

WMF 2018 - SUMMARY OF FINDINGS

27-29 JUNE 2018 - NANCY, FRANCE



The Future of Materials : Use Smarter, Less and Longer.

Philippe Varin, Chairman World Materials Forum
Victoire de Margerie, Vice Chairman World Materials Forum

► Opening debate on Plastic Recycling

- Jean-Louis Chaussade, CEO Suez (France) - Co Chair
- Jean Hornain, CEO CITEO (France) - Co Chair
- Brune Poirson, Secretary of State attached to the Minister of State, Minister of Ecological and Solidary Transition
- Joao Sousa, Marine Project Manager, IUCN (Switzerland)
- Karma Yonten, CEO Greener Way (Bhutan)
- Sander Defruyt, Lead New Plastics Economy, Ellen MacArthur Foundation (UK)

► Which KPIs for Using Materials Smarter, Less and Longer ?

- Shunichi Miyanaga, CEO Mitsubishi Heavy Industries (Japan) - Co Chair
- Gilles Michel, CEO Imerys (France) - Co Chair
- Marco Giovannini, CEO Guala Closures (Italy)
- Vincent Bamberger, MD Arthur D Little (France)
- Carla Gohin, Senior VP Innovation PSA (France)
- Carlos de Los Llanos, Scientific Director Citeo (France)

► 3D as an Industrial Process?

- Thierry Le Hénaff, CEO Arkema (France) - Co Chair
- Nick Stanage, CEO Hexcel (USA) - Co Chair
- Nicole Lecca, SVP Purchasing Airbus (France/Germany)
- Scott Crump, Chairman Stratasys (USA)
- Dr Adrian Keppler, CEO EOS (Germany)
- Dr Joe DeSimone, Founder & CEO Carbon 3D (USA)

► Reduce materials intensity for building industry ?

- Pierre André de Chalendar, CEO Saint-Gobain (France) - Co Chair
- Egil Hogna, CEO Hydro Extruded Solutions (Norway) - Co Chair
- Francisco Ruiz, CEO Keey Aerogel (Switzerland)
- Enrico Borgarello, Director Global Product Innovation, HeidelbergCement (Germany)
- Mark Sarkisian, Partner Seismic & Structural Engineering, Skidmore, Owings & Merrill LLP (USA)

► Future trends on critical materials

- Robert Friedland, Chairman Ivanhoe (Canada/Singapore) - Co Chair
- Patrick Koller, CEO Faurecia (France) - Co Chair
- Peter Carlsson, Founder & CEO Northvolt (Sweden)
- Pierre Toulhoat, COO BRGM (France)
- David Trafford, CEO CRU Consulting (UK)
- Franck Bekaert, Senior Partner McKinsey (Belgium)

► Societal Keynote Speech

- Jacques Attali, Chairman Positive Planet (France)

► Big Data/AI for Materials Efficiency

- Andy Reynolds Smith, CEO Smiths Group (UK) - Co Chair
- Greg Mulholland, CEO Citrine Informatics (USA) - Co Chair
- Prof. Reinhold Dauskardt, Stanford University (USA)
- Klaus Richter, Chief Procurement Officer, Airbus Group (France/Germany)
- Dr Heike Riel, Director IoT Technology & Solutions IBM Research (USA)
- Viet Le Hong, CTO FPT Software (Vietnam)
- Jean Sentenac, CEO Axens (France)

► Scientific Keynote Speech

- Prof. Eric Fullerton, UC San Diego (USA)

► E Wastes as a new Resource?

- Jean-Pierre Clamadieu, CEO Solvay (Belgium) - Co Chair
- Brett Olsher, Chairman Global Natural Resources Goldman Sachs International (UK)
- Moyo Kamgaing, Group Head Investment Bank EcoBank (Nigeria)
- Holy Ranaivozanany, Head of Corporate Social Responsibility Huawei (China)
- Prof. Nicola Marzari, EPFL (Switzerland)

► Political Keynote Speech

- Daniel Calleja-Crespo, Director General DG Environment (EEC)

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27 June / 7.00 pm – Opening Debate on Plastic Recycling – Moderator: Philippe Bideau

Plastics are offering great advantages to **our society and economy**: they are lightweight, versatile, convenient, and cheap. This is why production and use of plastic are fast expanding: Plastic production has surged from 15 million tons in 1964 to 311 million tons in 2014 and is expected to double again over the next 20 years.

However, plastics also **harm our environment**: Yet only 14% of all plastic packaging globally is collected for recycling and about 80% of marine waste is plastic waste. Each year, 8 to 12 million tons are dumped into the oceans. “More plastic than fish in the sea by 2050” to quote Ellen Mc Arthur. And the recently announced ban on imports from China on all plastic waste increases the pressure on Europe to adapt tremendously.

Even though **the impact on environment could in fact be quite positive** Each ton of plastic that we recycle equates to 5 barrels of saved oil while, at the same time, reducing CO2 emission by 1.6 tons

But Plastic recycling is profitable only when oil price is above 50 \$ and can be impacted by unilateral decisions. The recently announced ban on imports from China on all plastic waste, for example, has already had a major impact on recycled plastics prices and offtakes (i.e. LDPE films were down by 150€/t). **So, it's our joint responsibility** to take a long-term and holistic approach covering a broad range of different aspects, such as: raising public awareness, improving regulatory framework, creating fiscal incentives to support demand for recycled plastic, promoting infrastructure for collecting and sorting waste, mitigating negative transformation effects in interim phase (like job losses in plastic-driven sectors), transforming business models, fostering eco-design (taking into account higher quality, reduction, and reusability of plastic even before building the product). So everybody agreed that coordinated action between stakeholders is but different views were expressed in terms of modalities: rewarding or not waste collection, ban or positive action etc...



28 June / 9.00 am – Opening Speech – Philippe Varin

Genesis of World Materials Forum: By 2030, global middle class will have grown to 1.5 billion people. That's great news. However, it raises the challenge of **decoupling economic growth from materials consumption while creating value for our industries.**

Key questions that WMF aims to answer: Do we envisage a **shortage of certain materials** (driven by **technical, economical and societal disruptions**)? How can we **measure the effectiveness & efficiency of how we process materials** (KPIs)? What are the **solutions for using materials smarter, less and longer?**

28 June / 9.15 am – Future trends on critical materials – Moderator Victoire de Margerie

Uncertainty of Demand is huge for two core industry segments: Automotive Body and Power Trains + Energy Generation and Storage.

The **drive towards automotive electrification is clear but not its pace** and the evolution of the mix of power train solutions (Combustion vs diesel vs EVs vs fuel cells vs hybrid) and of car body materials (Aluminium vs steel vs composites) -

The **cost of renewable energy is decreasing constantly but** we need to find **better solutions for storing and transporting energy.** Lithium based batteries are the most common solution referred to Vanadium could also be a viable alternative for large-scale storage solutions. In particular, due to its durability, vanadium offers new financing models like leasing. But it is **still hard to predict the respective use of Lithium and Vanadium for energy storage.**

This uncertainty of demand does not drive a change of criticality for “usual suspects” that will remain high in criticality whatever the mix in power trains and energy: **Cobalt and 3 Rare Earth (Dysprosium, Neodymium & Praseodymium) are “Red” and Nickel as well as some other RE are “Red/Orange”.** **Recycling** of these materials will be **key to support the growth of electrification of cars.**

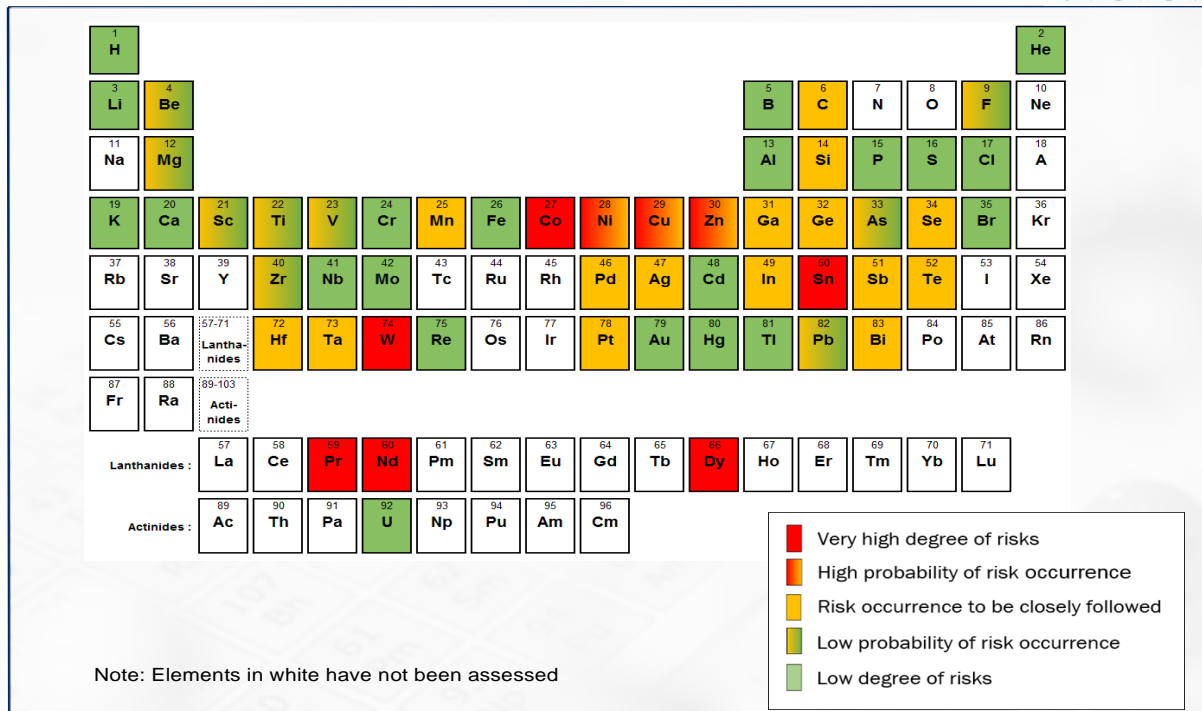
Large investments will be required for new Electric Vehicles (all categories). Estimates are: \$9bn and \$5.6bn per 1 million vehicles produced per year for bill of **materials**, \$2bn and \$5bn for **infrastructure** per additional 1 million vehicles on the market. This raises the question of who will take the risk of financing these long-term infrastructure capex. Public institutions, private companies or a mix of both? -

Beyond electrification related materials, some “surprise criticality” comes from materials that are critical only because some core industry segments are vulnerable to their absence of substitution such as Tungsten

Finally, some materials usually seen as “non sexy” are becoming increasingly critical due to under investment for many years: Tin & Zinc

The WMF assessment by BRGM, CRU and Mc Kinsey is summarized in the Mendeleev table below.

WMF Criticality assessment by BRGM, CRU & McKinsey



28 June / 11.30 am – KPIs for using materials smarter, less, and longer – Moderator: Johan Menckel

Over the last 3 years, **WMF has taken a pragmatic approach**, proposing some **KPIs to measure progress on decoupling sustainable growth and materials consumption** thanks to Using materials Smarter, Less and Longer ...and tested these KPIs with different industries – metals, aircrafts, cars and now smartphones and packaging.

WMF believes that – thanks to the past years effort – we are getting **close to reaching a consistent and relevant set of KPIs** – while including energy consumption this year and water consumption in 2019.

Meaningful **examples of using Materials smarter, less and longer** were presented: a **new Steel technology** of continuous production that allows a reduction of heating energy by 45% and scrap losses (oxidized steel) by 50%, **an innovative new material - composite of micro fibrillated cellulose and mineral** - that allows a weight reduction of White Top Liners by 35% while maintaining strength, opacity and brightness and further examples down the supply chain to reduce gauging or generating less scrap in the production of aluminium caps and closures.

The set of KPIs allows us to measure the full value chain of final product manufacturing. For example, the energy consumption a week's supply of food for one person along the supply chain. **Each stakeholder acting in the value chain (for example to manufacture a smartphone) could find one or several KPIs relevant to monitor.** It could enable the creation of a **"benchmark" of best performer and best practitioner...**and could lead to better communication by industry about its efforts. The **next challenge** will be to spread the word and **roll out these KPIs to more companies and industries.**

The **current set of KPIs** comprises:

Updated set of KPIs		Description
Use Less	Buy-to-use	Material value in the product / material value used in production
	% of recycled materials	Weight of recycled / total weight of materials in new product
	End-of-life recycling	Weight of materials effectively recycled / total weight of materials
	Energy	Total energy consumption to produce the product
Use Longer	Product lifetime	Total lifetime of the product, from completion to waste
	Resale price	Resale price after Y years / initial price (Y is industry specific)
Use Smarter	% of innovative materials	Weight of new or innovative materials / total weight of materials
	Product performance vs. weight	Performance measurement of the product key functions vs. weight
	Overall product usage	% of the time the product is used relatively to its full capacity

Source: WMF & Arthur D. Little analysis

28 June/2.45 pm – 3D as an industrial process? – Moderator: Victoire de Margerie

3D printing as a manufacturing technology can enhance the **freedom of design, chosen materials, and location of manufacturing**. It represents a huge **opportunity for the industry to use materials “smarter, less and longer”**. Various examples showed the possibility to reduce weight up to 65% of parts through different design concept.

3D printing and additive manufacturing currently account for ~ \$7.3B in business for materials, systems and services, across the materials categories of polymers, metals, ceramics and composites. **Only a third of this value now comes from functional parts production**, with short cycle time applications.

It is starting to **show its full value to deliver economic solutions** for demanding, high volume applications. Continuing **progress requires system improvements** to ensure repeatability and designing differently to facilitate materials combinations, new 3DAM processes and IT tools. **Lowering the cost of materials is also a “must”** on the road to industrialize additive manufacturing.

Influential enablers have emerged: **linking partners along the value chain** from design to production to deliver integrated solutions; culture change thanks to training; and a new approach to materials data management in order to support IT-based design and processes.

The potential and trajectory of growth of 3DAM will broaden further to cover more high-volume applications and **capture more value of the overall \$12 trillion manufacturing sector**.

28 June / 5.00 pm – Reduce materials intensity for building industry – Moderator: Philippe Varin

Urban and rural population will double from about 3 to 6 billion over next 30 years (particularly in emerging markets) - By then, about **70% of global population will live in cities**. Serving these trends of **growing population** and **increasing urbanization** will require significant **construction of buildings & facilities**. While **population tripled over last 70 years**, the **use of cement grew by the factor 34**.

But **construction industry** is, by nature, very **resource-intense**: Building accounts for 40% of raw materials used, and 40% of materials wastes generated. And it takes **20 years before the carbon emitted by operating a building equals the carbon emitted by constructing it**.

Also today's construction is **characterized by a fragmented value chain lagging in productivity**: 90% of world's infrastructure projects today are either late, over-budget or both and the **construction industry has lowest productivity gains** of any industry.

For existing buildings, the solutions have a lot to do with proper handling of secondary materials which means **ensuring that deconstruction and sorting is done correctly** (to avoid contamination and ensure material quality) and to **make the usage of secondary materials competitive versus alternatives such as landfilling**.

For new buildings, a step change in resource intensity needs to be organized by increasing building efficiency on all fronts (new architecture structures & frames such as mesh structures or spirals, modular & prefabricated solutions, 3D printing, digital tools), **by increasing durability of buildings or reusability of materials** (eco-design to create buildings that last longer, flexibly adapt to changing usage, reuse materials after deconstruction...) and **by promoting circularity** altogether through "labels for circularity", regulations to incentivise recycled content.

28 June/6.45 pm: Political Keynote Speech: Daniel Calleja Crespo

Daniel Calleja Crespo presented the EEC New Waste Legislation that aims to position further the EU as the leading region in the world for turning waste into resources. The objectives are ambitious with 70% recycling of packaging waste in 2030 and phasing out landfilling of all recoverable waste. The conclusion was a quote of a famous Nancy native Henri Poincaré : « It is through science that we prove... But through intuition that we discover ».



28 June/8 pm: Welcome Speech: André Rossinot

André Rossinot reminded all participants about the long story of Nancy region in developing materials' innovations, hosting both R&D, production sites – from steel and glass to composites and nanomaterials - and World Materials Forum since the 1st edition in 2015. He also values World Materials Forum as a great example of collective intelligence and would wish such model of collective intelligence to be more widely used in the political arena.



28 June/9.30 pm: Start Up Challenge Awards

The WMF Jury composed of world experts from WMF, Academia (EIT Raw Materials, Mines Paris Tech, Stanford University), Industry (Citrine Informatics, IBM, Johnson Matthey) and Key Opinion Leaders (Special Chem, Usine Nouvelle) had listed 12 high quality nominees at the end of April (Australia: 1, Belgium: 1, Canada: 1, France: 3, Portugal: 1, Switzerland: 1, USA: 4).

The themes approached by the nominees were also split between new catalysts (Polyspectra, Thrupore), new materials (BComp, Imagine, Mallinda, Rein4CED) or new material solutions (Cuberg), valorization of critical materials (Ajelis, Econick), recycling of commodity materials (Polystyvert), and new production processes (Akryvia, Smallmatek).

Three Awards were handed out during the Gala Dinner:

- The **WMF Grand Prix** was given to **CUBERG (Berkeley, California)** that offers a non flammable and thermally stable liquid electrolyte compatible with both high voltage metal oxide cathodes and lithium metal anodes with the results of high energy density & very safe rechargeable batteries.
- The **WMF Coup de Coeur** was given to **POLYSTYVERT (Montréal, Canada)** that offers a unique combination of 2 technology breakthroughs: the ability to separate dissolved PS from the solvent for high quality recycled PS and an in depth purification process to upcycle a,d get a final recycled product with the properties of a virgin one.
- The **EIT Raw Materials Award** was given to **SMALLMATEK (Aveiro, Portugal)** that offers a Chromium free technology with higher metal corrosion resistance while requiring lower consumption of additives thanks to encapsulated nano corrosion inhibitors into coatings. Pilot scale plant with 500l reactor in test.

29 June/8.30 am – Societal Keynote – Jacques Attali

For the Positive Planet Chairman, **collective work and transparency** are key to achieve an efficient management of our resources. He stated that **these great principles** - which are those of the World Materials Forum - **are also the two foundations of democracy** and peace thanks to free trade and economic development. Current geopolitical tensions can have huge impact on the criticality of certain materials like cobalt or rare earth but there is also a message of optimism by reminding as **scarcity always stimulates innovation**.



29 June / 9.00 am – Big data & AI driving materials Efficiency – Moderator: John Miller

This session showed that **this is possible to use Big Data/AI with a meaningful impact on Using Materials Smarter, Less and Longer**.

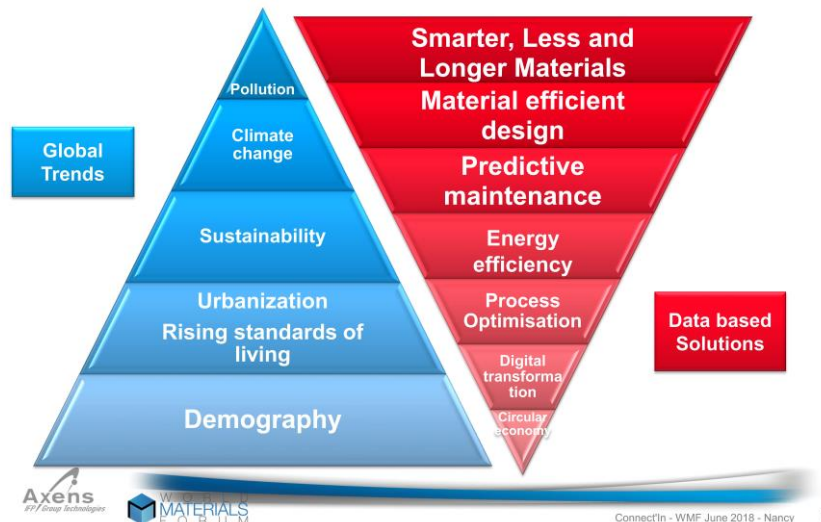
Even in aerospace that has specific materials challenges - lowest possible weight to reduce fuel burn, operation reliability & safety under versatile & extreme conditions and long product life.

Successful examples of the use of Big Data/AI covered both the quicker discovery of new materials (**identification of zirconium as a new additive to make aluminium alloys 3D printable** with the result of reducing the buy to fly ratio of certain aeronautic parts by 80%), new product design requiring less materials for the same performance (**selective integration of InGaAs onto silicium thanks to epitaxy**) and breakthrough performance improvements for existing production processes (**reducing telecom network rewiring needs – and consequent copper usage** – through better prediction of network usage)

Attention will need to be paid to optimizing energy consumption required by this novel way to use Big Data/AI such as self-powered IoT devices and low cost perovskite solar cells.

And the conclusion is:

Data management: a key lever to answer global challenges



June 29 / 11.15 am – E-wastes as a new resource? Moderator: Stéphane Mangin

The amount of **E – Waste (Waste from electronic devices)** is **growing rapidly**: the 45 Million tonnes in 2016 valued at €55 bn is estimated to reach 70 Million tonnes by 2021. For example, 1 billion phones will be produced in 2018 and to comply with Paris climate agreement, 140 million electric cars are needed requiring 11 million tons of lithium ion batteries.

The main materials contained in e-waste are: plastics, gold, copper, iron, palladium, silver and aluminum. However new electronic devices use an increasing amount of critical material such as Cobalt, Platinum and Rare-earth elements. The **main producer of e-waste** are China (16%) and the USA (14%) followed by Japan, India, Germany, UK (less than 5% each) However the **e-waste collection rate differs drastically** between Europe (35%) Americas (17%) Asia (15%) and Africa (0%).

Africa in particular faces an uphill struggle, since it has the smallest number of equipment manufacturers but also imports vast quantities of e-devices. **This results in an intense e-waste burden due to insufficient public awareness**, ineffective policies and legislation; underdeveloped collection infrastructure.

To **drive the circular economy**, we need to encourage **collaboration** (particularly across the entire value chain), **initiative** (either common goals jointly set by the industrial players themselves or by public regulation – up to labels that attract consumers), and **innovation** (across the board, from eco-design over new technologies to new business models).

29 June / 1 pm – Scientific Keynote – Eric Fullerton

Collecting and processing big data is fuelling our knowledge and insights. In 2017, **the world generated 15 zettabytes of data**, or 480 terabytes every single second! And **this amount of data continues to grow exponentially**, doubling every two years, mainly driven by the increasing number of users who use expanded storage devices & applications which produce data that is stored with ever-increasing capacity at lower cost – even though this progress is expected to slow down due to physical limits. **Storing and processing this data requires huge amount of energy**: Google alone consumes as much power as San Francisco.

So in order to keep on **fuelling Big Data storage and analysis**, the **next materials challenges** are in the field of **power, power density, and energy**. Over the **past 30 years**, we have seen a **10^5 increase in storage density** – which **provided the technology** for the **digital world**. In the next 30 years, we must achieve a **10^6 decrease in energy use in storing, transmitting and processing data**.

29 June / 1.30 pm – Closing remarks: Mayor Laurent Hénard

Laurent Hénard reiterated his pride that Nancy has hosted World Materials Forum since the 1st edition in 2015 and praised the presence of so many international participants that he sees as a very positive sign for the bright future of materials. He also expressed the wish of the city of Nancy to further create a favorable ecosystem for start ups willing to establish their headquarters or their European operations in Nancy.



28 June / 1.30 pm – Closing remarks – Philippe Varin

What did we achieve during WMF 2018?

We have presented a **Criticality Assessment as a world premiere offering flexibility of usage** to all materials stakeholders whatever their geographical location or position in the supply chain.

We have established a **KPIs toolkit** that is easy to understand and apply for everyone. These KPIs must now be spread over various industries and value chains, permanently refined and developed.

We had a **vivid exchange of rich information** (... even if the format sometimes was close to “death by power point”) and we have **fostered connectivity** among our broad & deep **network**.

What are the key questions and challenges that the WMF must address in future?

How can we manage to **expand our geographic reach** (in terms of awareness, participants)?

How can we continue to **increase diversity** and **attract people from younger generations** (who will ultimately be even more impacted by the issues of materials scarcity and use that we discuss here)?

How can we **leverage** and **share the knowledge** and **insights** that we have discussed at our WMF to **broader audiences** (for instance via MOOCs, etc.)?

