Circular machining systems – approaches for reuse and reconfiguration (REFUSE)

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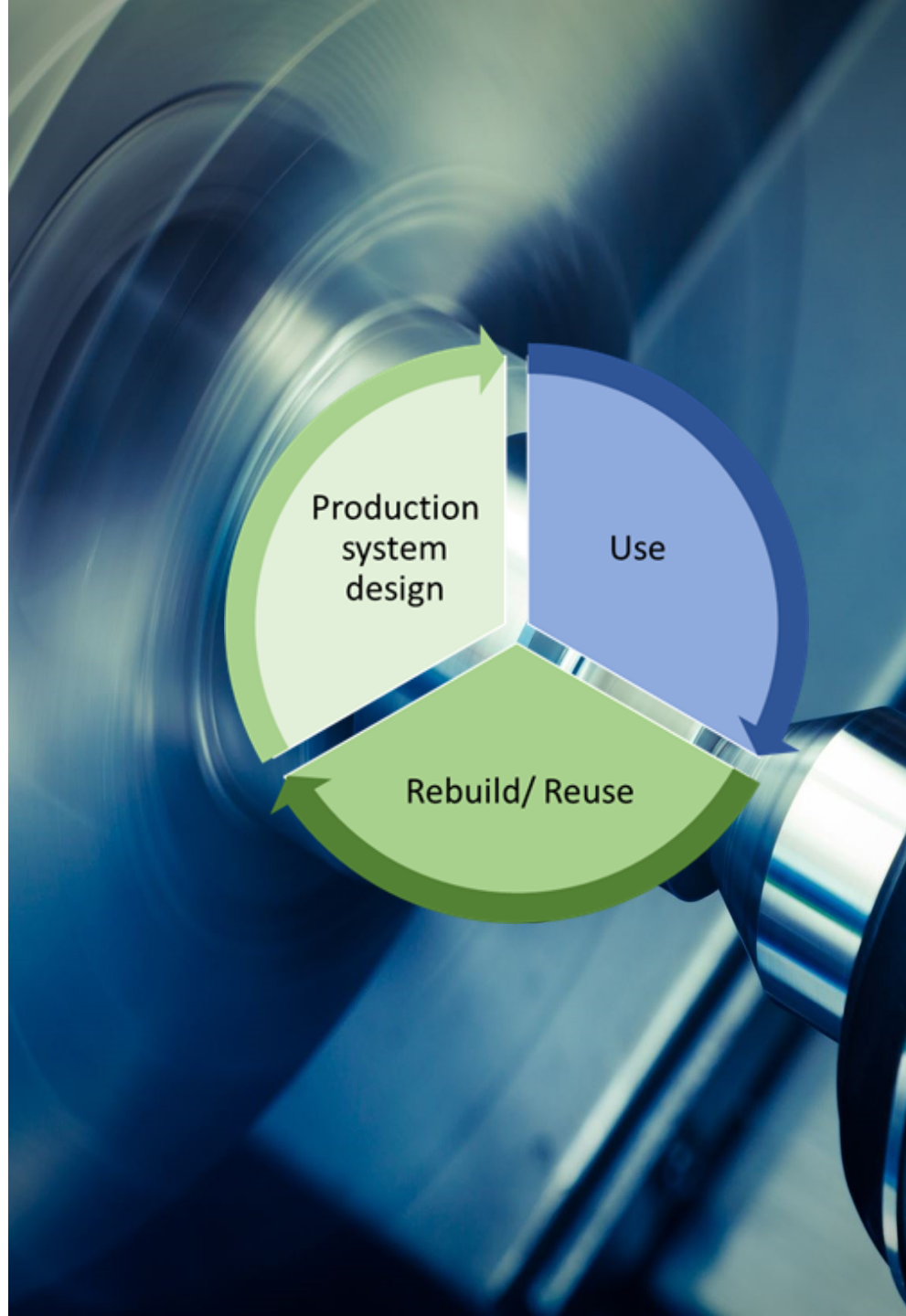
REFUSE

REFUSE

- ✓ 3 years with formal start 22-11-01
- ✓ Specify, justify, design and operate reconfigurable and circular machining systems
- ✓ 6 industrial partners + IDC West + 2 academic partners



REFUSE Purpose

The project aims to **enable resource-efficient use, maximize utilization and extend the lifetime of machining systems** by **developing and demonstrating systematic and virtual model-based methods** to be used in the Swedish automotive industry to jointly **specify, motivate, design and use reconfigurable and circular machining system** for generations of product models.

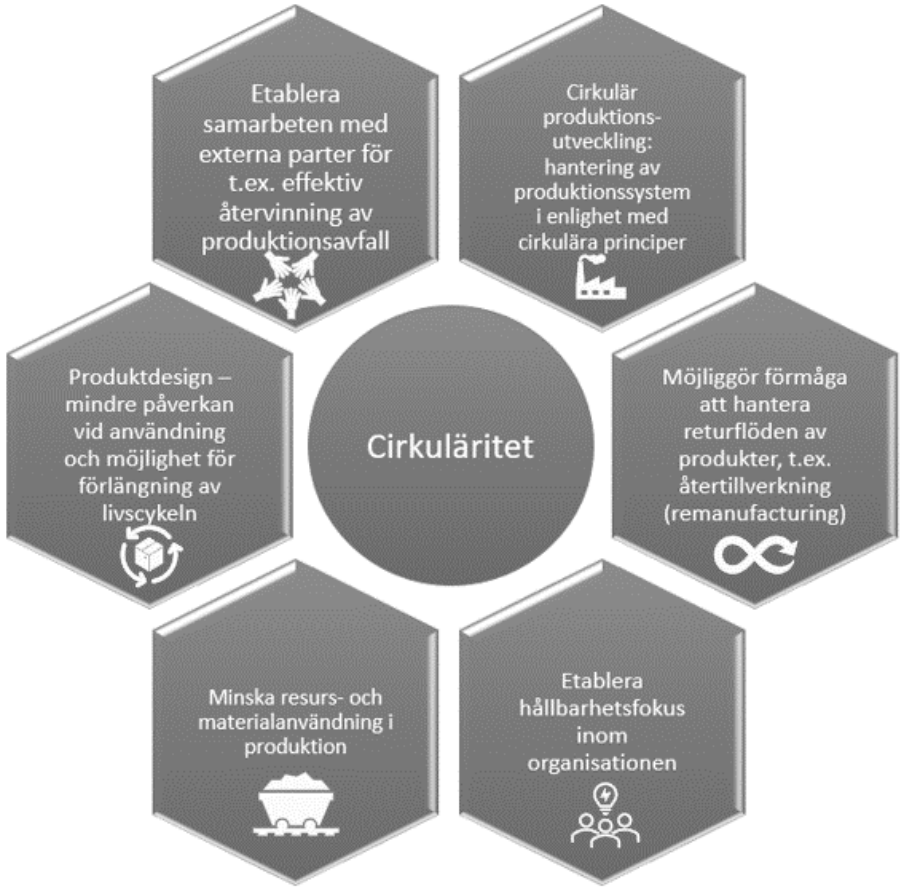
REFUSE

Circularity

...an economic system that replaces the ‘end-of-life’ concept with e.g. reducing, reusing, recycling and recovering materials in production/distribution and consumption processes.

..the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers.

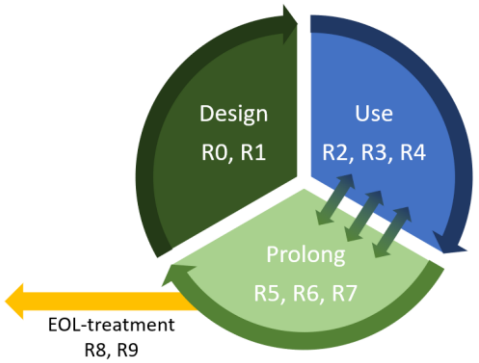
(Kirchherr et al. 2017)



REFUSE

Circular manufacturing

- In this project we regard the ***machining system*** as circular
- How to achieve a circular machining system, i.e., a system to be ***re-used*** **over generations of products**?
- ***Changeable and reconfigurable*** manufacturing principles as enablers to achieve circularity



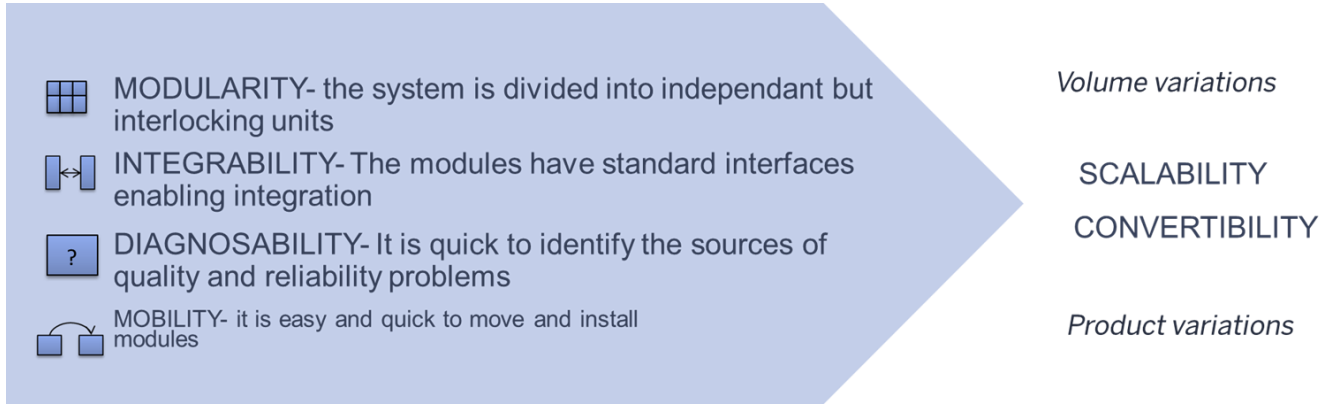
Design	R0 - Refuse	Make parts of the production system redundant by abandoning its function or by offering the same ability and function in a fundamentally different production system
	R1 - Rethink	Rethinking the ownership of production systems, e.g. leasing or co-purchasing production system
Use	R2 - Reduce	Efficient production of the products in the system, e.g. through minimizing natural resource and material usage
	R3 - Reuse	The production system is reused by the manufacturing company for new products with minimal change efforts
	R4 - Reconfigure	Reconfigure the production system by e.g. add/remove modules in order to cope with new product introductions or significant changes in demand
Prolong	R5 - Repair	Repair the production system to enable original abilities to properly function
	R6 - Rebuild	Rebuild parts of the production system through and reuse parts of the system in other systems or in the same system
	R7 – Redesign	Redesign the production system and strive towards keeping as much of the old system as possible
End-of-life treatment	R8 - Recycle	Process the production system to obtain materials which can be reused in other systems or products
	R9 - Recover	Incineration of the material in the production system for energy recovery

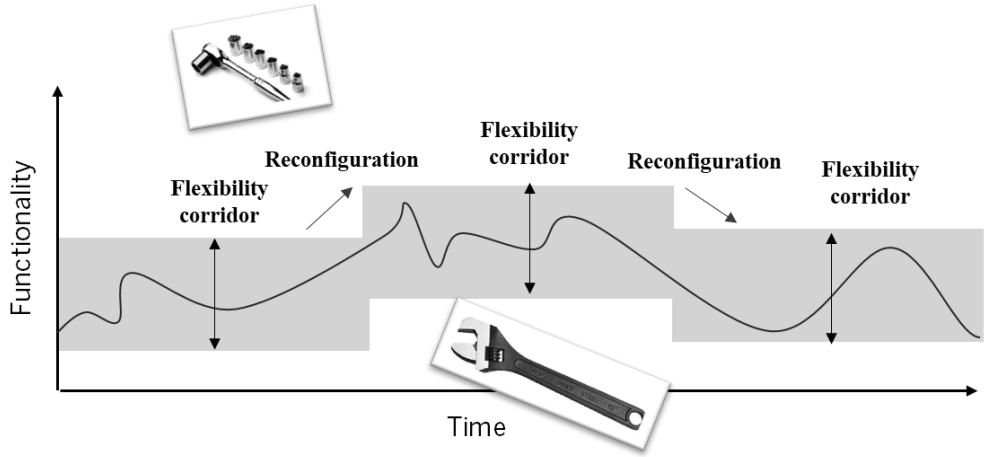
REFUSE

Reconfigurable manufacturing

Reconfigurable manufacturing systems are designed for rapid changes in structure, as well as in hardware and software components, in order to quickly adjust production capacity and functionality within a product family in response to sudden changes.

(Koren, 2010)





Project goals

Objective 1: Provide knowledge and a frame of reference for how reconfigurability and circularity can be incorporated and applied in the development, design and use of machining systems to extend life cycles and maximize resource efficiency for multiple product model generations.

Objective 2: Develop a method to analyze, measure and economically justify reconfigurability and circularity in machining systems.

Objective 3: Create methods to translate reconfigurability requirements into concepts and detailed solutions for circular machining systems.

Objective 4: Demonstrate development and use of circular machining systems using virtual models and provide best-practice.

Objective 5: Establish collaborative models to develop and use reconfigurable and circular machining systems between involved parties.

REFUSE

Aurobay

2023-04-05

OUR VISION

Re-imagining motion for a brighter tomorrow

“We develop and produce next-generation powertrain solutions for the automotive and beyond. All the while, pushing the environmental impact towards zero.”

Aurobay in the Geely Holding Group

Aurobay is a Tier 1 supplier to OEMs inside and outside the Geely ecosystem

GEELY

Passenger cars	Geely Auto group
	Volvo Car Group
	Aurobay
	Zeekr Intelligent Technology
	Lotus group
	smart Automobile
	LEVC

Lotus Cars

Lotus Technology

Aurobay in numbers

2,850

people across R&D, manufacturing and digital innovation

2021

founding year

776 000

hybrid engines and e-drive units in 2022

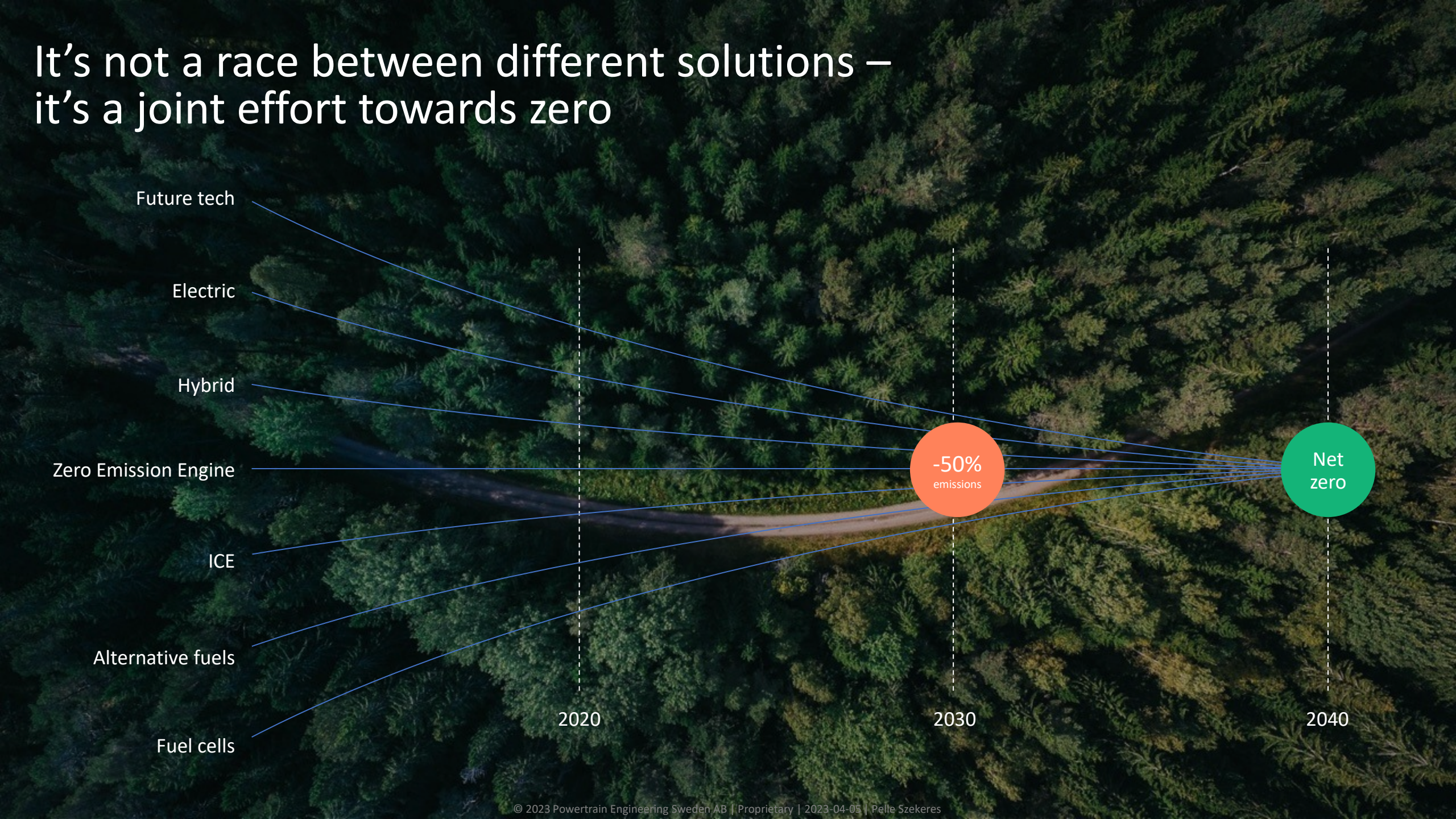
1.75

bn Euros turnover

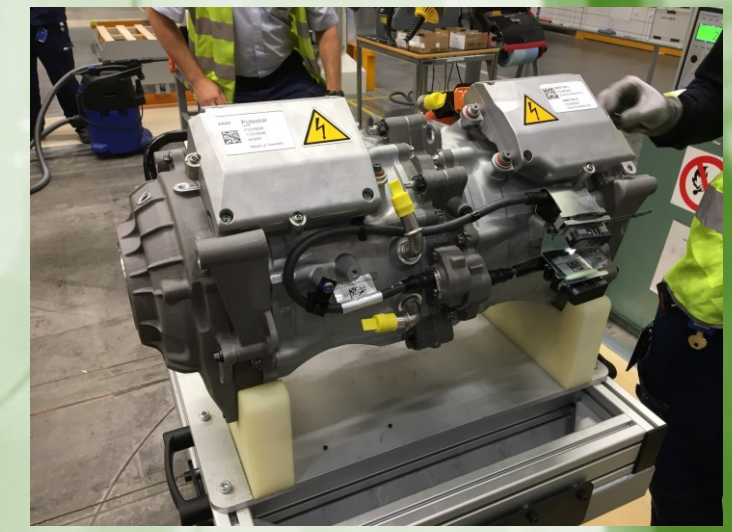
2

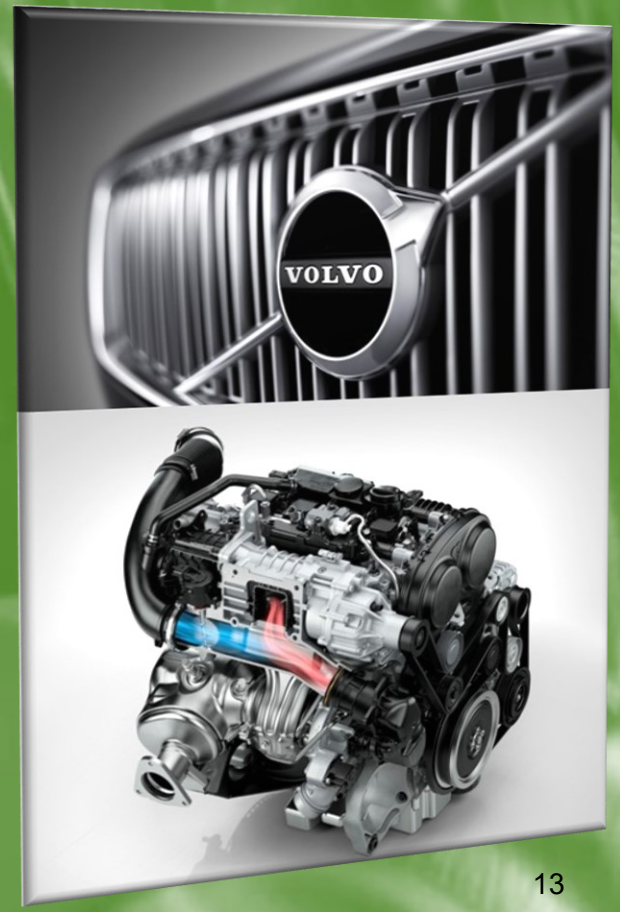
manufacturing sites, in Skövde, Sweden and Zhangjiakou, China

It’s not a race between different solutions – it’s a joint effort towards zero



Powertrain Engineering Sweden (ASDE) & Zhangjiakou (AZJK)



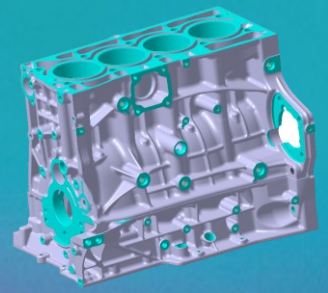


Today's components

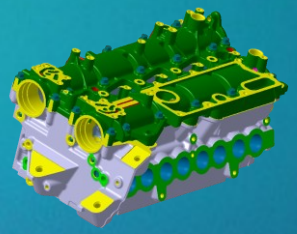
Current Machining portfolio includes both Prismatic- & Cylindrical- products in Aluminum, Grey Cast Iron & Steel

PRISMATIC

Cylinder Block

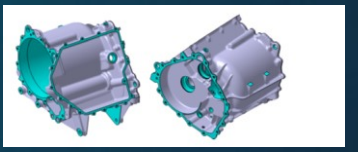


Cylinder Head



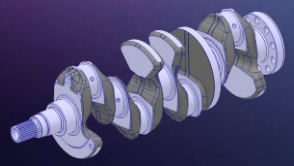
Mass Balancer Unit

E-machine & Transmission Housing



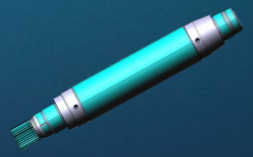
CYLINDRICAL

Crankshaft

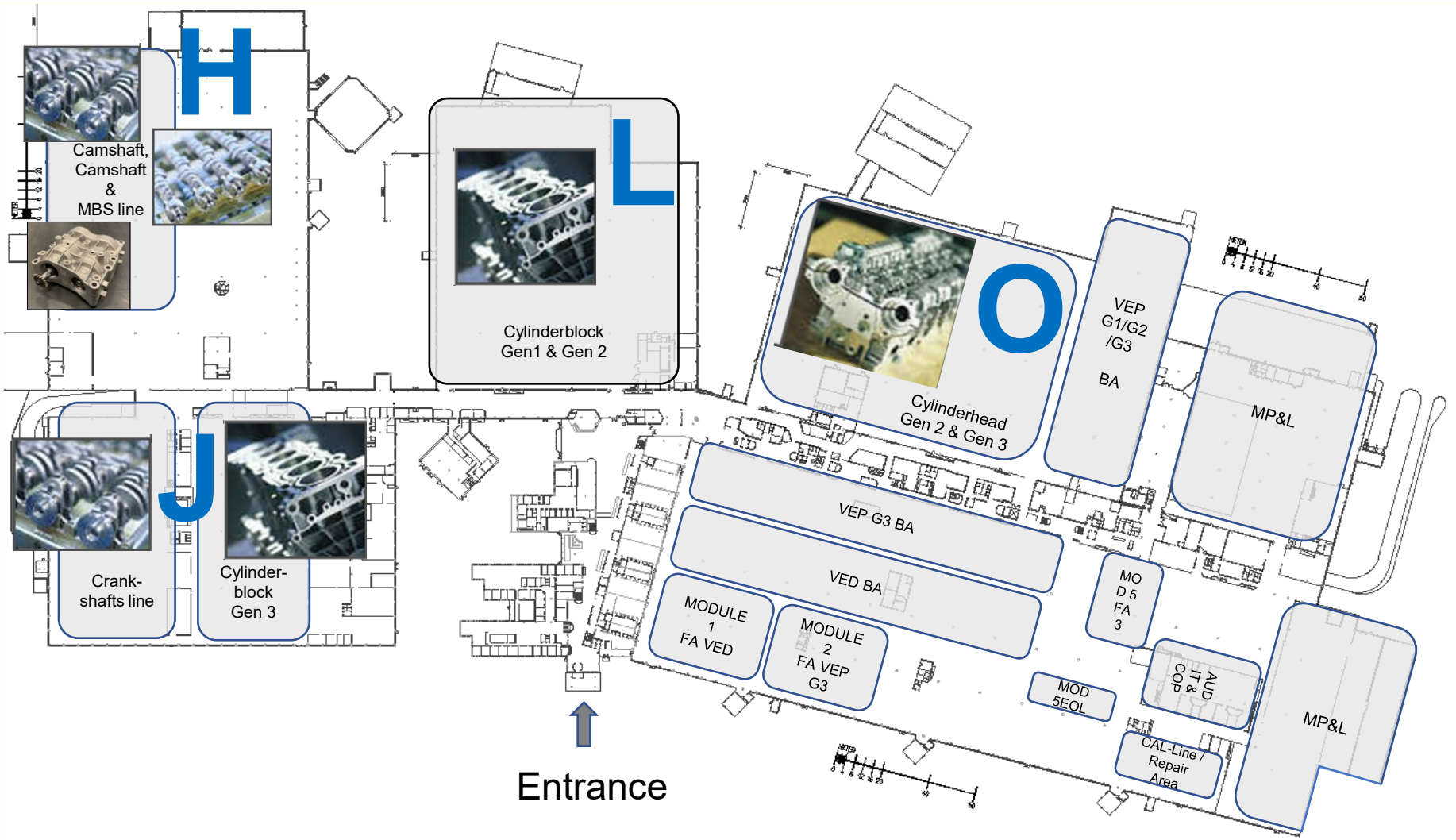


Camshaft

Rotorshaft



Aurobay Skövde Factory



					Mtrl fördelning				
>> Re-Used Equipment to E-machine @ ASDE	Antal	Vikt ton	Tot vikt to	Area m2	Stål	Alu	Koppar	CO2 i ton	CO2 i kg
11 x 2-spindle Machining Centres + Loading Equipment	11	28,2	310,2		279,18	15,51	15,51	**971,5**	
3 x Turning Machines	3	25	75		67,5	3,75	3,75	**234,9**	
2 x Grinding Machines	2	25	50		45	2,5	2,5	**156,6**	
1 x Flexible Robot Washer	1	33	33		29,7	1,65	1,65	**103,4**	
1 x Tunnel Washer	1	10	10		9	0,5	0,5	**31,3**	
Various Automation, Robots, Conveyors, etc.			15		13,5	0,75	0,75	**47,0**	
>> Cooling Filters	2	30	60		54	3	3	**187,9**	
>> Measuring Room and Equipment			25		22,5	1,25	1,25	**78,3**	
>> Pre-setting Room and Equipment			25		22,5	1,25	1,25	**78,3**	**1 889 222**
				Area m2					
>> Facilities and Area tot volym				140000					**40 740 000,0**
>> Facilities and Area 300k volym				50000					**14 550 000,0**

∑ Tot new	**46 407 667**
∑ 300k	**16 439 222**

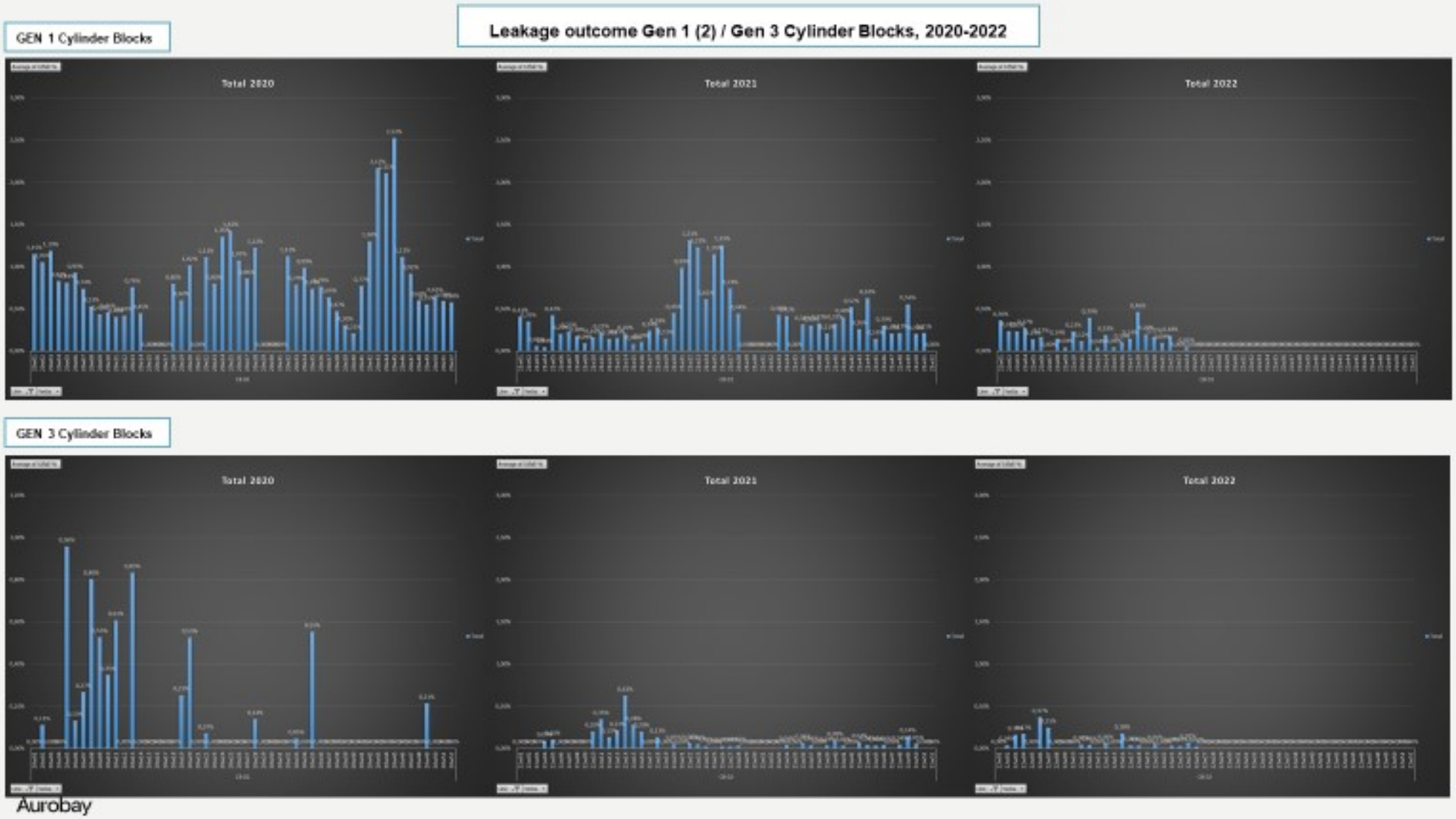
Available equipments

Machining areas	# Equipments
SCB01 -	96
SCB02/03 -	107
SCH01 -	42
SCH02 -	40
SCH03 -	44
SCH04 -	21
SCS01 -	66
MBS -	25
SCR02 -	47
SCR03 -	45
Plan 1 -	17
Sum:	**550** Equipments (not included tool grinding, tool calibration or measuring rooms)

Aurobay

2023-04-05

Casting improvements



Cylinder block

Standardised work and coaching for

- Final inspection,
- Frequent inspection,
- How to react/acting upon deviations,

- Basic skills Machining training

- Training Problem Solving, PPS

- Continous Improvement with suppliers – weekly follow up.

- Continous improvement and Cooperation ME and PD.

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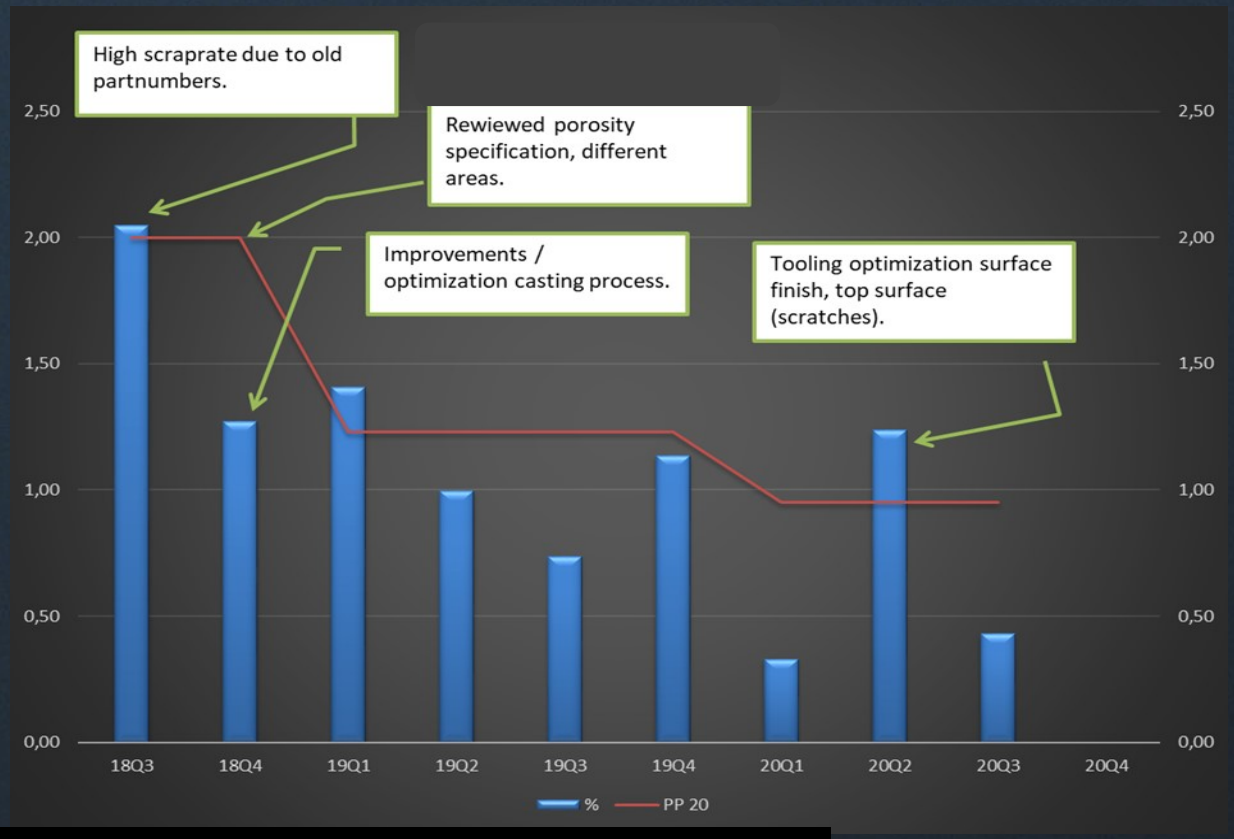
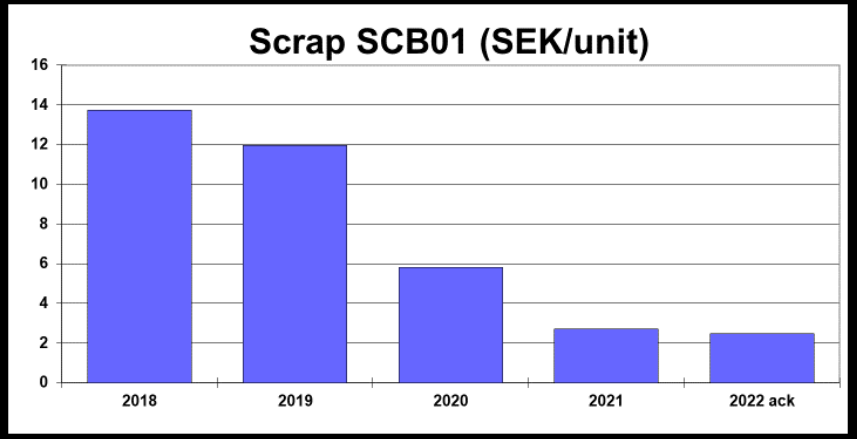
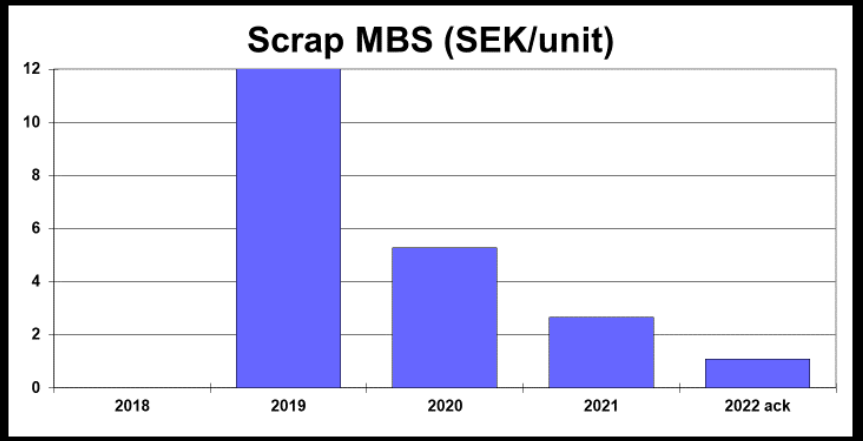


YE 2020

- LTCR - 50%
- Defects/unit - 50%
- Leadtime - 20%
- Total mfg cost - 30%
- Tied up capital - 20%





A footprint on two continents

Headquarters

Gothenburg, Sweden
R&D, Digital, Corporate functions

Skövde plant

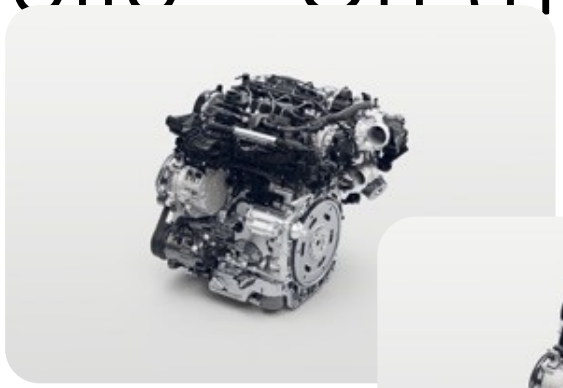
Sweden
Manufacturing Engineering, Assembly, Production
VEP4, VED4, (Rotor)

Zhangjiakou plant

China
Manufacturing Engineering, Assembly, Production
VEP4, GEP3, MEP1, MEP2, Geely CH/CB/CS

Aurobay Product Portfolio – On the market

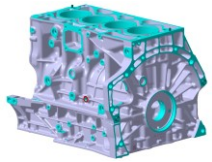
- **Combustion Engines, ~550 000 units/year**
- 3 cyl, 1.5 l, petrol (95 kW), 12 V + 400 V PHEV
- 4 cyl 2.0 l, petrol LP (145 kW), 48 V BISG
- 4 cyl 2.0 l, petrol MP (184 kW), 48 V BISG
- 4 cyl 2.0 l, petrol HP (220 kW), 48 V BISG + 400 V PHEV
- 4 cyl 2.0 l, diesel HP (173 kW), 48 V BISG
- **Electric Drive Units, ~225 000 units/year**
- PMSM, coaxial design, 150 kW
- PMSM, coaxial design, 180 kW

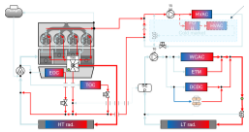


Aurobay R&D

Design

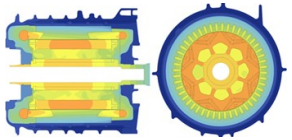
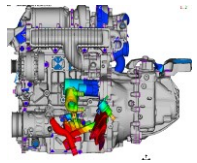
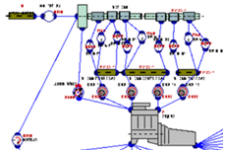
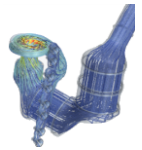
Structure, Dynamic, Cooling, Lubrication, Gas Exchange, EATS, FIE and more.





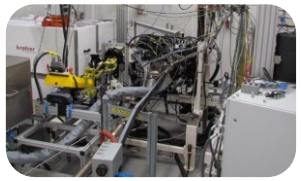
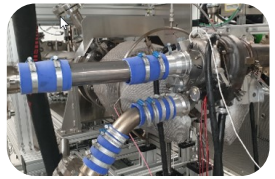
CAE

FEA, Dynamic, CFD, Cooling, Electromagnetics, NVH and more

Testing

Dynamic, Controls, Cooling, Gas exchange, NVH, Vibration, Corrosion, DV/PV testing and more


Control and Diagnostics

Engine Control & Diagnostics, Vehicle Control & Diagnostics, Transmission Control & Diagnostics, E-Machine Control & Diagnostics, Data analyses of Field data and more

Since long, we have a well-trained development machine together with Volvo Cars for highly complex systems

We plan for and work with high commitment to meet tight demands, and we very seldom miss them

We have in our DNA to resolve problems to safeguard launches and high-volume production – every day