Resource efficiency in infrastructure structures

Plenary Session 2

"Which KPIs for more growth and more value creation with less materials?"

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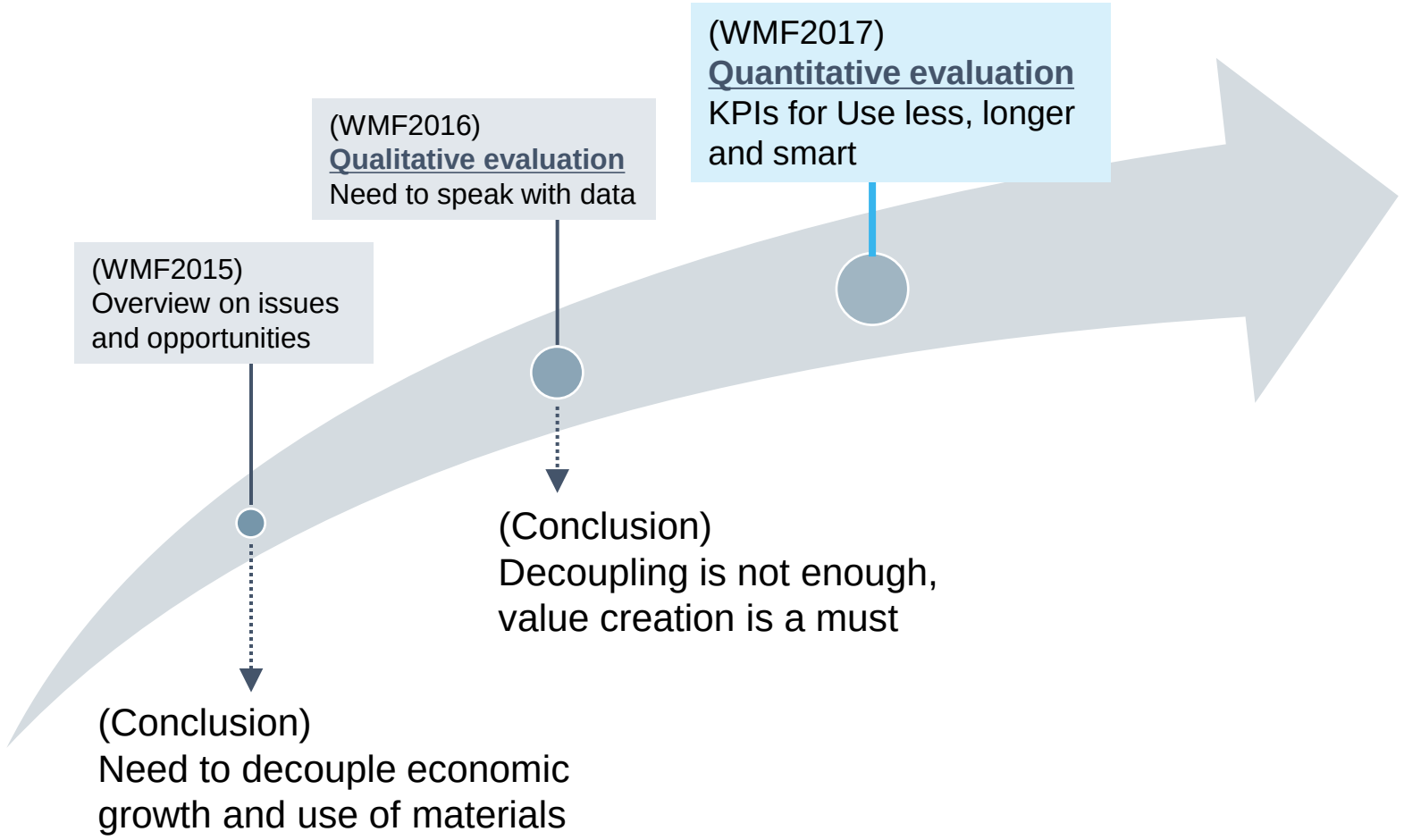
MITSUBISHI HEAVY INDUSTRIES, LTD.

Background

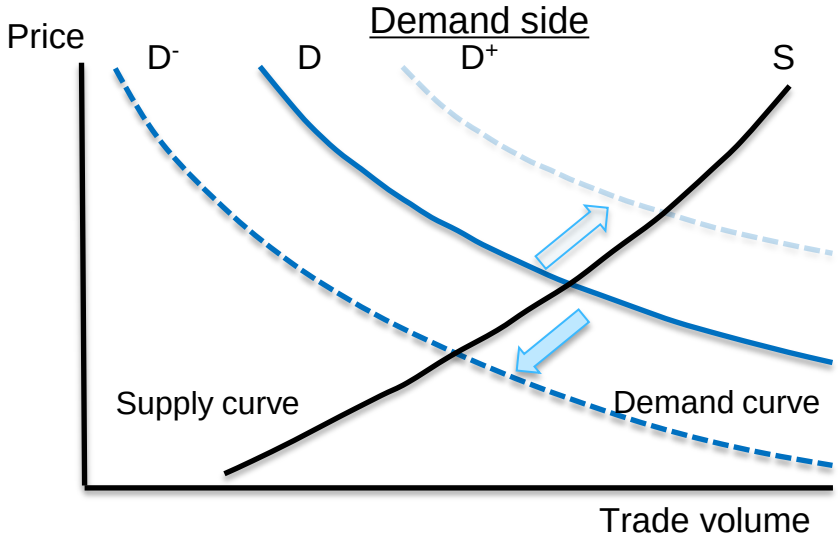
- MHI have partnered with WMF since the beginning.
- We have discussed on various topics since 2015. This time, we would like to discuss on ″Which KPIs for more growth and more value creation with less materials?″.

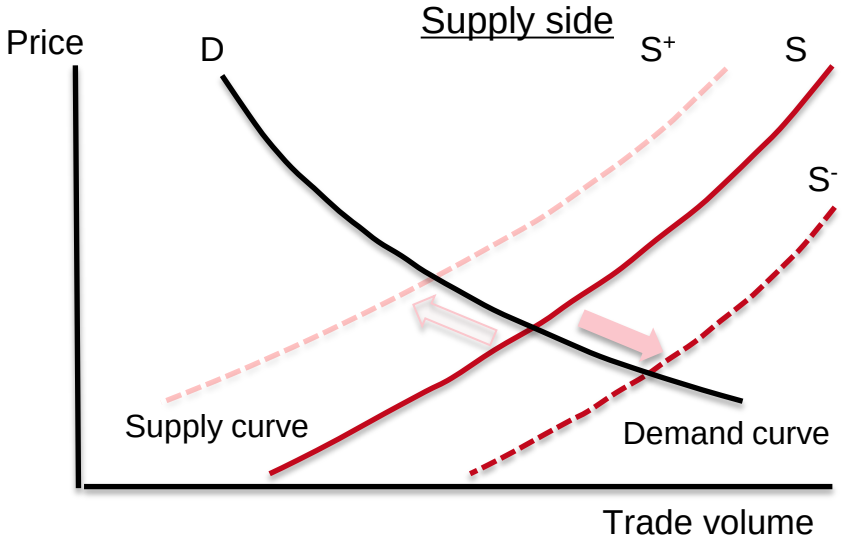


Factors affecting the prices of mineral resources (WMF2015)

The following supply/demand curves are prepared for the better understanding of the correlation of the various factorslusables with rather a simple and bold assumption.

【Inevitable】As the world economy develops, demand for mineral resources increase, thus the prices of mineral.
【Possible】Need innovation to control price rise by supply increase and usage reduction.





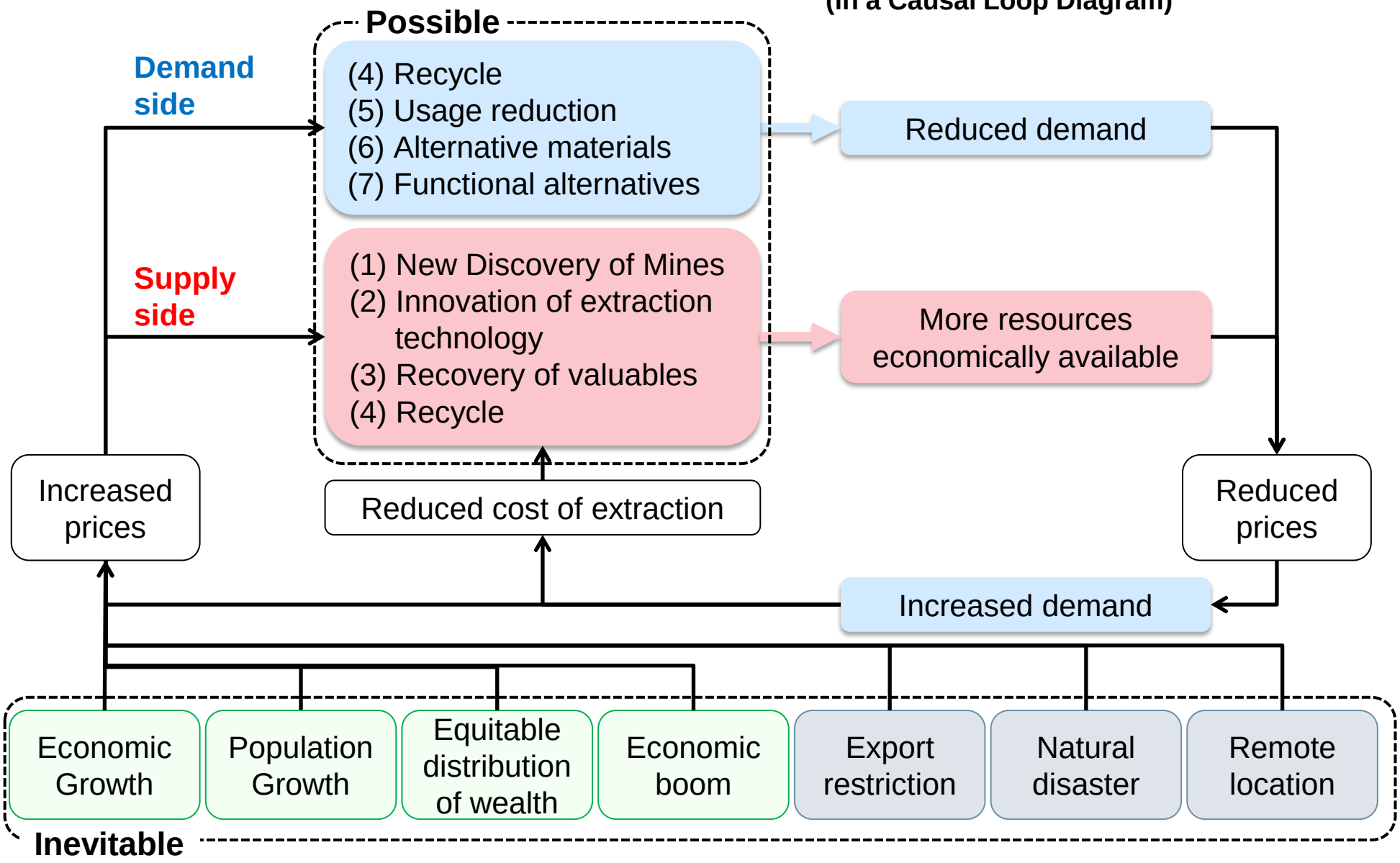
	Demand	Supply
Increasing	・Economic growth(Affluent society) ・Population growth ・Equitable distribution of wealth ・Economic boom	(1) New discovery of mines (2) Innovation of extraction technology (3) Recovery of valuables (4) Recycle
Decreasing	(4) Recycle (5) Usage reduction (6) Alternative materials (7) Functional alternatives	・Export restriction ・Natural disaster ・Remote location

Supply curve：Curve showing relationship between price and supply, the higher the price the higher the quantity supplied, and vice versa.
Demand curve： Curve showing relationship between price and demand, the lower the price the higher the quantity demanded, and vice versa.

Source: MHI presentation in WMF2015

Correlation between/among various factors (WMF2015)

(in a Causal Loop Diagram)



Source: MHI presentation in WMF2015

Meaningful KPIs for major products categories (WMF2016)

Life Cycle Stage	Principles (appropriate KPIs for each)	Digital Content Effectiveness	Major Products Category(Illustrative)				
		Effective through stages	EEE*1 	Vehicle 	Aircraft 	Power Plant 	Bridge 
Design	Material Choice	○	○	○	○	○	
	Modular				○	○	
	Use Less			○	○		
Procurement	More Recycle	○		○			
Production	Use Less	○	○				
	Less Waste	○	○		○	○	
Logistics	Use Less	○	○	○			
	Packaging		○				
Installation	Use Less					○	○
Use	Use Longer	○			○	○	○
	Repair			○	○	○	○
	Upgrade				○	○	
	Reuse	○		○	○		
	Use Less	○	○	○	○	○	
	Sharing	○		○			
End of Life	Less Waste	○	○	○			○
	More Recycle	○	○	○	○	○	○
KPI for Key Value Offering			CPU Power	PK*2	RPK*3	Electricity	Traffic

Effective on various products

Intermediate

Procurement Through Logistic dominant

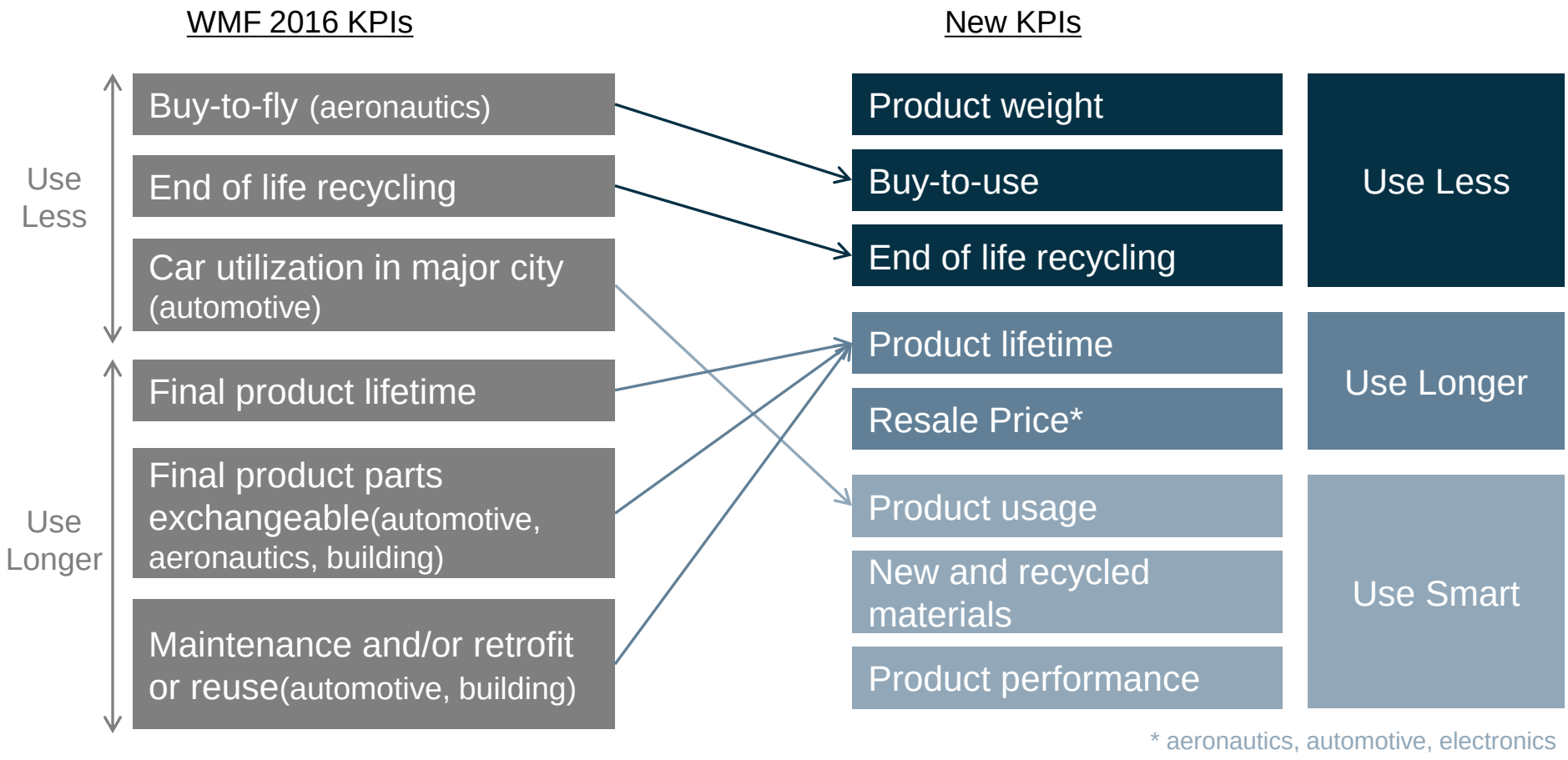
Use stage dominant

*1 : Electric and Electrical Equipment, *2 : Passenger Kilometer, *3 : Revenue Passenger Kilometer

Source: MHI presentation in WMF2016

Current list of 8 KPIs

The scope of KPIs:
decoupling materials efficiency from economic growth while creating value for all stakeholders involved.



Source: WMF & Arthur D. Little analysis

1. Introduction of MHI Group business

- The MHI Group conducts business in various social infrastructure fields such as power generation, transportation and environmental equipment.

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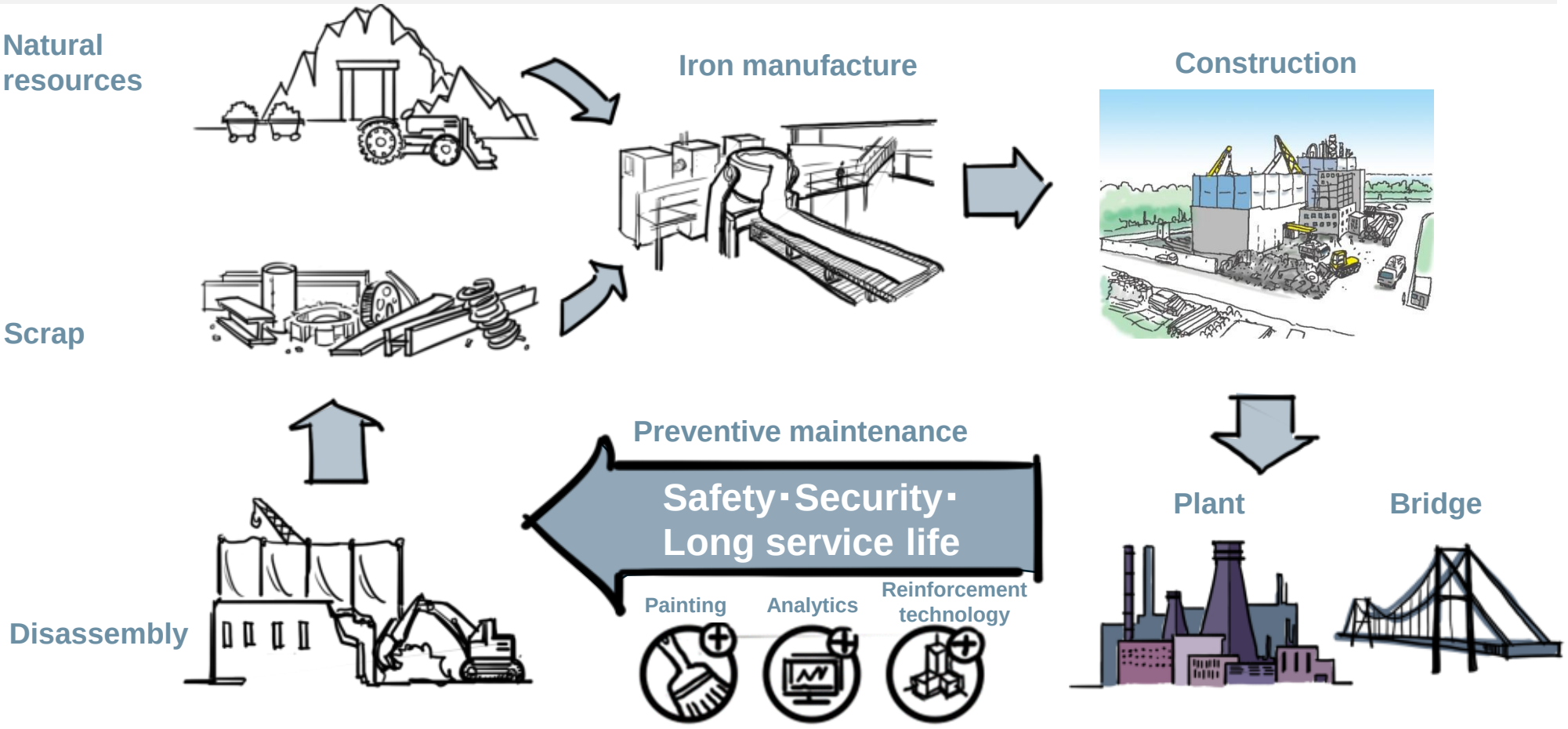
Infrastructure	Power generation	Transportation
Use Longer	Use Smart	Use Less
Environmental resistance	Improve efficiency	Lightweight

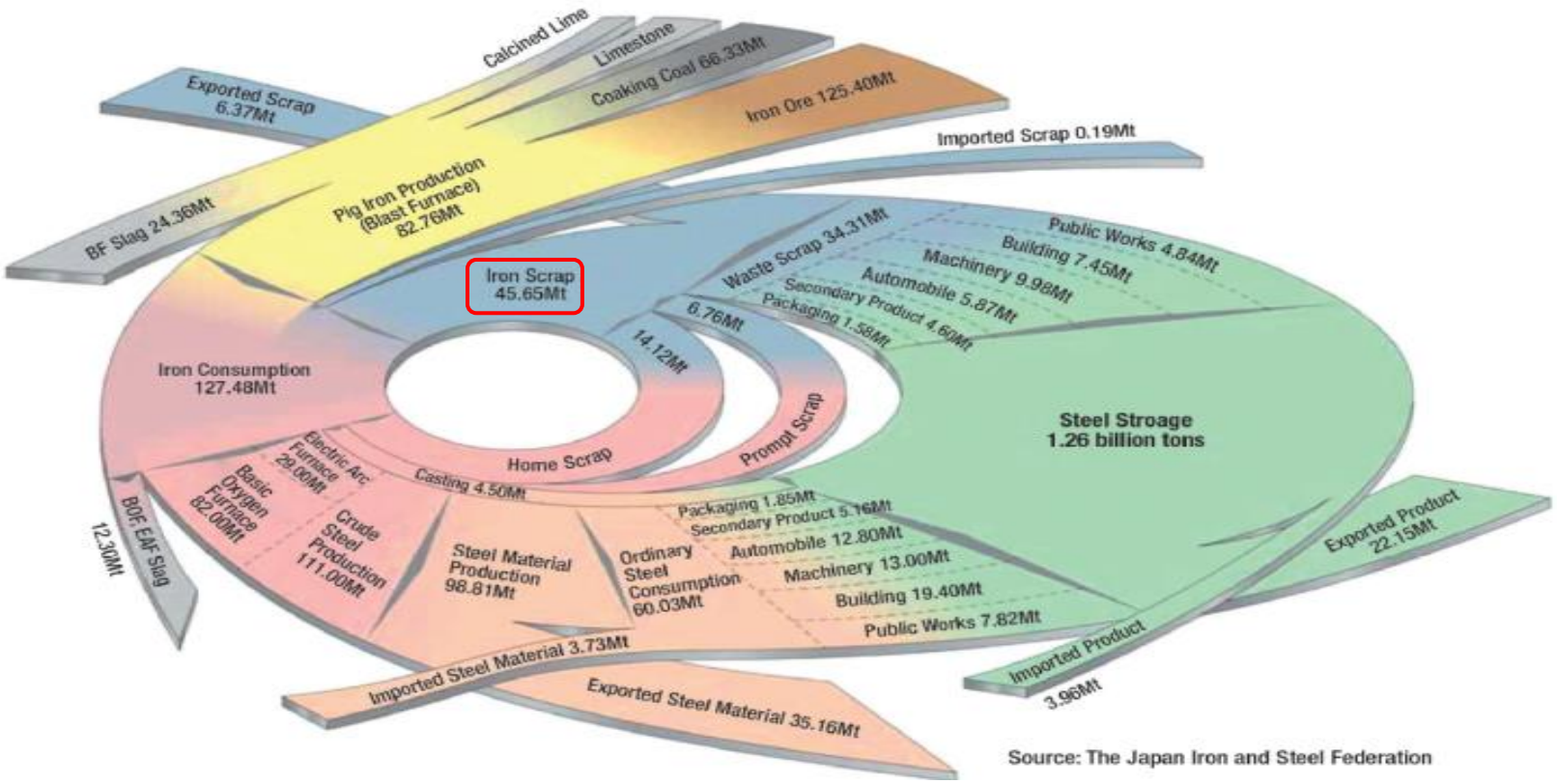
2. Resource efficiency of infrastructure structure

- We emphasize using infrastructure products while maintaining safety and performance for a long period of time.
- Iron and steel resources used for infrastructure products are already part of the “Use Less” recycling concept.



3. Steel Cycle of JAPAN

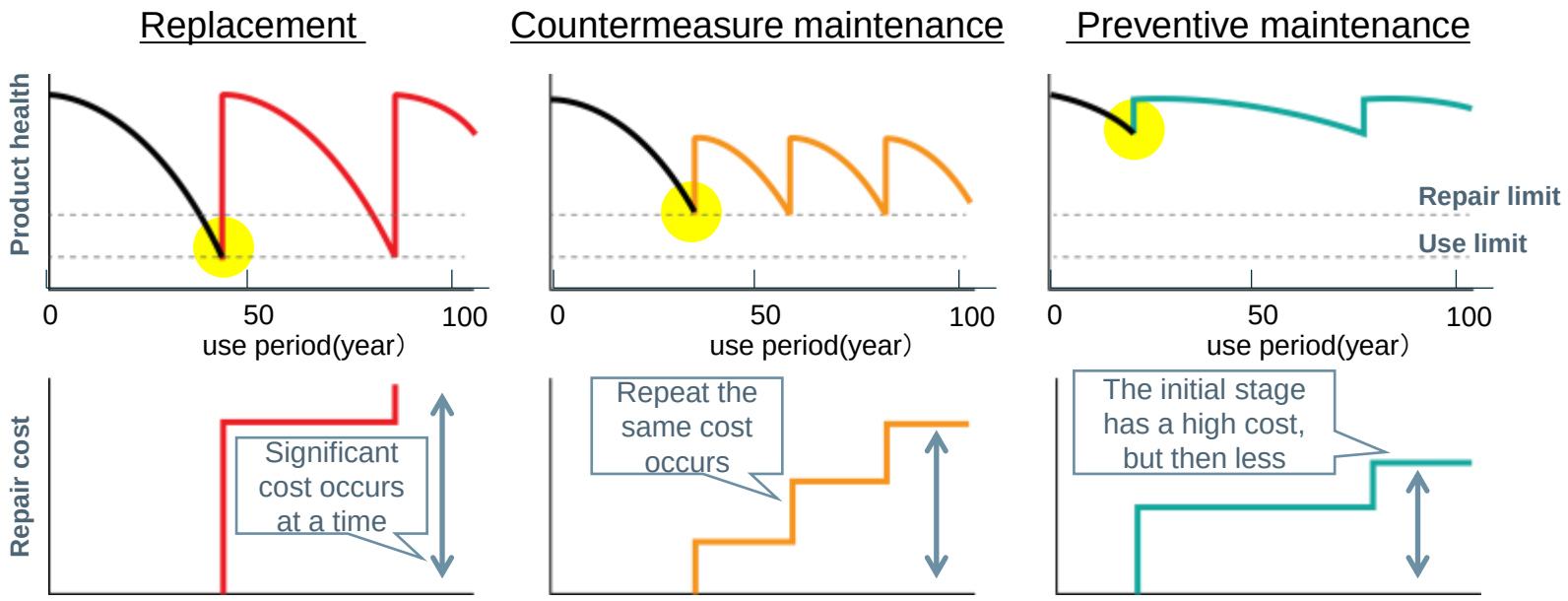
- Iron and steel materials are in closed loop recycling. They are collected as scraps after completed product life and will be used again as raw materials for the next project.
- To have a social system that enables implementation of closed loop recycling is very important.



Source: The Japan Iron and Steel Federation

4. Maintenance for longer life with repair efficiency enhancement

- Periodic inspection and repair are essential to ensure safety and extend product life.
- Here are 3 maintenance scenarios of a bridge. You can see that Preventive Maintenance can minimize the degree of damage and help reduce replacement cost and natural resource usage.



Damage degree until repair	**Up to use limit**	**Up to repair limit**	**slight damage**
Cost	**Highly expensive**	**Expensive**	**Affordable** in the long run

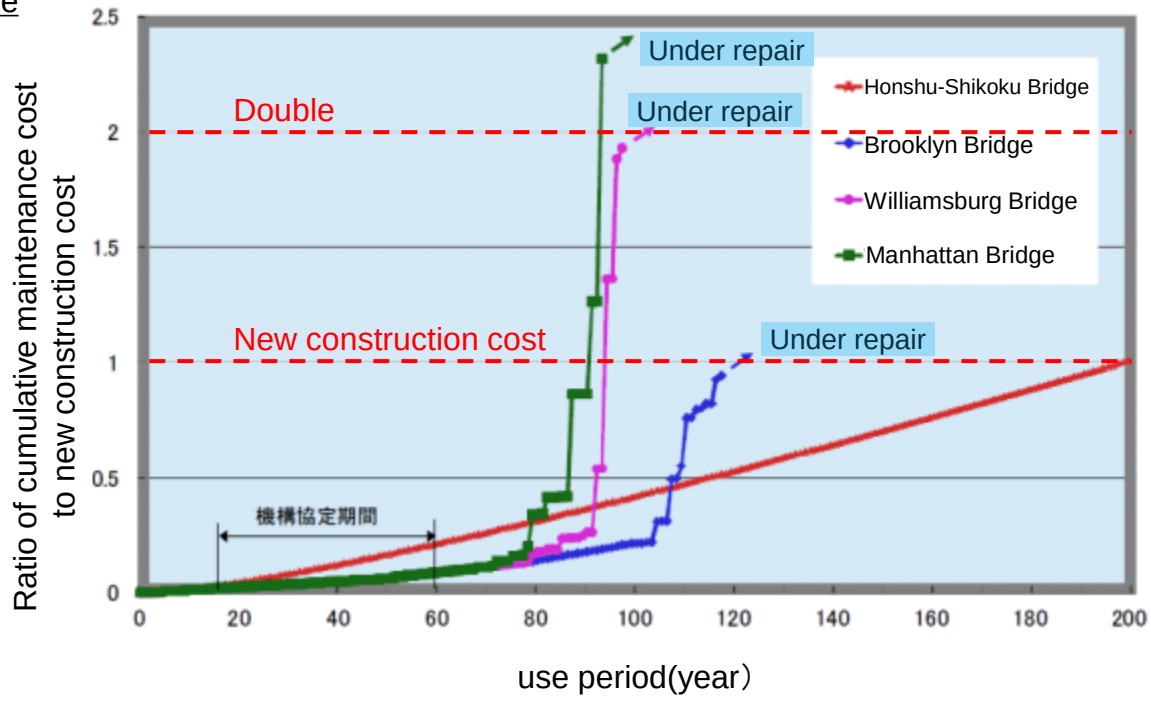
Source: Japan Civil Engineering Consultants Association

5. Expanding A Bridge's lifetime for over 200 years

- Honshu-Shikoku Bridge in Japan is aimed to realize efficient use for more than 200 years of service by introducing asset management with preventive maintenance program.
- For old bridges without proper maintenance and management, the total maintenance cost doubles the cost for new construction.

Honshu-Shikoku Bridge, the world's largest suspension bridge

Total maintenance cost of bridges in US(actual) and Honshu-Shikoku Bridge(plan)



Source: Honshu-Shikoku Bridge Expressway Company`s website

6. MHI Group's World Cultural Heritage

- The MHI Giant cantilever crane in Nagasaki was completed in 1909 and continued to be used for more than 100 years by regular inspection and maintenance. It was registered as World Heritage Site in 2015.

MHI's Nagasaki shipyard

World Heritage: Giant cantilever crane

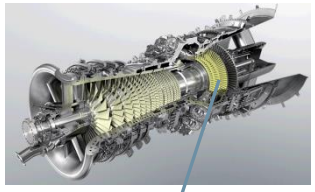
Source: World heritage of Kyushu, Giant cantilever crane in the MHI's Nagasaki Shipyard

7. Resource efficiency of power generation field(1/2)

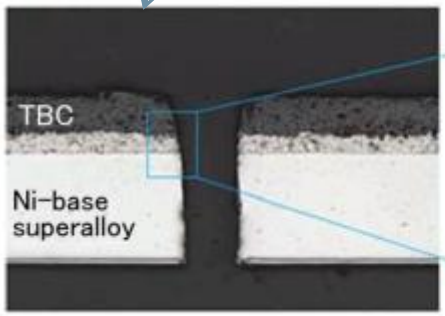
- The MHI Group continues to develop new materials such as advanced TBC*.
- Innovative TBC technologies highly contribute to increase a product lifetime.

*Thermal Barrier Coating

KPIs: New and recycled materials



Turbine blade

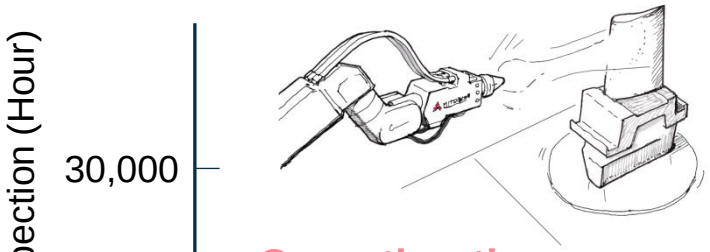


Whole image

Development of new materials (innovative TBC)

Enlarged image

KPIs: Product lifetime

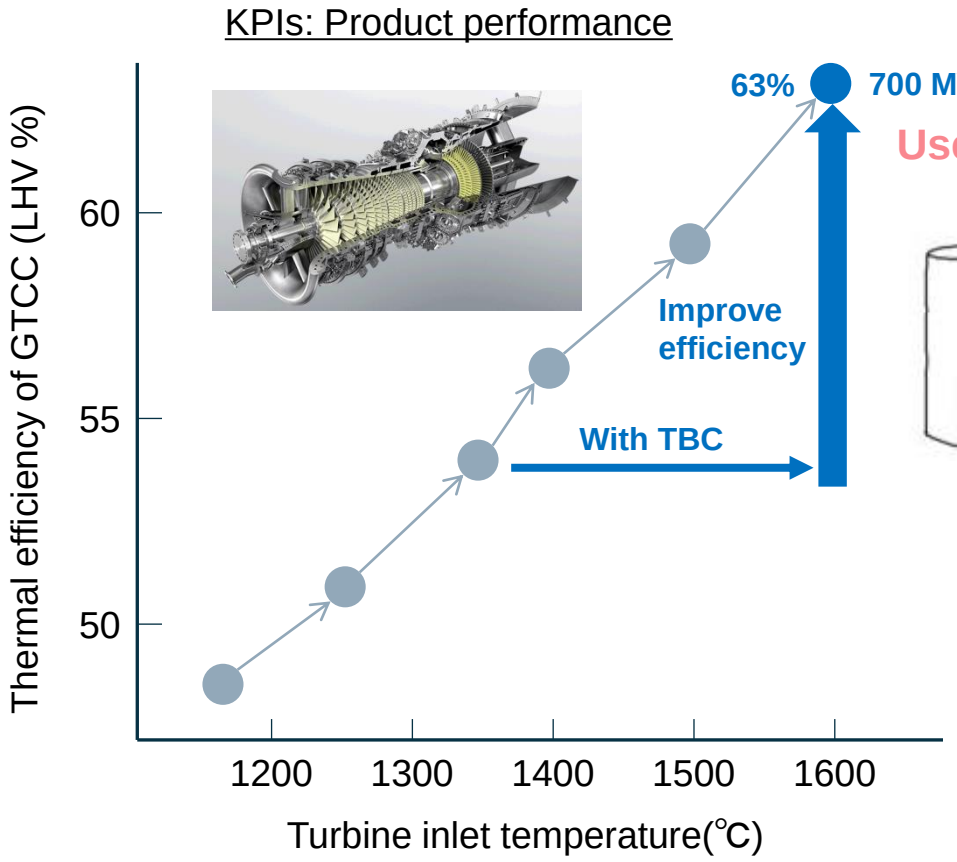


Source: Mitsubishi Heavy Industries Technical Review Vol. 52 No. 4 (December 2015)

7. Resource efficiency of power generation field(2/2)

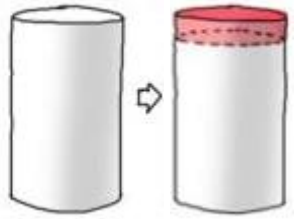
- TBC helps improve gas turbine efficiency by increasing combustion temperature.
- Therefore, innovative TBC technologies also help reduce fuel consumption.
- Once the efficiency of power plants is increased, the use of resources will also be reduced significantly.

KPIs: Product performance

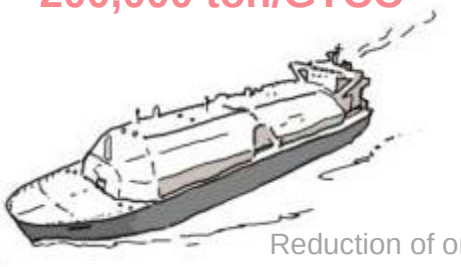


Use less fuel per year

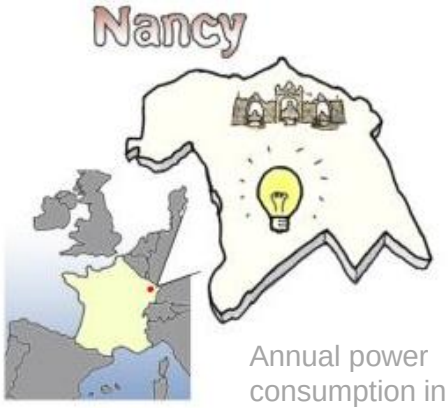
-14%



Less CO2 emissions
200,000 ton/GTCC



Reduction of one ship
(About 76,000ton)

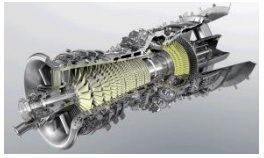


Annual power consumption in Nancy

Source: Mitsubishi Hitachi Power Systems' website

8. Conclusion

- What is important for resource efficiency of infrastructure products is to maintain product performance safely for a long period of time and to improve efficiency.

		Power generation Improve efficiency	Infrastructure Environmental resistance	Transportation Lightweight
				
Use Less	Product weight			✓
	Buy-to-use		✓	
	End of life recycling		✓	
Use Longer	Product lifetime	✓ One operation time +50%	✓	✓
	Resale price			
Use Smart	Product usage	✓ Availability 99.5%		
	New and recycled materials	✓ innovative TBC	✓	
	Product performance	✓ Use less fuel -14%	✓	✓

Survey theme

- We will introduce our efforts on the transport sector, which is one of the most important factors in resource circulation.

	Presenter	Company	Overview
1	(MD) Vincent BAMBERGER	Arthur D Little	Overall presentation describing how the 8 KPIs were selected + Real survey on all cars/ all brands sold on the French market between 2003 and 2013
2	(Senior VP) Nicole LECCA	Airbus	Real survey on all A320 sold over the past 25 years
3	(CEO) Johan MENCKEL	Granges	Real survey on Brazed Aluminium alloys used for car heat exchangers
4	(CEO) Jean-Pierre CLAMADIEU	Solvay	2 real surveys on Silica for tires and on Composites for aircraft engine blades

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