

AFRA 2019 Annual Conference

Aircraft EOL KPIs



AFRA KPI Study

Mandated by AFRA

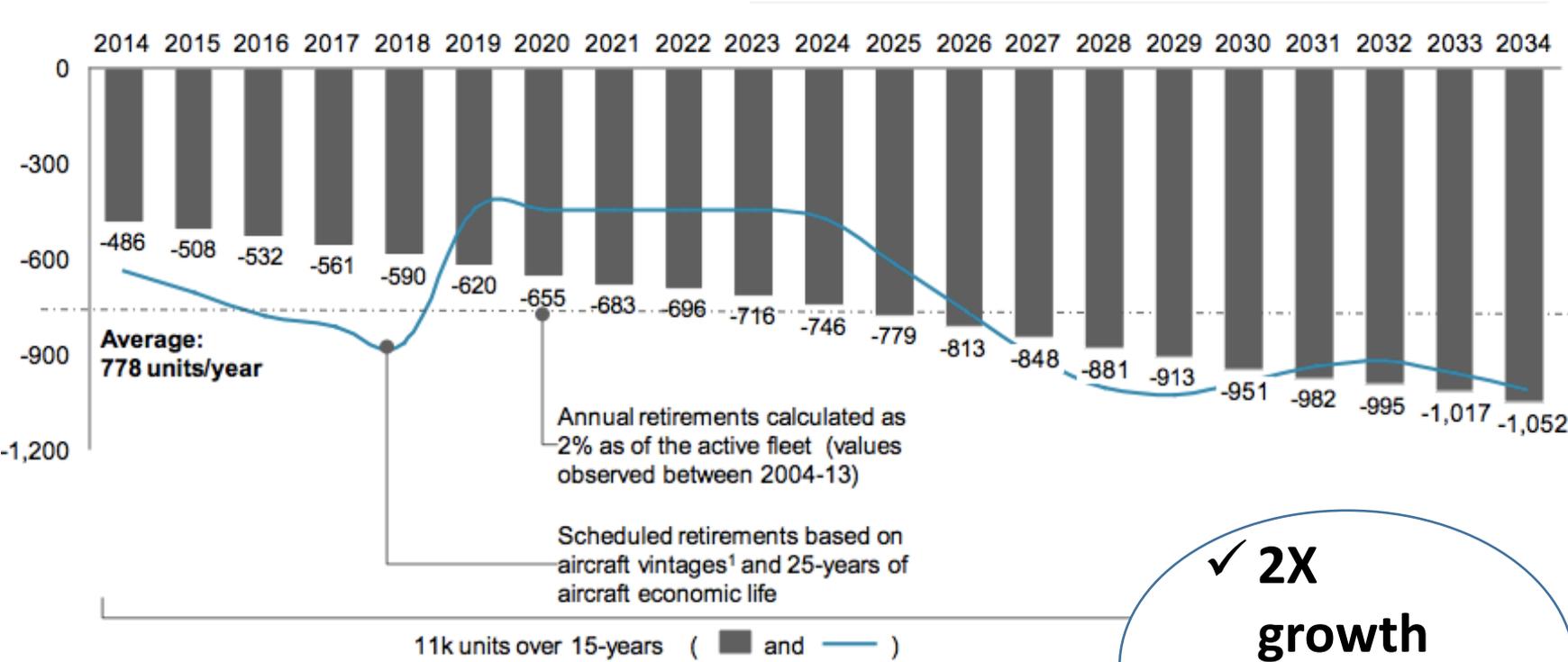
- ✓ Establish a methodology to measure the performance of the Aircraft End Of Life (EOL) sector
- ✓ Define a universally agreed list of KPIs to measure the performance

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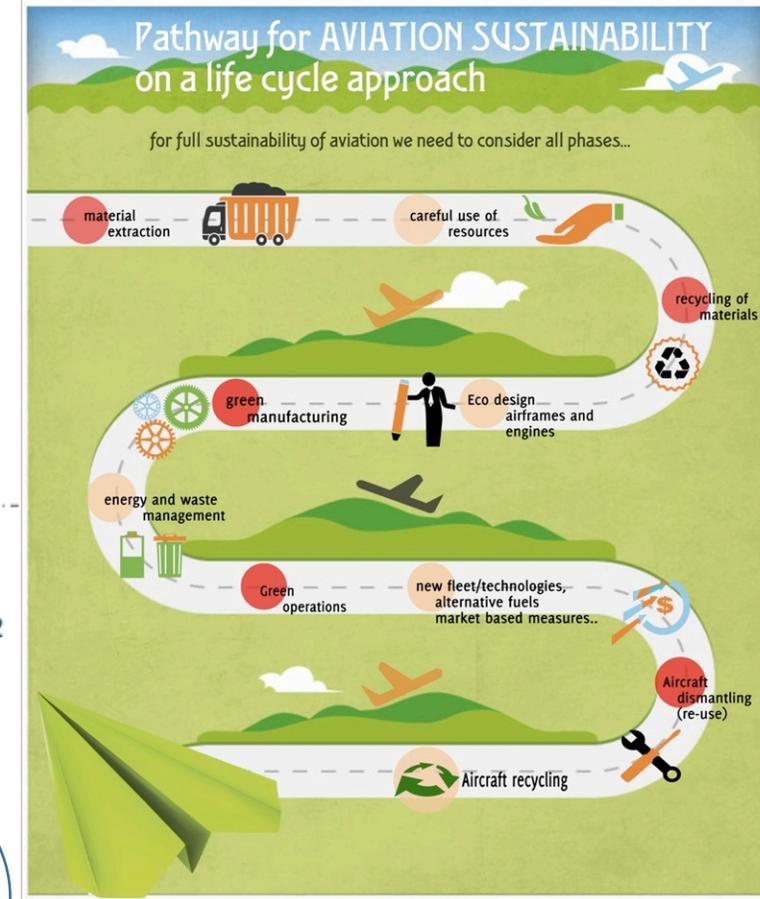
President, ENVISA (Paris, France)

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➤ Full environmental footprint



✓ **2X**
growth
 ✓ **800 a/c**
RET/YR



➔ Established in Paris, France in 2004, **Envisa** has been working exclusively on developing **solutions** for the **sustainable growth** of aviation and managing big structural European Projects (EASA, Eurocontrol..)

- ✓ AFRA R&D Partner
- ✓ Sustainability and Recycling Projects;
- ✓ Innovative digital tools adapted to the needs of individual airports, airlines, aircraft owners;
- ✓ Support on EOL (Aircraft End of Life) management (AiMeRe, AFRA R&D member, close relations with IATA, EASA, ACI).



European Cleansky Project: AiMeRe

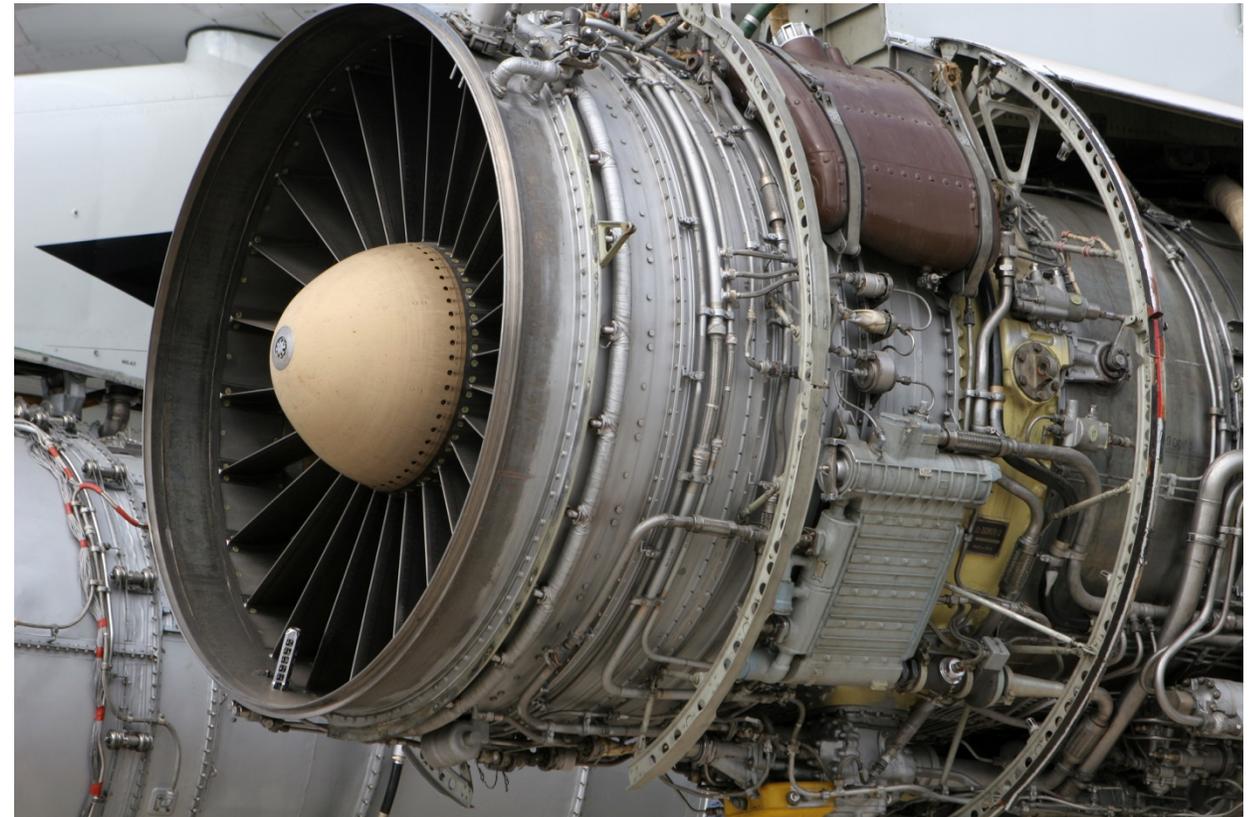




how to measure performance?

- ✓ Give insights to AFRA about *the areas that need to be improved* for better aircraft recyclability and strategies to further improve the efficiency of the whole industry.
- ✓ Establish a **methodology** to measure the performance of the Aircraft End Of Life (EOL) sector
- ✓ Define a **universally agreed list of KPIs** to measure the performance

For Aircraft EOL



Where we are?



- State of the Art Report prepared with an extensive list of KPIs used in other sectors
- (*On-going*) Initial recommended list of KPI will be used for scoping exercise: choosing the KPI selection criteria, and set the methodology and procedures.

The outcome of the study will be used in a consultation period with AFRA members during AFRA conference and during July-September period

Why KPI? standardised indicators that can provide **dependable** and **repeatable** means of evaluating the level of environmental performance

Choose KPIs that are directly related to **AFRA Business Goals**

Focus on a **Few Key Metrics**

Start to measure NOW!

KPIs can be different for every industry and business model

Some Definitions

home ●

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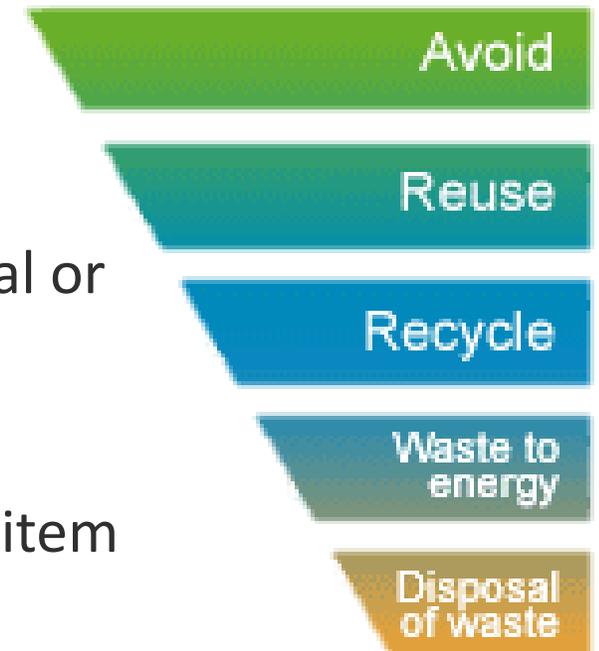
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Important definitions



- ✓ **Recycling:** Any recovery operation by which materials are reprocessed into products, material or substances whether for the original or other purposes
- ✓ **Disposal:** Materials that are not reused, remanufactured or recycled
- ✓ **Energy recovery:** Waste materials are used to produce energy
- ✓ **Alternative Reuse:** Parts used with another function, either educational or decoration purposes, for instance
- ✓ **Part:** Any component, part, sub-part, assembly, subassembly, or other item removed from the Asset

Waste Hierarchy



Important EOL definitions



- ✓ **Decomissioning:** Process by which the aircraft is taken out of services
- ✓ **Recovery:** Removal of fluids, security equipments, avionic, all metal alloys, thermoplastics etc
- ✓ **Disassembling:** The process comprising all the activities required to remove all the valuable components from an aircraft, which can be re-used in another aircraft.
- ✓ **Dismantling:** The process comprising all the activities required to make it possible to recycle materials from an aircraft.
- ✓ **Reuse:** Movable and structural parts which can be re-used with the same function

ISO Standard Definitions !

Recovery: any operation the principal result of which is waste serving a **useful purpose**.

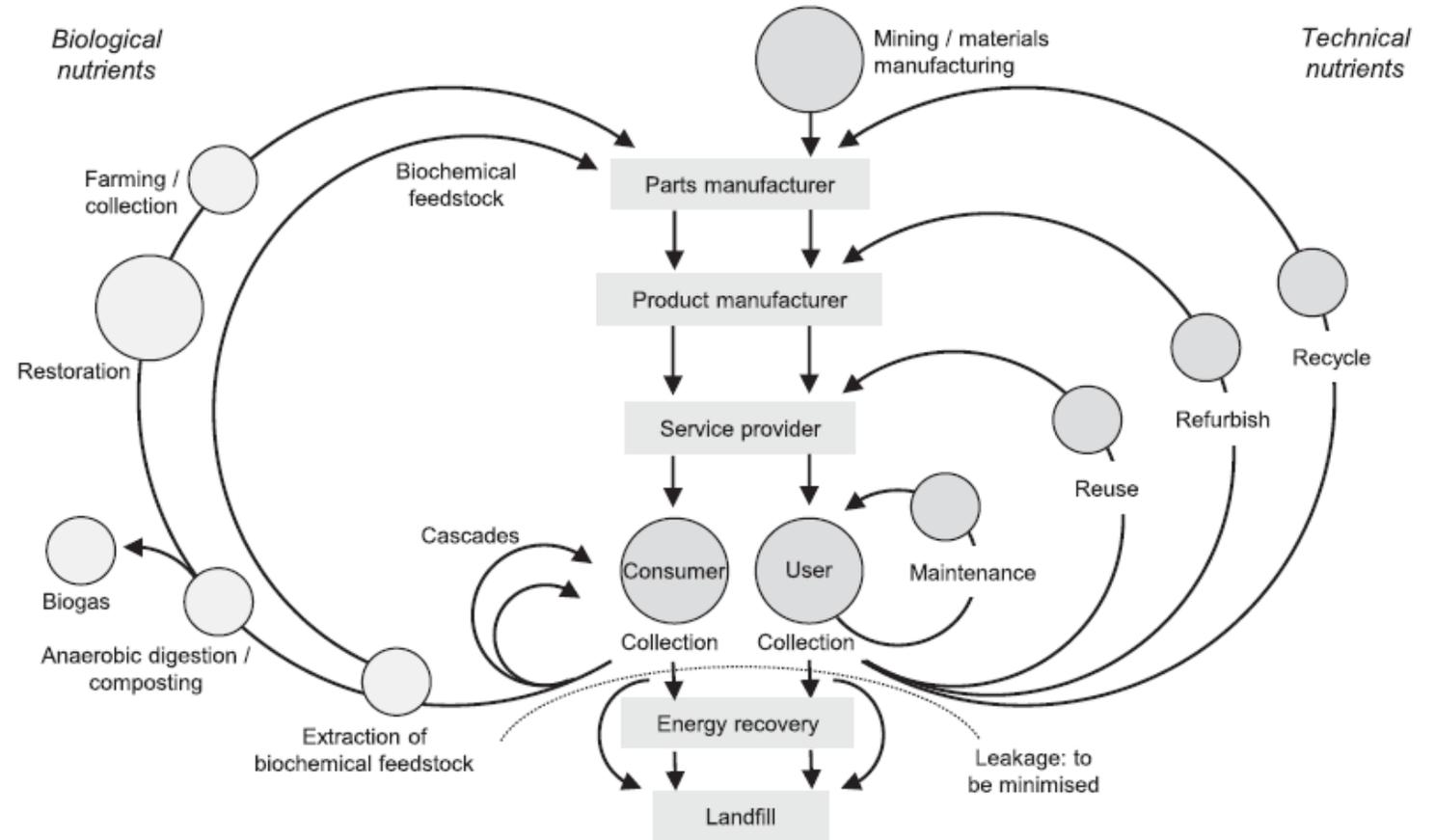
Recycling: any recovery operation by which waste materials are reprocessed into **products**, materials or substances whether for the original or other purposes.

Circular Economy definitions



Zero Waste :

- ✓ Through life cycle
- ✓ Compatible with sustainability concept
- ✓ Closed loops





MEASURE WHAT MATTERS...

What are the important parameters for selecting the right KPIs and for who?

Which stakeholders EOL involves ?

Important criteria for selection of right KPIs



✓ The KPI list has been drafted based on the following KPI criteria and considerations

Criteria:

- ✓ Measurable
- ✓ Relevant
- ✓ Understandable
- ✓ Reliable
- ✓ Data accessible
- ✓ Timely manner
- ✓ Long term orienter

Considerations :

- ✓ EOL Steps, and their environmental footprint
- ✓ Aircraft model, processes, materials...
- ✓ Available techniques and technologies
- ✓ Processes used for metal and material separations
- ✓ Impacts: on environment
- ✓ Data availability for EOL and the recycling activities

Complex Stakeholders



**Design
And
Manufa
cturing**

OEMs

Use

Operators



Air Centers at airports which offer hangars and storage space at their facilities (aeronautical aprons).



Warehousing and Logistics companies who provide parts storage and distribution, worldwide.

EOL



Dismantlers/MROs who fulfill parts removal in accordance to OEM guidelines, pollution standards and removal of dangerous materials before a/c scrapping.



Scrapping/Recycling Companies to handle the destruction of a/c and recovery of raw materials.



Cargo Agents and Freight Forwarders for packaging, custom operation and shipment of parts.



- **Equipment and Tools Suppliers**
- **Technology Specialists**
- **Service Providers**



**How are others
measuring their
performance?**

AFRA Deliverable : State of the Art Report

Comprehensive Review of KPIs...



- **Methods:**

- Sustainability concept, Circular Economy
- LCA
- MCA
- KPIs...

- **Sectors:**

- Aviation
- Automotive
- Railway
- Maritime
- Municipal solid waste
- Health care industry...

- **Directives & Standards:**

- EU Directive 2000/53/EC
- EU Ecodesign Directive
- ISO 22628
- ISO 14025, 14040, 14044

KPI description	
Content:	
Name	Total Energy Waste
ID	
Description	The total energy waste measures the difference between theoretical energy and the actual energy consumed by the process.
Scope	Process Level
Formula	Total Energy Waste = EC – NE, where EC = energy consumed by the process in kWh where NE = necessary energy in kWh
Unit of Measure	kWh
Range	Min: 0 Max: process dependent
Trend	The lower, the better
Context:	
Timing	Periodically
Audience	Operator, supervisor, management
Production methodology	Discrete, Batch
Notes	The total energy waste provides insight into energy waste at a process by comparing the energy needed at a process to the actual energy consumed.

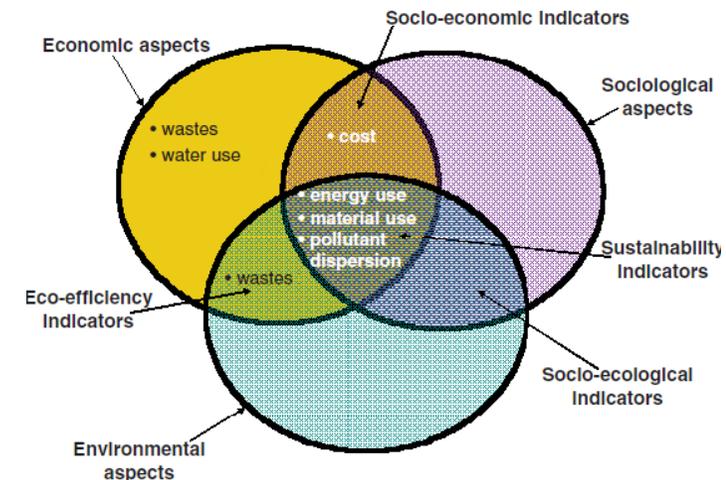
Metric	Description	Unit
<i>Reusability</i>	Amount of MCPs that retain their functionality and physical attributes after the end of their primary life, on a weight or item basis.	t (or item)/t (or item) input into the system
<i>Remanufacturability</i>	Potential to restore a component/product to like-new condition through measuring, disassembly, cleaning, inspection and sorting, part repair/ refurbishment/replacement, reassembly and final testing, on a weight or item basis.	% wt. or item
<i>Mass recyclability</i>	Amount of MCPs collected and/or sorted for recycling, on a weight basis.	t/t input into the system
<i>Technical recyclability</i>	Proportion of the material, or component made of only one material collected for recycling that will be recycled for producing high quality recycled MCPs.	% wt.
<i>Mass recoverability</i>	Amount of MCPs, and/or proportion of the material in the component/product that is captured after the EoU stage.	t or % wt.
<i>Energy recoverability</i>	Energy embodied in the materials, components (made of only one material), and component's and product's parts recovered by the EFW plants in the form of electricity and heat.	kWh/t input
<i>Lower heating value (LHV) or net calorific value</i>	Amount of heat released by combusting a specified quantity of MCPs (initially at 25 °C) and returning the temperature of the combustion products to 150 °C, which assumes the latent heat of vaporization of water in the reaction products is not recovered.	J/kg or kWh/t
<i>Technical recoverability of components and products</i>	Relates to components (made of more than one material) and products only. Assessed based on the component's and product's weight share that can be extracted for reuse, recycling, energy recovery and disposal, using the eco-design principles.	% wt.
<i>Technological advancement</i>	<i>Process based:</i> Advances in technology that improve the efficiency of technologies used in the processing steps of the RRFW system. <i>MCP based:</i> advances in the designed characteristics of existing and/or new	Unspecified (potentially quantified or semi-quantified)

Methodology & Selected KPIS

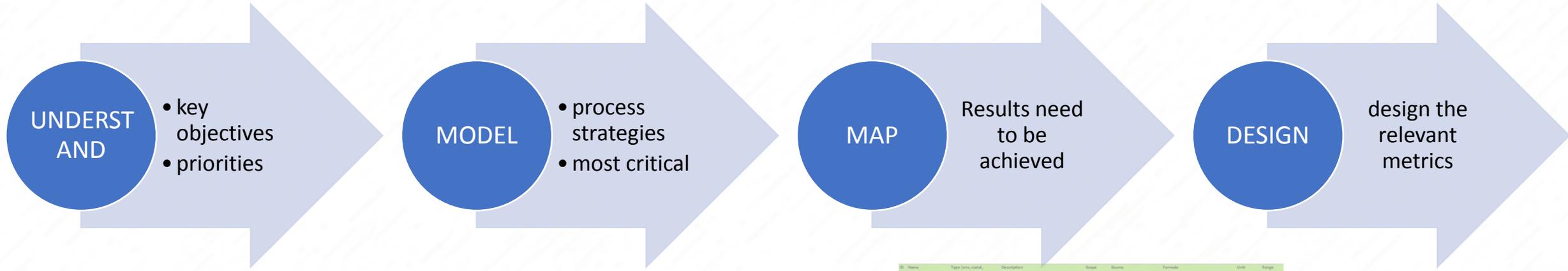


ID	Name	Type (env, social, economic, technical)	Description	Scope	Source	Formula	Unit	Range
1	Recyclability rate according to ISO 22628	Technical	Percentage of mass to be recycled, reused or both	Recycling	ISO 22628:2002ansport Committee	See Formulae tab	% of mass	0-100
2	Recoverability rate according to ISO 22628	Technical	Percentage of mass to be recovered, reused or both	Recycling	ISO 22628:2002	See Formulae tab	% of mass	0-100
3	Recyclability rate according to Railway Industry	Technical	Percentage of mass to be recycled, reused or both	Recycling	ISO 22628:2002 and Recyclability and Recoverability Calculation Method	See Formulae tab	% of mass	0-100
4	Recoverability rate according to railway Industry	Technical	Percentage of mass to be recovered, reused or both	Recycling	ISO 22628:2002 and Recyclability and Recoverability Calculation Method Railway Rolling Stock from UNIFE Sustainable Transport Committee	See Formulae tab	% of mass	0-100
5	Number of materials recycled	Technical	Number of the different materials that are recycled per aircraft type or facility	Recycling		Sum of the different materials recycled	Number of materials	>=1
6	Core Disposal Rate (CDR)	Technical	Percentage mass if materials that are not recycled	Recycling	Graham et al (2015)	$CDR = \text{Waste} / \text{Mass treated at the installation}$	% of mass	0-100
7	Reusability	Technical	Amount of materials that retain their functionality after the end of their primary life, so they can be reused	Disassembling	Iacovidou et al. (2017)		t/t input into the system	0-100
8	Circular Economy Index (CEI)	Environmental, social and economic	Ratio of the material value produced by the recycler by the material value entering the recycling facility	Recycling	Di Maio and Rem (2015)	See Formulae tab	Unitless	
9	Recycling Index	Economic	R is the recycling index, an estimated measurement of the recyclability of materials, Vm is the value of material of first-production/virgin (\$/kg) and Vp is the value of material post-recycled (\$/kg)	Recycling	Villalba et al (2002)	$R = Vp / Vm$	Unitless	0-1
10	Amount of toxic materials disposed	Environmental	Amount of toxic materials that are left at the end of the aircraft EOL process. Could also be expressed as % of total aircraft	Disposal			Mass of toxic materials or	
11	Jobs created by Aircraft EOL	Social	Number of jobs created due to the aircraft EOL process	Whole EOL	Iacovidou et al. (2017)			
12	Water Withdrawal	Environmental	Total volume of water withdrawn for internal use in the company's processes and activities	Any of the aircraft EOL steps or the	Graham et al (2015)		Volume	
13	Utilities costs	Economic	Energy costs + water costs + residues collection	Any of the aircraft EOL steps or the	Iacovidou et al. (2017)		\$	
14	Total Energy Consumption	Environmental	Total energy consumption	Any of the aircraft EOL steps or the	Graham et al (2015)		kWh	
15	Total Waste	Environmental	Total weight of waste by type and disposal method	Disposal	Graham et al (2015)		Weight by disposal material	

- Technical
- Environmental
- Social
- Economy
- Circular Economy index (CEI)



Our method...



How to choose?

ID	Name	Type (env, social, economic, technical)	Description	Scope	Source	Formula	Unit	Range
1	Recyclability rate according to ISO 25026	Technical	Percentage of mass to be recycled, reused, repaired or both	Recycling	ISO 25026:2008 Chapter 5	See Forecast tab	% of mass	0-100
2	Recyclability rate according to ISO 25028	Technical	Percentage of mass to be recycled, reused or both	Recycling	ISO 25028:2008	See Forecast tab	% of mass	0-100
3	Recyclability rate according to Railway Industry	Technical	Percentage of mass to be recycled, reused or both	Recycling	EN 22128:2002 and Recyclability Calculation Method	See Forecast tab	% of mass	0-100
4	Recyclability rate according to railway industry	Technical	Percentage of mass to be recycled, reused or both	Recycling	ISO 25028:2002 and Recyclability Calculation Method Railway Rolling Stock EN 22128 Sustainable Transport Committee	See Forecast tab	% of mass	0-100
5	Number of materials recycled	Technical	Number of the different materials that are recycled per aircraft type or facility	Recycling		Sum of the different materials recycled	Number of materials	1-1
6	Loss Obsolete Rate (LOR)	Technical	Percentage mass of materials that are not recycled	Recycling	Stuhnen et al. (2015)	LOR= Waste/Mass treated at the installation	% of mass	0-100
7	Reusability	Technical	Measure of materials that ensure their functionality after the end of their primary life, so that they can be reused	Disassembly	Secorides et al. (2015)		0-1 input into the system	0-100
8	Customer Economy Index (CEI)	Environmental, social and economic	Ratio of the material value produced by the recycler by the material value entering the recycling facility	Recycling	DI Mats and Rem (2013)	See Forecast tab	unitless	0-1
9	Recycling Index	Economic	It is the recycling index, an estimated measurement of the recyclability of materials, that is the value of material of first production/origin (EN ₁) and up to the value of material produced (EN ₂) ...	Disposal	Witalla et al. (2003)	R = kg/ton	unitless	0-1
10	Amount of toxic materials disposed	Environmental	Amount of toxic materials that are disposed	Disposal			Mass of toxic materials	0-1
11	Jobs created by Aircraft RCE	Social	Number of jobs created due to the aircraft RCE process	Disposal	Secorides et al. (2015)		Number of jobs	0-1
12	Water Withdrawal	Environmental	Volume of water used in the RCE process	Disposal	Stuhnen et al. (2015)		Volume	0-1
13	Wasteful costs	Economic	Costs of materials that are not recycled	Disposal	Stuhnen et al. (2015)		Cost	0-1
14	Total Energy Consumption	Environmental	Total energy consumption	Disposal	Stuhnen et al. (2015)		Energy	0-1
15	Total Waste	Environmental	Total weight of waste by type and disposal method	Disposal	Stuhnen et al. (2015)		Weight of waste	0-1



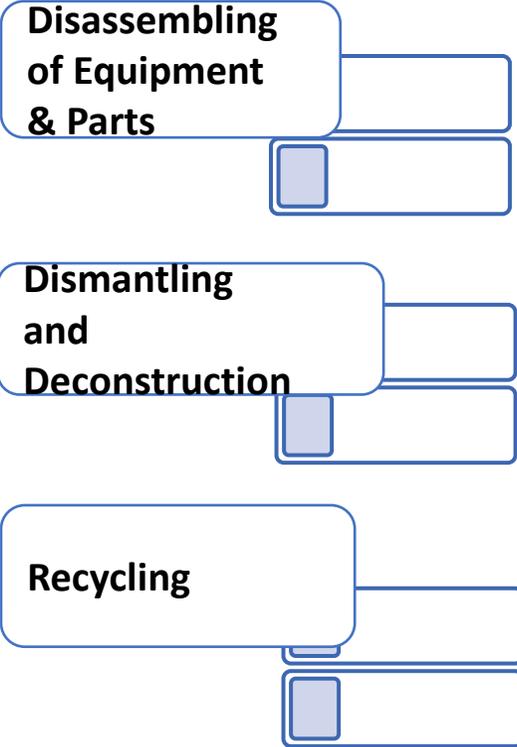
Testing the methodology with AFRA members



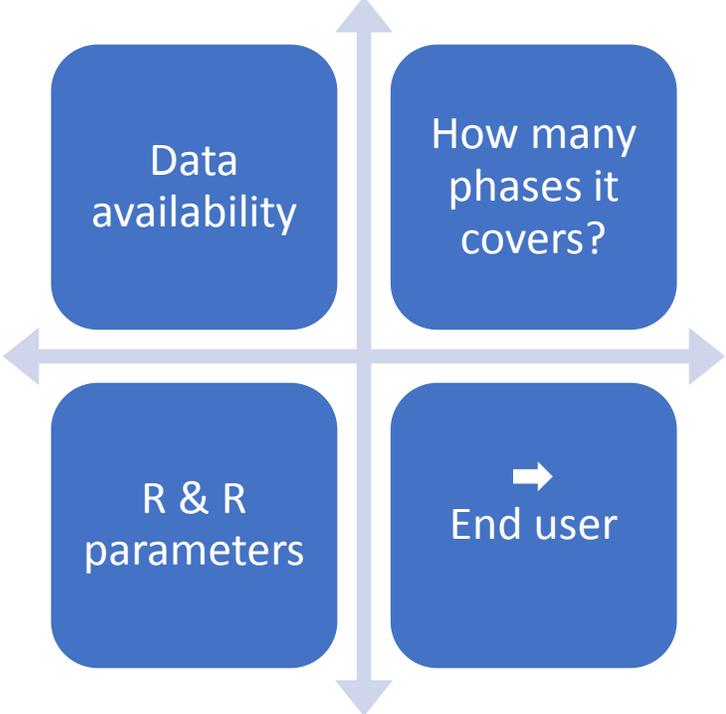
Initial KPI list

Recyclability rate according to ISO 22628	Technical	Percentage of mass to be recycled, reused or both
Recoverability rate according to ISO 22628	Technical	Percentage of mass to be recovered, reused or both
Recyclability rate according to Railway Industry	Technical	Percentage of mass to be recycled, reused or both
Recoverability rate according to railway Industry	Technical	Percentage of mass to be recovered, reused or both

EOL Steps



Scoping



Final KPI list

Recyclability rate according to ISO 22628	Technical	Percentage of mass to be recycled, reused or both
Recoverability rate according to ISO 22628	Technical	Percentage of mass to be recovered, reused or both
Recyclability rate according to Railway Industry	Technical	Percentage of mass to be recycled, reused or both
Recoverability rate according to railway Industry	Technical	Percentage of mass to be recovered, reused or both

Which indicators cover the objectives of AFRA ?

- ✓ **Which KPIs we want to cover (including which EOL steps) ?**
- ✓ **Process, or company? Or aircraft type? How AFRA wants to aggregate the data?**
- ✓ **Service/guidance from AFRA on how to do? (i.e. similar to BMP ?) Independent reviewer?**

(DECOMMISSIONING AND DISASSEMBLING) MAPPING with Working Group (AFRA R&D members)

2: DECOMMISSIONING

2.1 Inspection, cleaning and decontamination

(1,3,6,7,9,10,12,14,15,17,19,20) most relevant:
6:CDR, 10: amount of toxicmat 12:water withdrawal, 17:cost of disposal of hazardous and unprocessed waste

3: DISASSEMBLING

3.1 Physical disassembling process

3.2 Part and material handling

3.3. Material diagnosis

(7,8,12,13,14,15,16, 19,22) most relevant:
&: Reusability, 8:CEI, 13:utility cost, 16;
Remanufacturability, 22: number of parts disassembled

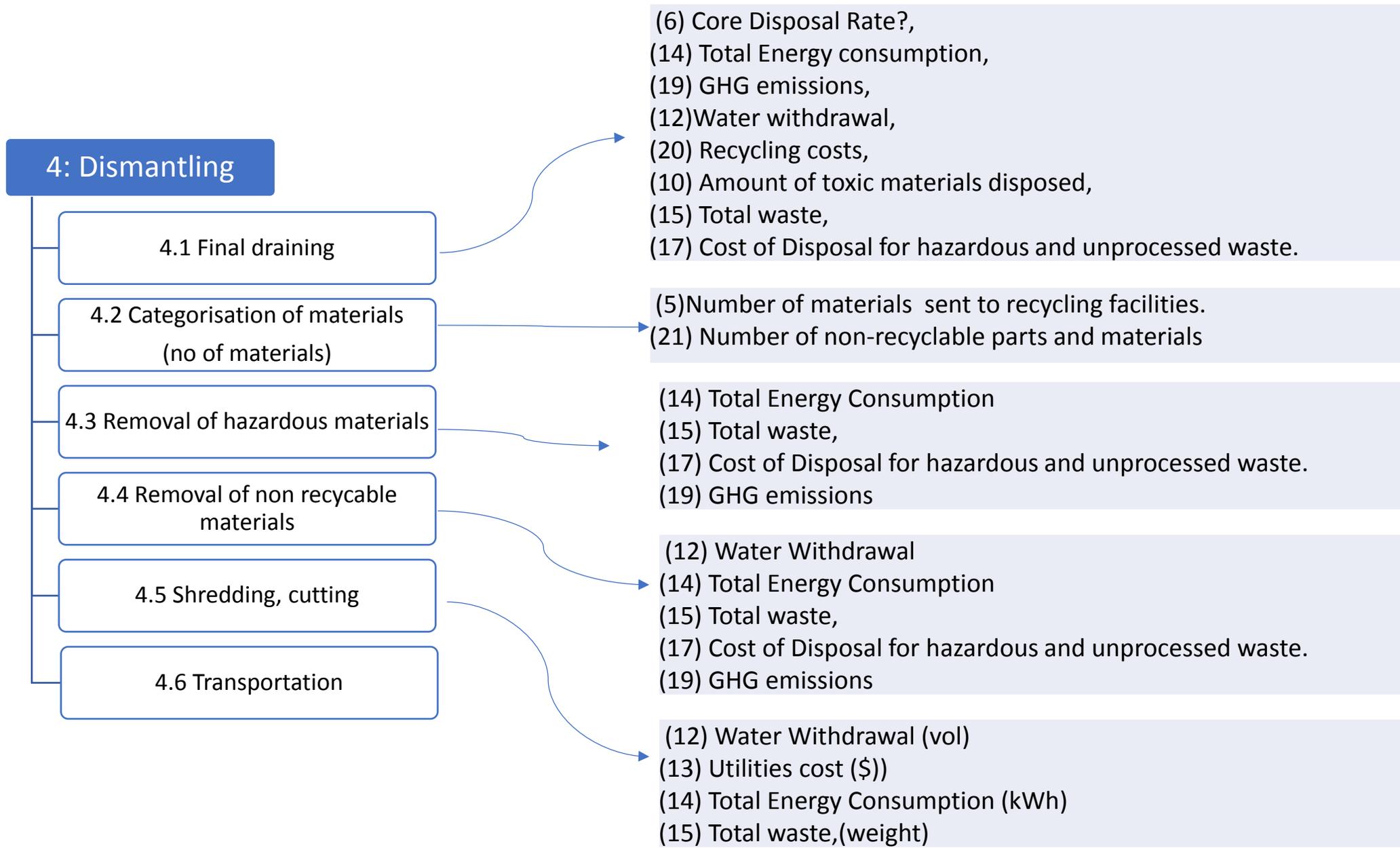
(12) Water withdrawal

(14) Total Energy Consumption (kWh)

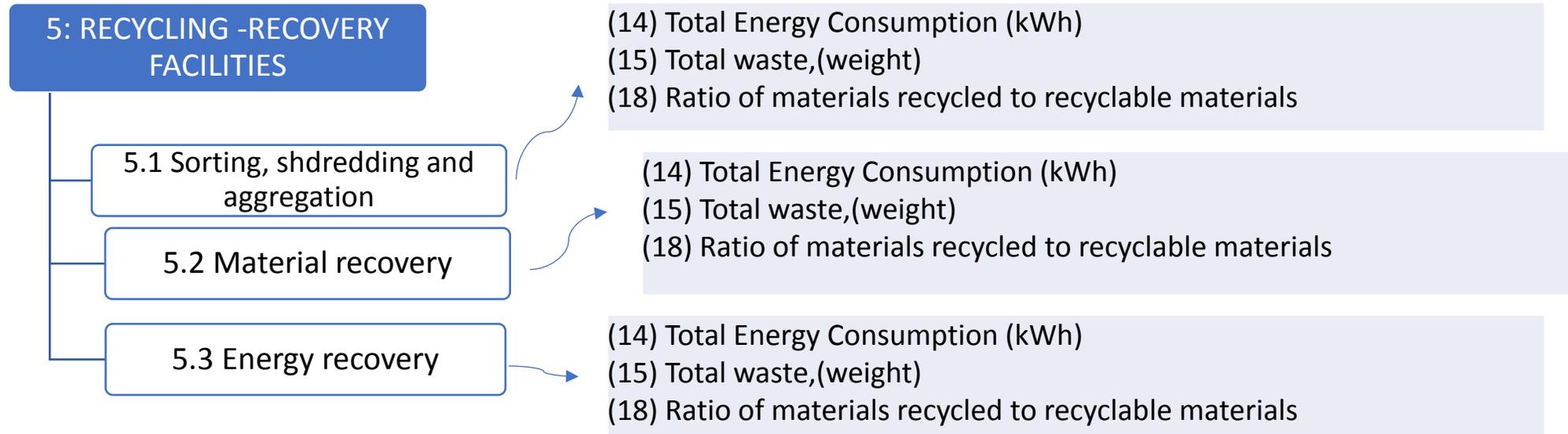
(5) Number of materials recycled

(14) Number of non-recyclable parts

(DISMANTLING) MAPPING with Working Group (AFRA R&D members)



(RECYCLING) MAPPING with Working Group (AFRA R&D members)



REVIEW with AFRA Project Team



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14	Total Energy Consumption	Environmental	Total energy consumption	Any of the aircraft EOL steps or the	Graham et al (2015)		kWh	
15	Total Waste	Environmental	Total weight of waste by type and disposal method	Disposal	Graham et al (2015)		Weight by disposal material	

TOO COMPLEX TO ADAPT TO EACH STEP

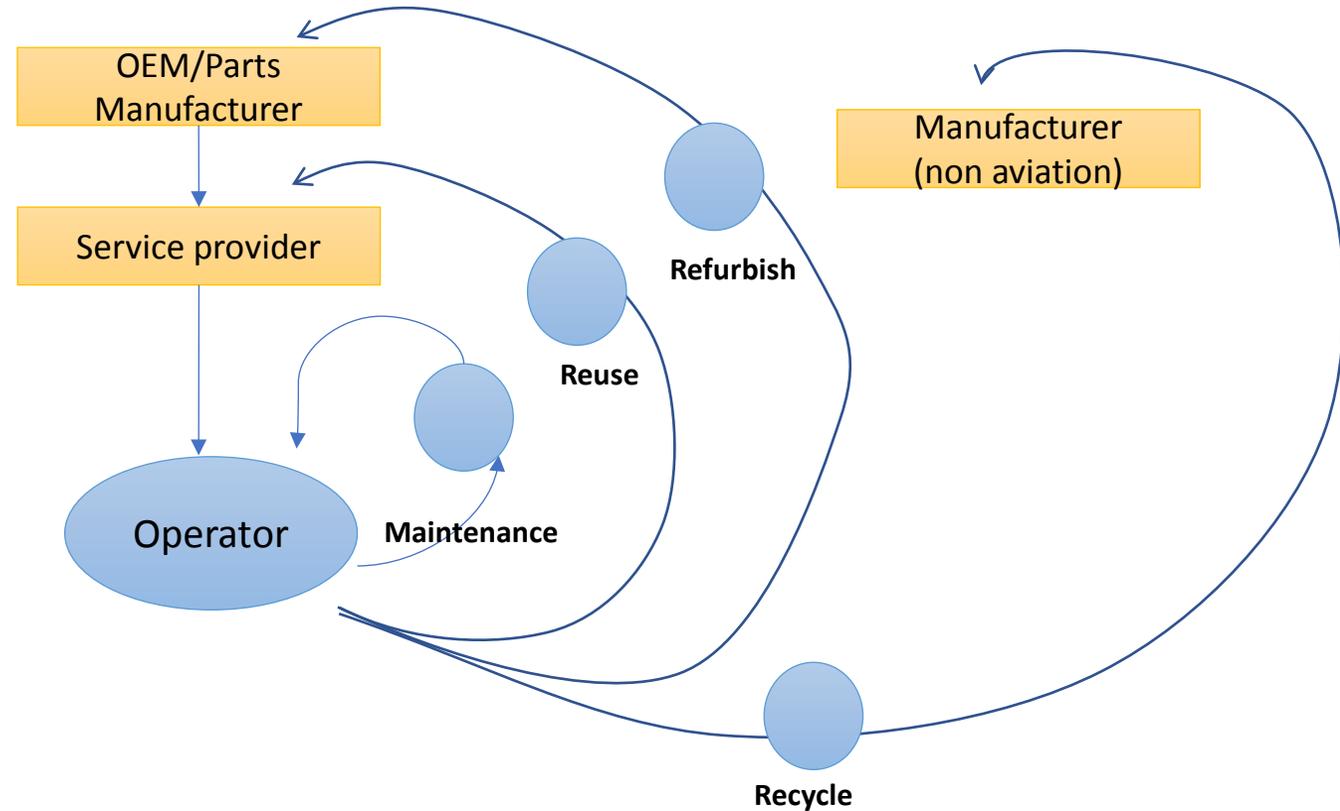
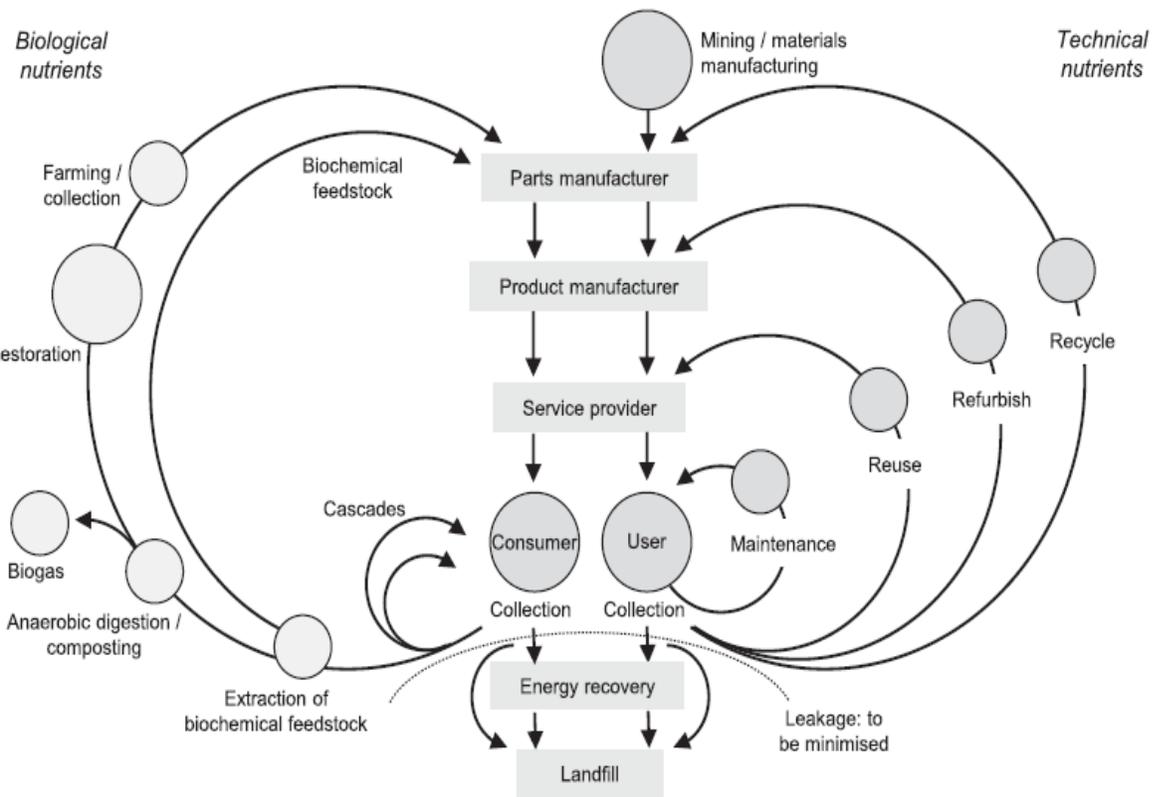
FOCUS ON

- DISMANTLING
- RECYCLING
- DISPOSAL

ADAPT

- RECYCLING / RECOVERY KPIs
- Avoid comparison
- Confidentiality of data
- Emphasize closed loops (under Circular Economy)

Circular Economy in the context of aircraft EOL



Next steps



- ✓ Demonstration case study with a selected AFRA partner
 - ✓ **Objective:** see how the process can be implemented in practise

- ✓ Final output:
 - ✓ Validated and tested KPIs
 - ✓ Report detailing the process followed to obtain the KPIs
 - ✓ List of KPIs proposed to AFRA members and beyond

THANK YOU



QUESTIONS?

Volunteer for the scoping exercise!

