense of whatsoever nature which is caused by any use you may or may not choose to make of this report, or which is otherwise consequent upon the gaining of access to the report by you.

Unizima has not carried out anything in the nature of an audit nor, except where otherwise stated, have we subjected the financial or other information and assumptions contained in this report to checking or verification procedures. Accordingly, we assume no responsibility and make no representations with respect to the accuracy or completeness of the information in this report, except where otherwise stated.
Abbreviations

BFS: Blow-Fill-Seal
BLA: Biologic License Applications
CAPEX: Capital Expenditures
CMO: Contract Manufacturing Organization
EUR: Euro
F/F: Fill & Finish
FCF: Free Cash Flow
G&A: General and administrative expenses
GMP: Good Manufacturing Practices
LDPE: Low-Density-PolyEthylene
LMIC: Low and Middle Income Countries
mAbs: Monoclonal Antibodies
Mio: millions
NCDs: non-communicable diseases
NPV: Net Present Value
OPEX: Operational Expenditures
PM: Project Management
QC: Quality Control
QA: Quality Assurance
SKU: Stock-Keeping Unit
WACC: Weighted Average Cost of Capital
Annexes

Note: for further details, refer also to the detailed Word study “Sustainable vaccines manufacturing in Africa” and the attached Excel financial model
Annex 1 – African market vaccines demand (1/2)

1 Vaccines prioritized to calculate market demand and manufacturing capacity

- Partnership for African Vaccines Manufacturing (PAVM) Framework for Action
- GAVI’s 2022 publication titled Sustainable Vaccines Manufacturing in Africa

**LEGACY**
- Pentavalent
- Tuberculosis
- Measles-Rubella
- Yellow fever
- Oral cholera vaccine
- Typhoid
- Meningococcus A Conjugate
- Polio
- Tetanus Diphtheria

**EXPANDING**
- Human papillomavirus
- Pneumococcal conjugate vaccine
- Rotavirus
- Malaria
- HIV
- Multivalent meningococcal vaccine

**OUTBREAK**
- Ebola
- Influenza
- Chikungunya
- Rift Valley
- Lassa fever
- Disease X
- Covid-19

**ADDITIONAL***
- Rabies
- Dengue
- Varicella

*Added based on Unizima expert analysis

**KEY TAKEAWAY**

2.1 billion doses would be required annually by 2040 to meet 100% of the estimated vaccines’ demand in Africa (excluding outbreak vaccines)
Annex 1 – African market vaccines demand (2/2)

2 Container volumes

The baseline assumption is that vaccines would be supplied as per PAVM presentations: liquid with 1, 2, 4, 5 or 10 doses; freeze-dried with 1 or 10 doses; oral with 1 dose and diluents with 1 or 10 doses.

<table>
<thead>
<tr>
<th>Containers volumes (million - 2040)</th>
<th>Liquid vaccines in glass vials</th>
<th>Oral vaccines &amp; diluents in BFS tubes</th>
<th>Freeze-dried vaccines in glass vials</th>
<th>Total containers volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (100% vaccines demand)</td>
<td>215</td>
<td>200</td>
<td>51</td>
<td>466</td>
</tr>
<tr>
<td>Total (60% vaccines demand)</td>
<td>129</td>
<td>120</td>
<td>31</td>
<td>280</td>
</tr>
</tbody>
</table>

3 Regions

Proposal for one F/F factory in each of the 5 regions:
- Manufacturing all vaccines for the local/regional market (except for vaccines with low demand)
- Medium size F/F factory to combine economy of scale with limitation of risks and complexity
- Medium size F/F factory in the East and two in the West (one for Central markets)
- Smaller F/F factory leveraging existing F/F capacities in North and South Africa
## Annex 2 – F/F factories capacities as per African market demand

<table>
<thead>
<tr>
<th>African markets demand in Y2040 - Volumes allocation to the five F/F factories assuming 60% - million containers</th>
<th>Central Africa market with West region factory nr1</th>
<th>East Africa market with East region factory</th>
<th>North Africa market with North region factory</th>
<th>South Africa market with South region factory</th>
<th>West Africa market with West region factory nr2</th>
<th>Total Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Demand liquid vaccines</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand allocation per factory</td>
<td>Penta - 10 doses vial</td>
<td>1,49</td>
<td>3,09</td>
<td>1,29</td>
<td>1,10</td>
<td>3,09</td>
</tr>
<tr>
<td></td>
<td>IPV - 10 doses vial</td>
<td>0,93</td>
<td>1,92</td>
<td>0,80</td>
<td>0,68</td>
<td>1,92</td>
</tr>
<tr>
<td></td>
<td>TD - 10 doses vial</td>
<td>0,75</td>
<td>1,54</td>
<td>0,65</td>
<td>0,55</td>
<td>1,54</td>
</tr>
<tr>
<td></td>
<td>PCV - 4 doses vial</td>
<td>3,20</td>
<td>6,60</td>
<td>2,77</td>
<td>2,34</td>
<td>6,60</td>
</tr>
<tr>
<td></td>
<td>HIV - 10 doses vial</td>
<td>0,99</td>
<td>2,05</td>
<td>0,86</td>
<td>0,73</td>
<td>2,05</td>
</tr>
<tr>
<td></td>
<td>HPV - 1 dose vial</td>
<td>3,24</td>
<td>6,70</td>
<td>2,81</td>
<td>2,38</td>
<td>6,70</td>
</tr>
<tr>
<td></td>
<td>MenC/WY - 1 dose vial</td>
<td>4,77</td>
<td>9,86</td>
<td>4,13</td>
<td>3,50</td>
<td>9,86</td>
</tr>
<tr>
<td></td>
<td>Typhoid - 5 doses vial</td>
<td>2,34</td>
<td>1,66</td>
<td>8,64</td>
<td>21,60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malaria - 2 doses vial</td>
<td>12,96</td>
<td>12,96</td>
<td>12,96</td>
<td>12,96</td>
<td>12,96</td>
</tr>
<tr>
<td>Total liquid vaccines demand allocated per factory</td>
<td>30,66</td>
<td>31,75</td>
<td>13,31</td>
<td>21,57</td>
<td>31,75</td>
<td>129,04</td>
</tr>
<tr>
<td><strong>2. Demand freeze-dried vaccines</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand allocation per factory</td>
<td>BCG - 20 doses vial</td>
<td>1,93</td>
<td>1,93</td>
<td>1,93</td>
<td>1,93</td>
<td>1,93</td>
</tr>
<tr>
<td></td>
<td>MR - 10 doses vial</td>
<td>2,21</td>
<td>2,21</td>
<td>2,21</td>
<td>2,21</td>
<td>2,21</td>
</tr>
<tr>
<td></td>
<td>Rabies - 1 dose vial</td>
<td>4,24</td>
<td>4,24</td>
<td>4,24</td>
<td>4,24</td>
<td>4,24</td>
</tr>
<tr>
<td></td>
<td>Varicella - 1 dose vial</td>
<td>2,18</td>
<td>2,18</td>
<td>2,18</td>
<td>2,18</td>
<td>2,18</td>
</tr>
<tr>
<td></td>
<td>YF - 10 doses vial</td>
<td>0,57</td>
<td>0,57</td>
<td>0,57</td>
<td>0,57</td>
<td>0,57</td>
</tr>
<tr>
<td></td>
<td>MenA - 10 doses vial</td>
<td>3,18</td>
<td>3,18</td>
<td>3,18</td>
<td>3,18</td>
<td>3,18</td>
</tr>
<tr>
<td></td>
<td>Dengue - 10 doses vial</td>
<td>0,54</td>
<td>0,54</td>
<td>0,54</td>
<td>0,54</td>
<td>0,54</td>
</tr>
<tr>
<td>Total freeze-dried vaccines demand allocated per factory</td>
<td>8,57</td>
<td>7,81</td>
<td>4,78</td>
<td>9,34</td>
<td>30,51</td>
<td></td>
</tr>
<tr>
<td><strong>3. Demand BFS oral vaccines and diluents</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand allocation per factory</td>
<td>Rota - 1 dose BFS tube</td>
<td>11,25</td>
<td>33,00</td>
<td>31,50</td>
<td>75,75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cholera - 1 dose BFS tube</td>
<td>13,80</td>
<td>13,80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dilkent 24/10 doses BFS tube</td>
<td>11,57</td>
<td>5,84</td>
<td>7,37</td>
<td>24,78</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dilkent 1 dose BFS tube (Rabies / Varicella)</td>
<td>1,78</td>
<td>1,97</td>
<td>1,97</td>
<td>5,72</td>
<td></td>
</tr>
<tr>
<td>Total BFS vaccines demand allocated per factory</td>
<td>38,41</td>
<td>40,81</td>
<td>40,81</td>
<td>120,06</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total F/F demand per factory</strong></td>
<td>77,64</td>
<td>80,37</td>
<td>18,10</td>
<td>21,57</td>
<td>81,93</td>
<td>279,60</td>
</tr>
</tbody>
</table>
Annex 3 – F/F factory process flows chart & conceptual lay-out &

- **Medium F/F factory**: green field, +/- 5000 sqm, 4 F/F lines, 80 millions containers per year, 89 million EURO Capex

- **Smaller F/F factory**: brown field, 2 F/F lines added to existing facilities (1 liquid glass vials and 1 freeze-dried glass vials or 2 liquid glass vials), leveraging existing QC labs, warehouses, packaging, …), 22 to 26 million containers per year, 32 million EURO Capex
Annex 4 – F/F factory project planning (medium factory)

- **Medium F/F factory**: 3 to 4 Tech Transfers per year, up to Y8 for last one
- **Smaller F/F factory**: expected to be one year faster, depending on building / equipment available in existing facilities
Annex 5 – Excel model instructions and financial parameters’ definitions

Excel inputs’ tabs
Tab “1.1 Pilot sheet” to select the F/F factory and the F/F lines
Tab “1.2 Pilot sheet details” and tabs “5.1 to 5.7” to change the F/F factory key parameters

Excel results’ tabs
Tab “2.1 FinPlan” with the four main financial parameters: NPV, IRR, CashFlow and Payback period
Tab “2.2 FF costs per SKU” with estimated F/F costs per container / dose

Financial parameters
Net Present Value: assess the current value of future earnings using a specific discount rate (WACC)
Internal Rate of Return: discount rate that makes the NPV of a project equal to zero
Payback Period: number of years until the factory cash position becomes positive
Cumulated Free Cash Flow: sum of all free cash flows calculated in the model throughout the years of the model
## Annex 6 – Simulations’ summary table
(5 F/F factories, East F/F factory, West nr2 F/F factory)

<table>
<thead>
<tr>
<th>Vaccines F/F factories - Key financial parameters</th>
<th>Baseline</th>
<th>Simulation 1 Vaccines volumes down by about 18% (no HIV and MenCWY)</th>
<th>Simulation 2 Project implementation extended by one year</th>
<th>Simulation 3 No freeze-dried vaccines</th>
<th>Simulation 4 Energy costs increased by +50% costs increased by 20%</th>
<th>Simulation 5 vials filling raw materials costs decreased by -10%</th>
<th>Simulation 6 Process equipment costs down by 15%</th>
<th>Simulation 8 Liquid injectable vaccines in multi-doses BFS tubes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 factories: 332m EUR Capex, 280m containers -- 1 factory: 89m EUR Capex, 68m containers</td>
<td>same as baseline</td>
<td>same as baseline</td>
<td>same as baseline</td>
<td>same as baseline</td>
<td>5 factories: 261m EUR Capex, 250m containers -- 1 factory: 75m EUR Capex, 72m containers</td>
<td>5 factories: 296m EUR Capex, 280m containers -- 1 factory: 80m EUR Capex, 80m containers</td>
<td>5 factories: 357m EUR Capex, 240m containers -- 1 factory: 97m EUR Capex, 80m containers</td>
<td></td>
</tr>
<tr>
<td>5 factories</td>
<td>Profitable from - Year</td>
<td>East</td>
<td>2031</td>
<td>2031</td>
<td>2031</td>
<td>2031</td>
<td>2031</td>
<td>2031</td>
</tr>
<tr>
<td>West</td>
<td>2029</td>
<td>2031</td>
<td>2031</td>
<td>2031</td>
<td>2031</td>
<td>2030</td>
<td>2030</td>
<td>2031</td>
</tr>
<tr>
<td>5 factories</td>
<td>Cumulated free cash flow in Year 2040 - K EUR</td>
<td>East</td>
<td>204.161</td>
<td>64.010</td>
<td>148.312</td>
<td>174.765</td>
<td>132.283</td>
<td>177.620</td>
</tr>
<tr>
<td>West</td>
<td>75.952</td>
<td>45.580</td>
<td>63.819</td>
<td>66.241</td>
<td>63.118</td>
<td>74.764</td>
<td>101.521</td>
<td>80.146</td>
</tr>
<tr>
<td>5 factories</td>
<td>IRR - %</td>
<td>East</td>
<td>14.48%</td>
<td>9.31%</td>
<td>11.67%</td>
<td>15.75%</td>
<td>11.12%</td>
<td>13.36%</td>
</tr>
<tr>
<td>West</td>
<td>11.48%</td>
<td>6.51%</td>
<td>9.36%</td>
<td>12.85%</td>
<td>8.42%</td>
<td>10.06%</td>
<td>14.48%</td>
<td>12.58%</td>
</tr>
<tr>
<td>5 factories</td>
<td>Pay-back period - Years</td>
<td>East</td>
<td>17.44%</td>
<td>12.95%</td>
<td>14.52%</td>
<td>18.79%</td>
<td>14.16%</td>
<td>16.91%</td>
</tr>
<tr>
<td>West</td>
<td>15</td>
<td>17</td>
<td>16</td>
<td>14</td>
<td>16</td>
<td>15</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>5 factories</td>
<td></td>
<td>East</td>
<td>16</td>
<td>18</td>
<td>17</td>
<td>15</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>West</td>
<td>13</td>
<td>15</td>
<td>14</td>
<td>13</td>
<td>14</td>
<td>13</td>
<td>12</td>
<td>13</td>
</tr>
</tbody>
</table>
Annex 7 – Other revenues’ summary & pandemic readiness

<table>
<thead>
<tr>
<th>Product</th>
<th>Estimated market demand</th>
<th>F/F factory capacity impact</th>
<th>F/F factory CapEx Impact</th>
<th>F/F factory OpEx Impact</th>
<th>F/F factory revenues &amp; NPV impact</th>
<th>Overall attractiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotherapeutics Low</td>
<td>Low</td>
<td>Low: use of free F/F capacities, +/- 5 million vials</td>
<td>-New change parts on existing F/F line(s)</td>
<td>-No additional HC</td>
<td>-Revenues ++ -NPV ++</td>
<td></td>
</tr>
<tr>
<td>Insulins</td>
<td>High</td>
<td>High: vaccines volumes to be reduced</td>
<td>-New change parts on existing F/F line(s)</td>
<td>-No additional HC</td>
<td>-Revenues + -NPV +</td>
<td></td>
</tr>
<tr>
<td>Insulin analogs Low</td>
<td>Low</td>
<td>Low: use of free F/F capacities</td>
<td>-New change parts on existing F/F line(s)</td>
<td>-No additional HC</td>
<td>-Revenues + -NPV+</td>
<td></td>
</tr>
<tr>
<td>Small Volume Parenterals High</td>
<td>Low: use of free F/F capacities, +/- 42.5 million BFS</td>
<td>-New mold(s) on existing F/F line</td>
<td>10 additional HC</td>
<td>-Revenues + -NPV+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pandemic readiness vaccine Very high but rare</td>
<td>High: vaccines F/F to be stopped</td>
<td>-Product’ Tech Transfer costs -Storage at ultra low temperature</td>
<td>High but temporarily</td>
<td>-Revenues = -NPV =</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F/F factory capable to manufacture common pandemic vaccine platforms

Pandemic vaccines supplied within few months, assuming F/F capacities re-allocated from routine to pandemic vaccines.

F/F factory to support the improvement of the pandemic preparedness on African continent
## Annex 9 – F/F costs summary table

### GIZ project - Vaccines F/F factory - 2.2- Fill & Finish (F/F) costs estimation per SKU - EUR

<table>
<thead>
<tr>
<th>SKU N°1</th>
<th>Liquid vaccines in glass vial, 10 doses per vial</th>
<th>Penta, IPV, Td, HIV</th>
<th>Units</th>
<th>31/12/2030</th>
<th>31/12/2035</th>
<th>31/12/2040</th>
<th>% per item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production cost per vial (Eur)</td>
<td>1,735</td>
<td>1,619</td>
<td>1,570</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per dose (Eur)</td>
<td>0,174</td>
<td>0,162</td>
<td>0,157</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SKU N°2</th>
<th>Liquid vaccines in glass vial, 5 or 4 doses per vial</th>
<th>Typhoid, PCV</th>
<th>Units</th>
<th>31/12/2030</th>
<th>31/12/2035</th>
<th>31/12/2040</th>
<th>% per item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production cost per vial (Eur)</td>
<td>1,562</td>
<td>1,431</td>
<td>1,379</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per dose (Eur)</td>
<td>0,312</td>
<td>0,286</td>
<td>0,276</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SKU N°4</th>
<th>Liquid vaccines in glass vial, 1 dose per vial</th>
<th>HPV, Men CWY</th>
<th>Units</th>
<th>31/12/2030</th>
<th>31/12/2035</th>
<th>31/12/2040</th>
<th>% per item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production cost per vial (Eur)</td>
<td>1,121</td>
<td>1,034</td>
<td>1,002</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per dose (Eur)</td>
<td>1,121</td>
<td>1,034</td>
<td>1,002</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SKU N°5</th>
<th>Freeze-dried vaccines in glass vial, 10 doses per vial</th>
<th>BCG, MR, YF, Men A, Dengue</th>
<th>Units</th>
<th>31/12/2030</th>
<th>31/12/2035</th>
<th>31/12/2040</th>
<th>% per item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production cost per vial (Eur)</td>
<td>1,850</td>
<td>1,666</td>
<td>1,611</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per dose (Eur)</td>
<td>0,185</td>
<td>0,167</td>
<td>0,161</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SKU N°7</th>
<th>Oral vaccines in BFS, 1 dose per tube</th>
<th>Cholera, Rota-virus</th>
<th>Units</th>
<th>31/12/2030</th>
<th>31/12/2035</th>
<th>31/12/2040</th>
<th>% per item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production cost per vial (Eur)</td>
<td>0,467</td>
<td>0,417</td>
<td>0,389</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per dose (Eur)</td>
<td>0,467</td>
<td>0,417</td>
<td>0,389</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SKU N°8</th>
<th>Diluents in BFS, multi doses</th>
<th>Units</th>
<th>31/12/2030</th>
<th>31/12/2035</th>
<th>31/12/2040</th>
<th>% per item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production cost per vial (Eur)</td>
<td>0,583</td>
<td>0,520</td>
<td>0,505</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per dose (Eur)</td>
<td>0,058</td>
<td>0,052</td>
<td>0,051</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SKU N°9</th>
<th>Diluents in BFS, mono dose</th>
<th>Units</th>
<th>31/12/2030</th>
<th>31/12/2035</th>
<th>31/12/2040</th>
<th>% per item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production cost per vial (Eur)</td>
<td>0,421</td>
<td>0,358</td>
<td>0,343</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per dose (Eur)</td>
<td>0,421</td>
<td>0,358</td>
<td>0,343</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Annex 10 – 3D layout of the F/F factory

PROPOSED 3D VIEW FOR GIZ-GERMANY.
This paper offers insights into the current African vaccine manufacturing landscape & plans to verify public pronouncements based on on-the-ground research.

Reports based on public announcements

**CHAI White Paper**
Summarizing current landscape of African vaccine manufacturing and publicly announced expansion plans.

**PATH Report**
Mapping the current state of vaccine production infrastructure in Africa

**Wellcome Report**
Perspectives from the African vaccine manufacturing industry on challenges and the need for support.

---

**Key questions still to be answered**

- What is the accurate assessment of installed capacity on the continent? What portion is commercialized for vaccines?
- What plans for African Vaccine Manufacturers have been proposed? How realistic are these plans based on companies’ technical and commercial capabilities?
- What challenges exist for manufacturers and how can they be addressed either bilaterally or through market shaping initiatives?